The Impact of Climate Change on Agriculture, Forestry, and Water Management Sectors of Tajikistan

The predicted climate-related effects. No adaptation scenario.

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1. Executive Summary

Tajikistan's relatively low level of socio-economic development, lack of infrastructure, and high dependence on climate-sensitive sectors make the country extremely vulnerable to the risks associated with climate change and related extreme weather events. This study analyzed the impacts of climate change in six districts: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, and Muminabad.

The climate change in Tajikistan is observed and can be predicted via temperature increase (0,26-0,37 ^{0}C per 10 years, all districts), through the increase in yearly precipitation (Kanibadam and Shaartuz), change in seasonality of precipitation (all regions), increase in wind (Kanibadam) and evaporation indices (all districts), and extreme weather events (sudden rains, spring frosts, heat waves, etc.)

The effects of climate change on agriculture, water resources, and forestry are difficult to separate from the impacts of 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 inter-governmental efforts in this domain makes it more difficult to separate the impacts of climate change from other factors.

This study attempted to analyze the impacts of climate change on agriculture, water resources, and forestry from the perspectives of the literature, multi-factorial mathematical models, statistical analyses of existing data, focus groups, and expert interviews. In the case of **water resources**, all the analyses presented similar outcomes – climate change negatively affects water quality and availability. Namely, it increases the 1) physical risk of quantity that comprises water stress, groundwater table decline, interannual variability, seasonal variability, drought risk, riverine flood risk, physical risk, 2) quality that encompasses untreated connected wastewater, eutrophication potential and 3) regulatory and reputational risks that consist of unimproved/no drinking water, unimproved/no sanitation water. However, the manifestations of these risks are highly dependent on the quality of infrastructure and water distribution on national and international levels. The adverse effects of climate change are aggravated by the increased demand for water, related to population increase.

The impact of climate change on **forestry** needs to be analyzed in the context of quality of infrastructure, forest use, and deforestation. The latter was pronounced over the last thirty years and was accompanied with reforestation efforts. The climate change negatively affects both the existing forests and newly afforested areas via the periods of droughts, extreme weather events such as water- and mud-flows, landslides, etc. The effects of climate change are then aggravated by the increased forest use by humans and domesticated animals and the degradation of forest infrastructure.

While analyses of the impacts of climate change on forestry and water resources produced clear pictures, the effects of climate change on **agriculture** were less consistent. According to the multi-factorial mathematical models and the qualitative analyses (focus groups and expert interviews), the adverse impacts of climate change on agriculture dominate in the short and long run, though some positive effects, such as increase in vegetation period, increase in yields of certain crops, may also be manifested. Contrary to the above, the statistical analyses of existing data on the crop yields, planted areas, and production reported stagnation or slight increase in crop yields and the total crop production.

This dichotomy in results may present significant challenges for the policymakers in adopting relevant adaptation measures as from the point of view of production data, the current adaptation efforts may seem sufficient. However, the relatively positive development of agricultural production and yields is affected by many factors, most of which are likely to cease in the short and long run. First, the positive developments are affected by the low base stating that the increase of agricultural production is compared with the steep drop in 1990th caused by the civil war. The development in 2000th just recovered from the period of decline in 1990th. Second, the existing data account for existing adaptation efforts on the side of government and international communities. Third, the population seems to be able to adapt to climate change to some extent. However, this adaptation has considerable limits. The limits are given by the limited amounts of alternative water sources (wells) that partly substitute for the scarce irrigation water in some districts; by the limited availability of unused agricultural land, which can be employed in case the traditionally used land deteriorates and needs to be taken out of production; limits of education and information that prevent the population from adopting the best agricultural technologies; the land fragmentation that diminishes the efficiency of water use and obstructs the fight against the pests; the limited emergency control which makes part of agricultural production swept away by the water of mudflows, which at the same time damage the infrastructure; limited availability of drought-resistant seeds, etc.

In other words, the adverse effects of climate change present themselves in the opportunities and options to increase production that have not been exploited, which, given the population growth, is likely to present considerable problems in the future.

Over the last thirty years, Tajikistan has experienced extensive population growth. The Tajik population currently amounts to 9.54 million and it is expected to reach 13.85 million by 2040 and 25.33 million by the end of the century. The population growth creates additional pressure on the water and food resources.

The agricultural production in Tajikistan reached a massive gross production value growth from 1992 to 2018 - the agricultural gross production value in constant prices increased from 988 million USD to 2.9 billion USD. During the analysed period, the average annual temperature increased from 11.9 °C to 14.2 °C. This study did not find any direct negative statistical relationship between temperature increase and agricultural performance over 1992-2018.

Though past agricultural production, as captured by statistical data, provides an optimistic picture, qualitative field analysis and the analysis of existing literature conducted in this study indicate that much of this growth cannot be attributed to climate change. On the contrary, the growth of agricultural production had to compensate for climate change. The population on the local level was able to adapt to climate change, massify and intensify the agricultural production, and use new water sources (wells) if the traditional ones presented shortages. However, the population seems to have reached the limits of this adaptation, and the further reliance on local adaptation does not seem appropriate.

Six main climate-related threats to the socio-economic wellbeing of households were identified in the field qualitative part of the study and the literature research: 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 potentially positive impact of climate change implied prolongation of vegetation period, which can enable three harvests per year contingent upon sufficient watering and limited soil degradation.

Human activities may substantially aggravate climate-related threats. The increasing demand for water and inefficiency of water use currently exacerbate the negative effects of climate change on water resources. Human-related land degradation - caused by inefficient land use, overgrazing of pastures and forests, cutting forests, improper use of fertilizers, non-existent crop rotation, lack of winter watering, lack of modern agricultural and water-use technologies, etc. - exacerbates the climate-related land degradation. Deterioration of infrastructure, population growth (leading to more houses in endangered areas), and a deteriorated or non-existent system of warning exacerbate the climate-related risks of emergencies.

As for the future prediction of agricultural production, it is possible to expect indirect negative impacts related to upcoming climate change. The reduction of the inter-annual growth rate of yields and production volume is expected. The analysis of target districts suggested marginal negative production impact on selected crop production performance up to 2030, respectively 2040. This result is supported by the results of CARD model, where the yields of particular crops are expected to stagnate after the increasing pro-growth 30-years trend, although the resulting yields are still predicted to be much lower than is biologically possible. Water seems to be the most important factor limiting the yield growth.

The quantitative twenty-year analysis of the complex risk of water stress[1] for optimistic, median, and pessimistic scenarios predicted high and extremely high risk in Muminabad, Kuhistoni Mastchoh, and Kanibadam, while the risks in three other districts were considered medium. The risk of seasonal variability (meaning that dry months are expected to become even drier and wet months even wetter) predicted high levels of risk in all the districts except

[1] Water risk refers to the possibility of an entity experiencing a water-related challenge (e.g., water scarcity, water stress, flooding, infrastructure decay, drought). The extent of risk is a function of the likelihood of a specific challenge occurring and the severity of the challenge's impact. The complex risk of water stress implies its availability and quality, the water risks for agriculture, and the seasonal risks.

Muminabad, where the risk is extremely high. This also implies increased risk of drought and extreme rains. The districts most affected by the lack of water supply are predicted to be Gissar, Fayzabad , and Shaartuz. Kuhistoni Mastchoh is the least affected area. The fact that the Kuhistoni area is alpine, where snowfall and melting are expected may play a role. The risk of higher water consumption was the highest in the Kanibadam area up to 2030, while on the horizon of 2040, Kuhistoni Mastchoh was added to the endangered zone. All in all, water-related risks are predicted to be very pronounced up to 2040, which, most likely, will not enable the country to capitalize on the positive effects of climate change and will worsen the negative ones. Adaptation measures are necessary.

The interpretation of the results presented above should be taken with care, as the substantial negative impacts of climate change are expected after 2040. Predictions and models available in the literature conclude that the direct negative climate change impact on agricultural production is expected in the period not covered by this analysis (after 2040). The majority of prediction models expect likely reductions in agricultural production during the period 2040 – 2060. The applied CARD model confirms the before-mentioned facts.

To sum it up, the expected population growth in Tajikistan is in desperate need to increase its agricultural production and the efficiency of water resource use. The past dynamics of agricultural production presents considerable growth, despite the climate change. The analysis suggests that adaptive measures of the local population cause at least part of this dynamics. However, this adaptation seems to be reaching its limits. The predictions suggest just small or negligible growth of agricultural production over the following twenty years, not sufficient for the population growth for optimistic and median scenarios. If a pessimistic scenario is realised, a fall in yields is expected. The predictions presented in this study were conducted for the time span of 2040. According to other studies, many of the negative effects of climate change are expected afterward. The biggest limiting factors are soil degradation and water resources. Adaptive measures are necessary.

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List of Abbreviations

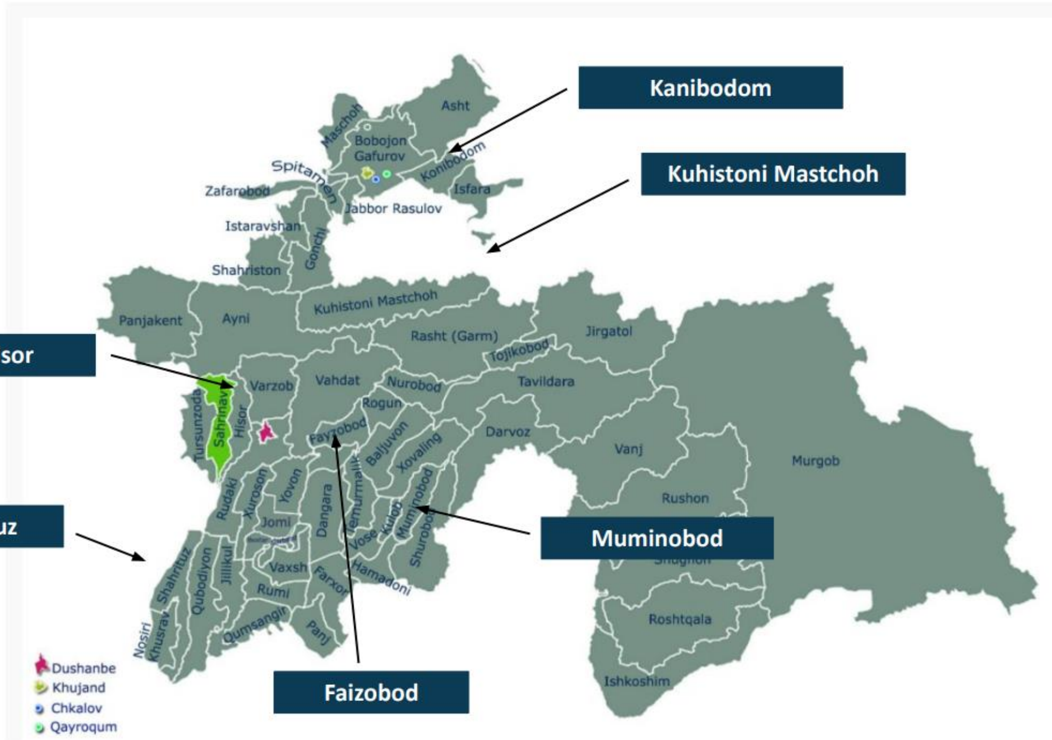
AEZ	Agro-Ecological zones
BCF	Big Fergana Canal
BFC	Big Fergana Canal
CARD	Climate Adaptation in Rural Development
CC effect	Climate Change Effect
CRED	Centre for Research on the Epidemiology of Disasters
CWWTP	Communal Wastewater Treatment Plant
DCM	Debt Capital Markets
EMDAT	Emergency Events Database
ESG risk	Environmental, Social and Governance
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	greenhouse gases
GIS	Geographic information system
GIZ	German Development Agency
GLOFs	Glacier Lake Outburst Floods
GNI	Gross National Income
GSL	Growing Season Length
GWP	Global Warming Potential
hPa	Hectopascal (Air pressure)
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISIMIP	Inter-Sectoral Impact Model Intercomparison Project
JMP	Joint Monitoring Programme
KRB	Kafirnigan River Basin
LGP	Length of growing period
LGPeq	Equivalent growing period
LGPt	Temperature growing period

NDS	National defense Strategy
NPK	nitrogen (N), phosphorus (P), and potassium (K) fertilizer
PIK	Potsdam Institute for Climate Impact Research
ppm	parts per million
RCP	Representative Concentration Pathway
SMB	small & medium business
SPEI	Standardised Precipitation Evaporation Index
SUE	State Unitary Enterprise
SV	Seasonal Variability
TJS	Tajikistani somoni
TNC	Transnational Corporation
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework. Convention on Climate Change.
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, Muminabad districts.

Figure 3-1 The target districts: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad



Shaartuz district climatic characteristic

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 exact methodology of the focus groups, the structure, the methods of jamoat selection, and the descriptions of socio-economic characteristics of the districts are presented in the Appendix 3 to this report. 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 appendix 4. 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.

Limitations

Like any analysis, this study is subject to a number of limitations. The more extensive discussion on limitations is provided in the Appendix 1 to this report. Here we summarise the most important points. The largest limitation concerned the availability and reliability of relevant data. In many cases, the requested data were not available or did not exist. For example, the interview data suggested, that all-encompassing data on forestry inventory are yet to be gathered at the end of 2022 with the help of the World bank. The high-quality time series on soil quality in the target districts also seem to be non-existent.

Another type of limitation concerns the quality of the available data. A more extensive discussion is provided in the Appendix 1. The available data on district-level agricultural production did not allow to statistically separate the effects of climate change from the effects of other variables. In order to do so, standardized modelling techniques were used. The difference in outcomes was then analysed in the context of the qualitative field research in order to increase the robustness of the study. The selection of indicators was also contingent on both the aim of the study and the data availability, which again provided certain limitations.

4. Introduction

Tajikistan is a mountainous country with an altitude of between 300 and more than 9000 meters, whereas 93 percent of the country is a mountain range, some of which are among the highest in Asia - Tien Shan and Pamir.

Tajikistan's relatively low level of socio-economic development, lack of infrastructure, and high dependence on climate-sensitive sectors make the country extremely vulnerable to the risks associated with climate change and related extreme weather events.

Tajikistan is generally the poorest country in the former Soviet republics, with low incomes with a gross national income (GNI) per capita of 4,050 Int $ and a population of 9,1 million by 2018.

Agriculture is the second largest sector of the economy, and in 2018 it represented 19% of the country's GDP of $ 7,523 billion and 51% of its employment. 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. Of the permanent arable land, 68 percent of the land is irrigated. Food is primarily produced to meet national consumption. However, about 120,000 tonnes of food products are exported each year, which represents about 2-3% of total exports by volume. Climate change could affect food production through direct and indirect effects on crop growth processes. Direct effects include changes in carbon dioxide availability, precipitation, and temperatures. Indirect effects include impacts on water availability and seasonality, soil organic matter conversion, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and the loss of arable land due to desertification. With projections of a significantly increased probability of drought and heat waves, agricultural production is likely to be less stable.

The most water-intensive are the most commonly grown market crops, such as cotton, fruit, and vegetables, so agriculture in the country is highly dependent on irrigation. This situation is partly responsible for Tajikistan's high vulnerability to the effects of climate change.

Climate change is already affecting the country's economy, society, and ecosystems. Tajikistan is at risk of soil erosion due to weather events, and water availability and quality are deteriorating. Extreme weather events (such as floods, droughts, avalanches, and landslides) regularly destroy land, crops, and infrastructure, with average annual losses between 1996 and 2015 estimated at 7,4% of the country's GDP. These losses indicate the need for immediate adaptation activities. The most common impacts are soil degradation and fertile topsoil erosion, as well as infrastructure impacts due to extreme weather events, such as torrential floods, drought, and more. The combination of increasingly unpredictable frequency and intensity of extreme weather events and changes in the hydrological cycle reduces productivity and food safety but also affects the health of the population. It is assumed that higher temperatures combined with high levels of flood-related water contamination will increase the risk of infectious diseases and gastrointestinal infections.

In the middle of the 20th century, about 6% of Tajikistan's area was covered by glaciers. At the beginning of this century, this number dropped to 5 percent. By the end of the century, glaciers in Central Asia are expected to lose about 50-70%. This melting is likely to have a very significant impact on the Amu Darja and Syr Darja river basins. Melting glaciers and snow usually ensure water availability throughout the year. Continued melting of glaciers will mean increased runoff, and once smaller glaciers disappear, flow on smaller tributaries can drop dramatically.

This study aims to identify the existing climate change experiences over the past ten years (changes in temperature, frequency/intensity of precipitation, seasonal temperatures, etc.) and observable impacts on agricultural production, forestry, and water quantity/availability. Based on existing climate forecasts and the past observed changes, the study aims to identify the likely climate change scenarios over the next ten and twenty years.

This study focuses on the six target districts in Tajikistan located in three main agro-climatic zones: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad. The districts represent a large variety of altitudes, slopes of agricultural land, types of soil and irrigation, and mixes of agricultural production. The study aims to identify the climate change experiences and the effects of climate change in the target districts as representative districts for Tajikistan.

Methodologically we rely on a combination of (1) study of relevant literature and documents, (2) secondary statistical analysis of existing data, (3) focus groups in target districts (one group per district), and semi-structured expert interviews.

The study is structured as follows. The first chapters describe the districts, the climatic trends, and predictions for Tajikistan and the districts. As climate change scenarios have minimal impact on the prediction of temperatures and precipitation in the short run of 10 to 20 years, we concentrate our prediction of climate change in the districts on a statistical analysis of existing trends. We contrast our results with the qualitative assessment of climate change in the target districts conducted on the basis of semi-structured interviews and focus groups. The results confirm an increase in average temperatures of about 0,27-0,37 ^{0}C per 10 years. The yearly precipitation proved to be a statistically significant increasing trend in Kanibadam and Shaartuz. In all the other regions, the trends were not statistically significant.

The next chapter analyses the impact of climate change on agriculture. The complex analysis of existing models described in the literature suggests that climate substantially damages the agrarian sector in the short and long run, both on the side of demand and supply. The positive effects of climate change, such as prolongation of growing period (thus enabling three harvests per year) or larger potential crop yields of certain crops (due to higher temperatures) are largely offset by the negative effects such as lack of water, climate-related soil degradation or negative extreme weather events. The total effect of climate on agriculture is predicted to be largely negative. The results of the qualitative part of the current study support this conclusion - climate change is viewed largely negatively by the local population and expert community in the target districts. The positive effects are offset by the negative ones.

The results of both modeling and the qualitative study were not supported by the results of statistical analyses of actual crop yields in the districts over an 11-year time span (2005-2016, the last data available for all the districts). Most of the districts in case of most of the crops showed a stagnant or positive trend. Similarly, the results of statistical analysis of crop yields for the whole Tajikistan in the time span 1992 to 2020 did not show any negative tendency.

The contradiction between the qualitative analysis and modeling analysis on one side and the results of actual yield data analyses suggest that the actual data are influenced by a number of other factors, which partly offset the effect of climate change – the effect of low base over 1990th (civil war), the effects of various government policies and the partial ability of the population to adapt to the change in climate. The potential of this adaptation is, however, limited and can be exhausted over the next few years. Thus, the activity of the government and international donors to help the country to adapt to climate change is necessary.

The following chapter analyzes the impact of climate change on water resources. Here we rely on quantitative modeling of the 1) physical risk quantity that comprises water stress, groundwater table decline, interannual variability, seasonal variability, drought risk, riverine flood risk, physical risk, 2) quality that encompasses untreated connected wastewater, eutrophication potential and 3) regulation and reputational risk that consists of unimproved/no drinking water, unimproved/no sanitation water, peak RepRisk country ESG risk index. The study contains four chapters - basic scenarios, scenarios for the agricultural sector, analysis of monthly data, and scenarios of future development. All model outputs show a high and very high risk for the country's water resources. Not only the quality of groundwater and surface water is endangered, but primarily the amount of available water as matched with demand. These results are then contrasted with the results of qualitative analysis in the districts and expert interviews. Both of the analyses supported the conclusions of the modeling above.

The next chapter analyzes the effect of climate change on forestry. Forestry in Tajikistan experienced significant deforestation as the population used the forest wood as a source of firewood if other energy resources were lacking. A large portion of forests was destroyed. The forestation and afforestation efforts largely depend on the district, as some districts (e.g. Kanibadam) do not possess much forests. The climate effects on forestry concerns both the existing forests (which suffer from droughts) and the new afforestation and forest regeneration efforts.

In conclusion, from the point of view of policymakers, the effects of climate change on agriculture, water resources, and forestry might be viewed as clearly damaging for water resources and forestry but largely unclear for agriculture. The mathematical models and qualitative analyses on one side and the analysis of actual data on crop yields on the other, present opposite results – while models and interviews predict largely negative effects of climate change on agriculture, the available data suggest stagnant or slightly increasing trends in crop yields. However, the actual data on crop yields are largely affected by a number of other factors, such as the effect of the low base in 1990th, the effects of governmental policies, the current national and international programs aimed at climate change adaptation, and the efforts of the population to adapt. These abilities have certain limits, which will most likely be exhausted in the near future.

Tajikistan experienced rapid population growth. Starting from 2 million in 1960, the Tajik population reached 9.54 million in 2021 and it is expected to grow to 13.85 million by 2040 and it almost double by the end of the century. Over three-quarters of the Tajik population are rural and dependent on agricultural production. Suppose the country does not undergo quick industrialization in the near future. In that case, the population pressures, lack of water resources, and land degradation will make the whole system unsustainable in the long run.

The long-term sustainability of agricultural production and availability of acceptable quality and quantity water resources can be highly compromised by climate change. Similarly, climate change may directly affect the living, health, and socio-economic standards of the population. This study aims to identify the direct threats to the socio-economic wellbeing related to climate change in six selected districts, predict how the impacts of climate change develop and assess the costs/benefits of climate change in the horizon of ten to twenty years (till 2030 and 2040). The selected target districts include Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad. The climate change effects are also studied on the level of the country as a whole.

Methodologically the study relies on district-level focus groups and semi-structured interviews, analysis of existing literature and data, and computation of predictions and trends via climate-related models.

We identified six main climate-related threats to the socio-economic wellbeing of households and one potentially positive outcome: 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. On the positive side, we expect the prolongation of the vegetation period, which can enable three harvests per year, contingent upon sufficient watering and limited soil degradation.

The direct and indirect influence of climate-related threats and benefits in Tajikistan are closely connected to the other factors related to agricultural production, such as land use, prevalent agrarian technologies, the level of education, the quality of infrastructure, land fragmentation, the socio-anthropological aspects of agricultural production and rural life. More often than not, the effects of climate change are indirect and interwoven with the other aspects. This study aims to study the most pronounced ones.

Human activities can substantially worsen the impacts of climate change. Human-related deforestation, inefficient land and water use, and inadequate agricultural technologies increase the effects of climate on land degradation and intensify the negative effects of higher temperatures. However, if reversed, these factors may also create opportunities to mitigate the climate effects. In particular, efficient water use seems to be a pressing issue.

In this study, we computed predictions of future water availability and usage. The future predictions for water stress were computed and analysed for optimistic, median, and pessimistic scenarios up to 2030 and 2040. The quantitative twenty-year analysis of the complex risk of water stress predicted high and extremely high risk in Muminabad, Kuhistoni Mastchoh, and Kanibadam, while the risks in three others districts were considered medium. The risk of seasonal variability predicted high levels of risk in all the districts except Muminabad, where the risk is extremely high. This implies that in all the districts, dry months are expected to become even drier and wet months even wetter. We also predicted higher risk of drought and extreme rains in all the districts.

The districts most affected by the lack of water supply are predicted to be Gissar, Fayzabad, and Shaartuz. Kuhistoni Mastchoh is the least affected area. The fact that the Kuhistoni area is alpine may play a role. The risk of higher water consumption was the highest in Kanibadam up to 2030, while on the horizon of 2040, Kuhistoni Mastchoh was added to the endangered zone.

From the above, it follows that all the districts are predicted to suffer from water-related risks, including the lack of water, water emergencies, or suboptimal quality of water. This, most likely, will not enable the country to capitalize on the positive effects of climate change. The negative effects of climate change (e.g., soil degradation) are likely to worsen. Adaptation is necessary. The future socio-economic wellbeing of population is highly dependent on agriculture. Agricultural production in Tajikistan reached a massive gross value growth in the period 1992 - 2018. The agricultural gross production value in constant prices increased from 988 mil. USD to 2.9 billion USD. The key drivers of the above-mentioned trend are both crops and livestock production.

According to our statistical data analysis, there is no direct climate-related impact associated with the agricultural production volume and value. Moreover, it is possible to identify the positive correlations between temperature increase and agricultural and national economic performance. The only statistically proven negative effects of agricultural production could be associated with the massive growth of necessary inputs utilization.

However, the political implications of this result should be taken with care, as it does not take into account the adaptive capacity of the population, the change in production technologies, the massification of agricultural production, the adaptation of new lands for agriculture that took please over the last 30 years. All these factors impact the relationship between climate change and agricultural production, limiting the negative effects of climate change. The qualitative part of this analysis suggests that the limits of this adaptation on the local level have already been reached in many cases. This result is supported by the results of CARD model, where the yields of particular crops are expected to stagnate after the increasing pro-growth 30-years trend, although the yields are still predicted to be much lower than is biologically possible. The future adaptation needs to be more centralized and will require more investments. Out of climate-related factors, water resources seem to be one of the most limiting. The predictions of water stress[2] conducting in this study suggest worsening prospects in most of the studied districts in the horizon of 20 years. Water stress includes not only the quantity and quality of water available but also the timeliness of water availability, the water-related emergencies, the regulation, and reputational risks. The lack

[2] Water risk refers to the possibility of an entity experiencing a water-related challenge (e.g., water scarcity, water stress, flooding, infrastructure decay, drought). The extent of risk is a function of the likelihood of a specific challenge occurring and the severity of the challenge's impact. The complex risk of water stress implies its availability and quality, the water risks for agriculture, the seasonal risks

of water may prevent the country from capitalizing on the positive effects of climate change on agricultural production, such as more harvests per year of increased crop yields.

As for the future prediction., it is possible to expect especially indirect negative effects impacts related to upcoming climate change. The reduction of the inter-annual growth rate of yields and production volume is expected. Considering results calculated for target districts – it is possible to highlight only marginal negative production impact on individual districts and selected crop production performance up to 2030, respectively 2040.

Agricultural production will suffer because of limited water availability. There is also a problem related to a continual process of land degradation as the result of too intensive agricultural activities and bad agricultural land management. The agricultural sector will suffer because of limited ability to reach effective economies of scale as the farm size is very low. The majority of farms are suffering because of too low agricultural land area and also because of limited access to capital. The only limited trade-off between labour and capital are also possible to consider as a significant weakness. Agricultural production and capacities are considered to be limited with respect to the only limited area of agricultural land suitable for intensive agricultural activities and also because of biological and genetic limits.

The available data could be considered as rather tricky speaking about the future prediction as the really negative impact of climate change development is expected after 2040. Taking in consideration available predictions and models, the direct climate change impact associated with agricultural production volume reduction is expected for the period not covered by this analysis. The majority of prediction models expect possible reductions during the period 2040 – 2060. The before mentioned fact is even confirmed by the applied CARD model.

5. Population development in Tajikistan

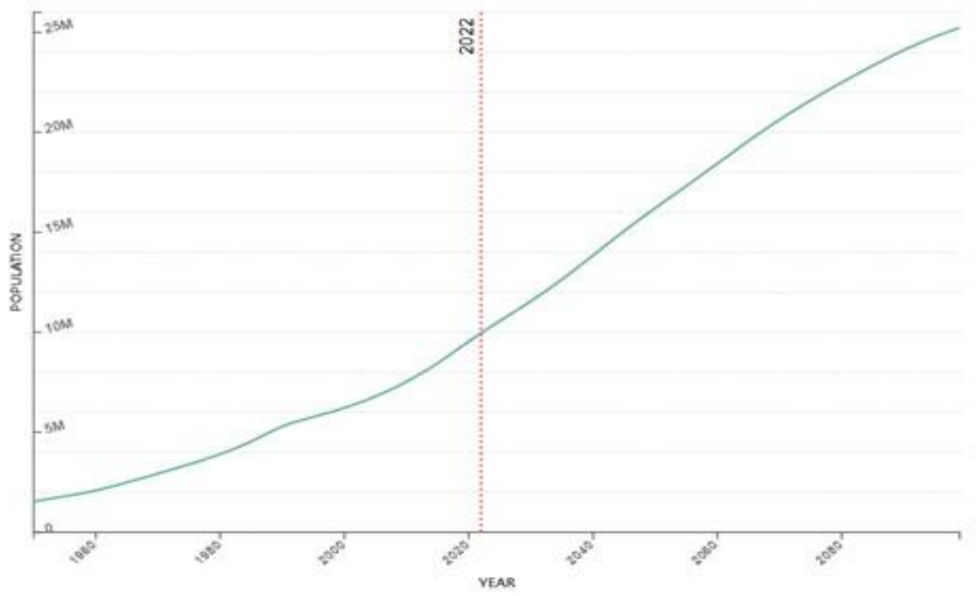
The population of Tajikistan currently amounts to 9.54 million and is expected to reach 13.85 million by 2040 and 25.33 million by the end of the century (UN, 2022). 75-100% of population in target districts is rural, dependent on agricultural production and water resources. If the country does not undergo industrialization in the near future, the expected population growth will put substantial pressure on agriculture and water resources.

Tajikistan, which currently has a population of 9.54 million, is projected to continue growing at a relatively quick rate for the rest of the 21st century (Figure 5-1, 5-2). According to current projections, Tajikistan's population will reach 13.85 million by 2040 and 25.33 million by the end of the century (UN, 2022).

Tajikistan's population growth rate from 2020 to 2021 was 2.22%. This added over 200,000 people to the population. Tajikistan's fertility rate is relatively high at 3.4 births per woman. The high fertility rate helps the population grow, despite negative net migration each year, and keeps the population young. The median age is 22.4 years (UN, 2022).

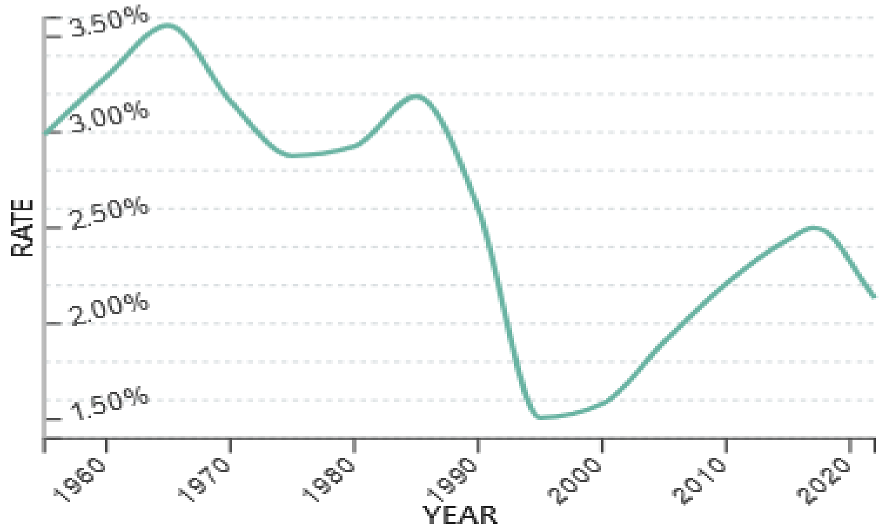
Tajikistan's population boom threatens its economy and resources. The government has implemented laws in the past to encourage contraception and while this has helped bring down the fertility rate, the country still has a long way to go (World population prospects, 2019).

Figure 5-1 Tajikistan – population development and prospect



Source: https://worldpopulationreview.com/countries/tajikistan-population, 2022

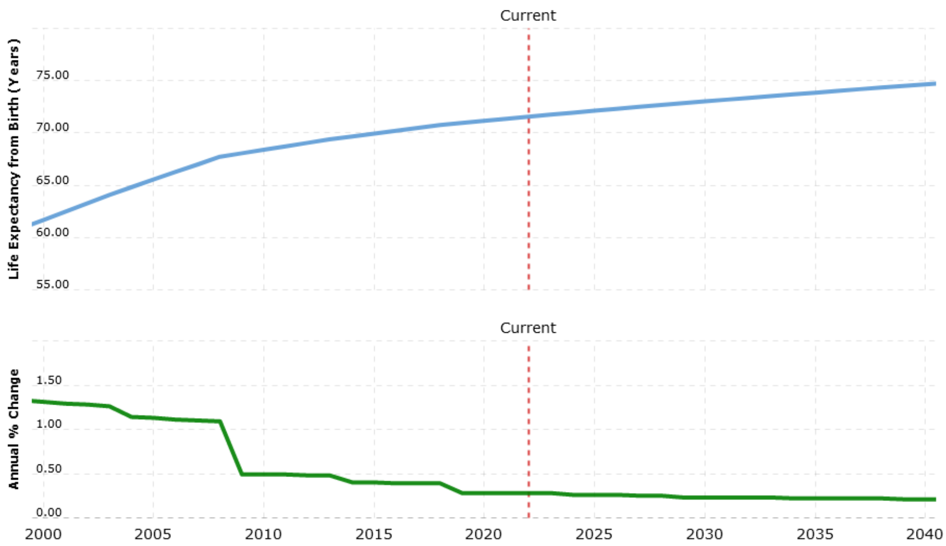
Figure 5-2 Tajikistan – population growth rate



Source: https://worldpopulationreview.com/countries/tajikistan-population, 2022

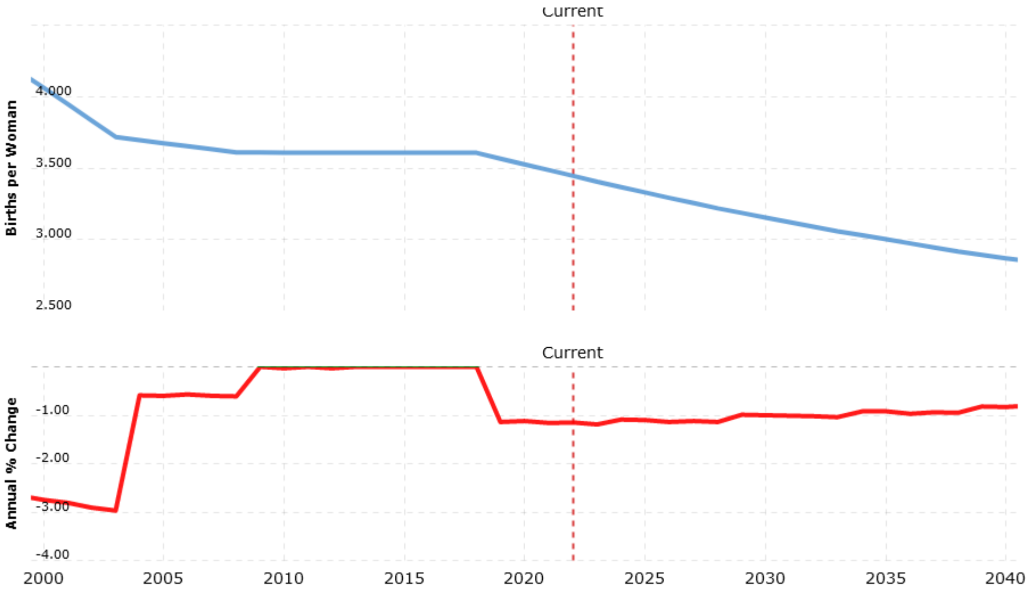
The population in Tajikistan is considered to be rather young and its population prospects is still enormous as there is still a massive share of the young population in the total population. The growth of the population is pushed by the mix of two drivers. First, life expectancy is constantly increasing. Only in the period 2000 – 2022, the life expectancy increased from 61.69 years to 71.56 years (for details see Figure 5-3). Second, despite of decreasing fertility rate, its value is possible to consider as rather high. While in 2000 the average fertility rate reached 4.06 births per woman, in 2022 the fertility rate still oscillated close to 3.4 births per woman. The prospects for 2030 and 2040 are estimated to be cc 3.2 respectively 2.9 births per woman (for details see Figure 5-4).

Figure 5-3 Tajikistan – life expectancy development and prospect (2000 – 2040)



Source: United Nations - World Population Prospects, 2022

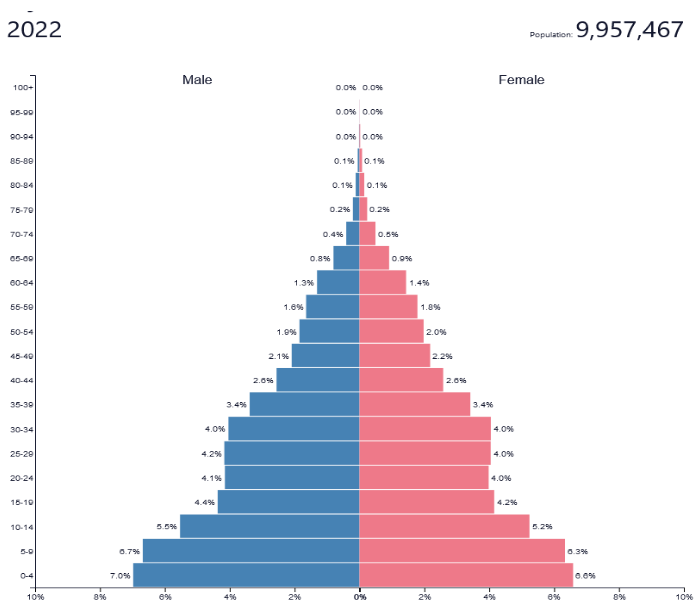
Figure 5-4 Tajikistan – fertility rate development and prospect (2000 – 2040)



Source: United Nations - World Population Prospects, 2022

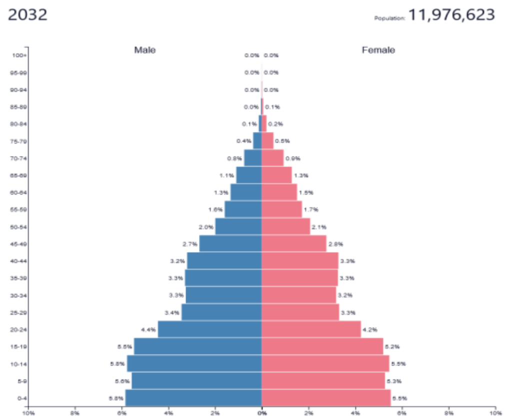
Another driver of population development is an extremely significant share of young people in the total population. Approximately 54% of the total population is not older than 24 years. But on the other hand, as life expectancy is considered to increase by 2040 to cc 75 years and the fertility rate is expected to be reduced to about 2.9 births per woman – the ageing process will become also significant as it is typical for many other countries. But, the growth of the population will be still significant. In 2100 the Tajik population is expected to reach over 25 million people if we take in consideration the UN prospect. The following figures provide an overview of expected population development in the upcoming decades.

Figure 5-5 Population Pyramid of Tajikistan in 2022



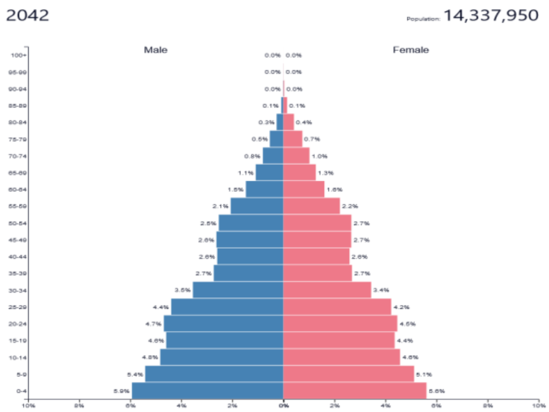
Source: https://www.populationpyramid.net, 2022

Figure 5-6 Population Pyramid of Tajikistan in 2032



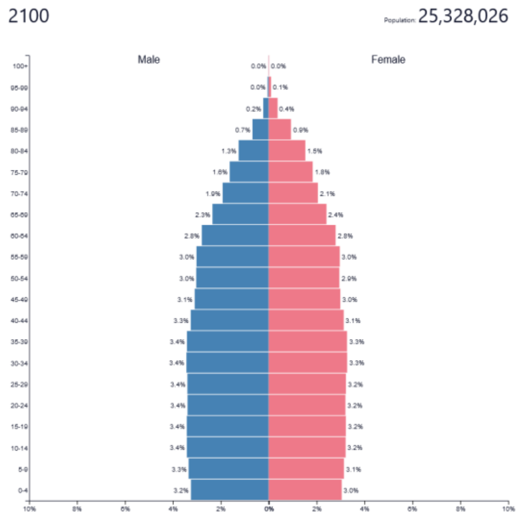
Source: https://www.populationpyramid.net, 2022

Figure 5-7 Population Pyramid of Tajikistan in 2042



Source: https://www.populationpyramid.net, 2022

Figure 5-8 Population Pyramid of Tajikistan in 2100



Source: https://www.populationpyramid.net, 2022

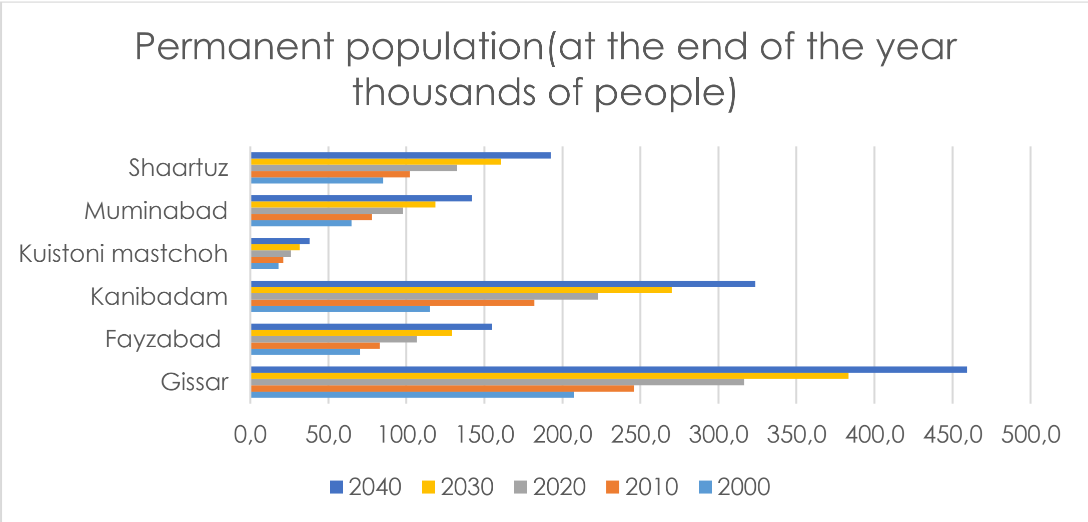
Speaking about selected districts' population development dynamics, it is possible to summarize their population development through the following Table 5-1 and Figure 5-9. All districts under the analysis are typical because of massive population growth. Only in the period 2000-2020 do individual districts record the growth of population by 61% i.e. 342 thous. people. The expected population growth for 2030 and 2040 is about 30% respectively 45% in comparison to 2020. The most significant population growth is expected in Gissar and Kanibadam.

Table 5-1 Population development and prospects in selected districts in Tajikistan

in thous. inhabitants	2000	2004	2008	2012	2016	2020	2030	2040
Gissar	207,3	222,2	242,9	259,3	287,4	316,4	383,4	459,3
Fayzabad	70,4	75,4	81,5	87,9	96,9	106,7	129,3	154,9
Kanibadam	115,0	123,3	176,7	188,9	202,5	222,9	270,1	323,6
Kuhistoni Mastchoh	18,0	19,3	20,7	22,0	23,7	26,1	31,6	37,9
Muminabad	64,8	69,4	76,0	81,6	88,9	97,9	118,6	142,1
Shaartuz	85,1	91,2	101,3	107,7	120,5	132,7	160,7	192,6

Source: own processing, TAJSTAT & UN, 2022

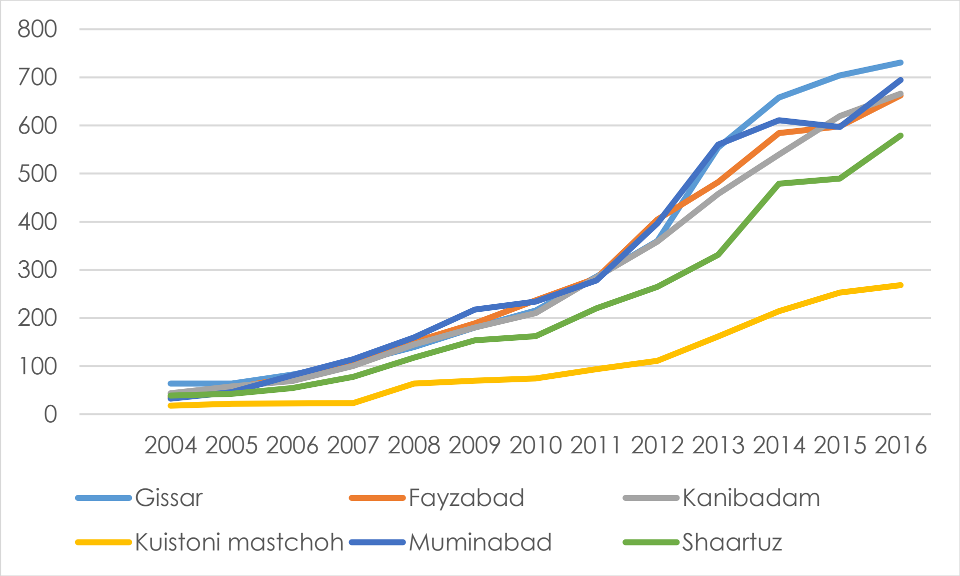
Figure 5-9 Permanent population development is selected districts in Tajikistan



Source: own processing, TAJSTAT & UN, 2022

In all the districts average monthly nominal wage wase increasing (figure 5-10) Some of this increase reflects inflation. Average wage is smallest Kuhistoni Mastchoh, which reflects detachment of the region from the rest of the country and lack of earning opportunities. The region is difficult to access in winter. However, the average wage might not be the best indicator of the economic well-being in the districts as in rural districts much of necessities the population produce themselves.

Figure 5-10 Average monthly nominal wage in selected districts in Tajikistan



Source: own processing, TAJSTAT & UN, 2022

Table 5-2 Rural population in target districts, %

	2004	2008	2012	2016
Gissar	85,7	85,3	85,4	85,8
Fayzabad	88,3	89,1	89,7	90
Kanibadam	72,7	73,8	74,5	74,8
Kuhistoni Mastchoh	100	100	100	100
Muminabad	83	84,1	84,4	84,7
Shaartuz	86	85,6	85,8	86,5

Source: own processing, TAJSTAT & UN, 2022

6. The observable climate change over the last 30 years, the predicted climate change

6.1. Climatic characteristics of the target districts

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

The territory of Shaartuz is located in a dry climate zone with very warm summers and mild winters. The meteorological station Shaartuz is located in the southern Tajik lowlands, in the valley of the Kafirnigan River. However, the meteorological station ceased its operation in 2008.

The district of Shaartuz covers a flat area of approx. 1,500 km^2. Approx. 9% of the total district area is covered with low mountain ranges (up to 2,100). The climate of the region is dry and subtropical, with warm-hot, dry summers and mild winters.

The average annual temperature is 15,9 ^{0}C.

The frost-free period lasts 254 days on average, whereas the warm summer period lasts. 190 days.

The average temperature of the coldest month (January) is 2,8^{0}C. The average minimum air temperature is 0^{0}C, but with the intrusion of large cold air masses, it can decrease to -22^{0}C below zero.

The average temperature of the warmest months, July and August, is 28 - 32^{0}C. In the hottest months, during the daytime, the air warms up to 37 - 40^{0}C, and the absolute maximum is 47^{0}C. At the same time, if the average minimum temperature in the summer months is 15 - 20^{0}C, then in the coldest years on some days it can decrease to 10^{0}C at night.

The annual amount of precipitation is 158 mm. In the low mountain areas, the average annual precipitation reaches 200 mm. Shaartuz is characterized by annual precipitation with a maximum in January - May, and precipitation is very rare in the summertime of the year. The distribution of precipitation is 40% in winter, 50% in spring, 9% in autumn, and 1% in summer of the total annual precipitation.

The average annual relative humidity is 50% and the monthly average ranges from 27% to 74%. In summer months the humidity reaches 23%.

Snow on the territory of Shaartuz is unstable. The maximum height of the snow cover was 10 cm.

In Shaartuz district, south and northeast winds prevail, the highest wind speeds are observed in March and July. The average monthly wind speed varies from 1,2 to 2,5 m/s throughout the year. Recorded maximum wind speed is 25 m/s.

Table 6-1 Hydro-meteorological station Shaartuz meteorological data (average 1961-2005)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual average
Air temperature, °C	2.8	5.5	11.5	18.6	24.4	29.3	31.1	28.8	23.1	16.5	10.2	5.3	17.3
Σ Precipitation, mm	24	22	37	30	12	0	1	0	0	6	9	18	158

Kuhistoni Mastchoh district climatic characteristics

The area of the district is located in the zone of insufficiently humid climate with warm summers and moderately mild winters. The Dehavz meteorological station is located in the spurs of the southern slopes of the Turkestan ridge, in the upper part of the Zeravshan river valley, upstream of Kuhistoni Mastchoh. The terrain is mountainous and highly rugged. At 10 km to the east there is a glacier feeding the Zeravshan River.

The average duration of sunshine is 2118 hours a year.

The average annual temperature is 4,3 °C.

The frost-free period lasts 152 days on average.

The average temperature of the coldest month (January) is - 7,1°C. The average minimum air temperature is -10.9°C, but when large cold air masses invade, it can decrease to -26-29°C cold. At the same time, during some days during the winter months the air can get as warm as 6-8°C during the daytime.

The average temperature of the warmest months, July and August, is 15,1-18,4 °C. In the hottest months, the daytime air temperature reaches 20-25^{0}C and the absolute maximum is 28 °C. At the same time, while the average minimum temperature in the summer months is 6-9°C, in the coldest years on some days it can decrease to 2 °C below freezing at night.

The annual total precipitation is 318 mm. Dehavz is characterized by an annual rainfall pattern, with a maximum in April-May and a small amount in August-September. The distribution of precipitation 47% in spring, 12% in winter, 13% in autumn and 28% in summer of the annual amount of precipitation.

The average annual relative humidity is 50%, and the average monthly humidity ranges from 39% to 56%

Snow cover may appear as early as the beginning of September, but becomes permanent in the first decade of November. The average ten-day snow cover height is 1-3 cm. The highest snow cover height was 33 cm. The start of snowmelt in mid-March. In some years, snow cover may be present until mid-May.

Winds in the Dehavz area are predominantly easterly (55% of the total number of occurrences). The average monthly wind speed is high and amounts to 3-4,7 m/sec throughout the year. The recorded maximum wind speed is 35 m/sec.

Table 6-2 Hydro-meteorological station Madrushkat meteorological data (average 1961 - 2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	-4,1	-2,6	1,9	7,7	11,9	15,2	18,4	18,4	14,3	7,9	2,1	-2,3	7,4
∑ Precipitation mm	8,7	10,1	26,3	39,4	43,8	27,6	18,5	8,4	5,8	14,7	10,1	10,3	223,7

Table 6-3 Hydro-meteorological station Dehavz Meteorological data (average 1961-2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	-7,3	-5,8	-1,7	4,1	8,7	12,1	15,1	15,1	11,4	5,2	-0,8	-5,1	4,3
∑ Precipitation mm	10,6	13,7	32,7	52,7	57,1	45,3	28,7	13,7	11,2	23,2	16,9	13	318,8

Kanibadam district climatic characteristics

Since there is no meteorological station on the territory of Kanibadam district, the district climatic characteristics were compiled based on the data from the closest meteorological station - Kayrakkum meteorological station.

The area of the district is located in an area of insufficiently humid climate with warm summers and moderately mild winters. The Kayrakkum meteorological station is located in the Tajik part of Fergana Valley, 500 meters from the right bank of the Kayrakkum reservoir. The terrain of the area is flat.

The average duration of sunshine is 2118 hours a year.

The average annual temperature is 13.4^{0}C.

The frost-free period lasts on average 234 days.

The average temperature of the coldest month (January) is – 0,7^{0}C. The average minimum air temperature is 1.0^{0}C , but when large cold air masses invade, it can drop to -15°C. At the same time, on some days during the winter months the air can get as warm as 8-12°C during the day.

The average temperature of the warmest months, July and August, is 32-36°C. In the hottest months, the daytime temperature reaches 39-42^{0}C and the absolute maximum is 43^{0}C. At the same time, while the average minimum temperature in the summer months is 16-21°C, in the coldest years on some days it can decrease to 9^{0}C at night.

The annual amount of precipitation is 159 mm. The district is characterized by an annual rainfall pattern with a maximum in March-April and a small amount in August-September. The distribution of precipitation is 45% in spring, 31% in winter 16% in autumn and 8% in summer of the annual amount of precipitation.

The average annual relative humidity is 60% and the average monthly humidity ranges from 39 - 75%.

The appearance of snow cover is possible in December. Snow in the district is unstable. Snow appears in the third decade of December, with an average snow depth of about 5 cm. The highest snow cover height was 40 cm.

Winds of westerly and north-easterly direction prevail in the district area. The average monthly wind speed is 4.1 m/sec throughout the year. The recorded maximum wind speed is 35 m/sec.

Table 6-4 Hydro-meteorological station Kayrakkum meteorological data (average 1961-2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	-0.1	1.8	8.2	15.6	21.1	25.9	27.3	25.0	19.9	13.5	7.6	2.5	13.4
∑ Precipitationmm	15.3	17.3	25.3	27.9	17.3	5.7	3.8	1.9	2.9	12.5	13	15.9	158.8

Gissar district climatic characteristics

The area of Gissar valley is located in an area of low humidity, with very warm summers and mild winters. Gissar meteorological station is located in the intermountain depression of Gissar valley and 15 km to the west of Dushanbe city.

The average duration of sunshine is 2,700 hours a year.

The average annual temperature is 14,0°C.

The frost-free period lasts on average 235 days.

The average temperature of the coldest month (January) is 2.6^{0}C. The average minimum temperature is -1.4^{0}C, but during incursions of large cold air masses it can drop to -25 -27^{0}C below zero.

The average temperature of the warmest months, July and August, is 25-27^{0}C. In the hottest months, the air temperature increases during the day to 35 - 37^{0}C and the absolute maximum is 43^{0}C. While the average minimum temperature in the summer months is 14 - 18^{0}C, in the coldest years on some days it can decrease to 7^{0}C at night.

Annual rainfall ranges from 580 to 653 mm. Gissar is characterized by an annual rainfall pattern with a maximum in January-May and very infrequent precipitation during the summer period of the year. The distribution of precipitation is 37% in the winter, 49% in the spring, 12% in autumn and 2% in summer of the annual amount of precipitation.

The average annual relative humidity is 60% and the average monthly humidity ranges from 45% to 71%.

The appearance of snow cover is possible in the second half of December. Snow in Gissar is unstable. The highest snow cover height was 19 cm.

The prevailing winds in Gissar are westerly and north-easterly, with the highest wind speeds in March. The average monthly wind speed varies throughout the year at 1,4 m/sec. Recorded maximum wind speeds are up to 30 m/s.

Table 6-5 Hydro-meteorological station Gissar meteorological data (average 1961-2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	1.1	3.0	8.7	15.2	19.5	24.8	26.6	24.3	19.4	13.4	8.3	4.0	14.0
∑ Precipitationmm	70.7	80.7	127.1	96.2	61.3	8.1	5.2	0.4	3.8	27.3	37.3	65.2	583.3

Table 6-6 Hydro-meteorological station Dushanbe meteorological data (average 1961-2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	2.3	4.2	9.1	15.3	19.8	24.9	27.1	25.0	20.1	14.0	8.8	4.4	14.6
∑ Precipitationmm	72.2	84.8	138	115.1	79.1	11	2.4	1.3	2.7	30.2	47.9	68.7	653.4

Fayzabad district climate characteristics

The Fayzabad district area belongs to the eastern part of Gissar valley and is located in an area of low humidity, with warm summers and mild winters. Fayzabad meteorological station is located in the Fayzabad district center.

The district of Fayzabad covers an area of approx. 900 km^2 and is situated at an average altitude of approx. 1,200 m a.s.l. Fayzobod climate is medium continental.

The average duration of sunshine is 2,670 hours per year.

The average annual temperature is 12,8°C.

The frost-free period lasts on average 230 days.

The average temperature of the coldest month (January) is 0,3^{0}C. The average minimum temperature is -2,2^{0}C, but it can decrease to -21^{0}C cold during incursions of large cold air masses.

The average temperature of the warmest months, July and August, is 24 - 26^{0}C. In the hottest months, the air warms to 32 - 38^0 and the absolute maximum is 41^{0}C. While the average minimum temperature in the summer months is 16 - 19^{0}C, in the coldest years on some days it can decrease to 6^{0}C at night.

The average annual rainfall is 840 mm. In the mountainous areas the average annual precipitation reaches 1,136 mm, whereas it is 767 mm in the valleys.

Fayzabad is characterized by an annual rainfall pattern with a maximum in January-May and very infrequent precipitation during the summer period of the year. The distribution of precipitation in winter 30%, in spring 53% in autumn 13% and 5% in summer of the annual amount of precipitation.

The average annual relative humidity is 51% and the average monthly humidity ranges from 36% to 63%.

The appearance of snow cover is possible in mid-November. Snow in Fayzabad is steady. The highest snow cover height was 26 cm.

North-east winds prevail in Fayzabad, with the highest wind speeds occurring in March. The average monthly wind speed varies throughout the year at 4,1 m/sec. Recorded maximum wind speeds are up to 25 m/s.

Table 6-7 Hydro-meteorological station Fayzabad meteorological data (average 1961-2010)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual average
Air temperature, °C	0.4	1.3	6.1	12.8	17.4	22.5	25.5	24.1	19.4	13.3	8.0	3.2	12.8
Σ Precipitation mm	76.2	98.8	166	161	121	21.6	5	2.4	3.6	42.9	65.8	75.9	840.5

Muminabad district climatic characteristics

The Muminabad district area is located in an area of low humidity, with warm summers and mild winters. The Muminabad meteorological station is located 5 km west of Muminabad district center.

The average duration of sunshine is 2,570 hours per year.

The average annual temperature is 12.1°C.

The frost-free period lasts on average 227 days.

The average temperature of the coldest month (January) is -1.0°C. The average minimum temperature is -2.3^{0}C, but when large cold air masses invade, it can decrease to -25^{0}C.

The average temperature of the warmest months, July and August, is 23 - 26^{0}C. In the hottest months, the air warms to 30 - 36^0 and the absolute maximum is 40^{0}C. While the average minimum temperature in the summer months is 16 - 18^{0}C, in the coldest years on some days it can decrease to 7^{0}C at night.

The average annual precipitation total is 841 mm. Muminabad is characterized by an annual rainfall pattern with a maximum in January-May and very infrequent precipitation during the summer time of the year. The distribution of precipitation in winter 33%, in spring 53%, in autumn 21% and in summer 2% of the annual precipitation amount.

The average annual relative humidity is 45% and the average monthly humidity ranges from 38% to 66%.

The appearance of snow cover is possible in mid-November. Snow in Muminabad is steady. The highest snow cover height was 51 cm.

Northeast and southwest winds prevail in the Muminabad area with the highest wind speeds in March. The average monthly wind speed varies throughout the year from 0,8 to 1,3 m/s. The recorded maximum wind speed is up to 23 m/sec.

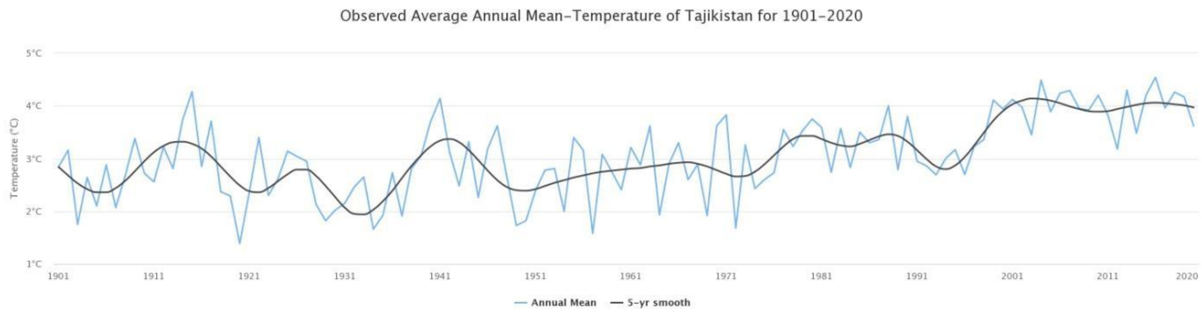
Table 6-8 Hydro-meteorological station Muminabad meteorological data (average 1961-2010)

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Annual average**
Air temperature, °C	-0.1	1.6	6.6	12.8	16.6	21.6	24.0	22.5	17.8	11.8	6.9	2.5	12.1
Σ Precipitationmm	84.7	107.4	175	161.4	112	15	4.6	1.5	2.9	38.2	57.3	81.4	841

6.1.1.The observable climate change over the last 30 years

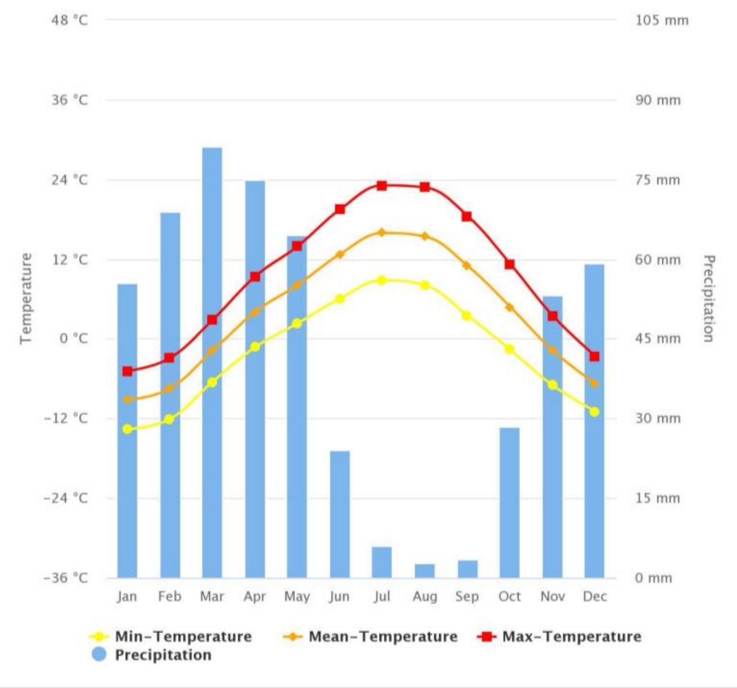
The country lies on the border of the subtropical and temperate zone, it is generally characterized by high intensity of sunlight, dry and dusty climate, low cloud cover and very large daily and seasonal temperature fluctuations. Aridness, extreme temperatures and significant year-on-year and regional climate variability are due to Tajikistan's location at the intersection of atmospheric circulation from the tropics to the southeast and Siberia to the north. Annual average temperatures range from 17 ° C in the south to -6 ° C in the lower part of the Pamirs. Maximum temperatures are usually observed in July and minimum in January. Minimum temperatures below -50 ° C have been recorded in the Eastern Pamirs, while in the south the maximum surface air temperature may exceed 40 ° C. Annual rainfall in the lowlands, hot deserts of northern Tajikistan and cold mountain deserts in the eastern Pamirs average 70 mm to 160 mm, while in central Tajikistan rainfall can exceed 1,800 mm per year. The lowest precipitation is observed during the months of July, August and September, which contributes to frequent droughts. The ten years in 2001-2010 were the warmest since instrumental temperature measurements began in Tajikistan in 1901 as seen in Figure 6-1. In the lowland areas the temperature increased by about 1°C above the long-term average, in the middle positions it warmed by 0.8°C and in the hills by 0.2°C. In the years 1930-2010, temperatures grew at an average rate of 0.1 ° C over the decades. The weather remains very unstable from year to year, mainly due to atmospheric circulation processes, which bring unusually hot or cold air. Over the last century, temperature rises have been most pronounced in the autumn and winter months and lower - less pronounced - in the spring and summer as seen in Figure 6-2. The precipitation trend is very diverse and is subject to changes according to the microclimate of the site. In general, an increase in average annual precipitation of approximately 5-10% was observed. However, this increase is primarily associated with higher intensity rainfall events, and in some areas the frequency of rainfall days has actually decreased. This has led to some of the last extremely dry years - notably 2000, 2001 and 2008, when rainfall was 30-50% below average. The changes in the precipitation regime observed in the 20th century are in line with global trends. Extreme rainfall increases with temperature, which is consistent with evidence from various countries in the Asian regions. Projections suggest that this trend will continue into the future.

Figure 6-1 Observed average annual mean temperature for Tajikistan from 1901 to 2020



Source: https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

Figure 6-2 Monthly Climatology of Min Temperature and Mean Temperature, Max Temperature and Precipitation 1991-2020 for Tajikistan



Source https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

Climatic characteristics of Tajikistan

Climatic conditions. The territory of Tajikistan is characterized by an arid climate, an abundance of heat and significant intra-annual variability in almost all climatic elements[3].

Tajikistan's climate covers a wide range of temperatures, moisture conditions, rainfall patterns, and intensity of solar radiation. Average annual temperatures, depending on the altitude of the area, can range from + 17°C or more in the south of the country to - 6°C or less in the Pamirs. The maximum temperature is in July and the minimum in January. The climate is particularly harsh in the Eastern Pamirs, where the absolute minimum reaches -63°C. In the south of the country, the absolute maximum temperature reaches + 47°C. In the hot lowland deserts of Southern Tajikistan and the cold highland deserts of the Eastern Pamirs, average annual precipitation ranges from 70 to 160 mm, while the maximum precipitation is observed in Central Tajikistan, and can exceed 1,800 mm.

The territory of Tajikistan is under the influence of two powerful and active centers of atmospheric action, which determine the climate not only of Central Asia, but also of most of the Eurasian continent. One is a Siberian anticyclone and the other is a summer thermal depression. Despite the different nature of thermal effects, their development is associated with the predominance of north and northeast winds. The atmospheric circulation is significantly distorted by mountainous topography, which leads to the development of different types of local circulation.

Air temperature. Given the diversity of Tajikistan's climate, a number of areas with similar physical and geographical conditions have been identified to characterize the thermal regime of its territory.

Wide valleys and plains with altitudes up to 1,000 m are the main areas for agriculture and cotton growing. These include the south-western part of the republic, Gissar, Vakhsh, Lower-Kafirnigan, Kulob valleys, and Fergana valley with adjacent plains of Sugd region. Broad valleys and plains are characterized by high air temperatures in summer, when summer thermal depression prevails. Summers are characterized by clear and hot weather, when the maximum temperatures can reach 43-47°C. The average monthly temperature in the hottest month of July is 28-30°C.

The transition zone from valleys to highlands up to an altitude of 2,500 m includes: Zeravshan Valley, mountainous areas of Central Tajikistan and part of the Western Pamirs. In summer, low clouds and dry weather persist here, but it is cooler. This zone is characterized by a consistent decrease in temperature with altitude. The hottest month of the year is July, with average monthly temperatures ranging from 25°C in the Zeravshan Valley to 18°C in the mountains of Central Tajikistan. The absolute maximum reaches 36-40°C.

[3] Leningrad Gidrometeoizdat 1988. Scientific and applied reference book on the climate of the USSR, series 3, long-term data, part 1-6, issue 31, Tajik SSR.

High altitude areas above 2,500 m include the Central and Eastern Pamirs and mountain ranges. The climatic conditions in the Eastern Pamirs are particularly harsh. Winters here are long and cold. The average January temperature drops to -14°C to -26°C. The absolute lowest temperature is -63°C (Bulunkul). Summers are short and cool. The average temperature in July does not exceed +15°C (Ircht). Absolute maximums range from +20°C (Fedchenko Glacier) to +34°C (Ircht).

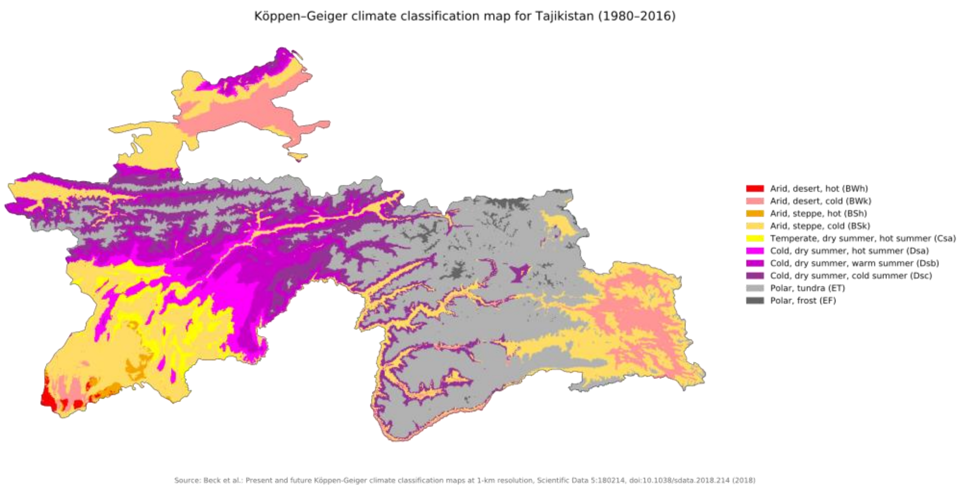
Atmospheric precipitation. There are mainly two zones in Tajikistan in terms of precipitation conditions. The dry climate zone covers the valleys of South-Western and Northern Tajikistan, the foothills of the Turkestan mountain range, as well as the vast highland area of the Eastern Pamirs (50-300 mm per year). The rest of the territory belongs to the zone of insufficient moisture (up to 900 mm). The exception is the windward southern slopes of the Gissar Ridge, where the zone of humid climate (more than 1800 mm) is distinguished by separate spots.

The annual course of precipitation varies in different regions of the republic. Most of the territory is characterized by an annual pattern of precipitation, with a minimum in the summer months. The maximum of precipitation falls in March-April in the valleys and foothills, and in April-May in the highlands.

The maximum monthly precipitation in most parts of the country is 30-100 mm, and in some areas up to 200-300 mm. In the north of Tajikistan and the Eastern Pamirs the maximum precipitation decreases to 12-20 mm per month. During the months of minimum precipitation throughout the territory, the amount of precipitation does not generally exceed 5 mm, and only in some high-altitude areas does it amount to 10-20 mm per month.

On average, 15-20% of all precipitation falls as snow in the foothills of Tajikistan during the year. With altitude, the amount of solid precipitation increases to 50-70%, reaching a maximum in the Pamirs (85-90%), including the Fedchenko glacier (100%). The number of days with precipitation of 0.1 mm and more varies in the plain part within 50-80 days, in the foothills - 80-100 days, which number increases with altitude up to 125 days. The lowest number of days with precipitation in the highland desert of the Eastern Pamirs is 50 days.

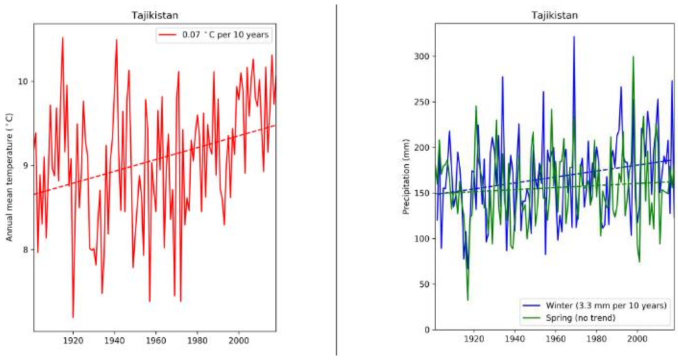
Figure 6-3 Köppen -Geiger Map of Tajikistan (Beck et al. 2018)



6.1.2. Climate trends and predictions in Tajikistan

The existing trends in Tajikistan suggest temperature increase of approximately 0,07 °C per 10 years, increase in precipitation in winter by approximately 3,3 mm per year, and no increase in precipitation in spring (Pfefferle, 2020, GIZ.)

Figure 6-4 Average temperatures Precipitation rates (winter, spring) in Tajikistan (1900-2016)



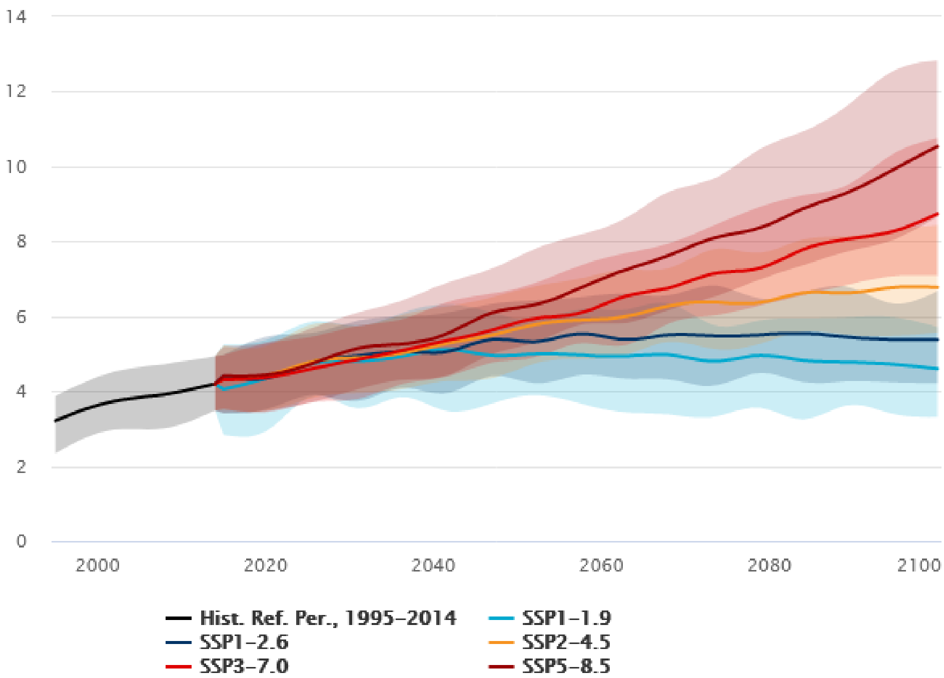
Source: Pfefferle, 2020, GIZ

6.1.3. The projected climate trends

Most of the existing scenarios of climate change in Tajikistan predict an increase in average temperatures (Pfefferle, 2020; Climate Risk Country Profile: Tajikistan, 2021; Climate change knowledge portal, 2022). The extent of this increase varies according to the scenario of CO_2 production, the model and the time span. Compared to 1986-2005 levels, the average annual temperature in Tajikistan is to increase by 1.3-6.3 °C by 2080 depending on the emission scenario of (Pfefferle, 2020). Similarly, Climate Risk Country Profile: Tajikistan (2021) predicts average temperature increase of 1.5 to 5.8 °C by 2080.

The multi-model predictions expect the temperature increase approximately till 2040 followed by a wide variation of the scenarios till 2100 (Climate change knowledge portal, 2022, Figure 6-5). Some of these scenarios predict a decrease in the average temperatures if the underlying factors including the emissions of greenhouse gasses develop in a more favorable way (ibid.).

Figure 6-5 Projected Mean Temperatures, Tajikistan. Reference period 1995-2014, Multi-Model Ensemble

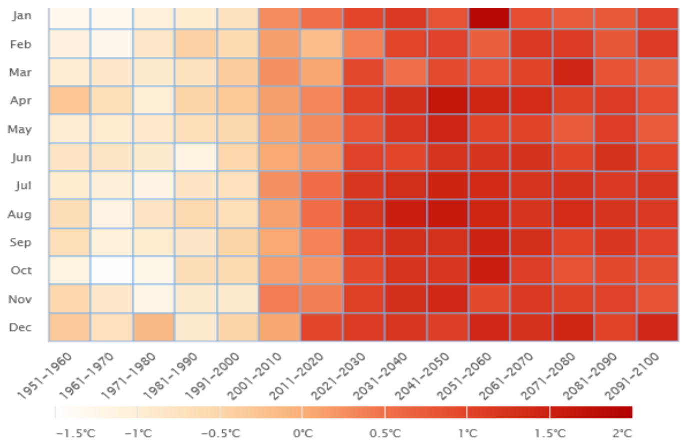


Source - Climate change knowledge portal (2022)

From the predictions follow, that the impact of the particular model or scenario on the temperature increase is most pronounced starting from 2040. Given that this study concentrates on the period till 2040, we can effectively exclude the impact of the emission model from the analysis and concentrate on trend predictions.

The regional distribution of the temperature increase by 2040 does not present any significant variations with the average increase of approximately 1 (ibid).

Figure 6-6 Projected Mean-Temperature Anomaly, Tajikistan Reference period 1995-2014, Multi-Model Ensemble.



Source - Climate change knowledge portal (2022)

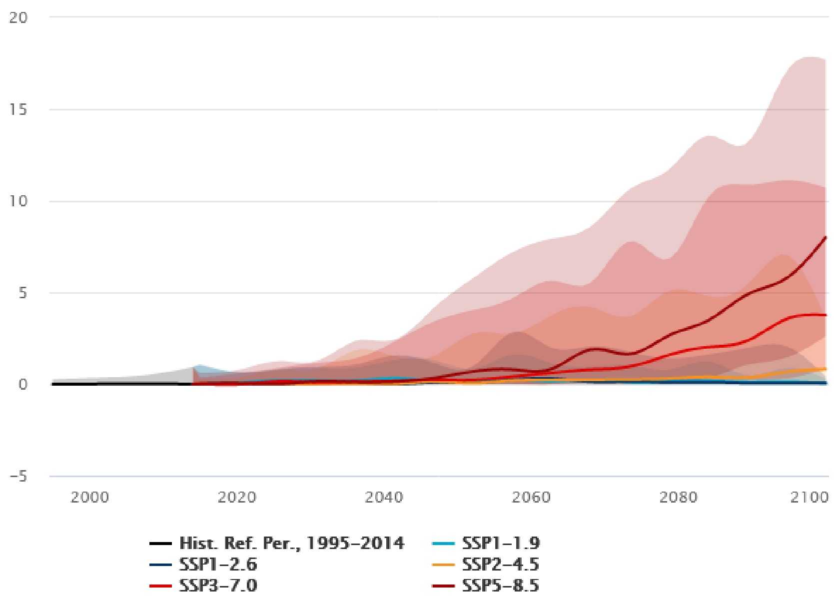
The change in the average temperatures by 2040 is least pronounced in February (+0.37 °C) and, surprisingly in May (+0,81 °C) and the most pronounced in summer months (up to 1.2 °C, Figure 6-6, ibid.) This distribution is rather unfortunate for agricultural production in Tajikistan, as in most of the regions, including most of the target districts (excluding Kuhistoni Mastchoh), the summers are already very hot, which is disadvantageous for many agricultural crops, increases the need for irrigation and damages the human health.

The limited mean temperature increase in February may be also viewed as disadvantageous, as farmers tend to move the planting season from March to February. The low temperature increase may be associated with the sudden frosts, which will damage the production. However, this effect might be eliminated with the further increase in the temperatures beyond 2040.

Similarly to average temperatures, the heat waves, approximated by the projected number of days with heat index >35 °C start also to be more pronounced from 2040 on (Figure 6-7), which is out of the time span of the current study.

The regional distribution of the projected number of days with heat index >35 °C show significant regional variations. In the Sogd region (including the districts of Kuhistoni Mastchoh and Kanibadam), no increase in the number of days with heat index >35 °C is expected by 2040. In the middle of Tajikistan (including the districts of Gissar and Fayzabad) the increase is 0,32 days. In the region of Khatlon (including the districts of Muminabad and Shaartuz), the increase in the number of days with heat index >35 °C equals to 3.53. However, the Kuhistoni Mastchoh and Fayzabad are on the edge between the regions, thus the changes might be smaller.

Figure 6-7 Projected days with heat index >35 °C, Tajikistan, Reference period 1995-2014, Multi-Model Ensemble

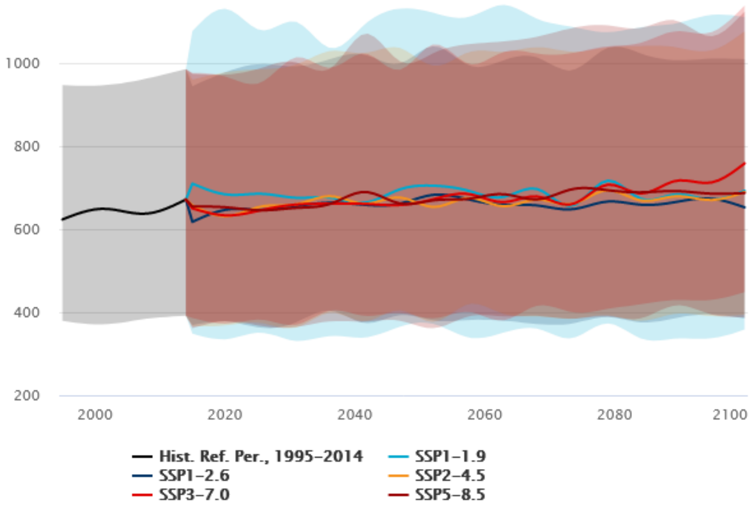


Source - Climate change knowledge portal (2022)

6.1.4. The projected precipitation

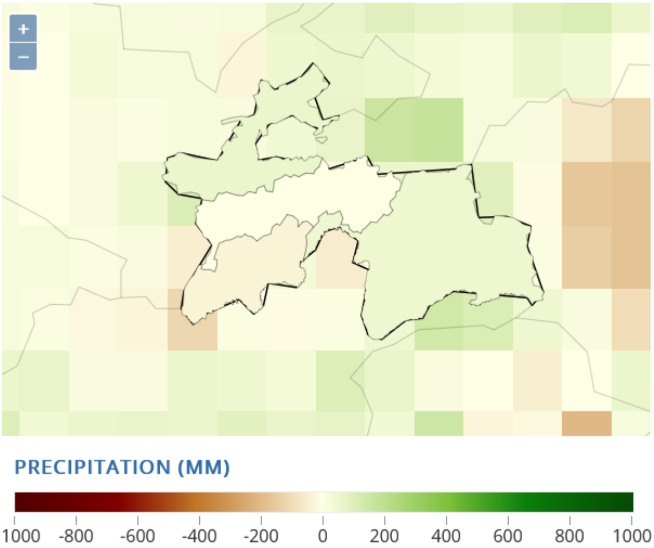
The projected precipitation over the country presents a slight upward sloping trend with relatively small change till 2040. However, there are significant intra-regional variations.

Figure 6-8 The projected precipitation, Tajikistan, Reference period 1995-2014, Multi-Model Ensemble



There are significant intra-regional variations in precipitation projections (Figure 6-9) In the Sogd region (including the districts of Kuhistoni Mastchoh and Kanibadam), the overall precipitation is supposed to increase by 53 mm, by 2040. In the middle of Tajikistan (including the districts of Gissar and Fayzabad) the increase is smaller and will amount to only 0,51 mm by 2040. In the southern region of Khatlon (including the districts of Muminabad and Shaartuz), the precipitation is supposed to decrease -31 mm. However, the Kuhistoni Mastchoh and Fayzabad are on the edge between the regions, thus the changes might be smaller.

Figure 6-9 The projected precipitation anomaly 2020-2040, Tajikistan, Reference period 1995-2014, Multi-Model Ensemble



Source: Climate change knowledge portal (2022)

From the above follows, that we expect all the districts to experience the increase in average temperatures by approximately 1 °C. The southern districts Muminabad and Shaartuz will be more affected by the increase in number of days with heat index >35 °C and the diminishing precipitation, while the Kuhistoni Mastchoh and Kanibadam is supposed to experience no change in the number of days with heat index >35 °C and increase in overall precipitation. The districts in the middle part of Tajikistan (Gissar and Fayzabad) present the middle way between the scenarios above.

The following climatic characteristics of the six target districts were compiled based on the long-term average meteorological information Agency for Hydrometeorology for the period 1961-2010.

6.2. The climate change, as observed in the target districts by population and expert community

The following climate changes have been observed by the population in all the districts: temperature increase, decrease in precipitation leading to lack of water for irrigation. The latter was manifested through reduction in snow and glacier cover, and earlier flowering of trees. Intermittent rainfall, flash floods in spring and summer and change in the period of warm winds are also observed (Kanibadam). Frosts appear in spring damaging the agricultural production.

6.2.1. Methodology

This section methodologically relies on results of focus groups and expert interviews conducted in the districts. The methodologies of focus groups and their outcomes are presented in the Appendix 4 to this report.

6.2.2. Results

The following changes have been observed by the population in all of the districts: decrease in precipitation leading to lack of water for irrigation and increase in temperatures.

Fayzabad

"The reason for the reduction of water in the canal and, consequently, the lack of water for dekhkan (farm) households is, first of all, a decrease in the annual amount of precipitation during the autumn-winter period."

"The reduction in snow cover has been much reduced; while previously you could see water in the canal being covered in ice, freezing, this phenomenon has not been seen in the last, about 10 years. Especially the lack of water is observed during the re-seeding period - June-July months"

"The flowering of trees comes earlier by about 7-10 days. (In 2020, it unexpectedly snowed during the flowering of trees; however, this phenomenon is rare)."

Gissar

"Snow and the glacier cover has been decreasing over time, which led to the lack of water in summer and water emergencies in winter. Glacier area shrinking. Snowfall has decreased to around 30% in recent years. In some cases, the reduction of water flows was up to 60%. The acute shortage of water is perceived at the end of July."

"Average summer temperature in extremes increased by 10^0C-15^0C. 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"

"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."

"Although temperatures are above average in winter, frosts appear in spring, damaging production. This fact may be in part caused by the earlier planting season."

Kuhistoni Mastchoh

"Gradual increase in temperature in summer and winter"

"Reducing precipitation, in the last 10 years there has been almost no snowfall in the valley (Zarafshan valley)"

"Irregular precipitation, flash floods in spring and summer"

"Reduction of drinking and irrigation water coming from mountain springs (almost 100% of the district)"

"In winter, there is little precipitation and dry air, in spring there is an increase in rainfall above the norm, as a result, mudflows, avalanches, rockfalls and landslides are observed"

"There is an excessive reduction in wild mountain plants and shrubs"

"Increasing cases of dental, kidney and other diseases due to poor quality of drinking water."

Muminabad

"At present, 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 m^3 /sec) in the spring period of the year, is 2 m^3 /sec, and in June - 0.15-0.20 m^3 /sec. This leads to a shortage of irrigation water in dekhkan (farm) households. An increase in atmospheric air temperature has led to a reduction in snow cover (maximum temperature in summer is 40-42^{0}C)."

Shaartuz

"Agriculture and the population are affected by the heat in the summer and this is being felt more and more every year. As a result of less or no snow cover, various infectious diseases increase."

"Indeed, there has been a decrease in rainfall in recent years. Consequently, the water level in the canals is going down. We have until May 15 when the grain harvest is completed and then we re-sow in June and July and there is a particular shortage of water for irrigation during this period."

"Compared to previous years, the trees are flowering a month earlier (end of February). For example, last year, it snowed on March 14 and these trees dried out as a result of sub-zero temperatures."

"Temperatures can, in the last decade, reach 50^{0}C. At such high temperatures, Shaartuz district grows fine-fiber varieties of cotton. Once again, it should be noted that air temperature tends to rise over the years and precipitation is lower than in Dushanbe."

Kanibadam

"A gradual increase in temperature during the summer and winter period, a sudden cold spell in the spring period at the start of the sowing season;"

"Intermittent rainfall, flash floods in spring and summer;"

"A change in the period of warm winds, contributing to the melting of glaciers in the Isfara River spring;"

"Reduced drinking water coming from the Big Fergana Canal (BFC) in the western part of the district (about 60% of the district);"

"Increased drilling of boreholes and use of groundwater (technical) not only for irrigation but also for drinking purposes;"

"Increase in the threat of drought on about 16,000 hectares of agricultural land;"

"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."

6.3. The observable climate changes in 6 target districts, the predictions

The predictions presented in this section suggest a temperature increase of 0.26-0.37 ^{0}C per 10 years in all the districts except Kuhistoni Mastchoh and Shaartuz, where the temperature increase was not statistically significant. The precipitation showed statistically significant positive trends in Kanibadam and Shaartuz only. The seasonal distribution of precipitation varied by district. Mean daily vapor pressure is predicted to increase in all the districts by 0.17-0.28 hPa per year indicating higher need for irrigation. Kanibadam proved to be the district most affected by the climate change as all trends in all the studied indicators were increasing and statistically significant (temperature, precipitation, wind, evaporation and Penman potential evaporation indices). Shaartuz is the next most affected region, where all the indicators except increase in temperature proved to be significant.

6.3.1. Methodology and data

The following analysis relied on the yearly meteorological data for 1984-2021 for target regions collected by Big Terra[4] via satellite imaging. The data were provided to the researchers on a commercial basis. Methodologically the section relied on analysis of linear trends (linear regression analysis) including the prediction for the next ten and twenty years.

6.3.2. Indicators

- VAP Mean daily vapor pressure hPa
- WIND Mean daily wind speed at 2 m above ground level $msec{-}1$
- RAIN Precipitation (rainfall or water equivalent in case of snow or hail) m$mday{-}1$
- IRRAD Daily global radiation $Jm{-}2day{-}1$
- E0 Penman potential evaporation for a free water surface m$mday{-}1$
- ES0 Penman potential evaporation for a bare soil surface m$mday{-}1$
- ET0 Penman or Penman-Monteith potential evaporation for a reference crop

6.3.3. Results

The statistical predictions are presented in the table below. The graphical presentation follows the tables.

[4] https://bigterra.com/

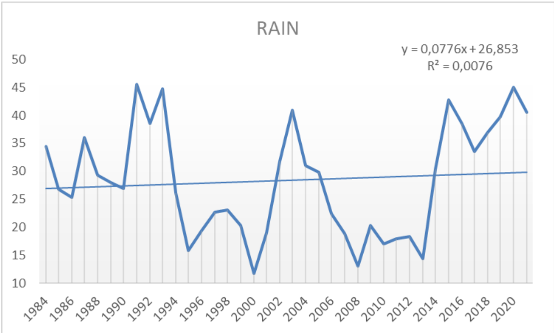
Table 6-9 Predictions of average temperature, precipitations, wind, evaporation and Penman potential evaporation indices. Values for 1984, 2021, 2030, 2040 and annual predicted changes. The statistically significant results are highlighted green.

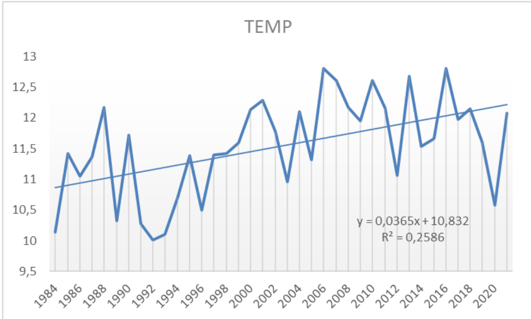
FAZYBOD							**HISOR**						
	1984	2021	2030	2040	annual change	10-years change		1984	2021	2030	2040	annual change	10-years change
RAIN	34,48	40,54	30,50	31,28	0,0775	0,7752	RAIN	32,64	28,75	25,47	24,97	-0,0502	-0,5024
TEMP	10,14	12,08	12,55	12,91	0,0365	0,3646	TEMP	12,06	14,15	14,45	14,82	0,0371	0,3708
WIND	1,49	1,49	1,50	1,50	-0,0003	-0,0032	WIND	1,56	1,56	1,58	1,58	0,0612	0,6118
VAP	5,34	6,20	6,51	6,76	0,0253	0,2532	VAP	5,59	6,22	6,63	6,84	0,0211	0,2105
E0	108,78	107,85	106,85	106,90	0,0046	0,0465	E0	114,50	115,04	113,77	114,03	0,0260	0,2604
ES0	94,06	93,06	92,59	92,62	0,0026	0,0262	ES0	99,70	100,10	99,36	99,61	0,0249	0,2485
ET0	105,28	105,29	105,07	105,35	0,0287	0,2871	ET0	112,12	114,08	113,52	114,13	0,0814	0,8138
KANIBADAM							**KUHISTONI MASTCHOH**						
	1984	2021	2030	2040	annual change	10-years change		1984	2021	2030	2040	annual change	10-years change
RAIN	14,25	27,68	21,08	22,71	0,1622	1,6225	RAIN	23,91	57,15	28,64	31,23	0,2584	2,5843
TEMP	15,58	17,04	17,35	17,62	0,0263	0,2632	TEMP	-0,26	0,63	1,49	1,75	0,0258	0,2581
WIND	2,73	2,72	2,89	2,96	0,0069	0,0687	WIND	1,53	1,47	1,58	1,59	0,0004	0,0041
VAP	5,72	7,07	7,33	7,61	0,0283	0,2825	VAP	3,39	4,19	4,27	4,45	0,0175	0,1751
E0	154,16	150,19	154,44	156,41	0,1967	1,9667	E0	81,57	75,59	77,17	76,99	-0,0183	-0,1835
ES0	138,94	134,95	139,51	141,49	0,1982	1,9824	ES0	69,55	63,86	65,70	65,49	-0,0211	-0,2107
ET0	150,57	148,12	152,45	154,63	0,2181	2,1814	ET0	75,39	69,57	71,47	71,27	-0,0203	-0,2030
MUMINABAD							**SHAARTUZ**						
	1984	2021	2030	2040	annual change	10-years change		1984	2021	2030	2040	annual change	10-years change
RAIN	32,85	36,85	26,84	27,42	0,0574	0,5745	RAIN	15,88	22,98	21,02	22,79	0,1770	1,7697
TEMP	10,98	12,65	13,19	13,53	0,0340	0,3397	TEMP	15,90	17,15	17,40	17,53	0,0133	0,1333
WIND	1,62	1,62	1,65	1,65	-0,0002	-0,0021	WIND	1,66	1,71	1,85	1,90	0,0048	0,0482
VAP	5,28	5,99	6,32	6,57	0,0252	0,2520	VAP	6,19	6,95	7,34	7,59	0,0248	0,2483
E0	115,08	114,28	114,53	114,88	0,0355	0,3552	E0	131,65	138,57	141,63	144,04	0,2408	2,4078
ES0	100,42	99,18	99,80	99,96	0,0164	0,1645	ES0	115,51	121,87	125,39	127,72	0,2334	2,3341
ET0	109,87	111,04	111,64	112,30	0,0665	0,6652	ET0	126,26	132,47	136,33	138,65	0,2317	2,3174

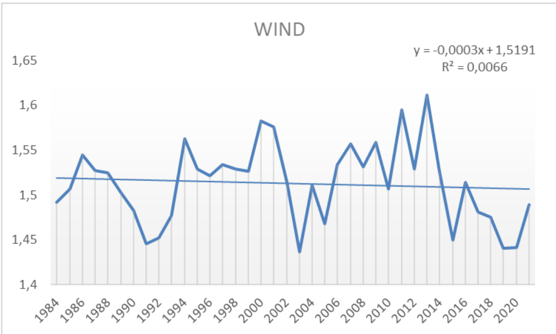
Source: computations of the authors. VAP Mean daily vapor pressure hPa; WIND Mean daily wind speed at 2 m above ground level $msec{-}1$; RAIN Precipitation (rainfall or water equivalent in case of snow or hail) m$mday{-}1$; IRRAD Daily global radiation $Jm{-}2day{-}1$; E0 Penman potential evaporation for a free water surface m$mday{-}1$; ES0 Penman potential evaporation for a bare soil surface m$mday{-}1$; ET0 Penman or Penman-Monteith potential evaporation for a reference crop. Statistically significant trends are highlighted green .

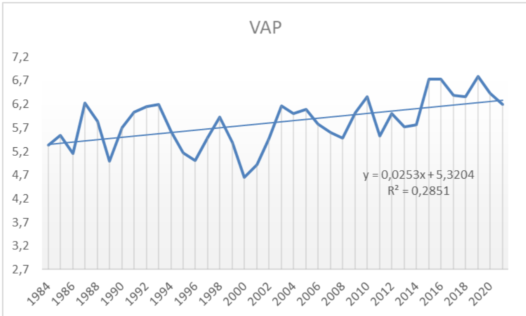
6.3.4. Trends in precipitation (RAIN), temperature (TEMP), wind speed (WIND) and evaporation pressure (VAP). Graphical presentation

FAYZABAD

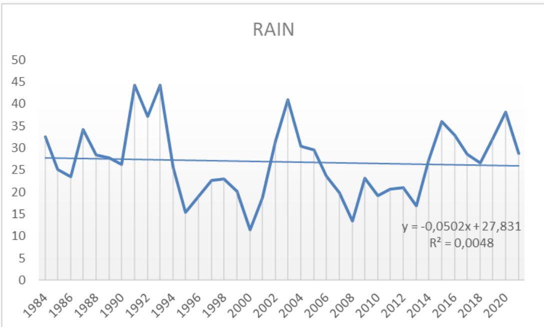


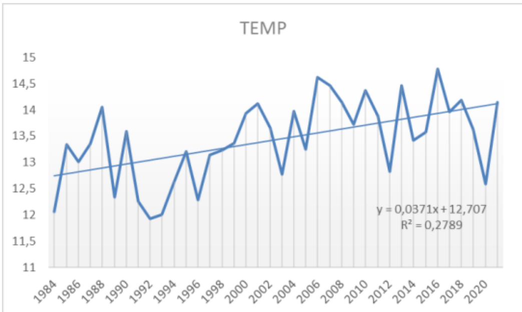


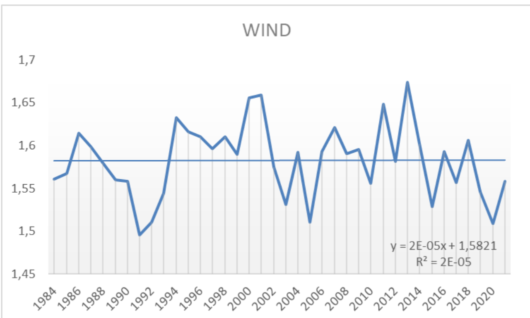


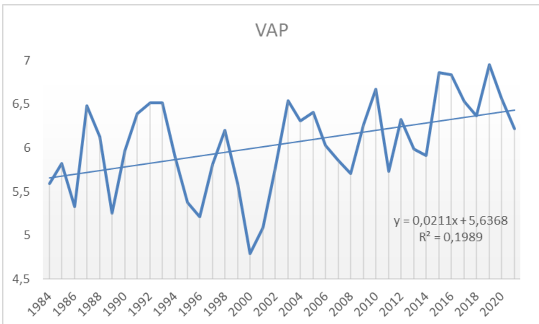


GISSAR





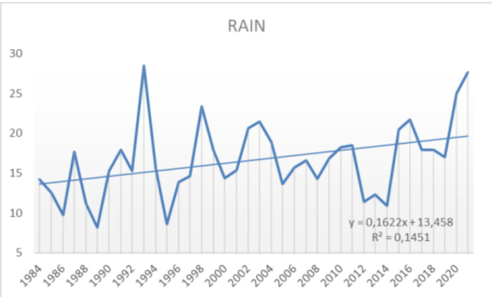


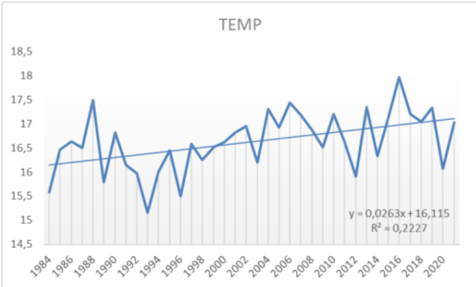


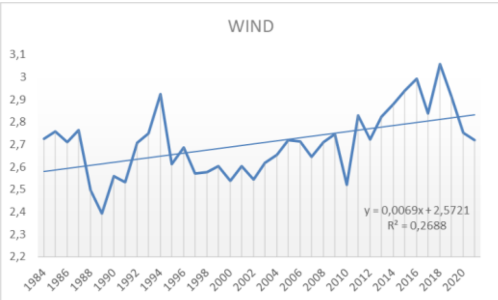
Source: computations of the authors

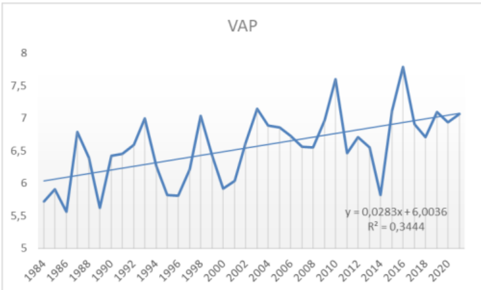
The seasonal predictions for the 6 target districts are presented in the Appendix 2 to this report. All the 6 districts showed different trends in meteorological factors both in the past as well as in future. The type of trend is different even within the seasons. Generally, the decreasing trend of irradiation can be connected to an increasing trend of precipitation – the more clouds, the less sun. Temperature and evapotranspiration showed an increasing trend during the seasons in almost all districts, but not always. Air humidity increases at all studied locations in all seasons. It must be said that the presented results are very rough and no modern statistical methods were used for the prediction of future values of meteorological factors.

KANIBADAM









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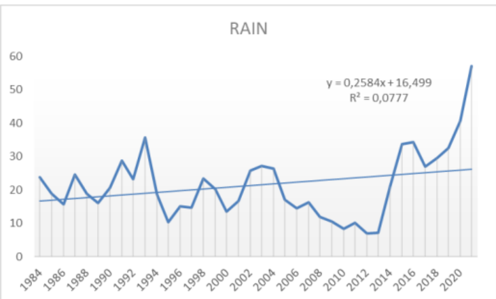
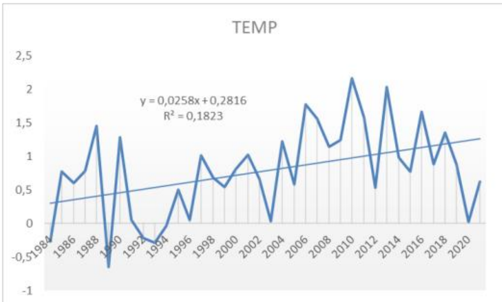
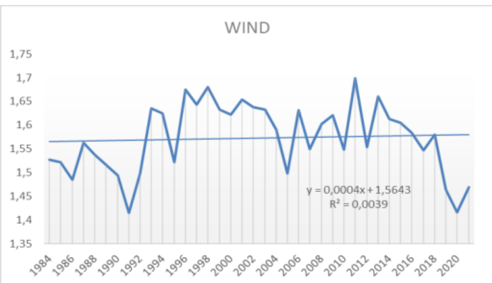
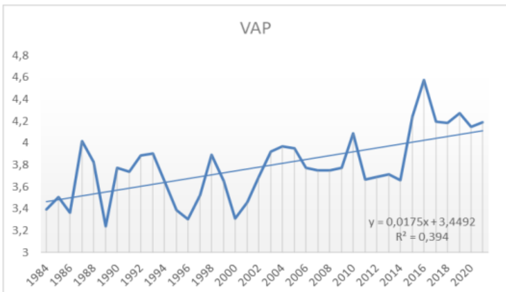
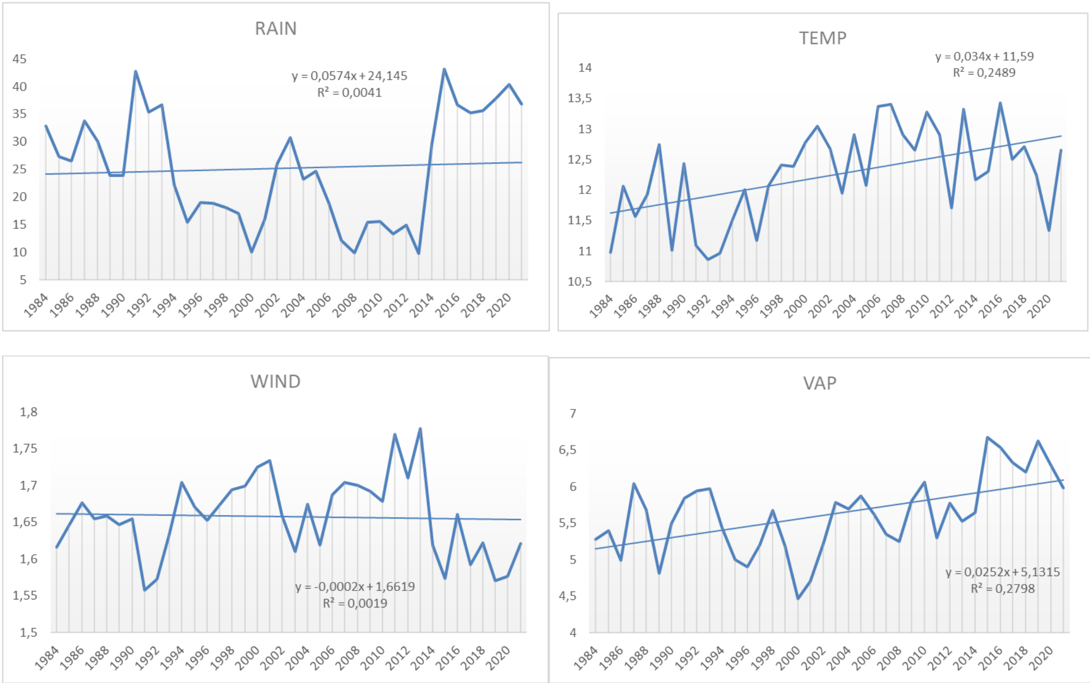




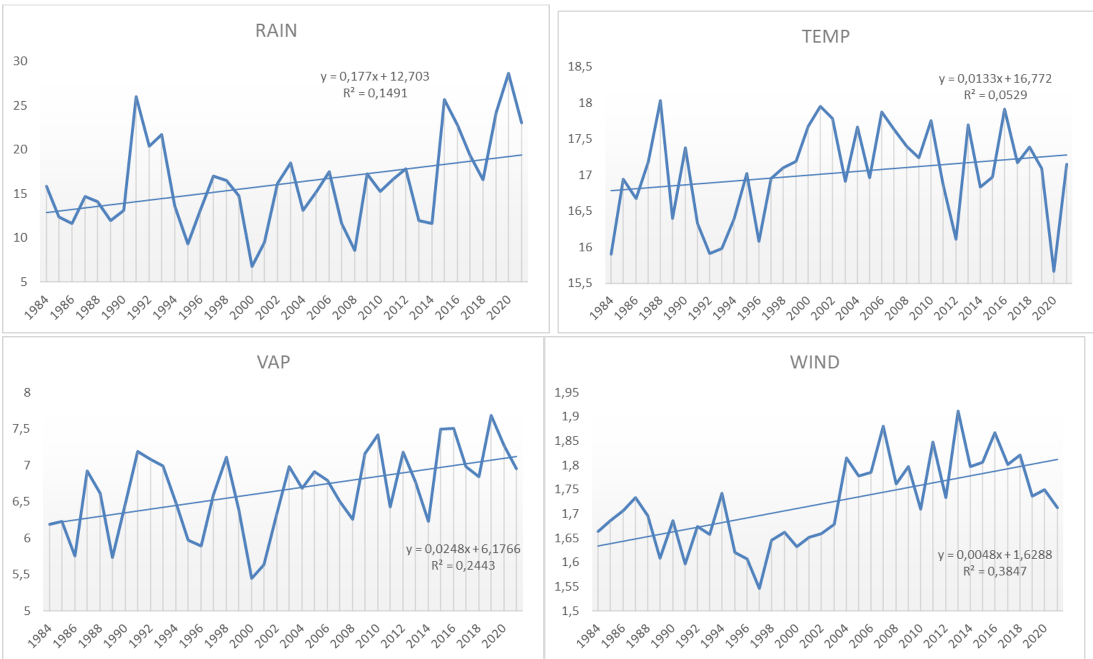




MUMINABAD



SHAARTUZ



Source: computations of the authors

7. The effects of climate change on agriculture

Tajikistan has a large and diverse agricultural sector with overall production amounting to 24% of GDP in 2020 (World Bank data, 2022) employing an estimated 44% of the workforce in 2020 (World Development Indicators, 2022). Key crops in production include grain, potato, fruits and vegetables. The strategic export crop is traditionally cotton. The strategic import crop is grain. The national policy of Tajikistan ensures almost total self-sufficiency in food production. The exports of agricultural products are relatively low, ranging from around 120,000 tons of exported food products per year, which constitutes 2% to 3% of the total exports by volume (TajStat, 2018).

7.1. The effects of climate change in Tajikistan

The following effects of climate change are described in the literature (Pfefferle et. al., 2020; Zholdosheva et al., 2017).

The movement of ecosystem zones (forests, pastures) upwards vertically in mountainous areas. Along with this, there is an observed shift in species composition of biodiversity of flora and fauna. There is a shift in species composition of plant and animal biodiversity and in species ranges and their quantity, which affects agricultural activities in mountainous areas - changes in pasture rotation and crop rotations.

Rising temperatures and changes in precipitation patterns lead to changes in the hydrological regime and the reduction of water resources. The problem with projected decline in water resources is exacerbated by the increasing demand for water due to the growth of the population.

Increase in the number of extreme weather events and natural disasters, affecting the safety of people and countries' economies. Each year these disasters cause significant damage to settlements, agricultural land and infrastructure.

Climate change is likely to exacerbate existing vulnerabilities and risks to infrastructure. Roads are particularly susceptible, caused by temperature fluctuations and extreme heat. Moreover, changes in river flow levels can lead to fluctuations in the production of hydropower. In addition, identified risks associated with climate change to infrastructure due to climate change include debris flows, droughts, high temperatures, and high winds.

Rising temperatures can lead to snow line retreat and loss of glacial mass and, as a result, reduced water retention capacity. An increase in temperature will lead to increased variability in streamflow, as well as fluctuations in water availability and quality; in this negative effects are to be expected for agriculture. In addition, an increase in temperature is associated with a probable increased risk of springtime flooding and glacial lake outbursts in the process of melting snow.

The temperature growth is expected to result in a decrease in the number of frosty days. According to the scenario with high emissions - RTC 8.5 - the number of frosty days would decrease to about 212 days in 2030 2030, to 200 days in 2050, and to 170 days in 2080. The pest invasion is then probable.

The number of hot days with temperatures above 40°C is expected to increase by 2080 by 12.5 over the period from 1986 to 2005. Consequently, this will lead to an increase in cases of heat-related illnesses such as heat stroke and increased heat-related mortality rates. Increased food shortages combined with expected declines in agricultural agriculture and pastureland will likely have a negative impact on the already critical nutritional population's nutritional status. Along with increased pollution waters associated with flooding, as well as increased exposure to disease, water- and food-borne diseases, gastrointestinal gastrointestinal infections are predicted to increase. Climate change increases the likelihood of more frequent and severe outbreaks of infectious diseases, particularly the resurgence of the spread of malaria.

In some cases, climate change is also creating new opportunities in some sectors of the economy. For example, the agroforestry sector is becoming more promising to develop as a result of shifting climate belts or changing precipitation patterns. Climate change is also contributing to the development of adaptation measures aimed at more efficient use of natural resources and to improve management practices in other spheres of human activity (Zholdosheva et al., 2017).

The growing season length (GSL). According to the high emission scenario - RTC 8.5 - in 2030, the GSL would be 150 days, In 2050 - 165 days and in 2080 - 200 days. However, rising temperatures counteracts the positive effect of a longer RTP period (Pfefferle et. al., 2020). In addition, the lack of water does not allow to capitalize on the prolongation of the growing season.

7.1.1. Climate change impacts on agriculture

Taking in consideration already published available materials it is possible to confirm the following statements: food security, health, livelihood assets, food production, and distribution channels are affected by climate change (FAO 2008; UNECE 2012). Heltberg, Reva, and Zaidi (2012) suggest that climate change can potentially deepen poverty by lowering agricultural yields, raising food prices. In their earlier work, Heltberg and Bonch-Osmolovskiy (2011) assessed Tajikistan’s vulnerability and capacity to adapt to ongoing and future climatic changes.

Projecting impacts, vulnerabilities, and adaptations in Asia, Hijioka et al. (2014) suggest that water scarcity is expected to become a major challenge in many parts of Asia, including Central Asia. Tajikistan’s main agricultural valleys are among the most vulnerable to the impact of climate change, where water availability is a major climate-change-related concern (Heltberg and Bonch-Osmolovskiy 2011). Bobojonov and Aw-Hassan (2014) suggest that the impact of climate change on incomes derived from agriculture in Tajikistan is expected to be crop-specific.

There have been a number of analytical assessments of the impact of climate change on agriculture and food security in Tajikistan (e.g. Bobojonov and Aw-Hassan 2014; OSCE 2010; CAREC 2013; Heltberg, Reva, and Zaidi 2012; Lerman and Wolfgramm 2011; Makhmadaliev et al. 2008; Bann et al. 2012; FAO 2008; Fay, Block, and Ebinger 2010; Khakimov and Mahmadbekov 2009).

7.1.2. The character of Tajik agriculture

Tajikistan has an area of around 141,000 km² (14,100,000 ha) of which about 90% is considered upland and mountainous. More than two thirds of the population is rural and dependent on 4.6 million ha of agricultural land, the majority of which is rain-fed pasture. More than 90% of the total rangeland is degraded. All pasture lands of Tajikistan are strongly subject to erosion - with 89% of the summer pastures and 97% of winter pastures suffering from medium to strong erosion (FAO, 2021).

Agriculture is the second largest sector of the economy, accounting for 20% of the country's GDP of 7,523 billion USD and about fifty per cent of its employment in 2020 (WB, 2018). While the agriculture and livestock sector dominates the Tajik economy, only around 30% of the country's total land area is classified as agricultural and 7% as arable. Of these agricultural lands, 81% consist of rainfed pastureland (USDA, 2016). Of the permanent cropland, only 68% is being irrigated which makes Tajikistan the Central Asian country with the lowest irrigated land to population ratio (USDA, 2016). Moreover, cotton, the country's most important cash crop, as well as other primary agricultural products such as fruits and vegetables are all water-intensive crops that withstand the current arid climate conditions; therefore, Tajikistan's agriculture is heavily dependent on irrigation (FAO, 2018). This situation partially accounts for Tajikistan's high susceptibility to the effects of climate change (Pfefferle et al., 2020).

Tajikistan has a large and diverse agricultural sector. Key crops in production include wheat, potato, vegetables (particularly onion), melon and other fruits. Food is primarily produced to satisfy national consumption. Climate change could influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation and temperatures. Indirect effects include through impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to desertification.

The outlook projected for agricultural production in Tajikistan is mostly negative. One study suggests yield declines are likely for several key crops including wheat, barley, maize, vegetables, and fruits, typically in the order of 5%–10% by 2050. Rice, potato and cotton yields are projected to experience small (<5%) yield gains over the same period (Aliev, 2016).

Taken together these changes could reduce national food security and community well-being. There is some disagreement over the outlook for wheat, a key staple crop.

Studies have suggested that rising temperatures may, over the long-term, improve conditions for wheat growth, increasing achievable yields by up to 12% (Sommer et al., 2013).

However, such projections should be treated with extreme caution because models typically assess the compatibility of average climate conditions with plant physiology and do not capture the impact of climate extremes. In addition, over the longer-term future, there is concern that loss of glacier and snow cover could significantly reduce the available water resource, potentially leading to major water shortages for irrigation purposes (Reyer et al., 2017).

With projections of considerably increased drought and heat wave probability, agricultural production is likely to become less stable, and net production may suffer (Bobojonov & Aw-Hassan, 2014).

7.1.3. Historical Trends of Temperature and Precipitation Changes

Relying on historical and projected trends in temperature and precipitation, Broka et al. (2016) suggest that Tajik agriculture is particularly vulnerable to climate change, with rising temperatures and falling precipitation projected in both the medium and long term. In the medium term, rising temperatures are expected to increase the rate of glacial melt and the associated risks of flooding. In the long term, together with falling precipitation, water availability for irrigation will become a major challenge (Khakimov et al., 2020).

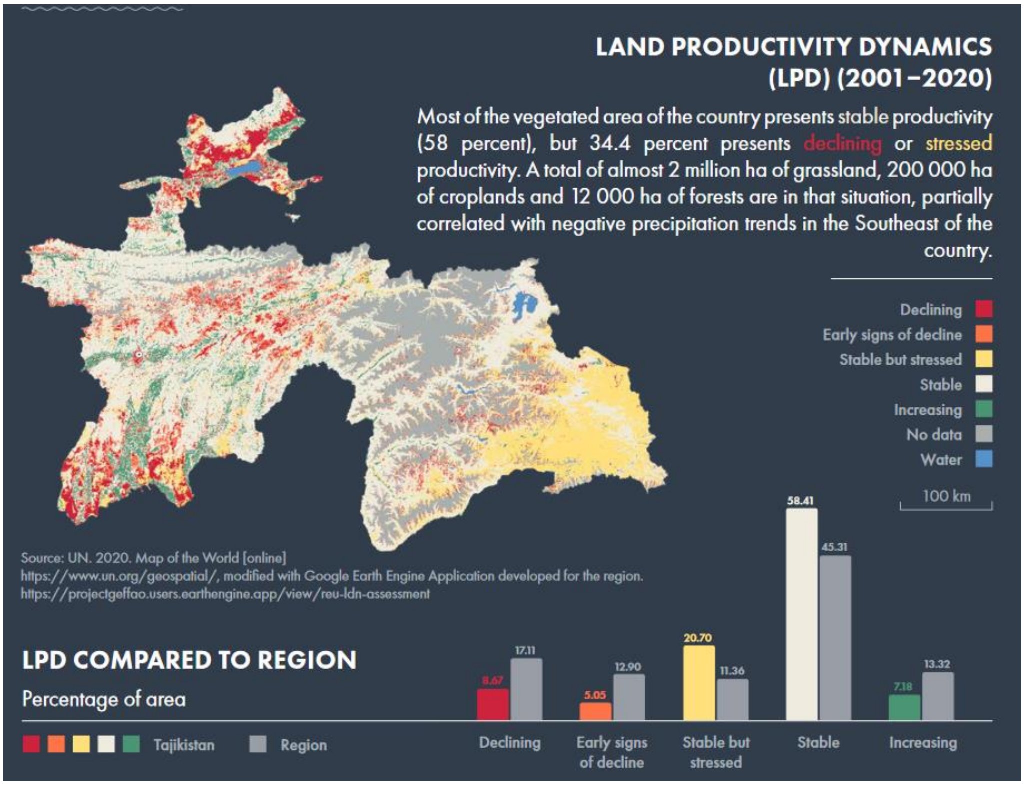
According to historical data provided by the Climate Change Knowledge Portal for Development Practitioners and Policy Makers (CCKP), average annual precipitation levels might not be significantly different between the periods of 1961–1990 and 1991–2016. However, changes in precipitation levels have taken a more seasonal pattern, which directly affects agricultural activities. While precipitation levels increased in January–February of the 1991–2016 period more than from 1961–1990, the reverse can be observed during March–May. From August onward precipitation patterns for the two date ranges remain more or less the same. Contrary to precipitation data, the average monthly temperature has increased for all months during the 1991–2016 period compared to 1961–1990. Overall, the average annual temperature increased by about 0.63°C between 1991 and 2016 compared to 1961–1990 (Khakimov et al., 2020).

7.1.4. The impact climate change effect on Land, Soil, and Biodiversity

Historical warming has already had an impact on large scale vegetation health across Central Asia and locally in Tajikistan. Over the period 1992–2011, rising air temperatures were associated with significant loss of ‘greenness’ (Zhou et al., 2015). Above mentioned trend was even accelerated during the last decade. These losses have been linked to increased water deficits driven primarily by greater evapotranspiration which can result in stunted plant growth and desiccation. Tajikistan's lowlands are also among the areas already being affected by increased aridity, Huang & Xie (2016) as reported in the nation's TNC. Persistent drought periods degrade grassland areas, causing transition to sparsely vegetated lands and shrubs (Khakimov et al., 2020).

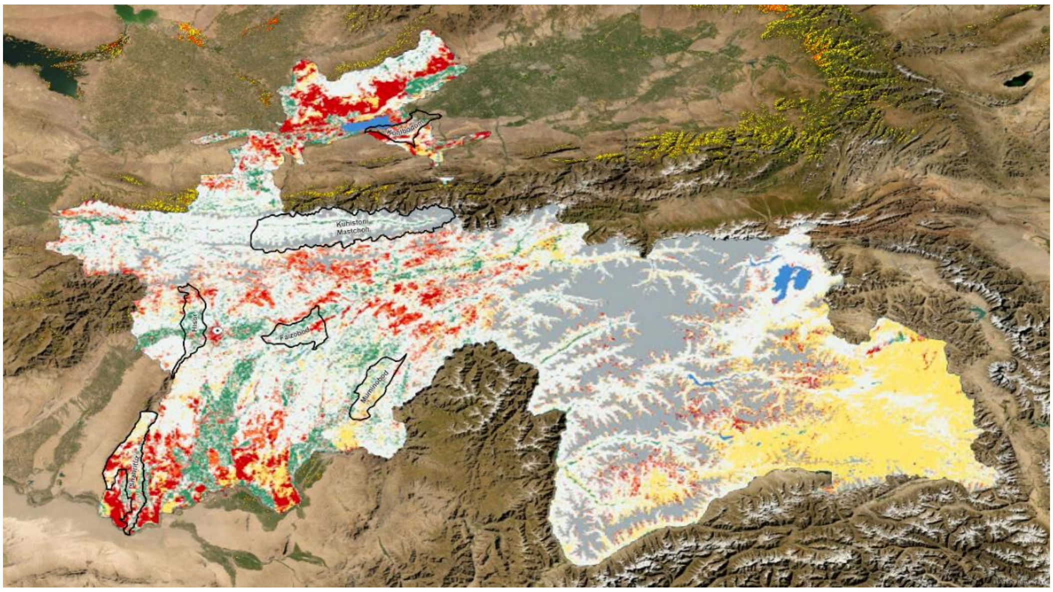
Indeed, over the Central Asian region, an estimated 8% of grasslands and 10% of forest land converted to shrubland between 2000–2013 (Li et al., 2015). The Central Asia region is identified as a hotspot of potential dryland expansion under future climate change (Huang et al., 2016). Desertification may also be a risk, but evidence from 2017 suggested Tajikistan contained most of the land that is immediately vulnerable (Zhang et al., 2018). The future of land and soil health in Tajikistan will depend strongly on local land management and development practices, such as biomass burning and soil conservation, Loboda et al. (2012) but sustainability challenges are likely to be exacerbated by climate change. Issues such as the projected increase in the erosive capacity of rain, and its impact on soil quality, will increase the pressure on key ecosystem functions (Duulatov et al., 2019). These changes, in combination with issues such as glacial melt and drought will likely result in significant shifts in species' viable ranges (both in natural ecosystems and for agricultural purposes) (Luo et al., 2018). Climate change impact is also associated with the problem of significant changes in the area of land productivity dynamics (FAO, 2021) (Khakimov et al., 2020).

Figure 7-1 Agricultural land productivity dynamics development in Tajikistan



Source: FAO, 2021

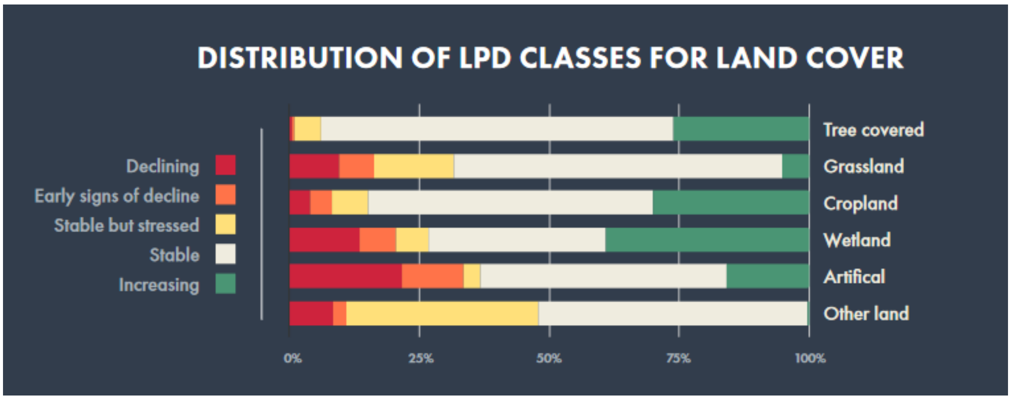
Figure 7-2 Agricultural land productivity dynamics development in Tajikistan – selected regions specifics



Source: own processing and FAO, 2022

The problem of land productivity development under the climate change process is related to both positive and also negative dynamics development. On the other hand, the negative trend is associated with only marginal agricultural land area (FAO, 2021).

Figure 7-3 Distribution of land productivity dynamics at the level of individual land areas



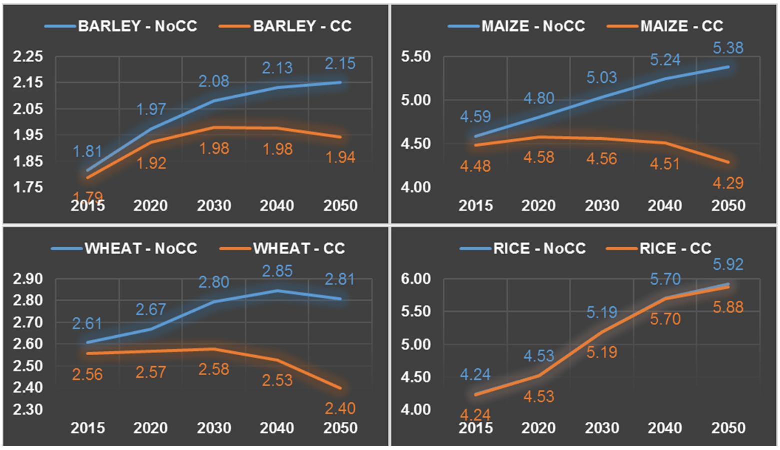
Source: FAO, 2021

7.1.5.Changes in Crop Yields

Quite important material devoted to the problem of changes in agricultural production under the process of climate change was published by Khakimov et al. (2020). The key findings related to climate change's impact on agricultural production are stated below.

Climate-change 'CC' effects on individual crops will depend on their tolerance of heat and water availability. Winter crops in temperate climates often increase productivity in warmer temperatures, in contrast to spring crops which are more likely to experience heat stress in response to warming. Changes in seasonal rainfall patterns and severe weather events may affect planting and harvesting. Most arable land under major crops is irrigated in Tajikistan. Figure below presents projections on yield changes on irrigated land. The climate change scenario 'CC' represents the average value obtained from the four different climate models (Khakimov et al., 2020).

Figure 7-4 Irrigated crop yields in climate-change vs no-climate-change scenarios, metric tons/ha: barley, maize, wheat, and rice.

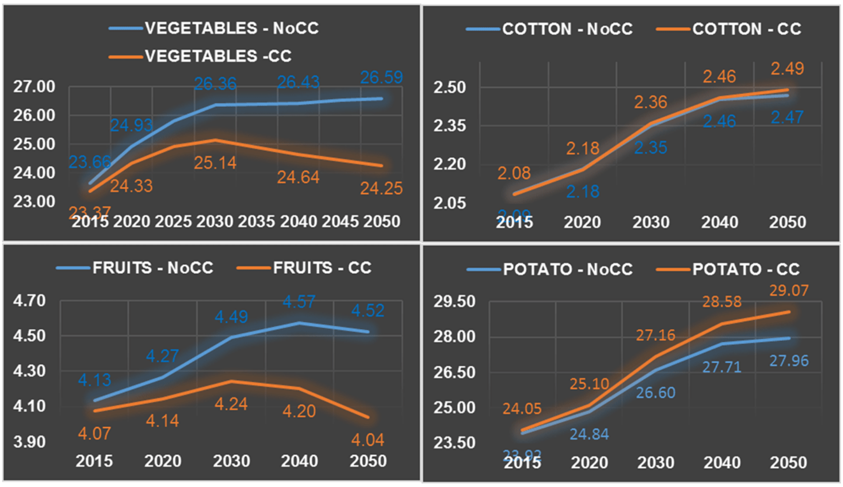


Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)
Note: 'CC' averages the yields from the four different climate models.

The findings suggest that by 2050, barley, wheat, and maize yields will suffer a substantial decline due to climate change. On the other hand, the growth in rice yields between 2015 and 2050 shows virtually no difference between the baseline and climate-change scenarios. Overall, rice yields are expected to increase by about 40 per cent (Khakimov et al., 2020).

Figure 7-5 shows the results of a similar exercise involving crop categories such as vegetables, fruit, potatoes, and cotton. Under the no-climate-change scenario, vegetable yields are projected to rise steeply until around 2030 and then level off through 2050. Under the climate-change scenario, however, yields are projected to rise more modestly through 2030, then decline through 2050. A similar pattern can be observed in the case of temperate fruits (Khakimov et al., 2020).

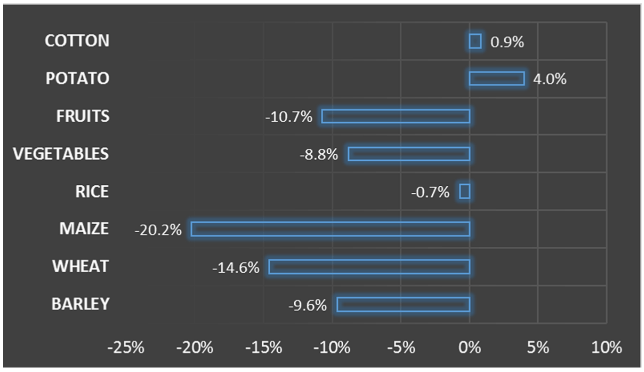
Figure 7-5 Irrigated crop yields in climate-change vs no-climate-change scenarios, metric tons/ha: vegetables, cotton, fruit, and potatoes.



Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)
Note: 'CC' averages the yields from the four different climate models.

Two points must be considered with respect to how fruit and vegetables are estimated. First, they are aggregates of many different crops, and as such, it is difficult to interpret effects on individual crop types. Second, climate impact on yields is inferred from the crop model results for other crops, and therefore one should exercise caution in making direct comparisons. For potatoes, the climate impact on yield is expected to be small but positive, unlike for any of the other aforementioned crops. Potato yields are projected to increase by about 21 per cent under the climate-change scenarios. Likewise, cotton yields are projected to increase by about 20 per cent over the same timeframe. Projected climate-change-induced yield changes for 2015–2050 are summarized in Figure 7-6 (Khakimov et al., 2020).

Figure 7-6 Changes in irrigated crop yields under climate-change scenario, 2050/2015 (%).

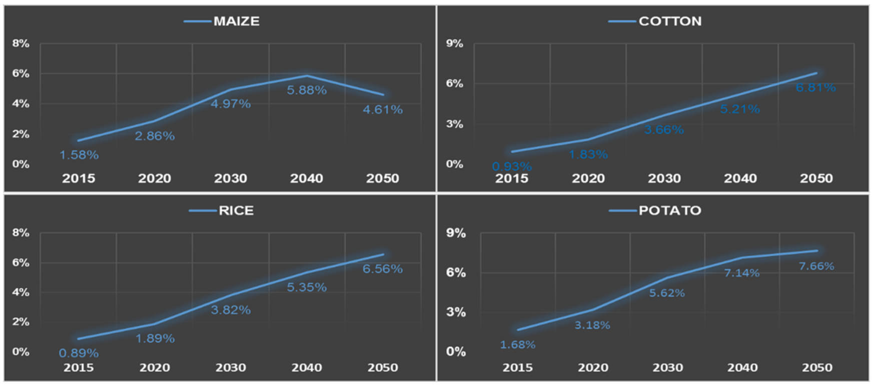


Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

7.1.6. Area Changes

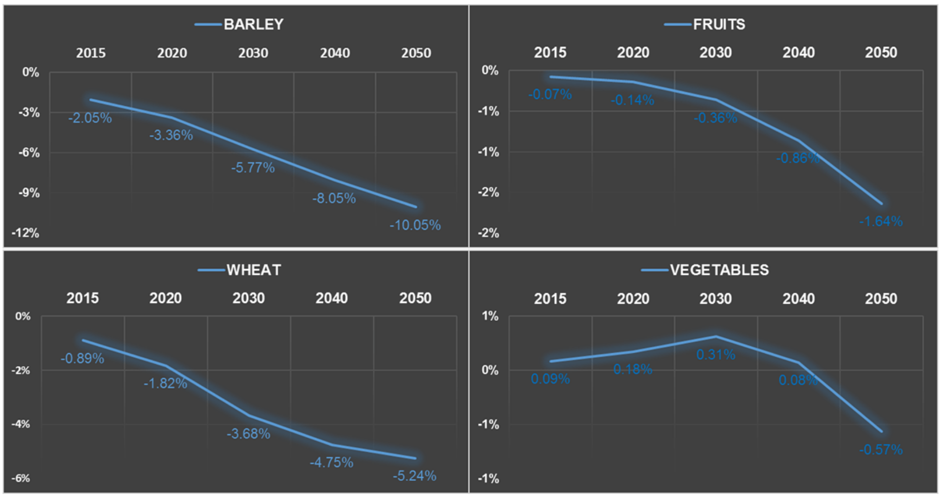
Farmers make choices about expanding or reducing the area allocated for crops in response to signals such as productivity, expected prices, competition from other crops, and land demand. These are all factors that alter the profitability of a particular crop. Climate change ultimately affects area choices through all of these avenues. Figures 7-7 and 7-8 display differences in allocated area between the climate change and baseline scenarios (Khakimov et al., 2020).

Figure 7-7 Changes in areas allocated to crops in climate-change vs no-climate-change scenarios (%): maize, cotton, rice and potatoes



Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

Figure 7-8 Changes in areas allocated to crops in climate-change vs no-climate-change scenarios: barley, wheat, vegetables, and fruit.



Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

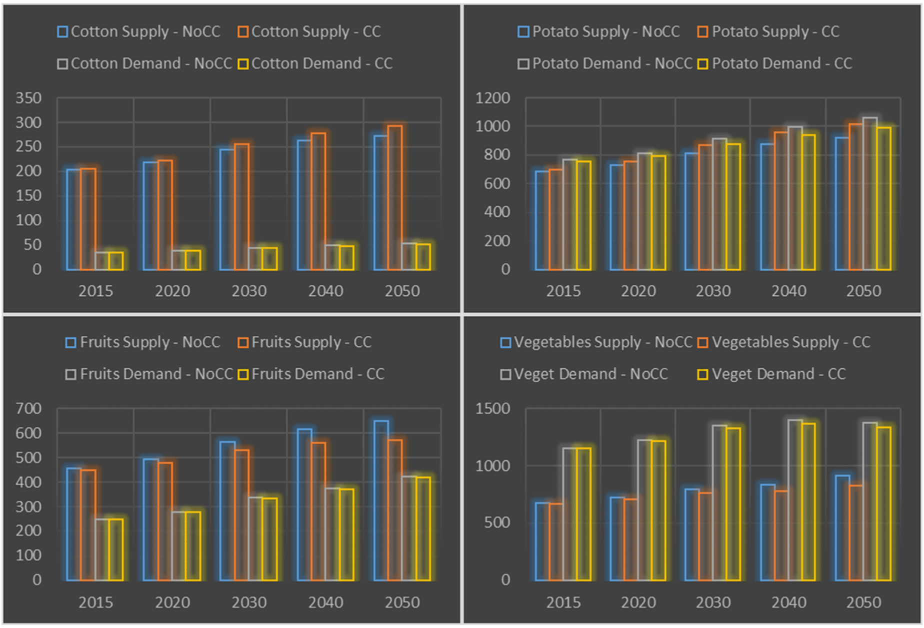
7.1.7. Changes in Domestic Supply and Demand

Continuing population growth in Tajikistan is expected to lead to an increased demand for many agricultural products. The ability of farmers to expand production will be limited by climate change and the other constraints mentioned earlier. The excess demand can be satisfied by importing foods. Figures 7-9 and 7-10 show projected shifts in domestic supply and demand for selected categories of crops by 2050. Projection estimates suggest that climate change is going to have a negative effect on domestic supplies of barley, wheat, and maize, whereas the supply of rice is projected to be positively affected (Khakimov et al., 2020).

Figure 7-9 Crop supply and demand shift in response to climate change (000 metric tons).

Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

Figure 7-10 Crop supply and demand shift in response to climate change (000 metric tons).



Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

7.1.8. Overall effect of climate change

Speaking about individual already published studies and research outputs – it is possible to highlight the following: The findings show that the effect of climate change on Tajikistan's agricultural sector is mostly negative. Table 7-1 summarizes the overall impact of climate change on area, production, demand, and producer prices for selected agricultural products. From the table, we note that wheat, barley, maize, fruit, and vegetables seem to be particularly vulnerable to climate change in Tajikistan, having some large negative values in the yield and supply columns. Increases in producer prices could be specifically good for export crops, because they improve the trade balance. Yet while the effect is somewhat mixed for farmers, price increases are bad for consumers who have to use a higher proportion of their income on food (Khakimov et al., 2020).

Table 7-1 Overall effects of climate change: climate-change vs no-climate-change in 2050 (percentage difference).

	Yield	**Area**	**Supply**	**Demand**	**Producer price**
Maize	-21,80	3,90	-18,60	-4,70	41,00
Cotton	0,90	7,00	7,90	-1,90	17,00
Rice	-1,20	6,40	5,40	-4,90	20,50
Potatoes	3,90	7,70	10,70	-6,90	30,60
Barley	-9,60	-10,00	-18,20	0,20	-3,10
Fruit	-10,70	-1,60	-12,20	-1,30	9,70
Wheat	-14,60	-5,30	-21,10	-2,20	10,10
Vegetables	-8,80	-0,60	-9,20	-2,70	10,70

Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

Table 7-1 only tells part of the story – what will probably happen, compared to what could have happened without climate change. Table 7-2 presents a more complete story and displays what the future will look like compared to what the present is. From this table, we can better understand that while both wheat and maize yields are projected to decline in absolute terms between 2015 and 2050, the area under wheat will decline while the maize area will expand, because wheat prices will only rise by 28 per cent while maize prices will rise by 75 per cent (Khakimov et al., 2020).

Table 7-2 Change in agriculture between 2015 and 2050 under climate change (percentage difference)

	Yield	**Area**	**Supply**	**Producer price**
Wheat	-7,50	-9,40	-16,10	27,90
Cotton	18,60	21,00	45,20	36,90
Fruit	-2,20	27,80	25,00	27,80
Barley	6,90	-9,90	-3,60	9,80
Maize	-8,60	29,20	17,90	75,30
Potatoes	16,10	27,30	48,40	41,30
Vegetables	2,50	19,40	22,40	47,20
Rice	38,70	19,50	66,20	42,40

Source: Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020)

7.1.9. Conclusion and Policy Implications

Climate change is one of the main challenges for Tajikistan's agricultural development and food security both in the medium and longer term. It is considered one of the key obstacles to achieving the country's strategic objectives as defined in the National Development Strategy for 2016–2030, which includes ensuring food security and access to quality nutrition by 2030. Climate change will be one of the main challenges for food security, leading to an increased number of people at risk of hunger, malnourishment, especially among children and other vulnerable groups, and insufficient per capita calorie intake. Lower food availability may lead to higher food prices, which would negatively affect the livelihood of the population (Khakimov et al., 2020)

Available data analysis of main crop yields shows that climate change will have a negative impact on crop yields with three exceptions – cotton, potatoes, and rice, which will have either small positive gains or an almost indiscernible reduction in the case of rice.

Taking in consideration the key findings published by Khakimov et al. (2020) – the following statements have to be highlighted.

Climate change will negatively affect the demand side through changes in global prices, reducing consumption and slowing the reduction of malnutrition and food insecurity. The net trade situation will worsen in both scenarios, due to increased domestic demand through population and income growth, and the negative effects of climate change on the production of most commodities.

The Growing Season Length (GSL) is expected to increase. Under the high emissions scenario, RCP8.5, GSL will be approximately 150 days in 2030, 165 days in 2050, and 200 days in 2080. Increased temperatures, however, counteract the positive effect of a longer GSL.

Despite an extended GSL, agricultural productivity during the growing season is at risk due to rising temperatures, more frequent and intense heat waves, as well as the risk of less irrigation water availability due to higher evaporation and glacier retreat (especially in late summer).

Climate change will likely increase the existing vulnerabilities and risks for agriculture. Further climate-related risks identified regarding infrastructure are mudflows, droughts, high temperatures, and strong winds.

Increasing temperatures will lead to a retreating snowline and a loss of glacial mass which will cause a decrease in water storage capacity. Increasing temperatures will generate an increase in the variability of river discharge as well as fluctuations in water availability and quality; therefore, negative repercussions on agriculture are to be expected. Additionally, increasing temperatures are associated with a likely increase in the risk of spring flooding and glacial lake outbursts during snowmelt.

The number of heat days above 40°C is expected to increase by 12.5 days by 2080 compared to the 1986-2005 period. Consequently, this will lead to an increase in heat-related health issues such as heat stress and heat-related mortality. An increase in food insecurity in conjunction with an expected reduction in agriculture and pasture productivity will likely cause negative effects on the already-critical nutritional status of the population. An increase in gastrointestinal infections is projected alongside an increase in floods, flood-related water contamination, and the increase of exposure to water and foodborne diseases. Frequent and severe infectious disease outbreaks are more likely because of climate change, as is the re-emergence of Malaria.

Climate change can be considered one of the key obstacles to the achievement of the country's strategic objective defined in NDS 2016–2030, which is to improve the living standards of the population, and one of the four strategic priorities, which is to ensure food security and access to quality nutrition in 2030.

7.2. The trends in agriculture of Tajikistan – quantitative analysis

7.2.1. Methodology

Analysis of existing data on agricultural production. Source of the data: TajStat, 2022

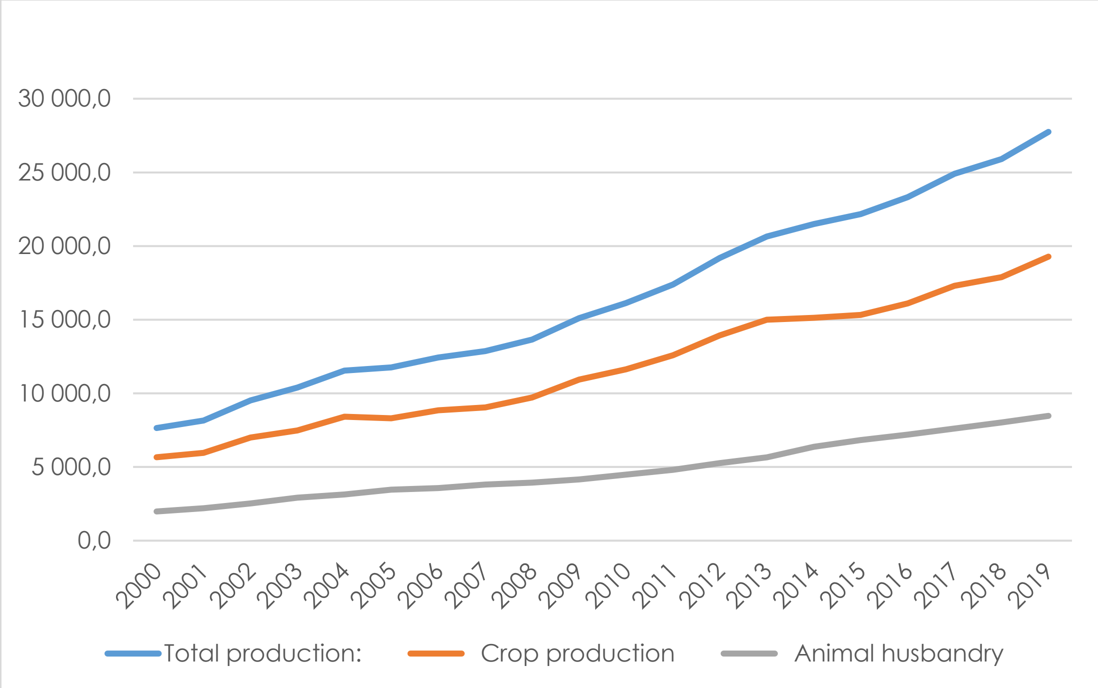
7.2.2. Results

The development of the agricultural sector in Tajikistan has been substantially determined by socio-political processes, governmental regulations, deterioration of soil and infrastructure, and climate change. More often than not these effects are difficult to separate.

On the first sight, the monetary value of total agricultural production has been increasing over the last 20 years (Figure 7-11). However, this effect was largely caused by the effect of low base, as production substantially decreased in the 1990s due to the civil war and the dissolution of the Soviet Union (Figure 7-12).

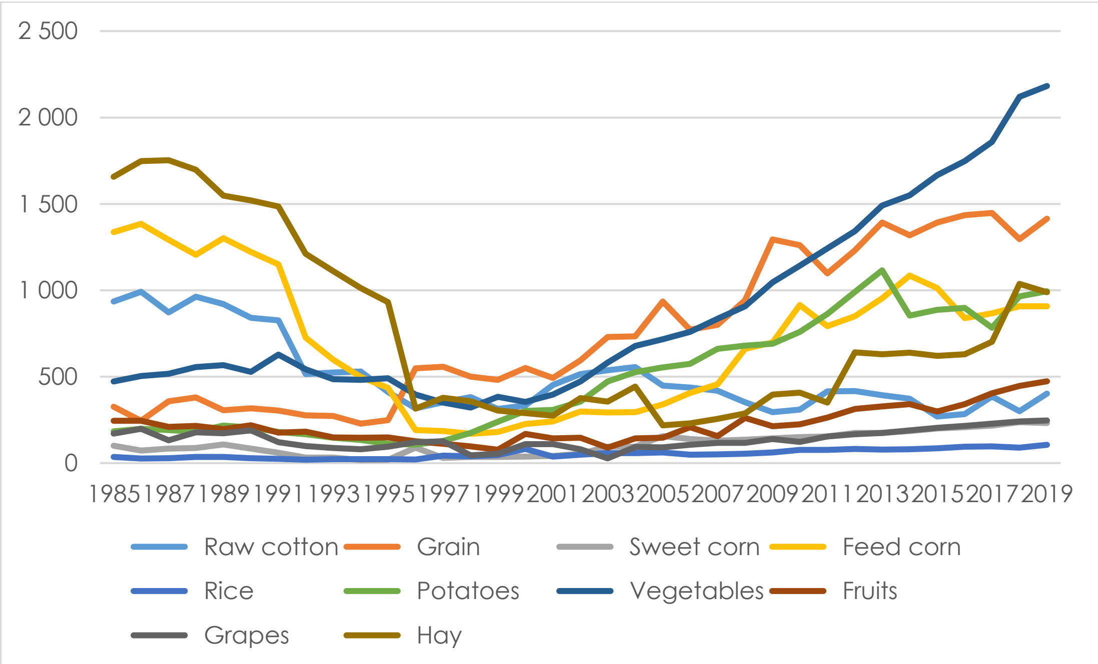
In fact, the country seems to have just recovered from the fall in production of the 90th (Figure 7-12). Therefore, the empirical analysis of agricultural production and the possible effects of climate change must take into account the historical pathway and the time span longer than the last 20 years. One should be aware that some changes in agricultural production, caused by historical development, could be incorrectly attributed to climate change or increase in efficiency in production. The graph of the latter (measured as yield in kg per hectare) essentially copied the patterns of total crop production presented in Figure 7-12 (see Figure 7-13). With the exception of the rapid increase in yields per hectare of feed corn and sweet corn in 2010 followed by the decline in 2017, yields essentially declined in the 1990s (after the dissolution of the Soviet Union and during the civil war) and grew after 2000 (Figure 7-15).

Figure 7-11 Agricultural production, Tajikistan, 2000-2019, in thousands of somoni at constant 2000 prices



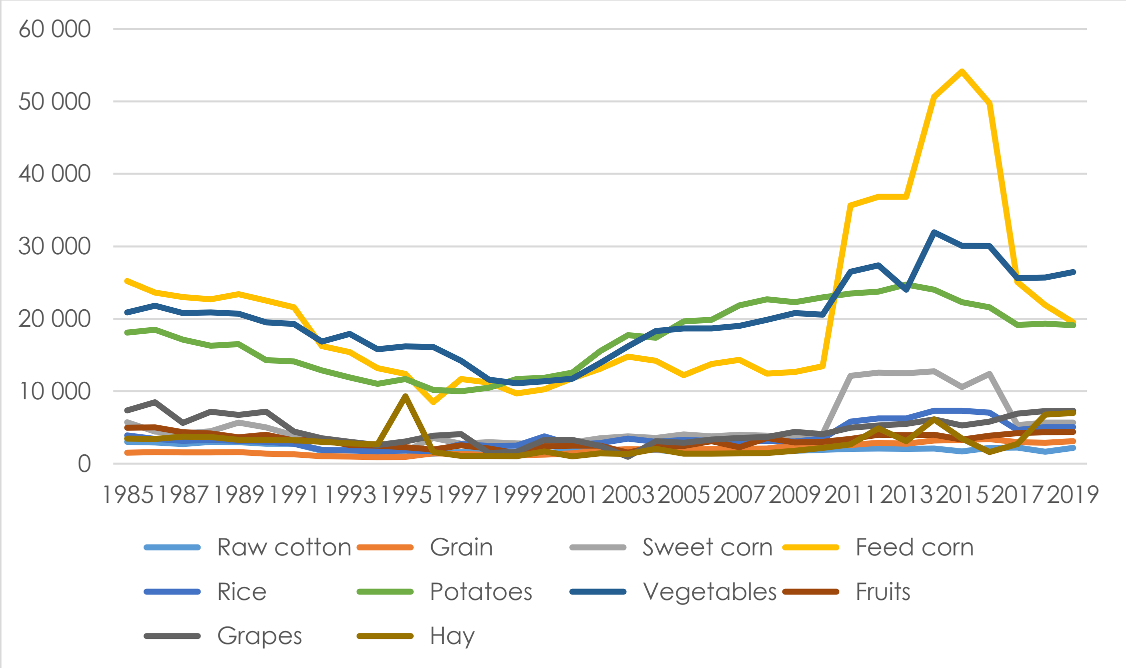
Source of the data: TajStat, 2022

Figure 7-12 Crop production in Tajikistan. 1985-2019. Thousands of tons.



Source of the data: TajStat, 2022

Figure 7-13 Yield in kg per hectare (1985-2019)



Source of the data: TajStat, 2022

Additionally, the analysis of the direct effects of climate change on the total production, or on the efficiency of production is largely subject to the following interfering factors

- The availability and costs of water and fertilizers
- The legislative policy that led to land fragmentation (presidential lands)
- The change in the structure of the land users, where the land was given to the population with little or no agrarian education
- Deterioration of infrastructure including the state of irrigation canals and pumping stations
- The deterioration of infrastructure shielding the agricultural sector from climate-related emergencies such as water- and mud- flows
- The dismantled centralized and all-encompassing land use strategy that existed under the Soviet Union
- The degradation of soil including erosion in some regions and salinization in other regions
- The ability of the population to partly adapt to climate change by looking for new water sources (wells), using the crops more productive at rising temperatures, adopting unused lands for agricultural production, etc.

The last point, however, needs to be analyzed separately as the preliminary analysis suggests that the ability of the population to adjust to climate change with no additional investment on the side of the government or international donors seems to have reached its limits. Taking into account the population growth that will place even higher demands on food availability and variability, the implementation of new, more effective adaptation mechanisms is indispensable.

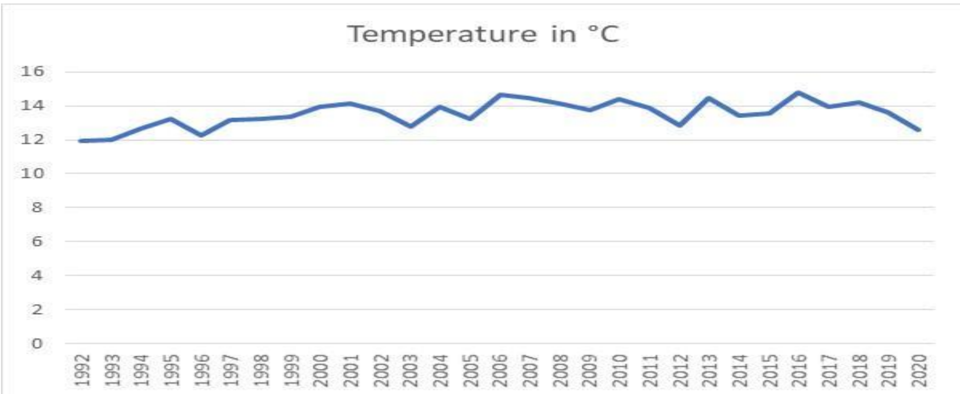
Climate change could influence food production through direct and indirect effects. Direct effects include alterations of levels and seasonality in precipitation and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to desertification (Climate Risk Country Profile: Tajikistan, 2021).

Having said all above, the analysis of the agricultural production in the focus regions and the effects of climate should be taken with care as, given the short time span the quality of the data and the multiple variables interfering we could hardly separate the effects of climate from others. In general, we might assume that the effects of climate change might be underestimated especially in the regions, where these effects are negative due to the adaptability of the local population. Thus, most likely, the lack of adaptation measures may be visible not via decrease in agricultural outputs, but rather in inability of the population to realize the full potential of agricultural production, so much needed given the population growth.

7.2.3. The effects of climate change in Tajikistan on agricultural production in period 1992-2020

During the period 1992 – 2020, the limited growth of average temperature in Tajikistan was recorded. The average temperature increased from 11.9 °C to about 14.78 (maximum value in 2016). During the period under the analysis, we recorded the growth of temperature on average by 0.2% a year (for details see Figure 7-14).

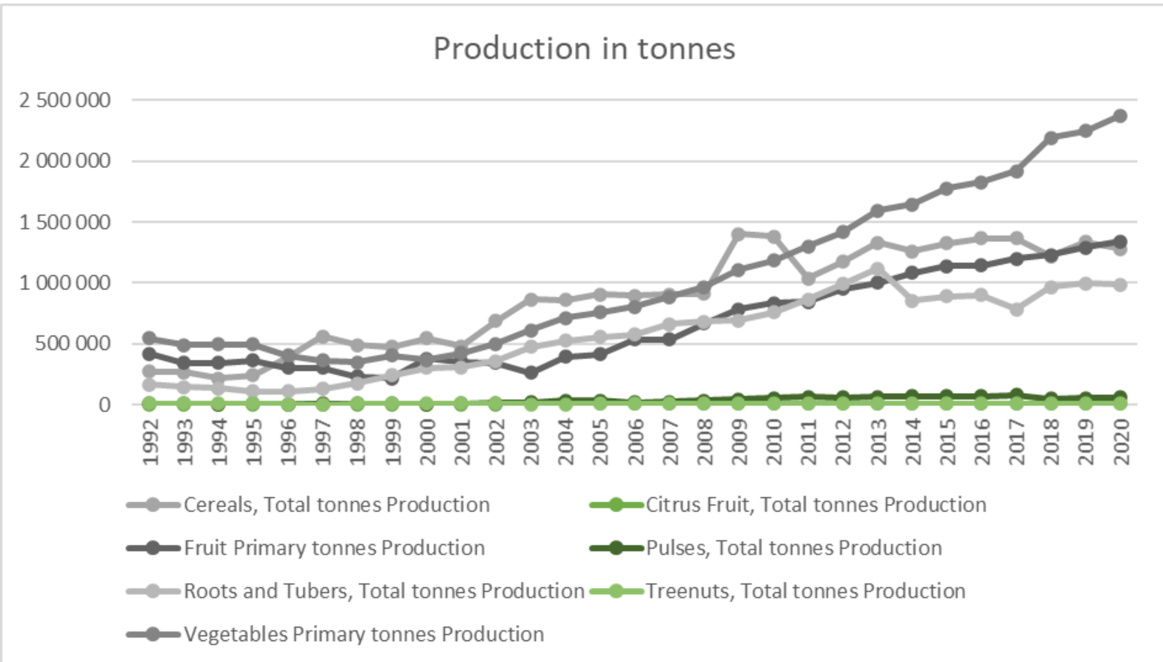
Figure 7-14 Tajikistan average temperature development between 1992-2020



Source: own processing, Faostat, 2022

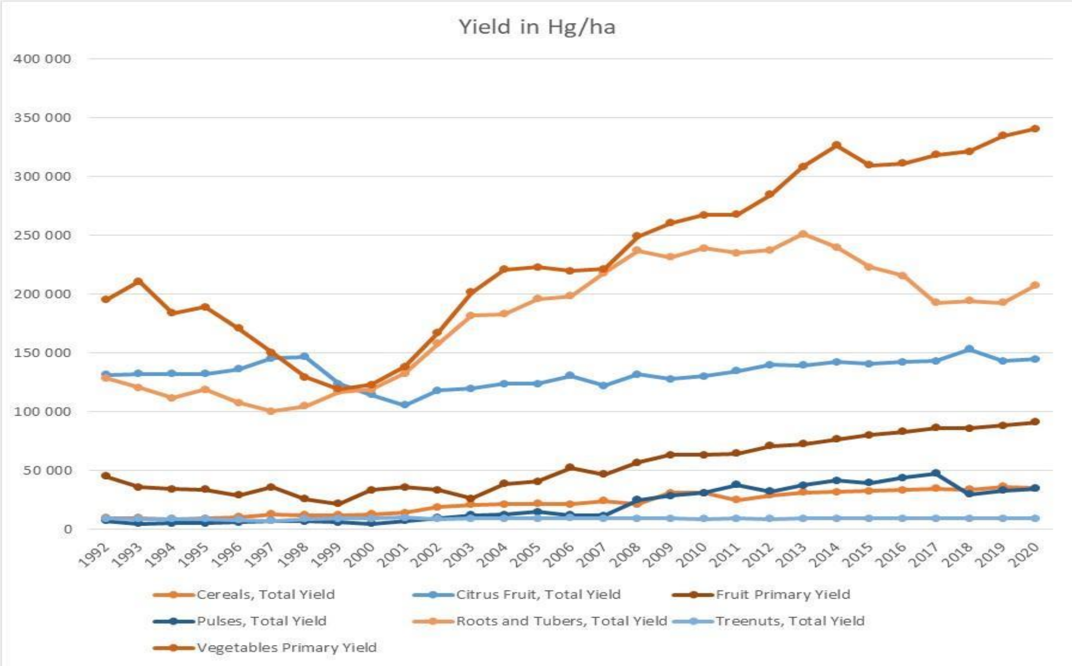
At the same time, agricultural production recorded a massive growth. The volume of the production of the crop increased from 1.2 million tonnes to about 6 million tonnes. And the average inter-annual growth rate of crop production reached about 5.3%. The positive growth of crop production was recorded especially in the case of cereals, fruit, pulses, roots and tubers and vegetables. The only negative development was recorded in the case of tree nuts production volume. For details see figure 7-15 and 7-16. The growth of production performance was pushed both by the growth of the harvested area and yields per hectare (for details see Figure 7-16 and Figure 7-17). In Particular, the growth of yields must be considered as the key source of production volume growth. Taking into consideration the results of logarithmic decomposition analysis, the growth of yields is able to explain cc 70.7% of production volume development, while the growth of the harvested area is associated with only 29.3% of crops production volume development. The positive yield development is the key driver of production volume growth mainly in the case of cereals, fruits and pulses. On the other hand, the growth of the harvested area is the dominant driver explaining the growth of crops production volume development in the case of citrus fruit, roots and tubers, tree nuts and vegetables. A detailed overview of harvested area development and yields per hectare development in Tajikistan in the period 1992 – 2020 is demonstrated in Figures 7-16 and 7-17. While in the period under the analysis, the average growth of production volume recorded the rate cc 5.3%, the average growth rate of the harvested area reached 1.5% and the average growth rate of yields per hectare reached 3.7%.

Figure 7-15 Tajikistan – crops production volume performance development in 1992-2020



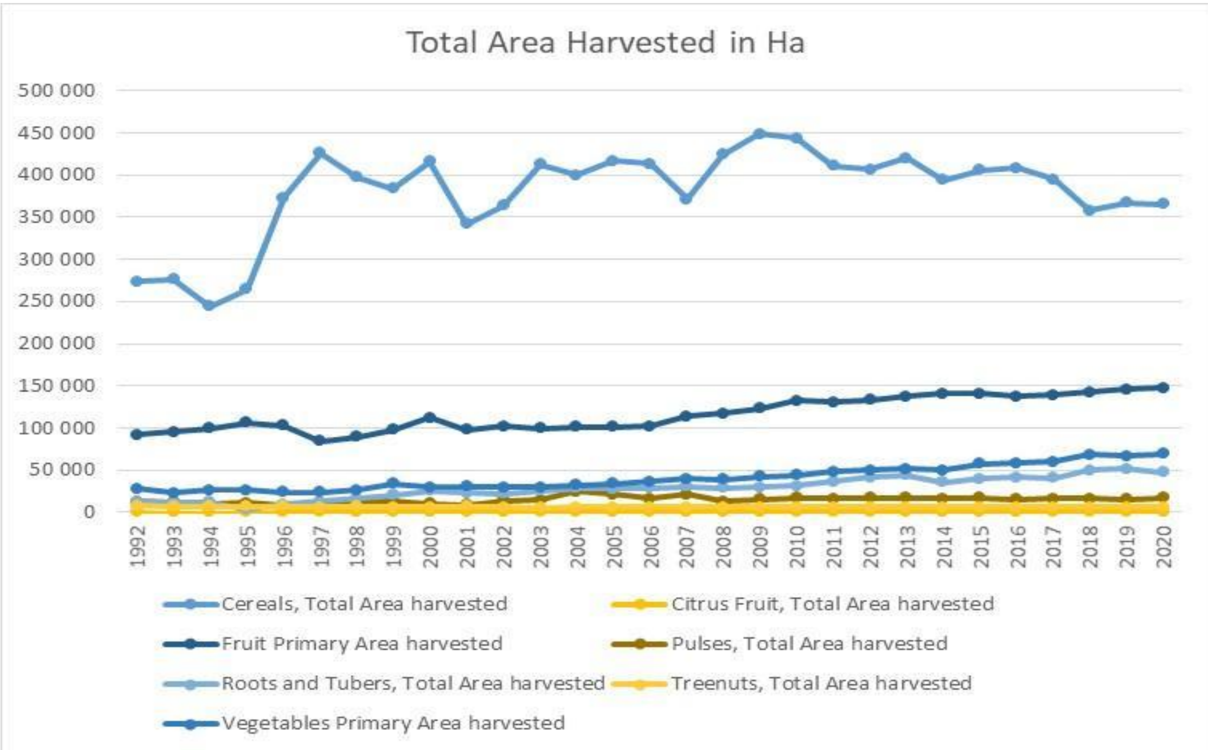
Source: own processing, Faostat, 2022

Figure 7-16 Tajikistan – crops yields per hectare development in 1992-2020



Source: own processing, Faostat, 2022

Figure 7-17 Tajikistan – harvested crops area development in 1992-2020



Source: own processing, Faostat, 2022

The growth of crops volume production is affected not only by the positive growth of harvested area and yields but also by the impact of upcoming climate change must be taken into consideration. If we processed the analysis characterizing the relationship between average temperature development and crop volume performance it is possible to confirm the positive correlation (for details see Figure 7-3). A low, but positive correlation is possible to confirm between temperature development and cereals, citrus fruit, pulses and roots and tubers volume performance development.

Table 7-3 Tajikistan – correlation between average temperature development and crops production performance

	Correlations (Spreadsheet1) Marked correlations are significant at p < ,05000 N=29 (Casewise deletion of missing data)		
Variable	Means	Std.Dev.	Temperature
Cereals, Total	876856	409788	0,536499
Citrus Fruit, Total	5078	2422	0,456230
Fruit Primary	663158	377211	0,326872
Pulses, Total	33189	25122	0,401806
Roots and Tubers, Total	566819	332083	0,496314
Treenuts, Total	5967	510	-0,233651
Vegetables Primary	1039206	651209	0,297823
Total crops production	3190271	1732178	0,411616
Temperature	14	1	1,000000

Source: own processing, Faostat, Big Terra, 2022

Table 7-4 Tajikistan – crops production performance development overview in 1992-2020

Item	Unit	Element	1992	1996	2000	2004	2008	2012	2014	2020	GEO-MEAN	Ln	Final impact
Cereals, Total	ha	Area harvested	273 460	372 924	415 790	400 077	424 794	406 573	394 424	365 900	1,010	0,010	0,188
Cereals, Total	hg/ha	Yield	9 937	10 388	13 107	21 504	21 410	28 911	31 894	35 005	1,046	0,045	0,812
Cereals, Total	tonnes	Production	271 733	387 377	544 994	860 340	909 500	1 175 450	1 257 989	1 280 841	1,057	0,055	
Citrus Fruit, Total	ha	Area harvested	152	188	253	480	484	581	570	453	1,040	0,039	0,919
Citrus Fruit, Total	hg/ha	Yield	131 579	136 383	114 625	124 021	131 777	139 880	142 351	144 790	1,003	0,003	0,081
Citrus Fruit, Total	tonnes	Production	2 000	2 564	2 900	5 953	6 378	8 127	8 114	6 559	1,043	0,042	
Fruit Primary	ha	Area harvested	92 382	102 936	112 462	101 250	117 198	133 392	140 895	147 304	1,017	0,017	0,401
Fruit Primary	hg/ha	Yield	45 420	29 141	33 386	38 760	57 077	71 243	76 670	91 113	1,025	0,025	0,599
Fruit Primary	tonnes	Production	419 600	299 964	375 462	392 447	668 928	950 328	1 080 241	1 342 138	1,042	0,042	
Pulses, Total	ha	Area harvested	12 831	7 983	10 567	25 137	13 368	17 459	16 360	16 821	1,010	0,010	0,149
Pulses, Total	hg/ha	Yield	7 423	6 109	4 834	12 435	25 196	32 502	41 422	34 746	1,057	0,055	0,851
Pulses, Total	tonnes	Production	9 524	4 877	5 108	31 259	33 682	56 746	67 767	58 447	1,067	0,065	
Roots and Tubers, Total	ha	Area harvested	13 000	10 000	25 471	28 810	28 676	41 738	35 543	47 492	1,047	0,046	0,730
Roots and Tubers, Total	hg/ha	Yield	128 769	107 700	119 046	183 006	237 053	237 444	240 199	207 683	1,017	0,017	0,270
Roots and Tubers, Total	tonnes	Production	167 400	107 700	303 223	527 240	679 774	991 044	853 738	986 327	1,065	0,063	
Tree Nuts, Total	ha	Area harvested	8 050	6 950	6 567	5 988	6 212	6 600	6 200	6 164	0,991	-0,010	1,012
Tree Nuts, Total	hg/ha	Yield	9 398	8 058	9 289	9 380	9 176	9 091	9 516	9 427	1,000	0,000	-0,012
Tree Nuts, Total	tonnes	Production	7 565	5 600	6 100	5 617	5 700	6 000	5 900	5 811	0,991	-0,009	
Vegetables Primary	ha	Area harvested	27 945	23 712	29 912	32 202	38 690	49 772	50 348	69 679	1,033	0,033	0,621
Vegetables Primary	hg/ha	Yield	195 121	170 978	123 140	221 248	249 370	284 772	326 576	340 789	1,020	0,020	0,379
Vegetables Primary	tonnes	Production	545 267	405 422	368 335	712 463	964 813	1 417 368	1 644 245	2 374 585	1,054	0,053	
Total crops production	ha	Area harvested	427 820	524 693	601 022	593 944	629 422	656 115	644 340	653 813	1,015	0,015	0,293
Total crops production	hg/ha	Yield	33 264	23 128	26 723	42 686	51 933	70 187	76 326	92 606	1,037	0,037	0,707
Total crops production	tonnes	Production	1 423 089	1 213 504	1 606 122	2 535 319	3 268 775	4 605 063	4 917 994	6 054 708	1,053	0,052	

Source: own processing, Faostat, Big Terra, 2022

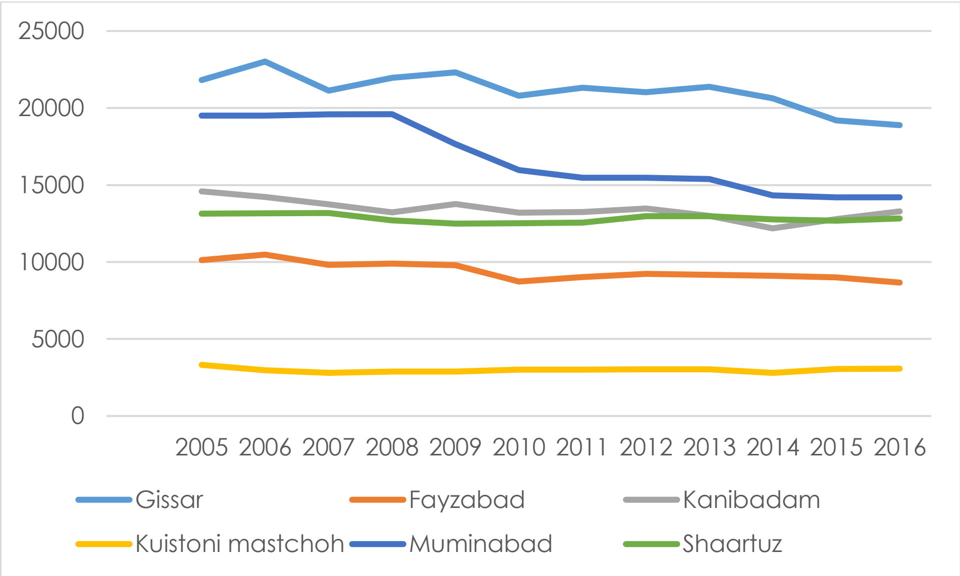
The weakness of the above-processed analysis is in its tricky character. However, the significant climate changes already approved many available and already published research outputs (Bobojono & Aw-Hassan, 2014; Broka, 2016; Helberg & Bonch-Osmolovskiy, 2011; Hijioka, 2014; Met Office Hadley Centre, 2019 etc.) and the growth of average temperature is more than evident, there is no real negative impact on agricultural production performance development. Even more, agricultural production performance has never been so productive and production itself has never been so massive as it is nowadays. The only explanation for such development is the ability of farmers to run the continual process of adaptation to climate changes. Farmers are able to pass the process of agricultural activities adaptation. They are able, through the massive investments and technology and innovation transfer, to adapt their activities and agricultural performance to slowly coming climate changes. The negative impact of climate change is compensated by farmers' activities applied as their response to already running climate change and its associated characteristics (lack of water, land degradation, loss of biodiversity, soil erosion etc.). Taking in consideration available data, farmers are doing their best to fight against climate change impact, but their ability to compensate for individual negative effects is limited as their resources, especially available capital, are limited. Taking into consideration already published outputs, it is possible to estimate the edge between farmers' ability to compensate the negative climate development and the moment when their ability to eliminate negative processes will not be enough. According to IFPRI research (Khakimov et al., 2020) – the farmers lose their ability to compensate negative climate development impact on agriculture between 2020 and 2030. To prevent a negative impact on agriculture and its possible collapse – it is necessary to implement massive changes in national agricultural policy strategies and foster necessary infrastructure and especially foster farmers' capacities to eliminate negative processes. It is necessary to transform the agricultural system in Tajikistan and to make individual farms and farmers more resistant.

7.3. The trends in agriculture of the target districts

Sowing areas

One of the possible effects of climate change is land degradation, including salinization and erosion, which eventually, may take some of the territory out of agricultural production. In addition, increased water- and mud-flows may make some of the land unusable for agriculture. On the other hand, some target regions, but not others, possess unused land, which may eventually be used for agriculture. However, according to interview data, most of this new land is located in difficult-to-access areas, which often lack sufficient water resources. Thus, the use of this land is highly dependent on the location and particular conditions.

Figure 7-18 Sowing areas of agricultural crops in target districts, all types of farms and crops (hectares)



Source of the data: TajStat, 2022

Having said all that, it is very worrisome that sawing areas in some regions (Gissar, Muminabad) are decreasing. On the other hand, some of these areas are likely to be transferred to orchards, which should be reflected in increased fruit production.

7.3.1. Crop yields and sowing areas

The overall tendencies of most of the crop yields presented in figures 7-19 to 7-30 do not indicate any negative scenario (see figures 7-19 to 7-30). Except for some single years, where the yields showed significant drops, most of the overall tendencies seem to be positive or at least stagnant. These drops most likely are caused by unfavorable weather events such as spring freezes or summer heat waves, which might be considered the products of climate change. However, at least in the time span considered, they do not alter the trend.

Moreover, it is likely that the effects of temperature increase in the regions are largely positive for melons, fruits, and grapes (see Figures 7-27 to 7-30). However, these crops seem to be very susceptible to extreme weather events such as spring frosts, which substantially reduced production in particular years.

The results above should not be interpreted in the way that there is no effect of climate change or land degradation as there are many other factors involved. Crop production might have been moved to more suitable land, or unsuitable land was taken out of production (e.g. the sowing areas were substantially reduced in some regions (Muminabad, Fayzabad, Figure 7-18).

There are two particular crops to consider from the point of view of the self-sufficiency of Tajikistan and the export potential of it: grain and cotton. In 2020 the country imported 1,988,333 tons of grain worth 4.86 million USD (TajStat, 2022). The same year, the country exported 206.5 tons of cotton worth 265 million USD (ibid.). The production of cotton is indispensable for international trade balance at least in the sphere of agricultural products. However, the production of cotton suffers from low prices the farmers get. In many districts the biggest price margin is received by wholesalers reducing the attractiveness of cotton production to the local farmers. Given the extensive irrigation required by the cotton fields, the lack of water in some regions and the low prices, the farmers are incentivized to reduce the production of cotton. The state had to take its role in forcing farmers to allocate a part of their land to cotton (interview data)[5]. Thus, the reduction of cotton sowing areas displayed in

[5] The interview data from Kanibadam and Gissar suggest that the farmers are reluctant to produce cotton as it brings less revenues compared to other crops (especially fruits). Moreover, they consider their soil not suitable for efficient cotton production, which, in addition, is very dependent on abundant watering. Given the relative lack of water in the regions it is not surprising that the farmers move their production to other crops. According to the farmers, the government forces them to plant cotton on some proportion of their land as cotton is considered one of the few export commodities. The farmers considered cotton production as a remnant of the communist era, when the country was forced to produce cotton for export, though the land could be better used otherwise.

the figure 8 cannot be attributed to climate change per se, but rather to the motivational schemes of the farmers. This conclusion is also supported by the fact that the cotton yields per hectare did not present any substantial reduction.

The example of cotton illustrates the tendency of farmers to adjust to changing environments including climate change by devoting their land to crops that are more suitable given the current climate and water environment.

Figure 7-19 Grain and leguminous in the target regions. Sowing areas, all types of farms (hectares)

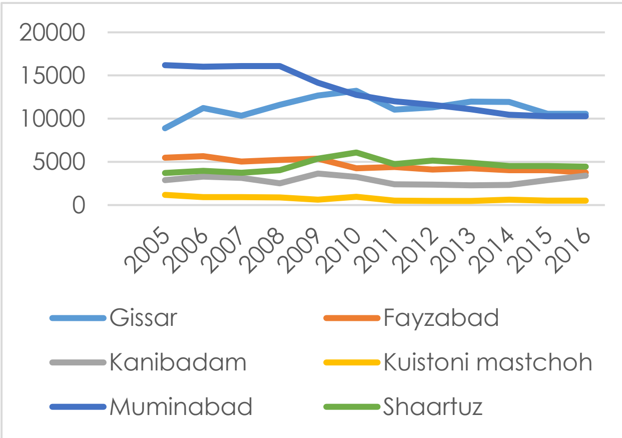


Figure 7-20 Grain and leguminous yields in target regions (hundredweight per hectare)

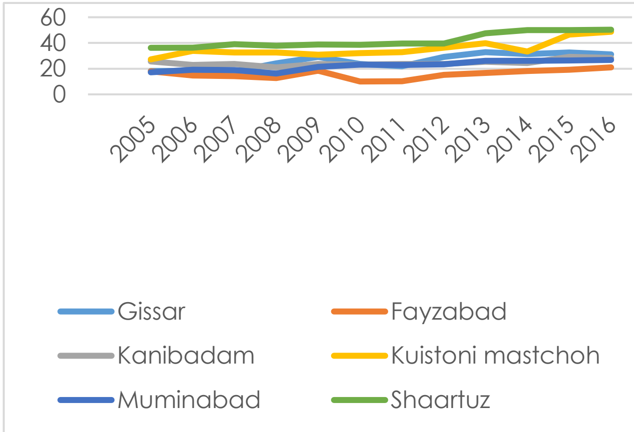


Figure 7-21 Cotton yields in target regions (hundredweight per hectare)

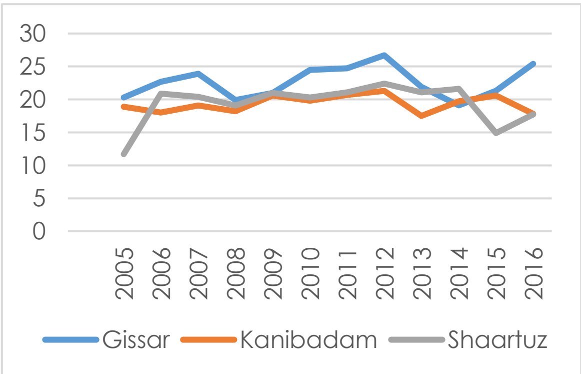


Figure 7-22 Cotton sowing areas in target regions (hectares)

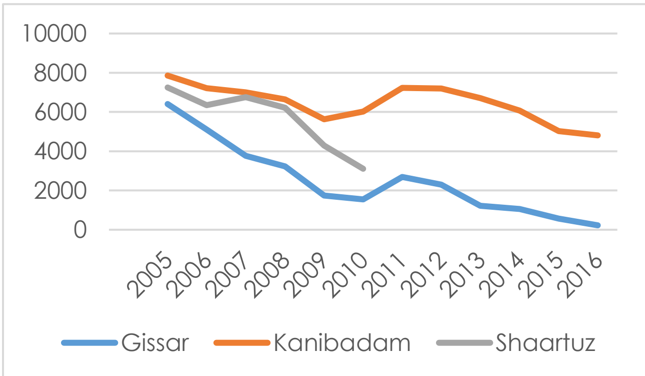


Figure 7-23 Potato yields in target regions (hundredweight per hectare)

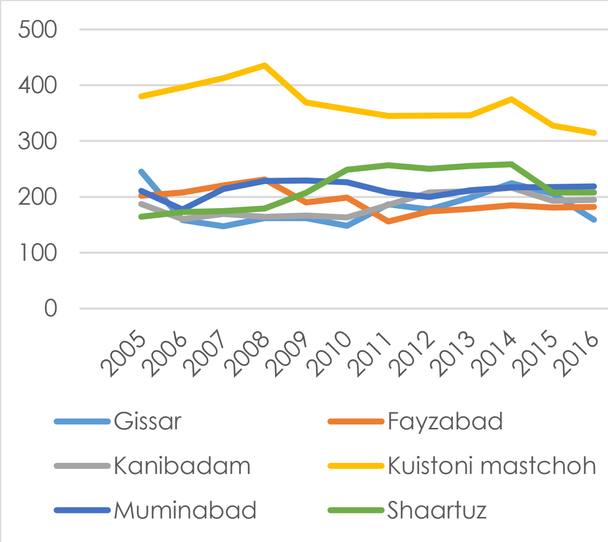


Figure 7-24 Potato sowing areas in target regions (hectares)

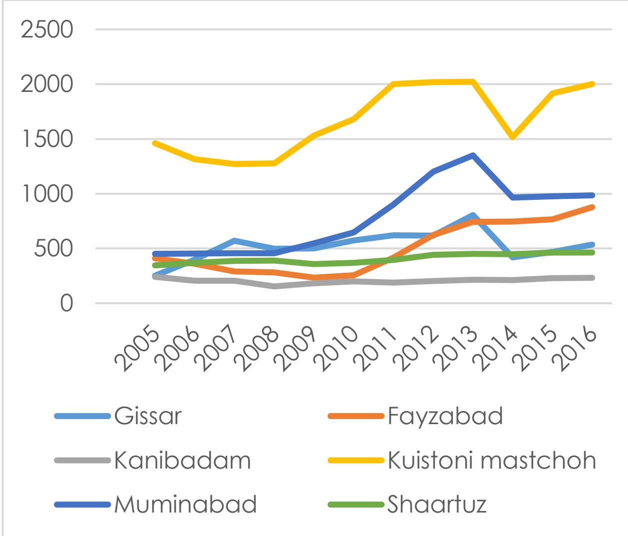


Figure 7-25 Vegetable yields in target regions (hundredweight per hectare)

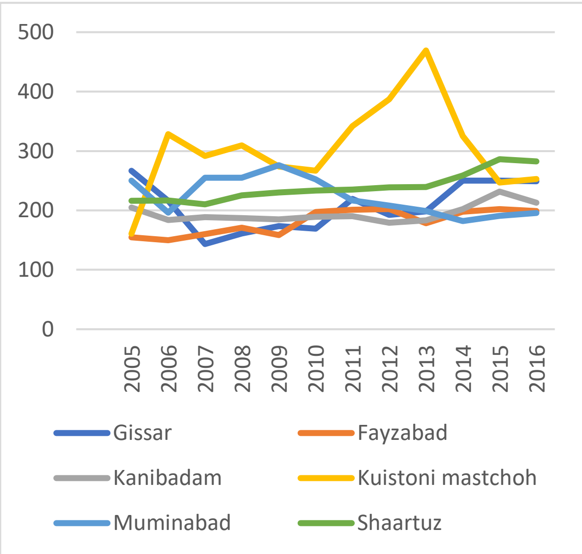


Figure 7-26 Vegetable sowing areas in target regions (hectares)

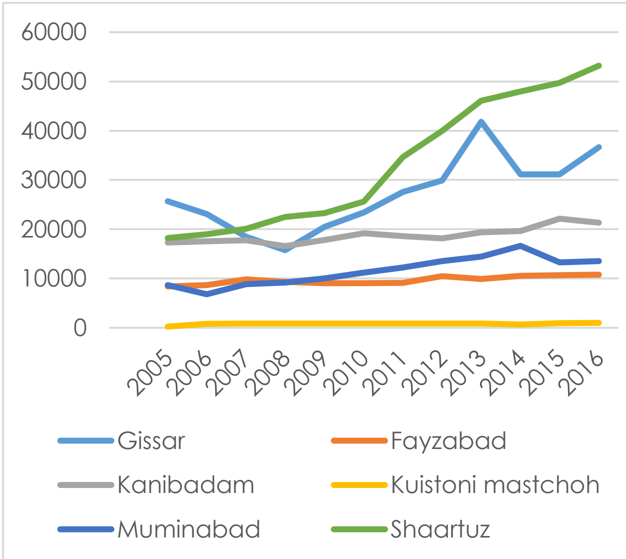


Figure 7-27 Melon yields in target regions (hundredweight per hectare)

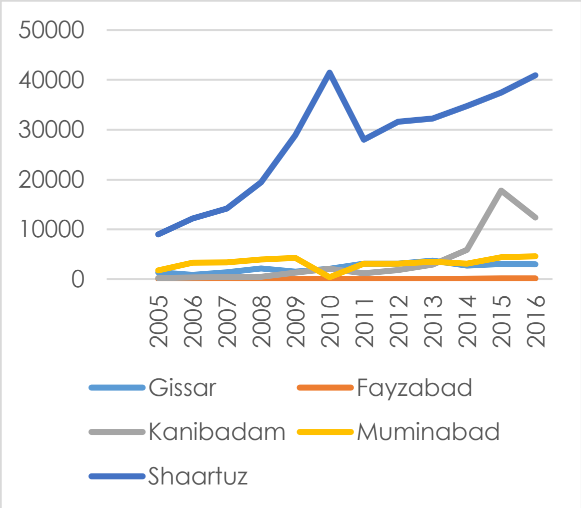


Figure 7-28 Melon sowing areas in target regions (hectares)

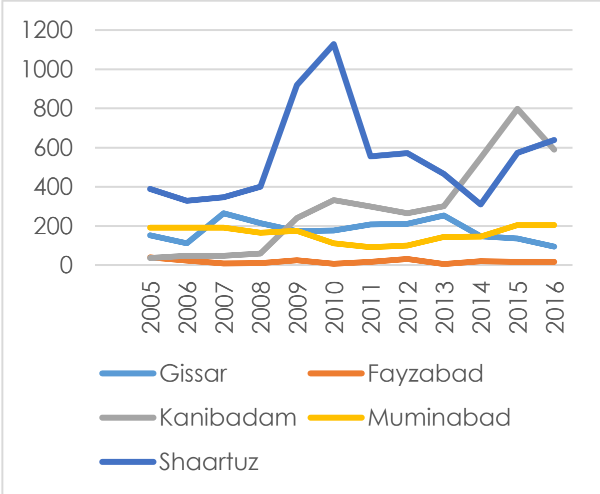


Figure 7-29 Fruits yields in target regions (hundredweight per hectare)

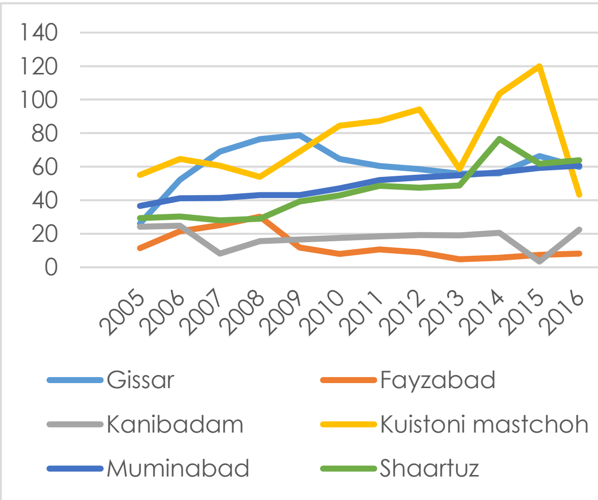
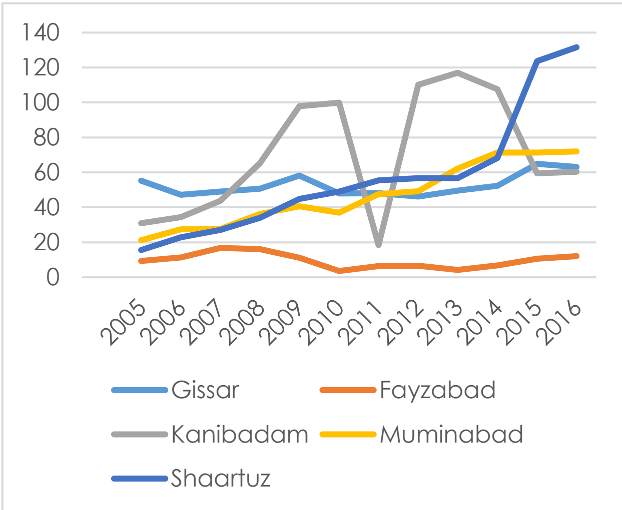


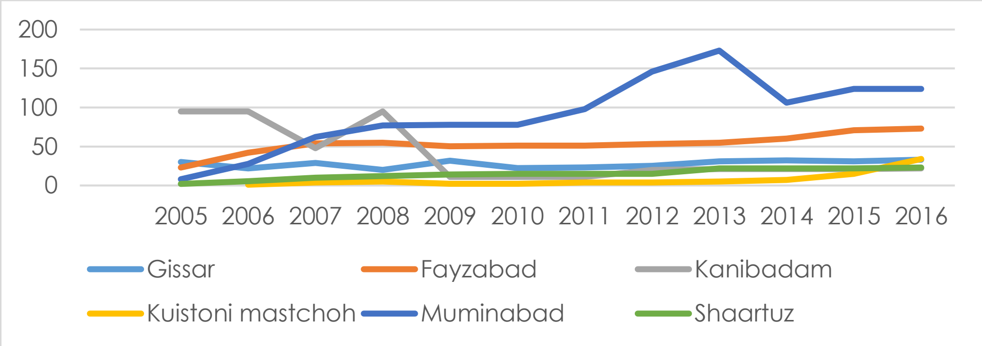
Figure 7-30 Grapes yields in target regions (hundredweight per hectare)



Source of the data: TajStat, 2022. The graphs for cotton suffered from the lack of data

Honey

Figure 7-31 The production of honey in regions (tons).



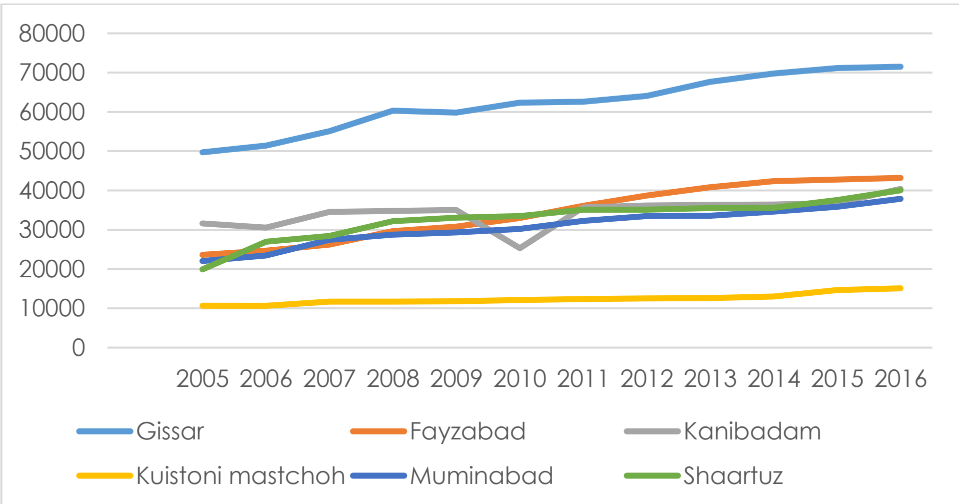
Source of the data: TajStat, 2022

Honey production dropped in Kanibadamin 2009 due to low profitability (interview data). In all the other regions the production of honey is stagnant or slightly increasing over time.

Livestock

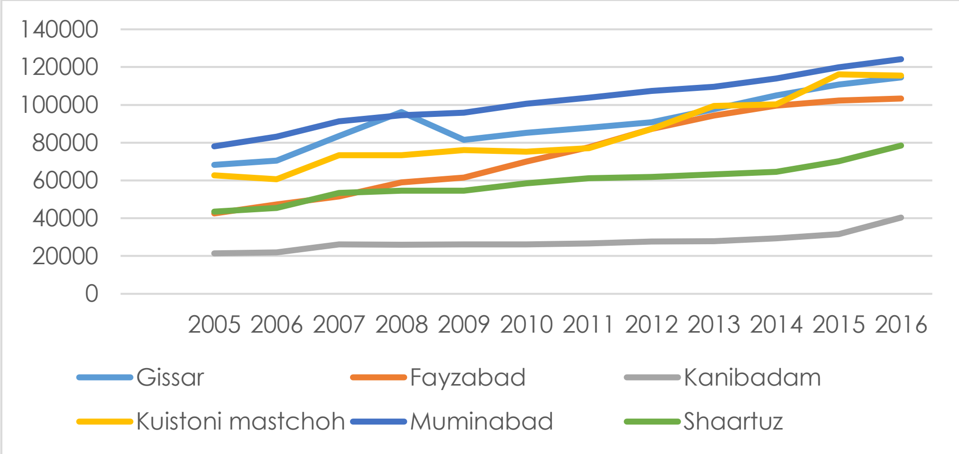
The numbers of livestock have been steadily increasing over the years (see Figures 7-32 and 7-33). This implies that, according to this indicator and on the first sight, the population seems to be able to adjust to adverse climate and other factors described above. However, this result needs to be taken with care, as it produces numerous negative implications. One of them relates to the extensive overgrazing of pastures in some areas and further deterioration of forest areas, as forest areas are often used for pastures (interview data). The access of the increased number of livestock to some areas make it difficult, if not impossible, to conduct successful the afforestation of forest regeneration efforts. The cattle damage the existing forests and especially the newly planted ones (interview data).

Figure 7-32 Cattle in target regions in target regions (heads)



Source of the data: TajStat, 2022

Figure 7-33 Sheep and goats in target regions (heads)



Source of the data: TajStat, 2022

7.3.2. Conclusion

The trends in agricultural production in Tajikistan after 2000 are heavily influenced by the period of 90th when much of the production was destroyed as a consequence of the dissolution of the Soviet Union and the civil war. The trends in agricultural production after 2000 are then affected by the effect of low base. The increase in production at the beginning of 2000th can thus be attributed to this effect of recovery. In some cases, the country was able to recover the levels of production of the soviet period only in the second decade of the 21st century, which given the substantial increase of population presents considerable social problems.

Besides that the agricultural production was substantially influenced by the availability and costs of water and fertilizers, the legislative policy that led to land fragmentation (presidential lands), the change in the structure of the land users, the deterioration of infrastructure including the state of irrigation canals and pumping stations, the deterioration of infrastructure shielding the agricultural sector from climate-related emergencies such as water- and mud- flows, the dismantled centralized and all-encompassing land use strategy that existed under the Soviet Union, the degradation of soil including erosion in some regions and salinization in other, the lack of water in some regions in irregular water in the other, the climate change, and the ability of the population to partly adapt to climate change by looking for new water sources (wells), using the crops more productive at rising temperatures, adopting unused lands for agricultural production, etc.

Analysis of agricultural production in the target districts revealed the following tendencies. The biggest increases in crop yields were achieved in crops positively impacted by the temperature increase such as melons, grapes, and, in some regions, fruits. However, these are also the crops that are most vulnerable to extreme temperatures such as sudden spring frosts. As a result, in most affected years the yields dropped substantially. These drops did not alter the overall trend.

Most of the other crops presented with relatively stable or slightly increasing yields per hectare and stable or increasing sowing areas. The greatest decline was observed in the case of cotton and grain, the crops that are heavily used in international trade. Tajikistan is not self-sufficient in grain and in 2020 covered 54% of costs of grain import with cotton export. Wheat sowing areas were declining in some regions and relatively stable in the other, while cotton areas produced more decline, although the yields remained relatively stable. The qualitative analysis explained this fact by the low cotton prices for farmers, making the production of cotton low margin compared to other crops. The highest profits are collected by wholesalers (interview data).

Overall, the analysis above did not present many negative scenarios as for the sowing area and yields, although these might have been expected in the context of climate change and from the analysis of qualitative data. That is, systematic drops in crop yields suggested by some experts were not observed. At most, the analysis showed substantial drops in yields in particular years, most likely caused by negative weather events (frosts). These weather events did not cause change in the trend and, if to be analyzed in the context of climate change, need to be studied for much longer periods of time.

The population seems to be able to adapt to climate change to some extent. However, this adaptation has considerable limits. The limits are given by the limited amounts of alternative water sources (wells) that partly substitute for the lacking irrigation water in some districts; by the limited availability of unused agricultural land, which can be employed in case the traditionally used land deteriorates and needs to be taken out of production; limits of education and information that prevent the population from adopting the best agricultural technologies; the land fragmentation that diminishes the efficiency of water use and obstructs the fight against the pests; the limited emergency control which makes part of agricultural production swept away by the water of mudflows and damages the infrastructure; of the difficult to get seeds, which are more resistant to drought etc.

In other words, the negative effects of climate change present themselves in the opportunities and options to increase production that have not been exploited, which, given the population growth, is likely to present considerable problems in the future.

7.4. The observable effects of climate change on agriculture – qualitative analysis

The following effects have been observed by the population in all the districts: lack of water leading to less production. Salinization of soil is considered to be a result of the lack of water (Shaartuz, Kanibadam). Reduction in vegetation leads to a shortage of fodder for the livestock industry. The insufficient frosts in winters lead to more pests in summer. Frosts in spring damage the production. Climatic erosion reduces fertility of soil. Temperature shocks in summer damage the production. Vegetation period is prolonged, however, lack of water prevents capitalizing on it. In forestry, there is a reduction in the number of trees in the rows. Dust storms damage the production.

7.4.1. Methodology

This section methodologically relies on results of focus groups and expert interviews conducted in the regions. The methodologies of focus groups are presented in the appendix 4.

7.4.2. Overview

In eventually all of the districts the following climate changes were observed with the following effects on agricultural production, water resources, soil quality and forestry. The extent of these effects differed, according to the geographical location of the region, the average temperature, the available sources of water and the type and quality of soil, however, the main effects mentioned were essentially the ones presented in Table 7-5. For more information see the qualitative studies for particular regions and particular areas (water resources, agriculture, forestry)

Table 7-5 The observed effect of climate change, and their impact on agriculture. Temperature change

The climate effect on temperature	**Gradual increase in temperature in summer**	**Gradual increase in temperature in winter**	**Increase in temperature extremes in summer, spring, and autumn**
The positive effects	Ability co collect three harvests per year (if water is available)	Positively affects the winter crops (small proportion of all crops)	
	If the temperatures are too high, some crops do not survive (all districts except Kuhistoni Mastchoh)		Frosts in spring and dust storms in autumn damage the production
The districts affected	Effectively all the districts.	Effectively all the districts	Effectively all the districts
The existing method of adaptation	Planting crops less affected by the high temperatures (difficult to apply in the regions concentrated on gardening)	Use of pesticides in some areas (expensive)	Effectively no adaptation. If the year is too bad the whole yearly production can be reduced by a third.

The observed effects of climate change, and their impact on agriculture. Precipitation

The effects of the changes in precipitation are especially pronounced in the districts with more precipitation-dependent agriculture and districts prone to water-related emergencies

Table 7-6 The observed effect of climate change, and their impact on agriculture. Precipitation

The climate effect on precipitation	**Decrease in precipitation in spring**	**Dry summer**	**Increase precipitation in winter**	**Irregular extremes in precipitation**
The negative effects	Less water at the beginning of agricultural season	Lack of water for agriculture in the period of reseeding	This water is difficult to use for agriculture unless collected in reservoirs	Intermittent rainfall, flash floods in spring and summer damage the production and infrastructure
			Danger of floods and mudflows.	If the soil is frozen, extreme precipitation causes floods. If not, it leads to mudflows and landslides. Especially pronounced in Kuhistoni Mastchoh
				Water erosion
Adaptation measures taken	If possible, building the artesian wells to provide an alternative source of irrigation. In some areas (such as Gissar) dry summer may mean large portion of agricultural land excluded from production Relying more on the livestock Planting crops adapted to droughts			All the measures related to control of water and mudflows. Afforestation.

In addition it the following effects were noted: Decrease of overall precipitation noted in (Kuhistoni Mastchoh)

7.4.3. Results

<u>Climate change and its effect on agriculture - expert opinion</u>

The agricultural sector in Tajikistan contributes almost 20 percent to the national GDP and provides 61 percent of the country's employment (IFAD data).

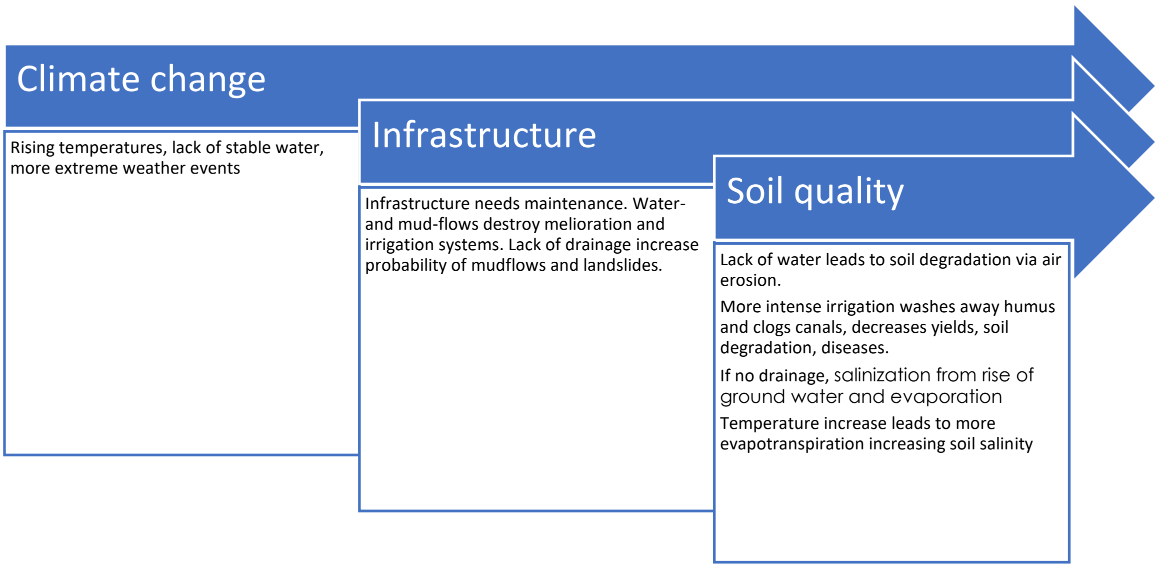
Currently, the country faces 2.2% population growth yearly. The overall area of arable lands amounts to 762,000 ha (interview data, 846 989 in 2019 according to the statistical office) , which is approximately 0.08 ha per person (interview data, the current population of Tajikistan in 2020 is 9,500,000 UN data, 0.089 ha per person). In the early 1960th there was 0.17 ha per person (interview data).

If there will be population growth and if we don't develop additional lands, there will be a problem with food security. The proposed area of arable land in 2050 is 0,04 ha per person.

Out of 1.5 million ha of land suitable for agricultural production, approximately of which 762,000 are developed (interview data, 846 989 in 2019, according to the statistical office). The remaining land is hard to reach. The increase of arable land will be difficult to achieve.

A similar problem will occur with water resources. Currently, 90% of water is used in agriculture. More watering, necessary if the agricultural land is increased, or in case of more than two harvests per year, will be indispensable but difficult to achieve. Most likely, the lack of stable water in some regions and excess watering in the other regions will lead to limited use of new lands and degradation of existing land due to water or air erosion.

Figure 7-34 The effect of climate change on water resources and soil quality



The climate change in Tajikistan is manifested via temperature rise, lack of stable water for irrigation, land degradation, and extreme weather events. If people cannot raise water by pumping and using other water sources, the country will have to face increasing migration both within and outside the country.

The effects of climate change are aggravated by the unfavorable technical condition of irrigation and melioration systems that are being destroyed by mudflows and floods. In addition, an inadequate drainage system leads to higher risks of mudflow and landslides.

If we don't prepare drainage systems, there is an extreme risk of soil salinization from the rise of groundwater and evaporation. Similarly, in case of repeated irrigation with mineralized groundwater, the danger of soil mineralization will increase.

Fayzabad

- “In recent years, in the jamoat "Buston" a significant impact of climate change on the agro-industrial complex of the district is felt, and it is assessed as a significant problem. The water supply to the jamoat is provided from the "50 Years" canal of Vahdat city by contract, and the canal receives water from the Kafernigan River. The reason for the reduction of water in the canal and, consequently, the lack of water for dekhkan (farm) households is, first of all, a decrease in the annual amount of precipitation during the autumn-winter period. Also, more well-to-do dekhkan farmers in some farms drill vertical wells using this water both for irrigation and for drinking purposes - about 50 farms in total. The groundwater level in the jamoat is 30-35 m.”
- “The lack of water is observed during the re-seeding period - June-July months.”
- “Significant reduction of vegetation, mainly on rainfed lands, on pastures, which led to a shortage of fodder for the livestock industry. Consequently, the price of fodder, and therefore of dairy products, has increased several times.”
- “The effect on the yield of fruit trees, mainly apple trees - the flowering of trees comes earlier by about 7-10 days. (In 2020, it unexpectedly snowed during the flowering of trees; however, this phenomenon is rare).”
- 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;

Gissar

- "Higher temperatures lead to more frequent watering and more water erosion. The land is often on a slope, which increases erosion with watering. The soil erosion may be as high as 0.5 centimeters per year"
- "Higher temperatures contribute to soil erosion and accelerate wind and water erosion"
- "Climatic erosion leads to a reduction in the quality of grazing areas and a reduction in the overall fertility of the soil"
- "Hectare yields are reduced by up to 50% (not supported by empirical data, not only the effects of climate change)"
- "Higher temperatures allow for 2 to 3 harvests per year, which intensifies the food production and increases the demands for inputs, including water"
- "More frequent frosts in the springs and dust storms in the autumns damage the production"
- "The insufficient frosts in winters lead to more pests in summer"
- "Temperature shocks in summer damage the production and health of people and animals"
- "In the parts of the jamoat with no forced irrigation, the lack of precipitation in a single year effectively takes these territories out of agricultural production"

Kuhistoni Mastchoh

- "Due to climate change, there is a change in the timing of sowing crops (mainly potatoes) and the application of agrotechnical measures, and this, in turn, has affected the yield and gross harvest of agricultural products;"
- "Reducing the volume of water in the springs leads to a shortage of irrigation water during the irrigation period;"
- "Decreased quality of soil fertility due to lack of crop rotation and dry soil;"
- "The standard of living of the population is decreasing, as a result of which there is an increase in the flow of internal migration and migration abroad (emigration);"

- “As a result of climate warming in winter and summer, an increase in the number of crop pests is observed;”
- “The forests have completely disappeared, only a part of the shrub zones remained.”

Muminabad

- “Reduced water resources in due to reduced rainfall; Particularly water shortages are observed during the re-seeding period - June-July months;”
- “Significant reduction in vegetation on rangelands and rainfed land, resulting in a shortage of fodder for the livestock industry. “
- “Lack of irrigation water during the growing season of crops; Particularly water shortages occur during the re-seeding period - June-July months;”
- “In forestry, there is a reduction in the number of trees in the rows; Forestry is exemplary, covering a large area, with plantings such as 'Isparset' and 'Katra boron';”
- “The spread of various infectious diseases in general increased;”
- “Reduced quality and volume of drinking water, as well as difficulties in distribution among water users due to the difficult terrain;”

Shaartuz

- Lack of irrigation water leads to lower crop yields
- Salinization of land
- “The main reason for salinization of pasture land is lack of water. On irrigated land, the main reason for soil salinization is that over the years, the collector-drainage network has mostly fallen into disrepair (siltation) and requires cleaning and rehabilitation. “
- “Also, three dust storms called "afghans" are observed in a period of six months, their duration ranging from 12 hours to 24 hours (24 hours). This process strongly affects crop yields and soil salinity.”

- "The water level in the Kafernigan River rises so high in autumn and spring that it floods the banks and consequently washes away 40-50 hectares of soil every year. "
- "During agricultural work, there is an acute shortage of workers. Mostly women are working in the fields. If temperatures continue to rise, it is likely that the population will move to a more comfortable place to live."

Kanibadam

- 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));
- The use of saline, unsuitable irrigation water from open drains;
- Shortage of irrigation water during the irrigation period;
- A decrease in the quality of soil fertility;
- Reduction of irrigation water sources;
- Reduced crop yields;
- The sudden change in warm and cold air flows increases the frequency of thunderstorms, hail and storms accompanying mudflows;
- The standard of living of the population is declining, resulting in an increased flow of migrants abroad (emigration);
- As a result of a warmer climate, there has been an increase in crop pests during the winter and summer.

7.5. The effects of climate change on agriculture in target districts. The predictions

The chapter analyses three most important crops: wheat, cotton and potato.

Our predictions, based on the CARD modelling tool, expects 2 basic scenarios for wheat. In particular, the rainfed systems seems to be more sustainable and predictions expect yield to increase to certain extend. On the other hand, the production system with the full irrigation expects negative effects of climate change, where significant decline could occur. As far as the potatoes production is concerned, rainfed systems seems to be more resistant to climate expectations. Pessimistic scenario with full irrigation expects the yield down to 18 tons per hectare. Cotton is still considered to be a very important cash crop in Tajikistan, very important for sustaining local rural income flow. The predicted cotton yields up to 2015 evince the highest volatility among the 3 commodities.

The district forecasts suggest that we can expect an increase in grains yields in optimistic scenario in all districts regardless the type of scenario – rainfed or irrigated. The opposite can be said for pessimistic scenario. Median scenario differs in selected districts and is different for rainfed and irrigated scenario as well. As far as rainfed median scenario is concerned we may expect positive grains yield trend in Kuhistoni Mastchoh, Gissar, Muminabad and Fayzabad. Shaartuz and Kanibadam do not show significant changes in grains yield in rainfed median scenario. Furthermore, irrigated median scenario suggests grains yields decline in all selected districts.

The cotton yield forecasts indicate that we can expect a decrease in cotton yields in all scenarios and districts. These results suggest the due to the climate change the cotton production can be further reduced in Tajikistan.

7.5.1. Summary

Tajikistan agriculture is expected to be affected by climate change in the following decades, rising temperature and heavy precipitation are expected to be damaging agriculture. As a result, farmers revenues are expected to fall.

This chapter aimed to forecast future yield in the 2 most represented agricultural commodities – cotton and wheat. The outlined scenarios shall be base for proposal of adaptation and/or mitigation strategies. Firstly, predictions are done for the whole Tajikistan, based on 1992 – 2020 data, secondly more particular predictions on individual districts are concluded (based on 2005 – 2016).

Yield predictions are based on the International Fund for Agricultural Development (IFAD) modelling tool called The Climate Adaptation in Rural Development (CARD) assessment tool, which allowed us to use highly valuable models on climate change and apply them to the whole territory of Tajikistan and to the districts. All underlying simulations used the greenhouse gas emission scenario RCP8.5, an emission scenario that leads to around 4°C global warming by 2100.

Total land area used for agriculture production increased by approximately 30 % between 1992 and 2004 and stagnated around 900,000 hectares afterwards. Over the last 3 decades, Tajikistan experienced considerable changes in commodity production structure. While in 1992, cotton has been grown on about 40% of Tajikistan arable land, in 2020 cotton accounted only 23% of the agricultural land. Land utilisation growth patters has been identified for fruits and vegetables production.

Changing patterns are also visible among personal consumption habits. In most of the commodity groups per capita consumption increased over the last 20 years. In Tajik diet, bakery products play the most important role, as average Tajik consumed 165 kilos of bakery products in 2020.

From the above stated, it was clear, how important are grains for Tajik society. Even thou total area dedicated to grains and legumes increased, total consumption is not covered by local production. Self-sufficiency level in grains (wheat and barley) are not sufficient and this export is essential for sustaining local nutrition habits.

As indicated by International Food Policy Research Institute, the climatic change will cause negative effects in 2030, however until 2050 effects are expected to be intensified. Tajik production of pulses could be the most affected while on contrary, the Institute doesn't expect large effects to meat or root and tubers production.

Our predictions, based on the CARD modelling tool, expects 2 basic scenarios for wheat. In particular, the rainfed systems seems to be more sustainable and predictions expect yield to increase to certain extend. On the other hand, the production system with the full irrigation expects negative effects of climate change, where significant decline could occur. As far as the potatoes production is concerned, rainfed systems seems to be more resistant to climate expectations. Pessimistic scenario with full irrigation expects the yield down to 18 tons per hectare. Cotton is still considered to be a very important cash crop in Tajikistan, very important for sustaining local rural income flow. The predicted cotton yields up to 2015 evince the highest volatility among the 3 commodities.

Further predictions have been made to individual Agro-Ecological zones (AEZ), which appear in 6 selected districts. For Desert/Arid predictions for managed grass, peas and wheat are available. Optimistic scenario project the strong increase in managed grass yield, mild increase in wheat yield and mild decrease in peas yield. Dry, good soils (AEZ) indicate yield declines in majority of commodities in median scenario. Dry, moderate soils (AEZ) indicate similar patterns in all scenarios as the dry, good soils with even more pronounced dynamics. Dry, poor soils (AEZ) provide the evidence on the negative yield expectations in median and pessimistic scenario. Optimistic scenario shows the growth in soy and wheat yields. The yield forecasts in irrigated soils (AEZ) are characterized by negative trends in all commodities with only one exception, increasing wheat yield in optimistic scenario. Steep terrains

(AEZ) indicate mixed development in median scenario. In particular, the growth in yield can be expected for millet, wheat, and managed grass yield. Peas, sunflower, and soy shall experience a yield decline. The results of the wheat yield forecast for different scenarios and different AEZ suggest that in majority of cases we may expect the decrease in wheat yields. The only exception is optimistic scenario.

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 Kaisar (-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 districts are 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. Sown agriculture land usage in six selected districts go in the opposite direction to general trend of the whole Tajikistan.

Yields of grains and legumes had an increasing trend in selected six districts. Unfortunately, there are no specific data available on yields, areas of specific grain and legumes products in the districts. Between 2005 and 2016 largest yield has been reached in Shaartuz and Kuhistoni Mastchoh, where grain and legumes yield approached almost 5 tons per hectare. Other commodities grown in the selected districts are also characterized by weak increasing trend.

The district forecasts suggest that we can expect an increase in grains yields in optimistic scenario in all districts regardless the type of scenario – rainfed or irrigated. The opposite can be said for pessimistic scenario. Median scenario differs in selected districts and is different for rainfed and irrigated scenario as well. As far as rainfed median scenario is concerned we may expect positive grains yield trend in Kuhistoni Mastchoh, Gissar, Muminabad and Fayzabad. Shaartuz and Kanibadam do not show significant changes in grains yield in rainfed median scenario. Furthermore, irrigated median scenario suggests grains yields decline in all selected districts.

The cotton yield forecasts indicate that we can expect a decrease in cotton yields in all scenarios and districts. These results suggest the due to the climate change the cotton production can be further reduced in Tajikistan.

7.5.2. Methodology

This chapter aims to forecast future yield in main agricultural commodities. The outlined scenarios will help to accurate policies aiming on adaptation and/or mitigation strategies.

The chapter is divided into two main parts. In the first part, Tajikistan as a whole is assessed. Data on 30 year development (production, yields, harvested area) are sourced from Food and Agriculture Organizations of the United Nations (Food and Agricultural Organization, 2022), where data on main grown commodities has been gained. The second part is dedicated to individual (selected) districts (Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad) where data on yield, production and seeded area is sourced from the Tajikistan statistical office (Stat.tj, 2022a).

Yield predictions are 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 selected districts.

CADR 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[6].

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

- Rainfed – median
- Rainfed – pessimistic

[6] 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.

- Rainfed – optimistic
- Irrigated – median
- Irrigated – pessimistic
- Irrigated – optimistic.

Rainfed and irrigated models takes in consideration whether 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 10th 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 90th percentile of all underlying crop yield predictions (i.e., close to the model with least decline, or largest increase in crop yields).

According to the model we may identify eight different agro-ecological zones in Tajikistan, which are based on FAO GAEZ methodology (Food and Agriculture Organization of the United Nations, 2017).

Arid soils are defined as LGPt < 0.15 or LGPeq < 60 days.

Dry soils are defined as LGPt between 0.15-0.40 or LGPeq between 60–119 day[7].

Moist conditions are defined as LGPt between 0.15-0.40 or LGPeq between 120 – 179 days.

The moist regimes are combined with soil classes - good; moderate; poor soils; irrigated, hydro-morphic soils (Food and Agriculture Organization of the United Nations, 2017).

[7] LGP - length of growing period, i.e., number of days when temperature and soil moisture permit

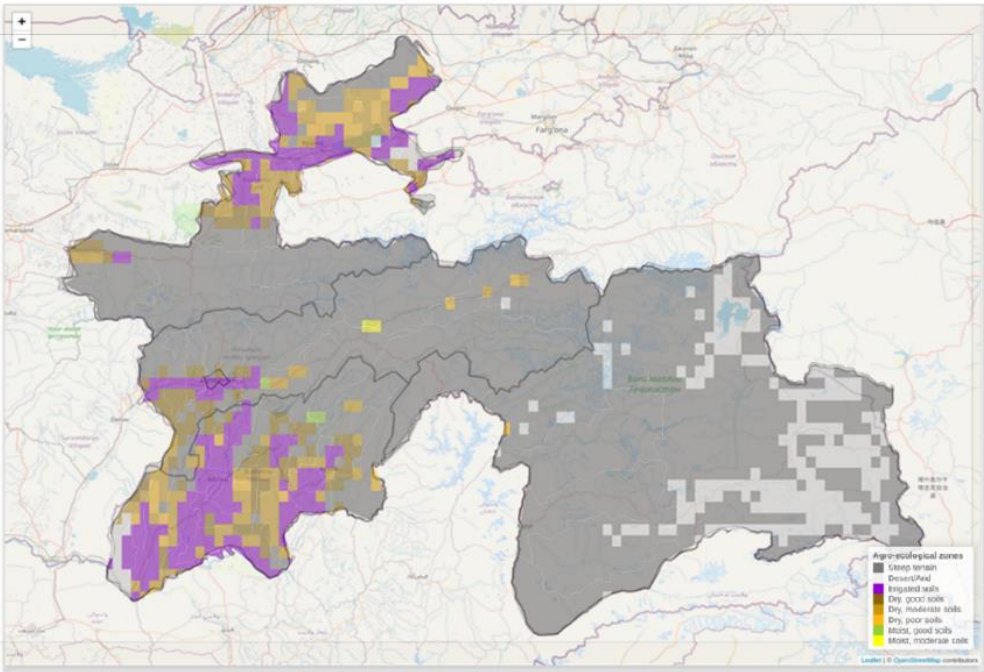
crop growth. LGPt - Temperature growing period; LGPeq - Equivalent growing period

Based on the above-mentioned characteristics, the Tajikistan was divided mainly to those Agro-ecological zones.

- steep terrains (Terrain slopes > 16% for more than two-thirds of grid cell)
- desert/Arid
- irrigated soil (20% of grid cell irrigated)
- dry good soils,
- dry moderate soils,
- dry poor soils,
- moist goods soils, and
- moist moderate soils.

In 6 selected districts, mostly stee terrains, irrigated soils, dry moderate soils, and dry good soils appear. Moist good and moist moderate occur only minimally in Tajikistan.

Figure 7-35 Soil map



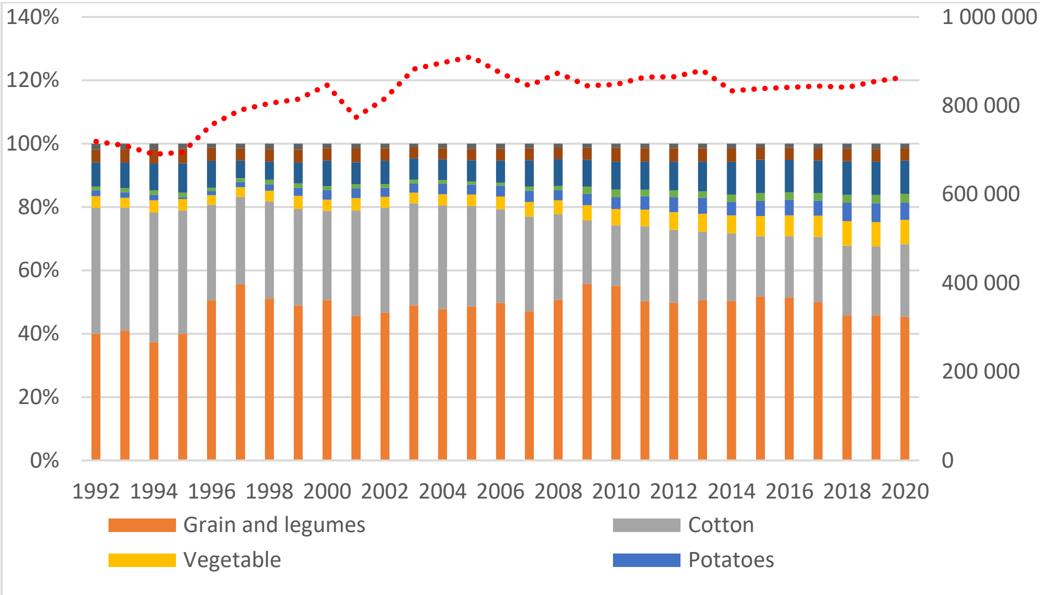
Source: own processing based on the IFAD (2022)

Based on the data from IFAD CARD tool, we identified distribution of individual soil types in particular districts. As CARD tool only provides information about yields in given zones and does not allow to run predictions on district level, representation of individual agro-ecological zones in particular districts were taken into consideration (weighted) and used for the calculation of regional predictions.

7.5.3. Tajikistan agriculture and its future perspectives

7.5.3.1. Current situation

Figure 7-36 Commodity production structure



Source: FAO (2022b)

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).

Over the last 3 decades, Tajikistan experienced considerable changes in commodity production structure. While in 1992, cotton has been grown on about 40% of Tajikistan arable land, in 2020 cotton accounted only 23% of the agricultural land. At the same time three commodity groups increased their presence. First, we observed increased area dedicated to potatoes. While in 1992 13,000 hectares has been used for potato production, in 2020 the area exceeded 47,000 hectares. Similar growth pattern was identified in the case of fruits and vegetable. Whereas fruits occupied 8% of agricultural land in 1992, it was already 10 percent in 2020. Vegetables doubled the cultivated area, from 4% in 1992 to almost 8% in 2020.

Table 7-6 Rate of self-sufficiency in selected commodities, Tajikistan

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Barley and products	91%	76%	85%	95%	87%	95%	96%	94%	89%	91%
Cottonseed	93%	102%	92%	104%	105%	101%	100%	99%	98%	99%
Potatoes and products	91%	103%	101%	105%	97%	95%	94%	88%	95%	94%
Wheat and products	60%	44%	44%	51%	47%	46%	44%	46%	39%	41%
Eggs	68%	78%	89%	95%	90%	95%	86%	63%	89%	89%
Fruits - Excluding Wine	96%	98%	100%	100%	131%	122%	118%	110%	109%	103%
Meat	72%	76%	62%	59%	68%	78%	64%	131%	125%	131%
Milk - Excluding Butter	100%	100%	99%	99%	100%	100%	100%	100%	100%	100%
Oil crops	94%	103%	93%	104%	101%	99%	97%	94%	94%	93%
Pulses	84%	83%	92%	96%	99%	105%	96%	99%	109%	104%
Vegetables	109%	105%	103%	106%	103%	105%	104%	102%	103%	102%

Source: FAO (2022a)

Total agriculture production of the country can be also assessed by using self-sufficiency indicator. Self-sufficiency is calculated as a total Tajikistan production divided by total available supply. Based on the data from FAOstat, we can identify main commodities and their status of production. Moreover, we can observe whether the country is self-sufficient in its production, weather it has to rely on imports, or weather has potential for export due to overproduction. The table above suggests that Tajikistan can be considered as self-sufficient in majority of commodities except for wheat and wheat products. Wheat Production is smaller than total amount of wheat required by population, agriculture and food industries and therefore has to be imported. Despite the fact that wheat dominates crop production and occupies the largest portion of land, the production is not sufficient. In addition, the level of self-sufficiency in wheat has diminished over the last ten years. On the other hand, positive trend can be observed at the level of fruit and pulses, where self-sufficiency improved.

Table 7-7 Average food consumption per capita

Kg/year	00 - 05	06 - 10	11 - 15	2016	2017	2018	2019	2020	AAGR
meat & meat products	6.5	10.7	13.3	14.8	14	14.2	13.1	28.1	6.3%
milk & milk products	52.1	56.9	56.1	59.5	58.1	60.5	63.8	63.3	0.9%
eggs, units	22.3	31.8	62.2	68	76	84	92	158	10.1%
sugar & confectionery	8.7	12.1	13.4	14.3	15.9	16.9	15.4	19.5	4.2%
bakery goods	153.7	156.1	154.8	151.5	161.4	165.4	158.69	165.4	0.3%
potatoes	31.8	34.7	35.3	39.1	42.4	46.4	42.4	41	1.7%
vegetables & melons	81.5	76.3	78.8	80.4	89	88.5	86.4	137.1	0.9%
fruits, berries & grape	39.0	43.3	36.4	30.4	33.3	38.7	33.2	30.6	-1.2%
vegetable oil	10.5	13.3	15.3	17.1	16.7	18.3	17.5	18.4	3.4%

Source: Tajikistan Statistical Office (2022b)

Tajikistan statistical office published household data on average personal consumption of selected food commodities. In most of the published commodity groups we observe per capita increase consumption over the last 20 years. The only exception is the group called fruits berries and grapes. Eggs evinced the largest improvement in consumption, average annual growth rate off eggs was 10.1%. The second fastest growing category is meat and meat products, its annual average growth rate exceeded 6%. However, the largest amount of consumption is clearly connected two bakery products. Average Tajik person consumed between 150 and 165 kilos of bakery goods.

These figures suggest that wheat and other cereal product are crucial for Tadjik diet and as such are important for Tajikistan agriculture as well as for local food security. Any negative effects on wheat connected to climatic change, would necessarily result in instability of production, decrease supply, worsen food self-sufficiency ratio and as a consequence provide negative effects directly or indirectly to Tadjik meat sector.

International Food Policy Research Institute published a study (International Food Policy Research Institute (IFPRI), 2019), how agriculture of individual countries could be affected by climate change. As the following tables present, total production of selected agriculture commodity groups is expected to rise under situation with climate change as well as under situation without climate change. However, the climate change it's expected to negatively affect commodities like cereals, oil seed, pulses or fruits and vegetables. Under climate change scenarios, Tajik production of pulses could be the most affected by climatic changes. On the contrary, the Institute doesn't expect large effects of climate change to meat or root and tubers production. Roots and tubes are even expected to be positively affected by climatic changes in Tajikistan contributing to higher production.

Table 7-8 Total production

	(Thousand metric tons)					**%**	
		Without climate change (N)		**With climate change (Y)**		**(N/Y)**	
	2010	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Cereals	903.5	1056.3	1095.5	980.8	964.5	92.9%	88.0%
Meat	62.7	104.8	163.5	104.5	162.0	99.7%	99.1%
Fruits and Vegetable	1748.0	2228.0	2572.7	2096.2	2239.3	94.1%	87.0%
Oil seed	9.9	14.8	20.4	11.9	12.0	80.2%	58.8%
Pulse	31.7	54.0	86.7	42.3	52.8	78.3%	60.8%
Root and tuber	712.2	891.4	1009.0	981.6	1152.0	110.1%	114.2%

Source: International Food Policy Research Institute (2019)

As for production, per capita consumption is not expected to change much under circumstances of climate change. Those expectations however are in contradiction to self-sufficiency. Increasing population together with rather constant patterns of food consumption could only lead to increase pressure on imports of basic agricultural commodities like grains.

Trade balances, predicted by the institute, suggest being still net importer of grains and meat. However, future expectations of increased production in other agriculture commodity groups leads to predictions of increased trade surpluses.

Table 7-9 Per capita food consumption

	(Kg per capita per year)					**%**	
		Without climate change (N)		**With climate change (Y)**		**Difference (N/Y)**	
	2010	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Cereals	203.2	221.0	224.6	218.6	216.8	98.9%	96.5%
Meat	11.6	17.5	23.2	17.5	23.0	99.6%	99.3%
Fruits and Vegetable	137.3	151.4	149.0	149.1	144.8	98.4%	97.2%
Oil seed	0.180	0.191	0.197	0.187	0.190	98.0%	96.3%
Pulse	0.908	1.002	1.058	1.000	1.056	99.9%	99.8%
Root and tuber	35.2	39.5	45.4	37.3	41.5	94.2%	91.3%

Source: International Food Policy Research Institute (2019)

Table 7-10 Net trade

	(Thousand metric tons)					**%**	
		Without climate change		**With climate change**		**Difference (N/Y)**	
	2010	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
Cereals	-902.5	-1,192.9	-1,262.4	-1,235.2	-1,293.8	103.6%	102.5%
Meat	-17.3	-34.5	-22.9	-34.3	-23.1	99.4%	100.7%
Fruits and Vegetable	625.9	745.4	984.5	637.1	698.4	85.5%	70.9%
Oil seed	2.1	4.3	7.9	1.0	-2.0	24.1%	-24.8%
Pulse	0.4	16.0	43.4	4.7	10.5	29.6%	24.2%
Root and tuber	86.3	88.5	75.6	223.7	297.3	252.8%	393.5%

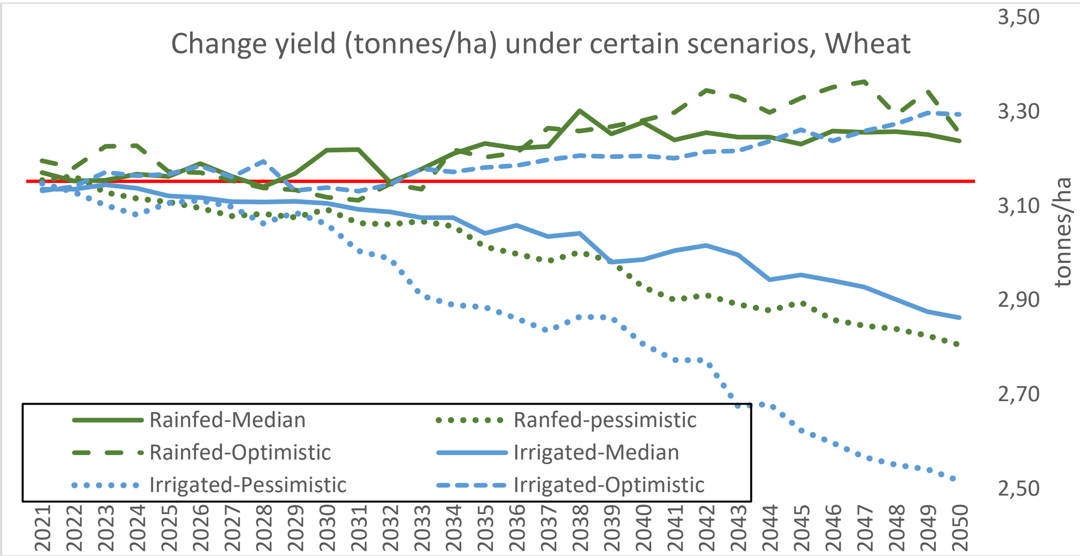
Source: International Food Policy Research Institute (2019)

7.5.3.2. Predictions 2050

Based on the IFAD CARD model, yield predictions of main commodities were estimated for period of 2021 – 2050. The yield of 2020 is used as a baseline (redline in the graph) to which 6 standard scenarios of yield development are compared.

Wheat as the most important commodity in Tajikistan agriculture may experience considerable opposite development under different scenarios. In particular, the rainfed systems seems to be more sustainable and predictions expect yield to increase. On the other hand, the production system with the full irrigation expects negative effects of climate change to wheat yield for two out of three scenarios - median and pessimistic.

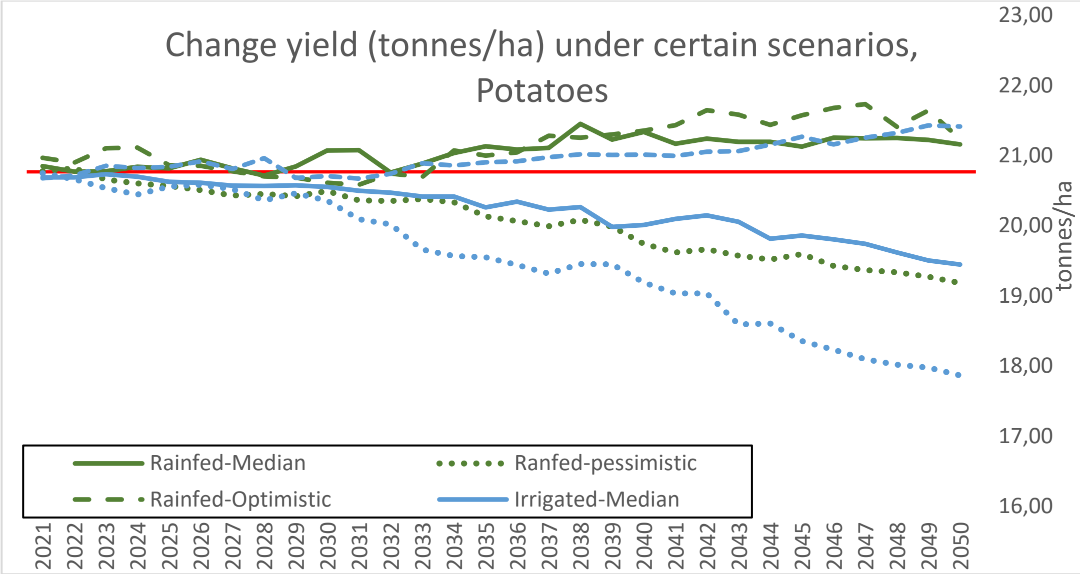
Figure 7-37 Yield Change, Wheat



Source: own results based on IFAD/CARD (2022)

As far as the potatoes production is concerned, Tajikistan was always self-sufficient in potatoes from about 90 to 95% over the last ten years. Average yield off potatoes was close to 21 t/ha in 2020. Climate change in Tajikistan, under irrigation pessimistic scenario, expects the deal could go down to 18 tons per hectare. The importance of potatoes in the diet increased over the last 20 years, possible negative effects on yields would similarly to weed result in decreased food security of Tajik people. However, median rainfed scenario, the most probable, expect slight increase of yield.

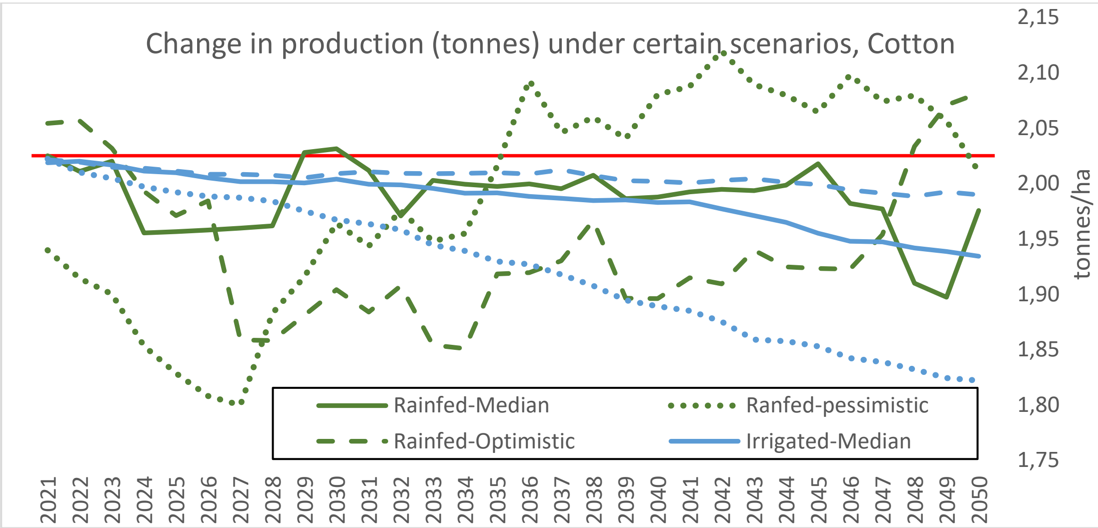
Figure 7-38 Yield Change, Potato



Source: own results based on IFAD/CARD (2022)

Cotton is still considered to be a very important cash crop in Tajikistan, very important for sustaining local rural income flow. Taking into consideration climatic threats, most of the scenarios predicts adverse effects on cotton yield. The most serious effects of climate change are expected to occur under fully irrigated systems, where additional water shortage problems could appear, as compared to the 2020 yield (Food and Agricultural Organization, 2022).

Figure 7-39 Yield Change, Cotton



Source: own results based on IFAD/CARD (2022)

7.5.4. Agro-ecological zones – expected yield developments

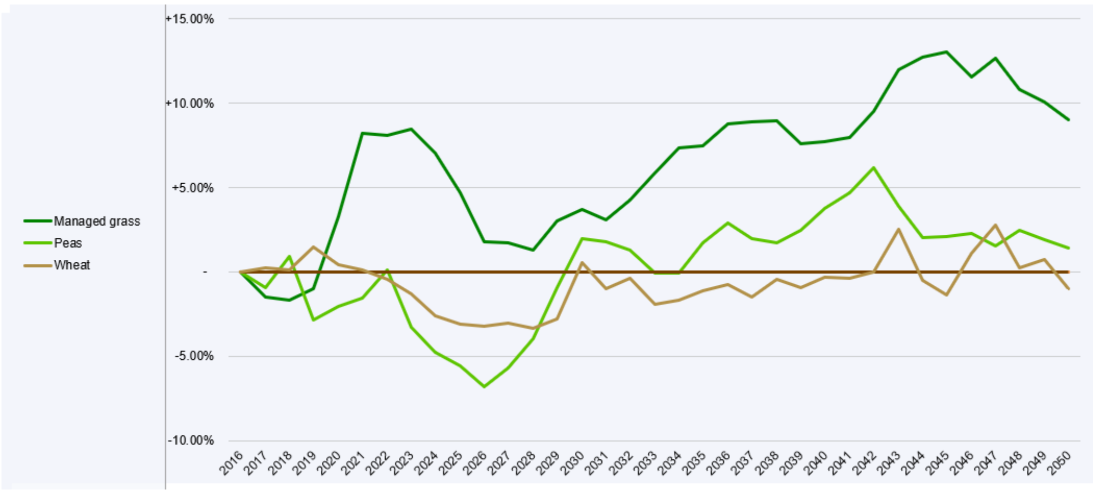
In the following section we present the anticipated development trends in different agri-environmental zones. AS mentioned above, there are 6 main different agro-environmental zones in Tajikistan. Those zones evince differences in production potential, differences in production capacity. As information is taken from the IFAD CARD prediction tool, it needs to be stated, that CARD tool only present data about commodities with certain level of probability. If the production value is below 500 tonnes or simulation results are unreliable or uncertain, then results are not present (IFAD, 2019). This leads to the differentiation of crops presented in below presented simulations.

7.5.4.1. Desert/Arid

For Desert/Arid zone the tool provides only limited number of commodities and their yield predictions. The most optimistic and median scenario expects increase in yield of managed grasslands and wheat.

The most probable median scenario suggests the slight decrease in peas and wheat yields in the next ten years which are then recovered to initial values for wheat and slightly higher values of peas yield. Managed grass seems to experience considerable growth in yields.

Figure 7-40 Tajikistan - DESERT/ARID – Median scenario

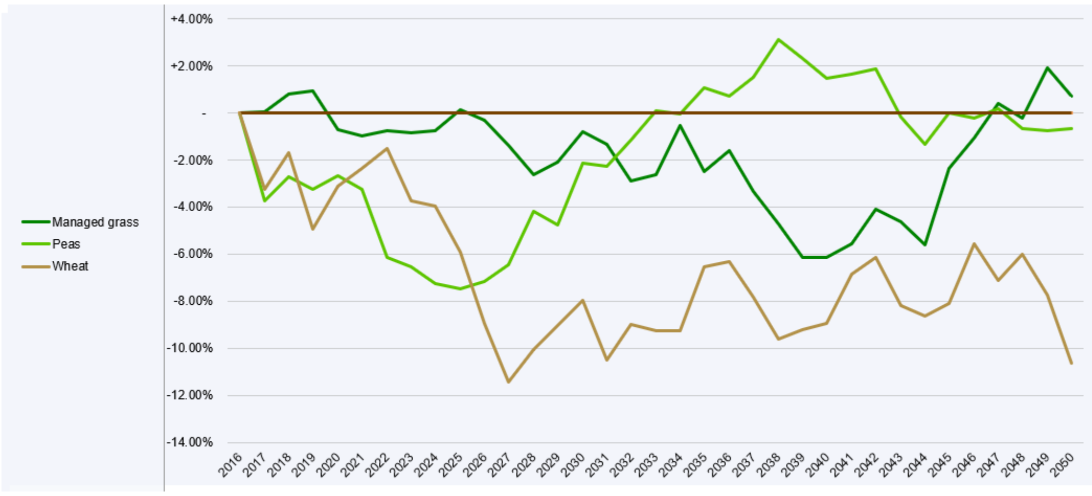


Source: (IFAD, 2022)

Pessimistic scenario in desert/arid expects substantial decrease in wheat yield already within first ten years of forecasting horizon. The different dynamics can be observed for peas and managed grass yields. Whereas peas yield will recover to initial values around 2030, managed grass yield may reach their current values at the end of forecasting horizon.

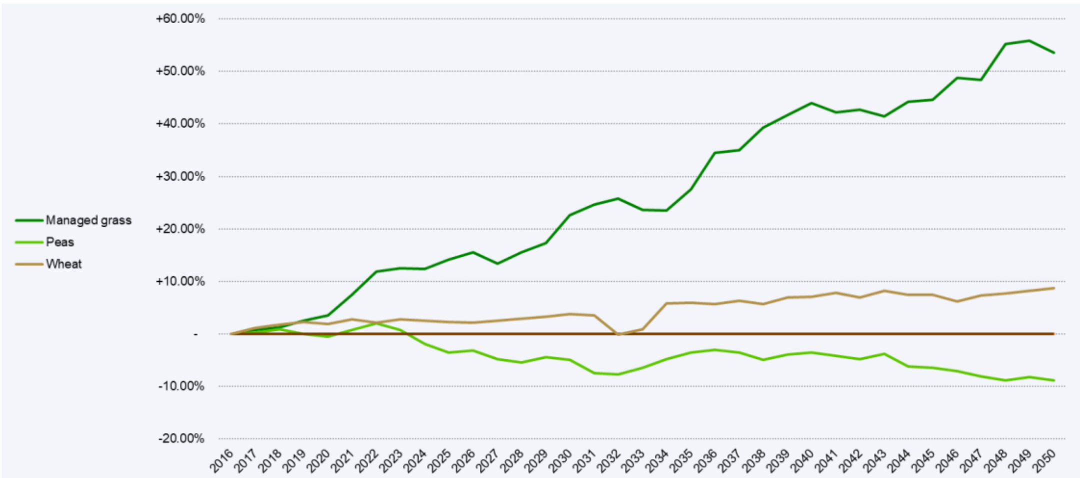
Optimistic scenario project the strong increase in managed grass yield, mild increase in wheat yield and mild decrease in peas yield.

Figure 7-41 Tajikistan - DESERT/ARID – Pessimistic scenario



Source: (IFAD, 2022)

Figure 7-42 Tajikistan - DESERT/ARID – Optimistic scenario

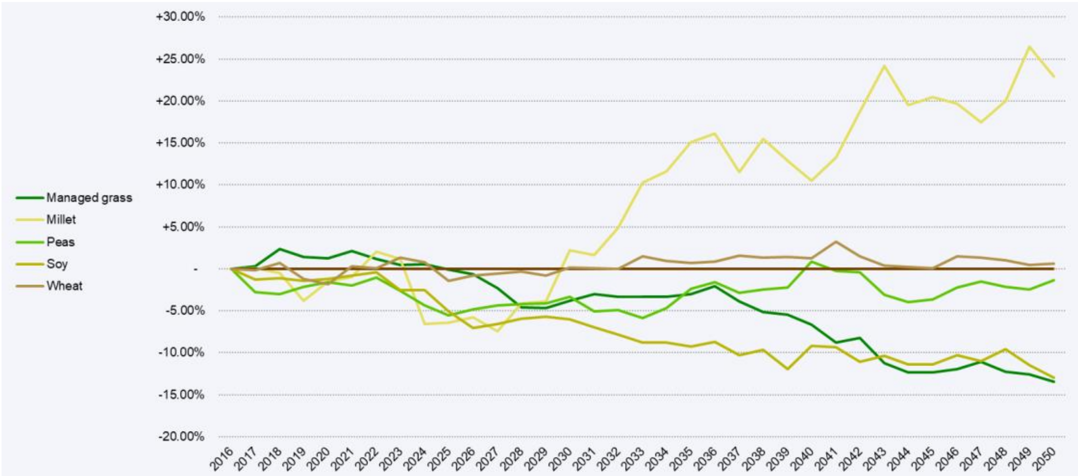


Source: (IFAD, 2022)

7.5.4.2. Dry, good soils

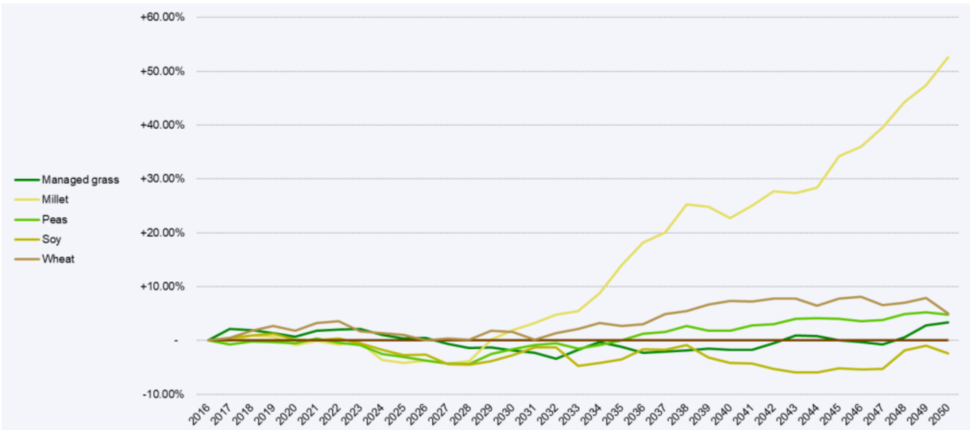
Dry, good soils agro-ecological zone indicate yield declines in majority of commodities in median scenario. The only exceptions are wheat and millet yields. Whereas wheat yield is expected to oscillate around the initial values, millet yield shall increase considerably. Similar patterns can be observed for optimistic scenario with even more pronounced millet yield increase. On the other hand, pessimistic scenario forecasts substantial yield decreases for all commodities.

Figure 7-43 Tajikistan – Dry, good soils – Median scenario



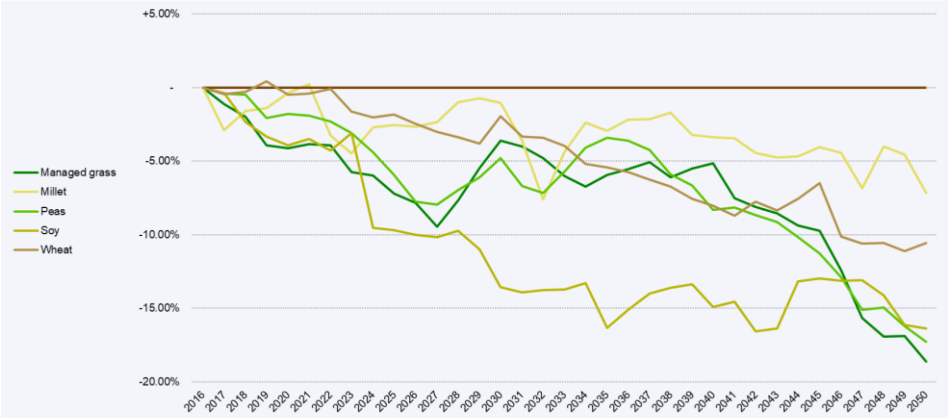
Source: (IFAD, 2022)

Figure 7-44 Tajikistan – Dry, good soils – Optimistic scenario



Source: (IFAD, 2022)

Figure 7-45 Tajikistan – Dry, good soils – Pessimistic scenario

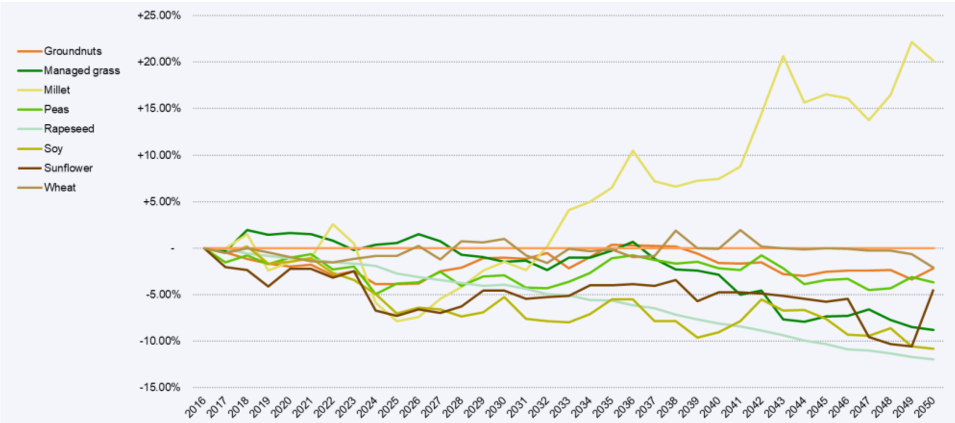


Source: (IFAD, 2022)

7.5.4.3. Dry, moderate soils

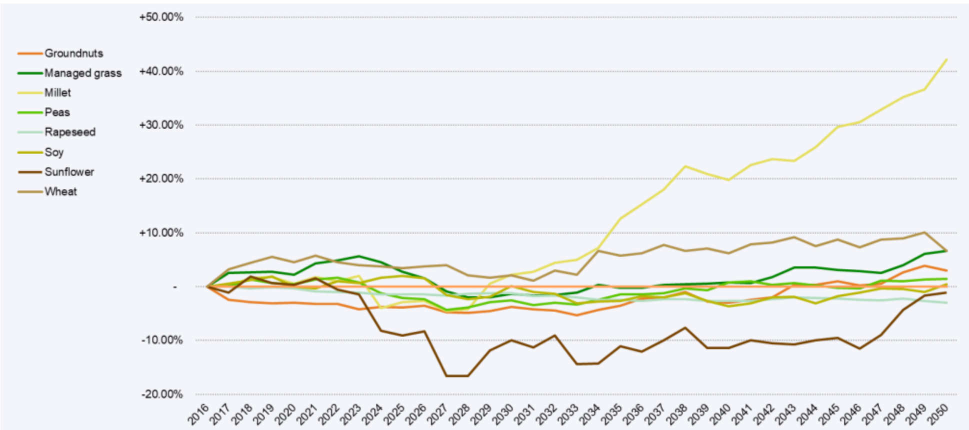
Dry, moderate soils zone indicate similar patterns in all scenarios as the dry, good soils with even more pronounced dynamics.

Figure 7-46 Tajikistan – Dry, moderate soils – Median scenario



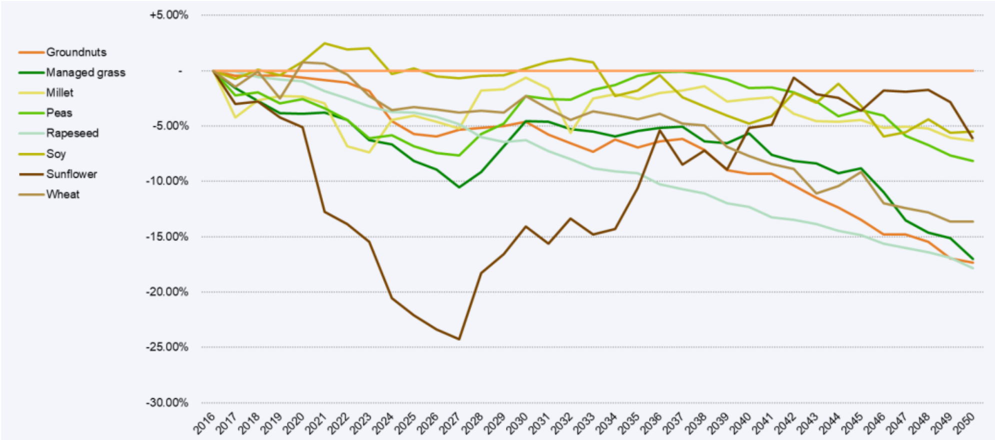
Source: (IFAD, 2022)

Figure 7-47 Tajikistan – Dry, moderate soils – Optimistic scenario



Source: (IFAD, 2022)

Figure 7-48 Tajikistan – Dry, moderate soils – Pessimistic scenario

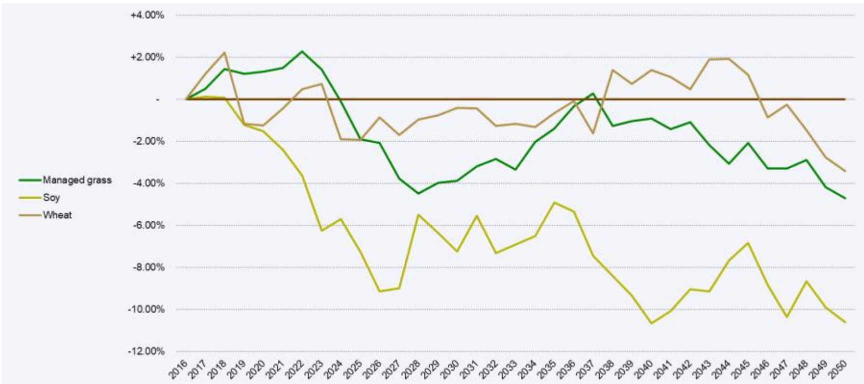


Source: (IFAD, 2022)

7.5.4.4. Dry, poor soils

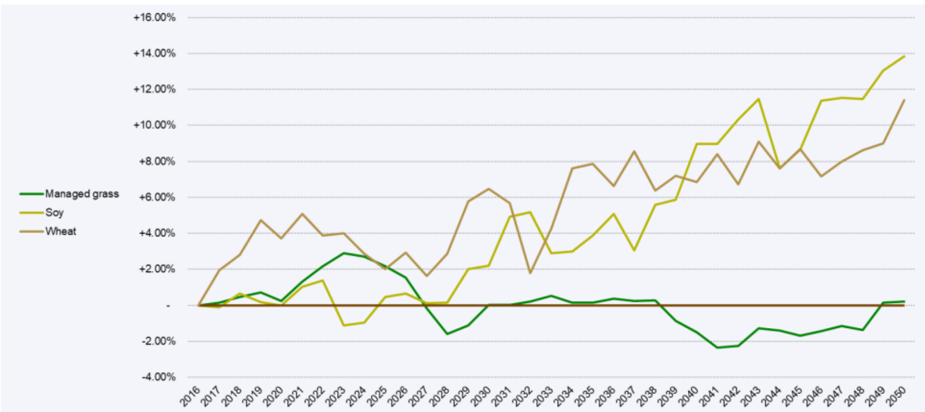
Dry, poor soils zone provide the evidence on the negative yield expectations in median and pessimistic scenario. Optimistic scenario shows the growth in soy and wheat yields.

Figure 7-49 Tajikistan – Dry, poor soils – Median scenario



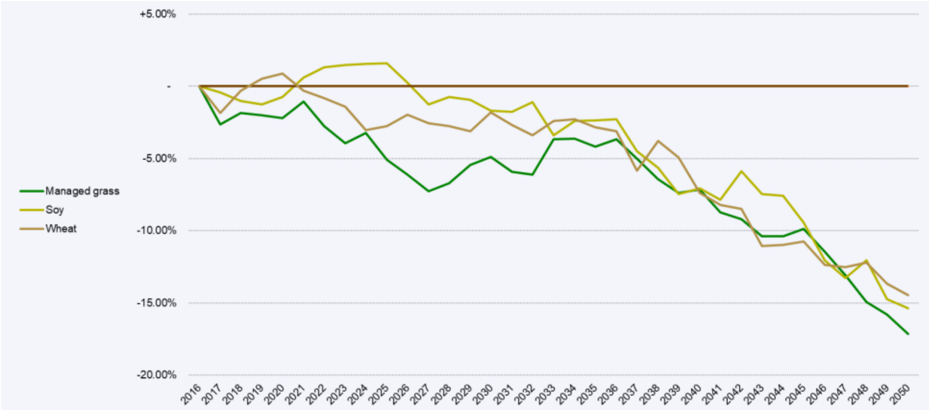
Source: (IFAD, 2022)

Figure 7-50 Tajikistan – Dry, poor soils – Optimistic scenario



Source: (IFAD, 2022)

Figure 7-51 Tajikistan – Dry, poor soils – Pessimistic scenario

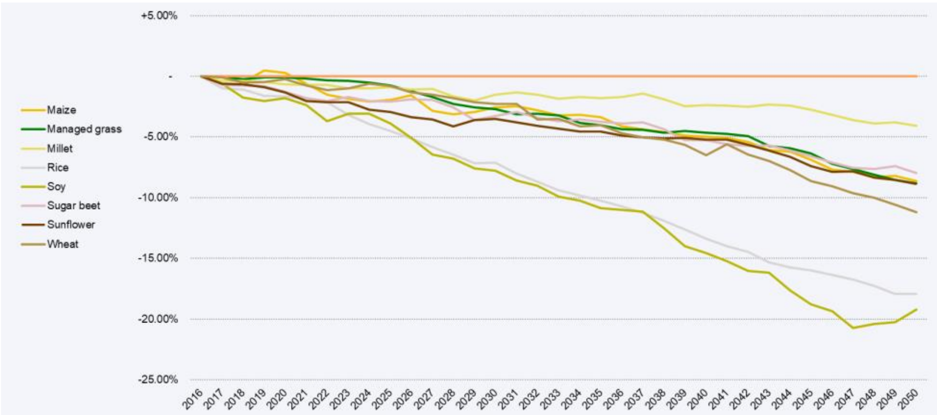


Source: (IFAD, 2022)

7.5.4.5. Irrigated soils

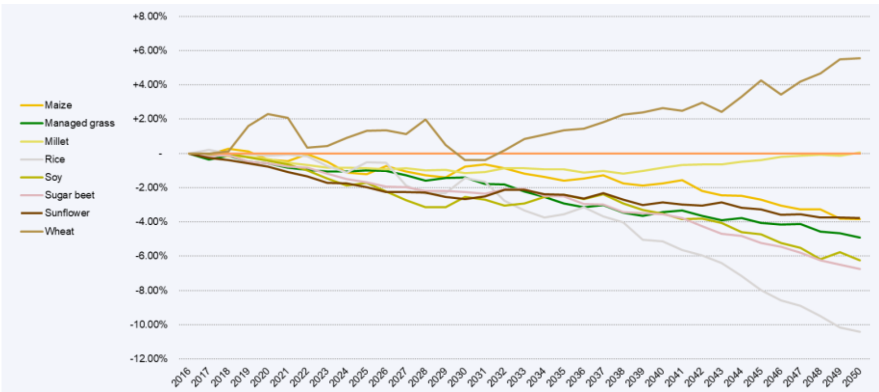
The yield forecasts in irrigated soils zones are characterized by negative trends in all commodities with only one exception, increasing wheat yield in optimistic scenario.

Figure 7-52 Tajikistan – Irrigated soil under full irrigation – Median scenario



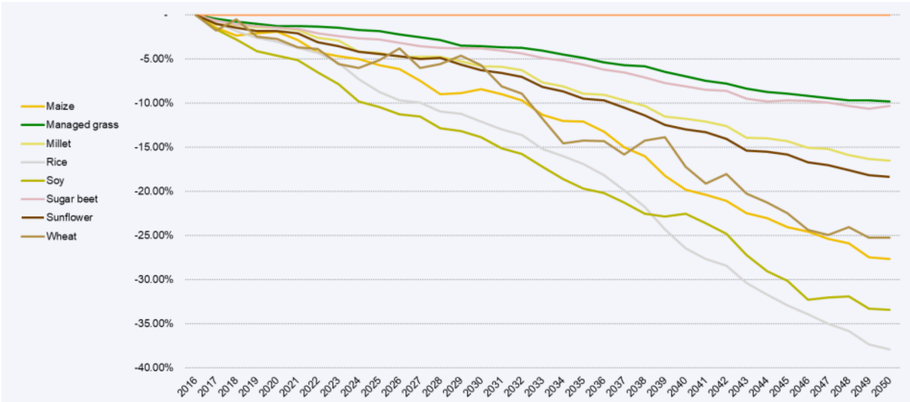
Source: (IFAD, 2022)

Figure 7-53 Tajikistan – Irrigated soil under full irrigation – Optimistic scenario



Source: (IFAD, 2022)

Figure 7-54 Tajikistan – Irrigated soil under full irrigation – Pessimistic scenario



Source: (IFAD, 2022)

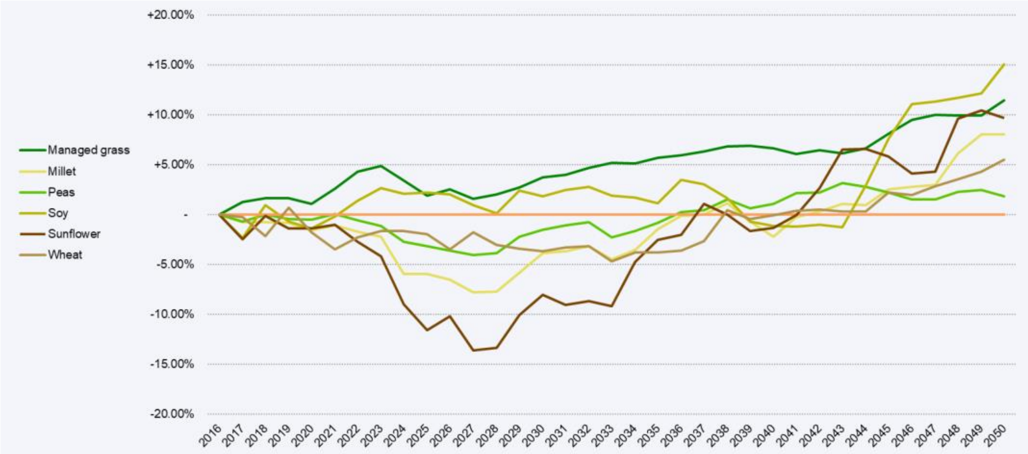
7.5.4.6. Steep terrain

Steep terrain zone indicates mixed development in median scenario. In particular, the growth in yield can be expected for millet, wheat and managed grass yield. Peas, sunflower and soy shall experience a yield decline. Optimistic scenario provides evidence on the increasing trend for all commodities since 2028. On the contrary, pessimistic scenario project yield declines in all commodities.

Figure 7-55 Tajikistan – Steep terrain – Median scenario

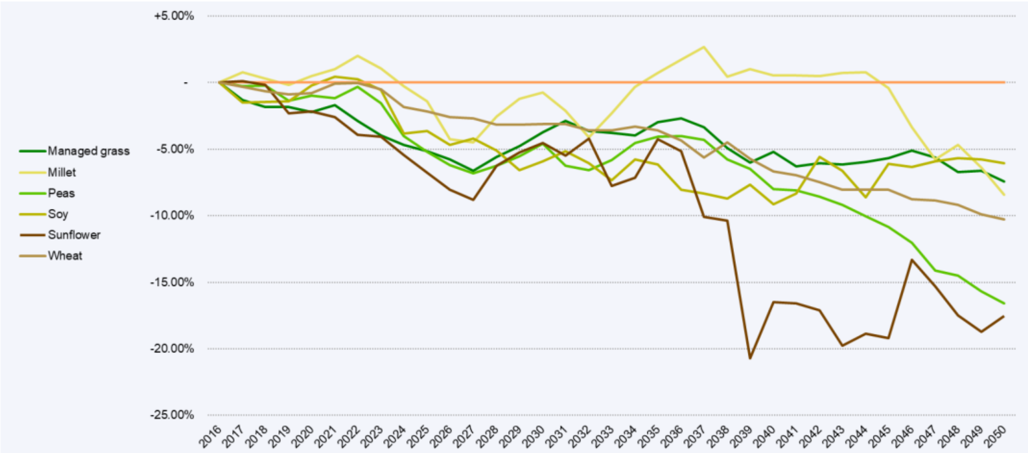
Source: (IFAD, 2022)

Figure 7-56 Tajikistan – Steep terrain – Optimistic scenario



Source: (IFAD, 2022)

Figure 7-57 Tajikistan – Steep terrain – Pessimistic scenario



Source: (IFAD, 2022)

7.5.5. Districts and its Agricultural characteristics

7.5.5.1. Overall agriculture land usage

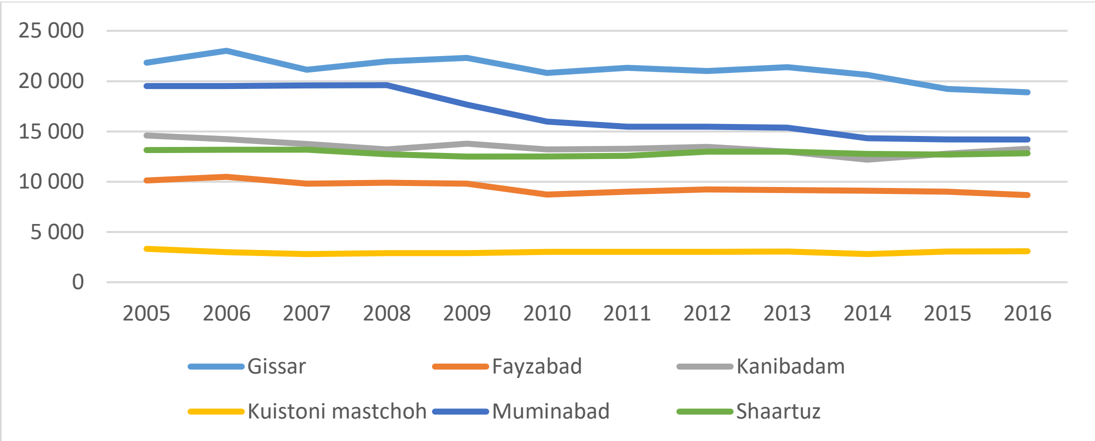
Data for the regional productions has been collected from the Tajikistan Statistical Office, online resources available only up to 2016.

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 Kaisar (-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 districts are 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 districts go in the opposite direction to general trend of the whole Tajikistan. As presented above, food agriculture organization data present increasing size of agricultural land used.

Figure 7-58 Sown area for the selected districts



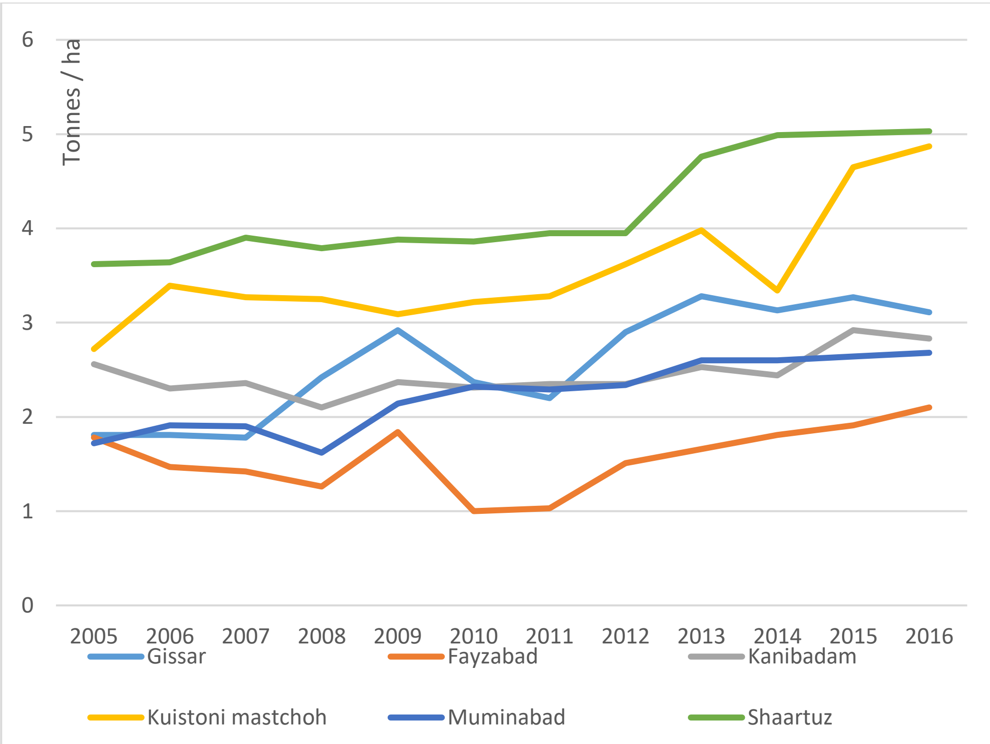
Source: own processing based on stat.tj (2022a)

Table 7-11 Agriculture land usage

Average 2012 - 2016	Gissar	Fayzabad	Kanibadam	Kuhistoni Mastchoh	Muminabad	Shaartuz
Cultivated area (ha)						
Grain Crops	11268.2	4049	2651.4	525.2	10738.2	4701.4
Cotton	1073.6		5964.6			5230
Potato	569.4	751.2	217.6	1894.4	1095.4	453
Vegetables	1265.8	512.8	851.2	27.8	650.4	1330.2
Melon farming	168.8	18.8	500.2		160.2	511.6
Forage crops	4385.8	3081	2759.6	558	1354.4	863.8
Share on total land (% of total land)						
Grain Crops	55.7%	44.8%	20.5%	17.5%	73.0%	36.6%
Cotton	5.3%	0.0%	46.1%	0.0%	0.0%	40.7%
Potato	2.8%	8.3%	1.7%	63.1%	7.4%	3.5%
Vegetables	6.3%	5.7%	6.6%	0.9%	4.4%	10.3%
Melon farming	0.8%	0.2%	3.9%	0.0%	1.1%	4.0%
Forage crops	21.7%	34.1%	21.3%	18.6%	9.2%	6.7%
Yield per hectare (t/ha)						
Grain and leguminous	3.138	1.798	2.614	4.092	2.572	4.748
Cotton	2.288	1.938	0	0	0	1.954
Potato	19.302	18.004	20.444	34.184	21.308	23.614
Vegetables	22.806	19.586	20.184	33.622	19.518	26.11
Melon farming	17.492	6.526	14.27	0	19.226	34.228

Source: stat.tj

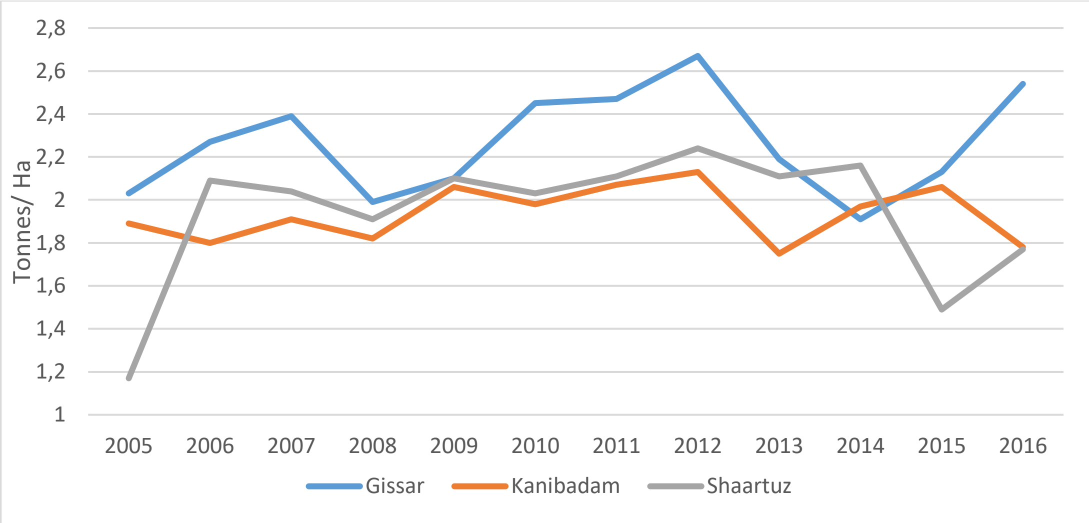
Figure 7-59 Grain and leguminous yields, districts (2005 - 2016)



Source: own processing based on stat.tj (2022a)

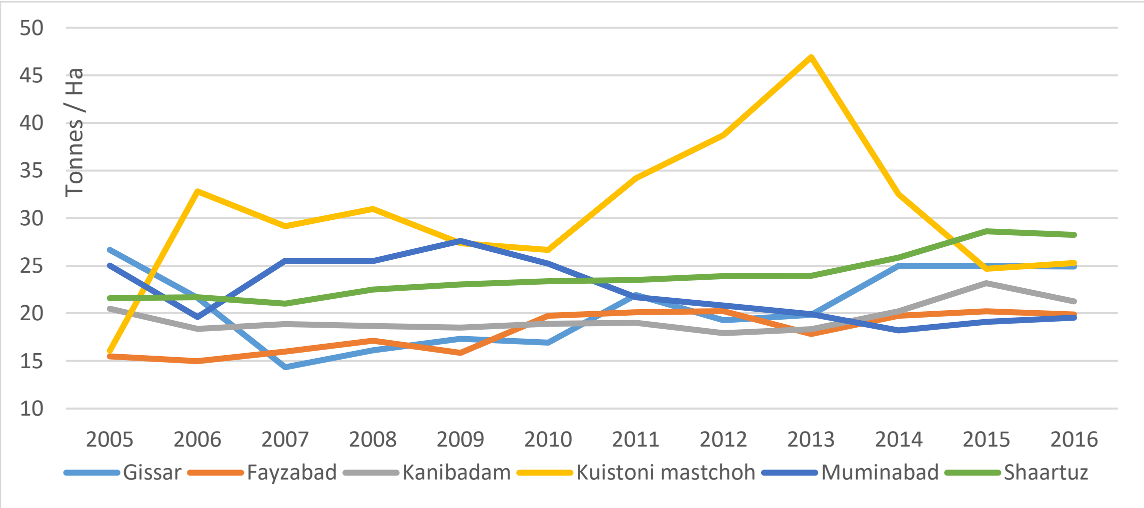
Yields of grains and legumes had an increasing trend in selected six districts. Unfortunately, there are no specific data available on yields, areas of specific grain and legumes products in the districts. Between 2005 and 2016 largest yield has been reached in Shaartuz and Kuhistoni Mastchoh, where grain and legumes yield approached almost 5 tons per hectare. Other commodities are also characterized by weak increasing trend (see following figures).

Figure 7-60 Cottonseed yields, districts (2005 - 2016)



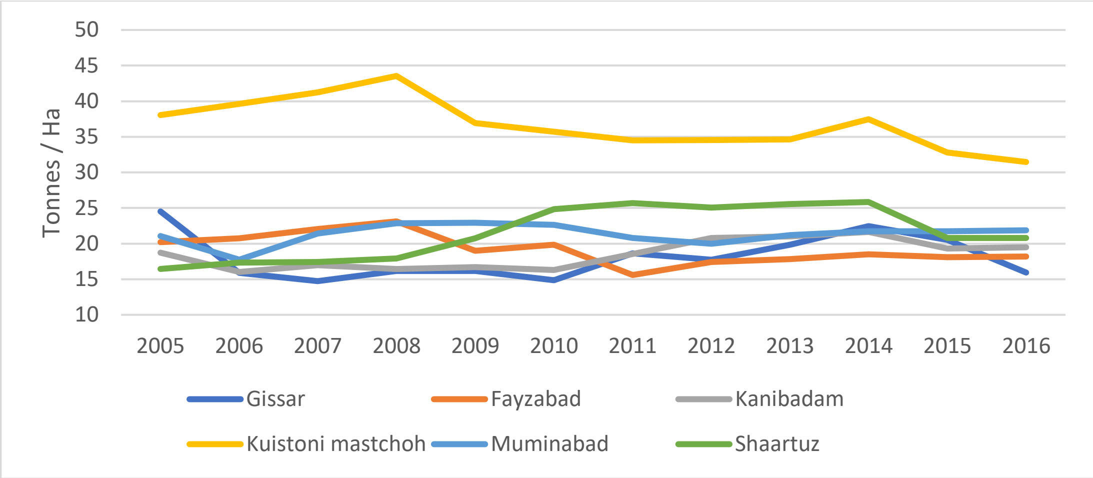
Source: own processing based on stat.tj (2022a)

Figure 7-61 Vegetable's yield, districts (2005 - 2016)



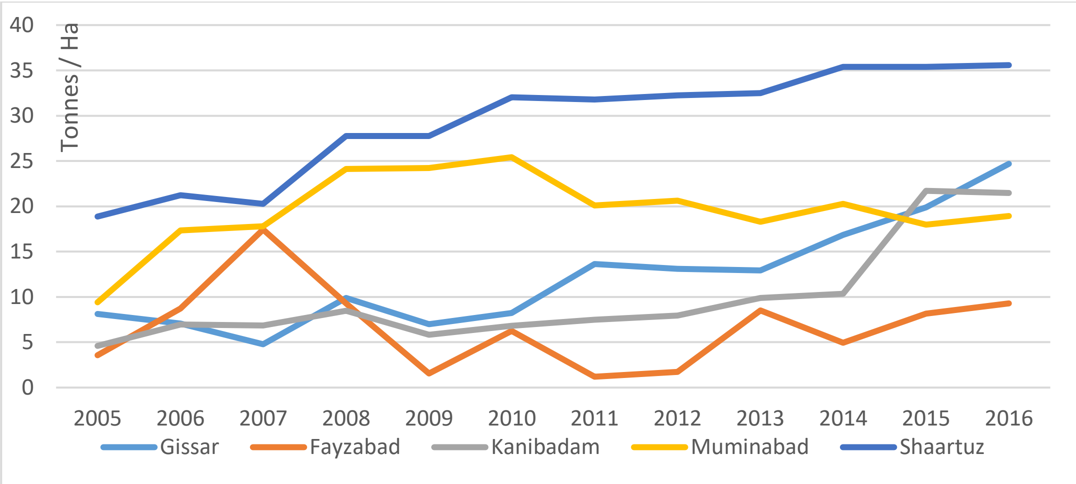
Source: own processing based on stat.tj (2022a)

Figure 7-1 Potatoes yields, districts (2005 - 2016)



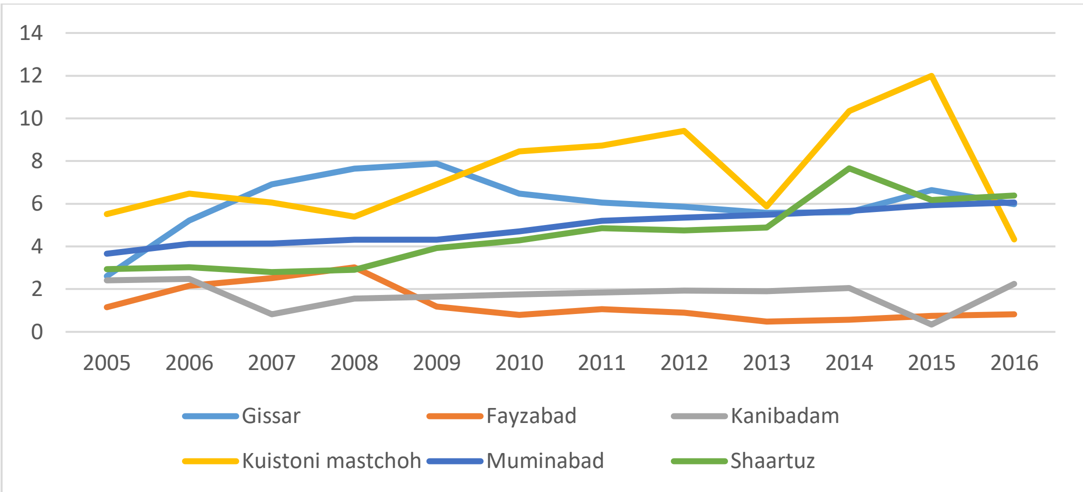
Source: own processing based on stat.tj (2022a)

Figure 7-63 Melons yields, districts (2005 - 2016)



Source: own processing based on stat.tj (2022a)

Figure 7-64 Fruits yields, districts (2005 - 2016)



Source: own processing based on stat.tj (2022a)

7.5.5.2. Wheat and cotton predictions for the districts

District predictions are based on the CARD model climate adaptation in rural development assessment tool developed under the IFAD UN organization to explore the effects of climate change on the yield of basic crops. The CARD outputs are then recalculated based on the derived distribution of agri-ecological zones in the selected districts.

Table 7-12 Distribution of Agro-ecological zones in the selected districts

	Steep terrain	Dessert / Arid	Irrigated soils	Dry, good soils	Dry, moderate soils	Dry, poor soils
Kuhistoni Mastchoh	100%					
Gissar	50%		15%	35%		
Shaartuz		15%	45%	10%	20%	10%
Fayzabad	50%				50%	
Kanibadam			90%	10%		
Muminabad	45%			45%	10%	

Source: own processing based on IFAD/CARD model data (IFAD, 2022)

Table 7-13 Forecasts for each agro-ecological zone – Wheat

WHEAT – median and rainfed	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	0.55%	-1.02%	-3.33%	-1.15%	-1.22%	0.02%	0.51%
Dry, good soils	-0.08%	0.32%	-0.59%	0.70%	1.36%	1.49%	1.16%
Dry, moderate soils	0.27%	-0.66%	0.43%	0.17%	0.49%	0.89%	-0.16%
Dry, poor soils	-0.69%	-1.67%	-2.43%	-2.11%	-1.26%	0.12%	-2.94%
Irrigated soils	1.24%	-0.58%	0.52%	2.23%	2.46%	0.44%	-1.96%
Steep terrain	0.34%	0.43%	1.58%	1.44%	2.95%	3.90%	5.40%

WHEAT – median and irrigated	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	-0.34%	-1.41%	-2.12%	-3.02%	-5.71%	-6.91%	-9.36%
Dry, good soils	-0.43%	-0.69%	-1.68%	-2.64%	-3.88%	-4.51%	-6.55%
Dry, moderate soils	-0.55%	-1.45%	-2.22%	-3.95%	-5.73%	-7.27%	-9.59%
Dry, poor soils	-0.28%	-1.09%	-2.15%	-2.83%	-5.38%	-6.04%	-8.97%
Irrigated soils	-0.35%	-0.75%	-1.51%	-3.15%	-4.94%	-6.65%	-10.09%
Steep terrain	0.16%	-0.05%	-0.07%	-0.38%	-1.65%	-2.82%	-4.54%

WHEAT – optimistic, rainfed	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	1.70%	2.38%	2.61%	2.74%	6.07%	7.50%	7.61%
Dry, good soils	1.67%	2.33%	0.68%	1.70%	4.55%	7.34%	6.93%
Dry, moderate soils	4.38%	4.52%	3.02%	3.03%	6.69%	7.81%	8.36%
Dry, poor soils	3.16%	3.91%	3.04%	5.17%	7.32%	7.73%	8.84%
Irrigated soils	4.40%	4.64%	3.15%	1.56%	4.31%	6.48%	6.22%
Steep terrain	-0.56%	-2.16%	-2.74%	-3.71%	-1.99%	0.31%	3.63%

WHEAT – optimistic, irrigated	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	-0.36%	-0.66%	-0.53%	0.29%	2.18%	2.32%	3.35%
Dry, good soils	0.29%	0.20%	1.05%	1.49%	3.01%	3.82%	5.77%
Dry, moderate soils	0.60%	-0.07%	0.02%	0.93%	2.21%	3.10%	4.97%
Dry, poor soils	-0.03%	0.19%	-2.37%	-2.06%	-1.88%	-2.08%	-0.15%
Irrigated soils	0.56%	1.21%	1.25%	0.27%	1.85%	2.77%	4.67%
Steep terrain	-0.92%	-0.72%	-1.25%	-4.66%	-4.07%	-3.01%	-1.65%

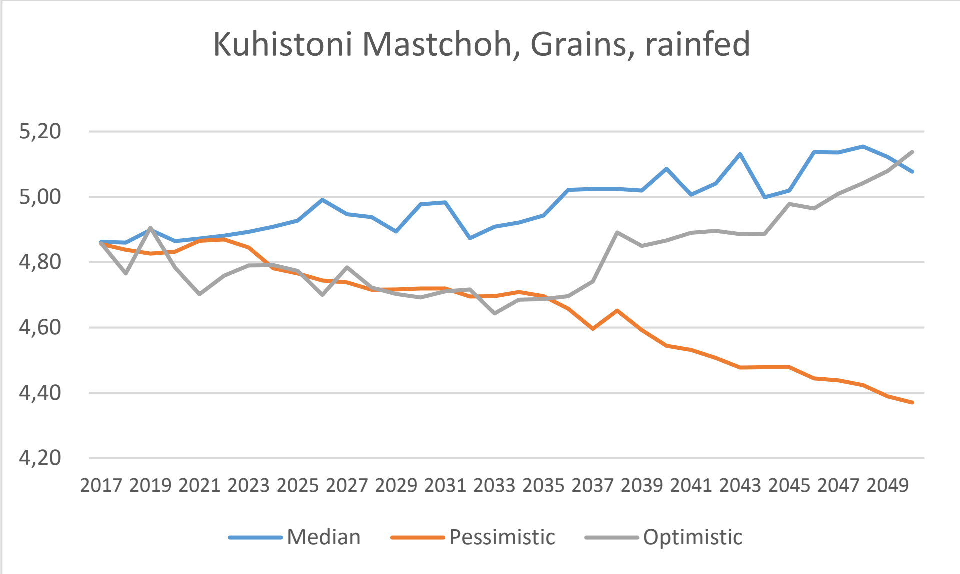
WHEAT – pessimistic, rainfed	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	-3.30%	-2.94%	-9.06%	-9.18%	-7.89%	-7.74%	-7.40%
Dry, good soils	-2.01%	-4.86%	-10.12%	-13.66%	-14.48%	-15.12%	-14.57%
Dry, moderate soils	-1.33%	-0.96%	-3.59%	-3.56%	-4.98%	-9.30%	-12.88%
Dry, poor soils	-0.55%	-0.94%	-2.63%	-2.52%	-4.10%	-9.23%	-13.05%
Irrigated soils	-1.15%	-1.90%	-3.41%	-2.62%	-5.38%	-7.92%	-11.28%
Steep terrain	-0.62%	-0.65%	-2.75%	-3.33%	-4.75%	-7.44%	-9.39%

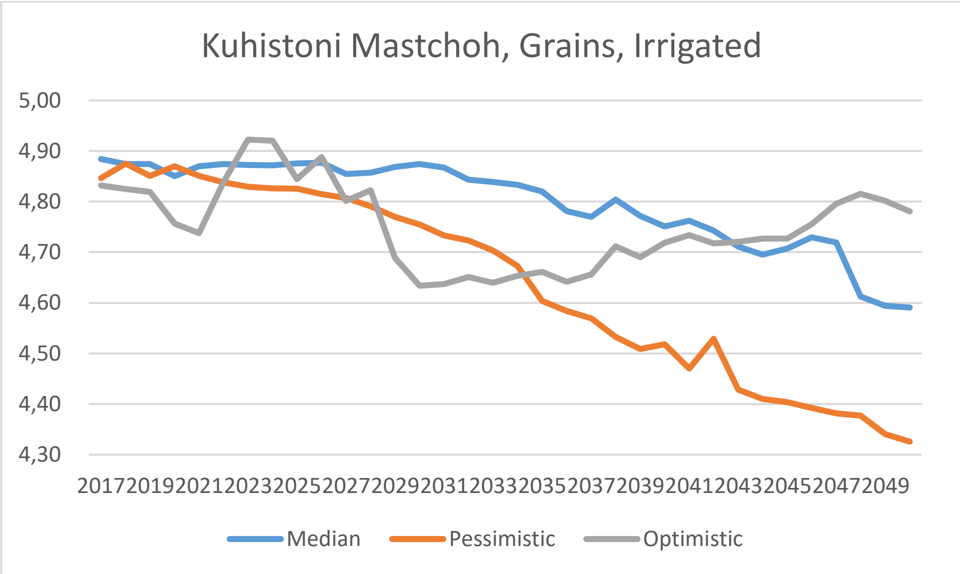
WHEAT - pessimistic, Irrigated	2017 - 19	2020 - 24	2025 - 29	2030 - 34	2034 - 39	2040 - 44	2045 - 50
Desert/Arid	-1.17%	-4.00%	-8.55%	-11.39%	-14.73%	-18.74%	-26.67%
Dry, good soils	-0.69%	-1.30%	-2.40%	-7.82%	-9.38%	-13.67%	-16.59%
Dry, moderate soils	0.20%	-2.44%	-2.87%	-8.93%	-12.84%	-17.74%	-23.05%
Dry, poor soils	-1.04%	-0.99%	-2.73%	-6.73%	-10.43%	-15.39%	-20.60%
Irrigated soils	-1.62%	-4.39%	-5.04%	-9.81%	-14.50%	-19.19%	-24.77%
Steep terrain	-0.26%	-0.56%	-1.41%	-3.13%	-6.37%	-8.19%	-10.40%

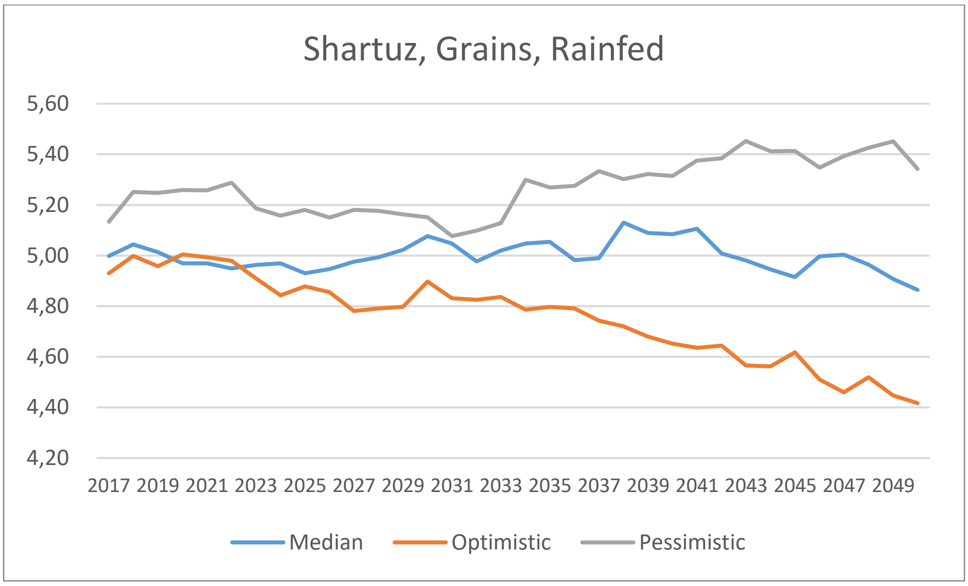
Source: own processing based on IFAD/CARD model data (IFAD, 2022)

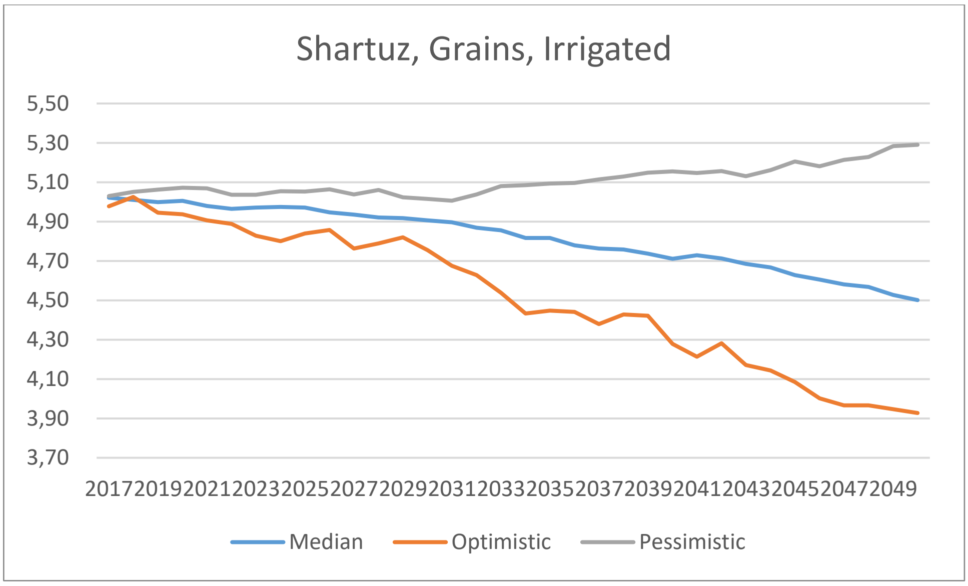
The results of the wheat yield forecast for different scenarios and agro-ecological zone suggest that in majority of cases we may expect the decrease in wheat yields. The only exception is optimistic scenario. Optimistic scenario indicates positive changes in wheat yields for both rainfed and irrigated land in almost all agro-ecological zones.

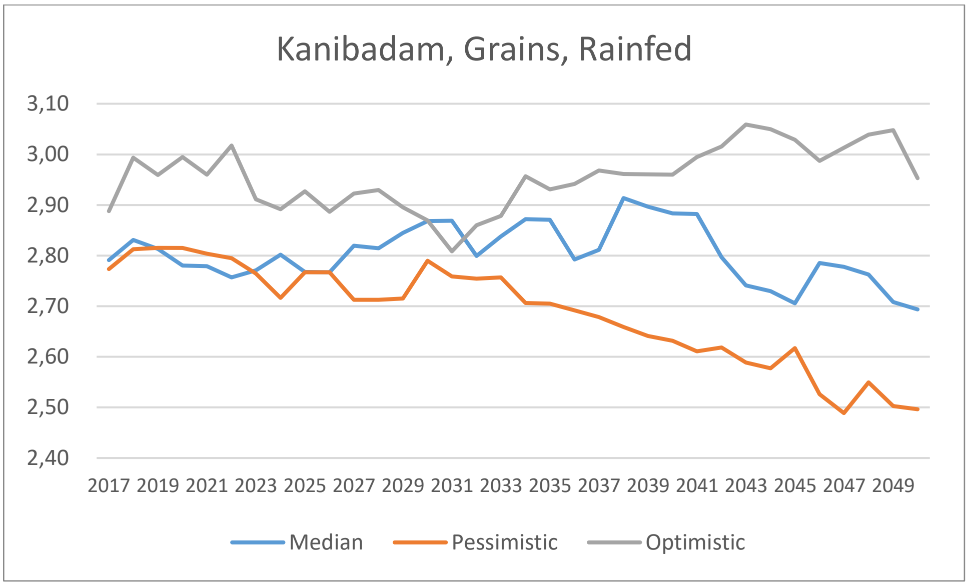
Figure 7-65 Grains yield forecasts based on the Agro-Ecological zone distribution

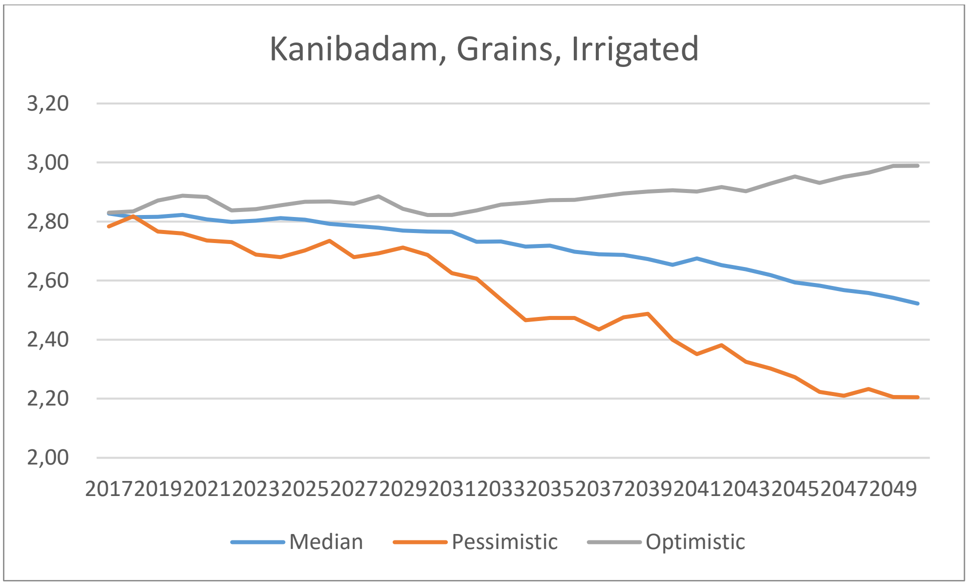


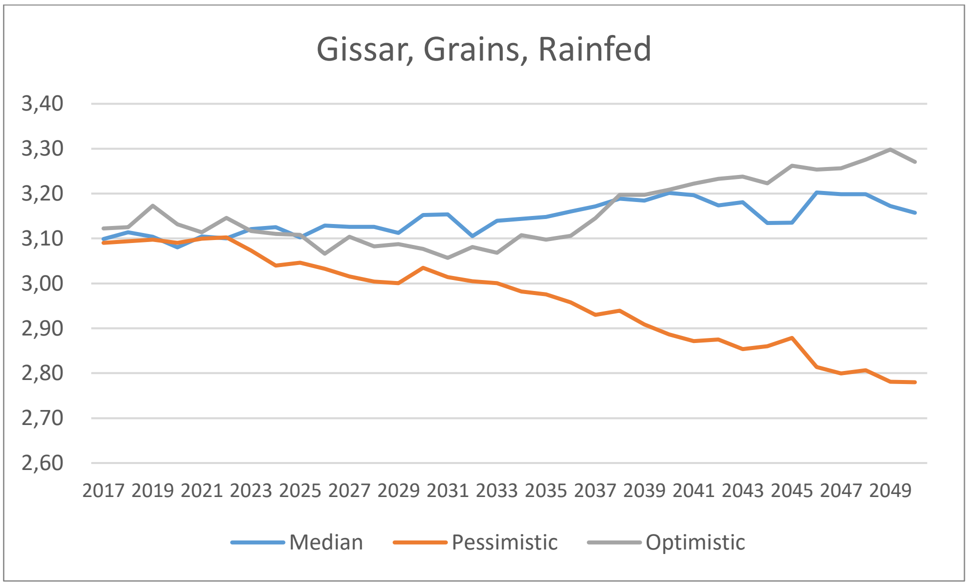


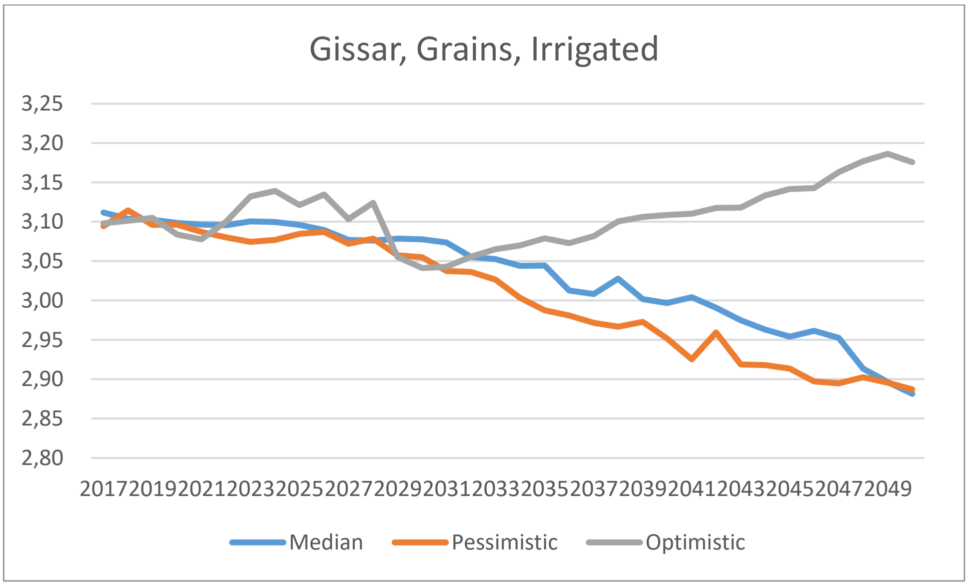

Shartuz, Grains, Rainfed
5,60
5,40
5,20
5,00
4,80
4,60
4,40
4,20
2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049
Median
Optimistic
Pessimistic

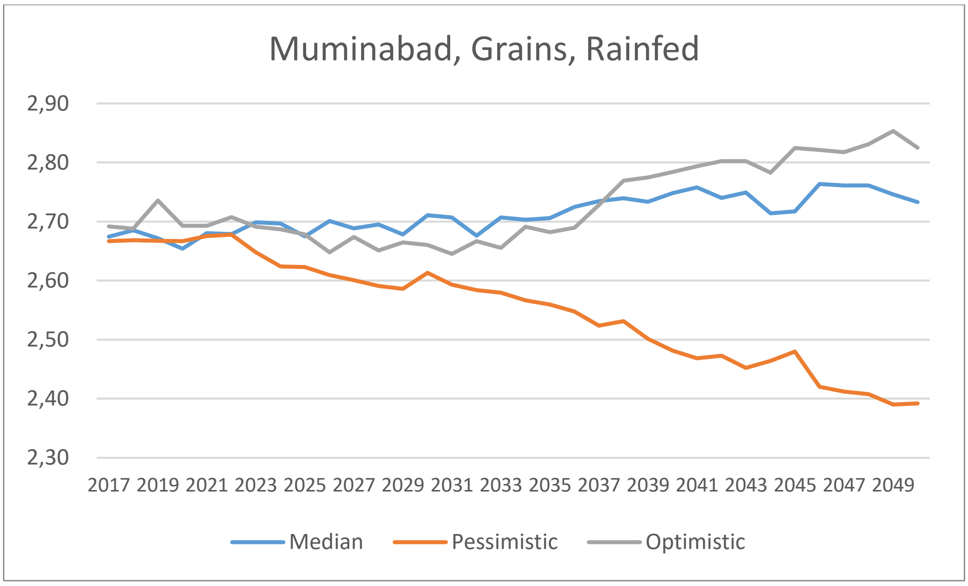

Shartuz, Grains, Irrigated
5,50
5,30
5,10
4,90
4,70
4,50
4,30
4,10
3,90
3,70
20172019202120232025202720292031203320352037203920412043204520472049
Median
Optimistic
Pessimistic

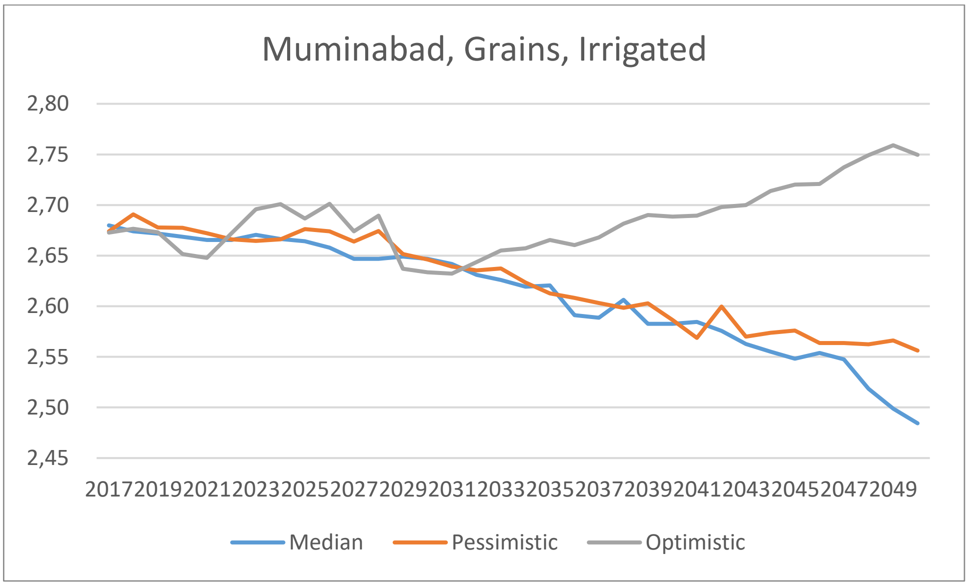

Kanibadam, Grains, Rainfed
3,10
3,00
2,90
2,80
2,70
2,60
2,50
2,40
2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049
Median
Pessimistic
Optimistic

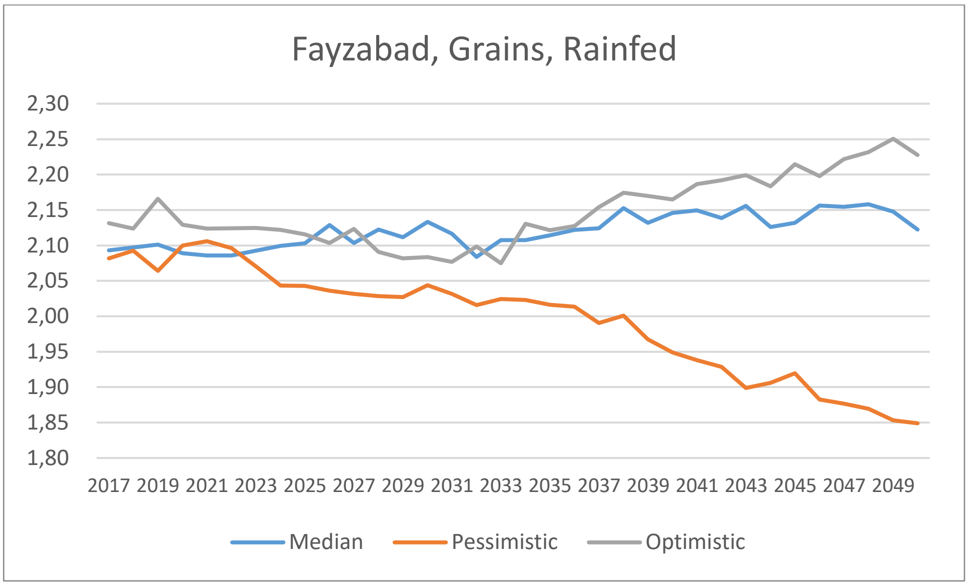

Kanibadam, Grains, Irrigated
3,20
3,00
2,80
2,60
2,40
2,20
2,00
20172019202120232025202720292031203320352037203920412043204520472049
Median
Pessimistic
Optimistic

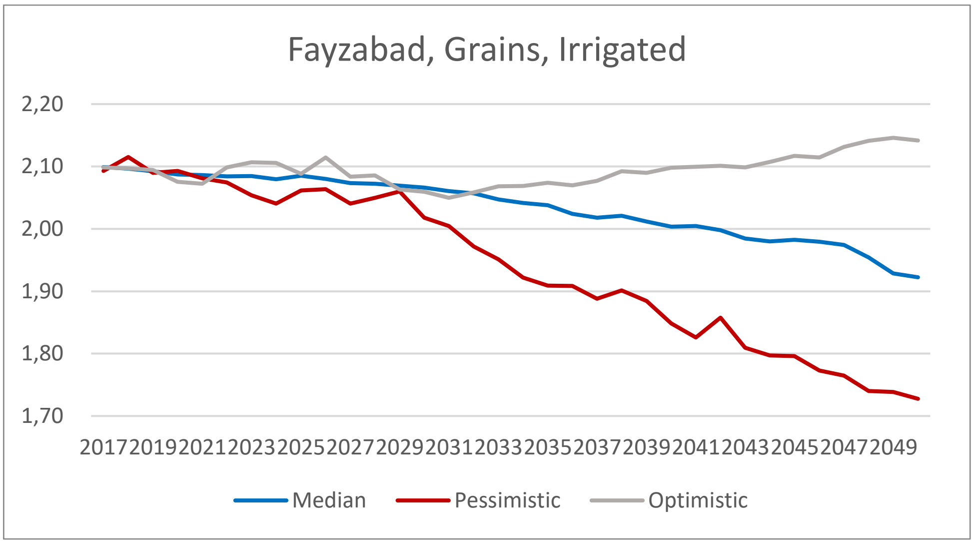

Gissar, Grains, Rainfed
3,40
3,30
3,20
3,10
3,00
2,90
2,80
2,70
2,60
2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049
Median
Pessimistic
Optimistic


Gissar, Grains, Irrigated
3,25
3,20
3,15
3,10
3,05
3,00
2,95
2,90
2,85
2,80
20172019202120232025202720292031203320352037203920412043204520472049
Median
Pessimistic
Optimistic


Muminabad, Grains, Rainfed
2,90
2,80
2,70
2,60
2,50
2,40
2,30
2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049
Median
Pessimistic
Optimistic


Muminabad, Grains, Irrigated
2,80
2,75
2,70
2,65
2,60
2,55
2,50
2,45
20172019202120232025202720292031203320352037203920412043204520472049
Median
Pessimistic
Optimistic



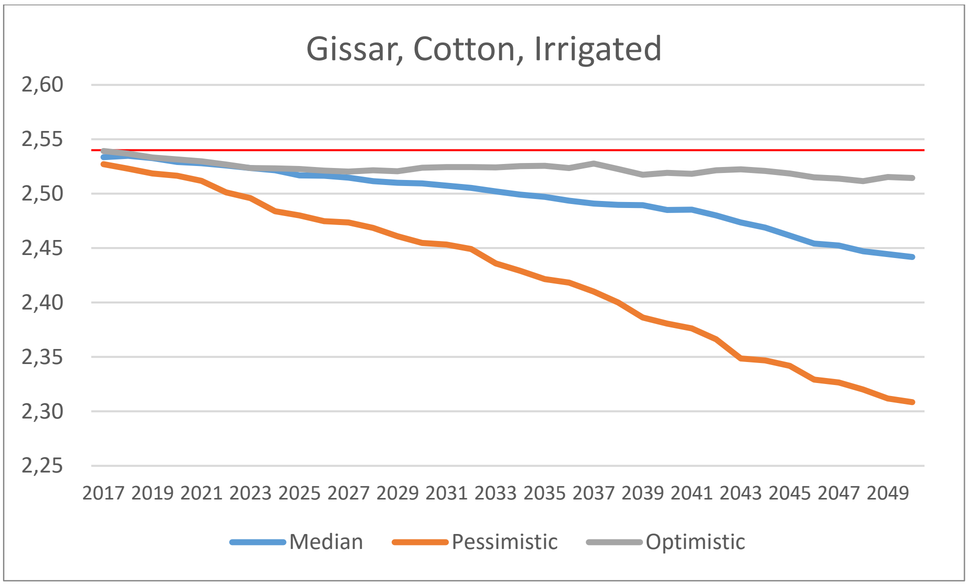


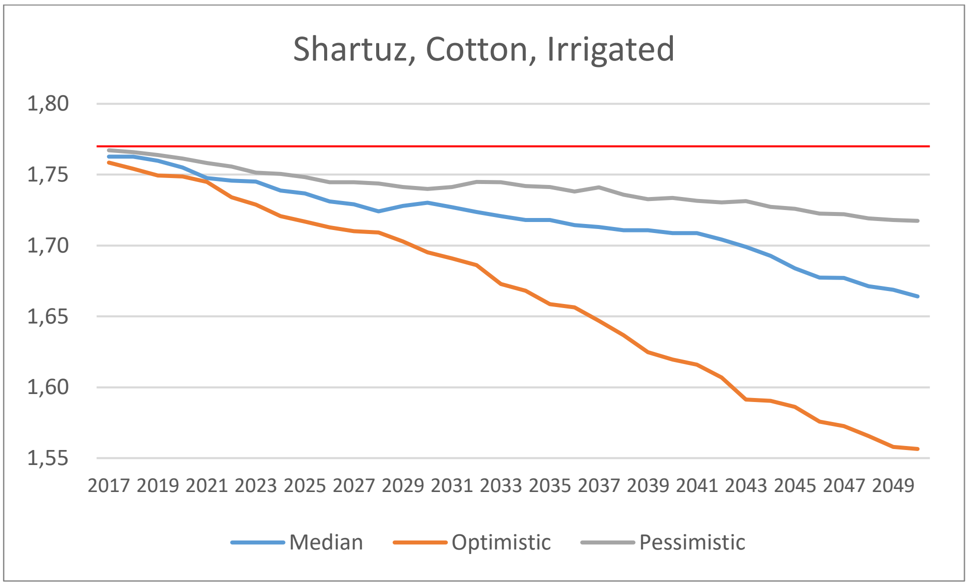
Source: own results based on IFAD/CARD (2022)

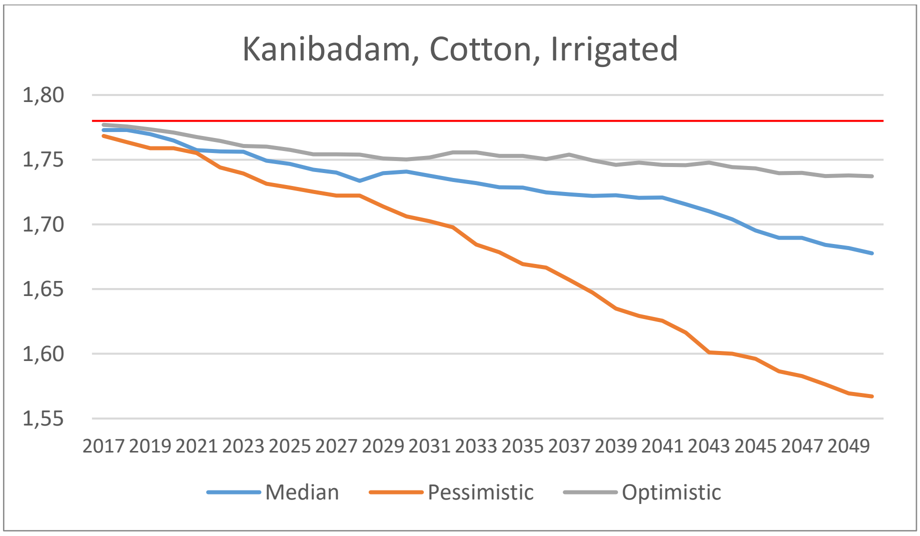
The following figures show the forecasts of wheat yield for selected districts. These forecasts are based on the weighted yield changes in relative measures (see previous tables) and the average wheat yield in tonnes in particular district. The weights are given by the distribution of agri-ecological zones.

The district forecasts suggest that we can expect an increase in grains yields in optimistic scenario in all districts regardless the type of scenario – rainfed or irrigated. The opposite can be said for pessimistic scenario. Median scenario differs in selected districts and is different for rainfed and irrigated scenario as well. As far as rainfed median scenario is concerned we may expect positive grains yield trend in Kuhistoni Mastchoh, Gissar, Muminabad and Fayzabad. Shaartuz and Kanibadam do not show significant changes in grains yield in rainfed median scenario. Furthermore, irrigated median scenario suggests grains yields decline in all selected districts.

Figure 7-66 Cotton yield forecasts in districts







Source: own results based on IFAD/CARD (2022)

The cotton yield forecasts indicate that we can expect a decrease in cotton yields in all scenarios and districts. These results suggest the due to the climate change the cotton production can be further reduced in Tajikistan.

7.5.5.3. Assessment of direct and indirect economic effects related to agricultural performance during the last three decades

Agricultural production in Tajikistan reached a massive gross value growth in the period 1992 - 2018. The agricultural gross production value in constant prices increased from 988 mil. USD to 2.9 billion USD. The key drivers of the above-mentioned trend are both crops and livestock production. For details see Table 7 - 14

Table 7-14 Tajikistan - agricultural gross production value development

	Agriculture, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Cereals, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Food, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Livestock, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Meat indigenous, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Milk, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Oil crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Roots and Tubers, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Vegetables and Fruit, Gross Production Value (constant 2014-2016 in 1000 thousand US$)
1992	988 170	67 117	482 192	809 612	340 378	141 461	168 733	16 965	40 043	341 436
1993	843 696	66 909	417 974	660 790	257 163	86 127	157 226	17 352	35 163	288 898
1994	817 244	55 516	400 290	634 502	246 762	79 783	156 605	17 477	32 053	288 141
1995	756 089	61 143	405 312	614 732	218 681	85 012	127 330	13 659	26 695	295 829
1996	630 708	92 647	383 138	525 210	147 061	85 775	58 625	10 259	25 762	247 781
1997	695 259	142 040	429 691	573 748	151 956	72 195	77 588	11 650	30 647	232 346
1998	668 644	126 480	400 814	533 939	144 443	56 348	85 742	12 757	41 752	197 202
1999	665 422	124 183	404 185	555 199	159 666	56 983	99 684	10 657	57 315	195 084
2000	802 632	149 366	531 407	685 948	163 367	57 014	102 036	11 273	72 532	288 382
2001	839 149	123 549	500 138	687 222	193 432	61 937	125 896	15 326	73 720	281 623
2002	981 077	175 791	592 282	808 787	223 041	74 412	142 081	17 607	85 325	297 473
2003	1 065 628	220 375	639 400	889 048	253 439	92 994	151 378	18 900	113 223	265 539
2004	1 225 932	216 678	773 561	1 040 837	273 269	100 549	161 323	19 514	126 118	356 596
2005	1 247 764	229 256	805 085	1 098 324	298 649	112 740	175 290	16 464	132 788	378 588
2006	1 312 114	223 748	859 636	1 165 776	311 637	113 739	179 236	17 330	137 228	452 530
2007	1 352 208	227 579	883 869	1 212 256	333 355	120 916	191 858	15 724	158 375	444 526
2008	1 483 056	229 171	1 016 311	1 364 764	353 190	132 172	197 451	13 370	162 605	555 500
2009	1 682 643	348 040	1 208 959	1 582 483	378 499	142 481	206 866	13 106	165 255	594 552
2010	1 780 361	346 415	1 283 369	1 675 015	397 130	146 733	217 053	14 932	181 828	632 193
2011	1 837 409	264 046	1 283 173	1 697 606	420 312	157 035	228 576	18 464	206 457	687 030
2012	2 015 758	298 205	1 425 573	1 875 037	455 782	161 270	255 645	19 783	237 062	769 056
2013	2 212 664	333 436	1 569 750	2 079 665	516 604	176 442	296 919	19 364	266 879	831 451
2014	2 208 307	317 163	1 539 897	2 082 206	548 582	202 111	303 527	19 105	204 218	873 051
2015	2 310 020	333 591	1 587 518	2 217 144	635 668	271 565	318 170	17 523	212 274	923 923
2016	2 331 132	346 258	1 623 862	2 233 713	615 721	248 584	322 223	18 048	214 833	932 237
2017	2 825 309	345 908	1 681 902	2 695 184	1 019 123	640 638	332 874	23 613	187 271	982 054
2018	2 965 352	310 099	1 794 938	2 862 920	1 073 838	677 171	344 032	21 212	230 747	1 073 875

Source: FAOSTAT, 2022

Agricultural production value performance is pushed by both massive growth of agricultural added value and also through even more massive growth of agricultural production volume. Available data covering the period 1992-2018 provides an overview of amazing agricultural production volume growth. The volume of crops production increased from 1.4 million tonnes to 5.7 million tonnes. The key drivers of above-mentioned growth are mainly vegetables, roots and tubers, fruit and cereals. For details see Table 7-15.

The growth of production value and also volume performance has never been interrupted by the negative effects of climate change. There is no direct impact associated with the agricultural production volume and value performance development. However, during the analysed time period, the average annual temperature increased from 11.9 °C to 14.2 °C, and there is no direct negative impact on the agricultural performance itself. The only negative effects could be associated with the massive growth of necessary inputs utilization.

Table 7-15 Tajikistan - agricultural production volume development

	Cereals, Production in tonnes	Citrus Fruit, Production in tonnes	Fruit Primary	Pulses, Production in tonnes	Roots and Tubers, Production in tonnes	Treenuts, Production in tonnes	Vegetables Primary Production in tonnes	Production in tonnes crops production
1992	271 733	2 000	419 600	9 524	167 400	7 565	545 267	1 423 089
1993	266 735	1 600	343 900	6 039	147 000	6 300	487 890	1 259 464
1994	215 435	1 600	340 700	5 219	134 000	6 344	493 199	1 196 497
1995	242 350	1 600	361 100	5 672	111 600	6 252	495 876	1 224 450
1996	387 377	2 564	299 964	4 877	107 700	5 600	405 422	1 213 504
1997	559 463	2 200	303 691	8 307	128 119	4 900	361 990	1 368 670
1998	490 619	2 100	232 113	8 974	174 545	6 200	347 255	1 261 806
1999	474 338	2 640	214 564	8 144	239 609	6 250	403 352	1 348 897
2000	544 994	2 900	375 462	5 108	303 223	6 100	368 335	1 606 122
2001	477 651	2 200	350 398	6 087	308 189	7 400	424 113	1 576 038
2002	687 559	3 678	343 787	13 017	356 703	5 800	498 701	1 909 245
2003	866 197	5 744	263 174	18 252	473 331	5 466	609 511	2 241 675
2004	860 340	5 953	392 447	31 259	527 240	5 617	712 463	2 535 319
2005	902 912	5 800	413 330	31 968	555 125	5 875	755 761	2 670 771
2006	892 884	6 350	536 103	19 398	573 687	6 100	803 939	2 838 461
2007	906 552	6 391	532 895	24 652	662 093	5 700	885 351	3 023 634
2008	909 500	6 378	668 928	33 682	679 774	5 700	964 813	3 268 775
2009	1 399 868	6 370	781 026	44 587	690 853	5 700	1 105 579	4 033 983
2010	1 382 559	6 551	835 343	53 972	760 139	5 700	1 180 989	4 225 253
2011	1 034 798	8 551	846 351	62 394	863 100	5 900	1 298 699	4 119 793
2012	1 175 450	8 127	950 328	56 746	991 044	6 000	1 417 368	4 605 063
2013	1 328 800	7 913	1 002 811	63 549	1 115 696	5 900	1 592 913	5 117 582
2014	1 257 989	8 114	1 080 241	67 767	853 738	5 900	1 644 245	4 917 994
2015	1 324 045	9 484	1 136 857	67 136	887 418	5 801	1 778 034	5 208 775
2016	1 367 078	5 732	1 144 978	67 019	898 116	5 751	1 824 282	5 312 956
2017	1 365 515	5 998	1 200 828	79 578	782 892	5 789	1 918 738	5 359 338
2018	1 218 840	5 980	1 228 986	49 662	964 644	5 820	2 191 989	5 665 921

Source: FAOSTAT, 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 districts in Tajikistan. According to local data – the number of local harvests increased in several districts. 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 districts in Tajikistan is limited and upcoming climate changes could make water availability even more limited. Another weakness of Tajik agricultural sector performance development is associated with the growth of people employed in agriculture. As agricultural employment increased during the period under the analysis from 740 thous. people to more than one million economically active in agriculture. Agriculture is even more sensitive as the number of people dependent on agricultural activities (so-called agricultural population) increased even more from 3.8 million to 6.6 million. There is even a massive pressure on agriculture to increase its production even more as the total population in Tajikistan in the period under the analysis increased from 5.5 million to nearly 10 million people and the future prospects calculated by UN for the year 2100 is nearly 25 million habitants. On the other hand, agricultural production is pushed and supported through the massive growth of national GDP value performance and gross fixed capital formation. For details see Table 7-16.

Table 7-16 Tajikistan – selected indicators performance development

	Temperature change	Gross Domestic Product, Value US$, 2015 prices, in millions	Gross Fixed Capital Formation, in millions USD	Employment in agriculture, forestry and fishing - ILO in thous. persons	Female employment in agriculture in thous. persons	Male employment in agriculture in thous. persons	Rural population in thous. persons	Total population in thous. persons
1992	0,23	4 682,77	3 569,65	740,01	377,03	363,75	3 823,06	5 502,49
1993	0,12	3 914,80	2 857,19	733,34	368,77	365,16	3 917,46	5 593,32
1994	0,47	3 080,95	2 312,72	739,49	365,47	374,34	4 008,75	5 679,17
1995	0,39	2 698,91	2 176,35	753,42	365,71	388,09	4 100,05	5 764,81
1996	0,35	2 246,51	1 420,91	753,80	359,83	394,50	4 191,93	5 851,36
1997	1,37	2 284,38	1 857,39	769,53	365,73	404,32	4 284,20	5 938,41
1998	0,83	2 405,12	1 339,88	766,18	363,92	402,76	4 379,00	6 027,39
1999	1,15	2 494,03	1 600,17	793,81	377,85	416,50	4 478,56	6 119,66
2000	1,03	2 700,97	659,49	814,65	389,82	425,22	4 568,85	6 216,34
2001	1,49	2 958,68	1 089,20	832,31	402,47	430,35	4 650,26	6 318,51
2002	1,25	3 278,65	825,77	849,51	416,02	434,13	4 738,75	6 426,87
2003	0,53	3 643,13	1 217,09	868,03	430,65	438,20	4 833,58	6 541,55
2004	1,31	4 017,89	1 151,24	893,10	451,33	442,84	4 933,38	6 662,39
2005	0,79	4 287,81	1 320,69	908,20	451,42	457,77	5 037,12	6 789,32
2006	1,57	4 570,55	1 449,08	925,81	450,61	475,83	5 144,56	6 922,59
2007	1,20	4 925,08	1 614,01	937,54	446,68	491,16	5 256,00	7 062,67
2008	0,95	5 298,57	1 678,71	942,97	439,94	503,07	5 371,49	7 209,93
2009	0,82	5 511,54	1 495,93	955,87	439,30	516,57	5 491,20	7 364,75
2010	1,33	5 871,84	1 560,71	976,10	454,35	521,80	5 615,10	7 527,39
2011	1,48	6 013,46	1 678,90	988,48	466,73	521,78	5 743,05	7 697,51
2012	0,01	6 467,22	1 242,31	1 001,93	480,69	521,33	5 872,81	7 874,84
2013	1,29	6 947,66	1 490,45	1 011,29	493,76	517,63	6 003,41	8 059,77
2014	0,54	7 412,16	1 783,67	1 019,97	505,68	514,42	6 133,66	8 252,83
2015	1,33	7 854,58	2 218,26	1 025,66	516,63	509,15	6 262,55	8 454,03
2016	1,86	8 400,41	2 667,48	1 029,74	527,36	502,50	6 389,52	8 663,58
2017	1,40	9 468,81	2 767,57	1 008,51	512,74	495,30	6 514,20	8 880,27
2018	1,70	10 144,51	3 204,01	991,44	500,85	489,69	6 636,03	9 100,84

Source: FAOSTAT, 2022

Speaking about the climate change impact on agricultural production performance and other national economy indicators development, it is possible to identify the positive correlations between temperature development and agricultural and national economy performance development. Following Tables 7-17, 7-18 and 7-19 provide an overview of bilateral correlations existing between temperature development and selected variables in the period 1992 – 2018. A strong correlation between temperatures development is existing especially in relation to crop production value and volume development (especially roots and tubers and cereals).

Table 7-17 Tajikistan – correlation existing between temperature development and agricultural gross value-added growth

	Correlations (Spreadsheet2) Marked correlations are significant at p < ,05000 N=27 (Casewise deletion of missing data)
Variable	Temperature in degree of Celsius
Agriculture, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,517314
Cereals, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,681124
Crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,587557
Food, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,534943
Livestock, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,383483
Meat indigenous, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,318605
Milk, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,435786
Non Food, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	-0,522302
Oilcrops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,174661
Roots and Tubers, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,668225
Vegetables and Fruit, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,491889

Source: FAOSTAT, own processing, 2022

Table 7-1 Tajikistan – correlation existing between temperature development and selected economy and society related variables development

	Correlations (Spreadsheet2) Marked correlations are significant at p < ,05000 N=27 (Casewise deletion of missing data)
Variable	Temperature in degree of Celsius
Gross Domestic Product, Value US$, 2015 prices, in millions	0,426919
Gross Fixed Capital Formation	-0,220435
Employment in agriculture, forestry and fishing - ILO in ths. persons	0,678174
Female	0,610601
Male	0,706421
Rural population	0,668012
Total population	0,631879

Source: FAOSTAT, own processing, 2022

Table 7-19 Tajikistan – correlation existing between temperature development and crops production volume development

Correlations (Spreadsheet2)
Marked correlations are significant at p < ,05000
N=27 (Casewise deletion of missing data)

Variable	Temperature in degree of Celsius
Cereals, Production in tonnes	0,670748
Citrus Fruit, Production in tonnes	0,573312
Fruit Primary	0,493462
Pulses, Production in tonnes	0,528196
Roots and Tubers, Production in tonnes	0,668226
Treenuts, Production in tonnes	-0,248088
Vegetables Primary Production in tonnes	0,484134
Production in tonnes crops production	0,601437

Source: FAOSTAT, own processing, 2022

Taking in consideration the massive growth of agricultural production and volume development performance it is possible to confirm the idea of the marginal negative impact of the climate change process on agriculture in Tajikistan. The volume of agricultural production recorded within the last three decades the interannual growth rate equal to 5.4% a year. But on the other hand, there are significant differences between individual decades. While the first decade was affected by the negative impact of civil war and the inter-annual growth rate of agricultural production volume reached only 1.5%/year. The second decade recorded a much more significant inter-annual growth rate about 10.7%/year. The last decade resulted in much lower production volume dynamics – only 3.8%/year. The reduction of production volume dynamics could be a result of limited water availability, slow process of land degradation and constantly decreasing soil quality (For details see Table 7-20).

Table 7-20 Tajikistan - Selected agricultural items average inter-annual growth rate volume development

Average inter-annual growth rate	Cereals, Production in tonnes	Citrus Fruit, Production in tonnes	Fruit Primary	Pulses, Production in tonnes	Roots and Tubers, Production in tonnes	Treenuts, Production in tonnes	Vegetables Primary Production in tonnes	Production in tonnes crops production
1992 - 2020	1,059423	1,043026	1,042198	1,065577	1,069681	0,989965	1,054969	1,054577
1st decade	1,090891	1,047541	0,986203	0,925079	1,077087	0,973453	0,952147	1,015239
2nd decade	1,110508	1,091368	1,084787	1,272187	1,095812	0,992492	1,129896	1,107744
3rd decade	0,984731	0,993005	1,051661	1,01205	1,037789	1,002318	1,079015	1,038468

Source: FAOSTAT, own processing, 2022

The same trend could be confirmed at the level of agricultural gross production value development. Especially, crop production is very sensitive to climate development and land quality and water availability and it recorded a significant value development dynamic reduction. A very significant drop between the second and third decade was indicated mainly in the case of cereals and roots and tubers. For details see Table 7- 21.

Table 7-21 Tajikistan - Selected agricultural items average inter-annual growth rate gross production value development

	Agriculture, Gross Production Value (constant 2014-2016 in 1000 US$)	Cereals, Gross Production Value (constant 2014-2016 in 1000 US$)	Crops, Gross Production Value (constant 2014-2016 in 1000 US$)	Food, Gross Production Value (constant 2014-2016 in 1000 US$)	Livestock, Gross Production Value (constant 2014-2016 in 1000 US$)	Meat indigenous, Gross Production Value (constant 2014-2016 in 1000 US$)	Milk, Gross Production Value (constant 2014-2016 in 1000 US$)	Oil crops, Gross Production Value (constant 2014-2016 in 1000 US$)	Roots and Tubers, Gross Production Value (constant 2014-2016 in 1000 US$)	Vegetables and Fruit, Gross Production Value (constant 2014-2016 in 1000 US$)
1992 - 2020	1,043171	1,060631	1,051853	1,049778	1,045181	1,062078	1,02778	1,00863	1,069681	1,045057
1st decade	0,97434	1,105166	1,012222	0,979494	0,912327	0,892623	0,939062	0,950191	1,077086	0,979112
2nd decade	1,085724	1,09855	1,095633	1,097334	1,097854	1,107127	1,081693	1,016881	1,095812	1,083711
3rd decade	1,064983	0,987257	1,044891	1,06809	1,122844	1,189093	1,058146	1,054957	1,037789	1,067897

Source: FAOSTAT, own processing, 2022

The following Table 7-23 provides an overview of logarithm regression analysis of mutual relations between selected agricultural and economy-related variables on one side and average annual temperature development in Tajikistan during the period of the last three decades. Based on the regression – we can estimate elasticities between temperature development and selected variables' performance development. Taking into consideration available results – it is possible to confirm the significant relations existing between climate/temperature and agricultural value and production performance. Crop production is estimated to be more sensitive in comparison to livestock production as it is more climate oriented and sensitive in general. Very sensitive are mainly roots and tubers and cereals. Another very sensitive feature was identified at the level of employment in agriculture and rural population growth. The male population is considered to be even more sensitive in comparison to the female population employed in agriculture. Changes in climate are considered to be a push driver for the especially male population to leave the agricultural sector. On the other hand, the female population is more stable and the number of women employed in agriculture is constantly increasing. The above-mentioned trend is typical especially for the last decade (For details – see Table 7-22 and the following Table 7-23).

Table 7-22 Tajikistan - Selected agricultural sector and economy-related variables average inter-annual growth rate development

Average inter-annual growth rate	Gross Domestic Product, Value US$, 2015 prices, in millions	Gross Fixed Capital Formation	Employment in agriculture, forestry and fishing - ILO in thous. persons	Female employment in agriculture in thous. persons	Male employment in agriculture in thous. persons	Rural population in thous. persons	Total population in thous. persons
1992 - 2020	1,030179	0,995852	1,011313	1,010982	1,011501	1,021437	1,019541
1st decade	0,933528	0,809698	1,012084	1,004178	1,019709	1,022526	1,015364
2nd decade	1,082473	1,095273	1,017921	1,013366	1,021859	1,020642	1,019015
3rd decade	1,070138	1,088313	1,004068	1,014677	0,99408	1,021264	1,023797

Source: FAOSTAT, own processing, 2022

Table 7-23 Tajikistan - logarithm regression analysis of mutual relations between selected agricultural and economy-related variables on one side and average annual temperature development in Tajikistan during the period of the last three decades

	Temperature in degree of Celsius					
	b*	Std. Err. of b*	b	Std. Err. of b	t-25	p-value
Agriculture, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,5173	0,1712	4,2924	1,4202	3,0224	0,0057
Cereals, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,6811	0,1464	6,9286	1,4896	4,6514	0,0001
Crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$) (Spreadsheet2)	0,5876	0,1618	5,6062	1,5442	3,6306	0,0013
Food, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,5349	0,1690	5,0402	1,5921	3,1658	0,0040
Livestock, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,3835	0,1847	3,6292	1,7481	2,0761	0,0483
Meat indigenous, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,3186	0,1896	3,5168	2,0926	1,6806	0,1053
Milk, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,4358	0,1800	3,5101	1,4499	2,4209	0,0231
Non-Food, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	-0,5223	0,1706	-2,9790	0,9728	-3,0624	0,0052
Oil crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,1747	0,1969	0,6492	0,7320	0,8869	0,3836
Roots and Tubers, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,6682	0,1488	8,9017	1,9821	4,4910	0,0001
Vegetables and Fruit, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	0,4919	0,1741	4,5722	1,6186	2,8248	0,0092
[redacted]						
Gross Domestic Product, Value US$, 2015 prices, in millions	0,4269	0,1809	3,3311	1,4112	2,3605	0,0264
Employment in agriculture, forestry and fishing - ILO in thous. persons	0,6782	0,1470	1,4049	0,3045	4,6140	0,0001
Female	0,6106	0,1584	1,3224	0,3430	3,8551	0,0007
Male	0,7064	0,1416	1,4735	0,2953	4,9903	0,0000
Rural population	0,6680	0,1488	1,9138	0,4264	4,4884	0,0001
Total population	0,6319	0,1550	1,6531	0,4055	4,0763	0,0004
[redacted]						
Cereals, Production in tonnes	0,6707	0,1483	6,8399	1,5127	4,5218	0,0001
Citrus Fruit, Production in tonnes	0,5733	0,1639	5,8508	1,6723	3,4986	0,0018
Fruit Primary	0,4935	0,1740	4,7577	1,6772	2,8368	0,0089
Pulses, Production in tonnes	0,5282	0,1698	9,0713	2,9166	3,1102	0,0046
Roots and Tubers, Production in tonnes	0,6682	0,1488	8,9017	1,9821	4,4910	0,0001
Treenuts, Production in tonnes	-0,2481	0,1937	-0,3565	0,2784	-1,2805	0,2121
Vegetables Primary Production in tonnes	0,4841	0,1750	4,9707	1,7967	2,7665	0,0105
Production in tonnes crops production	0,6014	0,1598	5,9244	1,5739	3,7641	0,0009

Source: FAOSTAT, own processing, 2022

Speaking about individual districts covered by this analysis – it is possible to confirm the above-mentioned trends existing at the level of the whole of Tajikistan. For details see the following Table 7-24. Available data related to grain/cereals production, yields and harvested areas is in line with the above-mentioned text except for Fayzabad and Kuhistoni Mastchoh. Speaking about cotton production – the situation is very critical as it is suffering because of a lack of available water and production performance is constantly decreasing mainly in Gissar and Kanibadam.

Table 7-24 Selected districts' agricultural production performance focused on grain and cotton production specifics

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
AREA	Grain crops (hectares)											
Gissar	8895,00	11239,00	10333,00	11598,00	12689,00	13228,00	11045,00	11305,00	11959,00	11947,00	10575,00	10555,00
Fayzabad	5482,00	5659,00	5040,00	5213,00	5384,00	4276,00	4417,00	4126,00	4269,00	4034,00	4052,00	3764,00
Kanibadam	2897,00	3306,00	3146,00	2528,00	3649,00	3268,00	2401,00	2372,00	2288,00	2316,00	2875,00	3406,00
Kuhistoni Mastchoh	1179,00	914,00	929,00	892,00	614,00	956,00	512,00	480,00	486,00	638,00	510,00	512,00
Muminabad	16197,00	16016,00	16085,00	16091,00	14177,00	12749,00	12025,00	11599,00	11078,00	10442,00	10286,00	10286,00
Shaartuz	3716,00	3967,00	3739,00	4055,00	5370,00	6083,00	4725,00	5140,00	4905,00	4518,00	4509,00	4435,00
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
	Cotton in hectares											
Gissar	6407,00	5101,00	3767,00	3231,00	1744,00	1546,00	2696,00	2290,00	1221,00	1059,00	573,00	225,00
Kanibadam	7856,00	7215,00	7001,00	6638,00	5626,00	6022,00	7226,00	7203,00	6715,00	6074,00	5022,00	4809,00
Shaartuz	7250,00	6351,00	6760,00	6216,00	4284,00	3107,00	5350,00	5200,00	5300,00	5300,00	5175,00	5175,00
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
YIELD	Grain yields											
Gissar	1,81	1,81	1,78	2,42	2,92	2,37	2,20	2,90	3,28	3,13	3,27	3,11
Fayzabad	1,78	1,47	1,42	1,26	1,84	1,00	1,03	1,51	1,66	1,81	1,91	2,10
Kanibadam	2,56	2,30	2,36	2,10	2,37	2,31	2,35	2,35	2,53	2,44	2,92	2,83
Kuhistoni Mastchoh	2,72	3,39	3,27	3,25	3,09	3,22	3,28	3,62	3,98	3,34	4,65	4,87
Muminabad	1,72	1,91	1,90	1,62	2,14	2,32	2,29	2,34	2,60	2,60	2,64	2,68
Shaartuz	3,62	3,64	3,90	3,79	3,88	3,86	3,95	3,95	4,76	4,99	5,01	5,03
	Cotton yield											
Gissar	2,03	2,27	2,39	1,99	2,10	2,45	2,47	2,67	2,19	1,91	2,13	2,54
Kanibadam	1,89	1,80	1,91	1,82	2,06	1,98	2,07	2,13	1,75	1,97	2,06	1,78
Shaartuz	1,17	2,09	2,04	1,91	2,10	2,03	2,11	2,24	2,11	2,16	1,49	1,77
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
PRODUCTION	Grain											
Gissar	20281,00	21240,00	20678,00	24263,00	38179,00	30834,00	24795,00	33942,00	40412,00	38982,00	35826,00	34873,00
Fayzabad	10043,00	8299,00	7174,00	6448,00	9885,00	4275,00	4575,00	6236,00	7080,00	7293,00	7729,00	7905,00
Kanibadam	8104,00	7896,00	7953,00	5188,00	8727,00	7678,00	6532,00	6009,00	6115,00	6356,00	8679,00	10093,00
Kuhistoni Mastchoh	3465,00	3094,00	3101,00	2895,00	1893,00	1918,00	15498,00	1736,00	1933,00	2180,00	2374,00	2490,00
Muminabad	27879,00	30575,00	30585,00	26288,00	30371,00	29741,00	27641,00	27745,00	28916,00	27214,00	27225,00	27638,00
Shaartuz	18925,00	18924,00	18950,00	19787,00	25591,00	30164,00	27305,00	30315,00	31472,00	32711,00	34832,00	35363,00
	Cotton											
Gissar	12784,00	11575,00	9011,00	6438,00	3669,00	3817,00	6668,00	6121,00	2680,00	2026,00	1166,00	572,00
Kanibadam	14818,00	12998,00	13350,00	11666,00	11535,00	11455,00	14765,00	15136,00	11776,00	11941,00	10368,00	8415,00
Shaartuz	8498,00	13256,00	13824,00	11851,00	9004,00	6292,00	11265,00	11666,00	11191,00	11462,00	7720,00	9016,00

Source: Tajikstat, 2022

Last three decades' development summary

Agricultural production in Tajikistan is constantly growing. The general agricultural volume and value performance significantly increased during the period 1992-2020. The volume of agricultural production increased from less than 1.4 million tonnes to more than 6 million tonnes. Agricultural performance growth is associated to both crop and livestock production. The key drivers of productivity growth are mainly crop products like cereals, fruit and vegetables and roots and tubers. The growth of production is mainly stimulated through the growth of agricultural land productivity as yields per hectare significantly increased during the last nearly thirty years (from 3 tonnes/hectare to nearly 9 tonnes per hectare). The key drivers of yields per hectare growth are mainly cereals, potatoes and fruit and vegetables. Agricultural production itself is more and more intensive. If we compare the intensity of production performance activities in nowadays and thirty years ago, the situation is rather different. Agricultural production is run by mainly small farmers and the size of individual farms is rather limited on the other hand the production activities are more intensive. The growth of production is pushed by increasing labour input and also through slowly increasing investments into agriculture. An important driver of production and also productivity growth is also research and development and newly available crop varieties are much more effective in comparison to crop varieties available thirty years ago. Newly available varieties are not so water demanding and they are also more resistant with respect to pests and diseases. Their production potential is, even more, higher in comparison to the varieties available in the past. Key problem of agricultural production management in Tajikistan is its sustainability as the total population is constantly increasing and also the agricultural population is still growing. The growth of the population is related to the necessity to increase agricultural production to feed people and to manage food security to secure stability both at the level of the national economy and also at the level of the whole society. Tajik government is developing constant pressure to increase national food security and to stimulate the growth of agricultural production performance. On the other hand, the growth of production is connected to the growth of necessary inputs especially fertilizers, water and capital. Speaking about fertilizer the situation is rather critical only in period 1992 till 2008 NPK nutrients utilization decreased from 128 thous. tonnes to about 5 thous. tonnes. Since 2011, we recorded some growth up to 15.5 thous. tonnes in 2019, but that growth is not able to compensate before mentioned reduction. That problem of very low utilization of NPK fertilizers is partly compensated by using animal manure. Its consumption was reduced in period 1992-2000 from 115 thous. tonnes to 85 thous. tonnes. But since 2001, its utilization increased up to 203 thous. tonnes (in 2019). The increasing content of applied fresh manure is partly responsible for better crop production performance and together with the application of better crop varieties – it is responsible for increasing yields. Better manure management is also important to protect arable land against fast degradation and also improve soil ability to keep water. Another problem is related to the issue of water availability and irrigation as only in the period 2003 – 2019 the irrigated area increased from 720 thous. hectares to 822 thous. hectares. However, the current agricultural production seems to be constantly increasing and the prevailing production trend could be considered as satisfactory – it is necessary to understand the situation as extremely critical as the current approach to agricultural activities management is not sustainable.

7.5.5.4. Assessment of direct and indirect economic effects related to agricultural performance during the next 10 respectively 20 years

Table 7-25 Tajikistan - agricultural gross production value development and prospect

	Agriculture, Gross Production Value (constant 2014-2016 in thousand US$)	Cereals, Gross Production Value (constant 2014-2016 in thousand US$)	Crops, Gross Production Value (constant 2014-2016 in thousand US$)	Food, Gross Production Value (constant 2014-2016 in thousand US$)	Livestock, Gross Production Value (constant 2014-2016 in thousand US$)	Meat indigenous, Gross Production Value (constant 2014-2016 in thousand US$)	Milk, Gross Production Value (constant 2014-2016 in thousand US$)	Oil crops, Gross Production Value (constant 2014-2016 in 1000 thousand US$)	Roots and Tubers, Gross Production Value (constant 2014-2016 in thousand US$)	Vegetables and Fruit, Gross Production Value (constant 2014-2016 in thousand US$)
1992	988 170	67 117	482 192	809 612	340 378	141 461	168 733	16 965	40 043	341 436
1993	843 696	66 909	417 974	660 790	257 163	86 127	157 226	17 352	35 163	288 898
1994	817 244	55 516	400 290	634 502	246 762	79 783	156 605	17 477	32 053	288 141
1995	756 089	61 143	405 312	614 732	218 681	85 012	127 330	13 659	26 695	295 829
1996	630 708	92 647	383 138	525 210	147 061	85 775	58 625	10 259	25 762	247 781
1997	695 259	142 040	429 691	573 748	151 956	72 195	77 588	11 650	30 647	232 346
1998	668 644	126 480	400 814	533 939	144 443	56 348	85 742	12 757	41 752	197 202
1999	665 422	124 183	404 185	555 199	159 666	56 983	99 684	10 657	57 315	195 084
2000	802 632	149 366	531 407	685 948	163 367	57 014	102 036	11 273	72 532	288 382
2001	839 149	123 549	500 138	687 222	193 432	61 937	125 896	15 326	73 720	281 623
2002	981 077	175 791	592 282	808 787	223 041	74 412	142 081	17 607	85 325	297 473
2003	1 065 628	220 375	639 400	889 048	253 439	92 994	151 378	18 900	113 223	265 539
2004	1 225 932	216 678	773 561	1 040 837	273 269	100 549	161 323	19 514	126 118	356 596
2005	1 247 764	229 256	805 085	1 098 324	298 649	112 740	175 290	16 464	132 788	378 588
2006	1 312 114	223 748	859 636	1 165 776	311 637	113 739	179 236	17 330	137 228	452 530
2007	1 352 208	227 579	883 869	1 212 256	333 355	120 916	191 858	15 724	158 375	444 526
2008	1 483 056	229 171	1 016 311	1 364 764	353 190	132 172	197 451	13 370	162 605	555 500
2009	1 682 643	348 040	1 208 959	1 582 483	378 499	142 481	206 866	13 106	165 255	594 552
2010	1 780 361	346 415	1 283 369	1 675 015	397 130	146 733	217 053	14 932	181 828	632 193
2011	1 837 409	264 046	1 283 173	1 697 606	420 312	157 035	228 576	18 464	206 457	687 030
2012	2 015 758	298 205	1 425 573	1 875 037	455 782	161 270	255 645	19 783	237 062	769 056
2013	2 212 664	333 436	1 569 750	2 079 665	516 604	176 442	296 919	19 364	266 879	831 451
2014	2 208 307	317 163	1 539 897	2 082 206	548 582	202 111	303 527	19 105	204 218	873 051
2015	2 310 020	333 591	1 587 518	2 217 144	635 668	271 565	318 170	17 523	212 274	923 923
2016	2 331 132	346 258	1 623 862	2 233 713	615 721	248 584	322 223	18 048	214 833	932 237
2017	2 825 309	345 908	1 681 902	2 695 184	1 019 123	640 638	332 874	23 613	187 271	982 054
2018	2 760 204	374 903	1 765 990	2 648 659	888 936	356 743	342 933	19 659	200 376	1 045 460
2019	2 903 453	387 415	1 807 005	2 791 998	991 174	419 940	353 003	18 552	209 711	1 078 366
2020	3 046 702	400 162	1 848 021	2 935 336	1 093 411	483 137	363 073	19 811	219 046	1 111 273
2021	3 189 951	412 909	1 889 036	3 078 674	1 195 649	546 334	373 143	23 459	228 381	1 144 179
2022	3 333 200	425 655	1 930 052	3 222 012	1 297 886	609 530	383 213	25 393	237 716	1 177 085
2023	3 476 450	438 402	1 971 067	3 365 351	1 400 124	672 727	393 283	26 686	247 051	1 209 991
2024	3 619 699	451 149	2 012 083	3 508 689	1 502 361	735 924	403 353	27 302	256 386	1 242 897
2025	3 762 948	463 895	2 053 098	3 652 027	1 604 599	799 121	413 423	24 256	265 721	1 275 803
2026	3 906 197	476 642	2 094 114	3 795 365	1 706 837	862 318	423 493	22 841	275 056	1 308 709
2027	4 049 446	489 389	2 135 129	3 938 703	1 809 074	925 514	433 563	22 748	284 391	1 341 616
2028	4 192 695	502 135	2 176 145	4 082 042	1 911 312	988 711	443 633	22 171	293 726	1 374 522
2029	4 335 944	514 882	2 217 160	4 225 380	2 013 549	1 051 908	453 703	21 063	303 061	1 407 428
2030	4 479 193	527 629	2 258 176	4 368 718	2 115 787	1 115 105	463 773	22 322	312 396	1 440 334
2031	4 622 442	540 375	2 299 191	4 512 056	2 218 024	1 178 301	473 843	25 971	321 731	1 473 240
2032	4 765 691	553 122	2 340 207	4 655 395	2 320 262	1 241 498	483 913	27 904	331 066	1 506 146
2033	4 908 940	565 868	2 381 222	4 798 733	2 422 499	1 304 695	493 983	29 197	340 401	1 539 052
2034	5 052 189	578 615	2 422 238	4 942 071	2 524 737	1 367 892	504 053	29 813	349 736	1 571 958
2035	5 195 439	591 362	2 463 253	5 085 409	2 626 974	1 431 088	514 123	26 768	359 071	1 604 865
2036	5 338 688	604 108	2 504 269	5 228 747	2 729 212	1 494 285	524 193	25 353	368 406	1 637 771
2037	5 481 937	616 855	2 545 284	5 372 086	2 831 450	1 557 482	534 263	25 260	377 741	1 670 677
2038	5 625 186	629 602	2 586 300	5 515 424	2 933 687	1 620 679	544 333	24 682	387 076	1 703 583
2039	5 768 435	642 348	2 627 315	5 658 762	3 035 925	1 683 875	554 403	23 575	396 411	1 736 489
2040	5 911 684	655 095	2 668 331	5 802 100	3 138 162	1 747 072	564 473	24 834	405 746	1 769 395

Source: FAOSTAT, own processing, 2022

Taking in consideration the available data and prevailing agricultural performance development trends, it is necessary to expect the continual growth of agricultural production performance (For details see Table 7-25). On the other hand, its dynamic growth is expected to be reduced. The most significant agricultural value dynamic growth is expected in the case of livestock production. But the significant dynamic reduction is also expected in the case of crop production value performance. The most affected aggregations are expected to be the following: roots and tubers, oil crops and cereals on the other hand vegetables and fruit production value performance are expected to continue rather progressive production value dynamic (For details see the Table 7-26).

Table 7-26 Tajikistan – an average inter-annual growth rate of agricultural gross production value development

	Agriculture, Gross Production Value (constant 2014-2016 in thousand US$)	Cereals, Gross Production Value (constant 2014-2016 in thousand US$)	Crops, Gross Production Value (constant 2014-2016 in thousand US$)	Food, Gross Production Value (constant 2014-2016 in thousand US$)	Livestock, Gross Production Value (constant 2014-2016 in thousand US$)	Meat indigenous, Gross Production Value (constant 2014-2016 in thousand US$)	Milk, Gross Production Value (constant 2014-2016 in thousand US$)	Oil crops, Gross Production Value (constant 2014-2016 in thousand US$)	Roots and Tubers, Gross Production Value (constant 2014-2016 in thousand US$)	Vegetables and Fruit, Gross Production Value (constant 2014-2016 in thousand US$)
1992-2000	0,982001	1,070151	1,004068	0,981954	0,939139	0,912317	0,9679836	0,988774	1,0701656	0,978828
2001-2010	1,082	1,079	1,099	1,095	1,081	1,098	1,061	1,019	1,108	1,093
2010-2020	1,056715	1,045725	1,039431	1,0613355	1,110205	1,132782	1,0502301	1,024233	1,0101434	1,05233
2021-2030	1,037788	1,027269	1,019843	1,0389654	1,063742	1,079891	1,0241791	1,010223	1,034864	1,0256
2031-2040	1,027711	1,021621	1,016682	1,0283348	1,039311	1,044735	1,0196366	0,995039	1,0261142	1,020561

Source: FAOSTAT, own processing, 2022

The above-mentioned problem could be demonstrated also at the level of expected production volume. However, data available for future production prospect development provides the pro-growth production trend – the inter-annual production volume dynamic is expected to be reduced (For details see Table 7-27 and Table 7-28). The only exceptions are expected to be roots and tubers and citrus fruits.

Table 7-2 Tajikistan – an average inter-annual growth rate of agricultural production volume development

	Cereals, Production in tonnes	Citrus Fruit, Production in tonnes	Fruit Primary	Pulses, Production in tonnes	Roots and Tubers, Production in tonnes	Treenuts, Production in tonnes	Vegetables Primary Production in tonnes	Production in tonnes crops production
1992-2000	1,0647	1,0106	0,9802	0,9515	1,0702	0,9976	0,9725	1,0114
2001-2010	1,0804	1,1454	1,0922	1,2620	1,1085	0,9776	1,1184	1,1009
2010-2020	1,0469	0,9827	1,0470	1,0360	1,0101	0,9816	1,0617	1,0349
2021-2030	1,0273	1,0351	1,0223	1,0176	1,0349	1,0192	1,0342	1,0099
2031-2040	1,0217	1,0263	1,0184	1,0151	1,0261	0,9866	1,0257	1,0091

Source: FAOSTAT, own processing, 2022

Table 7-3 Tajikistan - agricultural production volume development and prospect

	Cereals, Production in tonnes	Citrus Fruit, Production in tonnes	Fruit Primary	Pulses, Production in tonnes	Roots and Tubers, Production in tonnes	Treenuts, Production in tonnes	Vegetables Primary Production in tonnes	Production in tonnes crops production
1992	271 733	2 000	419 600	9 524	167 400	7 565	545 267	1 423 089
1993	266 735	1 600	343 900	6 039	147 000	6 300	487 890	1 259 464
1994	215 435	1 600	340 700	5 219	134 000	6 344	493 199	1 196 497
1995	242 350	1 600	361 100	5 672	111 600	6 252	495 876	1 224 450
1996	387 377	2 564	299 964	4 877	107 700	5 600	405 422	1 213 504
1997	559 463	2 200	303 691	8 307	128 119	4 900	361 990	1 368 670
1998	490 619	2 100	232 113	8 974	174 545	6 200	347 255	1 261 806
1999	474 338	2 640	214 564	8 144	239 609	6 250	403 352	1 348 897
2000	544 994	2 900	375 462	5 108	303 223	6 100	368 335	1 606 122
2001	477 651	2 200	350 398	6 087	308 189	7 400	424 113	1 576 038
2002	687 559	3 678	343 787	13 017	356 703	5 800	498 701	1 909 245
2003	866 197	5 744	263 174	18 252	473 331	5 466	609 511	2 241 675
2004	860 340	5 953	392 447	31 259	527 240	5 617	712 463	2 535 319
2005	902 912	5 800	413 330	31 968	555 125	5 875	755 761	2 670 771
2006	892 884	6 350	536 103	19 398	573 687	6 100	803 939	2 838 461
2007	906 552	6 391	532 895	24 652	662 093	5 700	885 351	3 023 634
2008	909 500	6 378	668 928	33 682	679 774	5 700	964 813	3 268 775
2009	1 399 868	6 370	781 026	44 587	690 853	5 700	1 105 579	4 033 983
2010	1 382 559	6 551	835 343	53 972	760 139	5 700	1 180 989	4 225 253
2011	1 034 798	8 551	846 351	62 394	863 100	5 900	1 298 699	4 119 793
2012	1 175 450	8 127	950 328	56 746	991 044	6 000	1 417 368	4 605 063
2013	1 328 800	7 913	1 002 811	63 549	1 115 696	5 900	1 592 913	5 117 582
2014	1 257 989	8 114	1 080 241	67 767	853 738	5 900	1 644 245	4 917 994
2015	1 324 045	9 484	1 136 857	67 136	887 418	5 801	1 778 034	5 208 775
2016	1 367 078	5 732	1 144 978	67 019	898 116	5 751	1 824 282	5 312 956
2017	1 365 515	5 998	1 200 828	79 578	782 892	5 789	1 918 738	5 359 338
2018	1 483 987	6 294	1 240 801	83 787	837 678	5 906	2 079 846	5 623 699
2019	1 534 650	6 591	1 273 865	85 479	876 703	6 215	2 174 328	5 683 866
2020	1 585 313	6 887	1 306 929	87 171	915 728	5 424	2 268 810	5 744 033
2021	1 635 976	7 183	1 339 993	88 863	954 753	4 898	2 363 292	5 804 201
2022	1 686 640	7 480	1 373 056	90 555	993 779	5 682	2 457 774	5 864 368
2023	1 737 303	7 776	1 406 120	92 247	1 032 804	5 803	2 552 256	5 924 535
2024	1 787 966	8 072	1 439 184	93 939	1 071 829	5 761	2 646 738	5 984 703
2025	1 838 629	8 369	1 472 247	95 631	1 110 854	6 070	2 741 220	6 044 870
2026	1 889 292	8 665	1 505 311	97 323	1 149 879	5 279	2 835 702	6 105 037
2027	1 939 955	8 961	1 538 375	99 015	1 188 905	4 753	2 930 184	6 165 205
2028	1 990 619	9 258	1 571 439	100 707	1 227 930	5 538	3 024 666	6 225 372
2029	2 041 282	9 554	1 604 502	102 399	1 266 955	5 658	3 119 148	6 285 539
2030	2 091 945	9 850	1 637 566	104 091	1 305 980	5 616	3 213 630	6 345 707
2031	2 142 608	10 147	1 670 630	105 783	1 345 005	5 926	3 308 112	6 405 874
2032	2 193 271	10 443	1 703 693	107 475	1 384 030	5 135	3 402 594	6 466 041
2033	2 243 934	10 739	1 736 757	109 167	1 423 056	4 609	3 497 075	6 526 209
2034	2 294 598	11 035	1 769 821	110 859	1 462 081	5 393	3 591 557	6 586 376
2035	2 345 261	11 332	1 802 885	112 551	1 501 106	5 514	3 686 039	6 646 543
2036	2 395 924	11 628	1 835 948	114 243	1 540 131	5 472	3 780 521	6 706 711
2037	2 446 587	11 924	1 869 012	115 935	1 579 156	5 781	3 875 003	6 766 878
2038	2 497 250	12 221	1 902 076	117 628	1 618 182	4 990	3 969 485	6 827 045
2039	2 547 913	12 517	1 935 139	119 320	1 657 207	4 464	4 063 967	6 887 213
2040	2 598 577	12 813	1 968 203	121 012	1 696 232	5 248	4 158 449	6 947 380

Source: FAOSTAT, own processing, 2022

The available data could be considered as rather tricky speaking about the future prediction as the really negative impact of climate change development is expected after 2040. Taking in consideration available predictions and models the direct climate change impact associated with agricultural production volume reduction is expected for the period not covered by this analysis. The majority of prediction models expect possible reductions during the period 2040 – 2060. The before mentioned fact is even confirmed by the applied CARD model. The CARD model results for selected crop items (cotton, potatoes, wheat) at the level of the whole of Tajikistan are available in the following Tables (Tables 7-29, 7-30 and 7-31). Data forecast for individually selected districts i.e., Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam and Muminabad for wheat (both rain feed and irrigated) is available in Tables 7-32 and 7-33 respectively Tables 7-34 and 7-35. Prediction for cotton (both production volume and yield) is available in the Table 7-36 and Table 7-37. Taking into consideration individual results calculated for individual districts under the analysis – it is possible to highlight only marginal negative production impact on individual districts and selected crop production performance up to 2030, respectively 2040. The limit/weakness of the above-mentioned statements is the choice of the only CARD model.

Table 7-4 Expected change in production of cotton with respect to 2020

	COTTON Expected change of production (t/ha), with respect to year 2020					
	Rainfed land - scenarios			Full Irrigation - scenarios		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2021	2,02	1,94	2,05	2,02	2,02	2,02
2022	2,01	1,91	2,06	2,02	2,01	2,02
2023	2,02	1,90	2,03	2,02	2,00	2,01
2024	1,96	1,85	1,99	2,01	2,00	2,01
2025	1,96	1,83	1,97	2,01	1,99	2,01
2026	1,96	1,81	1,98	2,00	1,99	2,01
2027	1,96	1,80	1,86	2,00	1,99	2,01
2028	1,96	1,88	1,86	2,00	1,98	2,01
2029	2,03	1,92	1,88	2,00	1,98	2,01
2030	2,03	1,96	1,90	2,00	1,97	2,01
2031	2,01	1,94	1,88	2,00	1,96	2,01
2032	1,97	1,98	1,91	2,00	1,96	2,01
2033	2,00	1,95	1,85	2,00	1,94	2,01
2034	2,00	1,95	1,85	1,99	1,94	2,01
2035	2,00	2,02	1,92	1,99	1,93	2,01
2036	2,00	2,09	1,92	1,99	1,93	2,01
2037	2,00	2,05	1,93	1,99	1,92	2,01
2038	2,01	2,06	1,97	1,98	1,91	2,01
2039	1,99	2,04	1,90	1,98	1,89	2,00
2040	1,99	2,08	1,90	1,98	1,89	2,00
2041	1,99	2,09	1,91	1,98	1,88	2,00
2042	1,99	2,12	1,91	1,98	1,88	2,00
2043	1,99	2,09	1,94	1,97	1,86	2,00
2044	2,00	2,08	1,92	1,96	1,86	2,00
2045	2,02	2,06	1,92	1,95	1,85	2,00
2046	1,98	2,10	1,92	1,95	1,84	1,99
2047	1,98	2,07	1,95	1,95	1,84	1,99
2048	1,91	2,08	2,03	1,94	1,83	1,99
2049	1,90	2,06	2,07	1,94	1,82	1,99
2050	1,98	2,01	2,08	1,93	1,82	1,99

Source: CARD and own calculation, 2022

Table 7-5 Expected change in production of potatoes with respect to 2020

	POTATOES Expected change of production, with respect to year 2020					
	Rainfed land - scenarios			Full Irrigation - scenarios		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2021	20,85	20,78	20,97	20,69	20,75	20,68
2022	20,77	20,82	20,90	20,69	20,66	20,72
2023	20,78	20,66	21,11	20,73	20,54	20,85
2024	20,84	20,60	21,11	20,70	20,44	20,82
2025	20,82	20,57	20,86	20,63	20,56	20,84
2026	20,94	20,51	20,85	20,61	20,58	20,92
2027	20,82	20,43	20,78	20,57	20,52	20,81
2028	20,72	20,45	20,70	20,57	20,36	20,96
2029	20,84	20,42	20,68	20,58	20,46	20,68
2030	21,07	20,50	20,61	20,55	20,36	20,71
2031	21,08	20,36	20,58	20,50	20,09	20,67
2032	20,76	20,35	20,74	20,47	20,02	20,74
2033	20,89	20,38	20,69	20,41	19,66	20,89
2034	21,03	20,33	21,07	20,42	19,57	20,86
2035	21,13	20,13	21,00	20,26	19,55	20,90
2036	21,09	20,07	21,04	20,34	19,44	20,92
2037	21,11	19,99	21,28	20,23	19,32	20,98
2038	21,45	20,08	21,26	20,26	19,46	21,02
2039	21,23	19,99	21,30	19,98	19,45	21,01
2040	21,34	19,74	21,36	20,01	19,19	21,01
2041	21,17	19,62	21,43	20,10	19,04	20,99
2042	21,24	19,67	21,65	20,15	19,03	21,05
2043	21,20	19,58	21,59	20,06	18,59	21,06
2044	21,20	19,52	21,44	19,81	18,61	21,16
2045	21,13	19,59	21,58	19,86	18,36	21,27
2046	21,26	19,43	21,68	19,81	18,23	21,16
2047	21,24	19,37	21,73	19,74	18,09	21,26
2048	21,25	19,34	21,41	19,62	18,02	21,32
2049	21,22	19,27	21,64	19,51	17,98	21,43
2050	21,16	19,18	21,24	19,45	17,87	21,42

Source: CARD and own calculation, 2022

Table 7-31 Expected change in production of wheat with respect to 2020

	WHEAT Expected change of production, with respect to year 2020					
	Rainfed land - scenarios			Full Irrigation - scenarios		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2021	3,17	3,15	3,20	3,14	3,15	3,13
2022	3,15	3,16	3,18	3,14	3,13	3,14
2023	3,15	3,13	3,23	3,14	3,10	3,17
2024	3,17	3,12	3,23	3,14	3,08	3,16
2025	3,16	3,11	3,17	3,12	3,11	3,17
2026	3,19	3,10	3,17	3,12	3,11	3,18
2027	3,16	3,08	3,15	3,11	3,10	3,16
2028	3,14	3,08	3,14	3,11	3,06	3,19
2029	3,17	3,08	3,13	3,11	3,09	3,13
2030	3,22	3,09	3,12	3,11	3,06	3,14
2031	3,22	3,06	3,11	3,09	3,00	3,13
2032	3,15	3,06	3,15	3,09	2,99	3,15
2033	3,18	3,07	3,14	3,07	2,91	3,18
2034	3,21	3,06	3,22	3,07	2,89	3,17
2035	3,23	3,01	3,20	3,04	2,88	3,18
2036	3,22	3,00	3,21	3,06	2,86	3,19
2037	3,23	2,98	3,26	3,03	2,83	3,20
2038	3,30	3,00	3,26	3,04	2,86	3,21
2039	3,25	2,98	3,27	2,98	2,86	3,20
2040	3,28	2,93	3,28	2,99	2,81	3,21
2041	3,24	2,90	3,30	3,00	2,77	3,20
2042	3,26	2,91	3,34	3,02	2,77	3,21
2043	3,25	2,89	3,33	3,00	2,68	3,22
2044	3,25	2,88	3,30	2,94	2,68	3,24
2045	3,23	2,89	3,33	2,95	2,62	3,26
2046	3,26	2,86	3,35	2,94	2,60	3,24
2047	3,26	2,85	3,36	2,93	2,57	3,26
2048	3,26	2,84	3,29	2,90	2,55	3,27
2049	3,25	2,82	3,34	2,88	2,54	3,30
2050	3,24	2,81	3,26	2,86	2,52	3,29

Source: CARD and own calculation, 2022

7-6 – Wheat, rainfed – yield per hectare development and prediction in selected districts

	Kuhistoni Mastchoh (4.87)			Gissar (3.11)			Shaartuz (5.03)			Fayzabad (2.1)			Kanibadam (2.83)			Muminabad (2.68)		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2017	4,86	4,86	4,86	3,10	3,09	3,12	5,00	4,93	5,13	2,09	2,08	2,13	2,79	2,77	2,89	2,67	2,67	2,69
2018	4,86	4,84	4,77	3,11	3,09	3,13	5,04	5,00	5,25	2,10	2,09	2,12	2,83	2,81	2,99	2,69	2,67	2,69
2019	4,90	4,83	4,91	3,10	3,10	3,17	5,01	4,96	5,25	2,10	2,06	2,17	2,81	2,82	2,96	2,67	2,67	2,74
2020	4,86	4,83	4,78	3,08	3,09	3,13	4,97	5,00	5,26	2,09	2,10	2,13	2,78	2,82	2,99	2,65	2,67	2,69
2021	4,87	4,87	4,70	3,10	3,10	3,11	4,97	4,99	5,26	2,09	2,11	2,12	2,78	2,80	2,96	2,68	2,68	2,69
2022	4,88	4,87	4,76	3,10	3,10	3,15	4,95	4,98	5,29	2,09	2,10	2,12	2,76	2,79	3,02	2,68	2,68	2,71
2023	4,89	4,85	4,79	3,12	3,07	3,12	4,96	4,91	5,19	2,09	2,07	2,12	2,77	2,76	2,91	2,70	2,65	2,69
2024	4,91	4,78	4,79	3,13	3,04	3,11	4,97	4,84	5,16	2,10	2,04	2,12	2,80	2,72	2,89	2,70	2,62	2,69
2025	4,93	4,76	4,77	3,10	3,05	3,11	4,93	4,88	5,18	2,10	2,04	2,12	2,77	2,77	2,93	2,67	2,62	2,68
2026	4,99	4,74	4,70	3,13	3,03	3,07	4,95	4,86	5,15	2,13	2,04	2,10	2,77	2,77	2,89	2,70	2,61	2,65
2027	4,95	4,74	4,78	3,13	3,02	3,10	4,98	4,78	5,18	2,10	2,03	2,12	2,82	2,71	2,92	2,69	2,60	2,67
2028	4,94	4,72	4,72	3,13	3,00	3,08	4,99	4,79	5,18	2,12	2,03	2,09	2,81	2,71	2,93	2,70	2,59	2,65
2029	4,89	4,72	4,70	3,11	3,00	3,09	5,02	4,80	5,16	2,11	2,03	2,08	2,84	2,72	2,90	2,68	2,59	2,66
2030	4,98	4,72	4,69	3,15	3,03	3,08	5,08	4,90	5,15	2,13	2,04	2,08	2,87	2,79	2,87	2,71	2,61	2,66
2031	4,98	4,72	4,71	3,15	3,01	3,06	5,05	4,83	5,08	2,12	2,03	2,08	2,87	2,76	2,81	2,71	2,59	2,65
2032	4,87	4,69	4,72	3,11	3,00	3,08	4,98	4,82	5,10	2,08	2,02	2,10	2,80	2,75	2,86	2,68	2,58	2,67
2033	4,91	4,70	4,64	3,14	3,00	3,07	5,02	4,84	5,13	2,11	2,02	2,07	2,84	2,76	2,88	2,71	2,58	2,66
2034	4,92	4,71	4,68	3,14	2,98	3,11	5,05	4,79	5,30	2,11	2,02	2,13	2,87	2,71	2,96	2,70	2,57	2,69
2035	4,94	4,70	4,69	3,15	2,98	3,10	5,05	4,80	5,27	2,11	2,02	2,12	2,87	2,71	2,93	2,71	2,56	2,68
2036	5,02	4,66	4,70	3,16	2,96	3,11	4,98	4,79	5,28	2,12	2,01	2,13	2,79	2,69	2,94	2,73	2,55	2,69
2037	5,02	4,60	4,74	3,17	2,93	3,15	4,99	4,74	5,33	2,12	1,99	2,15	2,81	2,68	2,97	2,73	2,52	2,73
2038	5,02	4,65	4,89	3,19	2,94	3,20	5,13	4,72	5,30	2,15	2,00	2,17	2,91	2,66	2,96	2,74	2,53	2,77
2039	5,02	4,59	4,85	3,18	2,91	3,20	5,09	4,68	5,32	2,13	1,97	2,17	2,90	2,64	2,96	2,73	2,50	2,77
2040	5,09	4,54	4,87	3,20	2,89	3,21	5,08	4,65	5,31	2,15	1,95	2,16	2,88	2,63	2,96	2,75	2,48	2,78
2041	5,01	4,53	4,89	3,20	2,87	3,22	5,11	4,64	5,37	2,15	1,94	2,19	2,88	2,61	2,99	2,76	2,47	2,79
2042	5,04	4,51	4,90	3,17	2,87	3,23	5,01	4,64	5,38	2,14	1,93	2,19	2,80	2,62	3,02	2,74	2,47	2,80
2043	5,13	4,48	4,89	3,18	2,85	3,24	4,98	4,57	5,45	2,16	1,90	2,20	2,74	2,59	3,06	2,75	2,45	2,80
2044	5,00	4,48	4,89	3,13	2,86	3,22	4,95	4,56	5,41	2,13	1,91	2,18	2,73	2,58	3,05	2,71	2,46	2,78
2045	5,02	4,48	4,98	3,14	2,88	3,26	4,92	4,62	5,41	2,13	1,92	2,21	2,71	2,62	3,03	2,72	2,48	2,82
2046	5,14	4,44	4,96	3,20	2,81	3,25	5,00	4,51	5,35	2,16	1,88	2,20	2,79	2,53	2,99	2,76	2,42	2,82
2047	5,14	4,44	5,01	3,20	2,80	3,26	5,00	4,46	5,39	2,15	1,88	2,22	2,78	2,49	3,01	2,76	2,41	2,82
2048	5,15	4,42	5,04	3,20	2,81	3,28	4,96	4,52	5,43	2,16	1,87	2,23	2,76	2,55	3,04	2,76	2,41	2,83
2049	5,12	4,39	5,08	3,17	2,78	3,30	4,91	4,45	5,45	2,15	1,85	2,25	2,71	2,50	3,05	2,75	2,39	2,85
2050	5,08	4,37	5,14	3,16	2,78	3,27	4,86	4,42	5,34	2,12	1,85	2,23	2,69	2,50	2,95	2,73	2,39	2,83

Source: CARD and own calculation, 2022

Table 7-33– Wheat, irrigated – yield per hectare development and prediction in selected districts

	Kuhistoni Mastchoh (4.87)			Gissar (3.11)			Shaartuz (5.03)			Fayzabad (2.1)			Kanibadam (2.83)			Muminabad (2.68)		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2017	4,88	4,85	4,83	3,11	3,09	3,10	5,02	4,98	5,03	2,10	2,09	2,10	2,83	2,78	2,83	2,68	2,67	2,67
2018	4,87	4,88	4,82	3,10	3,11	3,10	5,01	5,03	5,05	2,10	2,12	2,10	2,82	2,82	2,83	2,67	2,69	2,68
2019	4,87	4,85	4,82	3,10	3,10	3,10	5,00	4,95	5,06	2,09	2,09	2,09	2,82	2,77	2,87	2,67	2,68	2,67
2020	4,85	4,87	4,76	3,10	3,10	3,08	5,01	4,94	5,07	2,09	2,09	2,08	2,82	2,76	2,89	2,67	2,68	2,65
2021	4,87	4,85	4,74	3,10	3,09	3,08	4,98	4,91	5,07	2,09	2,08	2,07	2,81	2,74	2,88	2,67	2,67	2,65
2022	4,87	4,84	4,84	3,10	3,08	3,10	4,96	4,89	5,04	2,08	2,07	2,10	2,80	2,73	2,84	2,67	2,67	2,67
2023	4,87	4,83	4,92	3,10	3,07	3,13	4,97	4,83	5,04	2,08	2,05	2,11	2,80	2,69	2,84	2,67	2,66	2,70
2024	4,87	4,83	4,92	3,10	3,08	3,14	4,97	4,80	5,05	2,08	2,04	2,11	2,81	2,68	2,86	2,67	2,67	2,70
2025	4,88	4,83	4,84	3,10	3,08	3,12	4,97	4,84	5,05	2,09	2,06	2,09	2,81	2,70	2,87	2,66	2,68	2,69
2026	4,88	4,81	4,89	3,09	3,09	3,13	4,95	4,86	5,06	2,08	2,06	2,11	2,79	2,74	2,87	2,66	2,67	2,70
2027	4,85	4,81	4,80	3,08	3,07	3,10	4,94	4,76	5,04	2,07	2,04	2,08	2,79	2,68	2,86	2,65	2,66	2,67
2028	4,86	4,79	4,82	3,08	3,08	3,12	4,92	4,79	5,06	2,07	2,05	2,09	2,78	2,69	2,89	2,65	2,67	2,69
2029	4,87	4,77	4,69	3,08	3,06	3,06	4,92	4,82	5,02	2,07	2,06	2,06	2,77	2,71	2,84	2,65	2,65	2,64
2030	4,87	4,75	4,63	3,08	3,06	3,04	4,91	4,75	5,01	2,07	2,02	2,06	2,77	2,69	2,82	2,65	2,65	2,63
2031	4,87	4,73	4,64	3,07	3,04	3,04	4,90	4,68	5,01	2,06	2,00	2,05	2,77	2,63	2,82	2,64	2,64	2,63
2032	4,84	4,72	4,65	3,06	3,04	3,06	4,87	4,63	5,04	2,06	1,97	2,06	2,73	2,61	2,84	2,63	2,64	2,64
2033	4,84	4,70	4,64	3,05	3,03	3,07	4,86	4,54	5,08	2,05	1,95	2,07	2,73	2,54	2,86	2,63	2,64	2,65
2034	4,83	4,67	4,65	3,04	3,00	3,07	4,82	4,43	5,09	2,04	1,92	2,07	2,72	2,47	2,86	2,62	2,62	2,66
2035	4,82	4,60	4,66	3,04	2,99	3,08	4,82	4,45	5,09	2,04	1,91	2,07	2,72	2,47	2,87	2,62	2,61	2,67
2036	4,78	4,58	4,64	3,01	2,98	3,07	4,78	4,44	5,10	2,02	1,91	2,07	2,70	2,47	2,87	2,59	2,61	2,66
2037	4,77	4,57	4,66	3,01	2,97	3,08	4,76	4,38	5,11	2,02	1,89	2,08	2,69	2,43	2,88	2,59	2,60	2,67
2038	4,80	4,53	4,71	3,03	2,97	3,10	4,76	4,43	5,13	2,02	1,90	2,09	2,69	2,48	2,90	2,61	2,60	2,68
2039	4,77	4,51	4,69	3,00	2,97	3,11	4,74	4,42	5,15	2,01	1,88	2,09	2,67	2,49	2,90	2,58	2,60	2,69
2040	4,75	4,52	4,72	3,00	2,95	3,11	4,71	4,28	5,16	2,00	1,85	2,10	2,65	2,40	2,91	2,58	2,59	2,69
2041	4,76	4,47	4,73	3,00	2,93	3,11	4,73	4,21	5,15	2,00	1,83	2,10	2,68	2,35	2,90	2,58	2,57	2,69
2042	4,74	4,53	4,72	2,99	2,96	3,12	4,71	4,28	5,16	2,00	1,86	2,10	2,65	2,38	2,92	2,58	2,60	2,70
2043	4,71	4,43	4,72	2,98	2,92	3,12	4,69	4,17	5,13	1,98	1,81	2,10	2,64	2,33	2,90	2,56	2,57	2,70
2044	4,70	4,41	4,73	2,96	2,92	3,13	4,67	4,14	5,16	1,98	1,80	2,11	2,62	2,30	2,93	2,55	2,57	2,71
2045	4,71	4,40	4,73	2,95	2,91	3,14	4,63	4,09	5,20	1,98	1,80	2,12	2,59	2,27	2,95	2,55	2,58	2,72
2046	4,73	4,39	4,76	2,96	2,90	3,14	4,60	4,00	5,18	1,98	1,77	2,11	2,58	2,22	2,93	2,55	2,56	2,72
2047	4,72	4,38	4,80	2,95	2,89	3,16	4,58	3,97	5,21	1,97	1,76	2,13	2,57	2,21	2,95	2,55	2,56	2,74
2048	4,61	4,38	4,82	2,91	2,90	3,18	4,57	3,97	5,23	1,95	1,74	2,14	2,56	2,23	2,97	2,52	2,56	2,75
2049	4,59	4,34	4,80	2,90	2,90	3,19	4,53	3,95	5,28	1,93	1,74	2,15	2,54	2,21	2,99	2,50	2,57	2,76
2050	4,59	4,33	4,78	2,88	2,89	3,18	4,50	3,93	5,29	1,92	1,73	2,14	2,52	2,21	2,99	2,48	2,56	2,75

Source: CARD and own calculation, 2022

Table 7-34 Wheat, rainfed – production volume prediction 2030 and 2040 in thous. tonnes in selected districts

	Kuhistoni Mastchoh (4.87)			Gissar (3.11)			Shaartuz (5.03)			Fayzabad (2.1)			Kanibadam (2.83)			Muminabad (2.68)		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2030	2548,298	2416,283	2402,419	33273,92	32028,52	32473,62	22512,8	21721,34	22843,86	8029,891	7692,384	7842,914	9769,126	9502,495	9772,587	27880,9	26879,5	27365,12
2040	2604,149	2326,656	2491,552	33793,3	30463,72	33866,57	22549,89	20629,67	23570,56	8077,519	7336,41	8148,399	9820,657	8963,341	10080,77	28269,11	25526,17	28638,8

Source: CARD and own calculation, 2022

Table 7-7 Wheat, irrigated – production volume prediction 2030 and 2040 in thous. tonnes in selected districts

	Kuhistoni Mastchoh (4.87)			Gissar (3.11)			Shaartuz (5.03)			Fayzabad (2.1)			Kanibadam (2.83)			Muminabad (2.68)		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2030	2495,443	2434,332	2372,521	32485,01	32246,03	32100,94	21756,67	21085,37	22240,69	7776,79	7594,421	7752,128	9420,837	9151,661	9612,867	27224,01	27218,67	27089,49
2040	2432,594	2313,263	2416,07	31631,14	31156,21	32810,88	20893,44	18975,73	22864,79	7540,332	6957,975	7897,662	9037,476	8175,595	9898,576	26563,56	26602,3	27655,54

Source: CARD and own calculation, 2022

Table 7-8 Cotton, irrigated - yield per hectare development and prediction in selected districts

	GISSAR			Shaartuz			Kanibadam		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2030	3,15	3,03	3,08	1,73	1,7	1,74	1,74	1,71	1,75
2040	3,21	2,89	3,21	1,71	1,62	1,73	1,72	1,63	1,75

Source: CARD and own calculation, 2022

Table 7-9 Cotton, irrigated - production volume prediction 2030 and 2040 in thous. tonnes in selected districts

	GISSAR			Shaartuz			Kanibadam		
	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic	Median	Pessimistic	Optimistic
2030	708,75	681,75	693	8952,75	8797,5	9004,5	8367,66	8223,39	8415,75
2040	722,25	650,25	722,25	8849,25	8383,5	8952,75	8271,48	7838,67	8415,75

Source: CARD and own calculation, 2022

<u>Next two decades' development summary (prediction for 2030 and 2040)</u>

Speaking about the next two decades' development – it is possible to expect especially indirect negative effects impacts related to upcoming climate change. The reduction of the inter-annual growth rate of yields and production volume is expected. Agricultural production will suffer because of limited water availability. There is also a problem related to a continual process of land degradation as the result of too intensive agricultural activities and bad agricultural land management. The agricultural sector will suffer because of limited ability to reach effective economies of scale as the farm size is very low. The majority of farms are suffering because of too low agricultural land area and also because of limited access to capital. The only limited trade-off between labour and capital is also possible to consider as a significant weakness. Agricultural production and capacities are considered to be limited with respect to the only limited area of agricultural land suitable for intensive agricultural activities and also because of biological and genetic limits.

Taking in consideration the state of Tajik agriculture, its dependency on old technologies and its extreme decomposition into many extremely small farms – it is not possible to continue in the current trend forever. Agriculture is pressed to produce more and more outputs – but the main limit of production growth is water availability. More production means more water consumption, but there is no additional source of water. The frequency of precipitation is not increasing. In some districts, the amount of precipitations is even decreasing and a significant portion of precipitation is even realized in the non-vegetative part of the year. Glaciers as a significant source of water could be considered only as a temporary source. As the volume and area of key glaciers are constantly decreasing – it is not possible to consider glaciers as a long-term and sustainable water source. Speaking about underground water sources – there is also a significant problem. Underground water accumulation takes hundreds or even thousands of years. Underground water extraction for agricultural purposes cannot be considered as full compensation of low precipitations and increasing water demand. It is also necessary to highlight the fact, that agriculture is not the only sector consuming water. As the population is increasing and also as Tajikistan is in the process of economic transition – the water consumption at the level of households, services and industry is also increasing and the agricultural sector has to compete for water to other consumers. It is also necessary to mention the problem of water transfer at the international level. However, there are several significant rivers spread over the territory of Tajikistan – the water availability for local purposes is limited. A significant portion of water is already consumed in countries taking control over individual rivers before the water reaches Tajikistan. The second problem is the obligation of Tajikistan not to consume all available water and to transfer the specific amount of water into neighbour countries.

Taking in consideration the above-mentioned arguments – it is necessary to manage the transformation of the agricultural and water distribution sector and systems in Tajikistan. It is necessary to apply better water distribution schemes and technologies. It is also necessary to make the agricultural sector more water consumption effective.

8. The effects of climate change on water resources

8.1. Tajikistan's glaciers

The main problems connected with climate change affecting glaciers

The retreat of the 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 fresh water 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;

River flow. The recently observed increases in river flows are unlikely to continue until the middle of the 21st century in the rivers of the Western and Eastern Pamir (the Pyanj River basin). In the absence of 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 increases. 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 are breached. 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.

Tajikistan has more than 8,000 glaciers, 19 of them large. They are involved in feeding the main rivers of the republic and during the hottest days of summer they give fresh water, which is very necessary not only for Tajikistan, but also for other countries of the Central Asian region. In recent decades, under the influence of climate change, some large glaciers have shrunk and retreated by kilometers. Scientists argue that the melting of glaciers is virtually irreversible, and the industrial age has only accelerated the process.

Tajikistan is the leader in the number of glaciers in Central Asia. Although glaciers cover only 6-8% of the country's territory (8,476.2 square kilometers), they hold several hundred cubic kilometers of freshwater. The main share of glaciation is concentrated in the territory adjacent to the highest peaks of the republic – the peaks of Somoni and Abu Ali ibn Sino.

Large glaciers in Tajikistan feed the Amu Darya and Zaravshan river systems, whose water flows down to the downstream countries – Uzbekistan, Turkmenistan, and Kazakhstan. Therefore, it is customary to say that most of the region's water is generated in Tajikistan (CABAR, 2021).

The largest glaciers

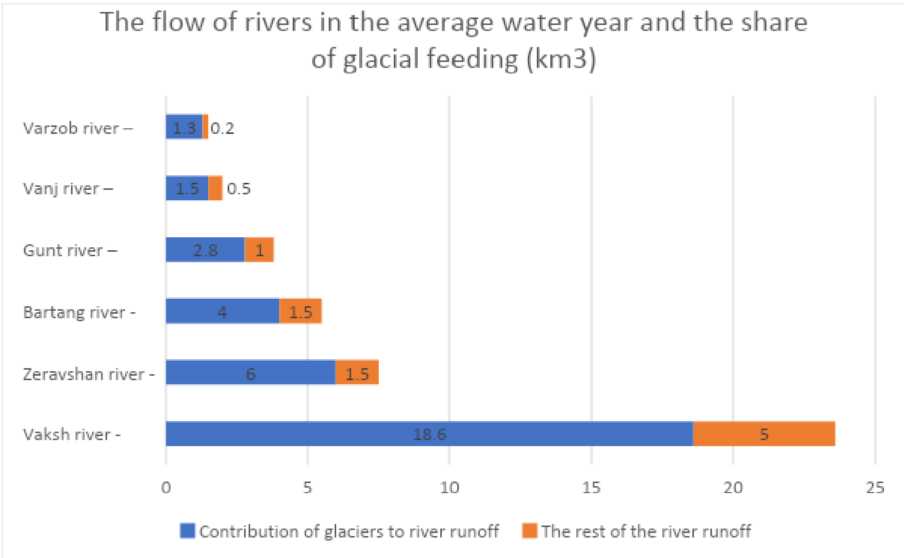
Tajikistan has the largest glaciers in the Central Asian region. According to the "Centre for the Study of Glaciers of Tajikistan", glaciers originating on the slopes of the Somoni peak reach a height of 7,400 meters above sea level, while in the basins of the Surkhob and Kafirnigan rivers rarely exceed 4,500-5,000 meters above sea level.

The largest glaciers of Tajikistan are confined to the glaciation knot at the junction of the highest ridges: Akademiya Nauk, Darvaz, Peter the Great, Vanch and Yazgulem. The largest glacier in Central Asia – Fedchenko – originates here. In total, there are 18 types of glaciers in the republic, the main share of which is concentrated in the east of the country.

The largest glacier in Central Asia – Fedchenko, located in the Pamirs, used to be three times bigger and its length reached Lakhsh (Tajikistan's border area with Kyrgyzstan). Then it began to melt and now its length reaches 70 km, and in a **decade, it will shrink by another 2 km.**

According to the Centre of Glaciology of the Agency for Hydrometeorology of Tajikistan, the main hydrological role of glaciers is to form the flow of the country's major rivers. Normally, the share of glacial feeding in the annual runoff of large rivers is on average small and amounts to 10 – 20% (not including runoff from melting of seasonal snow on glaciers), however, in dry years, when there is little precipitation in winter, the share of glacial runoff reaches 50-70%. Therefore, the role of glaciers in this process is extremely important. Glaciers give water, and this is the main wealth. And they do it in those months of the year when the country needs it most, i.e., in summer and autumn. When the snow and firn at mountains have already melted, the glaciers start supplying water to the valleys. 80% of the water provided by Tajikistan's glaciers goes to neighboring countries through the Zeravshan, Amu Darya and Syr Darya rivers (see Figure 8-1).

Figure 8-1 Glaciers feed a little more than 20% of the flow of Tajikistan's rivers



Source: Agency for Hydrometeorology of Tajikistan

Main glacier

Fedchenko Glacier is located in the Gorno-Badakhshan Autonomous Region of Tajikistan. It is the longest glacier in the world outside the polar regions, and it is one of the ten largest glaciers in the world.

It has about 50 tributaries, some of which are the largest glaciers in Central Asia, exceeding 30 square kilometers in area. (Bivachny, Nalivkin, Vitkovsky, Academy of Sciences glaciers). The area of Fedchenko Glacier with all its tributaries is 651.7 sq. km, and its greatest length is 77 km. In total, there are 45 glaciers in the Fedchenko Glacier system.

The upper reaches of the tributaries of the glacier reach a height of 7480 meters above sea level, and the end of its tongue descends to a height of 2910 meters. The thickness of ice in the upper zone of the glacier exceeds 800 meters, and the total volume of ice, including tributaries of the glacier, is about 130 cubic km.

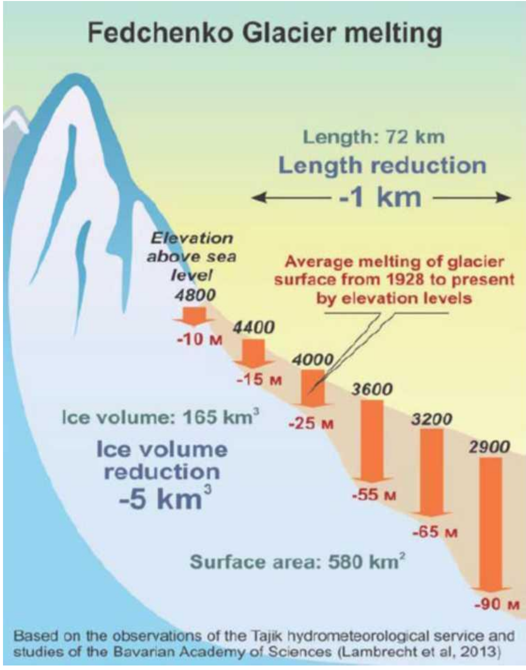
Tajik glaciologists have been studying this huge object for decades, and as it turns out, Fedchenko is moving. For almost forty years of observations, the average annual rate of movement of this glacier varied from 63 to 89 cm per day, averaging 73 cm per day.

But according to scientists, the most disappointing news is that the glacier is shrinking every year, and it is happening faster than it needs to. According to the latest data, in 40 years Fedchenko has lost more than 3 km2 of its area and settled down by 50 meters (see Table 8-1).

The ongoing melting and retreat of glaciers associated with climate change is a concern for Tajikistan, since glaciers and snow reserves in Tajikistan are the main sources of irrigation water. Approximately 30% of the ice sheet has been lost since 1930; the current melting rate is 0.5% -0.8% loss in annual terms. The largest glacier in Tajikistan, the Fedchenko Glacier, retreated to a distance of 1 km, and lost about 5 km3 of ice since the beginning of the twentieth century (Figure 8-2). The objectives of the study of Ambinakudige & Joshi (2015) were to estimate the extent of glacial retreat of the Fedchenko glacier from 1933 to 2014, and to estimate the mass balance of the Fedchenko in the Pamir region of Tajikistan. ASTER and Landsat satellite images were used in the study. Glacier terminus of the Fedchenko glacier retreated about 1.7 km over the last 81 years. However, in recent years, the rate of retreat has slowed down. The lower part of the ablation zone, which is mostly debris covered, has exhibited a higher surface lowering trend compared to the area between the altitude of 3800m to the equilibrium line altitude (ELA).

Small glaciers in the lower reaches are getting the greatest impact from climate change and are melting at an unprecedented rate. For example, in Diakhandarya, a glacier with a surface area of less than 1 km2, located in the upper reaches of the Karatag River, completely melted. The size of the Zeravshan Glacier decreased by 10% between 1927-2010, and retreated by 2.5 km. (DGRT, 2019).

Figure 8-2 Melting of Fedchenko glacier



Tajik glaciologists have calculated the rate of glacial retreat, and it turns out that another major glacier, the Zeravshan Glacier, has also retreated significantly.

From 1960 to 2019, its retreat was 4.8 km. According to calculations, the rate of its retreat was 80 meters per year. Specialists have concluded that the main share of glaciers in Tajikistan is in the stage of degradation, i.e., retreat. Decrease of length of glaciers, accordingly, leads to reduction of their areas and volumes.

Table 8-1 Area of large glaciers in Tajikistan and their decrease from 1980 to 2020, in km^2

Glacier	Glacier Area in 1980	Glacier Area in 2020	Difference
Fedchenko	156,0	152,3	-3,7
Zaravshan Glacier	132,6	126,5	-6,1
Garmo	114,6	110,5	-4,1
RGS (Russian Geographical Society Glacier)	64,4	64,9	0,5
Bivachniy	37,1	41,3	4,2
Kosinenko	27,4	25,1	-2,3
Medvezhiy	24,7	25,3	0,6
Mazarskiy	23,0	20,9	-2,1

Source: Glaciology Center of Tajikistan

Climate change and melting of glaciers

In the middle of the 20th century, around 6% of Tajikistan's surface area was covered by glaciers. By the early 21st century this was believed to have declined to 5%. Simultaneously, the volume of ice mass found in Tajikistan's glaciers is reported in its Third National Communication to the UNFCCC to have reduced by 30% over the same period. By the end of the century, glacier mass loss is projected in the region of 50%–70% over the Central Asian region, dependent on the emissions pathway (Reyer et al, 2017). Glacial melting is likely to have a very significant impact in the primary river basins encompassing most of Tajikistan, that of the Amu Darya and Syr Darya. An estimated 50% of the runoff of the Amu Darya River is believed to derive from glacier meltwater (a lower percentage is estimated for the Vakhsh river; Sorg et al., 2012), with similarly high dependence seen in most of Tajikistan's rivers (Alford et al., 2015). Additional research is required on the impacts from increased temperatures on the country's glacial melt scenarios and subsequent flow rates over the short-term and long-term.

Glacier and snow melting typically provides regulation of flows, ensuring water resources are available all year round. The ongoing melting of glaciers is already delivering slightly increased runoff (typically less than 10%) in many of Tajikistan's rivers, as reported in its TNC, but uncertainty in precipitation and snowfall projections surrounds future runoff trends. One study has suggested that the increase in runoff due to accelerated melting could peak in the Naryn basin by around 2040 (Gan, Zuo, Sun, 2015). As smaller glaciers disappear entirely, the runoff of smaller tributary rivers can fall dramatically. The cumulative effects of glacier loss are likely to grow over the longer-term future, dependent on global emissions reductions, potentially leading to significant declines in runoff. As processes of climatic change unfold the runoff regime is likely to shift, increases in the variability of flows are projected, amplifying the April-June peak, and reducing late summer and autumn flows (Kure et al. 2013). In combination with the projected increase in the frequency of meteorological drought climate change is likely to present major water supply challenges. If flow rates and related water availability does reduce, there are potential challenges for the sharing of water resources among riparian zones.

Tajik climatologists assessed the impact of global climate change on the glaciers of Tajikistan. According to the results of observations, since 1930, the total area of glaciers of the republic has decreased by about 30%.

According to the Agency for Hydrometeorology of Tajikistan, the average annual temperature in the republic, both in the valleys at an altitude of 1000 meters from sea level and in the mountains at an altitude of 2500 meters and more, has increased over the past 70-80 years and this leads to the retreat of most of the glaciers. This trend is also observed in the highlands, where most of the country's glaciers and snowfields are located. While in 1950 the average annual temperature in these places was at -2.1 degrees Celsius, in 2020 it has risen to -0.9 degrees.

According to the Center for the Study of Climate Change and the Ozone Layer of the Tajik Hydrometeorology Agency, it is already calculated that the average annual temperature increase by the end of the 21st century in Central Asia may be from 3.7 to 5.6 degrees Celsius. At the same time the increase in winter temperatures will be from 3.0 to 5.8 degrees Celsius, and in summer from 3.8 to 5.5 degrees Celsius. The temperature increase will occur against a background of decreased precipitation throughout the region. If the current rate of glacier degradation continues over the next 30-40 years, many small glaciers in Tajikistan will completely disappear and this will significantly affect the water regime of some rivers in Tajikistan, including the Zeravshan, Kafarnigan, Karatag and Obihingou. The glaciation area of the country is expected to decrease by 15-20% compared to today. The probability of reduction of water volume in glaciers by 80-100 km3 is assumed. The calculation method has established that, despite the significant retreat, some large glaciers will still remain.

The agency predicts that the potential impact of glacier degradation on water resources could lead to an intense increase in river flows in the short term, but in the long term, it is likely to lead to water shortages due to the depletion of the volume of glaciers. Some Tajik experts believe that the way to preserve the country's water resources, which may obviously decrease because of intensive melting of glaciers, is to build medium and small reservoirs and to increase forests in mountainous areas (CRG-NAST, 2022).

The importance of temperature change becomes even greater in snow or glacier dominated basins where it controls the snowmelt processes during the late-winter, spring, and summer months. In study of Kure et al. (2012) hydrologic responses of streamflow in the Pyanj and Vaksh River basins to climate change were analyzed with a watershed hydrology model, based on the downscaled atmospheric data as input, in order to assess the regional climate change impact for the snow fed and glacier fed river basins in the Republic of Tajikistan. As a result of this analysis, it was found that the annual mean river discharge is increasing in the future at snow and glacier dominated areas due to the air temperature increase and the consequent increase in snow/ice melt rates until about 2060. Then the annual mean flow discharge starts to decrease from about 2080 onward because the small glaciers start to disappear in the glacier areas. Most reports state that all the glaciers in west Tajikistan may completely disappear by 2050 due to small size (less than 1 km^2; NAPRT, 2003); the loss of glaciers is much more rapid in the Zarafshan Range than of glaciers in other regions globally (SNC-TJK, 2008). It was also found that there is a gradual change in the hydrologic flow regime throughout a year, with the high flows occurring earlier in the hydrologic year, due to the warmer climate in the future.

Glaciers support mountain agriculture by the following (Christmann & Aw-Hassan, 2015):

- delaying the snowmelt,
- regulating the water supply,
- adding substantial amounts of melt water during the growing period
- watering points on rangelands,
- providing moisture for nutritious summer pastures.

In mountainous Central Asia, glacier shrinkage is most rapid at lower elevations, such as near the densely populated forelands of the Tian Shan and Zeravshan Ranges (SNC-TJK, 2008; Sorg et al. 2012). The Tajik Government is aware of the rapid deglaciation in the Zarafshan Range (NAPRT, 2003; SNC-TJK, 2008), but there is yet no holistic project for the adaptation of mountain villages. In addition to glacier loss, an increase in temperature of 1 °C shifts the snowline up by about 150 m (Beniston 2003). Since mountains have a conical shape, this results in a significantly and progressively smaller area for snow storage; thus the total amount of delayed down-flow decreases.

Global warming might prolong the growing season and allow crop production at higher altitudes, but a lack of glacial water, increasing seasonal abnormalities, aggravated evaporation (from water reservoirs) and high losses of biodiversity (especially pollinator diversity) have potential to significantly reduce benefits; as does disturbance of the timely interaction within agro-ecosystems (Inouye 2009; Christmann and Aw-Hassan 2011). Loss of freshwater resources for humans, livestock and agricultural production and loss of agricultural income might cause increasing migration and final abandonment of mountain villages, which might cause higher food insecurity, loss of biodiversity and conflicts in areas of immigration.

The Intergovernmental Panel on Climate Change (IPCC) report (Parry et al., 2007) forecasts a 3.7 °C temperature increase by 2100 for Central Asia. Tajikistan was identified as the country most vulnerable to climate change (of 28 European and Central Asian countries), having limited capacity to adapt and recover (Fay et al., 2010). West Tajikistan has more than seven million inhabitants and current precipitation is around 691 mm/year.

Quantifying the relative contribution of climate change and anthropogenic activities to runoff alterations are essential for the sustainable management of water resources in Central Asian countries. In the Kofarnihon River Basin (KRB; Figure 8-3) in Central Asia, both changing climate conditions and anthropogenic activities are known to have caused changes to the hydrological cycle. Therefore, quantifying the net influence of anthropogenic contribution to the runoff changes is a challenge. In the study of Gulahmadov et al. (2021) applied the original and modified Mann–Kendall trend test, including the Sen's slope test, Pettitt's test, double cumulative curve, and elasticity methods. These methods were applied to determine the historical trends, magnitude changes and change points of the temperature, precipitation, potential evapotranspiration, and runoff from 1950 to 2016 (Figure 8-4). In addition, the contributions of climate change and anthropogenic activities to runoff changes in the KRB were evaluated. The trend analysis showed a significant increasing trend in annual temperature and potential evapotranspiration, while the annual precipitation trend showed an insignificant decreasing trend during the 1950–2016 time period. The change point in runoff occurred in 1986 in the upstream region and 1991 in the downstream region. Further, the time series (1950–2016) is separated into the prior impacted period (1950–1986 and 1950–1991) and post impacted period (1987–2016 and 1992–2016) for the upstream and downstream regions, respectively. During the post impacted period, climate change and anthropogenic activities contributed to 87.96% and 12.04% in the upstream region and 7.53% and 92.47% in the downstream region of the KRB. The results showed that in runoff changes, the anthropogenic activities played a dominant role in the downstream (97.78%) and the climate change impacts played a dominant factor in the upstream region (87.96%). In the land-use type changes, the dominant role was played by construction land, which showed that the area from 248.63 km^2 in 1990 increased to 685.45 km^2 (175.69%) in 2015. These findings suggest that it is essential to adopt effective steps for the sustainable development of the ecological, hydrological, and social order in the KRB in Central Asia.

Figure 8-3 (a) Location of the KRB area; (b) digital elevation model, hydrological, and meteorological stations.

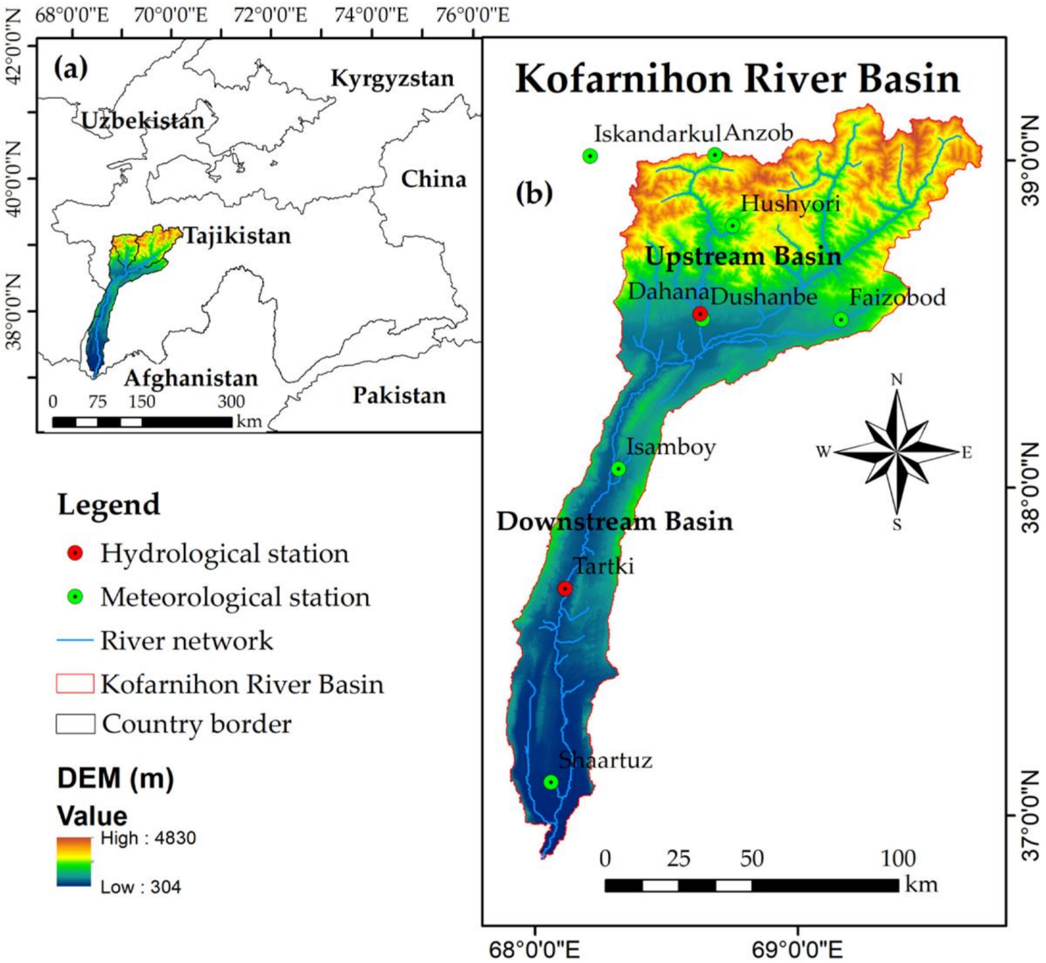
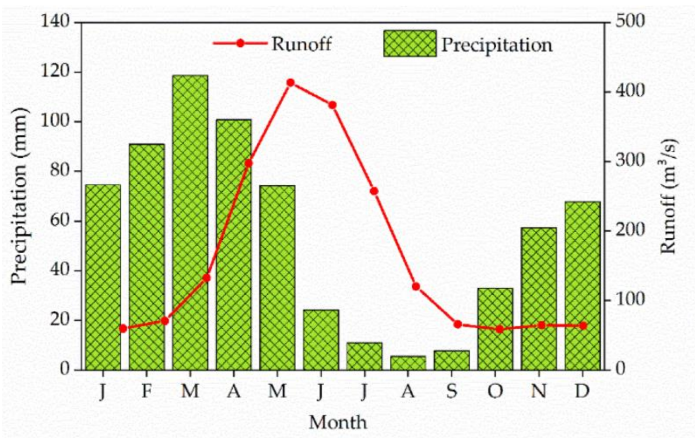


Figure 8-4 The mean monthly values of the runoff and mean monthly precipitation in the Kofarnihon River Basin, Central Asia.



The main problems connected with climate change affecting glaciers:

The retreat of the 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 Zeravshan, Kafernigan, Karatag and Obikhingou rivers, which will further exacerbate tensions over the rights to use water resources, both inside and outside the state borders.

River flow. The recently observed increases in river flows are unlikely to continue until the middle of the 21st century in the rivers of the Western and Eastern Pamir (the Pyanj River basin). In the absence of 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 increases. 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 are breached. These events can also happen as a result of, or cause, landslides, and dangerous mudflows (Zaripova, 2018). 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 (WBG, 2021).

Two primary types of droughts may affect Tajikistan, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). At present, Tajikistan faces an annual median probability of severe meteorological drought of around 3%, as defined by a standardized precipitation evaporation index (SPEI) of less than −2. The smoothing effect of the glacier and snow meltwater contribution to runoff has historically provided some protection against hydrological drought (Pritchard, 2019).

8.2. Water characteristics of the target districts – irrigation, water supply, emergencies

<u>Kuhistoni Mastchoh</u>

Rivers -Zeravshan river

The total length of the Zeravshan River is 877 km and the catchment area of the river covers an area of 40,600 km^2. The river is fed by snow and glaciers, the maximum discharge by the end of spring - the beginning of the summer months and the minimum discharge correspond to the winter months. The average long-term water flow at the Tajik-Uzbek border is 158 m^3/s, and the average annual water flow is 5 km^3.

Irrigation.

The irrigated area of agricultural land in Kuhistoni Mascho totaled 3536 hectares; irrigation is carried out by gravity from the stream of the Zeravshan River.

Water supply and sewerage.

Kuhistoni Mascho does not have a unified water supply and sewerage system; for water supply, settlements use the water resources of the river, springs and mountain stream. There is a public utilities department in the area.

Emergencies

The territory of the district is located in a mountainous area, so natural disasters are mainly observed in the form of mudflows, avalanches, rock falls. Because of rock falls and mudflows, the main road of Kuhistoni Mascho is often blocked.

<u>Kanibadam</u>

Rivers - Syrdarya, Isfara

The Syrdarya River, being one of the main rivers of Central Asia, has a length of only 150 km through the territory of Tajikistan. The sovereign states of Central Asia are located on the territory of the Syrdarya basin: the Republic of Kyrgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and the Republic of Kazakhstan.

The length of the Syrdarya River from the confluence of the Naryn and Karadarya rivers to the Aral Sea is 2,337 km, and together with the Naryn River (2,790 km). The total area of the basin is 150,100 km2, and its Tajik part is 12,569 km2 or 8.4% of the total area of the entire Syrdarya basin. The hydrological characteristics of the Tajik part of the Syrdarya river basin are quite complex, also due to excessive irrigation networks built during the Soviet Union.

The Isfara river is formed by the confluence of the Kshemysh and Karavshin sai rivers from the glaciers of the Turkestan Range (Aksu glacier) at an altitude of more than 5000 m in the

Batken region of Kyrgyzstan. Food is glacier-snow, high water from the end of April to October, maximum runoff in July and August. The average annual water flow on the Isfara River is 14.8 m^3/s.

Irrigation.

The irrigated area of agricultural land in the city of Kanibadam totaled 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.

Water supply and sanitation.

In the field of water supply and sewerage management, in the territory of the city of Kanibadam and the villages adjacent to it, a subsidiary enterprise "water supply and sewerage of the city of Kanibadam", SUE "Khojagii Manziliyu Kommunali" operates.

The main sources of drinking water for the population are artesian wells, which are located in the lower part of the city of Kanibadam. The water lines of the city of Kanibadam were built between 1960 and 1985, and as a result of long-term operation, 70% of them are worn out. Provision of the population with drinking water in the city and jamoats is 40%.

Disinfection and testing of water quality is carried out by the subsidiary “water supply and sewerage of the city of Kanibadam”, control is carried out by the State Service for Sanitary and Epidemiological Surveillance.

Wastewater is discharged through sewer networks to a treatment plant and the number of treatment plants in the city is 4 units, one facility carries out biological treatment of wastewater and 3 facilities carry out mechanical treatment of wastewater.

Emergencies

In the city of Kanibadam, emergency situations, in particular natural disasters such as earthquakes, floods and mudflows, strong winds, severe frosts have been recorded and noted in different years. In the foothill settlements, during the passage of heavy precipitation, the passage of mudflows is observed.

Gissar

Rivers -Khanaka River

The Khanaka River is the right tributary of the Kofarnigan River, flows through the territory of the Gissar region, originating in the southern slopes of the Gissar Range. The river is snow-rain fed. The average annual water consumption is 10 m^3/s.

Irrigation.

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.

Water supply and sanitation.

In the field of water supply and sewerage management, on the territory of the Gissar district, a subsidiary enterprise “water supply and sewerage of the Gissar district”, State Unitary Enterprise “Khojagii Manziliyu Kommunali” operates.

The main sources of drinking water for the population are artesian wells and surface water. The water lines available in the city of Gissar were built in 1970-1985, and as a result of long-term operation, 75% of them are worn out. Provision of the population with drinking water in the city and jamoats is 39%. The population uses springs, canals, water pumps with hand pumps and other sources.

The sewerage system is available only on the territory of the city of Gissar and was built in 1975-1980. In the southern part of the city of Gissar there is one treatment plant (CWWTP), where wastewater from two main pipelines annually flows from 150 to 200 thousand cubic meters. The wastewater treatment plant performs biological treatment of wastewater.

Emergencies

Natural disasters that annually threaten the population of the Gissar region are mudflows, floods, landslides, hail, severe frosts and heavy rains.

Fayzabad

Rivers - Kofarnigan River

The Kofarnigan River originates in the Romit Gorge after the confluence of the Sardaimiyon and Sarob rivers, the total length is 387 km, and the catchment area is 11,600 km^2. The Kofarnigan River will fall into the Pyanj River in the Shaartuz region of the Republic of Tajikistan.

The river is snow-glacial. The flood lasts from March to September with a maximum flow in June-August, a minimum flow is observed in the Earth months. The average annual water flow is 164 m^3/s, however, depending on the season and weather conditions, the flow varies from 30 to 1200 m^3/s. The average annual water runoff is 5.2 km^3.

Irrigation.

The arable land of the Fayzabad district of 3566 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 Kofarnigan River.

Water supply and sanitation.

In the region, springs and vertical wells are the main source of drinking water, water from which is taken from a depth of up to 120 meters.

State Unitary Enterprise "Khojagii manziliyu kommunali" of the district mainly provides drinking water to the population of the Fayzabad settlement. This company has been operating since 1974 to the present. The total capacity of the pumps is 2000 cubic meters. meters / per day, currently produced water in the amount of 1870 cubic meters. meters/day. This enterprise has 34.4 kilometers of water pipes on its balance sheet.

Provision of the population with drinking water in the village and jamoats is 74%. There is a local sewerage system in the Fayzabad settlement.

Emergencies

Natural disasters that annually threaten the population of the Fayzabad region are mudflows, landslides, hail, heavy snowfalls, frosts and heavy rains.

Shaartuz

Rivers - Kofarnigan River

The Kofarnigan River originates in the Romit Gorge after the confluence of the Sardaimiyon and Sarob rivers, the total length is 387 km, and the catchment area is 11,600 km^2. The Kofarnigan River will fall into the Pyanj River in the Shaartuz district of the Republic of Tajikistan.

The river is snow-glacial. The flood lasts from March to September with a maximum flow in June-August, a minimum flow is observed in the Earth months. The average annual water flow is 164 m^3/s, however, depending on the season and weather conditions, the flow varies from 30 to 1200 m^3/s. The average annual water runoff is 5.2 km^3.

Irrigation.

On the territory of Shaartuz region 14216 hectares are irrigated lands. In the district, the “State Enterprise of Water Management of the Lower Kafarnigan 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, 2706 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.

Water supply and sanitation.

The SUE "Khojagii manziliyu kommunali" operates in the district, which is mainly engaged in landscaping, lighting and sanitation. The enterprise provides water supply services only to customers of the regional center Shaartuz. The district center has a drinking water line, but the system does not meet the needs of customers sufficiently, and water is supplied to users only 7-8 hours a day. The rest of the population of villages and damoats uses gravity water, as well as water from ditches and springs. In general, only 52 percent of the district's population uses drinking water lines. On the territory of the district there are only 6 lines of drinking water (26 km long), the source of which is groundwater due to wells 60 meters deep. The drinking water line of the Shaartuz settlement is included in these lines. There is no sewerage network in the area that meets the needs.

Emergencies

Natural disasters that are observed in the Shaartuz region are droughts, dust storms, mudflows, landslides and floods.

Muminabad

Rivers - Pyanj

The Pyanj River flows downstream along the southern border of the country into the Amu Darya River, which originates at the confluence of the Vakhsh Pyanj Rivers. The Pyanj is the longest and largest river in Tajikistan and is fed from a number of regions, the largest of which are Pamir, Gunt, Bartang, Yazgulem, Vanj and Kyzylsu.

The Pyanj River Basin is the largest of the six basins in Tajikistan with a catchment area of approximately 113,000 km^2, located just above the confluence with the Vakhsh River, a predominantly mountainous area in southeastern Tajikistan and northern Afghanistan. About 60% of the watershed is located in Tajikistan and 40% in Afghanistan. The source of the river lies in the Pamir Mountains at an altitude of more than 7000 m, descending to a level of 330 m, to the confluence with the Vakhsh at a distance of 921 km. The average annual water flow in the Pyanj River is 1026 m^3/s. The annual flow is about 32 km^3.

The Kyzylsu and Yahsu rivers form from the southern slopes of the Vakhsh mountain range, flow south through the foothills and then across the plains of the Kulyab zone with its vast irrigated agricultural land before joining the Pyanj River.

Irrigation

The State Administration for Land Reclamation and Irrigation and the WUA Buston' operate in the district. 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.

Water supply and sanitation.

On the territory of the district, the Subsidiary State Enterprise of Water Supply, as well as water supply networks, is engaged in water supply and maintenance of water supply facilities and regulation of water supply norms. This enterprise has 2 pumps, 5 vertical wells, a 1500 m3 water collection tank and 16.5 km of water supply lines on its balance sheet.

The specified enterprise provides services only to the population of the regional center, that is, the village of Muminabad. The drinking water line of the Muminabad district is not able to fully meet the needs of the population. In general, only 48.7 percent of the population is provided with drinking water, who use natural sources of drinking water from springs and the Surkhak and Yohsu rivers. For most of the population of the region, drinking water supply is established by a natural method. The main sources of drinking water supply for the population of Muminabad district are the central water supply line, street water supply lines, water from rivers, lakes, reservoirs, ditches and canals, springs, natural precipitation, and vertical wells.

There is no sewerage network and treatment facilities in the area at all, and this situation leads to the accumulation of a large amount of waste and environmental pollution.

Emergencies

Rural jamoats of Muminabad district are mainly prone to mudflows, landslides and rock falls. In addition, the climatic conditions of the region are harsh, with heavy snowfalls and rains, severe cold and avalanches.

8.3. The observable effects of climate change on water resources– qualitative analysis

In all districts the population noticed a considerable decrease of irrigation water. In part this decrease is caused by climate change. The other part is caused by population increase, distribution of water on the national and international levels. Population adapts to the lack of water by drilling the wells. However, this water may increase the soil salinization. In some districts the availability and quality of drinking water was also reduced (Muminabad, Kanibadam). In addition, the more frequent water- and mud- flows damage the infrastructure.

8.3.1. Methodology

This section methodologically relies on results of focus groups and expert interviews conducted in the regions. The methodologies of focus groups are presented in the Appendix 4 to this report.

8.3.2. Results

Expert opinion:

Climate change is most visible via the rise in temperatures. As a result, the levels of Pyandj River, Vakhsh (Shaartuz) rise. Glaciers melt. The rise of the temperatures was most visible starting in 2000. Until 2000, the warming was moderate and amounted to approximately 0.1-0.4 degrees per year. There was a good winter and moderate spring. There were no sharp fluctuations in temperature. Starting with 2000, we experience general warming in winter, more intensive rains and mudflows in spring, and dry and hot summer. Mudflows and floods intensified.

In addition, the country experiences a lack of stable water. Some of this lack is due to climate change. The other factors include increased need of water due to population increase and problems with distribution of water on the national and international levels.

Fayzabad

- “The water supply to the jamoat is provided from the "50 Years" canal of Vahdat city by contract, and the canal receives water from the Kafernigan River. The reason for the reduction of water in the canal and, consequently, the lack of water for dekhkan (farm) households is, first of all, a decrease in the annual amount of precipitation during the autumn-winter period. Also, more well-to-do dekhkan farmers in some farms drill vertical wells using this water both for irrigation and for drinking purposes - about 50 farms in total. The groundwater level in the jamoat is 30-35 m.”

- “Especially the lack of water is observed during the re-seeding period - June-July months;”
- “A sharp decrease in the groundwater table due to reduced precipitation, which will negatively affect not only drinking but also agricultural water supply;”
- “Sharp increase of mudflows, landslides, rockfalls, etc.;”

Expert opinion:

There are two canals and 3000 hectares left on the balance of the Agency of melioration and irrigation (previously, it was 6000 hectares). The river of Elok experiences a lack of water. Irrigation is dependent on pumping stations, which are in bad technical condition.

Gissar

- The lack of water in the river during the irrigation period, as described above.
- The population notices the declining strength of small mountain springs
- The dynamics of water flows is increased due to the rapid melting of snow (water flows more slowly in the past), leading to water- and mudflows
- The climate-related need for water increases due to several reasons:
- They have to water crops more frequently due to increasing temperatures leading to more water evaporation from the soil and water surfaces and from the lack of rain.
- In case of more than two harvests per year, the need for water increases proportionally
- The inclusion of new lands to the agricultural fund is not possible in Gissar as there is no possibility to increase agricultural land via new lands that have not been used for agricultural production before.
- Much agricultural land is located on the slopes of the hills, which increases the demand for irrigation water as the water simply flows down the hill.
- The more frequent water- and mud- flows damage the infrastructure of water management

- The increase of watering in areas where agricultural land in slopes leads to an increase in water erosion that damages the water channels. The latter need to be cleaned more often.
- Increased temperatures lead to more water lost in the transportation process (evaporation)

Expert opinion:

The district can be divided into two parts: northern and southern parts. The northern part is primarily rainfed. If there is a lack of precipitation, the soil is not usable for agricultural production. In addition, there is a problem of subsiding soil.

The other part, which is below the Gissar canal, is in good condition. Irrigated agriculture. The district is characterized by agricultural land located on the steep slopes of the hills. The intensified irrigation leads to more soil flushed down with the irrigation water.

The effects of climate change are manifested in droughts or floods. Some years are dry; rivers dry up. These years are followed by years of floods. Usually, the mudflows and floods are caused by warm winters. Temperature rise provokes flooding in summer; snow melting in the mountains in June and July lead to floods in July. Reservoir cascades could not hold that much water. The Aprils and Mays are characterized by mudslides.

Kuhistoni Mastchoh

- Irregular precipitation lead to flash floods in spring and summer;
- Reduction of drinking and irrigation water coming from mountain springs (almost 100% of the district);
- In winter, there is little precipitation and dry air, in spring there is an increase in rainfall above the norm, as a result, mudflows, avalanches, rockfalls and landslides are observed;
- Reduction the volume of water in the springs leads to a shortage of irrigation water during the irrigation period;

Expert opinion:

There is no problem with water. There is no irrigation system. The water comes from creeks and springs. They build canals and give them to the balance of the WUA, but there is no system of its own. The main problem is the mud-flows that damage the agricultural production (specializes in potato)

Muminabad

- Reduced water resources due to reduced rainfall; Particularly water shortages are observed during the re-seeding period - June-July months;
- Lack of irrigation water during the growing season of crops; Particularly water shortages occur during the re-seeding period - June-July months;
- Reduced quality and volume of drinking water, as well as difficulties in distribution among water users due to the difficult terrain;
- "As a result of decreasing precipitation, water resources are decreasing. For example, the flow rate in the Kululu canal (design capacity 2.8 m^3 /sec) in the spring period of the year, is 2 m^3 /sec, and in June - 0.15-0.20 m^3 /sec. This leads to a shortage of irrigation water in dekhkan (farm) households. An increase in atmospheric air temperature has led to a reduction in snow cover (maximum temperature in summer is 40-42 ^{0}C)."

Expert opinion:

There is one filling of the water reservoir per year. In addition, if the year is dry with little precipitation, the reservoir cannot be filled for the whole year. The district is a rural, mountainous part. There is a lack of machines and machinery for cleaning the irrigation canals. Canals along the mountainous part suffer from mudflows, which flush the canal. It is very expensive to restore the canals afterward.

Shaartuz

- "We close the river and fill the canal with water, but already in the Kafirnigan River itself the water level decreases in June. During this period, crops are reseeded for which there is not enough water for irrigation. To solve this problem, the focus group participants suggested building a reservoir."
- "The water level in the Kafernigan River rises so high in autumn and spring that it floods the banks and consequently washes away 40-50 hectares of soil every year."
- "There has been a decrease in rainfall in recent years. Consequently, the water level in the canals is going down. We have until May 15 when the grain harvest is completed and then we re-sow in June and July and there is a particular shortage of water for irrigation during this period."

Expert opinion:

The water from the Kafernigan river comes through 2 large canals. The region experiences a shortage of water due to three main reasons. First, climate change reduces the stable water supply. Second, two big canals from other districts are taking the water away. Last but not least, climate change leads to higher evaporation as the region suffers from temperatures amounting to 45 degrees in summer. Now it takes 8-10 watering instead of 3-4 watering sufficiently before. In addition, the plants get sick because of the high temperature.

Kanibadam

- Reduction of irrigation water sources;
- Reduced drinking water coming from the Big Fergana Canal (BFC) in the western part of the district (about 60% of the district);
- Increased drilling of boreholes and use of groundwater (technical) not only for irrigation but also for drinking purposes;
- Increase in dental disease, kidney disease and other types of illness due to poor quality drinking water;
- Intermittent rainfall, flash floods in spring and summer;
- Unstable water supply from the BFC will affect the change in groundwater levels;
- The use of saline, unsuitable irrigation water from open drains;
- Shortage of irrigation water during the irrigation period;

Expert opinion:

The region gets most of the water from three main sources: Syr Darya and Isfara rivers and Big Fergana canal.

Water on the Syr Darya comes from the hydroelectric complex with four reservoirs. Out of the total of 100 cubic meters, 15 cubic meters should come to the district according to international agreements. However, only five cubic meters will really come. Karakul reservoir releases water in portions of 5-8 cubic meters. There is a water shortage. Plus, the region suffers from mudflows and floods. In this region, the Big Fergana canal needs to be cleaned.

Both the Isfara river and the Fergana canal have less water. Moreover, the Fergana canal and reservoir is silted. There are three sources of water, and the problem is from three sides.

In addition, Isfara River is damaged by floods.

8.4. The modeled effects of climate change on water resources – quantitative analysis

The model used in this report calculates all water-related risks using the WRI methodology (2019). The study contains four scenarios - basic scenario, scenario for the agricultural sector, analysis of monthly data and scenario of future development. The results suggest, that in the complex water stress[8] , there is a very high risk in all districts, only the districts of Muminabad and Kanibadam have a lower risk. In their vicinity there are watercourses and reservoirs. In the stress of water quantity, there are lower risks in the Muminabad and Kanibadam areas, in other areas we again see an extremely high risk associated with the amount of water.

This water stress[9] is very high in all areas again except Muminabad and Kanibadam. Similarly, there is a risk of water depletion - the areas in the middle and lower parts of the streams, i.e. Fayzabad, Gissar and Shaartuz, are at greater risk. The area of Kuhistoni Mastchoh shows the most seasonal variability[10]. The surveyed regions show only a medium risk of drought, the highest is in Kanibadam.

The risk to water quality is very high for all regions studied. Regulatory and reputational risk, represented by the access of the population to drinking water, is very high in all regions except in the Kanibadam (where the risk is just high but not very high).

The overall risk for the agriculture is extremely high except Muminabad and Kanibadam, The risk for the quantity of usable is high in all the districts, except Muminabad area. Water deterioration indicators are high in all districts, except Kanibadam area, where the risk is medium.

Spring moisture is extremely important for the start of the growing season. The summer months in the country are characterized by great drought, i.e. high levels of water stress. The most affected areas are Gissar, Shaartuz and Fayzabad. This increases the need for irrigation. The autumn months are the second driest in Tajikistan, the areas of Fayzabad, Gissar and Shaartuz show the highest risk.

Year-on-year variability is closely linked to climate change. This indicator will deteriorate as global warming deepens. In the winter months, the Kuhistoni Mastchoh, Gissar, Shaartuz and Fayzabad regions are most at high risk of reducing the available water supply. This is probably related to the decrease in winter precipitation in the form of snow

[8] The complex water stress implies its availability and quality, the water risks for agriculture, the seasonal risks

[9] Basic water stress gives us the ratio of total water abstraction and renewable groundwater and surface water reserves. Here, higher values may mean not only not renewed water supplies, but also subsequent competition between users. The indicator is important because, due to climate change, the demand for irrigation water will increase in the future and its deficit could have a knock-on effect - competition between sectors (95% of electricity in Tajikistan comes from hydropower) as well as between areas in different parts of the flow.

[10] it is the variability of available water reserves during the year and as a mountain area it has the highest variability

in the foothills and mountain areas, which these regions are. The spring months show the lowest fluctuations, variability, in the Muminabad area. The summer months show a high rate of change between years, which means heat waves and increasingly high temperatures in the summer months, which also carry the risk of drought. The most endangered are the Fayzabad, Kuhistoni Mastchoh, Gissar and Shaartuz regions. The autumn months show high year-on-year changes, which also means that the autumn months are warming.

All model outputs show a high and very high risk for the country's water resources. Not only the quality of groundwater and surface water is endangered, but primarily the amount of available water matched with demand.

8.4.1. Methodology

In the ensuing part of the report, insight into water-related issues in Tajikistan using World Resource Institute methodology (2019) is provided. The six selected districts for analysis are Gissar, Muminabad, Kuhistoni Mastchoh, Fayzabad, Shaartuz, and Kanibadam. All outputs are done in the form of tables and figures that illustrate quantitative outputs. The analysis consists of four main sections. First section deals with baseline scenario. This is followed by specification of individual weights for agricultural sector. Consequently, analysis is done by months and tied to crop production that is prevalent in each of the analyzed regions. Finally, scenario for future development of water related risks is done for 2030 and 2040.

8.4.2. Summary

In the report using the methodology of the World Resource Institute (2019) that 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. The areas of Gissar, Muminabad, Kuhistoni Mastchoh, Fayzabad, Shaartuz, and Kanibadam, which represent the diversity of conditions, were chosen as representatives.

The first part of the study, the baseline scenario, expresses the overall risk of water stress. In the complex output - water stress (Table 8-2 and Figure 8-5) there is a very high risk in all areas, only the areas of Muminabad and Kanibadam have a lower risk. In their vicinity there are watercourses and reservoirs.

Other outputs relate to individual elements of water stress, namely quantity, quality and regulatory and reputational risk (Tables 8-3, 8-4 and 8-5). The physical risk of the quantity (amount) of water represents a comprehensive summary of other partial risks, which we will elaborate further, its values are in Table 8-3 and Figure 8-6. There are lower risks in the Muminabad and Kanibadam areas and in other areas we again see an extremely high risk associated with the amount of water needed.

Basic water stress gives us the ratio of total water abstraction and renewable groundwater and surface water reserves. Here, higher values may mean not only not renewed water supplies, but also subsequent competition between users. The indicator is important because, due to climate change, the demand for irrigation water will increase in the future and its deficit could have a knock-on effect - competition between sectors (95% of electricity in Tajikistan comes from hydropower) as well as between areas in different parts of the flow. This water stress is very high in all areas again except Muminabad and Kanibadam. Similarly, there is a risk of water depletion, which, however, is calculated only from water abstraction. The areas in the middle and lower parts of the streams, ie Fayzobod, Gissar and Shaartuz, are at greater risk. The area of Kuhistoni shows the most seasonal variability, it is the variability of available water reserves during the year and as a mountain area it has the highest variability. Groundwater decline, as another indicator, is insignificant in these areas. There is a significant flood risk, a mountainous country like Tajikistan has a high risk of floods, with a large impact on the population. The risk of coastal floods is unexpressed / negligible due to the lack of coastal areas with a large population. The surveyed regions show only a medium risk of drought, the highest area being Kanibadam.

The risk to water quality (Table 8-4) is very high for all regions studied. The individual partial risks represent the insufficient capacity of the country for wastewater treatment (Table 8-4 and Fig. 8-16) and the associated risk of eutrophication (medium and higher risk, Fig. 8-17), which is the same for all areas studied.

Regulatory and reputational risk is represented by the access of the population to drinking water (Table 8-5, figure 8-19 and Figure 8-19), where the risk is very high, except in the Kanibadam area, where the risk is only high, and the level of threat by low levels of sanitation services. This level of threat is low in the studied areas. The risk index quantifies the exposure to business behavior related to environmental, social and administrative issues in a country. The index provides information on financial and reputational and compliance risks (human rights violations, environmental destruction). The risk index is very high in the examined areas (Fig. 8-21).

The overall risk was modeled mainly for the area of agriculture, namely the overall risk, where, in addition to the area of Muminabad and Kanibadam, it is extremely high. The risk for the quantity of usable water is the same as the overall risk; it is lower only in the Muminabad area. Water deterioration indicators are high, except in the Kanibadam area, where the risk is medium. In addition to the Muminabad area, medium risk is regulatory and reputational risk.

Looking at seasonal risks and monthly data, it can be shown that precipitation in Tajikistan is not evenly distributed throughout the year. The rainiest months are spring and winter, and summer and autumn are more prone to drought. This leads to an important aspect of the economy, namely the need for irrigation (e.g. vegetable production in the summer months). For the purposes of the study, the monthly data were sorted into groups corresponding to the season. Lack of water - water stress - in the winter is affected by the declining trend in the amount of winter precipitation. This fact can be very important for the so-called winter water supply in the soil and mainly affects spring areas and groundwater. The spring season is reported to be the rainiest in Tajikistan. Lower medium to low water stress was found from the model. Spring moisture is extremely important for the start of the growing season. The summer months in the country are characterized by great drought, i.e. high levels of water stress. The most affected areas are Shaartuz, Gissar and Fayzabad. Drought has an obvious impact on the production of commodities such as potatoes, melons, and vegetables. This increases the need for irrigation. The autumn months are the second driest in Tajikistan, in fact, drought in these months can be crucial mainly for the production of winter cereals, and the areas of Fayzabad, Shaartuz and Gissar show the highest risk.

Another indicator for seasonal risks was water abstraction - the ratio of total water consumption to available renewable water supplies. However, in addition to irrigation, total water consumption also includes industrial and domestic use, as well as consumption by domestic animals. High values indicate a high impact on local supply together with reduced availability for downstream users. The indicators calculated by the model show similar values as the indicators of water stress. The winter months show moderately low values, and the rainy spring months show low values. The summer and autumn months show high water abstraction.

Year-on-year variability, the last of the calculated indicators, quantifies the average year-on-year variability of available water reserves. It is closely linked to climate change, and in general these indicators will deteriorate as global warming deepens. Higher values here mean greater differences in the available offer from year to year. In the winter months, the Kuhistoni, Shaartuz, Gissar and Fayzabad regions are most at risk of year-on-year variability, i.e. a high risk of reducing the available water supply. This is probably related to the decrease in winter precipitation in the form of snow in the foothills and mountain areas, which these regions are. The spring months show the lowest fluctuations, variability, in the Muminabad area. The summer months show a high rate of change between years, which means heat waves and increasingly high temperatures in the summer months, which also carry the risk of drought. The most endangered are the Fayzabad, Kuhistoni, Shaartuz and Gissar districts. These are areas of growing cereals, potatoes. The autumn months show high year-on-year changes, which also means that the autumn months are warming.

8.4.3. Results

8.4.3.1. Baseline

Baseline scenario analysis overall water risk and its elements 1) physical risk quantity that comprises of water stress, groundwater table decline, interannual variability, seasonal variability, drought risk, riverine flood risk, coastal flood risk, physical risk, 2) quality that encompasses untreated connected waste water, coastal eutrophication potential and 3) regulatory and reputational risk that consists of unimproved/no drinking water, unimproved/no sanitation water, peak RepRisk country ESG risk index.

OVERALL WATER RISK

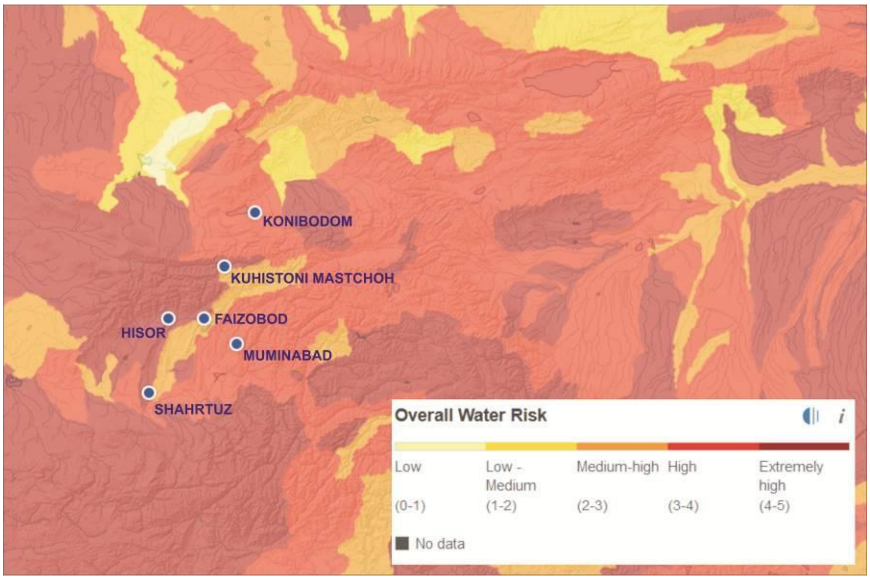
Overall water risk measures all water-related risks, by aggregating all selected indicators from the Physical Quantity, Quality and Regulatory & Reputational Risk categories. Higher values indicate higher water risk. This risk is represented in Table 8.2 and depicted in Figure 8.5.

Table 8-2 *Overall Water risk*

Name	**Input address**	**Latitude**	**Longitude**	**Major Basin**	**Minor Basin**	**Overall Water Risk**
Gissar, Tajikistan	Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan	Extremely High (4-5)
Muminabad, Tajikistan	Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Panji	High (3-4)
Kuhistoni Mastchoh, Tajikistan	Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan	Extremely High (4-5)
Fayzabad, Tajikistan	Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan	Extremely High (4-5)
Shaartuz, Tajikistan	Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan	Extremely High (4-5)
Kanibadam, Tajikistan	Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	High (3-4)

The table shows that all regions but Muminabad and Kanibadam face extremely high water risk which indicates significant level of water related threats to these regions.

Figure 8-5 Overall Water risk



PHYSICAL RISK QUANTITY

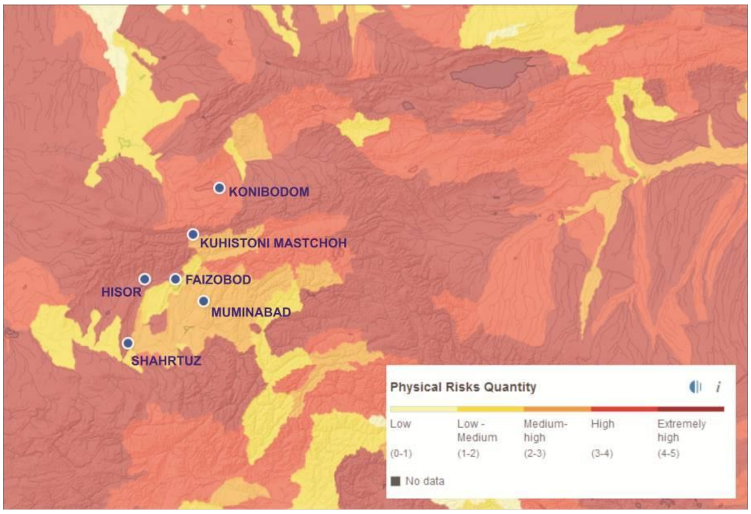
Physical risks quantity measures risk related to too little or too much water, by aggregating all selected indicators from the Physical Risk Quantity category. Higher values indicate higher water quantity risks. This risk consists of seven sub-risks that are combined together. This output is presented in Table 8-3.

Table 8-3 *Physical Risk Quantity*

Name	Major Basin	Minor Basin	Physical Risk Quantity	Water Stress	Water Depletion	Groundwater Table Decline	Interannual Variability	Seasonal Variability	Drought Risk	Riverine flood risk Stress	Coastal flood risk
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (>80%)	High (50-75%)	Insignificant Trend	Low - Medium (0.25-0.50)	High (1.00-1.33)	Medium (0.4-0.6)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000)
Muminabad, Tajikistan	Amu Darya	Panji	Medium - High (2-3)	Low - Medium (10-20%)	Low (<5%)	Insignificant Trend	Low - Medium (0.25-0.50)	Medium - High (0.66-1.00)	Medium (0.4-0.6)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely High (4-5)	High (40-80%)	Low-Medium (5-25%)	Insignificant Trend	Medium - High (0.50-0.75)	Extremely High (>1.33)	Medium (0.4-0.6)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (>80%)	High (50-75%)	Insignificant Trend	Low - Medium (0.25-0.50)	High (1.00-1.33)	Medium (0.4-0.6)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (>80%)	High (50-75%)	Insignificant Trend	Low - Medium (0.25-0.50)	High (1.00-1.33)	Medium (0.4-0.6)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (3-4)	Medium - High (20-40%)	Medium-high(25-50%)	Insignificant Trend	Medium - High (0.50-0.75)	Medium - High (0.66-1.00)	Medium - High (0.6-0.8)	Extremely High (more than 1 in 100)	Low (0 to 9 in 1,000,000

Summary of physical risk quantity shows that four out of six analyzed regions are facing extremely high risks. This is also represented in Figure 8-6. In this part, individual sub-risks of physical risk quantity are presented using relevant figures 8-7 to 8-14.

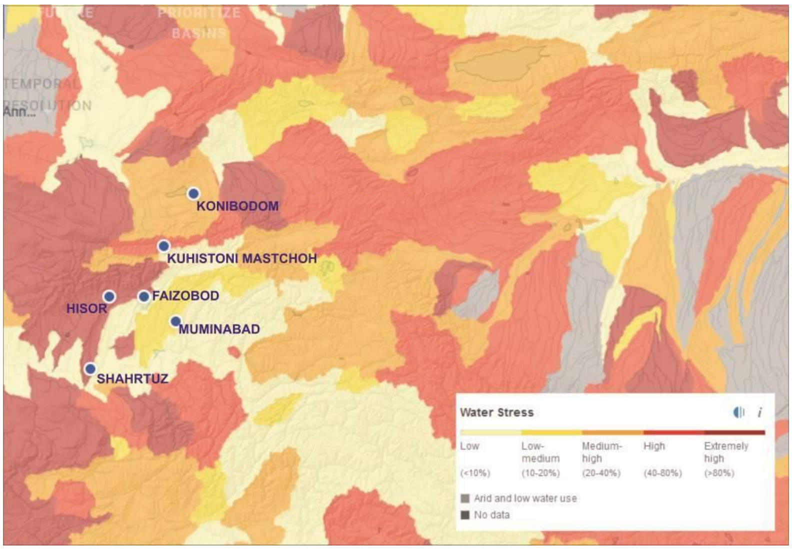
Figure 8-6 *Physical Risks Quantity*



- **Water Stress**

Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and nonconsumptive uses. Non-consumptive use implies that the water may be recovered and treated for reuse either by the same users or by downstream users. Examples include many industrial uses and domestic use. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users.

Figure 8-7 *Water Stress*

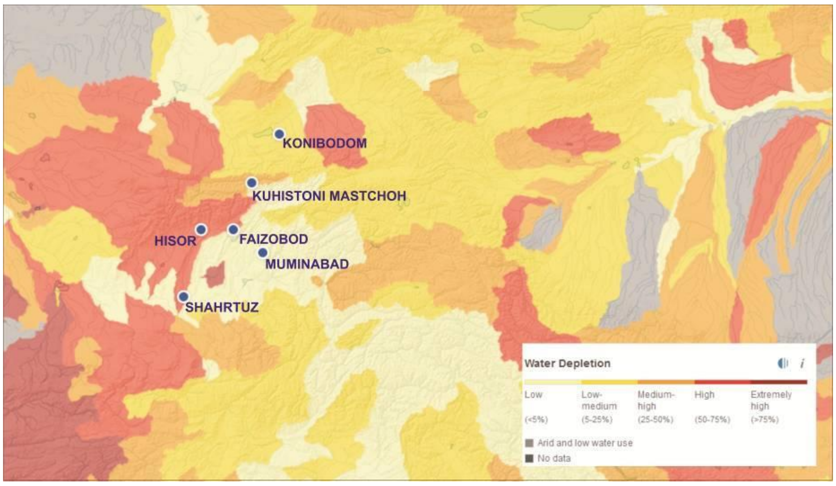


Water stress is worst in Gissar, Fayzabad, and Shaartuz.

- **Water Depletion**

Baseline water depletion measures the ratio of total water consumption to available renewable water supplies. Total water consumption includes domestic, industrial, irrigation, and livestock consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate a larger impact on the local water supply and decreased water availability for downstream users. Baseline water depletion is similar to baseline water stress; however, instead of looking at total water withdrawal (consumptive plus nonconsumptive), baseline water depletion is calculated using consumptive withdrawal only. Water depletion risk is high in Shaartuz, Gissar and Fayzabad.

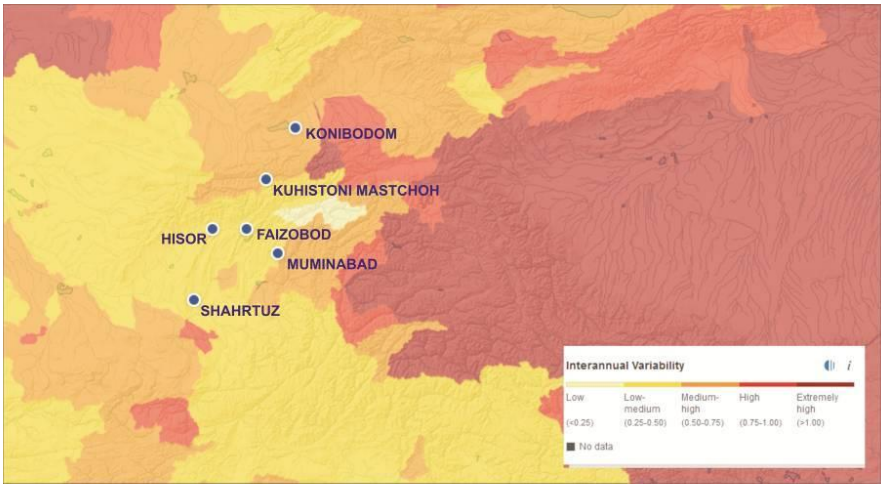
Figure 8-8 *Water Depletion*



- **Interannual Variability**

Interannual variability measures the average between year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations in available supply from year to year.

Figure 8-9 *Interannual Variability*

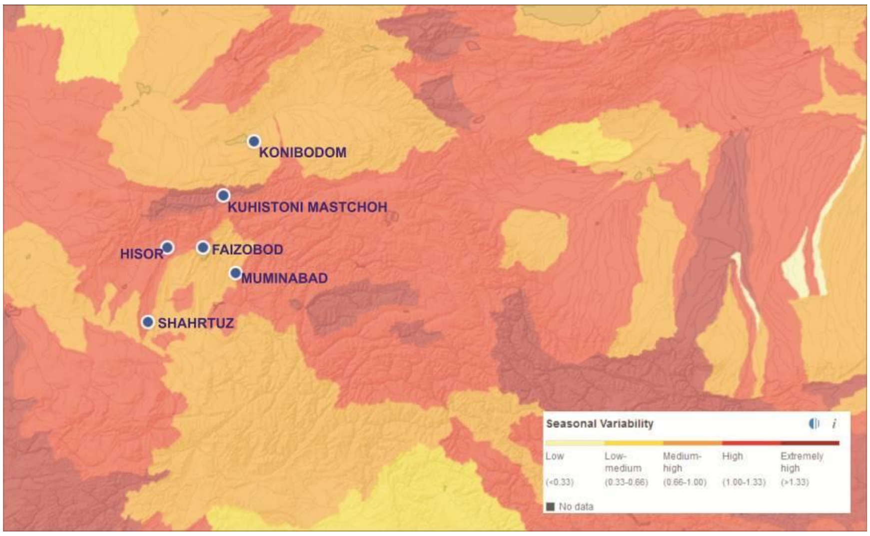


Interannual variability shows highest threats in Kanibadam (medium-high and Kuhistoni (medium-high).

- **Seasonal Variability**

Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available supply within a year.

Figure 8-10 Seasonal Variability

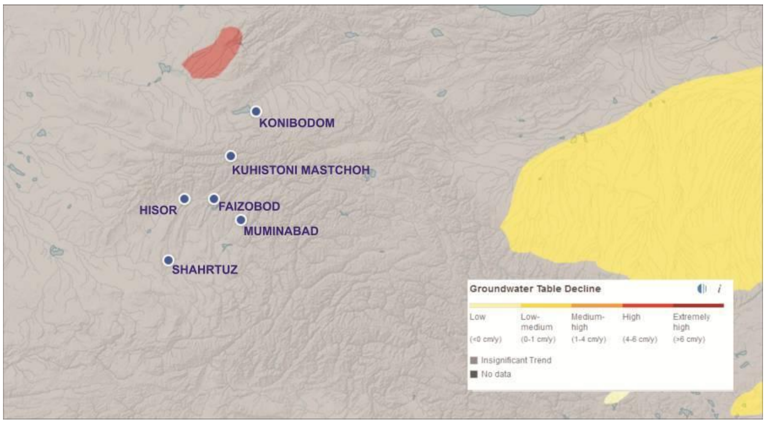


Seasonal variability shows different results and interannual variability and is highest for Kuhistoni (extremely high).

- **Groundwater Table Decline**

Groundwater table decline measures the average decline of the groundwater table as the average change for the period of study (1990–2014). The result is expressed in centimeters per year (cm/yr). Higher values indicate higher levels of unsustainable groundwater withdrawals.

Figure 8-11 Groundwater Table Decline

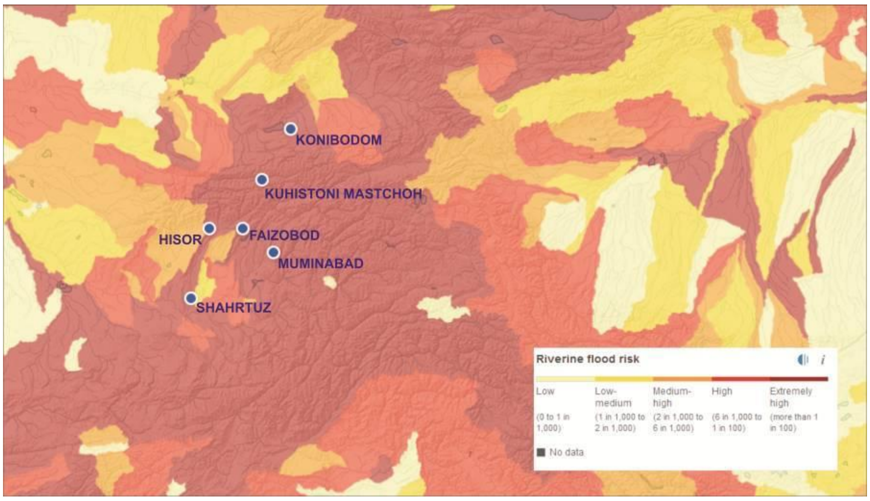


According to data groundwater table decline has insignificant trend for the analyzed regions.

- **Riverine flood risk**

Riverine flood risk measures the percentage of population expected to be affected by Riverine flooding in an average year, accounting for existing flood-protection standards. Flood risk is assessed using hazard (inundation caused by river overflow), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk not in terms of maximum possible impact but rather as average annual impact. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by Riverine floods on average.

Figure 8-12 River flood risk



This indicator shows the highest level of risk for all regions (extremely-high). This may be due to the mountainous character of the analyzed regions.

- **Coastal flood risk**

Coastal flood risk measures the percentage of the population expected to be affected by coastal flooding in an average year, accounting for existing flood protection standards. Flood risk is assessed using hazard (inundation caused by storm surge), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk not in terms of maximum possible impact but rather as average annual impact. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by coastal floods on average.

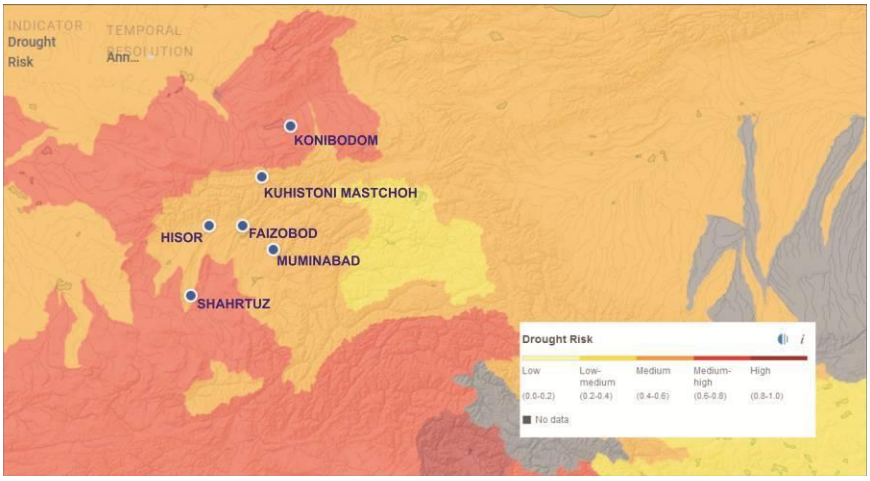
Figure 8-13 Coastal flood risk

Coastal flood risk is low in all regions. This is due to the lack of large coastal areas with significant populations.

- **Drought Risk**

Drought risk measures where droughts are likely to occur, the population and assets exposed, and the vulnerability of the population and assets to adverse effects. Higher values indicate higher risk of drought.

Figure 8-14 Drought Risk



Drought risk is medium-high for Kanibadam and medium for the remaining regions.

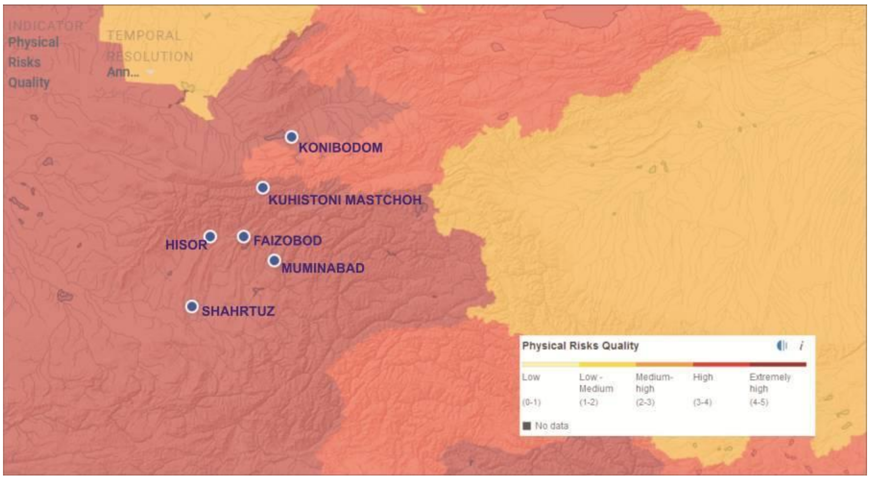
PHYSICAL RISK QUALITY

Physical risks quality measures risk related to water that is unfit for use, by aggregating all selected indicators from the Physical Risk Quality category. Higher values indicate higher water quality risks.

Table 8-4 *Physical Risk Quality*

Name	Major Basin	Minor Basin	Physical Risk Quality	Untreated connected wastewater	Coastal eutrophication potential
Gissar,	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)
Muminabad	Amu Darya	Panji	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)
Kuhistoni Mastchoh	Amu Darya	Zeravshan	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)
Fayzabad,	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)
Shaartuz,	Amu Darya	Kafirnigan	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)
Kanibadam	Syr Darya	Kayrakkum Reservoir	Extremely High (4-5)	Extremely High (100%)	Medium - High (0 to 1)

Figure 8-15 *Physical Risk Quality*

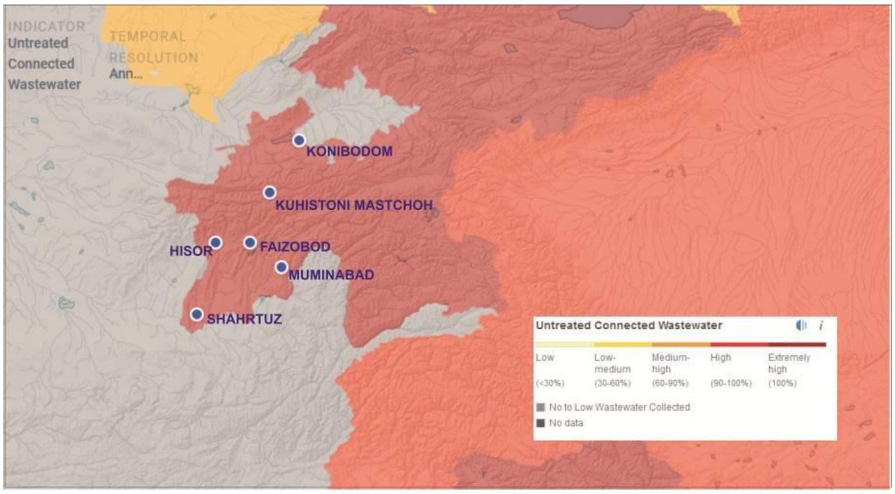


All districts according to Table 8-4 and Figure 8-15 are struck by extremely high quality related risks. These are analyzed in detail below.

- **Untreated Connected Wastewater**

Untreated connected wastewater measures the percentage of domestic wastewater that is connected through a sewerage system and not treated to at least a primary treatment level. Wastewater discharge without adequate treatment could expose water bodies, the general public, and ecosystems to pollutants such as pathogens and nutrients. The indicator compounds two crucial elements of wastewater management: connection and treatment. Low connection rates reflect households' lack of access to public sewerage systems; the absence of at least primary treatment reflects a country's lack of capacity (infrastructure, institutional knowledge) to treat wastewater. Together these factors can indicate the level of a country's current capacity to manage its domestic wastewater through two main pathways: extremely low connection rates (below 1 percent), and high connection rates with little treatment. Higher values indicate higher percentages of point source wastewater discharged without treatment.

Figure 8-16 Untreated Connected Wastewater



This risk is extremely high for all analyzed regions in Tajikistan.

- **Coastal Eutrophication Potential**

Coastal eutrophication potential (CEP) measures the potential for riverine loadings of nitrogen (N), phosphorus (P), and silica (Si) to stimulate harmful algal blooms in coastal waters. The CEP indicator is a useful metric to map where anthropogenic activities produce enough point-source and nonpoint-source pollution to potentially degrade the environment. When N and P are discharged in excess over Si with respect to diatoms, a major type of algae, undesirable algal species often develop. The stimulation of algae leading to large blooms may in turn result in eutrophication and hypoxia (excessive biological growth and decomposition that reduces oxygen available to other organisms). It is therefore possible to assess the potential for coastal eutrophication from a river's N, P, and Si loading. Higher values indicate higher levels of excess nutrients with respect to silica, creating more favorable conditions for harmful algal growth and eutrophication in coastal waters downstream.

Figure 8-17 Coastal Eutrophication Potential

This risk shows a medium-high level for all analyzed regions without any significant differences.

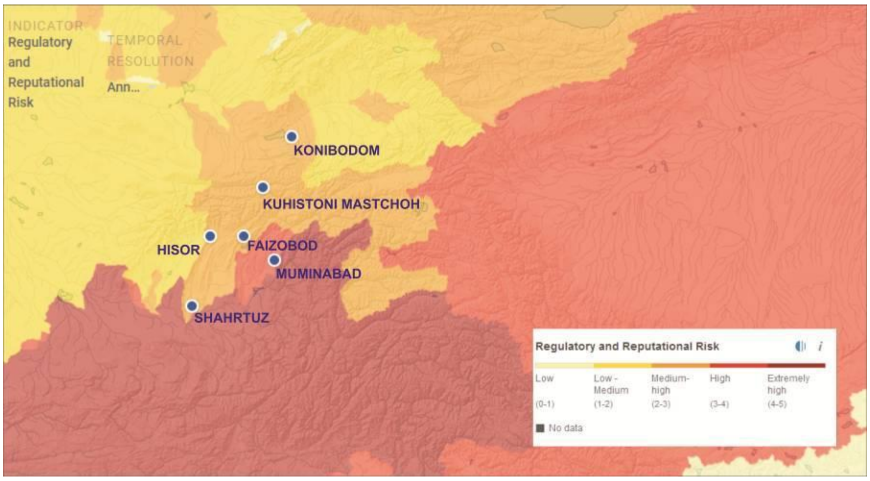
REGULATORY AND REPUTATIONAL RISK

Regulatory and reputational risks measures risk related to uncertainty in regulatory change, as well as conflicts with the public regarding water issues. Higher values indicate higher regulatory and reputational water risks.

Table 8-5 Regulatory and Reputational Risk

Name	**Major Basin**	**Minor Basin**	**Regulatory and Reputational Risk**	**Unimproved/No Drinking Water**	**Unimproved/No Sanitation**	**Peak RepRisk Country ESG Risk Index**
Gissar	Amu Darya	Kafirnigan	Medium - High (2-3)	Extremely High (>20%)	Low (<2.5%)	Extremely High (>75%)
Muminabad	Amu Darya	Panji	High (3-4)	Extremely High (>20%)	Low (<2.5%)	Extremely High (>75%)
Kuhistoni Mastchoh	Amu Darya	Zeravshan	Medium - High (2-3)	Extremely High (>20%)	Low (<2.5%)	Extremely High (>75%)
Fayzabad	Amu Darya	Kafirnigan	Medium - High (2-3)	Extremely High (>20%)	Low (<2.5%)	Extremely High (>75%)
Shaartuz	Amu Darya	Kafirnigan	Medium - High (2-3)	Extremely High (>20%)	Low (<2.5%)	Extremely High (>75%)
Kanibadam	Syr Darya	Kayrakkum Reservoir	Medium - High (2-3)	High (10-20%)	Low (<2.5%)	Extremely High (>75%)

Figure 8-18 Regulatory and Reputational Risk

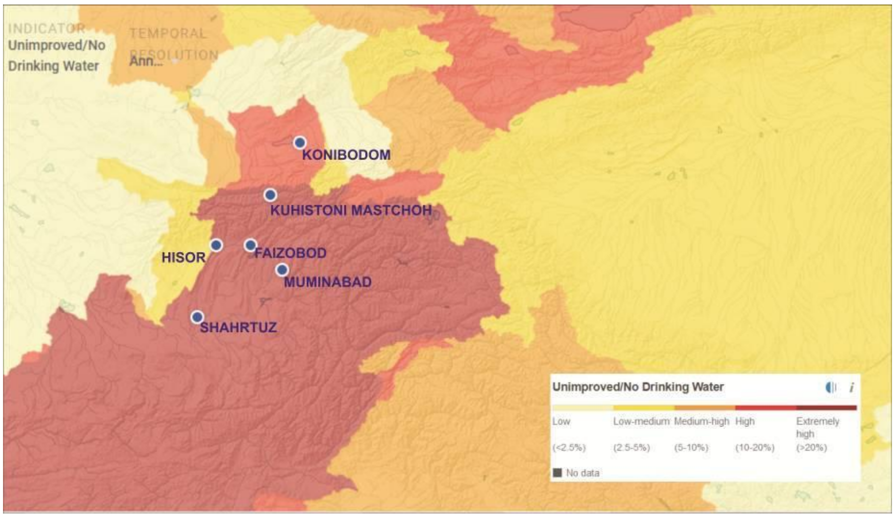


Regulatory and reputational risk is high for Muminabad and medium-high for the remaining regions. Subsets of this risk are analyzed below.

- **Unimproved/No Drinking Water**

Unimproved/no drinking water reflects the percentage of the population collecting drinking water from an unprotected dug well or spring, or directly from a river, dam, lake, pond, stream, canal, or irrigation canal (WHO and UNICEF 2017). Specifically, the indicator aligns with the unimproved and surface water categories of the Joint Monitoring Programme (JMP)—the lowest tiers of drinking water services. Higher values indicate areas where people have less access to safe drinking water supplies.

Figure 8-19 Unimproved/No Drinking Water

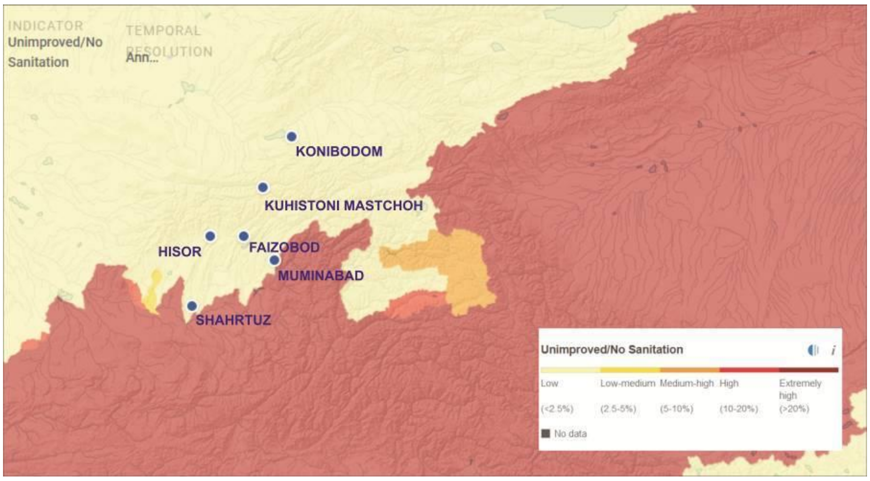


Unimproved and no drinking water shows extremely high risk for all areas but Kanibadam shows high levels.

- **Unimproved/No Sanitation**

Unimproved/no sanitation reflects the percentage of the population using pit latrines without a slab or platform, hanging/bucket latrines, or directly disposing human waste in fields, forests, bushes, open bodies of water, beaches, other open spaces, or with solid waste (WHO and UNICEF 2017). Specifically, the indicator aligns with JMP's unimproved and open defecation categories— the lowest tier of sanitation services. Higher values indicate areas where people have less access to improved sanitation services.

Figure 8-20 Unimproved/No Sanitation



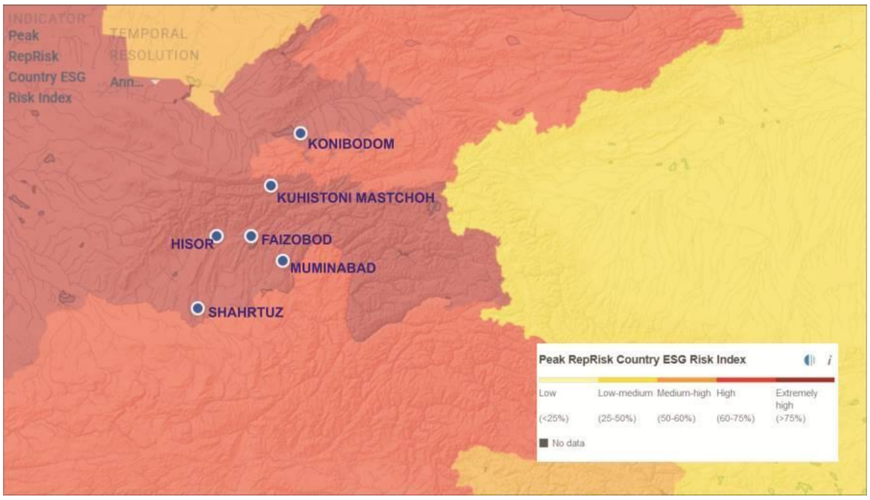
Unimproved/no sanitation risk is low for all analyzed districts.

- **Peak RepRisk Country ESG Risk Index**

The Peak RepRisk country ESG risk index quantifies business conduct risk exposure related to environmental, social, and governance (ESG) issues in the corresponding country. The index provides insights into potential financial, reputational, and compliance risks, such as human rights violations and environmental destruction. RepRisk is a leading business intelligence provider that specializes in ESG and business conduct risk research for companies, projects, sectors, countries, ESG issues, NGOs, and more, by leveraging artificial intelligence and human analysis in 20 languages. WRI has elected to include the Peak RepRisk country ESG risk index in Aqueduct Water Risk Atlas to reflect the broader regulatory and reputational risks that may threaten water quantity, quality, and access. While the underlying algorithm is proprietary, we believe that our inclusion of the Peak RepRisk country ESG risk index, normally unavailable to the public, is a value-add to the Aqueduct community. The peak value equals the highest level of the index in a given country over the last two years. The higher the value, the higher the risk exposure.

Final risk from the category of regulatory/reputational risks show extremely high levels for all regions.

Figure 8-21 Peak RepRisk Country ESG Risk Index



8.4.3.2. Agriculture

For the baseline water risk that would be representative of agriculture, researchers have established criteria for the agricultural sector so that it encompasses 69% of water quantity risk, 17% water quality risk and 14% regulatory and reputational risk. This is also evident from Figure 1 and hence these risks can be different from the previous section.

Figure 8-22 Weights of risks for Agriculture

OVERALL WATER RISK

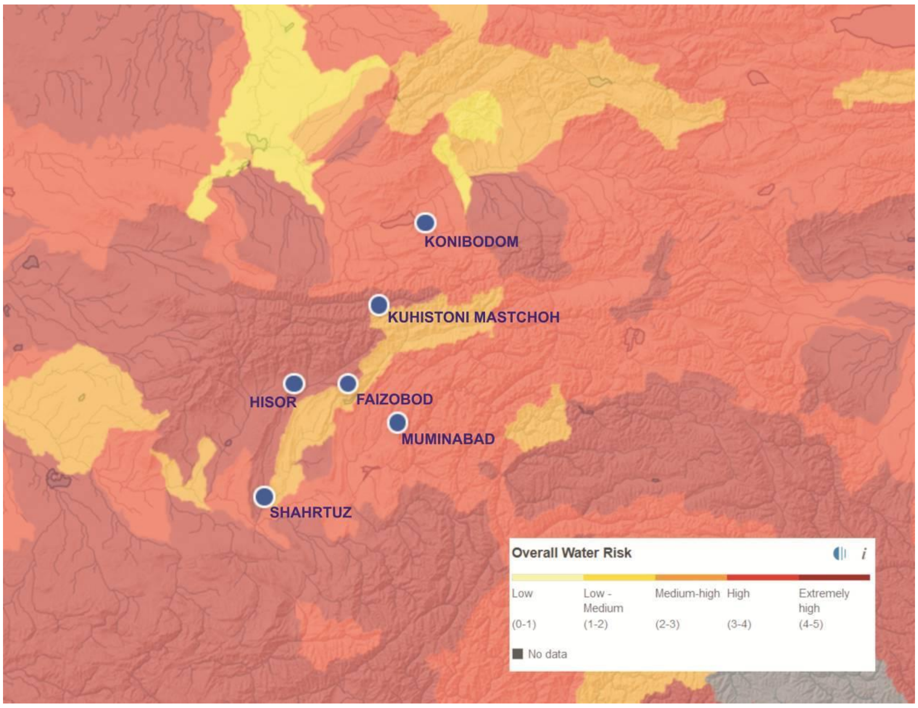
Overall Water Risk measures all water-related risks, by aggregating all selected indicators from the Physical Quantity, Quality and Regulatory & Reputational Risk categories. Higher values indicate higher water risk. This risk is analyzed for six districts in Table 8-6 and Figure 8-23.

Table 8-6 Agricultural sector – overall water risk

Name	Latitude	Longitude	Major Basin	Minor basin	Overall Water Risk
Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan	Extremely High (4-5)
Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan	Extremely High (4-5)
Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan	Extremely High (4-5)
Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan	Extremely High (4-5)
Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	High (3-4)
Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Panji	High (3-4)

Table 8-6 shows that four out of six regions are struck by overall water risk the most. These regions are Kuhistoni, Shaartuz, Fayzabad and Gissar. This shows that adaptation of the model for the agricultural sector does not change the overall water risk.

Figure 8-23 Agricultural sector - Overall Water risk



WATER QUANTITY RISK

Water Quantity Risk measures risk related to too little or too much water, by aggregating all selected indicators from the Physical Risk Quantity category. Higher values indicate higher water quantity risks. All analyzed regions show extremely high risk but for Gissar.

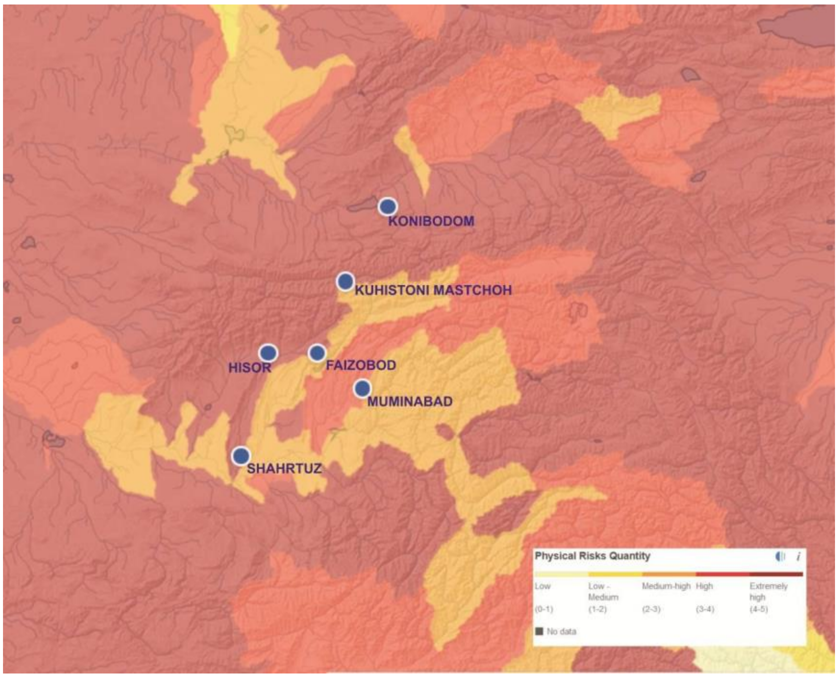
Table 8-7 *Agricultural sector – Water Quantity Risk*

Name	Latitude	Longitude	Major Basin	Minor basin	Water Quantity Risk
Kuhistoni Mastchoh	39.4001913	69.7644353	Amu Darya	Zeravshan	Extremely High (4-5)
Gissar	38.5318017	68.5552196	Amu Darya	Kafirnigan	Extremely High (4-5)
Shaartuz	37.2669052	68.1371795	Amu Darya	Kafirnigan	Extremely High (4-5)
Fayzabad	38.5291842	69.3235123	Amu Darya	Kafirnigan	Extremely High (4-5)
Kanibadam	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	Extremely High (4-5)
Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Panji	High (3-4)

Table shows that all regions but Muminabad are struck by extremely high risk when adjusted for the agricultural sector. This is different from the previous table 8-7 in

Muminabad and Kanibadam whereas when these regions are adjusted for ag-production, the risk is higher.

Figure 8-24 Agriculture sector Water Quantity Risk



WATER QUALITY RISK

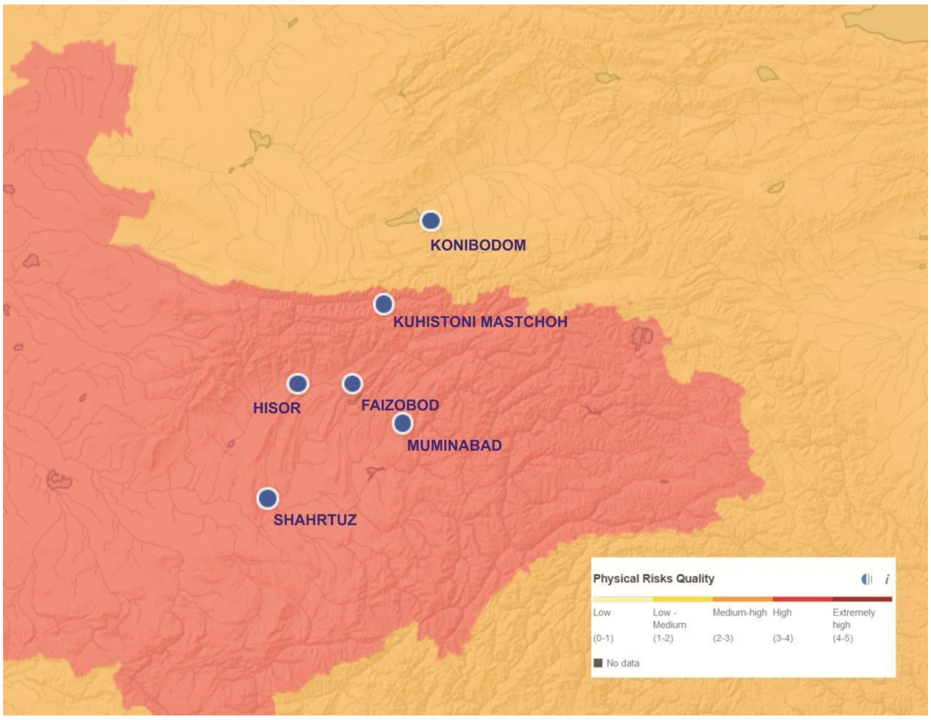
Physical risks quality measures risk related to water that is unfit for use, by aggregating all selected indicators from the Physical Risk Quality category. Higher values indicate higher water quality risks.

Table 8-8 *Agricultural sector – Water Quantity Risk*

Name	Latitude	Longitude	Major Basin	Minor basin	Water Quality Risk
Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan	High (3-4)
Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan	High (3-4)
Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan	High (3-4)
Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan	High (3-4)
Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	Medium High (2-3)
Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Panji	High (3-4)

The table shows that all regions but Kanibadam show high risks. This is different for the agricultural sector when compared to Table 8-8 that does not require high quality water.

Figure 8-25 Agriculture sector Water Quality Risk



REGULATORY AND REPUTATIONAL RISKS

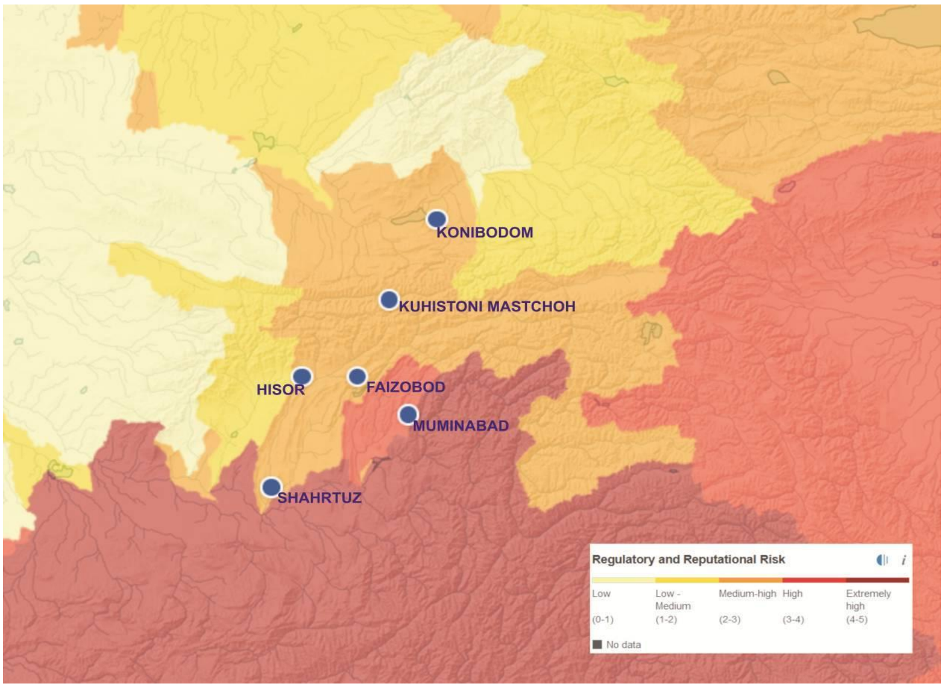
Regulatory and reputational risks measures risk related to uncertainty in regulatory change, as well as conflicts with the public regarding water issues. Higher values indicate higher regulatory and reputational water risks.

Table 8-9 Agricultural sector – Regulatory and Reputational

Name	Latitude	Longitude	Major Basin	Minor basin	Regulatory and Reputational
Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan	Medium - High (2-3)
Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan	Medium - High (2-3)
Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan	Medium - High (2-3)
Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan	Medium - High (2-3)
Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	Medium - High (2-3)
Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Panji	High (3-4)

This risk is highest for Muminaband (high) and medium-high for all other regions.

Figure 8-26 Agriculture sector Regulatory and Reputational Risk



8.4.3.3. Monthly data – water stress and deplation

WATER STRESS – MONTHLY DATA

For the project, data about current water stress, water depletion, and interannual variability are analyzed using groups of months that correspond roughly to climatic seasons in selected regions of Tajikistan.

- **Winter months**

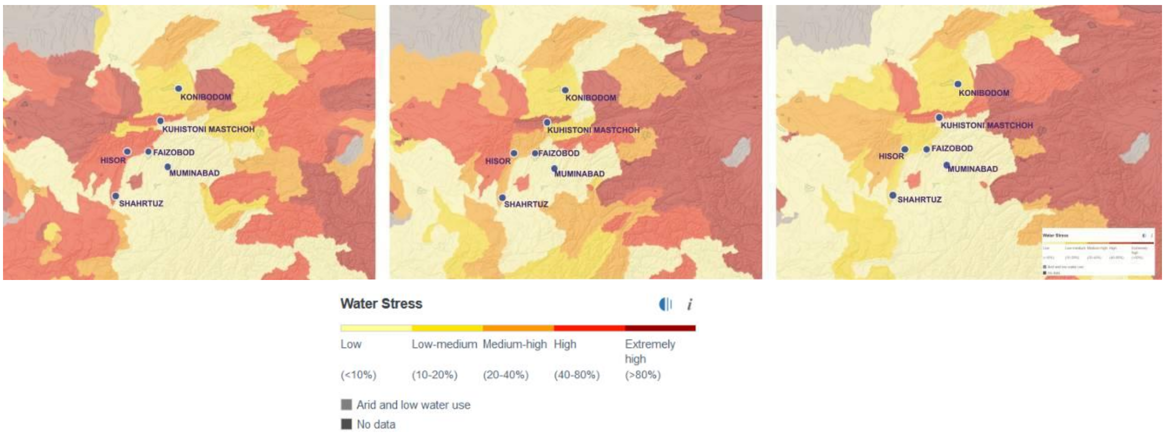
First indicator analyzed is water stress for winter months. Winter months are critical for storage of groundwater and subsequent supply for especially fruit trees. This is summarized in Table 8-10.

Table 8-10 Winter months water stress

Name	Major Basin	Minor basin	December	January	February
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low	Low - Medium	Low - Medium
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Medium - High	Low - Medium
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High	Extremely High	High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Medium - High	Low - Medium
Gissar, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Medium - High	Low - Medium

Source: own compilation from WRI (2019)

Figure 8-27 Winter months water stress



The analysis shows for the winter season that the most threatened region is Kuhistoni – Mastchoh. This region is known for potatoes, fruits and cereals production. Increased water stress in these months means that spring sprouting is threatened due to excessive water withdrawals relative to available water supply. The least threatened regions are Muminabad, followed by Kanibadam.

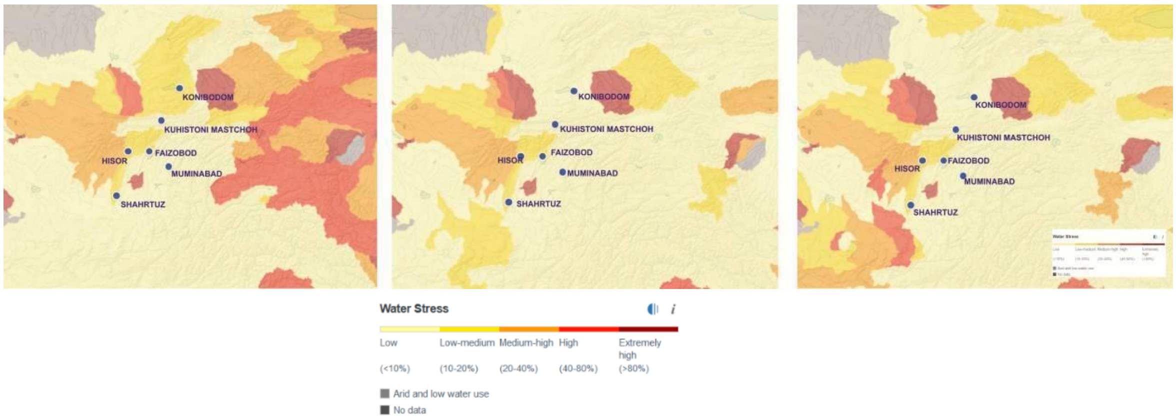
- **Spring months**

In Table 8-11, spring months for all analyzed regions are provided. Spring months are particularly important for spring cereals, potatoes, vegetables and cotton. Fruit trees are also susceptible to excessive water stress. Even though there is no revealed water stress higher than low-to-medium, some of the neighboring regions close to Gissar and Kanibadam could be threatened.

Table 8-11 Spring months water stress

Name	**Major Basin**	**Minor basin**	**March**	**April**	**May**
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low - Medium	Low	Low
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Low	Low	Low
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium
Gissar, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium

Figure 8-28 Spring months water stress



- **Summer months**

Summer months for the selected regions are analyzed in the Table 8-12 and subsequent Figure 8-29. In the summer months, water stress may be important for melons, potatoes, and fruit production. Provided analysis shows that the most threatened regions are Shaartuz, Gissar and Fayzabad. Melons production can be at risk in Gissar. Potatoes are at risk in Shaartuz.

Figure 8-29 Summer months water stress

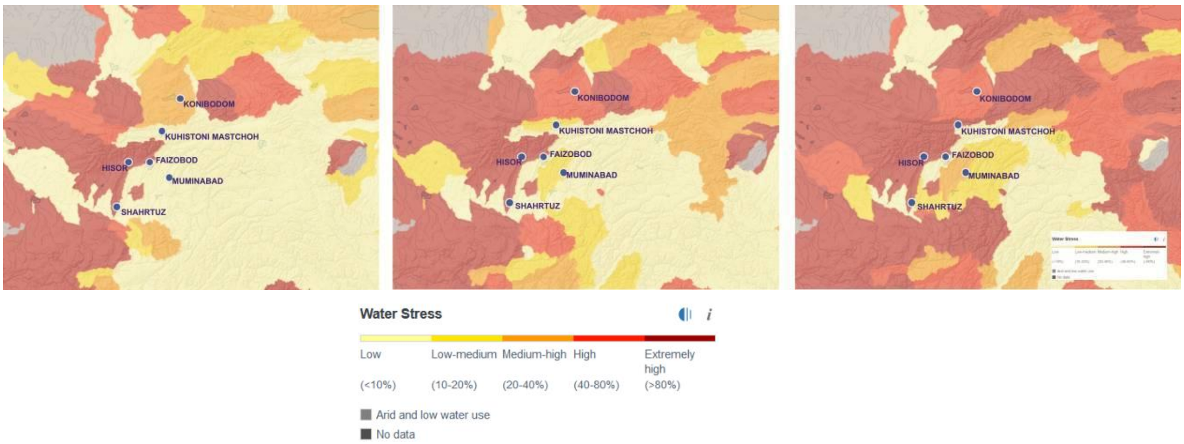


Table 8-12 Summer months water stress

Name	Major Basin	Minor basin	June	July	August
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Medium - High	High	High
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low - Medium	Medium - High
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Low	Low - Medium	Extremely High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High

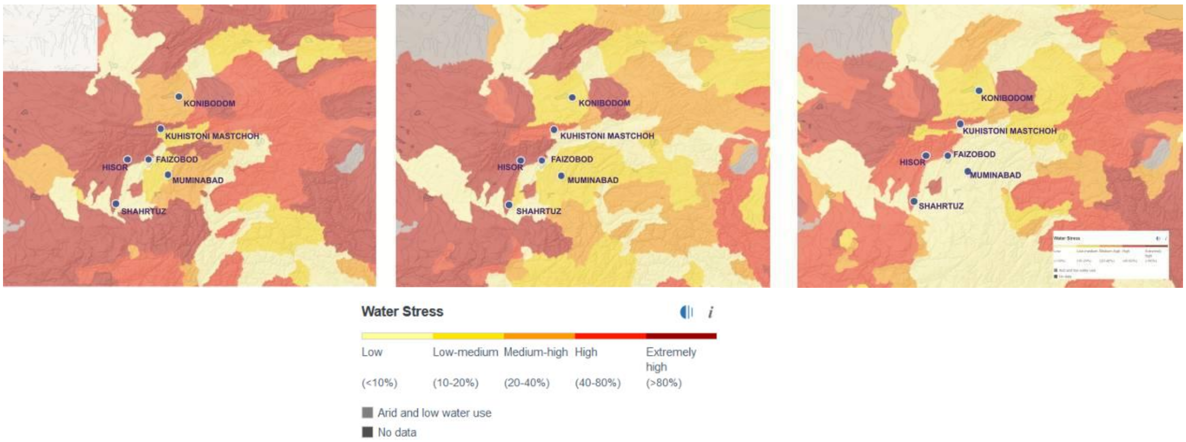
- **Autumn months**

Autumn months are analyzed in Table 8-13 and subsequent Figure 8-30. Autumn stress is particularly important for winter crops (cereals). The analysis shows that the most threatened regions are Fayzabad, Shaartuz, and Gissar where some cereals are grown.

Table 8-13 Autumn months water stress

Name	Major Basin	Minor basin	September	October	November
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Medium - High	Low - Medium	Low - Medium
Muminabad, Tajikistan	Amu Darya	Panji	Low - Medium	Low - Medium	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely High	High	High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	High

Figure 8-30 Autumn months water stress



WATER DEPLETION MONTHLY DATA

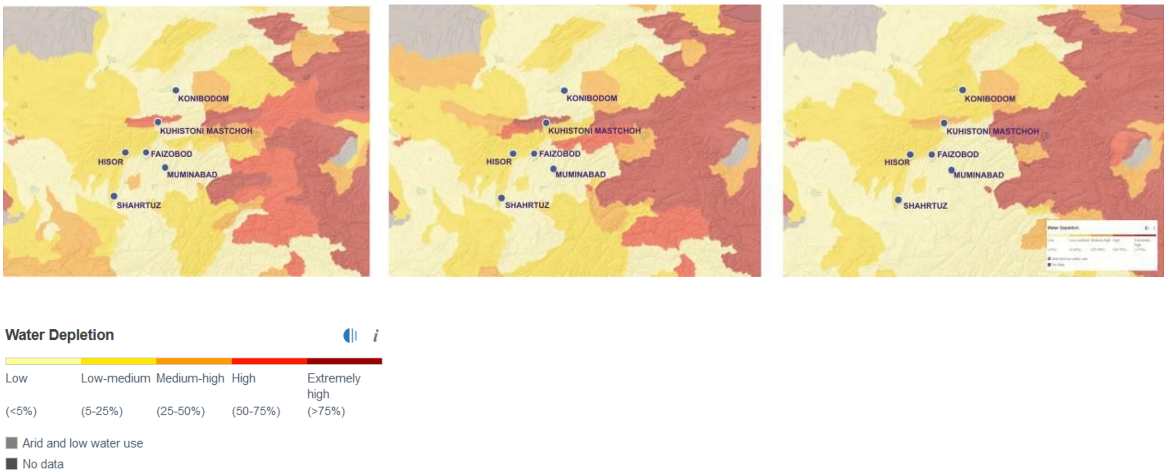
- **Winter months**

DJF

Table 8-14 Winter months water depletion data

Name	Major Basin	Minor basin	December	January	February
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low	Low	Low - Medium
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High	Extremely High	Medium - High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium
Gissar, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low - Medium	Low - Medium

Figure 8-31 Winter months water depletion data

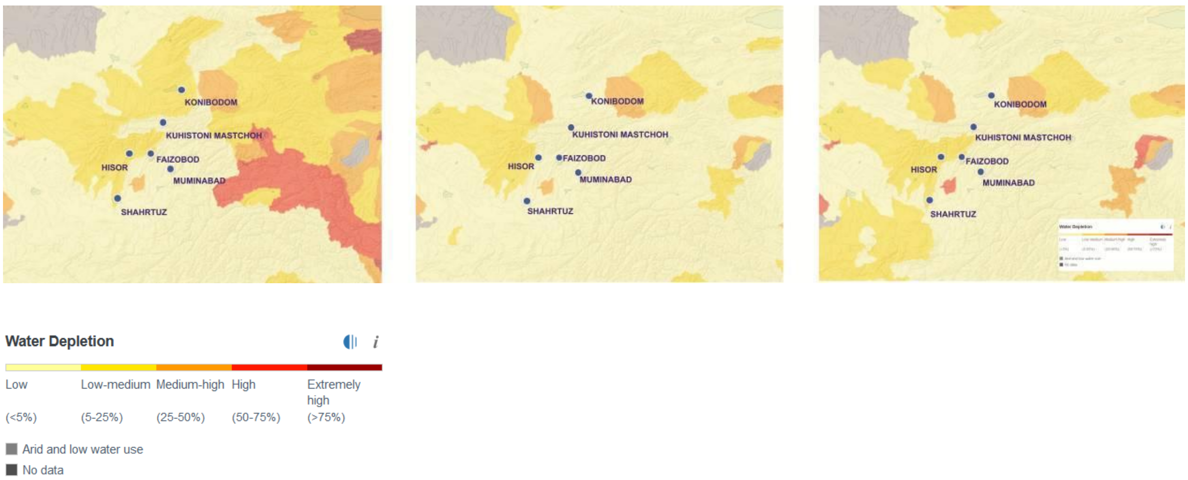


- **Spring months**

Table 8-15 Spring months water depletion data

Name	Major Basin	Minor basin	March	April	May
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low - Medium	Low	Low
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low	Low - Medium
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Low	Low	Low
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low	Low - Medium
Gissar, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low	Low - Medium

Figure 8-32 Spring months water depletion data



- **Summer months**

Table 8-16 Summer months water depletion data

Name	Major Basin	Minor basin	June	July	August
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low - Medium	Low - Medium	Low - Medium
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low - Medium
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Extremely High	Extremely High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Low	Low - Medium	Extremely High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Extremely High	Extremely High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Medium - High	Extremely High	Extremely High

Figure 8-33 Summer months water depletion data

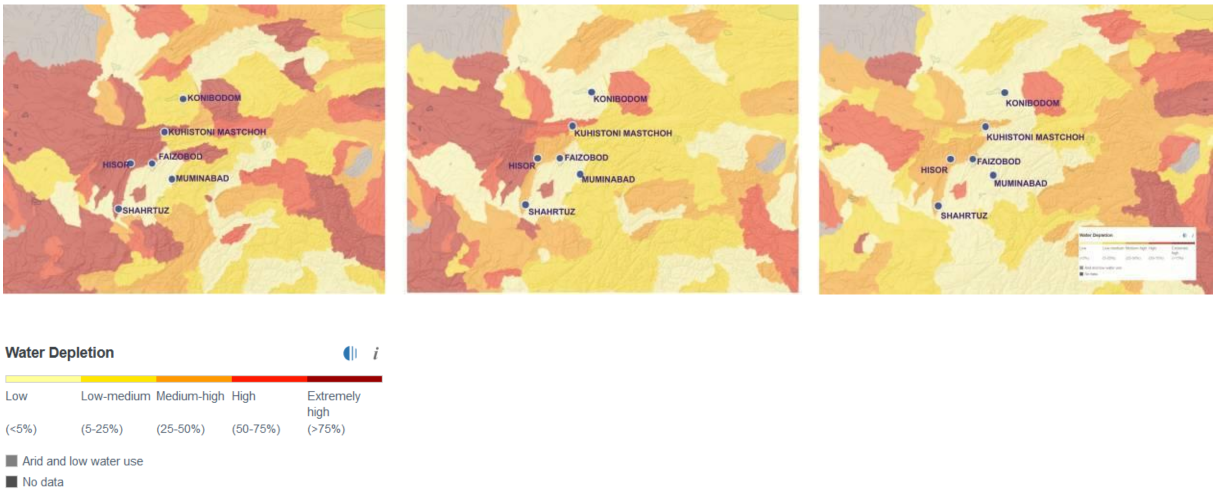
Autumn months

SON

Table 8-17 Autumn months water depletion data

Name	Major Basin	Minor basin	September	October	November
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Low - Medium	Low	Low
Muminabad, Tajikistan	Amu Darya	Panji	Low	Low	Low
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely High	High	Medium - High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High

Figure 8-34 Autumn months water depletion data



Based on the Tables 8-14 to 8-17, water depletion indicator shows very similar results like water stress and has the same implications for agricultural production in the analyzed regions of Tajikistan.

<u>Interannual Variability</u>

Interannual Variability in the Table 8-18 and Figure 8-35 measures the average between year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations in available supply from year to year. Like in the previous cases, monthly data are grouped into four groups corresponding to four seasons: winter, spring, summer and autumn.

- **Winter months**

Table 8-18 Winter months interannual variability data

Name	**Major Basin**	**Minor basin**	**December**	**January**	**February**
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High	High	High
Muminabad, Tajikistan	Amu Darya	Panji	Medium - High	Medium - High	Low - Medium
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely High	Extremely High	Extremely High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Medium - High	Medium - High

As opposed to water stress, interannual variability indicates variations between years and therefore, higher risk signifies faster reduction in available water supply. For this indicator, particularly threatened are the regions of Kuhistoni Mastchoh, followed by Shaartuz, Gissar and Fayzabad. For winter months this implies low supply of water into groundwater level. This can be a risk for trees.

Figure 8-35 Winter months interannual variability data

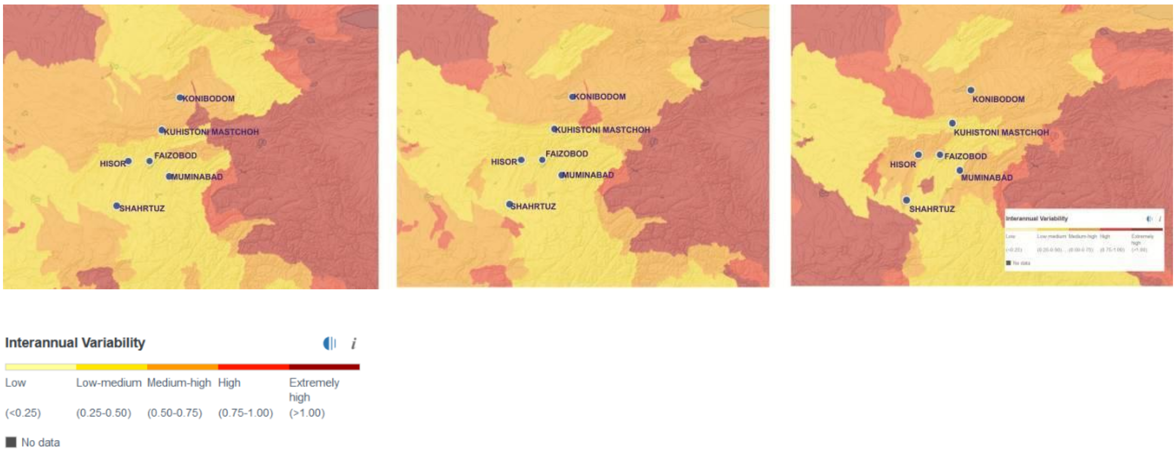
- **Spring months**

Spring months are the most critical months for agricultural production. Here, the interannual variability (Table 8-19 and Figure 8-36) shows that the most threatened region is Kanibadam, followed by Fayzabad, Shaartuz, Kuhistoni and Gissar. Least threatened region is Muminabad.

Table 8-19 Spring months interannual variability data

Name	Major Basin	Minor basin	March	April	May
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Medium - High	Medium – High	Medium - High
Muminabad, Tajikistan	Amu Darya	Panji	Low - Medium	Low – Medium	Low - Medium
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low – Medium	Medium - High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Medium - High	Low – Medium	Low - Medium
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low – Medium	Medium - High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Low - Medium	Low – Medium	Medium - High

Figure 8-36 Spring months interannual variability data



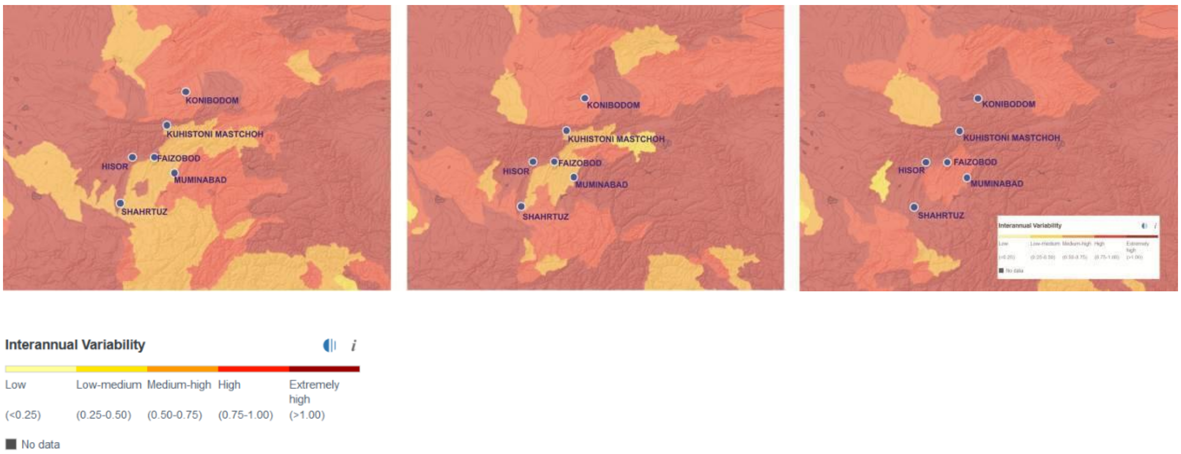
- **Summer months**

Summer months are critical for melons, fruits and potatoes. The most threatened regions are Fayzabad, Kuhistoni, Shaartuz and Gissar – see Table 8-20 and Figure 8-37. This means that these four regions enjoy the largest change in available supply between years.

Table 8-20 Summer months interannual variability data

Name	Major Basin	Minor basin	June	July	August
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High	High	Extremely High
Muminabad, Tajikistan	Amu Darya	Panji	Medium - High	Medium - High	High
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely High	Extremely High	Extremely High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High

Figure 8-37 Summer months interannual variability data



- **Autumn months**

Autumn months are presented in Table 8-21 and Figure 8-38. Here all regions are at risk with relatively lower risk in November for Kanibadam and October and November for Muminabad. In the remaining regions interannual variations are the highest possible hence signifying high risk to future development.

Table 8-21 Autumn months interannual variability data

Name	Major Basin	Minor basin	September	October	November
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Extremely High	Extremely High	High
Muminabad, Tajikistan	Amu Darya	Panji	Extremely High	High	Medium - High
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Kuhistoni Mastchoh	Amu Darya	Zeravshan	Extremely High	Extremely High	Extremely High
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High
Gissar, Tajikistan	Amu Darya	Kafirnigan	Extremely High	Extremely High	Extremely High

Figure 8-38 Autumn months interannual variability data

For the analysis crops were ranked in the Table 8-22 according to their popularity.

Table 8-22 Popularity of crops in the analyzed regions

Name	**crop 1**	**crop 2**	**crop 3**	**crop 4**	**crop 5**	**crop 6**
Kanibadam, Tajikistan	fruits	cereals	vegetable	melons	potatoes	
Muminabad, Tajikistan	cereals	potatoes	vegetable	fruits	melons	
Fayzabad, Tajikistan	cotton	cereals	potatoes	vegetable	melons	fruits
Kuhistoni Mastchoh, Tajikistan	potatoes	cereals	vegetable	fruits		
Shaartuz, Tajikistan	cereals	vegetable	melons	potatoes	fruits	
Gissar, Tajikistan	cereals	vegetable	fruits	potatoes	cotton	melons

Source: regions passports

8.5. The effect of climate change on water resources, future predictions

Complex risk of water stress[11] for all scenarios - optimistic, normal situation scenario and pessimistic until 2030 and until 2040 represent a medium risk, except in the areas of Muminabad, Kuhistoni and Kanibadam where the risk is extremely high.

Optimistic, current and pessimistic scenarios for both periods (2030 and 2040) show a high degree of **risk in seasonal variability**. 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. The fact that the Kuhistoni area is alpine, where snowfall and melting are expected, may play a role here.

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.

8.5.1. Methodology

In the report using the methodology of the World Resource Institute (2019) that 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. The areas of Gissar, Muminabad, Kuhistoni, Fayzabad, Shaartuz and Kanibadam, which represent the diversity of conditions, were chosen as representatives.

8.5.2. Summary

Chapter deals with the future of water supply in the study area. Complex risk of water stress for all scenarios - optimistic, normal situation scenario and pessimistic until 2030 (Table 8-23, 8-24 and 8-25 and the relevant figures 8-39, 8-40 and 8-41) represent a medium risk, except in the areas of Muminabad, Kuhistoni and Kanibadam where the risk is extremely high. For the period up to 2040, the model again calculates a medium-high risk in an optimistic, normal and pessimistic scenario, with the exception of the Muminabad, Kuhistoni and Kanibadam areas, where the risk is extremely high. Seasonal variability represents differences in water availability in individual months. In high probability, it may

[11] Water risk refers to the possibility of an entity experiencing a water-related challenge (e.g., water scarcity, water stress, flooding, infrastructure decay, drought). The extent of risk is a function of the likelihood of a specific challenge occurring and the severity of the challenge's impact. The complex risk of water stress implies its availability and quality, the water risks for agriculture, the seasonal risks.

mean a higher probability of extremely dry or extremely humid periods. The year-on-year variance coefficient for each year was used as an indicator in the model and then the estimated change in seasonal variability was estimated as the 21-year average of the target year compared to the base period. Optimistic, current and pessimistic scenarios for both periods (2030 and 2040) show a high degree of risk in seasonal variability. 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.

Water sources are another indicator. This is the so-called "blue water", or renewable surface water. The expected change in the amount of this water is equal to the 21-year average around the target year (2030 and 2040) compared to the base period 1950-2010. The highest risk in water supply is in the areas of Gissar, Fayzabad and Shaartuz, the lowest risk is in Kuhistoni. The fact that the Kuhistoni area is alpine, where snowfall and melting are expected, may play a role here.

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.

The model data presented in this study show a very high risk to water management in Tajikistan. Together with climate change and weather extremes, it will be necessary to take into account changes in the national economy and strict protection of the quality and quantity of water resources.

8.5.3. Results. Future Water stress

Water stress is an indicator of competition for water resources and is defined informally as the ratio of demand for water by human society divided by available water.

Baseline water stress is a particularly important indicator to understand when evaluating water-related risks. It measures the ratio of total water withdrawals (by industry, agriculture, and domestic users) to the available supply, taking into account upstream uses and depletion of water. Two variables determine baseline water stress: water supply availability, and demand for that water. Water supply estimates are obtained from a model that considers a wide variety of variables, including temperature, precipitation, wind speed, and soil moisture absorption. The outputs of the model show where precipitation is made available to users in the form of surface and shallow groundwater. The demand for water is computed by adding the total annual withdrawals from municipal, industrial, and agricultural sources, based on a series of reported and modelled global datasets.

Absolute value

Water stress - Water stress is an indicator of competition for water resources and is defined informally as the ratio of demand for water by human society divided by available water.

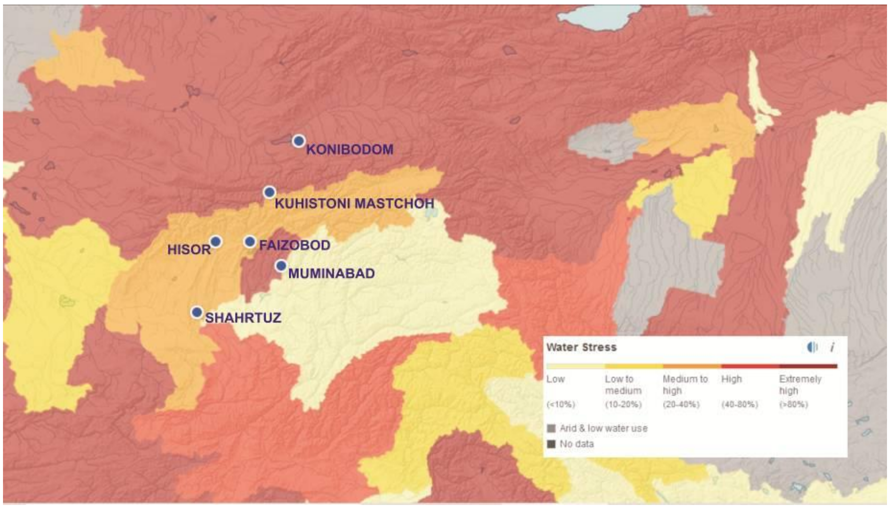
Optimistic 2030

The "optimistic" scenario (SSP2 RCP4.5) represents a world with stable economic development and carbon emissions peaking and declining by 2040, with emissions constrained to stabilize at ~650 ppm CO2 and temperatures to 1.1–2.6°C by 2100.

Table 8-23 *Projected Change in Water Stress - optimistic 2030*

Input address	Match address	Latitude	Longitude	Major Basin	Minor Basin	Aquifer	Country	Province	Projected Change in Water Stress (Value in Year To 2030 Optimistic)
Kuhistoni Mastchoh, Tajikistan	Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan		Tajikistan	Sughd	Extremely high (>80%)
GHJ4+P3H, Gissar, Tajikistan	GHJ4+P3H, Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan		Tajikistan	Tajikistan Territories	Medium-high (20-40%)
Shaartuz, Tajikistan	Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan		Tajikistan	Khatlon	Medium-high (20-40%)
Fayzabad, Tajikistan	Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan		Tajikistan	Tajikistan Territories	Medium-high (20-40%)
Kanibadam, Tajikistan	Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir		Tajikistan	Sughd	Extremely high (>80%)
Muminabad, Tajikistan	Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Pyanj		Tajikistan	Khatlon	Extremely high (>80%)

Figure 8-39 Projected Change in Water Stress - optimistic 2030



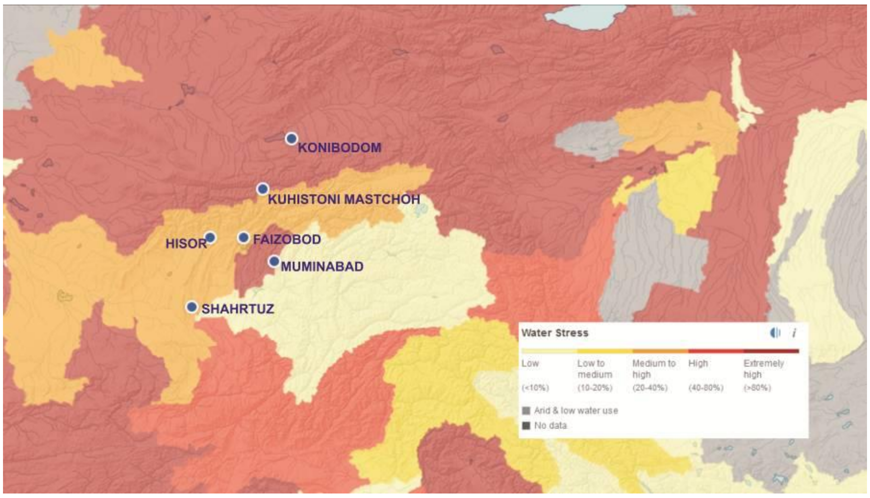
Business as usual 2030

The "business as usual" scenario (SSP2 RCP8.5) represents a world with stable economic development and steadily rising global carbon emissions, with CO_2 concentrations reaching ~1370 ppm by 2100 and global mean temperatures increasing by 2.6–4.8°C relative to 1986–2005 levels.

Table 8-14 Projected Change in Water Stress - business as usual 2030

Input address	Match address	Latitude	Longitude	Major Basin	Minor Basin	Aquifer	Country	Province	Projected Change in Water Stress (Value in Year To 2030 Business as usual)
Kuhistoni Mastchoh, Tajikistan	Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan		Tajikistan	Sughd	Extremely high (>80%)
GHJ4+P3H, Gissar, Tajikistan	GHJ4+P3H, Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan		Tajikistan	Tajikistan Territories	Medium-high (20-40%)
Shaartuz, Tajikistan	Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan		Tajikistan	Khatlon	Medium-high (20-40%)
Fayzabad, Tajikistan	Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan		Tajikistan	TajikistanTerritories	Medium-high (20-40%)
Kanibadam, Tajikistan	Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir		Tajikistan	Sughd	Extremely high (>80%)
Muminabad, Tajikistan	Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Pyanj		Tajikistan	Khatlon	Extremely high (>80%)

Figure 8-40 Projected Change in Water Stress - business as usual 2030



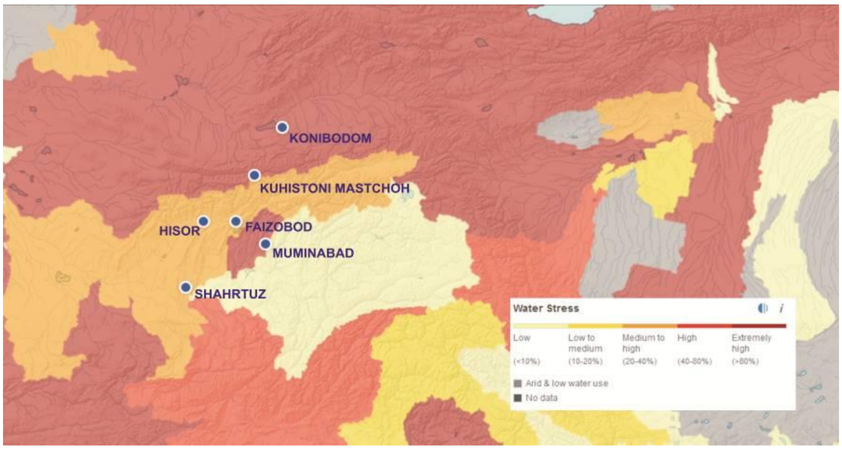
Pessimistic 2030

The "pessimistic" scenario (SSP3 RCP8.5) represents a fragmented world with uneven economic development, higher population growth, lower GDP growth, and a lower rate of urbanization, all of which potentially affect water usage; and steadily rising global carbon emissions, with CO_2 concentrations reaching ~1370 ppm by 2100 and global mean temperatures increasing by 2.6–4.8°C relative to 1986–2005 levels.

Table 8-25 Projected Change in Water Stress - pessimistic 2030

Input address	Match address	Latitude	Longitude	Major Basin	Minor Basin	Country	Province	Projected Change in Water Stress (Value in Year To 2030 Pessimistic)
Kuhistoni Mastchoh, Tajikistan	Kuhistoni Mastchoh, Tajikistan	39.4001913	69.7644353	Amu Darya	Zeravshan	Tajikistan	Sughd	Extremely high (>80%)
GHJ4+P3H, Gissar, Tajikistan	GHJ4+P3H, Gissar, Tajikistan	38.5318017	68.5552196	Amu Darya	Kafirnigan	Tajikistan	Tajikistan Territories	Medium-high (20-40%)
Shaartuz, Tajikistan	Shaartuz, Tajikistan	37.2669052	68.1371795	Amu Darya	Kafirnigan	Tajikistan	Khatlon	Medium-high (20-40%)
Fayzabad, Tajikistan	Fayzabad, Tajikistan	38.5291842	69.3235123	Amu Darya	Kafirnigan	Tajikistan	TajikistanTerritories	Medium-high (20-40%)
Kanibadam, Tajikistan	Kanibadam, Tajikistan	40.2982408	70.419388	Syr Darya	Kayrakkum Reservoir	Tajikistan	Sughd	Extremely high (>80%)
Muminabad, Tajikistan	Muminabad, Tajikistan	38.1058452	70.03245	Amu Darya	Pyanj	Tajikistan	Khatlon	Extremely high (>80%)

Figure 8-41 Projected Change in Water Stress - pessimistic 2030

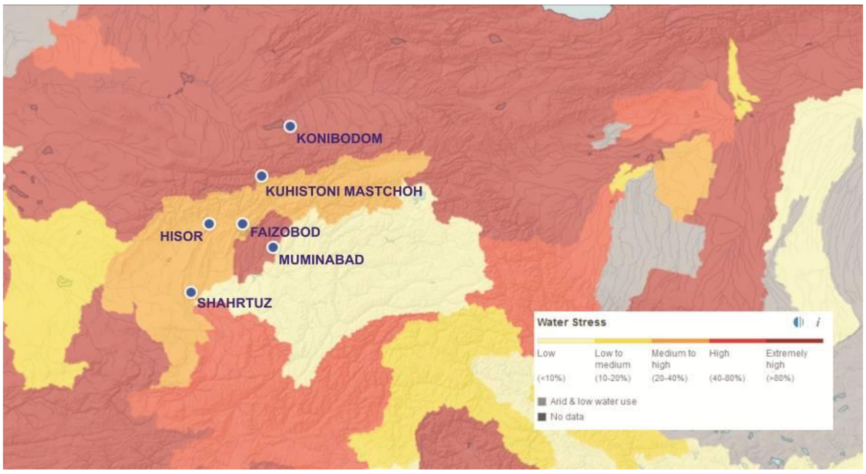


Optimistic 2040

Table 8-26 Projected Change in Water Stress - optimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Stress (Value in Year To 2040 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely high (>80%)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely high (>80%)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Extremely high (>80%)

Figure 8-42 Projected Change in Water Stress - optimistic 2040

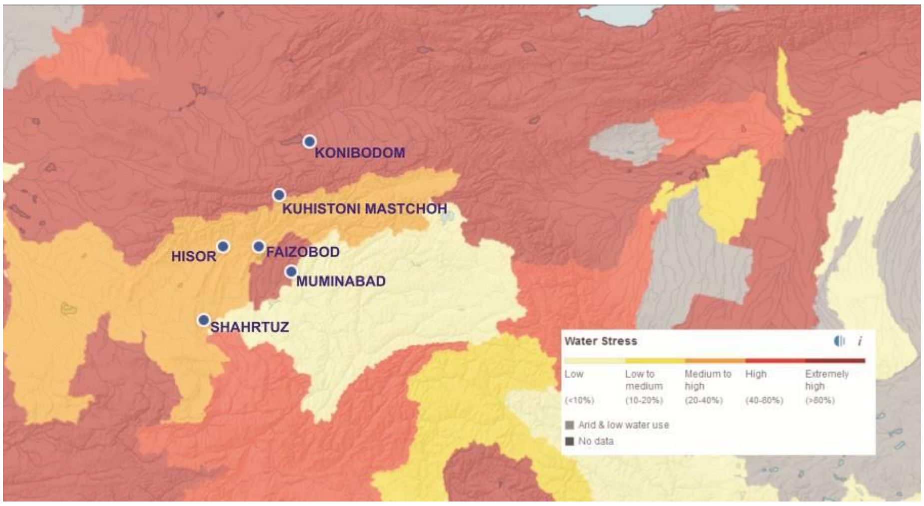


Business as usual 2040

Table 8-27 Projected Change in Water Stress - business as usual 2040

Name	Major Basin	Minor Basin	Projected Change in Water Stress (Value in Year To 2040 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Muminabad	Amu Darya	Pyanj	Extremely high (>80%)
Kuhistoni Mastchoh	Amu Darya	Zeravshan	Extremely high (>80%)
Fayzabad	Amu Darya	Kafirnigan	Medium-high (20-40%)
Shaartuz	Amu Darya	Kafirnigan	Medium-high (20-40%)
Kanibadam	Syr Darya	Kayrakkum Reservoir	Extremely high (>80%)

Figure 8-43 Projected Change in Water Stress - business as usual 2040

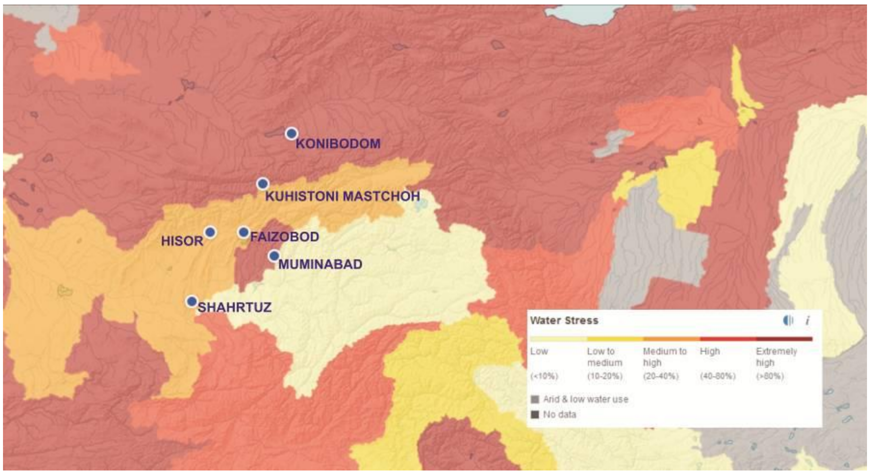


Pessimistic 2040

Table 8-28 Projected Change in Water Stress - pessimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Stress (Value in Year To 2040 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely high (>80%)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	Extremely high (>80%)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	Medium-high (20-40%)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	Extremely high (>80%)

Figure 8-44 Projected Change in Water Stress - pessimistic 2040



8.5.4. Results. Seasonal variability

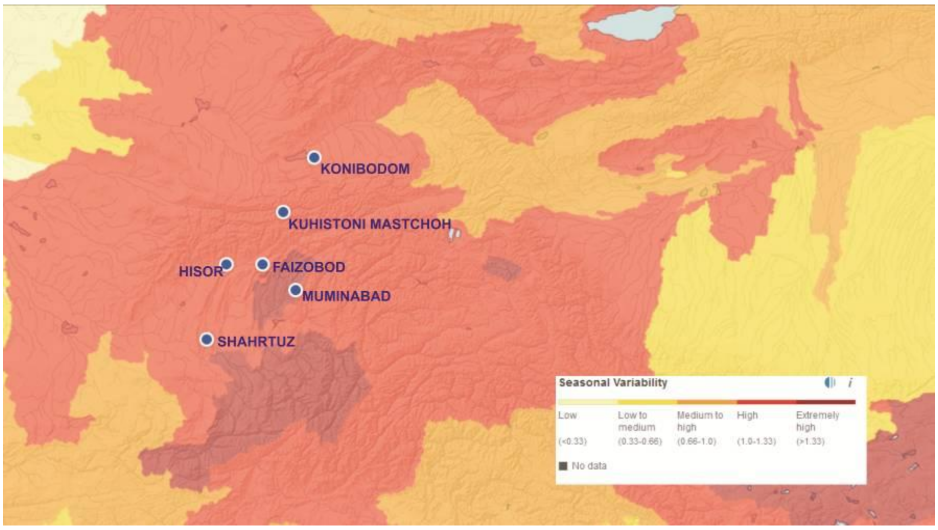
Seasonal variability (SV) is an indicator of the variability between months of the year. Increasing SV may indicate wetter wet months and drier dry months, and higher likelihood of droughts or wet periods. We used the within-year coefficient of variance between monthly total blue water as our indicator of seasonal variability of water supply. We calculated the coefficient of variance between months for each year, then estimated projected change in seasonal variability as the 21-year mean around the target year over the baseline period mean.

Optimistic 2030

Table 8-29 Projected Change in Seasonal Variability - optimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2030 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad, Tajikistan	Amu Darya	Pyanj~~i~~	Extremely High (>1.33)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-45 Projected Change in Seasonal Variability - optimistic 2030

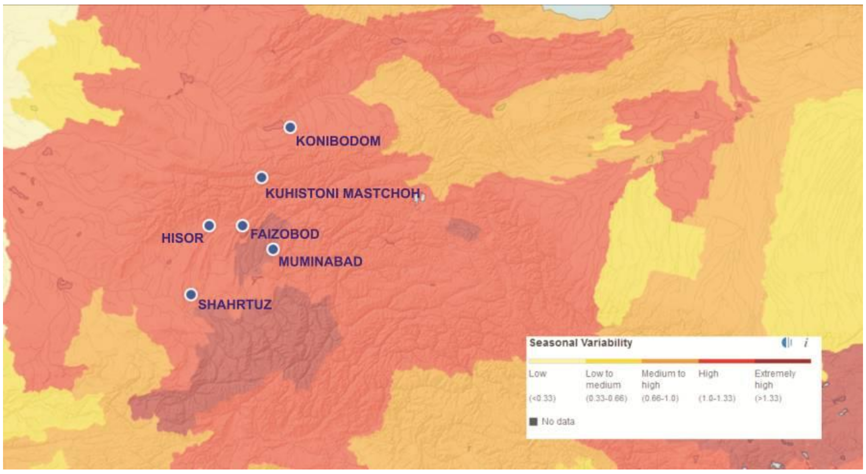


Business as usual 2030

Table 8-30 Projected Change in Seasonal Variability - business as usual 2030

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2030 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely High (>1.33)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-46 Projected Change in Seasonal Variability - business as usual 2030

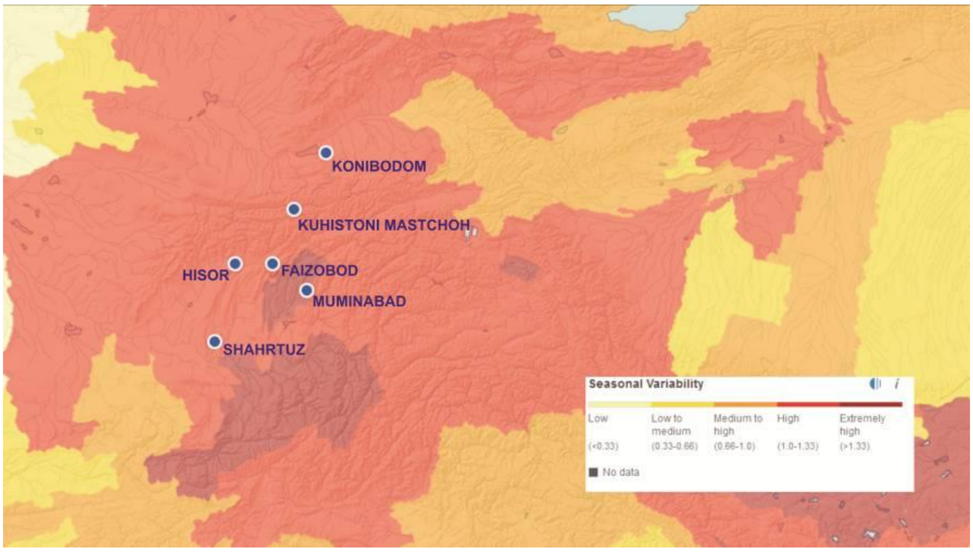


Pessimistic 2030

Table 8-31 Projected Change in Seasonal Variability - pessimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2030 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely High (>1.33)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-47 Projected Change in Seasonal Variability - pessimistic 2030

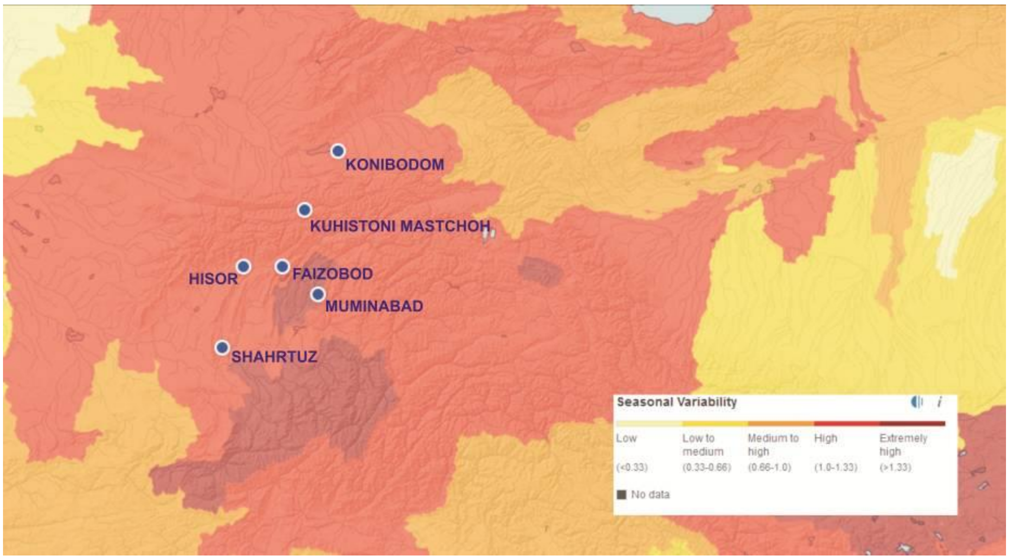


Optimistic 2040

Table 8-32 Projected Change in Seasonal Variability - optimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2040 Optimistic)
Gissar	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad	Amu Darya	Pyanj	Extremely High (>1.33)
Kuhistoni Mastchoh	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-48 Projected Change in Seasonal Variability - optimistic 2040

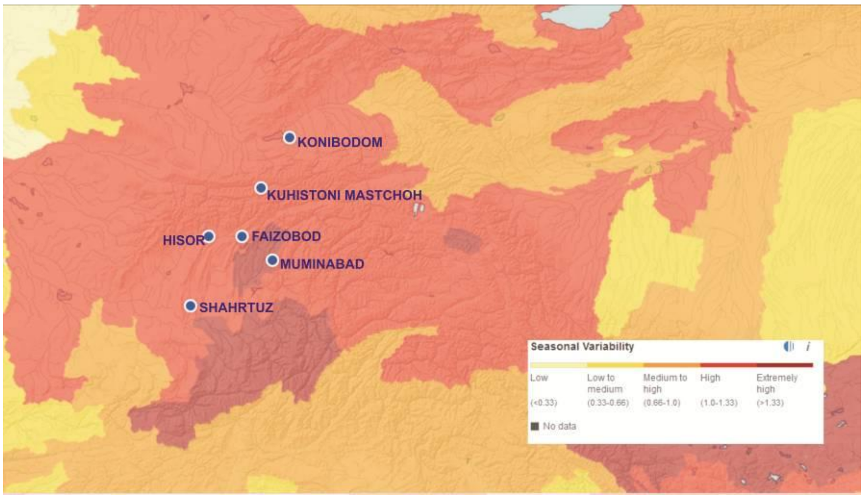


Business as usual 2040

Table 8-33 Projected Change in Seasonal Variability - business as usual 2040

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2030 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely High (>1.33)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-49 Projected Change in Seasonal Variability - business as usual 2040

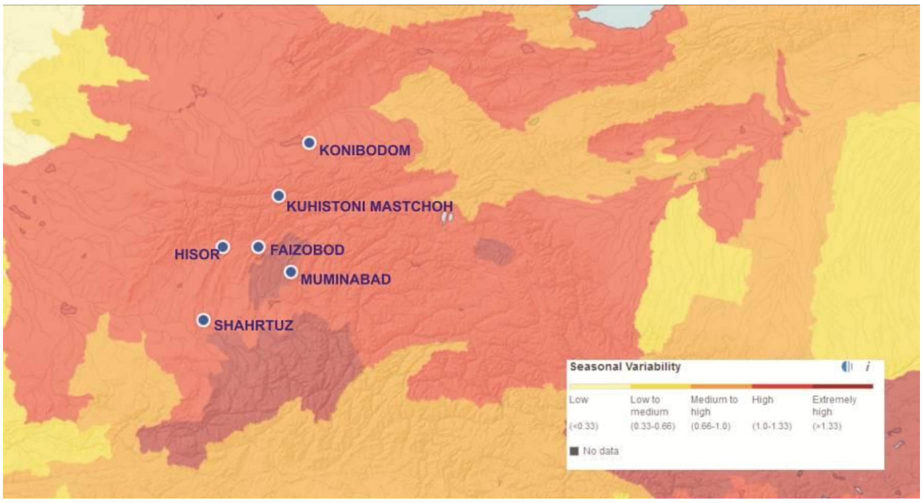


Pessimistic 2040

Table 8-34 Projected Change in Seasonal Variability - pessimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Seasonal Variability (Value in Year To 2040 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Muminabad, Tajikistan	Amu Darya	Pyanj	Extremely High (>1.33)
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	High (1.0-1.33)
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	High (1.0-1.33)
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	High (1.0-1.33)

Figure 8-50 Projected Change in Seasonal Variability - pessimistic 2040



8.5.5. Results. Water Supply

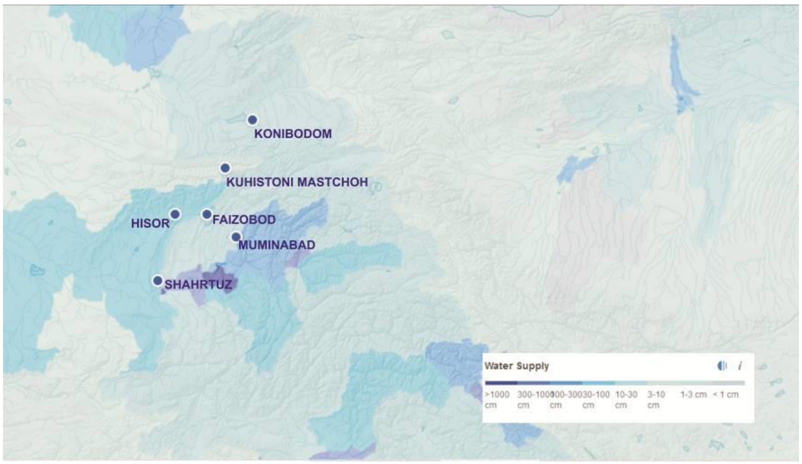
Total blue water (renewable surface water) was our indicator of water supply. Projected change in total blue water is equal to the 21-year mean around the target year divided by the baseline period of 1950–2010.

Optimistic 2030

Table 8-35 Projected Change in Water Supply - optimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2030 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-51 Projected Change in Water Supply - optimistic 2030

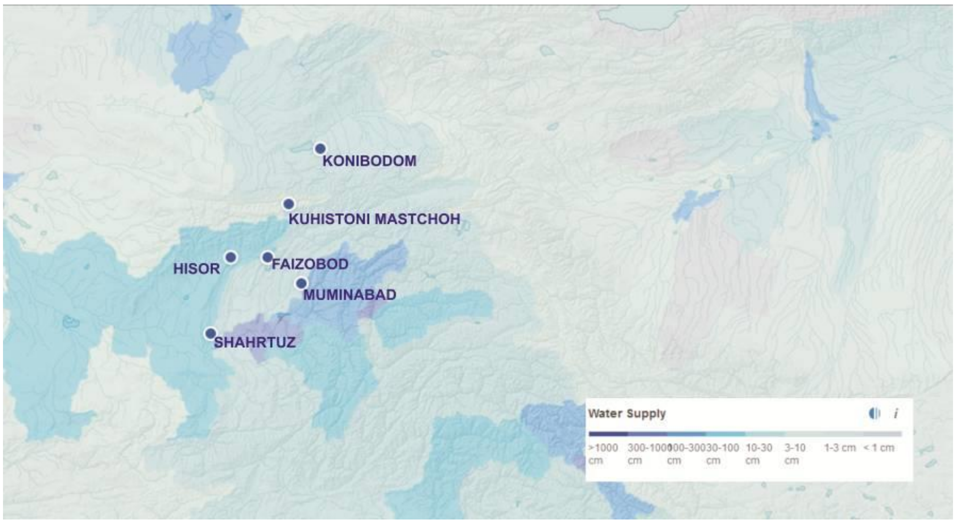


<u>Business as usual 2030</u>

Table 8-36 Projected Change in Water Supply - business as usual 2030

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2030 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-52 Projected Change in Water Supply - business as usual 2030

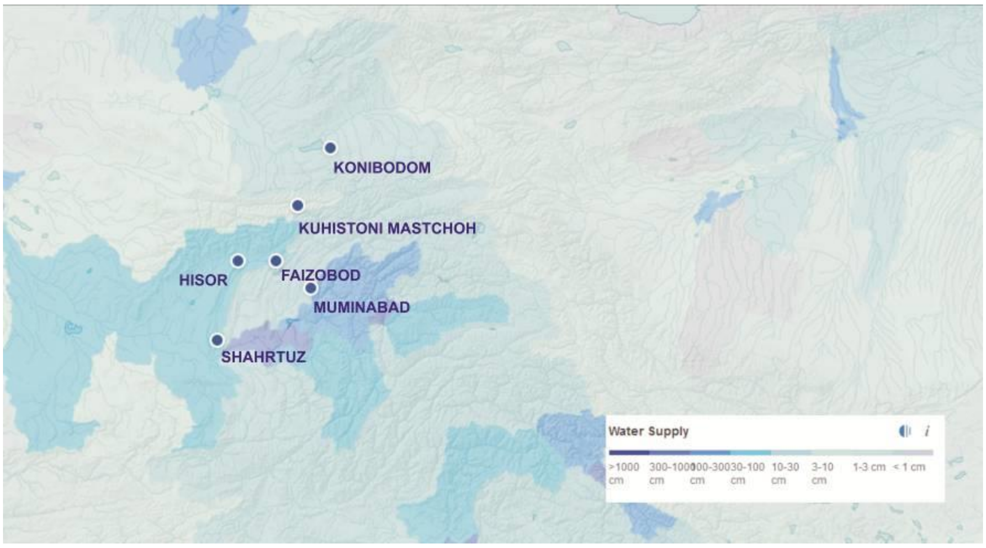


Pessimistic 2030

Table 8-37 Projected Change in Water Supply - pessimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2030 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-53 Projected Change in Water Supply - pessimistic 2030

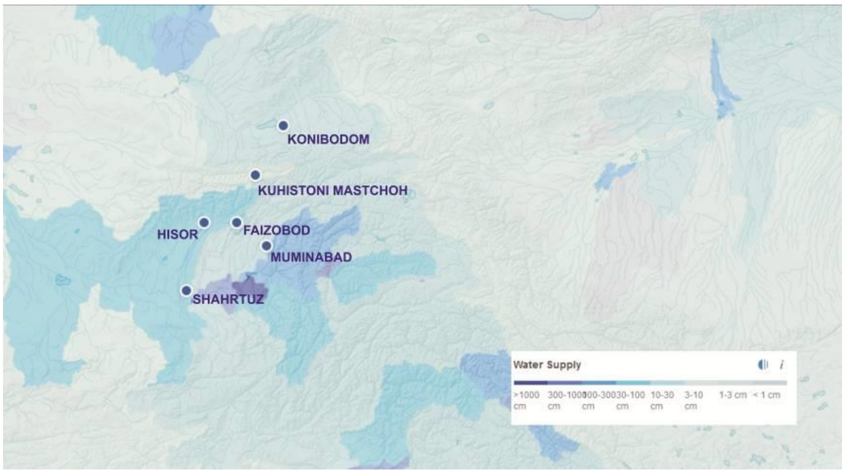


Optimistic 2040

Table 8-38 Projected Change in Water Supply - optimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2040 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-54 Projected Change in Water Supply - optimistic 2040

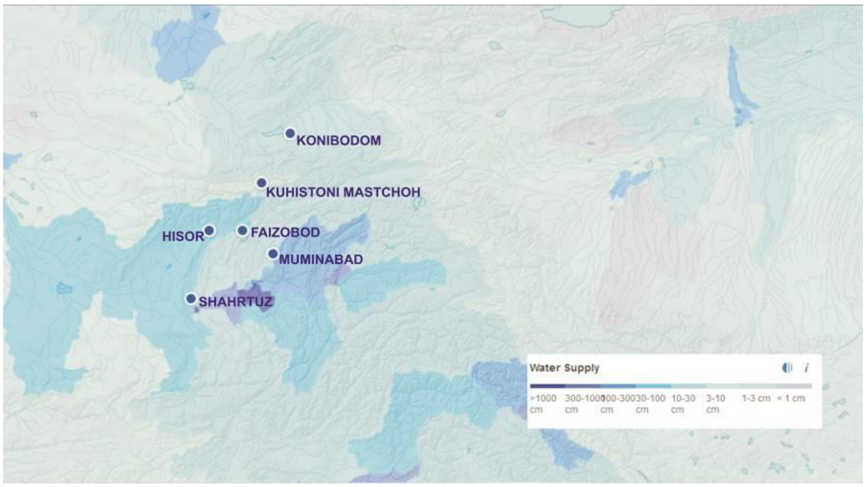


Business as usual 2040

Table 8-39 Projected Change in Water Supply - business as usual 2040

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2040 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-55 Projected Change in Water Supply - business as usual 2040

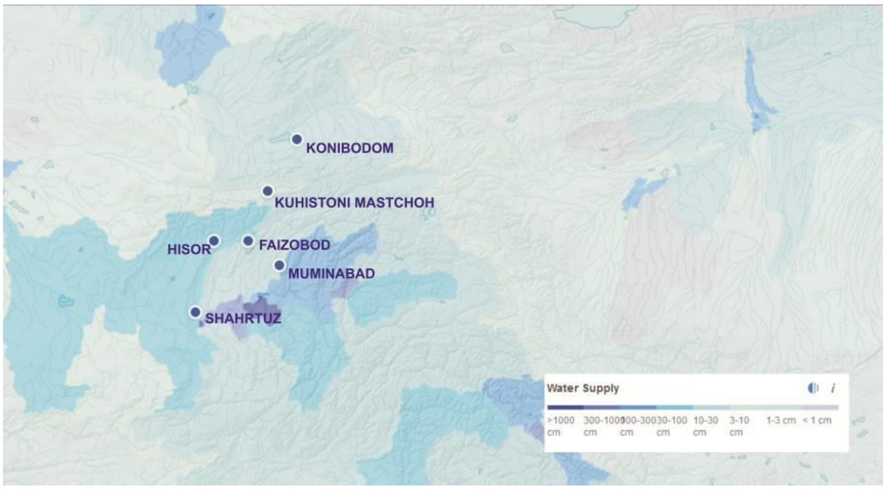


Pessimistic 2040

Table 8-40 Projected Change in Water Supply - pessimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Supply (Value in Year To 2040 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	3-10 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	30-100 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	10-30 cm

Figure 8-56 Projected Change in Water Supply - pessimistic 2040



8.5.6. Results. Water Demand

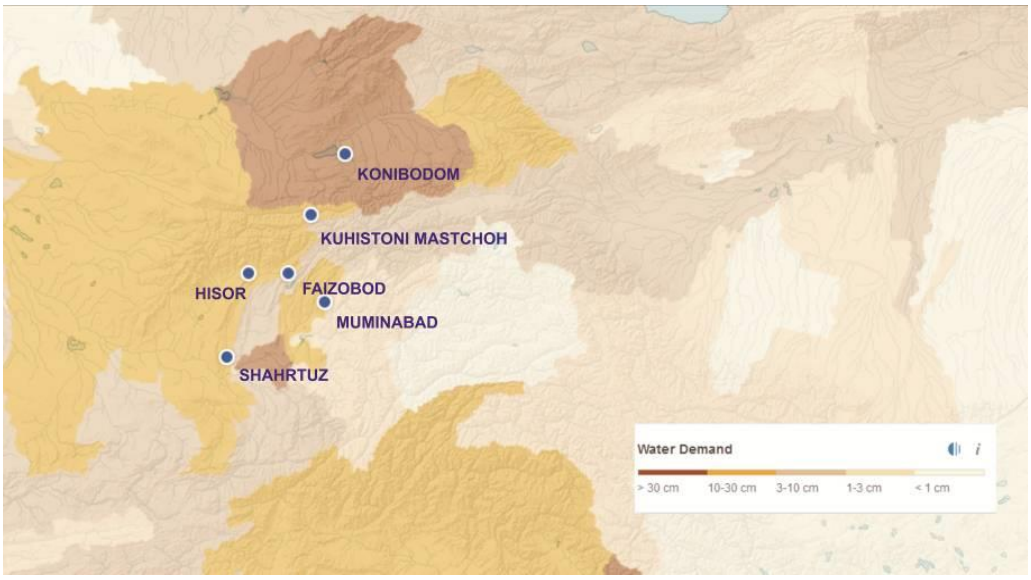
Water demand was measured as water withdrawals. Projected change in water withdrawals is equal to the summarized withdrawals for the target year, divided by the baseline year, 2010. Since irrigation consumptive use varies based on climate, we generated unique estimates of consumptive and non-consumptive agricultural withdrawal for each year. Estimates for consumptive and non-consumptive agricultural withdrawal for each ensemble member, scenario, and target year are the mean of the 21-year window around the target year.

Optimistic 2030

Table 8-41 Projected Change Water Demand - optimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Water Demand (Value in Year To 2030 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	10-30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-57 Projected Change Water Demand - optimistic 2030

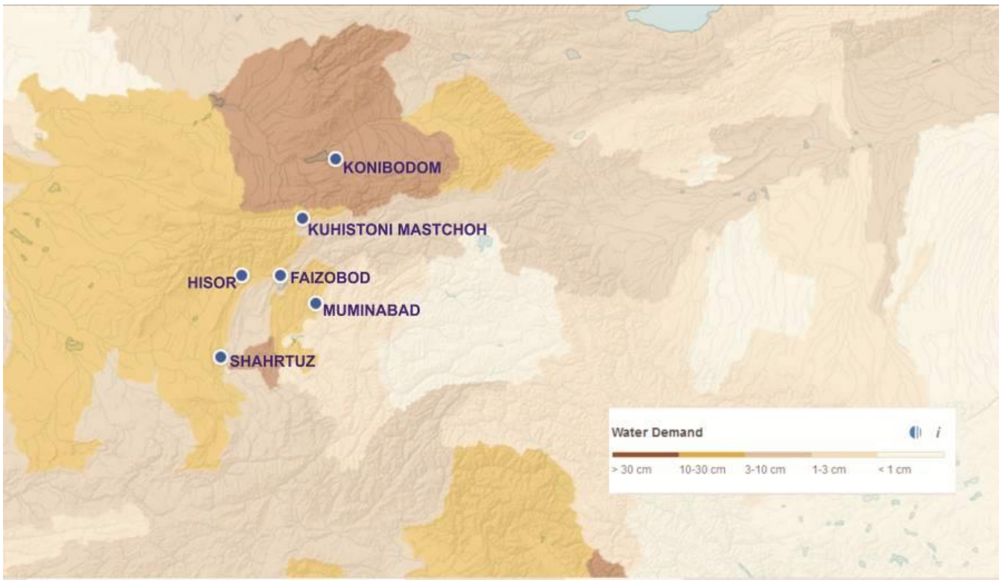


Business as usual 2030

Table 8-42 Projected Change Water Demand - business as usual 2030

Name	Major Basin	Minor Basin	Projected Change in Water Demand (Value in Year To 2030 Business as usual)
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	10-30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-58 Projected Change Water Demand - business as usual 2030

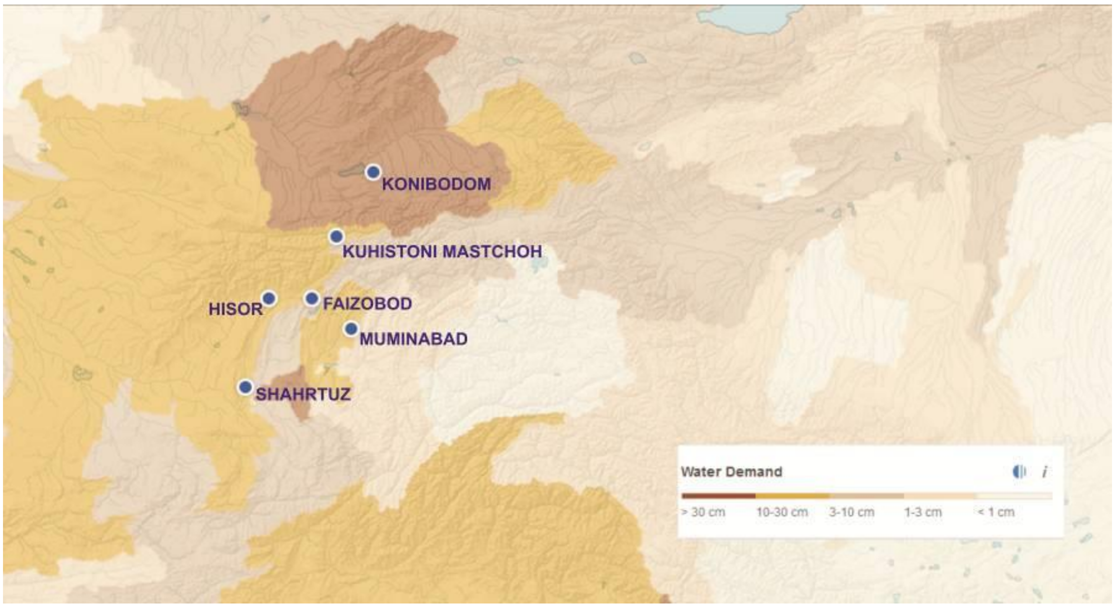


Pessimistic 2030

Table 8-43 Projected Change Water Demand - pessimistic 2030

Name	Major Basin	Minor Basin	Projected Change in Water Demand (Value in Year To 2030 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh	Amu Darya	Zeravshan	10-30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-59 Projected Change Water Demand - pessimistic 2030

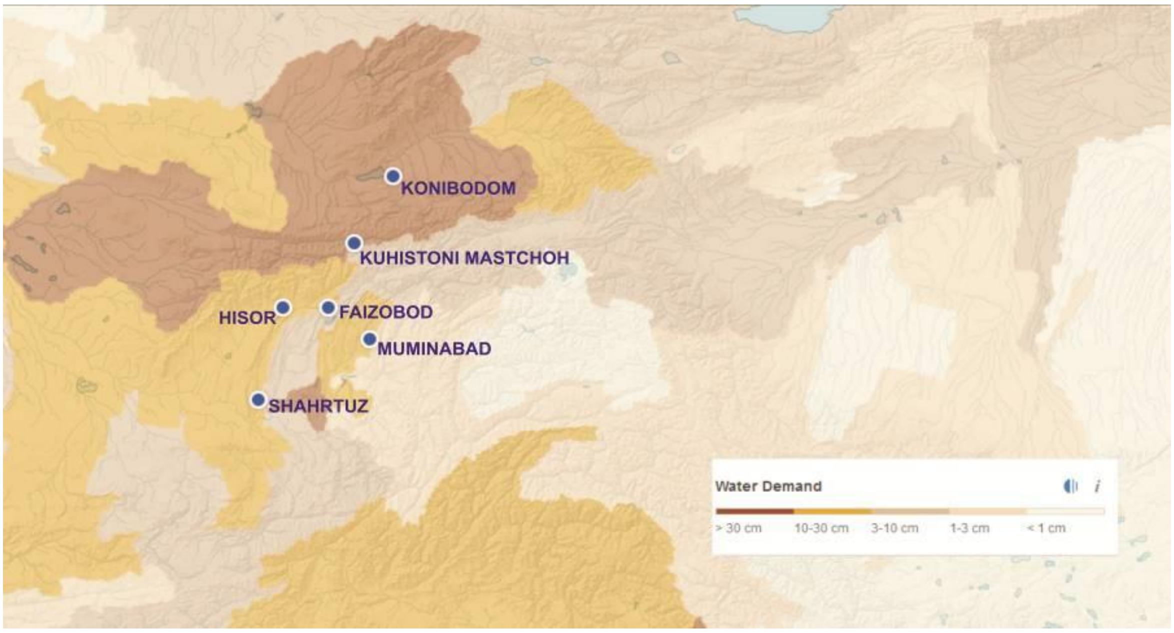


Optimistic 2040

Table 8-44 Projected Change Water Demand - optimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Demand (Value in Year To 2040 Optimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	> 30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-60 Projected Change Water Demand - optimistic 2040

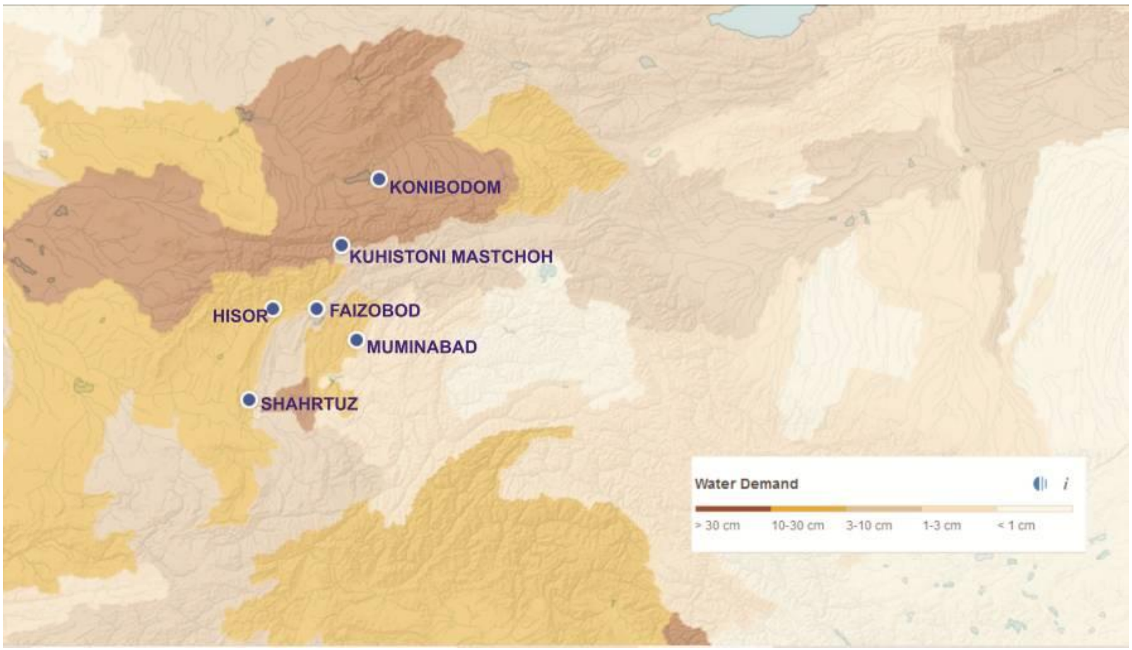


Business as usual 2040

Table 8-45 Projected Change Water Demand - business as usual 2040

Name	*Major Basin*	*Minor Basin*	*Projected Change in Water Demand (Value in Year To 2040 Business as usual)*
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	> 30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-61 Projected Change Water Demand - business as usual 2040

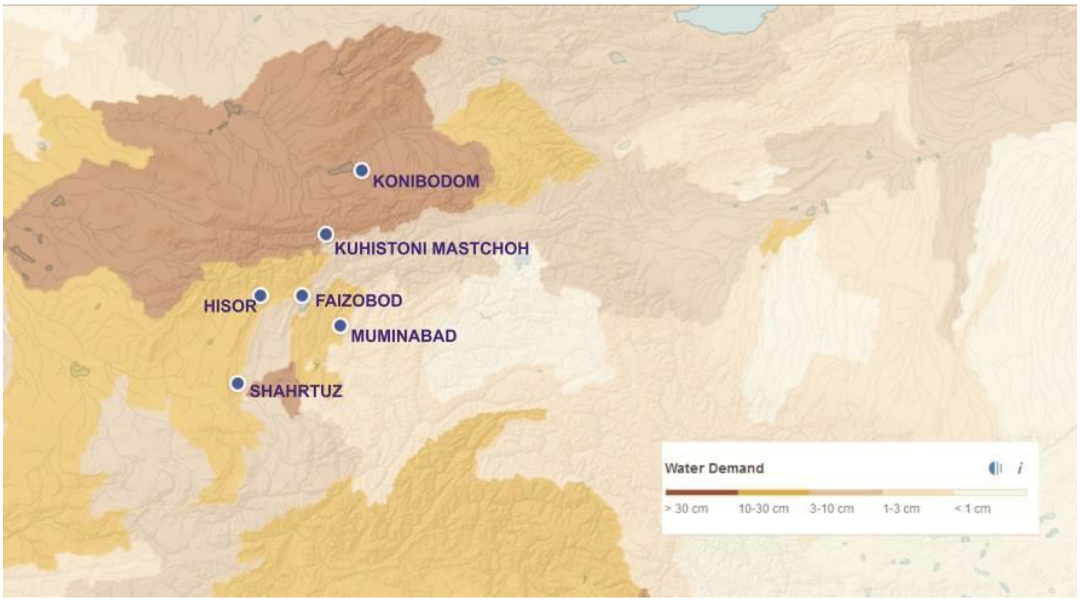


Pessimistic 2040

Table 8-46 Projected Change Water Demand - pessimistic 2040

Name	Major Basin	Minor Basin	Projected Change in Water Demand (Value in Year To 2040 Pessimistic)
Gissar, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Muminabad, Tajikistan	Amu Darya	Pyanj	10-30 cm
Kuhistoni Mastchoh, Tajikistan	Amu Darya	Zeravshan	> 30 cm
Fayzabad, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Shaartuz, Tajikistan	Amu Darya	Kafirnigan	10-30 cm
Kanibadam, Tajikistan	Syr Darya	Kayrakkum Reservoir	> 30 cm

Figure 8-62 Projected Change Water Demand - pessimistic 2040



To conclude, all the region are endangered by different aspects of water stress over the next 10 to 20 years. Complex risk of water stress for all scenarios - optimistic, normal situation scenario and pessimistic until 2030 and until 2040 - represent a medium risk, except in the areas of Muminabad, Kuhistoni and Kanibadam where the risk is extremely high.

Optimistic, current and pessimistic scenarios for both periods (2030 and 2040) show a high degree of risk in seasonal variability. 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. The fact that the Kuhistoni area is alpine, where snowfall and melting are expected, may play a role here.

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.

9. The effects of climate change on emergencies

Tajikistan has to 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)

According to the committee of the Committee of Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan, in 2020 3,052 emergency situations and incidents were registered in the Republic of Tajikistan, 11.5% less compared to 2019 (3,449) (OSCE, 2021).

Also base on the data from publicly available database of global serious emergencies (Emergency Events Database – EMDAT) managed by Center for Research on the Epidemiology of Disasters (CRED), in Tajikistan there were registered 80 serious events between years 1990 and 2021 (CRED, 2022).

This database identified 15 serious events in the 6 defined regions between 1996 and 2021. As understood from the above stated documents, the number of events does not fully reflect the reality, as it only includes most severe (nationwide) events and misses many locally important emergency situations.

Table 9-1 Events registered in the 6 targeted regions by the EMDAT database

Event	Disaster type	Start Year	Start Month	Start Day	Total Deaths	No Injured	No Affected	Total Damages ('000 US$)	
Biological	Bacterial disease	1996	5	31			7516		Muminobod, Gisar
Hydrological	Riverine flood	1998	4	24	51	39	40935	66000	Gisar, Kanibadam, Muminobod
Climatological	Drought	2000	5				3000000	57000	Shaartuz
Hydrological	Mudslide	2006	4	24	1		13000		Muminabad
Hydrological	Avalanche	2006	1	26	21	5	723		Fayzabad
Climatological	Drought	2008	10				800000		Kuhistoni Mastchoh, Shaartuz, Fayzobod
Meteorological	Severe winter conditions	2008	1				2000000	840000	Muminabad, Fayzabad, Shaartuz
Biological	Viral disease	2010	1	1	21		456		Shaartuz
Hydrological	Riverine flood	2010	5	6	73	300	6408	204000	Muminobod
Hydrological	Riverine flood	2010	4	11	2		1914		Fayzabad, Muminobod
Hydrological	Riverine flood	2012	2				5556	760	Kuhistoni Mastchoh
Hydrological	Flash flood	2019	6	1	4		6750		Fayzabad, Kanibadam
Hydrological	Flood	2020	5	14	2		2690		Muminabad, Fayzabad, Shaartuz
Hydrological	Mudslide	2021	7	19	12				Kuhistoni Mastchoh, Kanibadam
Hydrological	Flood	2021	5	7	7		25010	9000	Shaartuz, Fayzabad, Muminobod

Source: (CRED, 2022)

Incomplete information reached from EMDAT led us to request information directly from the Committee of Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan. Information on emergency situations has been identified in 5 targeted districts – Muminobod, Shaartuz, Gissar, Kuhistoni Mastchoh, Kanibadam. Unfortunately, information on Fayzabad district was not delivered.

Individual information on emergency situations are divided into 5 sections – according to the district division.

Muninobod

In Muninobod mostly floods, mudflow, winds and droughts are causing an emergency situation. Between 2004 and 2021, main emergency events have been identified in the town of Muminobod and rural jamoats Balkhobi, Sh.Shohin, Boghgai, Dehibaland, N. Nazarov and Childukhtaron. In total 22 different events have been registered, causing damage of a total 23 094 677 somoni. As a result of natural disasters damaged houses, roads, bridges, auxiliary facilities, cattle and small livestock, power transmission facilities, transformers, shore protection facilities, arable lands of rural households, pumping stations, hydraulic structures, etc.

Periodically, there are heavy rains and badflows registered every spring, which cause serious damage in the district.

In Muminabad, there are identified several projects managed by non-governmental organizations: United Nations, Caritas and Oxfam. Their task was to proceed with reconstruction of the buildings, planting trees in the hills and laying drinking water lines.

Shaartuz

In Shaartuz most frequent emergency situations are caused mostly by mudflows during spring rains and rising of the Kofarnihon River.

Between 2004 and 2016, the amount of damage amounted to 10,985,885 somoni. Mostly were affected houses and auxiliary facilities in the villages. Also agricultural lands were washed away by the Kofarnikhon River. The washed away lands are damaging the lands of Dehkan farms and settlements.

The most events were observed in Pakhtaobod rural jamoat, in Pakhtaobod village, and Jura Nazarov rural jamoat, Lubiyokor and Ayvag villages.

In the region of Shaartuz there were no projects carried out to eliminate or lower the effects of the emergency situation.

Gissar

In Gissar most frequent emergency situations are caused mostly by heavy rains causing mudflows.

Between 2007 and 2021, a total amount of 9 emergency situations were identified, the amount of damage amounted to 14,964,972 somoni and caused 2 deaths. Mostly were affected houses and auxiliary facilities in the villages. Also agricultural lands were washed away by the Kofarnikhon River. The washed away lands are damaging the lands of Dehkan farms and settlements.

In the region of Gissar, we do not have any information about projects being realized.

Table 9-2 Summary of emergency events in Gissar district

R/T	Date	Type of state emergency	Place of emergency	Quantity of states emergency	Amount of damage	Casualties (died)
1	2007	Heavy rains	-	1	27311	
2	2009	Heavy rains	-	2	5604300	
3	12-13.04.2010	Heavy rains	villages: Murutak, Chanorysukhta, Sharofobod, Chirtiki, and Jarteppai of rural jamoat Oriyon	1	1261800	
4	40674	Heavy rains and hail	Village Sholi of rural jamoat Khonaqoi kuhi	1	5665000	
5	41953	Heavy rains and mudflow	Village Nojii bolo of rural jamoat Mirzo-Rizo	1	128500	
6	05.04.2019 18.05.2019	Heavy rains and thunderstorm	Village Boghiston and Obshoron of rural jamoat Somon	2	493161	1
7	11-13.05.2021	Heavy rains and mudflow	V.Ganjrez of r/j Sharora, V.Sayod and Sarchashma od r/j Hissor	1	1784900	1

Source: Committee of Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan (2022)

Kuhistoni Mastchoh and Kanibadam

In Kuhistoni Mastchoh and Kanibadam most frequent emergency situations are caused by heavy rains causing mudflows and flooding.

Between 2000 and 2019, a total amount of 37 emergency situations were identified in the two stated districts, the amount of damage amounted to 33,579,025 somoni and 44 million Russian rubles (2000). And caused 4 deaths.

Most of the events were registered in the K. Mastchoh (33), while in Kanibadam only few, but with more severe effects. In K. Mastchoh total emergencies caused damage of 17 899 064 sonomi and 44 million Russian rubles, while in Kanibadam the four emergencies caused damages in the value of 15 680 239 sonomi.

Mostly were affected houses and auxiliary facilities in the villages. Also agricultural lands were washed away by the Kofarnikhon River. The washed away lands are damaging the lands of Dehkan farms and settlements.

In the region of Gissar, we do not have any information about projects being realized.

Table 9-3 Emergency events in K. Mastchoh and Kanibadam districts

					Affected facilities		
	List of cities and districts	**Type of natural disasters**	**Date of occurrence**	**Amount of damage in Somoni**	**Casualties (died)**	**residential houses (unit)**	**Other facilities**
1	K.Mastchoh	Mudflow	36626	44 million RUS ruble		25	2
2	K.Mastchoh	Mudflow	37056	8,4		12	
3	K.Mastchoh	Mudflow	37100	21,555		2	
4	K.Mastchoh	Mudflow	37077	17,5			
5	K.Mastchoh	Mudflow	37135	30,337			
6	K.Mastchoh	Earthquakes	37318	13,015			1
7	K.Mastchoh	strong wind	37424	1,55		9	
8	K.Mastchoh	Mudflow	37353	63,875		1	
9	K.Mastchoh	Mudflow	22-23.04.2002	790,6		26	8
10	K.Mastchoh	Mudflow	17-21.07.2004	1,548,217			
11	K.Mastchoh	Mudflow	28-30.03.2007	78			
12	K.Mastchoh	Mudflow	39218	8,3			
13	K.Mastchoh	Mudflow	20-21.07.2010	164		3	
14	K.Mastchoh	Floods	08-10.08.2010	91,565			
15	K.Mastchoh	Floods	41098	37,666			

					Affected facilities		
	List of cities and districts	**Type of natural disasters**	**Date of occurrence**	**Amount of damage in Somoni**	**Casualties (died)**	**residential houses (unit)**	**Other facilities**
16	K.Mastchoh	avalanche	40987	303,332		9	1
17	K.Mastchoh	severe cold	3-7.02.2012	40,794			
18	K.Mastchoh	avalanche	41303	-	2		
19	K.Mastchoh	Floods	41803	137,5			
20	K.Mastchoh	Mudflow	41823	79,147			
21	K.Mastchoh	Mudflow	41868	37,65			
22	K.Mastchoh	Floods	42209	428,61			
23	K.Mastchoh	Floods	42200	112,271			
24	K.Mastchoh	rockfall	42477	79			
25	K.Mastchoh	Mudflow	42565	442,498		2	
26	K.Mastchoh	Mudflow	42593	612,303			
27	K.Mastchoh	Floods	28.07 - 11.08.2017	212			
28	K.Mastchoh	rockfall	43588	-	1		
29	K.Mastchoh	Floods	43657	296,87			
30	K.Mastchoh	severe cold	8-9.04.2020	1,320,000			

					Affected facilities		
	List of cities and districts	**Type of natural disasters**	**Date of occurrence**	**Amount of damage in Somoni**	**Casualties (died)**	**residential houses (unit)**	**Other facilities**
31	K.Mastchoh	Mudflow	43950	8,490,574	1		7
32	K.Mastchoh	Mudflow	7-8.06.2020	198,376			2
33	K.Mastchoh	Mudflow	44396	2,233,555		13	14
34	Kanibadam	Floods	37778	886,471			10
35	Kanibadam	Mudflow	41029	814,11		10	
36	Kanibadam	Rain and strong wind	08-19.05.2016	5,634,055		8	6
37	Kanibadam	Mudflow	43618	8,345,329		20	
Total				33,579,025	4	115	49

Source: Committee of Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan (2022)

Overall we can conclude that emergencies are a significant factor that influences all the spheres of life in target regions. The effects of climate change on emergencies can be summarized as follows (interview data). Some of the effects of climate change are straightforward, while the link of others to climate change is yet not proven, though probable.

1. Temperature increase
    a. increase of average temperatures
        i. The meltdown of mountain snow and glaciers led to more floods, mudflows, and landslides. The latter damaged infrastructure and endangered food security. Increased humidity leads to more infectious diseases such as malaria
    b. increase in winter temperatures resulting in less snow and no freezing days in the valley parts of the country (Dushanbe region)
        i. increase in pests in forestry and agriculture

   c. sudden spring freezes
      i. damage the agriculture
   d. heatwaves in summer in mountain areas more than two weeks long with temperatures above 35-37^{0}C resulting in
      i. quick melting of glaciers leading to glacial lake outburst floods and mudflows. The water infrastructure, including the banks of the rivers, is damaged. The other infrastructure, including the houses and transportation routes, is damaged, which leads to substantial economic damage
      ii. The heatwaves have negative effects on human and animal health, including pressure increase, heart problems
2. Change in precipitation
   a. Increase in precipitation in separate years
      i. More intensive floods, avalanches, mudflows, and landslides damage the infrastructure and create significant damages on agriculture, forestry, and human lives
      ii. Increased humidity leads to more infectious diseases such as malaria
   b. Increase in hail. There used to be less hail over the year. Twenty years ago, the hail was located in the central part of the country. Now the hail is more frequent in the southern and northern parts of the country.
      i. Hail damages agriculture and may endanger human and animal lives
   c. Droughts in spring and autumn are more frequent
      i. Agriculture damage
      ii. Need more water, especially in the autumn
      iii. Forest damage, more pests in forests
   d. There is more snowfalls, avalanches, rains in separate years, leading to changes in geological processes and landslides, damaging the infrastructure forests, creating substantial economic damage, and taking human lives
3. Wind
   a. Strong winds are more frequent. The adaptation requires more investments to infrastructure, the different constructions of roofs in houses
   b. Dust storms (Afghan wind, dust from the deserts of Central Asia covers the whole of Tajikistan) damages human, and animal health brings more diseases to agriculture and forestry
4. Thunderstorms with bolts of lightning
   a. There are more thunderstorms with lightning taking away human lives and damaging the infrastructure

The noticeable changes that are not directly related to climate change

- In 2007 the invasion of butterflies,
- the invasion of locust

Both lead to allergies and agricultural damage.

10. The effects of climate change on forestry

10.1. Methodology

Method: literature review, data analysis, focus groups in regions, expert interviews in the regions: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad.

Scope of the analysis: The whole country and the districts.

10.2. Results

The specifics of the forestry in Tajikistan

The geographical conditions primarily define the forest sector in Tajikistan. As mountains of various heights cover 93% of Tajikistan, the ecosystems of the forest sector have a vertical structure along the slope of the hill and include different ecosystems depending on the height above the sea level. These ecosystems are generally defined by the decreasing temperatures as altitude increases that create conditions for different forest ecosystems. The lowest parts of the forest are exposed to the highest temperatures, and the lowest precipitation are generally covered with tugai forests. The higher altitudes are then sequentially covered with light forests (pistachios or almonds), mesophilic (small-leaved forests), juniper forests, riverine forests (over 2000 m above the sea, the beginning of mountain rivers), and mountain forests (over 3000 m.)

The Tajik forests are also specific as for the types of trees and bushes. Most of the trees and bushes, such as juniper and pistachio, live a very long time (3 kinds of juniper live 2000 years, pistachio 500 years), which presents better conditions for CO_2 absorption compared to the agricultural crops.

The regional representation of forests also varies. While in Kanibadam forests are virtually non-existent (as the area covered by forests constitutes only 0,80% of the total area) in Muminabad the areas covered with forests constitute 2,86% of the total area. In total in Tajikistan around 3% of the territory is covered with forests (see Table 10-1).

The definition of forest is also specific. The Forest Code of the Republic of Tajikistan defines the forest as "a complex of natural vegetation formed naturally and artificially in a certain area by a community of trees and shrubs (no less than 10% of the area should be covered by wood-forming plants, with a total area not less than 0.5 hectares and a width not less than 10 meters) and other components of wildlife interacting with the environment and having important ecological, economic and social value" (p. 1). This definition of forest implies that (1) the forest is defined with rather low density (above 10%), and (2) the forest can be used as gardens or pastures if needed, which is often done (see Table 10-2).

Table 10-1 Forest areas governed by the Forest Agency (Gosles, Ha).

	District	Total area	Total area governed by Forest Agency (gos les)	Free aera of gosles fond, Ha (% of total area)	Areas covered by forests										
						Including the areas covered with									
					Total, Ha (% of total area)	Juniper	Nuts	Pistachio	Bitter almond	Rose hip	Poplar maple	Sea buckthorn	Olucha (plum)	saxaul	Other species
1	Kanibadam	82 890	26381 (31,83)	2645 (3,19)	660 (0,80)	440	-	-	-	50	50	-	-	100	20
2	Kuhistoni Mastchoh	372 300	58496 (15,71)	54462 (14,63)	2705 (0,73)	2700			-	1	4				
3	Shaartuz	238 000	22968 (9,65)	407 (0,17)	4390 (1,84)	280		3000	1000		100				10
4	Muminobod	238 690	17423 (7.30)	17423 (7,30)	6820 (2,86)	1940	1920		200	80	2290		350		40
5	Fayzabad	87 410	15789 (18,06)	13637 (15,60)	1983 (2,27)	-	-		600	100	1220		60		3
6	Gissar	198 210	14705 (7,42)	1990 (1,00)	1810,7 (0,91)	500	50		380	30	570		270		10,7
Total in Tajikistan			1922512	1290036	382119,7	149980	9594	81520	18202	1983	100758	7182	3750	8910	250,7
The Tiger Forest in Tajikistan			49786	49786	41074										41074
Grand total Tajikistan		14 140 000	1972298 (13,95)	1339822 (9,48)	423193,7 (2,99)										

Source: Forest Agency

Table 10-2 The use of the forest land (Ha).

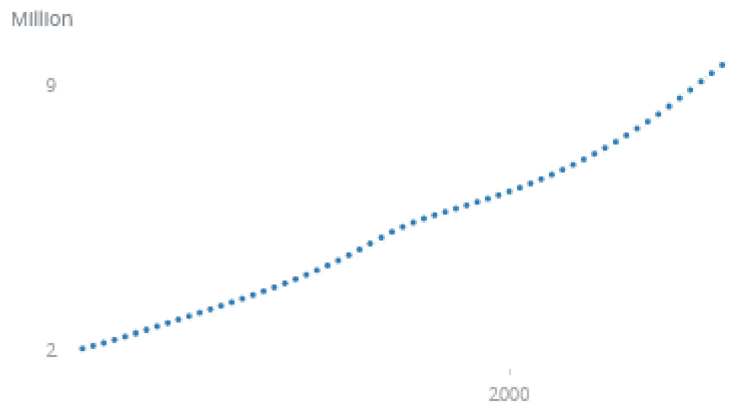
	District	Total area	Total area governed by Forest agency	Free aera of gosles fond, Ha (% of total area)	Including				
					Gar dens	Including irrigated gardens	Arable land	Including irrigated arable land	Pastures
1	Sughd province (including Kanibadam)	82 890	26381	2645 (3,19)	34	34	36	36	
2	Kuhistoni Mastchoh	372 300	58496	54462 (14,63)			8	8	21998
3	Shaartuz	238 000	22968	407 (0,17)			27	27	28
4	Muminobod	238 690	17423	17423 (7,30)	211	34	17	10	4477
5	Fayzabad	87 410	15789	13637 (15,60)	377	27	16		6934
6	Gissar	198 210	14705	1990 (1,00)	2		1		1875
Total in Tajikistan			1922512	1290036	3881	1594	2025	965	480575
The Tiger Forest in Tajikistan			49786	49786					
Grand total Tajikistan		14 140 000	1972298	1339822 (9,48)					

Source: Forest agency

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 data, 2020, see Figure 10-1). Over the same time, the rural population increased from 68% in 1990 to 72% in 2020 (ibid.) 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.

Figure 10-1 The population of Tajikistan 1960-2020, Million of persons.



Source: World Bank Indicators, 2020. Data limitation: lack of reliable census data, a compilation of data from various sources done by the World Bank

Besides the effects of humans, the ecosystems had to accommodate much larger livestock. In some categories, the number of heads per district has more than doubled from 2005 to 2016 (see table 10-3). As the density of forests is rather small, much of the forests were used as pastures, which inflicted substantial damage on the forest ecosystem. First, overgrazing damages the lowest levels of the forest on the levels of grass and small bushes. Second, the animals damage the newly planted trees, which substantially obstructs the regeneration of the forest systems.

Table 10-3 Livestock and poultry in all categories farms (in heads)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
		Cattle										
Gissar	49721	51454	55130	60327	59798	62366	62610	64046	67680	69762	71126	71500
Fayzabad	23621	24702	26196	29613	30818	33010	36131	38738	40792	42357	42740	43199
Kanibadam	31594	30535	34564	34827	35000	25310	35684	36192	36361	36441	36849	40397
Kuistoni mastchoh	10667	10672	11694	11704	11776	12134	12400	12529	12644	13004	14621	15099
Muminabad	22048	23488	27459	28719	29290	30252	32245	33448	33574	34607	35866	37874
Shaartuz	19913	26993	28427	32209	33103	33488	35151	35154	35493	35573	37577	40050
		sheep and goats										
Gissar	68258	70446	83509	96217	81440	85210	87901	90835	97702	105079	110841	114550
Fayzabad	42549	47351	51579	59060	61535	69950	77684	87317	94276	99565	102370	`103364
Kanibadam	21420	21894	26112	25935	26155	26153	26711	27763	27928	29295	31508	40358
Kuistoni mastchoh	62643	60651	73376	73392	76088	75241	77161	87301	99497	100302	116151	115513
Muminabad	78069	83220	91348	94500	95886	100622	103771	107377	109573	113986	119894	124197
Shaartuz	43498	45414	53449	54669	54626	58407	61256	61897	63280	64559	70134	78474

Source: UNDP data

The economic value of the forests in Tajikistan for the immediate citizens

The other specifics of the Tajik forest are the existence of the nut-bearing trees and, sometimes, the inflicts of fruit gardens, which increase the agrarian value of the forest products. For the population of Tajikistan, the economic value of the forest is defined as the value of

1. Pastures
2. Forest fruits, nuts, and other fruits
3. Firewood (if permitted to cut)

This economic value for the population creates threats and opportunities. The threats include the overuse of the economic capacity of the forest in the case of unlimited access. The opportunity presents itself in the idea that if the parts of the forests are left to private use (which essentially excludes the other subjects from using it), the pay-offs of this use may make the holders take care of the forests. The indirect value of the forest is presented in more detail in the cost-benefit analysis section.

The environmental and other value the forests in Tajikistan – the specifics

All the general environmental effects of the forests are in Tajikistan. Besides, one can point out the following specifics.

1. Tajikistan is a mountainous country with a high propensity for water erosion, sudden floods, and mudflows. The forests have the potency to substantially decrease the water's speed in two ways. First, the immediate effect of the forest slows down the water flow and prevents floods, mudflows, limits water erosion, and reduces the ravine formation. Second, the forests increase the absorptive capacity of the soil and direct part of the precipitation underground, resulting in more springs and higher soil humidity.

2. In the regions prone to mudflows, the forests can substantially reduce the risks of water and mudflows to infrastructure and agricultural production. Currently, the immense risks for agriculture endanger the governmental program of food sufficiency of Tajikistan, reduce the efficiency of food production, and cause substantial cross-district disparities. Moreover, the threat of weather-related disasters that could be mitigated by forests does not allow the country to fully exploit cross-district comparative advantages for food production.

Case study:

Gornaja Matcha is a region especially suitable for potato production with crop

yields 1,5 higher than nearby Kanibadam district and 15 times higher than in Shaartuz (See Table 4)

Table 10-4 Potato/ Crop yields (centner per hectare)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gissar	245,2	158,7	147,3	161,8	161,8	148,4	186,4	177,3	198,6	224,5	205,4	159,3
Fayzabad	202	207,6	220,3	231,2	189,9	198,5	155,9	174,1	178,4	184,8	181,1	181,8
Kanibadam	187,1	160,2	169,5	164,5	166,8	162,8	185,4	207,7	210	216,4	193,2	194,9
Kuistoni Mastchoh (Gornaja Matcha)	380,3	396,1	412,5	435,4	369,4	357,1	345	345,5	346,3	374,8	328	314,6
Muminabad	210,7	177,4	214,2	228,5	229,3	226,2	208	200	212	217,2	217,5	218,7
Shaartuz	164,4	173,1	174,3	179,2	207,5	248,4	256,8	250,6	255,7	258,4	208	208

Source: Data for UNDP Tajikistan (find the exact source)

However, these crop yields are highly endangered by the water and mudflows, making the production unreliable. In order to fulfill the requirements for food self-sufficiency, the farmers in the nearby Kanibadam region are forced by local authorities to devote a fixed part of their land to planting potatoes, although, as the farmers claim, the potato production is not paying off (interview data). A similar effect manifests itself in grain production.

1. Tajikistan has a high propensity for absorption of CO_2. Most of the trees and bushes, such as juniper and pistachio, live a very long time (3 kinds of juniper live 2000 years, pistachio 500 years), thus absorbing CO_2 during all this time.

2. The Tajik forests provide a home for wild animals such as the Siberian ibex snow leopard or markhor goat. Some of these animals are considered essentially extinct. The reduction of forest space reduces both the living space for the animals and the ability to feed themselves far from human dwellings. The immediate consequence is the unavoidable conflict between animals and humans when wild animals prey on farm animals.

Climate-related problems of forests in Tajikistan

In Tajikistan, the following signs of climate change can be observed. The first and the foremost effect observed by both the respondents and visible in numerical models are the increase in temperatures (interview data). The increase in the average temperature in Tajikistan in 2080 is predicted to reach 1,3–6,3 °C depending on the scenario of climate change (as compared 1986-2005). The number of hot days above 40°C is expected to increase by 12.5 by 2080. (Pfefferle, 2020).

As a result of higher temperatures, the number of frosty days is expected to decrease. Under the high emission scenario, RTC 8.5, the number of frost days would decrease to about 212 days in 2030, to 200 days in 2050, and to 170 days in 2080 (Pfefferle, 2020). Rising temperatures could lead to snowline retreat and loss of glacial mass, resulting in less water retention capacity. Rising temperatures will lead to increased variability in streamflow as well as fluctuations in water availability and quality. Higher temperatures are associated with a likely increased risk of springtime flooding and glacial lake outbursts during snowmelt. Winter precipitation will increase, while spring precipitation does not show a steady trend. Nevertheless, the amount of long-term precipitation (>20 mm) will continue to increase during the spring months. Projected temperature increases will increase the risk of drought due to higher evaporation and early snowmelt. (ibid).

Four main effects of climate changes on forests were pointed out in the interview analysis:

1. drying of existing forests,

2. mudflows and avalanches damaging the existing forests,

3. problems with new plantations as drylands are not suitable for seed planting, and seedlings need more watering.

4. As there are fewer frosty days in the winter, the forest is more damaged by pests. Typically, a large proportion of pests get frozen in the winter, thus diminishing the damage in the summer. If not frozen, the pests multiply above the typical rate and harm the forest more (typical for the southern part of the country, locust infestation, leafhoppers)

Surprisingly, forest fires were not pointed out as one of the possible effects of climate change as the density of forests in Tajikistan is rather small, and the grassfire can be extinguished quickly.

The prognosis for the forest ecosystems over the next 10-20 years if nothing is done.

As was pointed out before, 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. If nothing is done, the most probable outcome for the period of next 10-20 years will be (interview data):

1. increased devastation of forests by livestock and human activities will eventually lead to the elimination of forests in the areas accessible to humans
2. the existing forests will get older, which will limit their role in local ecosystems in locations far from humans
3. the droughts will damage the forests, especially in the lower altitudes
4. the mudflows and water flows will damage the forests in higher altitudes
5. 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 will be located 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:

1. 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.

2. 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

3. 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.

4. The population will have to face decreased air humidity, which may negatively affect the health status.

5. The pastures, originally covered by low-density forests, will lose the stability of their ecosystems and most likely will not be suitable for grazing

6. The population will lose the fruits, nuts, and other forest products it used to pick in forests

7. 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

8. 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

9. In some regions, conflicts of wild predatory animals and local farmers are more probable

10. 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 family.

11. 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.

The existing efforts on forest regeneration and afforestation

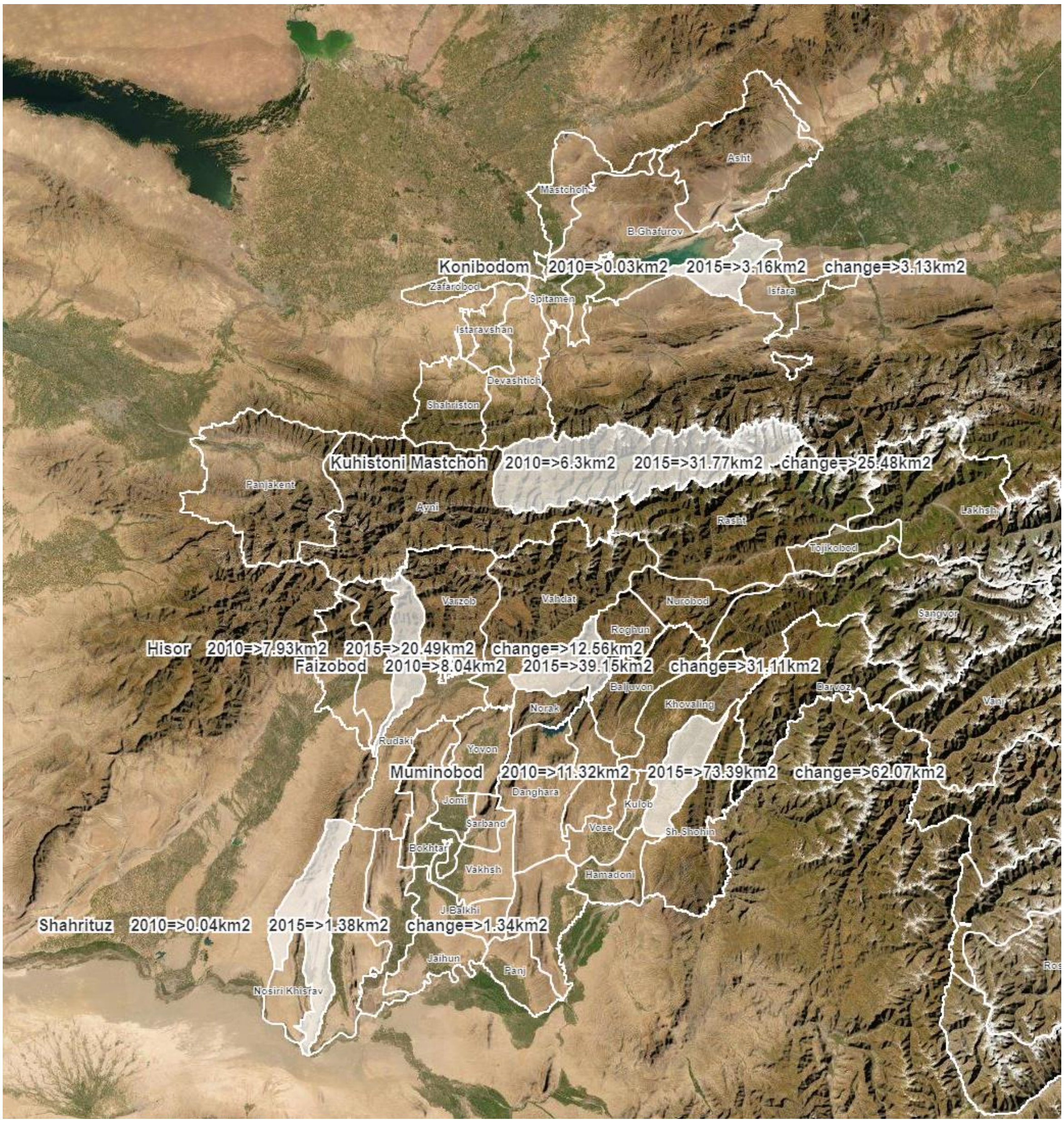
The existing efforts are of a scattered nature. Some projects are planned and financed by the state, while others are planned, performed, and financed largely on an ad-hoc basis by international donors. The significant language barrier prevents efficient communication between the local and international communities. The total afforestation efforts as measured by the digital mapping data are presented in table 10-5.

Table 10-5 Afforestation efforts in target regions 2010-2015

District	**Forest area in 2010, km²**	**Forest area in 2015, km²**	**Afforestation 2010-2015, km²**
	(1)	(2)	(2)-(1)
Kanibadam	0,03	3,16	3,13
Kuhistoni Mastchoh	6,3	31,77	25,48
Gissar	7,93	20,49	12,56
Fayzabad	8,04	39,15	31,11
Shaartuz	0,04	1,38	1,34
Muminobod	11,34	73,39	62,07

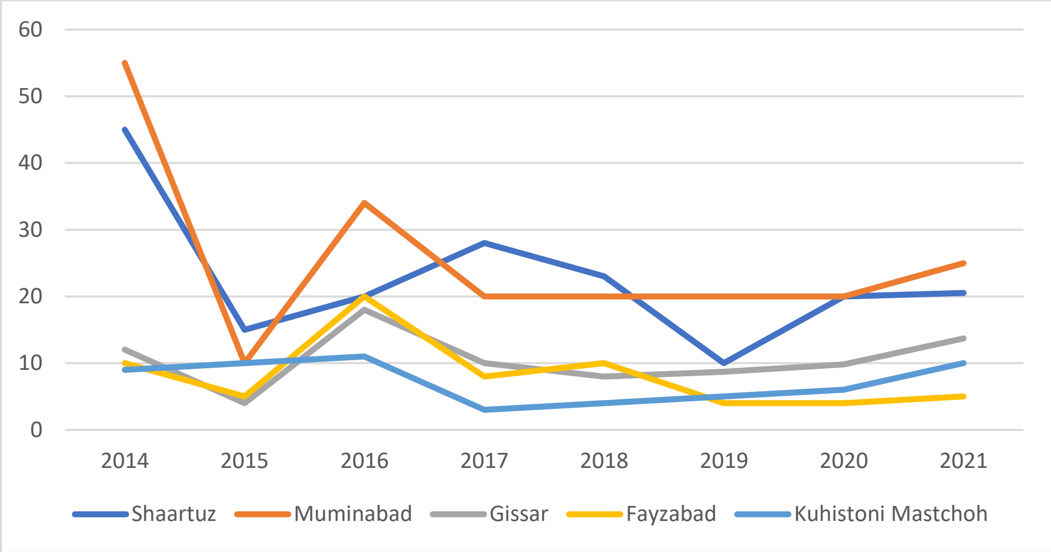
Source: GIZ, map data for 2010 and 2015, own computations, last available comprehensive data

Figure 10-2 The map of forests in Tajikistan. The afforestation efforts in 2010-2015 (the last available comprehensive data)



The efforts of forest cultivation and reforestation of the state Forest Agency in the six focus districts are presented below. The forest agency engages in two main efforts: forest regeneration and afforestation. Forest regeneration is defined as planting and seeding or promoting natural regeneration on lands of endangered or degraded forests. Afforestation refers to planting and cultivation of plantations on non-covered or non-forested areas or on lands designated for afforestation.

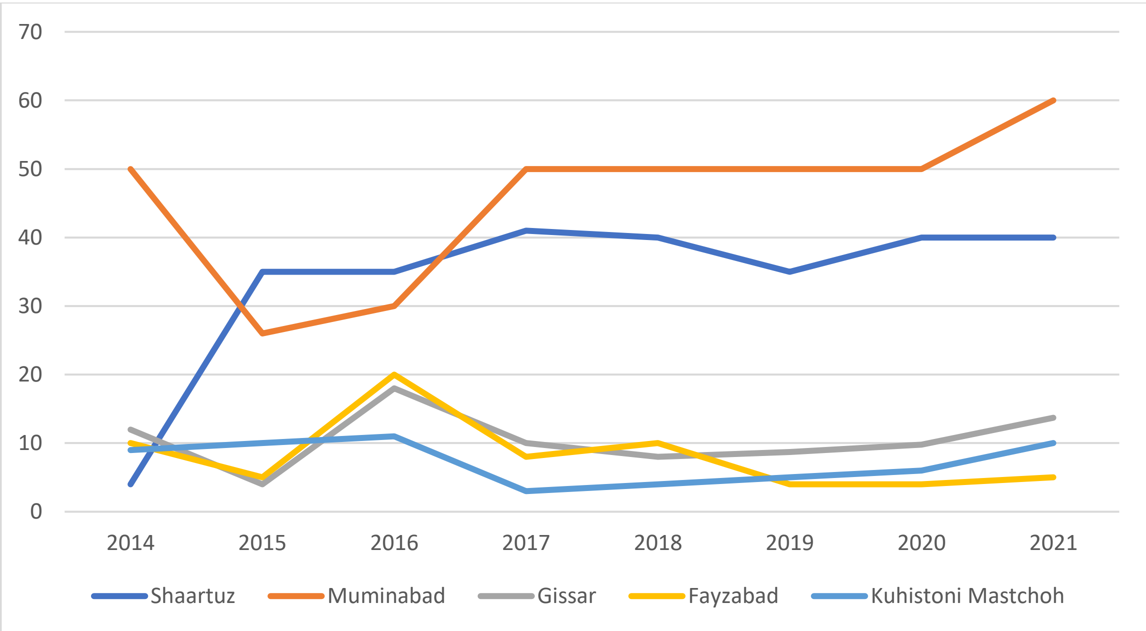
Figure 10-3 Forest regeneration by Forest Agency in districts, 2014-2021 (Ha)



Source of the data: Forest agency. Kanibadam is excluded from the analysis as it is not a representative region for the forestation efforts due to the climate conditions.

The agency is able to regenerate approximately 5-25 Ha per district and year (Figure 10-3). These numbers present just small proportions of what needs to be done. The afforestation efforts varied more greatly across the regions. In Mumonabad and Shaartuz the Agency managed to plant 30-60 hectares of forests per year, while in the other three regions, the afforestation efforts were limited to 5-20 hectares per year (Figure 10-4).

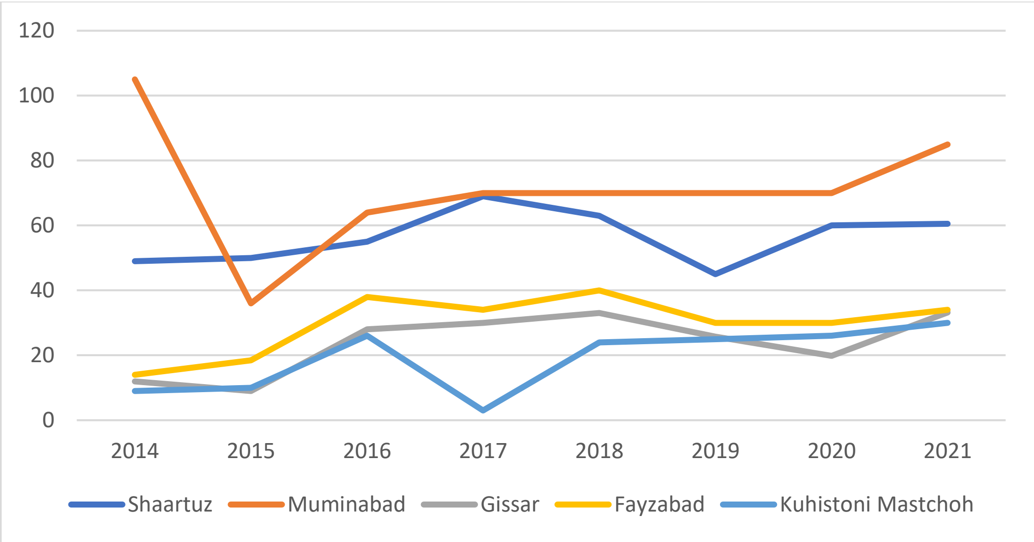
Figure 10-4 Afforestation by Forest Agency in districts, 2014-2021 (Ha)



Source of the data: Forest agency. Kanibadam is excluded from the analysis as it is not a representative region for the forestation efforts due to the climate conditions.

The total forest regeneration and afforestation efforts are presented in Figure 10-5.

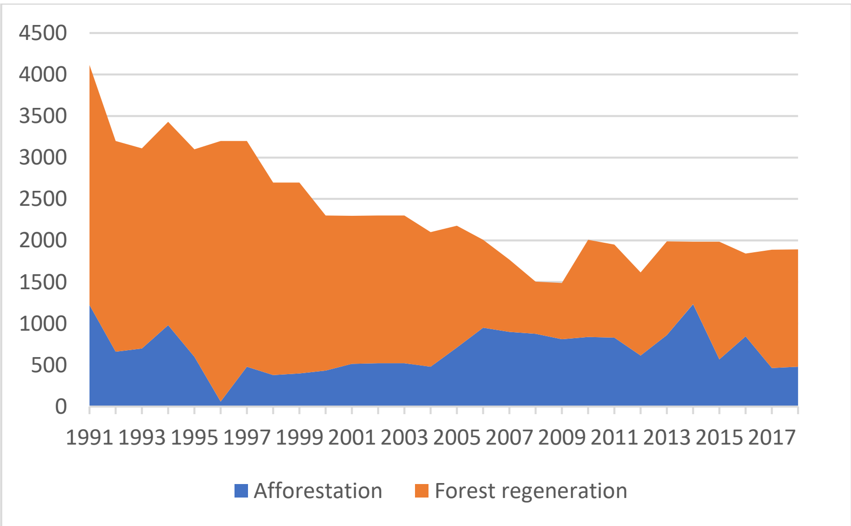
Figure 10-5 The total of afforestation and forest regeneration by Forest Agency in districts, 2014-2021 (Ha)



Source of the data: Forest agency. anibadam is excluded from the analysis as it is not a representative region for the forestation efforts due to the climate conditions.

While the afforestation and forest generation efforts in subject regions were relatively stable over the last seven years (Figure 10-5), the longer period presents a less optimistic picture. The overall efforts of forest regeneration and afforestation have been significantly diminished over the last thirty years (Figure 10-6). As forests are of immense importance for climate change adaptation reduction of CO2, the lowered efforts for afforestation and forest regeneration present a negative tendency.

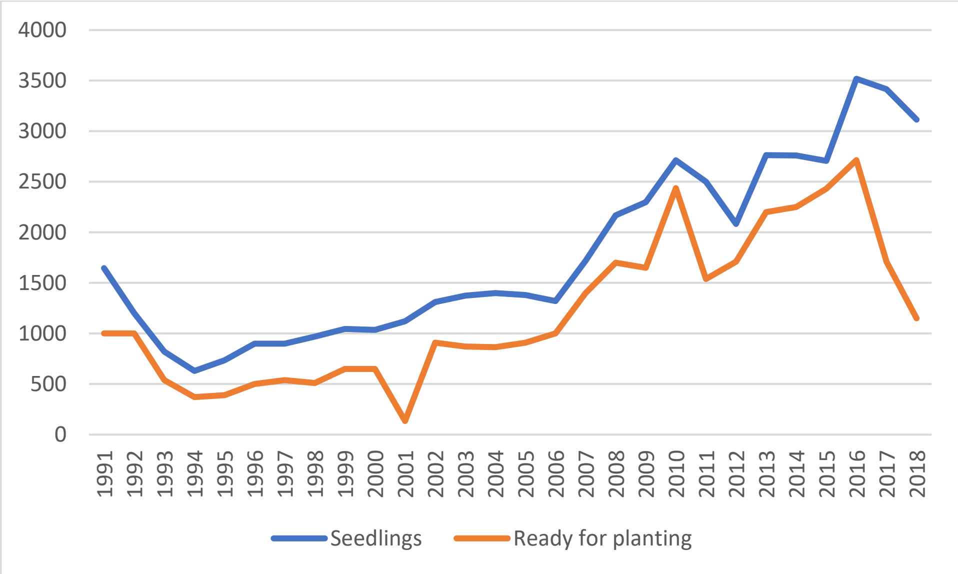
Figure 10-6 The total of afforestation and forest regeneration by Forest Agency in Tajikistan, 1991-2018 (Ha)



Source of the data: Forest agency of Tajikistan. The data are presented in Appendix 3.

On the other hand, the tendency to produce more seedlings and ready-for-planting trees, presented in Figure 10-8, raises a hope that future forest care will improve.

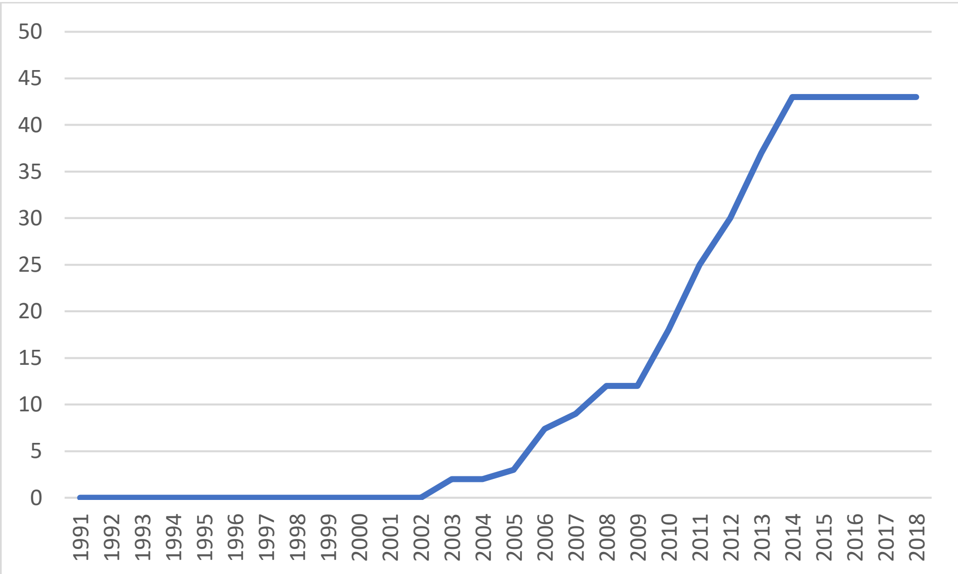
Figure 10-7 The total of afforestation and forest regeneration by Forest Agency in Tajikistan, 1991-2018 (Ha)



Source of the data: Forest agency of Tajikistan. The data are presented in Appendix 3.

A similar positive tendency is visible in the area covered by small forest nurseries. The latter was non-existent till 2002 and in 2018 covered an area of 43 Ha.

Figure 10-8 Small forest nurseries in Tajikistan, 1991-2018 (Ha)



Source of the data: Forest agency of Tajikistan.

Overall, the time analysis of the Figures 10-3 to 10-8 suggests that the government efforts on afforestation and forest regeneration in the districts have been relatively stable over the last seven years, though relatively small. On the scale of Tajikistan, the scope of afforestation and forest regeneration have been substantially diminished from 1991, which dampens adaptation to climate change. On the positive side, the increase in seedlings and ready for planting trees accompanied by more tree nurseries raise hope for better reforestation in the future. However, currently, the seedlings and small ready-to-plant trees produced are just enough for the state-financed reforestation and regeneration programs. The reforestation programs financed by international donors need to design and maintain their own tree nurseries and seedling production spaces (interview data).

While the state efforts for afforestation and regeneration are more of a systemic nature, the efforts of international donors are scattered and difficult to estimate (interview data). The authors suggest better coordination of forest-related efforts between the state Forest Agency and international donors. Besides others, the language problem needs to be solved.

Overall, the influence of climate change on forests in Tajikistan should be analyzed in the context of deforestation that occurred in Tajikistan over the last 30 years and earlier. The country struggles with afforestation and forest regeneration, which should be viewed in the context of climate change. In this sense, the forest sector is largely affected by climate change. Namely the lack of water in some periods and floods and mudflows in the others, severely damage the existing forests and make the afforestation efforts less effective. The rising temperatures divert the planting of tree species to higher altitudes.

10.3. The predicted effects of climate change on forestry over the next 10-20 years if nothing is done

10.3.1. Methodology

Method: literature review, data analysis, focus groups in districts, expert interviews in the districts: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad.

Scope of the analysis: The whole country and the districts.

10.3.2. Results

As was pointed out before, 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. If nothing is done, the most probable outcome for the period of next 10-20 years will be (interview data):

1. increased devastation of forests by livestock and human activities will eventually lead to the elimination of forests in the areas accessible to humans
2. the existing forests will get older, which will limit their role in local ecosystems in locations far from humans
3. the droughts will damage the forests, especially in the lower altitudes
4. the mudflows and waterflows will damage the forests in higher altitudes
5. 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 will be located 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:

1. 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.

2. The population will be more affected by sudden water- and mudflows in the districts vulnerable to this, as the area, originally covered by forests, will lose the capacity to slow the water down

3. 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.

4. The population will have to face decreased air humidity, which may negatively affect the health status.

5. The pastures, originally covered by low-density forests, will lose the stability of their ecosystems and most likely will not be suitable for grazing

6. The population will lose the fruits, nuts, and other forest products it used to pick in forests

7. 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

8. 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

9. In some districts, conflicts of wild predatory animals and local farmers are more probable

10. 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.

11. The country will lose a part of its capacity to accumulate CO2 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.

11. The direct threats of climate change to socio-economic welfare of households in target districts

The climate related factors that directly influence socio-economic welfare in target districts can be summarised as follows:

- lack of irrigation water (less pronounced in Kuhistoni Mastchoh, but also noticed) leading to lower production comparing to potential
- insufficient quality of drinking water (Fayzabad, Muminabad, Gissar, Kuhistoni Mastchoh, Kanibadam) leading to worsening of population health
- climate related land degradation leading to less productive pastures and sowing areas (salinization, drought, water and air erosion)
- climate related emergencies damaging infrastructure, crops, people and animal health
- climate related increase in pests (temperature in winter increases)
- climate related impact on health (temperature shocks, diseases)

The influence of these factors is then aggravated by inefficiencies in land and water use, sub-optimal agricultural technologies, lack of warning system of emergencies, etc.

Climate change produces positive potential for agriculture in the form of longer vegetation period, which eventually enables three harvests per year. This potential, however, can hardly be realised due to the lack of water and land degradation.

11.1. Methodology

This section relies on focus groups and expert interviews and literature analysis. In the case of Muminabad districts the results of focus groups conducted by the authors of the survey were amended by the results of Farmers survey, World Food Program (2016)

11.2. Brief summary

All the focus districts are mostly rural, dependent on agrarian production (see descriptions of districts in Appendix 2). Thus, the socio-economic wellbeing is largely dependent on agrarian production, which, in turn depends on water resources. From the point of view of climate change all the focus districts face similar problems, the extend differs by region. All the districts face:

- lack of water resources in irrigation period (less pronounced in Kuhistoni Mastchoh, but also noticed) leading to lower production comparing to potential
- lack or insufficient quality of drinking water (Fayzabad, Muminabad, Gissar, Kuhistoni Mastchoh, Kanibadam) leading to worsening of population health
    i. climate related land degradation including
    ii. salinization (Kanibadam, Fayzabad, Shaartuz)

- water and air erosion (all the districts, more pronounced in if on steep hills, Gissar, Muminabad)
- reduced crop yields (not supported by the quantitative analysis) due to lack of water and land degradation
- degradation of pastures leading to a shortage of fodder for the livestock industry (Fayzabad, Muminabad, Shaartuz)
- climate related extreme weather events, such as heat waves (Kanibadam, Gissar) and sudden frosts in spring (all districts) damaging the agricultural production, people and animal health
- climate related emergencies, such as water- mud- and land-slides, environmental disasters (all districts), strong winds and wind gust (Fayzabad), dust storms "Afghans" (Shaartuz, Kanibadam, Gissar)
- More pests due to higher temperatures in winter.

It should be noted, most of the effects above are multifactorial, when climate change presents one of the causes, not the only one. For example, lack of irrigation water is in part caused by

- Climate related factors such as
    i. Increase in temperature leading to higher evaporation, more need for watering
    ii. Change in seasonality of precipitation
    iii. Higher temperatures in winter leading lower capacity of water storage in the form of snow or ice
    iv. Melting of glaciers, which will lead to lack of water in the long run
- Human related factors such as
    i. The increased demand for water following the population increase, larger agricultural production, more harvests per year,
    ii. inefficiency of water use due to deteriorated infrastructure, land fragmentation, lower incentives to respect the crop-related watering technologies, poor knowledge of water-saving technologies, low prices of agricultural inputs leaving no funds for investment to better water saving technologies,
    iii. national and international problems with water distribution, international conflicts over the water use (Kanibadam).

Similarly, causes of land degradation are not related to climate only. The following causes can be listed

- Climate related degradation caused by higher temperatures, more droughts, winds, changes in precipitation
- Human related land degradation caused by inefficient land use, overgrazing of pastures and forests, cutting forests, improper use of fertilisers, non-existent crop rotation, lack of winter watering, lack of modern agricultural and water-use technologies, etc.

The extreme weather events could be analysed qualitatively, and, though present significant threat to human socio-economic welfare, could not be analysed quantitatively in this study due to the lack of data. The extreme climate related events are caused by

- Climate change factors such as temperature increase, temperature extremes, wind increase, change in precipitation. These factors lead to water- mud- and land-slides, quicker melting of glaciers and snow in the mountain areas, speeding the water, more dust storms in the valleys caused by temperature extremes, etc.
- Human related factors such as deterioration of infrastructure, population growth leading to more houses built in endangered areas
- Deteriorating or non-existent system of warning

The results of literature analysis and the focus groups in primarily climate-related problems are presented below. We summarise the main findings.

11.3. Lists of climate-related direct threats as perceived by the population in the districts. Threats as described in the literature and mentioned in focus groups and interviews

11.3.1. Fayzabad district

11.3.1.1. Results of literature survey

- Poor condition of the material and technical base, the equipment is idle due to the lack of spare parts and fuels and lubricants.
- The resources of most of the equipment of agricultural enterprises have been exhausted.
- Lack of modern technology.
- unsatisfactory ameliorative condition of 53 hectares of irrigated lands because of rising groundwater levels in the rural jamoats of Kalai dasht, Buston, Javonon and Mehrobod, the main reason is the lack of cleaning and the need to repair 56 km of on-farm drainage networks and 29 km of off-farm networks.
- unsatisfactory condition of 25 thousand 175 hectares of pastures located in jamoats and forestry, which leads to a reduction in the volume of animal feed.
- the need to restore 900 hectares and the effective use of 1000 hectares of orchards and vineyards.
- untimely collection of waste.
- strong winds and wind gust, wind soil erosion, lack of water for irrigation, torrential (strong) rains, floods - Ilok river.
- development of soil salinity. Due to the decrease in funding from the budget, maintenance of pumping networks, irrigation canals and drainage systems has not been carried out in recent years. Insufficient maintenance and condition of the drainage system leads to an increase in the level of groundwater and salinity of the soil.
- insufficiency or inefficient use of mineral fertilizers and other pesticides.
- non-use of the crop rotation system.
- Imperfect relations between dehkan* (is an individual or family farm) farms and the executive body of the state power of the region.
- Emergencies: natural disasters that annually threaten the population of the Fayzabad region are mudflows, landslides, hail, heavy snowfalls, frosts and heavy rains.

11.3.1.2. Results of qualitative analysis (focus group and interview data):

- Rising temperatures

"Rising temperatures and extreme weather increasingly affect food security, the crop yields, livestock, forestry"

- Land degradation and salinization

"Significant land degradation processes decrease its productivity"

- Lack of water:

"In recent years, in the jamoat "Buston" a significant impact of climate change on the agro-industrial complex of the district is felt, and it is assessed as a significant problem. The water supply to the jamoat is provided from the "50 Years" canal of Vahdat city by contract, and the canal receives water from the Kafernigan River. The reason for the reduction of water in the canal and, consequently, the lack of water for dekhkan (farm) households is, first of all, a decrease in the annual amount of precipitation during the autumn-winter period. Also, more well-to-do dekhkan farmers in some farms drill vertical wells using this water both for irrigation and for drinking purposes - about 50 farms in total. The groundwater level in the jamoat is 30-35 m."

- Reduction of vegetation leading to a shortage of fodder:

"Significant reduction of vegetation, mainly on rainfed lands, on pastures, which led to a shortage of fodder for the livestock industry. Consequently, the price of fodder, and therefore of dairy products, has increased several times."

- The spring freezes endangering fruit trees

"The effect on the yield of fruit trees, mainly apple trees - the flowering of trees comes earlier by about 7-10 days. (In 2020, it unexpectedly snowed during flowering of trees; however, this phenomenon is rare)."

- Unsatisfactory level of infrastructure (canals and pumping stations)

The following is necessary:

"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;"

- Lack of timely information

"- 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;"

11.3.2. Muminabad district

The results of the focus groups and interviews conducted by the authors of this study were amended by the results of Farmers survey, World Food Program, (2016)

11.3.2.1. Results of literature survey

There are many problems in the sphere of environmental protection, including the

- deterioration of the ameliorative condition of land, trees and forests,
- an increase in cases of tree felling and poaching,
- pollution of mountainous areas with solid domestic waste,
- the risk of emergencies (mudflows, landslides),
- development of foothill lands without regard to their relief,
- deterioration of pastures,
- illegal development of minerals, including soil, sand, stones, crushed stones, etc.
- Shortage of irrigated water and reclamation condition of irrigated lands
- Lack of access to drinking water
- no sewer lines
- State of pastures
- Little protection and effective use of forests
- Poor collection and disposal of waste
- Emergencies: rural jamoats of Muminabad district are mainly prone to mudflows, landslides and rock falls. In addition, the climatic conditions of the region are harsh, with heavy snowfalls and rains, severe cold and avalanches.

11.3.2.2. Results of interviews and focus groups

- Too high temperature for potato, dust for floral products, and heavy rain for fruits. Bee-keepers, livestock owners and farmers are the most affected ones. In response to the hazards, farmers tend to sell more livestock, plant fast growing produces or ultimately migrate to the Russian Federation for better job opportunities. (Farmers survey, World Food Program, 2016)
- Lack of irrigation water during the growing season of crops; Reduced water resources in the Chil Dukhtaron spring and springs due to reduced rainfall; Particularly water shortages are observed during the re-seeding period - June-July months;
- 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;
- The spread of various infectious diseases in general;
- high cost of agriculture input (i.e., fertilizers) and the lack of capital/credit have been big challenges to farmers in farming. (Farmers survey, World Food Program, 2016)
- Little access to marketing of agricultural products. Most of the profits from local agricultural production are going to traders. Farmers usually sell their products to collectors, traders and retailers in the DCM or regional markets. There are public warehouses, but farmers are afraid of the losses. Some of them have their own private warehouse but, due to lack of capital and liquidity, they tend to sell right after the harvest." (Farmers survey, World Food Program, 2016)
- Landslides and mudflows. Warning system is needed
- High prices of energy. In order to use energy economically and thereby reduce energy bills, use solar energy to run the pumping stations;
- deterioration of the ecological balance of the environment;

11.3.3. Shaartuz district

11.3.3.1. Results of literature survey

There are unresolved issues in the ecological problem of the region, including the spread of various fungal diseases and an increase in the number of pests, and the deterioration of the reclamation state of lands in the territory of jamoats and forestry, the reduction in forests and groves, an increase in cases of deforestation and environmental pollution with solid household waste. waste, deterioration of pastures on the territory of rural jamoats, inefficient development of natural resources.

- Poor condition of the material and technical base, the equipment is idle due to the lack of spare parts and fuels and lubricants.
- The resources of most of the equipment of agricultural enterprises have been exhausted.
- Lack of modern technology.
- The spread of various fungal diseases and an increase in the number of pests
- unsatisfactory ameliorative condition of irrigated lands
- unsatisfactory condition of pastures located in jamoats and forestry, which leads to a reduction in the amount of animal feed
- deforestation and reduction of forest areas
- the need for the restoration of over five hundred hectares and the effective use of 1000 hectares of orchards and vineyards
- untimely collection of waste
- lack of guarantee of freedom for dehkan farms in the choice of sowing crops
- lack of enterprises for the processing of agricultural products (fruits, vegetables, milk, and meat)
- unequal distribution of pastures among livestock farms
- non-compliance with agrotechnical rules and non-use of the crop rotation system
- Insufficiency of livestock farms with vaccines and difficulty in providing veterinary services at the jamoat level
- interference of state bodies in the activities of farms related to planning, production and processing of products, lack of enterprises for processing agricultural products, limited access of farms to concessional and long-term loans, low level of services and poor infrastructure of farms, especially in terms of irrigation water supply and condition of local roads.

- The main reason for the decline in yields is the spread of various fungal diseases and an increase in the number of pests, as well as the untimely provision of mineral fertilizers and pesticides, and climate change.
- Emergencies: natural disasters that are observed in the Shaartuz region are droughts, dust storms, mudflows, landslides and floods.

Main reasons for low crop yields compared to potential levels:

- due to the decrease in funding from the budget, maintenance of pumping networks, irrigation canals and drainage systems has not been carried out in recent years. Insufficient maintenance and condition of the drainage system leads to an increase in the level of groundwater and salinity of the soil
- insufficiency or inefficient use of mineral fertilizers and other pesticides
- non-use of the crop rotation system
- imperfection of relations between dehkan farms and the executive body of the state power of the region

11.3.3.2. Results of interviews and focus groups

- Temperature increase cause problems for animal and human health, however is favourable for the high-fibre cotton production. “Temperatures can, in the last decade, reach 50°C.”
- During agricultural work, there is an acute shortage of workers. Mostly women are working in the fields. If temperatures continue to rise, it is likely that the population will move to a more comfortable place to live.
- Lack of irrigation water due to decrease in rainfall in recent years and decrease the water level in Kafernigan river. “We close the river and fill the canal with water, but already in the Kafernigan River itself the water level decreases in June. During this period, crops are reseeded for which there is not enough water for irrigation. To solve this problem, the focus group participants suggested building a reservoir.”
- Soil salinization in pasture lands and abandoned lands “There are pasture lands, which constitute 107 thousand hectares; and abandoned lands (boirs), where the groundwater table is high - these lands constitute 2,385 hectares, (these lands are saline); here it is necessary to restore the collector-drainage network to lower the groundwater table. The main reason for salinization of pasture land is lack of water.”
- Soil salinization in irrigated lands. “On irrigated land, the main reason for soil salinization is that over the years, the collector-drainage network has mostly fallen into disrepair (siltation) and requires cleaning and rehabilitation. Also, three dust storms called "Afghans" are observed in a period of six months, their duration

ranging from 12 hours to 24 hours (24 hours). This process strongly affects crop yields and soil salinity"

- Spring and autumn floods wash soil away. "The water level in the Kafernigan River rises so high in autumn and spring that it floods the banks and consequently washes away 40-50 hectares of soil every year."

11.3.4. Gissar district

11.3.4.1. Results of literature survey

- The main problems of the agro-industrial complex are the lack of modern technologies, the lack of high-quality seeds and fertilizers.
- Irrigation and land reclamation is one of the most important problems of the region's agriculture. Solving these problems can affect the increase in agricultural production. In the region, more than 951 hectares of land are irrigated through 38 irrigation stations, 5 of which are not working. Mainly because of the old waterworks, there is not enough water when growing crops on irrigated land. Especially more than others in the Sharif dekhkan farms in the Khonakukh rural jamoat 105 ha of irrigated land and in the Gissar and Orion rural jamoats 231 ha of arable land with irrigated. (Anon., 2012)
- High ground water level. In the area of 1400 hectares are in a state of melioration. On the lands of Kalai Gissar and Orien Jamoats, the groundwater level has increased and part of the arable land has ceased to be used in agriculture.
- Insufficient access to drinking water. According to official data, 65% of the district's population do not have access to drinking water. (Anon., 2012)
- Old and broken machinery in agriculture, Lack of material and technical base and modern technology
- Not on time supplying high quality of seeds, rising fuel prices and fertilizers
- farmers have no access to low-interest loans and long-term
- Poor quality of service and poor condition of agricultural infrastructure, especially the irrigation system
- Lack of fruit, vegetable, milk and meat processing facilities
- 5 water stations do not work and do not supply water to 951 hectares of irrigated lands
- Poor situation with land reclamation and outdated irrigation systems
- Not provided animal husbandry with vaccine (Anon., 2012)
- Environmental disasters. According to official information, in 2007-2010. in the Hissar region, 22 cases of natural disasters were registered, from which

households were severely affected. The costs from these impacts amounted to 43% of the district budget. In the district, 34 villages are located in the unsafe zone. 32% of the population (60 thousand people) lives in the unsafe zone. Natural disasters that happen almost every year are mudflows, floods, hail, severe frosts and strong winds. (Anon., 2012)

- Emergencies: Natural disasters that annually threaten the population of the Gissar region are mudflows, floods, landslides, hail, severe frosts and heavy rains.

11.3.4.2. Results of interviews and focus groups

Lack of irrigation water. "Previously, ice and snow were collected over winter and melted in spring and summer. This provided enough water for the entire irrigation season as the precipitation of the whole year could be utilized for irrigation. Nowadays, ice and snow melt both in winter and summer, leading to a shorter water retention cycle. Moreover, the snow started to fall later in the year. Consequently, in winter, the water is effectively lost for irrigation (if not collected in water reservoirs). The frozen soil cannot effectively absorb the water, which creates the potential for water emergencies. Consequently, there is not enough water for irrigation, regardless of the fact that water is not used in farms for irrigation in winter. On the other hand, the technologies of watering the agricultural lands in winter are also used."

- The lack or irrigation water is accompanied by higher water requirements.
    - i. They have to water crops more frequently due to increasing temperatures leading to more water evaporation from the soil and water surfaces and from the lack of rain.
    - ii. In case of more than two harvests per year, the need for water increases proportionally. "An increase in average temperatures moves the start of 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"
    - iii. The inclusion of new lands to the agricultural fund is not possible in Gissar as there is no possibility to increase agricultural land via new lands that have not been used for agricultural production before.
    - iv. Much agricultural land is located on the slopes of the hills, which increases the demand for irrigation water as the water simply flows down the hill.
- The dynamics of water flows is increased due to the rapid melting of snow (water flows more slowly in the past), leading to water- and mudflows

- Unfair distribution of water "A schedule of water distribution to farms has been drawn up over the last five years for a fairer water distribution among farms. In previous years, water from the main canals was distributed among 2-3 farms (collective and state farms). After land distribution to the population and formation of farms (about 50-100 farms), difficulties with water distribution among them are observed."
- Temperature shocks and heat waves. "Average summer temperature in extremes increased by 10^0C-15^0C. 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"
- Frosts in spring damage the production. "Although temperatures are above average in winter, frosts appear in spring, damaging production. This fact may be in part caused by the earlier planting season. "
- In autumn, dust storms sometimes occur, leading to plant diseases
- In winter increase in temperature leads to more pests in planting seasons (they are not frozen enough in winter)
- The more frequent water- and mud- flows damage the infrastructure of water management
- The increase of watering in areas where agricultural land in slopes leads to an increase in water erosion that damages the water channels. The latter need to be cleaned more often.
- Increased temperatures lead to more water lost in the transportation process (evaporation)
- Higher temperatures lead to more frequent watering and more water erosion. The land is often on a slope, which increases erosion with watering. The soil erosion may be as high as 0.5 centimetres per year
- Higher temperatures contribute to soil erosion and accelerate wind and water erosion
- Climatic erosion leads to a reduction in the quality of grazing areas and a reduction in the overall fertility of the soil
- Hectare yields are reduced by up to 50% (not supported by empirical data, not only the effects of climate change)
- In the parts of the jamoat with no forced irrigation, the lack of precipitation in a single year effectively takes these territories out of agricultural production

11.3.5. Kuhistoni Mastchoh

11.3.5.1. Results of literature survey

- Protection, regeneration and expansion of forests, Preventing illegal logging
- 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. Population mainly using river water and springs.
- Feed animals effectively, taking into account their impact on the environment
- 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. Lots of dust due to poor road conditions and increasing disasters.
- Low level of education of the population in the field of ecology
- Careful use of natural resources to improve population lives
- Expansion of anthropogenic impact on the environment
- Despite the increase in agricultural production, farmers' profits are not so high due to high costs.
- The development of animal husbandry depends on the prevention of infectious diseases. Causes of the disease are lack of technology, lack of qualified personnel, lack of animal drugs and veterinary pharmacy.
- Despite the fact that the number of livestock increases every year, there are no enterprises in the district for the processing of wool, meat, leather, etc.
- Emergencies: the territory of the district is located in a mountainous area, so natural disasters are mainly observed in the form of mudflows, avalanches, rock falls. Because of rock falls and mudflows, the main road of Kuhistoni Mastchoh is often blocked.

11.3.5.2. Results of interviews and focus groups

- Reducing precipitation, in the last 10 years there has been almost no snowfall in the valley (Zarafshan valley);
- Irregular precipitation, flash floods in spring and summer;
- Reduction of drinking and irrigation water coming from mountain springs (almost 100% of the district);
- In winter, there is little precipitation and dry air, in spring there is an increase in rainfall above the norm, as a result, mudflows, avalanches, rockfalls and landslides are observed;
- There is an excessive reduction in wild mountain plants and shrubs;

- Increasing cases of dental, kidney and other diseases due to poor quality of drinking water.
- Due to climate change, there is a change in the timing of sowing crops (mainly potatoes) and the application of agrotechnical measures, and this, in turn, has affected the yield and gross harvest of agricultural products;
- Reducing the volume of water in the springs leads to a shortage of irrigation water during the irrigation period;
- Decreased quality of soil fertility due to lack of crop rotation and dry soil;
- As a result of climate warming in winter and summer, an increase in the number of crop pests is observed;
- The forests have completely disappeared, only a part of the shrub zones remained.
- The standard of living of the population is decreasing, as a result of which there is an increase in the flow of internal migration and migration abroad (emigration);

11.3.6. Kanibadam district

11.3.6.1. Results of literature survey

- Lack of water in irrigation period
- Irrational use of water resources. Losses of water when supplied to consumers (agricultural organizations) are about 30% (2004-2010). These losses are related to the fact that the irrigation networks in this area are mainly earthen, which leads to increased water seepage and water losses. In addition, consumers use the received water irrationally, without observing irrigation standards, depending on the type of crops, soil composition, terrain, etc.
- increase in the number of pests
- deterioration of the ameliorative condition of agricultural lands
- high level of waterlogging and soil mineralization, erosion
- pollution of the environment with solid household waste
- increase in emissions of harmful substances into the air
- the risk of pesticides being washed off due to rainwater from the Ramsar site in the upper reaches of the Kairakum reservoir
- toxic waste landfill
- inefficient development of natural resources.
- lack of sufficient knowledge about the processing and drying of fruits and vegetables

- poor condition of the material and technical base due to insufficient financial resources in the farms
- lack of access to spare parts, rising prices for fuel and lubricants, and depreciation of most of the agricultural machinery and equipment on the balance sheet of existing farms
- lack of funds for land irrigation, cleaning and restoration of drainage canals and collectors, and ditches
- untimely provision of fuel, pesticides, and other mineral fertilizers
- lack of effective pest control methods
- failure to repair roads between farms and the region.
- The main reasons for the low yield of agricultural crops compared to the potential level:
    - i. due to the decrease in funding from the budget, maintenance of pumping networks, irrigation canals and drainage systems has not been carried out in recent years. Insufficient maintenance and condition of the drainage system leads to an increase in the level of groundwater and salinity of the soil
    - ii. lack of modern agrotechnical technologies
    - iii. high debts of cotton farms
    - iv. insufficiency or inefficient use of mineral fertilizers and other pesticides
    - v. improper crop rotation
    - vi. poor quality of planting and seed materials
    - vii. low level of soil fertility
    - viii. lack of highly qualified specialists
    - ix. imperfection of relations between dekhkan farms and the executive body of the state power of the city.

Another, but also important problem is the reasons for the decline in productivity in agriculture, in the cultivation of cotton. The reason is primarily related to the unsatisfactory land reclamation state (high level of waterlogging and soil mineralization, erosion), improper crop rotation, low level of material and technical resources, poor quality of planting and seed materials, low soil fertility, lack of highly qualified specialists, fragmentation of individual dekhkan farms, lack of modern agricultural technologies, high prices for fuels and lubricants, high prices for mineral fertilizers and pesticides, lack of agricultural equipment and inadequate quality of agrotechnical measures, lack of information and advisory support and climate change issues.

Other obstacles to the development of cotton growing in recent years have been high debts of cotton farms to the water management enterprise, tax authorities, fluctuations in cotton prices, and because of reduced profitability and lack of incentive for farms. The development of the industry was facilitated by the cancellation of debts of cotton farms in 2007, in accordance with the Decree of the Government of the Republic of Tajikistan under No. 111, and the recent increase in cotton prices.

- Emergencies: In the city of Kanibadam, emergency situations, in particular natural disasters such as earthquakes, floods and mudflows, strong winds, severe frosts have been recorded and noted in different years. In the foothill settlements, during the passage of heavy precipitation, the passage of mudflows is observed.

11.3.6.2. Results of interviews and focus groups

- A gradual increase in temperature during the summer and winter period, a sudden cold spell in the spring period at the start of the sowing season;
- Intermittent rainfall, flash floods in spring and summer;
- A change in the period of warm winds, contributing to the melting of glaciers in the Isfara River spring;
- Reduced drinking water coming from the Big Fergana Canal (BFC) in the western part of the district (about 60% of the district);
- Increased drilling of boreholes and use of groundwater (technical) not only for irrigation but also for drinking purposes;
- Increase in dental disease, kidney disease and other types of illness due to poor quality drinking water;
- Increase in the threat of drought on about 16,000 hectares of agricultural land;
- Unstable water supply from the BFC will affect the change in groundwater levels;
- Climate change leads not only to abnormal heat waves, but also to 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.
- Increased erosion and salinity of agricultural land due to improper (non-normalized) irrigation and changes in the timing of agronomic measures as a result of climate change (untimely ploughing and cultivation of crops (cotton));
- The use of saline, unsuitable irrigation water from open drains;
- Shortage of irrigation water during the irrigation period;
- A decrease in the quality of soil fertility;
- Reduction of irrigation water sources;
- Reduced crop yields;

- The sudden change in warm and cold air flows increases the frequency of thunderstorms, hail and storms accompanying mudflows;
- The standard of living of the population is declining, resulting in an increased flow of migrants abroad (emigration);
- As a result of a warmer climate, there has been an increase in crop pests during the winter and summer.

From the above follows, all the districts suffer from similar problems – lack of water, land degradation impacting the crop yields, climate related emergencies and diseases. The following section analyses the predictions of water stress in the target districts.

12. Conclusion

The government and international efforts in combating climate change need to be contingent upon the relevant and methodological sound research. This study aimed at studying the manifestations of climate change in the six target districts of Tajikistan and the observable impacts on climate change of agriculture, forestry and water resources. Methodologically the study relied, where possible, on the results presented in the literature, mathematical modeling on existing data, focus groups and semi-structured expert interviews.

The results suggest that climate change in the six target regions Tajikistan is manifested via increase of average temperatures in five of the regions, increase in average precipitation in two regions, the change in seasonality of precipitation in all the regions, and increase in the index of evapotranspiration in all the regions. The latter reflects larger evaporation leading to more demand for water in the future.

The effects of these climate change on water resources and forestry proved to be large and negative. Existing forests and newly created ones intensely suffer from the lack of water and increasing temperatures, which diminishes their capacities to maintain environmental and water balance. The water resources are highly endangered by 1) physical risk quantity that comprises of water stress, groundwater table decline, interannual variability, seasonal variability, drought risk, riverine flood risk, physical risk, 2) quality that encompasses untreated connected waste water, eutrophication potential and 3) regulatory and reputational risk that consists of unimproved/no drinking water, unimproved/no sanitation water, peak RepRisk country ESG risk index, which is extremely high in all the target districts.

The effects of climate change on agriculture was less clear. The mathematical modeling techniques described in the literature and qualitative analyses conducted in this study on one side and the analysis of actual data on crop yields conducted in this study on the other, present opposite results – while models and interviews and focus groups predict largely negative effects of climate change on agriculture, the available data analysis suggest stagnant or slightly increasing trends in crop yields. We explain this contradiction by the fact that the actual data on crop yields are largely affected by a number of other factors such as the effect of low base in 1990th, the effects of governmental policies, the current national and international programs aimed at climate change adaptation, and the efforts of the population to adapt. These abilities of the population have certain limits, which will most likely be exhausted in the near future.

Tajikistan is a country most affected by climate change. This study aimed to identify the direct threats to the socio-economic wellbeing related to climate change in six selected districts, prognosed how the impacts of climate change develop, assessed the costs/benefits of climate change in the horizon of ten to twenty years (till 2030 and 2040). The selected target districts are Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad. The climate change effects are also generalised to Tajikistan.

Six main climate related threats to socio-economic wellbeing of households were identified in the qualitative part of the study and the literature review: 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 potentially positive impact of climate change implies prolongation of vegetation period, which can enable three harvest per year contingent upon sufficient watering and limited soil degradation.

The climate related threats may be substantially worsened or mitigated by the human activities. The increasing demand for water and inefficiency of water usage currently aggravate the negative effects of climate change on water resources. Human related land degradation is caused by inefficient land use, overgrazing of pastures and forests, cutting forests, improper use of fertilisers, non-existent crop rotation, lack of winter watering, lack of modern agricultural and water-use technologies, etc. is likely to exacerbate the climate related land degradation. Deterioration of infrastructure, population growth (leading to more houses in endangered areas), deteriorating or non-existent system of warning exacerbate the climate related risks of emergencies.

This study concentrated on climate threats related to water resources and agricultural production in six target districts and in Tajikistan as a whole. The future water stress was analysed in ten- and twenty-years' time spans. The quantitative twenty-year analysis of complex risk of water stress for optimistic, median and pessimistic scenario predicted high and extremely high risk in Muminabad, Kuhistoni Mastchoh and Kanibadam, while the risks in three others districts were considered medium. The risk of seasonal variability, measing that dry month are expected to become even drier and wet month even wetter predicted high levels of risk in all the districts except Muminabad, where the risk is extremely high. This also implies higher risk of drought and extreme rains. The districts most affected by the lack of water supply are predicted to be Gissar, Fayzabad and Shaartuz. Kuhistoni Mastchoh is the least affected area. An important fact is that Kuhistoni area is alpine, where snowfall and melting are expected. The risk or higher water consumption was the highest in Kanibadam area up to 2030, while in the horizon of 2040 Kuhistoni Mastchoh was added to the endangered zone. All in all, water related risks are predicted to be very pronounced up to 2040, which, most likely, will not enable the country to capitalise on the positive effects of climate change, and will worsen the negative ones. Adaptation measures are necessary.

While prediction of water stress provided rather clear picture, the prediction of agricultural production was less clear. The analysis of existing trends suggested increasing production despite climate change. The qualitative analysis implies, that these trends largely corresponded to overall massification and intensification of production following the period of civil war, and that local farming communities were able to adapt to climate change to some extent. However, the limits of adaptation on the local level seem to be reached. The future predictions according to most of the scenarios predict stagnation or slight increase of crop yields. However, these growth of crop yields could hardly compensate the population growth. Moreover, these growth do not reach the biologically possible limits of production. The main limiting factors related to climate change are water resources and land degradation. Adaptation measures are necessary.

This study concentrated on the period till 2040. The models of climate change and its effects suggest, that the largest negative effects will occur after 2040.

13. Appendix 1. Limitations and suggestion for further research

The current study is affected by the following limitations.

13.1. 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.

13.2. 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.

13.3. 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.

13.4. 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.

13.5. 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.

14. Appendix 2. Seasonal predictions for target districts

Indicators

- VAP Mean daily vapor pressure hPa
- WIND Mean daily wind speed at 2 m above ground level $msec{-1}$
- RAIN Precipitation (rainfall or water equivalent in case of snow or hail) $mmday{-1}$
- IRRAD Daily global radiation $Jm{-2}day{-1}$
- E0 Penman potential evaporation for a free water surface $mmday{-1}$
- ES0 Penman potential evaporation for a bare soil surface $mmday{-1}$
- ET0 Penman or Penman-Monteith potential evaporation for a reference crop

Fayzabad

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1714602941,18	1665712000,00	1628381393,94	-
	summer	2472643529,41	2477755500,00	2465795484,60	-
	autumn	1396098235,29	1365132000,00	1341475273,10	-
	winter	776549411,76	717782000,00	749519007,78	-
RAIN	spring	168,74	145,40	133,37	-
	summer	9,26	15,96	28,78	+
	autumn	39,13	48,14	103,41	+
	winter	117,09	126,51	103,16	-
E0	spring	105,91	110,39	110,82	+
	summer	216,18	215,53	213,11	-
	autumn	81,36	80,98	79,87	-
	winter	22,18	21,19	23,08	+
ES0	spring	91,70	95,94	96,86	+
	summer	190,67	189,85	187,42	-
	autumn	69,07	68,73	66,99	-
	winter	17,46	16,72	17,84	+
ET0	spring	94,64	100,10	101,04	+
	summer	201,40	202,69	200,15	-
	autumn	89,04	89,37	88,13	-
	winter	29,02	27,75	29,35	+
TMIN	spring	3,98	6,04	7,20	+
	summer	15,79	16,64	17,21	+
	autumn	5,72	6,64	6,31	+
	winter	-4,86	-4,08	-2,22	+
TMAX	spring	15,49	17,43	17,49	+
	summer	31,29	31,24	31,05	-
	autumn	18,51	18,68	17,69	-
	winter	4,48	4,81	6,76	+
TEMP	spring	9,75	11,74	12,66	+
	summer	23,75	24,11	24,51	+
	autumn	11,56	12,12	11,42	-
	winter	-0,70	-0,13	1,70	+
WIND	spring	1,40	1,47	1,52	+
	summer	1,80	1,84	1,84	+
	autumn	1,50	1,49	1,48	-
	winter	1,35	1,25	1,28	-
VAP	spring	7,22	7,91	8,94	+
	summer	6,67	7,11	7,84	+
	autumn	4,48	4,91	5,14	+
	winter	3,86	4,17	4,39	+

Gissar

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1710247058,82	1651451000,00	1597880477,05	-
	summer	2455930588,24	2466108000,00	2451132206,91	-
	autumn	1366840000,00	1364516500,00	1348317865,78	-
	winter	747163529,41	677301000,00	663966270,07	-
RAIN	spring	162,85	135,50	112,77	-
	summer	9,25	14,36	20,67	+
	autumn	37,81	45,83	70,72	+
	winter	114,56	120,86	90,85	-
E0	spring	112,87	117,02	119,26	+
	summer	226,86	227,20	221,63	-
	autumn	85,60	86,02	81,13	-
	winter	24,87	23,69	25,05	+
ES0	spring	98,27	102,31	107,78	+
	summer	201,11	201,19	197,97	-
	autumn	73,30	73,54	69,06	-
	winter	20,11	19,27	20,25	+
ET0	spring	102,08	107,63	110,31	+
	summer	213,20	215,76	213,43	+
	autumn	95,04	96,12	95,28	+
	winter	32,93	31,32	33,13	+
TMIN	spring	5,57	7,61	8,76	+
	summer	17,69	18,52	19,44	+
	autumn	7,33	8,13	7,64	+
	winter	-3,03	-2,45	-0,48	+
TMAX	spring	17,61	19,65	20,81	+
	summer	33,31	33,43	34,00	+
	autumn	20,28	20,55	19,44	-
	winter	6,50	6,79	9,06	+
TEMP	spring	11,63	13,66	14,65	+
	summer	25,83	26,25	26,86	+
	autumn	13,29	13,85	13,00	-
	winter	1,16	1,61	3,66	+
WIND	spring	1,47	1,51	1,55	+
	summer	1,90	1,94	1,91	+
	autumn	1,56	1,56	1,56	=
	winter	1,40	1,32	1,30	-
VAP	spring	7,65	8,28	8,89	+
	summer	6,85	7,19	7,85	+
	autumn	4,67	5,05	5,22	+
	winter	4,11	4,45	4,61	+

Kanibadam

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1823762941,18	1778151000,00	1754084858,80	-
	summer	2417307647,06	2439197000,00	2426870292,21	+
	autumn	1324582941,18	1311224000,00	1301379759,77	-
	winter	770622941,18	702383000,00	681717473,17	-
RAIN	spring	68,57	75,34	83,20	+
	summer	17,04	21,58	46,65	+
	autumn	36,31	42,30	44,86	+
	winter	61,33	70,86	74,45	+
E0	spring	162,93	168,73	172,05	+
	summer	274,20	281,58	281,14	+
	autumn	107,70	111,62	120,49	+
	winter	41,85	42,38	45,45	+
ES0	spring	146,50	152,20	155,18	+
	summer	248,19	255,26	255,61	+
	autumn	95,45	99,37	108,54	+
	winter	36,66	37,59	40,60	+
ET0	spring	149,16	155,43	159,12	+
	summer	257,25	266,72	272,07	+
	autumn	117,04	121,98	128,42	+
	winter	51,55	50,98	54,37	+
TMIN	spring	9,54	11,19	12,18	+
	summer	21,53	22,10	22,57	+
	autumn	10,23	10,83	10,69	+
	winter	0,13	0,38	2,55	+
TMAX	spring	22,67	24,34	25,31	+
	summer	37,21	37,16	36,87	-
	autumn	23,50	23,58	23,21	-
	winter	9,80	9,86	11,84	+
TEMP	spring	15,75	17,42	18,43	+
	summer	29,42	29,73	29,82	+
	autumn	15,98	16,38	16,15	+
	winter	4,03	4,23	6,00	+
WIND	spring	2,91	2,99	2,89	-
	summer	2,61	2,84	2,93	+
	autumn	2,35	2,49	2,83	+
	winter	2,69	2,73	2,78	+
VAP	spring	7,30	8,35	9,36	+
	summer	7,88	8,48	9,59	+
	autumn	5,38	5,79	5,69	+
	winter	4,41	4,61	4,88	+

Kuhistoni_Mastchoh

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1626322941,18	1586023500,00	1590283685,91	-
	summer	2308958235,29	2290906000,00	2262063339,25	-
	autumn	1324718235,29	1281429500,00	1277199276,75	-
	winter	759159411,76	709768500,00	771859197,72	+
RAIN	spring	111,08	105,60	119,25	+
	summer	15,84	27,49	110,28	+
	autumn	38,06	40,70	95,85	+
	winter	77,43	78,81	86,00	+
E0	spring	80,52	83,05	83,70	+
	summer	157,69	154,46	146,37	-
	autumn	57,77	57,76	56,54	-
	winter	15,15	15,59	16,30	+
ES0	spring	69,27	71,54	72,46	+
	summer	136,78	133,64	126,03	-
	autumn	47,66	47,86	44,54	-
	winter	11,78	12,31	12,22	+
ET0	spring	68,41	71,68	72,83	+
	summer	139,88	137,26	128,36	-
	autumn	61,61	61,04	60,23	-
	winter	18,33	18,75	19,53	+
TMIN	spring	-5,39	-3,46	-2,39	+
	summer	4,87	5,40	5,46	+
	autumn	-2,87	-2,58	-4,07	-
	winter	-15,79	-14,68	-13,76	+
TMAX	spring	5,13	6,69	7,22	+
	summer	18,87	18,48	17,06	-
	autumn	8,43	8,29	7,94	-
	winter	-5,08	-4,66	-3,03	+
TEMP	spring	-0,47	1,24	2,07	+
	summer	11,37	11,48	10,92	-
	autumn	1,86	1,98	0,60	-
	winter	-10,97	-10,19	-9,24	+
WIND	spring	1,61	1,67	1,59	-
	summer	1,54	1,52	1,47	-
	autumn	1,42	1,49	1,52	+
	winter	1,68	1,66	1,53	-
VAP	spring	4,02	4,42	4,78	+
	summer	5,40	5,84	6,62	+
	autumn	3,04	3,35	3,58	+
	winter	2,00	2,09	2,23	+

Muminabad

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1396801176,47	1349673500,00	1363895024,62	-
	summer	1588187058,82	1699283000,00	1717591299,33	+
	autumn	2459127647,06	2426392000,00	2418471930,94	-
	winter	735523529,41	754923500,00	845410553,13	+
RAIN	spring	34,19	39,87	126,66	+
	summer	156,80	128,09	140,00	-
	autumn	6,80	12,13	19,33	+
	winter	106,73	112,55	109,52	+
E0	spring	88,19	87,03	85,29	-
	summer	111,15	121,58	119,41	+
	autumn	222,97	219,99	216,23	-
	winter	29,13	28,25	29,59	+
ES0	spring	75,67	74,72	71,01	-
	summer	97,70	106,65	105,84	+
	autumn	197,55	194,78	191,07	-
	winter	24,43	23,35	25,61	+
ET0	spring	95,12	94,93	91,17	-
	summer	98,83	109,21	105,36	+
	autumn	205,62	206,15	203,97	-
	winter	34,72	33,40	34,94	+
TMIN	spring	6,90	7,82	7,56	+
	summer	4,90	6,91	8,12	+
	autumn	16,21	17,06	17,94	+
	winter	-3,39	-2,66	-1,39	+
TMAX	spring	19,04	19,23	18,13	-
	summer	16,57	18,52	18,54	+
	autumn	31,01	31,00	30,98	-
	winter	6,20	6,40	7,97	+
TEMP	spring	12,21	12,78	12,11	-
	summer	10,59	12,55	12,86	+
	autumn	23,69	24,07	24,66	+
	winter	0,77	1,24	2,62	+
WIND	spring	1,62	1,60	1,56	-
	summer	1,61	1,67	1,66	+
	autumn	1,95	2,00	2,00	+
	winter	1,44	1,38	1,35	-
VAP	spring	4,31	4,74	5,03	+
	summer	6,99	7,55	9,29	+
	autumn	6,44	6,88	7,61	+
	winter	3,78	4,11	4,30	+

Shaartuz

		1984–2000	2001–2020	2021–2040	Trend
IRRAD	spring	1887144705,88	1861846000,00	1860931520,80	-
	summer	2535162352,94	2579069000,00	2628720842,20	+
	autumn	1438129411,76	1467622500,00	1473753226,56	+
	winter	853533529,41	766254000,00	748592277,67	-
RAIN	spring	87,39	76,73	98,17	+
	summer	4,25	4,72	5,96	+
	autumn	18,05	30,63	69,71	+
	winter	68,44	89,55	87,90	+
E0	spring	145,10	151,91	152,66	+
	summer	249,90	265,42	279,91	+
	autumn	95,64	100,62	96,28	+
	winter	35,56	33,57	36,04	+
ES0	spring	127,91	134,45	135,06	+
	summer	222,47	237,52	251,34	+
	autumn	82,29	86,86	82,79	+
	winter	29,74	28,27	30,21	+
ET0	spring	131,17	138,19	139,15	+
	summer	232,06	248,19	260,72	+
	autumn	100,62	105,89	100,03	-
	winter	42,24	39,21	41,37	-
TMIN	spring	9,44	11,12	11,79	+
	summer	21,77	21,82	22,33	+
	autumn	10,17	10,58	10,16	-
	winter	-0,30	-0,09	1,05	+
TMAX	spring	23,65	25,30	25,31	+
	summer	38,06	38,03	38,26	+
	autumn	24,33	24,37	22,14	-
	winter	10,43	10,37	12,77	+
TEMP	spring	16,38	17,99	18,27	+
	summer	29,95	29,94	30,29	+
	autumn	16,64	16,71	14,78	-
	winter	4,30	4,39	5,85	+
WIND	spring	1,69	1,80	1,84	+
	summer	1,83	2,14	2,37	+
	autumn	1,43	1,56	1,57	+
	winter	1,67	1,62	1,59	-
VAP	spring	8,34	9,16	10,35	+
	summer	7,05	7,17	7,69	+
	autumn	5,28	5,65	5,85	+
	winter	5,02	5,46	5,73	+

15. Appendix 3. Socio-economic descriptions of the districts

15.1. Methodology

The following information are based on Program of socio-economic development of the Fayzabad district for 2016-2020 issued Executive body of the state authority, Tajikistan and other literary sources

15.2. Fayzabad district

15.2.1. Socio Demographic Conditions

Fayzabad district is in the eastern part of the republic. The area of Fayzabad district is 874.1 square kilometres, the total population is 141 031 (to 01/10/2020) people. The distribution according to sex and age is represented by Table 15-1.

Table 15-1 Administrative indicators of the Fayzabad district

Administrative indicators	unit	quantity
Number of city streets	items	16
Number of villages	items	71
Private households (to 01/10/2020)	households	12 252
Number of young people (to 01/10/2020)	people	30 538
Men	people	14 935
Women	people	15 603
Pensionable age population	people	7 603
Men	people	3 691
Women	people	3 912
Age of labour force	people	63 442
Men	people	31 586
Women	people	31 856
number of children (0-14 years old)	people	39 448

Source: UNDP, 2021

Table 15-2 brings the overview of population in the individual jamoats of Fayzabad district. The most populated jamoat is Kalai Dasht with 17698 citizens in 2015.

Table 15-2 Population and households as of 01.01.2015 by jamoats

№	Settlements and villages	Number of households	Population	Including women
1	Buston	900	8562	4200
2	Mehrobod	1302	11404	5587
3	Vashgird	698	5384	2720
4	Dusmurod Ali	1707	12539	6017
5	Fayzabad township	1556	13122	5404
6	Javonon	1581	7123	6456
7	Chashmasor	877	11685	3602
8	Kalai dasht	1553	17698	5787
9	Miskinobod	2072	10014	8429
Total		12252	97531	48202

Source: Executive body of the state authority, 2015

The average annual growth of the district's population over the past three years is 3.1 percent. 99% of population are Tajiks, see the Table 15-3.

In the age structure of the population, the number of children under the age of 14 is 36.1%, the population of middle age (working age) is 57.1% and the population of retirement age is 6.8% (data from 2015).

Table 15-3 Demographic situation of Fayzabad district for 2012–2014

Years	Number of births	Number of deaths	Natural population growth	Natural population growth in %	Total population, thousand people
2012	2839	337	2492	2,7	89100
2013	2456	307	2149	2,1	93255
2014	2755	329	2426	4,5	97531

Source: Executive body of the state authority, 2015

Considering the change in the demographic situation of the region and the high rate of population growth until 2020, there is a need to create 4900 new student places in basic schools, 2300 student places in preschool institutions, construction, and commissioning of 99.0 thousand m2 of residential buildings, and the creation of 8.7 thousand new jobs.

More than 87 percent of the able-bodied population of the district lives in rural areas and is mainly engaged in agricultural activities.

Figure 15-1 Map of Fayzabad region (district)

Source: Executive body of the state authority, 2015

15.2.2. Economic issues

Fayzabad district is included in the districts of republican subordination and is considered an agrarian region, and here the population is mainly engaged in agriculture, animal husbandry and business development. In the labour distribution of the republic, the district is considered one of the main producers of agricultural products.

Agriculture plays an important role in the structure of the region's economy and is the main engine of economic development. More than 87 percent or 48 thousand 430 people from among the able-bodied population are employed in this industry. The development of this industry is also of a social nature since 78.5 percent of the able-bodied population lives in rural areas and agriculture is the only source of income.

During 2011–2014 there was a real increase in all monetary incomes of the population, including wages and pensions. The average salary in the region in 2014 compared to 2011 increased by 238.1 percent, see the Table 15-4.

However, there are several social issues in the district, in particular issues in the field of labour, such as a high degree of income classification of the population, low wages of workers in the social sphere, agriculture, communications, budgetary organizations, and high wages of workers in the banking sector. services, construction, and industry.

As a result, civil servants annually leave their jobs due to low wages and engage in commercial activities and choose external labour migration or get jobs in construction and industrial enterprises.

The lowest average wage is in agriculture. After the transition to new forms of farming, the profitability of most dehkan farms decreased, which had debts to the relevant authorities. In these farms, recruitment methods and procedures are not properly established.

In addition, each farm manager individually sets the wages of his employees, who in most cases do not comply with the requirements stipulated by the Labour Code of the Republic of Tajikistan (Executive body of the state authority, 2015).

Table 15-4 Average salary by industry during 2011–2014

Sectors	Years				2014 compared to 2011 in %
	2011	2012	2013	2014	
Industry	159	259,48	343,06	370,85	233,2
Agricultural industry	314,25	475,46	500,69	296,87	189,9
Housing and communal services	224,11	430,36	471,36	520	232
Transport	165,52	323	428,63	470,08	284
Connection	282,63	415,00	448,06	506,18	179
Budget organizations	356	573,53	612	621	194
Education	202,22	330,7	480	581	287,3
Healthcare	183,24	340,54	450,14	505,72	275,9
Culture	181,96	331,22	432,12	486,51	267,3
Banks	439,87	792,11	1000,08	1055,21	239,9
Construction	204,03	188,05	190,62	308,74	151,3
Total by district (according to average calculations)	233,66	381,00	473,10	556,57	238,1

Source: Executive body of the state authority, 2015

15.2.3. Agriculture

Fayzabad district is agrarian, where 87.5 percent of the able-bodied population of the district is employed in agriculture. The total number of agricultural enterprises in the district (dehkan farms (farmers), collective farms (dehkans), state farms) as of December 31, 2014, is 3 086v (Executive body of the state authority, 2015).

Table 15-5 The number of jamoats, villages, farms, and population of the Fayzabad district as of 31.12. 2014

	Jamoats	Number of villages	Number of farms	Number of population
1	Buston	5	900	8562
2	Mehrobod	15	1302	11404
3	Vashgird	4	698	5384
4	Dusmurod Ali	12	1707	12539
5	Fayzabad township	1	1562	10014
6	Javonon	13	1581	13122
7	Chashmasor	7	877	7128
8	Kalai dasht	6	1553	11685
9	Miskinobod	8	2072	17698
	Total:	71	12252	97531

Source: Agency on Statistics under the President of the Republic of Tajikistan, 2021

In 2014, the volume of total agricultural production in all forms of economic activity in the district amounted to 201.9 million somoni (at current prices), which is 11.8 percent more than in 2013 and 2.5 times more than in 2009. By sectors, there is an increase in gross agricultural output in monetary terms, which mainly occurs because of price changes. In the total volume of agricultural products, the share of households was 38.3%, dehkan farms - 27.1% and the public sector (Murgi Khilol LLC) - 34.6 percent.

Fayzabad district produces various types of crop and livestock products. As noted, the volume of agricultural production in 2014 compared to 2013 increased by 11.8 percent, for each person grains amounted to 75 kg, vegetables - 108 kg, potatoes - 142 kg, fruits - 20 kg, grapes - 2, 3 kg, gourds - 1 kg, milk - 137 litres, meat - 13 kg, eggs - 1008 pcs.

Farms in the Fayzabad district mainly earn income from the sale of agricultural products, in particular eggs and poultry meat, cattle, small animals, and milk.

Regardless of the increase in the volume of agricultural production (cereals in 2014 compared to 2013 by 214 tons, potatoes - 600 tons, vegetables - 570 tons, meat - 67 tons, milk - 55 tons, eggs - 87 million pieces), household incomes have declined over the years.

Manufactured products, except for eggs and poultry meat, are not able to satisfy the internal needs of the region.

In the production of agricultural products, the share of the population is larger compared to other forms of management (Executive body of the state authority, 2015).

Table 15-6 Gross agricultural products by all types of management for 2009-2014 (million somoni)

Product List	2009	2010	2011	2012	2013	2014
Volume of agricultural products	78,2	101,9	123,7	159,7	180,6	201,9
Including:						
Crop production	29,9	39,3	52,5	67,0	80,8	86,7
Animal husbandry	48,3	62,6	71,2	92,6	99,8	115,2

Source: Executive body of the state authority, 2015

Based on the Table 15-6 the share of the livestock sector in the total volume of agricultural production for this period is 115.2 million somoni or 57.1 percent (2014). During this period, the number of large animals in the region was 42317 heads, which is more by 4 446 heads compared to the same period last year. The number of small animals is 98 418, which is 9 372 heads more than in 2013, the number of birds in the district is 725 954 heads.

It should be noted that households account for 85.9 percent of cattle, 70.2 percent of small cattle, 44.1 percent of horses and 6.4 percent of birds of the total animal population.

In 2014, The share of crop production in the total volume of agricultural production of the region amounted to 42.9 percent or 86.7 million somoni.

In 2014, crops were sown on an area of 9108 hectares in the district, of which 44.3 percent were cereals, 8.2 percent were potatoes, 6.9 percent were industrial crops, 5.8 percent were vegetables, and 34.8 percent were animal feed and other crops. In addition, during this period, 466 hectares of new gardens were created in the district, which ensured the implementation of the plan by 11.5 percent more. The total area of gardens in the district is 3828 hectares, of which 1437 hectares are irrigated lands.

In the production of agricultural products, the share of the population is larger compared to other forms of management.

In addition, in accordance with the proposal of local specialists of the district, an increase in the volume of agricultural production over the next five years as part of the implementation of the Program for the socio-economic development of the Fayzabad district for 2016-2020. is considered possible by introducing 1000 ha of pastureland into the category of arable land.

Even though they are not irrigated, nevertheless, soil moisture in the areas of Pechakzor, Gului zindon, hills above the villages of Duoba, Khochamard, Navobod and Hami savra of rural jamoats Kalai dasht, Chashmasor, Javoni, Dustmurod Ali, Miskinobod and Mehrobod is suitable for sowing grain crops (grain, oats, beans, mung bean), industrial crops (flax, mahsar*, sesame, sunflower) and fodder crops (clover, onobrychis, suli (oats)). Since the average annual humidity level in these areas is from 600 to 800 millilitres. In this area, the level of windiness in spring and summer is lower than in other districts (on average, from 5 to 10 meters per second) (Executive body of the state authority, 2015).

*herbaceous essential oil plant from the family of compound flowers.

Forms of activity in the agricultural sector. During 2014, on 9108 hectares of the total area of arable land (considering all forms of management, population, and household plots), crops were fully sown, of which 4034 hectares fall on cereals, potatoes - 747 hectares, vegetables - 529 hectares, melons - 21 ha, industrial crops (mahsar, flax) 631 ha, animal feed - 3146 ha.

As already noted, 3,086 agricultural enterprises of various forms of ownership operate in the Fayzabad district, of which 3,050 are dehkan farms, 19 collective farms, 5 state subsidiary farms, 1 State Unitary Enterprise Seed Farm named after A. Nazirov and 11 auxiliary small enterprises.

The provision of various modern equipment plays an important role for the steady development of agriculture. Over the past 20 years, the agricultural enterprises of the region have not received a single modern equipment (with the exception of the case through the creation of Agroleasing in 2009, the receipt of 1 unit of the M-82 tractor, 1 unit of YuMZ 6L (JuMZ 6), 2 units of YTO 4, 1 unit of YTO 1 and 5 units of the Tojiron brand tractor), and the equipment on the balance sheet of the Association of Dehkan Farms is partially out of order.

Of the 236 units of existing tractors of dehkan farms, 160 units are ready for work, 76 units are not working. Caterpillar tractors make up 11.0% (26 units, 14 in working order), wheat harvesters - 12.7% (30 units, 20 units in working order), tractor trailers - 44.0% (104 units, 85 units in operation), mowers - 8.5% (20 units, 10 units in operation), potato harvesters - 2.1% (5 units, 4 units in operation) and tractor plows - 21.7% (53 units, 48 units in working condition).

Along with this, the lack of spare parts, fuel, lubricants, and high prices for them has caused an increase in the cost of agricultural products.

Most of the tractors produced in the 80s of the last centuries do not meet today's requirements and the farms do not have the financial capacity to purchase new equipment. This situation creates obstacles to the further development of the agricultural sector.

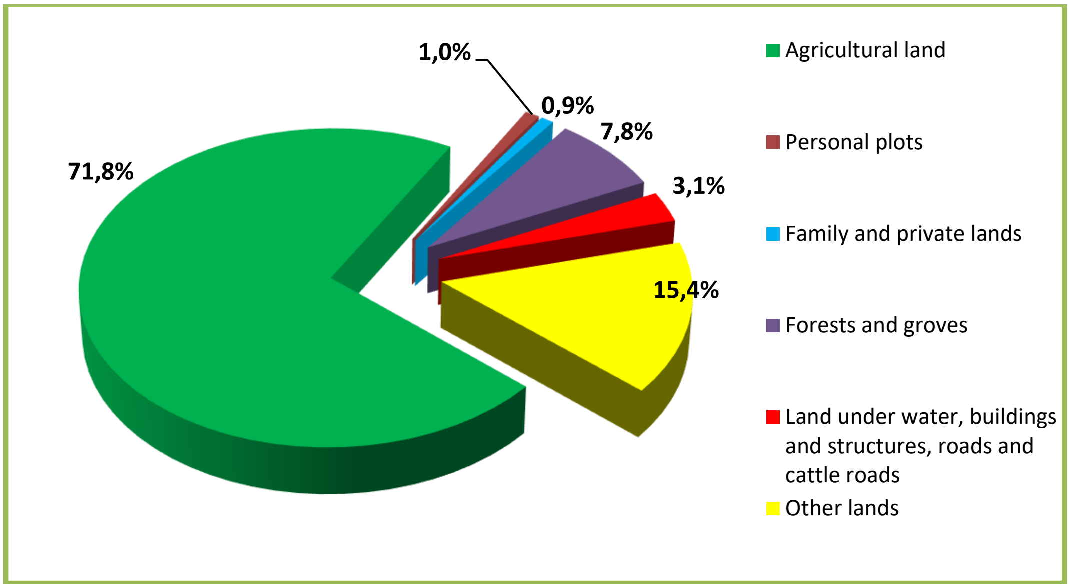
Due to the low level of profitability of production, a decrease in production and technical potential is observed in the farms of the region.

Land use. According to official data, as of January 31, 2014, the total land area in the district is 87,411 hectares (including 3,566 hectares or 4 percent irrigated) and the number of land users is 9,360 people. Of the total area of existing land, 69 585 ha are agricultural land, 849 ha are household plots (340 ha are irrigated), 830 ha are private subsidiary lands, 6 829 ha are forests and groves, 1149 ha are land under water, 573 ha are land for roads and livestock roads, 998 ha - land for buildings and structures, streets, and squares, and 11,378 ha - other land.

There are only 3,566 hectares of irrigated land in the district, of which 1,785 hectares are irrigated with the help of pumping networks. Rainfed lands of the district are mainly allocated for the use of dehkan farms, partly for household plots and subsidiary plots (presidential plots - 830 ha). Currently, 3,050 dehkan farms are registered in the region, of which 2,100 units of dehkan farms, along with the sowing of other crops, are partially engaged in gardening. In addition, the main area of gardens is located on the lands of dehkan farms and household plots. Most of the pastures belong to individual farms.

Of the total land area, perennial trees - 4341 ha, orchards - (1603 ha irrigated), 378 ha - vineyards (55 ha irrigated), mulberry forests - 134 ha (110 ha irrigated) and 3 ha nursery for growing seedlings (3 ha irrigated). Irrigated arable land is mainly used for potatoes, vegetables, cereals, industrial crops, animal feed and orchards, see the Figure 15-2.

Figure 15-2 The structure of the total use of agricultural land (in % terms)

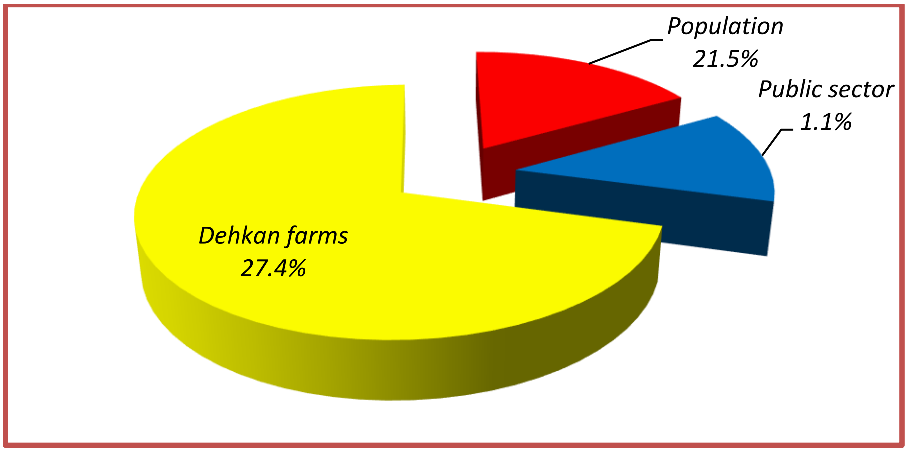


Source: Executive body of the state authority, 2015

In the region, there are opportunities to increase the volume of agricultural production only using existing resources (land) by taking intensive measures (using high-quality seeds, mineral and organic fertilizers, establishing crop rotation of land, winter irrigation of land, the introduction of modern technologies and autumn plowing).

In 2014, crops were sown on an area of 9 108 hectares, of which 6433 hectares were used by dehkan farms, 1127 hectares - on the public sector and 1548 hectares on the population.

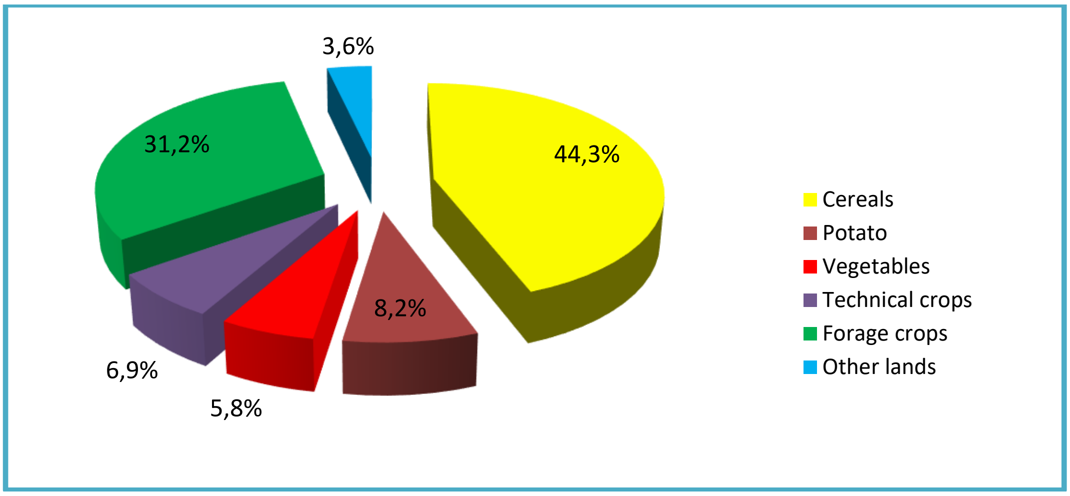
Figure 15-3 The share of farms in the total area of agricultural land in 2014



Source: Executive body of the state authority, 2015

In the structure of the area under crops, a large share falls on the sowing of cereals, potatoes, and industrial crops (44.3%, 8.2% and 6.9%).

Figure 15-4 Land use in the context of crops in 2014 (in all forms of management)



Source: Executive body of the state authority, 2015

In 2014, the area under crops in all types of farming per person is 0.09 ha, which is 0.01 ha less than in 2011. Since the main reason for the decline in this indicator is associated with natural population growth (annually on average 4.5 thousand people) and insufficient land area (in total for 5 years - 88 hectares). In addition, this was facilitated by the transfer of 53 hectares of agricultural land to rainfed.

Crop production. The share of crop production in 2014 in the total agricultural production of the district is 43 percent.

In 2014, 4566 tons of cereals, 9130 tons of vegetables, 6535 tons of potatoes, 180 tons of melons, 2194 tons of vegetables were produced.

Table 15-7 Production and productivity of crop products for 2009–2014

List of indicators	**Unit of measurement**	**Years**						**2014 compared to 2009, %**
		2009	**2010**	**2011**	**2012**	**2013**	**2014**	
Planting area	ha	5384	4276	4417	4126	4269	4034	74,9
Cereals	ton	9885	4275	4566	6236	7079	7693	73,7
Yield	cent/ha	18,3	10,0	10,8	15,1	16,6	18,1	98,9
Planting area	ha	567	456	453	516	459	529	93,2
Vegetables	ton	9039	9074	9130	10465	9884	10533	116,5
Yield	cent/ha	15860	198	201	202,1	215,3	199,1	125,5
Planting area	ha	234	255	415	622	743	747	3 м
Potato	ton	4411	5162	6535	10857	13273	13826	3 м
Yield	cent/ha	183,3	202	156	174,1	178,6	184,8	98,1
Planting area	ha	25	8	15	32	6	21	84,0
Melons	ton	62	77	180	56	57	106	170,9
Yield	cent/ha	24,8	9,6	12	17,2	95	50,4	2 m
Garden area and	ha	2377	2415	3001	3006	2835	3068	129,0

List of indicators	Unit of measurement	Years						2014 compared to 2009, %
		2009	2010	2011	2012	2013	2014	
vineyards								
Fruits and grapes	ton	2828	1770	2994	2646	1351	1780	62,9
Fruit yield	cent/ha	117	7,8	11,2	8,8	4,8	5,7	48,7
Grape yield	cent/ha	11,0	3,2	6,5	6,7	4,2	6,7	60,9
Planting area	ha	3206	3266	3133	3104	3115	3146	98,1
Forage crops	ton	10603	10620	11592	11600	11903	13070	123,2

Source: Executive body of the state authority, 2015

The analysis shows that the volume of crop production during these years, except for melons, tends to increase, the yield per hectare has increased relatively. The area under crops of melons and gourds decreases from year to year, the area under crops of cereals, vegetables, potatoes, and fruits has increased.

Cereals, including wheat, are produced in the region. In 2014, 4,034 hectares were allocated for growing cereals, 529 hectares for vegetables, 747 hectares for potatoes, 21 hectares for melons and 3,068 hectares for vineyards. Production at agricultural enterprises in 2014 increased compared to 2013, including grain by 103.1 percent, vegetables by 106 percent, potatoes by 101 percent, fruits by 31.7 percent. In the region, the share of dehkan farms that grow grain is 70.0 percent.

Main reasons for low crop yields compared to potential levels:

- development of soil salinity. Due to the decrease in funding from the budget, maintenance of pumping networks, irrigation canals and drainage systems has not been carried out in recent years. Insufficient maintenance and condition of the drainage system leads to an increase in the level of groundwater and salinity of the soil.
- insufficiency or inefficient use of mineral fertilizers and other pesticides.
- non-use of the crop rotation system.
- Imperfect relations between dehkan (is an individual or family farm) farms and the executive body of the state power of the region.

Cereals. In the district, land with an area of 4034 hectares has been allocated for sowing and growing grain products, including wheat, oats, and other grain crops. In the structure of the grain sowing area, 85 percent falls on wheat sowing. In the district, the proportion of households that grow wheat on most of the land is 80 percent.

In 2014, in all categories of agricultural enterprises of the district, 7293 tons of grain were produced, which is more by 213 tons or 3.0 percent compared to 2013. And this is even though the sowing of grain in this period compared to 2013 was reduced by 5.5 percent and the increase in production was mainly ensured by increasing the yield.

Analyses show that over the past five years, due to the reduction in the sowing of grain, the area under sowing vegetables and potatoes has been increased.

Along with the sowing of grain for the region, the cultivation of vegetables, melons and gardening are also priority areas. Over the past five years, the vegetable sowing area has been increased by 1.5 times, the production of vegetable products has increased by 1.5 times, and the yield by 5.0 percent. The population is mainly engaged in the cultivation of carrots, onions, tomatoes, cucumbers, onions, peppers, bell peppers, cabbage, potatoes, and pumpkins, which is considered the main source of income for most of the population.

According to the plan of forecast indicators during 2012–2015. the area under vegetable crops will increase from 100 to 103 percent, vegetable production will increase by 103 percent. In 2014, compared to 2010, the production of vegetables increased by 136%, potatoes by 140%, melons by 115%, fruits and grapes by 151%.

Compared to 2012, the area under crops in 2014 did not increase due to the allocation of 480 hectares for housing stock. However, there is a possibility of increasing the area under crops at the expense of other lands in the district.

In recent years, the insufficient development of the agricultural sector of the region, in particular animal husbandry and crop production, is associated with the following factors:

- absence of enterprises for processing agricultural products.
- limited access of farms to loans with a low interest rate and a long repayment period.
- low level of services and poor condition of infrastructure on farms, in the field of irrigation water supply and poor condition of local roads.
- the presence of debt from farms.
- lack of support for the initiatives of the dehkan to increase the volume of production.

Gardening. Horticulture is one of the main branches of agriculture, which occupies a certain place in providing the population with food, increasing export opportunities and in providing the population with permanent work. The favourable climate of the region makes it possible to grow fruits and grapes, the area of which is increasing annually due to high-yielding and intensive seedlings, fully satisfying the population's demand for fruits, most of which are exported.

The daily growing demand for fruits and building materials, for wood (due to the planting of barren trees) requires the development of horticulture and viticulture, considering the favourable climatic conditions of the area. There are only 4341 hectares of orchards, vineyards, and mulberry trees in the region.

Only during 2010-2014, more than 712 hectares of orchards and vineyards were created in the farms of the region, which in the future makes it possible to increase the volume of fruit and grape production and the development of this industry. The climatic conditions of the area are suitable for fruit production. Currently, half of the district's households are engaged in the cultivation of apples and pears, in recent years they have received large incomes from this.

The problems that hinder the development of horticulture are, first, the restoration of the material and technical base of the horticultural industry (the use and storage of pesticides, the storage, transportation and packaging of fruits and grapes). In addition, in recent years, the condition of most gardens in the region has deteriorated because of not carrying out agrotechnical measures, due to the aging of trees.

Table 15-8 The plan for the creation of orchards and vineyards for 2010-2014 (ha)

№	List of seedlings	Unit of measurement	Years					Creation of orchards and vineyards in 2014 compared to 2010
			2010	2011	2012	2013	2014	
1	Total perennial seedlings	ha	63,4	74,1	70	62,3	442	(in) 7 times
	Of these, irrigated:	ha	4,6	5	4,3	7	130	(in) 32 times
2	Seeds	ha	55,2	66,6	67,2	49,3	417	(in) 7 times
	Of these, irrigated:	ha	3	4	3	4	125	(in) 4 times
3	Stones (drupaceous)	ha	4,4	6,5	1,6	6,5	16	(in) 3 times
	Of these, irrigated:	ha	-	1	-	1	2	(in) 2 times
4	With a core	ha	-	-	-	0,5	2	(in) 2 times
5	Vineyards	ha	3,8	1	1,3	6	7	(in) 2 times
	Of these, irrigated:	ha	1,6	-	-	2	3	(in) 2 times

Source: Executive body of the state authority, 2015

In recent years, in order to implement the «Targeted State Program for the Development of Horticulture and the Gradual Increase in Fruit Production, the Growing of Seedlings of Fruit-bearing and Evergreen Trees in the Republic of Tajikistan for 2007-2010» and Decree of the President of the Republic of Tajikistan dated August 27, 2009 No. 683 "On Additional Measures in the field of development of horticulture and viticulture in the Republic of Tajikistan for 2010-2014, it is planned to increase the area of orchards and vineyards, the production of fruits and grapes over the next years.

In recent years, the failure to use pesticides and other agrotechnical measures against all pests has led to a decrease in productivity. Properly protecting orchards from diseases and pests can help increase yields and increase fruit production

15.2.4. Forestry

According to official data, as of January 31, 2014, the total area of forests and groves in the district is 6,829 hectares. There are no other data related to forestry in the region (district).

15.3. Muminabad district

15.3.1. Socio - Demographic characteristics

Rural area characteristic

Population density, infrastructure, population in cities and villages

The total population of Muminabad district as of 1 January 2015 is 84300 people, including 41725 men and 42575 women. The average annual population growth rate is 1.73 percent. From an economic point of view, Muminabad district is agrarian, where the population mainly lives in rural areas. Population density per one square km is 95 people. The ethnic composition of the population of Muminabad district: 98.1% - Tajiks and 1.9% - other nationalities.

Table 15-9 Information about the administrative units of Muminabad district

№	Name of *Jamoat*	Number of villages	Distance to the regional centre (km)	Population (people)	Number of households	Secondary schools	High schools	Primary school	Pre-school education centres	Libraries	Children music school	Hospitals	Health centres	Gas stations	Canteens	Shops & stalls	Sauna	Sewing shops	Hairdressers	Electric & water mills
1	Jamoat Muminabad	18 y		13400	1815	3	-	-	1	1	1	1	1	4	6	166	2	1	4	-
2	N. Nazarova	28	5	15840	2171	5	4	1		2	-	-	7	1	-	46				1
3	Childukhtaron	47	25	6498	842	4	5	2		-	-	-	6	-	-	15				
4	Dekhibaland	16	5	14362	1933	6	-	-		3	-	-	7	2	1	68				
5	Boggai	16	12	11931	1410	6	2	2		4	-	-	8	1	-	25		1		1
6	Sh. Shohin	17	27	10769	1275	3	2	-		2	-	-	8	-	-	15				1
7	Balhobi	14	50	11500	1365	6	4	-		1	-	-	8	2	2	11				
	Total:	138	124	84300	10811	33	17	5	1	10	1	1	45	10	9	346	2	2	4	3

Source: State executive authority of Muminabad district, 2015

Population

Age (average + age groups / age structure (at least 10 years intervals + decomposition to children, reproduction and post-reproduction groups)

Table 15-10 Demographic information of Muminabad district

№	Indicators	Unit of measurement	Total population of Muminabad district		
			2012	2013	2014
1	Number of households	unit	10461	10690	10831
2	Population	pers	81100	82600	84300
-	Male	pers	40348	42125	41725
-	Female	pers	40752	40475	42575
	Children (3-6 years old)	pers	8317	8472	8647
-	Children up to 14 years old	pers	32384	32984	34146
-	Children up to 17 years old	pers	36738	37417	38187
-	Middle age population (15-62 years old (57 for females))	pers	45101	46547	47275
-	Older population (63 (females- 57 years old) and above)	pers	3888	4015	4078
-	Labour migrants (information on Jamoat levels)	pers	2361	2193	2193
3	Able-bodied population	pers	45101	46547	47275
4	Unemployed	pers	1102	1122	1233
5	Population employed in organizations and enterprises	pers	5993	3785	3808
6	Number of employed people in economic sector	pers	8368	8585	8772

Source: State executive authority of Muminabad district, 2015

During 2012-2014, the permanent resident population increased by 3.9 percent, while external labour migration (according to jamoats) decreased by 0.9 percent.

Table 15-11 Death/birth rate in Muminabad district

2012	1738	234	1504	1,7	81,1
2013	1781	211	1570	1,8	82,6
2014	1748	224	1524	1,7	84,3

Source: State executive authority of Muminabad district, 2015

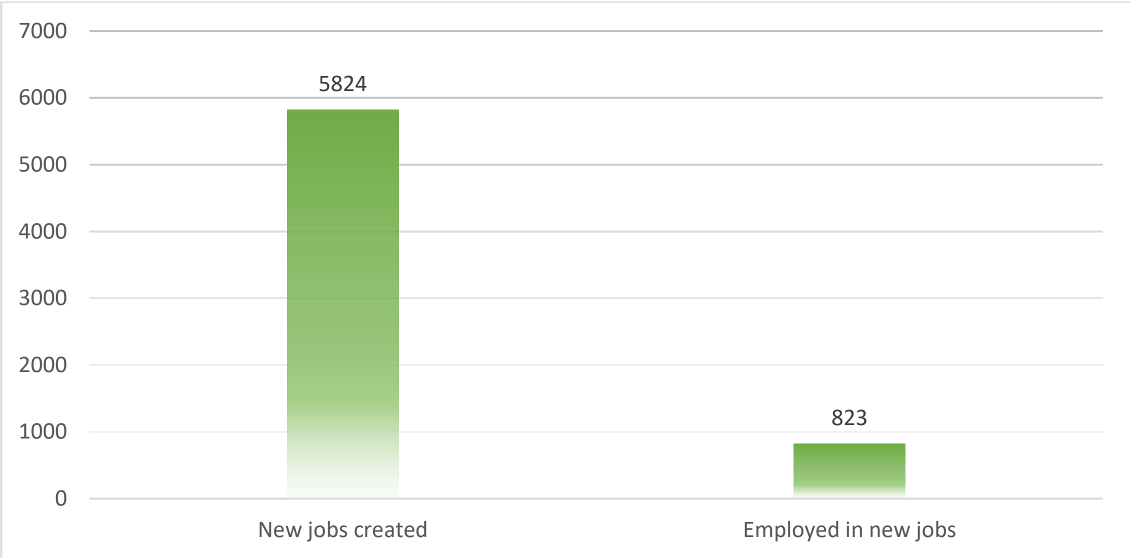
The ethnic composition of the population of Muminabad district: 98.1% - Tajiks and 1.9% - other nationalities. In Muminabad district, the average life expectancy is 65-75 years, which includes 60-65 years for men and 70-75 years for women. Taking additional measures and paying special attention to improving the physiological health and mental state of the population are among the priority tasks of the sphere. With this in mind, it is considered obligatory and necessary to create a home for disabled children and others in need in the district.

The main causes of mortality among the population of the district are mainly related to cardiovascular diseases and high blood pressure, cancer of various organs, gastrointestinal diseases and acute respiratory diseases.

Employment of population

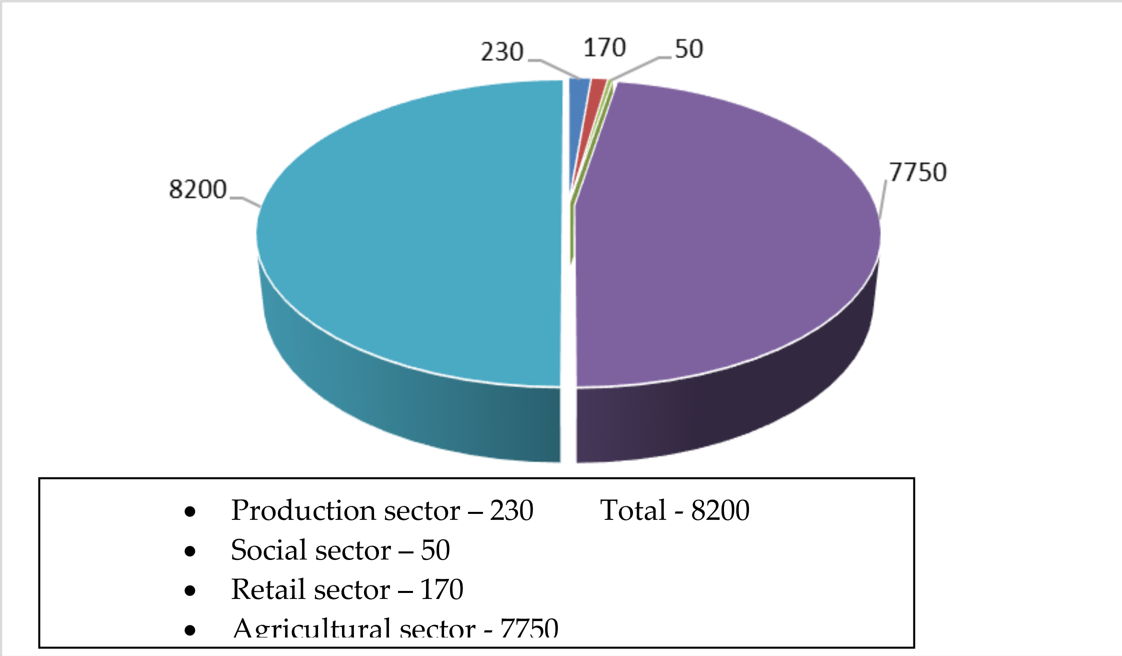
In Muminabad district in the framework of promotion of population and in order to provide the population of the district with jobs, during 2012-2014, 5,824 new jobs were created (including 2,752 new jobs in 2014), during this period, 823 people were provided with permanent jobs, which is 14.1 percent of the jobs created. The reason for this trend is due to the fact that the jobs created do not cover the working-age population due to low wages.

Figure 15-5 Creation of new jobs during 2012-2014 (person)



Source: State executive authority of Muminabad district, 2015

Figure 15-6 Structure of employment by industry in 2014 (people)



Source: State executive authority of Muminabad district, 2015

The main direction of the executive body of state power of the district in the labour market in the period up to 2020 is to attract appropriate institutions in the creation of new jobs and thereby increase the efficiency and development of the labour market.

Due to the formation of new economic relations and the development of various service sectors, there is an increase in the number of entrepreneurs, businesses and employees in all sectors

In Muminabad district during 2012-2014 the income of population in the form of wages and salaries has been constantly increasing. The average wage of workers in education and health care is growing steadily, this trend has a positive impact on the level of quality services in these sectors. In spite of this, wages remain low in agriculture, industry and construction.

Table 15-12 Average salary in Muminabad district by sectors during 2011-2014 (somoni)

Department	**Years**				**2014/2011 (in %)**
	2011	**2012**	**2013**	**2014**	
Agriculture	296	268	305	335	13,1
Industry	216	270	270	276	28
Construction	380	395	460	487	28,2
Finance & banking	650	681	710	799	23
Culture	288	310	384	473	64,2
Healthcare	356	396	482	680	91
Education	540	550	600	615	13,8
Other departments of public sector	410	470	570	590	44
Total in district (by average)	392	418	473	532	35,7

Source: State executive authority of Muminabad district, 2015

Unemployment

Addressing this issue is considered one of the main targets of the District Development Program and is aimed at providing jobs for the population during the next 5 years and thus reducing the unemployment rate. In order to achieve this goal within the framework of this Program in the district it is foreseen to use new production facilities.

The total number of able-bodied populations of Muminabad district as of 31.12.2014 has reached 47275 people. The total number of officially registered unemployed is 943 people, or 2.3 percent of the labour force. However, according to local experts, the unemployment rate in the district is approximately 30-35 percent. The majority of the unemployed are women, who are housewives.

In order to reduce the level of unemployment, to provide favourable conditions for further activities and financial support for the unemployed, the department of the State Agency for Social Protection, Employment and Migration of the district annually provides interest-free and soft loans to the unemployed at the expense of the national budget. During 2012-2014, the total number of unemployed people who received interest free loans was 129 people, the total amount of funds provided is 530 thousand Somoni.

The number of users of interest-free loans is limited due to the lack of sufficient information and the limited amount of funds available. Each year an average of 74 people in the district are granted interest-free loans to the amount of 7.1 thousand somoni. This is not enough to solve the socio-economic issues

One of the main directions of the executive body of state power of the district until 2020 is to attract and assist the relevant institutions to create new jobs in the labour market, to increase the effectiveness of the co-relevant structures of the industry and thereby contribute to the development of the labour market. From this point of view, 4,000 new jobs are expected to be created in the district by 2020.

Labour Migration. Since 2014, the issues of employment and labour, environmental and internal migration of the population in the district is dealt by the Department of the Agency of Labour and Employment of the Population of Muminabad district. Labour migration plays a big role in providing the population with jobs, and is one of the main sources of income of the population of Muminabad district. According to official statistical reports, the total number of migrants was 1,401 people in 2014. There is a high level of labour migration in the district, the qualification level of labour migrants of the district, in particular young migrants, is not competitive in the labour market. In 2014, 1.87 million U.S. dollars and 21.3 million Russian rubles were received through the district's banks at the expense of migrant workers.

One of the urgent problems of the sphere is the organization of environmental internal (voluntary) migration by relocating the population from dangerous areas to safe places. In order to solve this problem, the Resolution of the Government of the Republic of Tajikistan № 474 of November 2, 2013 "On approval of the medium-term plan of organized resettlement of environmental migrants for 2014-2016" was approved, which provides for the resettlement of 51 families from Muminabad district.

During 2012-2014, 30 households (173 people) of ecological migrants were registered in the district, who were resettled from dangerous areas of villages Degrez, Bogidilkusho of Childukhtaron rural jamoat, villages Gesh, Magak, Kulchashma, Margakiubara of N. Nazarov rural jamoat, Tutu village of Shokhin and villages Tuto and Bogi Habib of Balgob jamoat to safe areas of the district.

In order to help regulate the process of organized external labour migration, the following measures should be implemented within the framework of the Program:

- attracting labour migrants to vocational training and learning the state language of countries receiving the labour force and the rights of migrants through short-term courses for those citizens who want to leave for labour migration
- establishing effective cooperation with the relevant structures of the Republic for sending local labour force abroad, organization and implementation of the mechanism to provide local labour force abroad

The main problems of the social sphere:

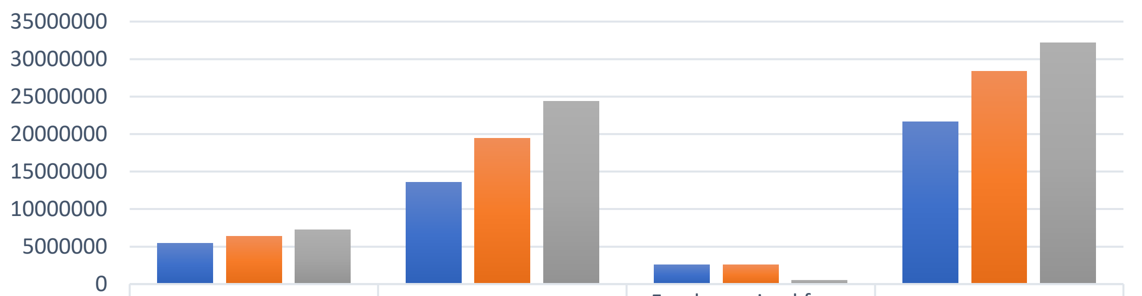
- lack of technical means, wheelchairs
- Inadequate organization of work to provide for the disabled, the elderly, and children with disabilities, and mismatch with generally accepted standards,
- Non-competitiveness of the official labour market with the unofficial market,
- The low level of qualifications and training among young people,
- Lack of modern equipment and technology in social care institutions,
- Lack of timely provision of jobs for the citizens who passed short-term vocational training courses,
- The absence of a state-run centre of social services for children with disabilities,
- Absence of a home for disabled children,
- The need to create a "Vocational Training Lyceum" for people with disabilities between the ages of 15 and 30, and the absence of a "Home for the Elderly" in the district.

15.3.2. Economic characteristics

- GDP – region
- Structure of regional economy
- Sector contribution to GDP/employment

In recent years, funds from the local budget for the development of the district have been allocated to a limited extent. The main sources of formation of the revenue part of the budget are the tax on income of individuals, value added tax, unified tax, tax on owners of vehicles, real estate tax, etc. During 2012-2014, the district's own revenues on average covered 26.9% of the expenditure part of the budget. In this regard, subventions are allocated to cover the budget deficit.

Figure 15-7 Plan of income and expenditure of Muminabad district budget

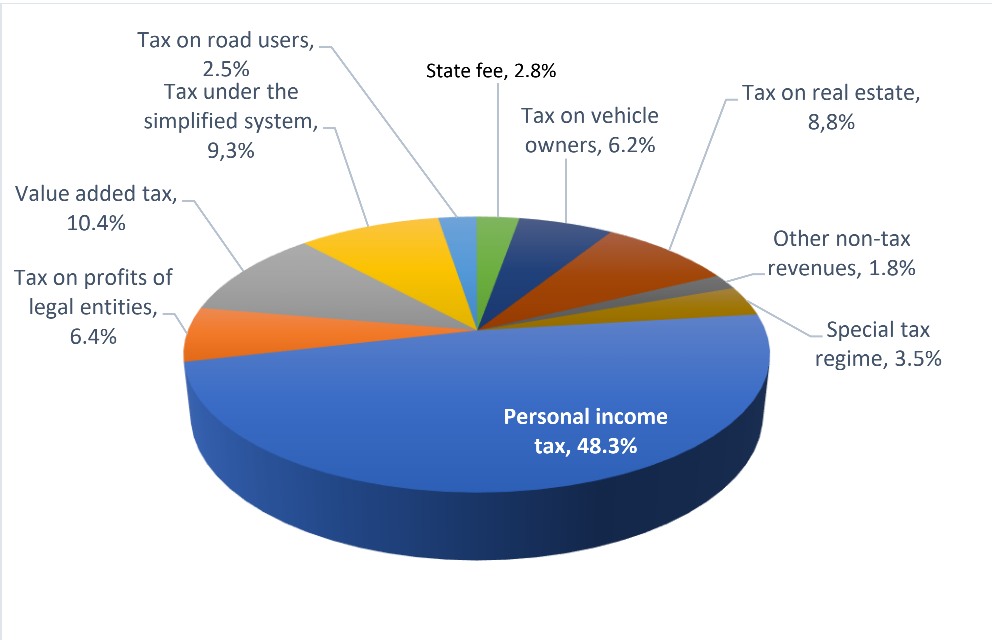


	Own income	Subvention	Funds received from the national budget for mutual settlements	Expenditures
2012	5472630	13588183	2558844	21619657
2013	6385538	19412755	2568040	28366333
2014	7261421	24400487	526064	32187972

Source: State executive authority of Muminabad district, 2015

Individual income tax, simplified tax, unified tax and value-added tax occupy a special place in the revenue part of the district budget.

Figure 15-8 The structure of the revenue part of the budget of Muminabad district



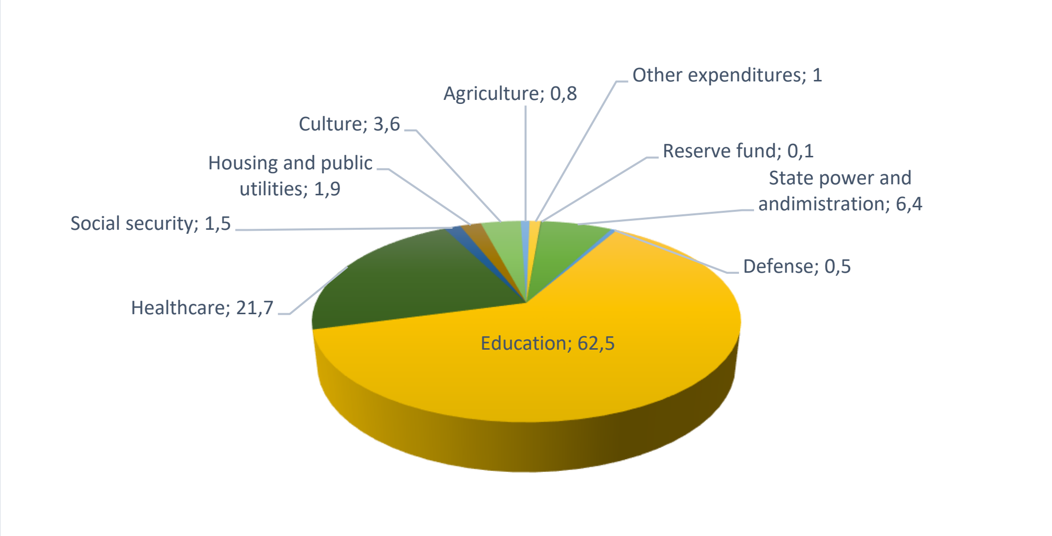
Source: State executive authority of Muminabad district, 2015

The diagrams show that the revenue part of the budget is mainly financed from tax on income of individuals, tax on profit of legal entities, value added tax, tax on simplified system, tax on road users, state dues, tax on vehicle owners, tax on real estate, single tax and other non-tax revenues.

Analysis shows that the funds allocated from the republican budget during 2012-2014 are more than 22400.3 thousand somoni, of which 20331.7 thousand somoni are targeted funds, and 2000.6 thousand somoni are means of mutual settlements.

In 2014, compared with 2012, the total amount of revenue increased 1.5 times, trust funds 1.8 times, and mutual settlements 1.7 times, with the total revenue increasing by 1.7

Figure 15-9 Share of local budget expenditures according to the functional classification



Source: State executive authority of Muminabad district, 2015

The budget of Muminabad district has a social nature, in its expenditure part, a significant share of expenditures consists of education and health care. In 2014, the average share of social expenditures in the local budget was 89.3 percent, including 62.5 percent, 21.7 percent, 3.6 percent, and 1.5 percent for education and health care, culture and social protection, respectively.

In connection with transition of general education schools to per capita financing, the share of expenses of education sphere has increased during the last years.

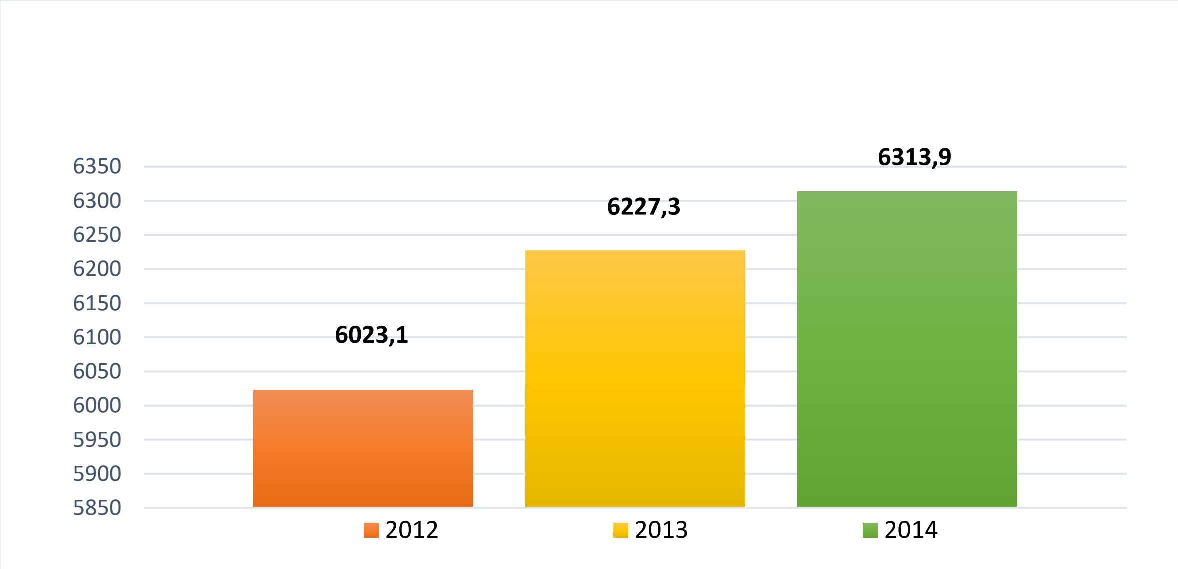
The structure of Muminabad district budget expenditures according to economic classification mainly consists of wages and state insurance, expenditures for purchase of goods and services, subsidies and capital expenditures. Capital expenditures are directed to construction of new objects, repair of buildings and purchase of equipment.

Income per capita, employment/unemployment (in sectors – mainly Agriculture), price index, etc.

Industry is one of the main directions of economic development of the district. Since the existing potential and resources of the district can contribute to the development of light industry, processing of agricultural products, and production of building materials. The development of industry should be based on the growth in the number of small and medium-sized enterprises for the production of industrial products.

There are 8 industrial enterprises, 90 mills and 4 butter-mills, which produce goods from local raw materials. Currently, the share of industry in the formation of the total volume of production in the district and the revenue part of the district budget is insignificant.

Figure 15-10 The volume of industrial production in Muminabad district during 2012-2014 in current prices of respective year (thousands of somoni)



Source: State executive authority of Muminabad district, 2015

Growth in nominal output of industrial products in current prices in 2014 compared to 2012 and 2013 increased 4.6 times and 1.4% respectively.

Table 15-13 Production of industrial products in real volume at industrial enterprises of the district

	List of products	Unit of measurement	Years			
			2011	2012	2013	2014
1	Plum drink	thousand/jar	11,1	15,0	19,0	3,5
2	Onion "Anzur"	thousand/jar	13,7	9,0	33,4	31,5
3	Cucumbers	thousand/jar	41,2	75,1	33,5	57,0
4	Assortment (Assorti)	thousand/jar	20,9	21,0	24,5	92,2
5	Construction bricks	thousand/pieces	75,0	93,0	117,0	187,0
6	Bread & bakery products	ton	671	678	679	712
7	Vegetable oil (seed oil)	ton	116,8	115,3	113	45,3

Source: State executive authority of Muminabad district, 2015

Existing potential and its effective use

In the territory of Muminabad district there is a large volume of reserves of gold, lead and raw materials for production of construction materials, but these reserves are currently not fully explored, and their processing and use is not established.

In medium-term perspective these reserves will contribute to creation of mining enterprises, and purposeful attraction of capital and its effective use can become a factor of sustainable economic development of Muminabad district.

Geographical and natural conditions, historical monuments and the location of Muminabad district contribute to the development of tourism, however, the current economic opportunities and existing infrastructure do not meet the requirements of tourism development.

In the case of rehabilitation of pumping stations and 12 vertical wells, and the introduction of 702 hectares of land in the territory of rural Jamoats Boggai, Dehbaland, N. Nazarova, it would be possible to increase the production of potatoes up to 12%, cereals up to 18%, honey up to 31%, vegetables up to 15% and animal feed up to 27%.

Currently the infrastructure of Muminabad district is in unsatisfactory condition, and this factor negatively affects the level of socio-economic development of the district. Taking into account the fact that the local roads have not been repaired for many years, at present the rehabilitation and reconstruction of local roads is considered one of the urgent problems of the district.

Table 15-14 SWOT analysis of general situation in Muminabad

Strength	Weakness
- Availability of free labour resources in the area. - Availability of sufficient land resources. - Favourable geographic location, favourable natural and climatic conditions for the creation of sanatorium-rehabilitation services and the development of agriculture. - Abundant natural resources. - Availability of high-yield arable land. - Presence of cultural and historical monuments. - A hardworking population. - Variety of flora and fauna. - Favourable conditions for attraction of foreign and local investors. - Availability of experienced dehkan (peasant) and private farms. - Experience of working with foreign investors. - Newspaper available in the district. -Support for agricultural producers.	- Long distance from the area to the railroad and the international airport. - Weak material and technical base of agriculture and insufficiency of agricultural processing facilities. - The district receives subventions. - Depreciation of existing fixed assets. - Lack of access to the necessary primary infrastructure. - Insufficient fundraising for the organization of natural resources processing enterprises. - Poor condition of local roads and the deterioration of the district's water supply facilities. - Absence of a master plan for the region - Lack of irrigation water supply facilities. - Insufficient number of small and medium-sized businesses in the district. - Lack of main highways in the region and the location of the region in a communications dead end. - Lack of agricultural and industrial processing facilities. - Inefficient use of existing facilities. - High percentage of bank loans and a lack of long-term and preferential loans - Lack of jobs and low wages. - High level of migration of the able-bodied population. - The absence of a mechanism for the assessment of the needs of vulnerable categories and the preparation of forecasts of budget financing
Opportunities	**Threats**
- Development of small and medium-sized businesses and creation of new jobs. - Construction and commissioning of mining enterprises. - Development of agriculture - Targeted attraction of domestic and foreign investments. - Creation of basic infrastructure. - Provision of small credits. - Construction of small and medium sized hydroelectric power stations. - Elaboration of a Region Development Program - Organize training courses for specialists in the sphere of health and social protection in the region	- Natural disasters (floods, hail, mudflows, drought, avalanches, etc.). - Corruption. - The possibility of the threat of an outbreak of infectious diseases.

Source: State executive authority of Muminabad district, 2015

The role of small and medium entrepreneurship in the local economy

Small and medium entrepreneurship occupies an important place in the economy of Muminabad district and should become the main sector of economic development of the district. Development of small entrepreneurship, privatization of state property, as the primary sign of transformation of the transition period to a market economy, is aimed to improve the efficiency of enterprises and their contribution to the financial stabilization and provision of the population with new jobs and expansion of the consumer market.

Table 15-15 The role of small & medium business in employment by industry in 2014

Sphere of economics	Number of registered small & medium businesses		Number of workplaces	Tax revenues including contributions to the Social Security Fund	
	Legal entities	Individuals (including individual entrepreneurs)		Thousands of somoni	% Of total budget revenues
Agriculture	166	3559	5423	1573173	11,9
Industry	7		35	24864	0,2
Construction	12		120	911802	6,9
Transportation & communication	4	35	82	517778	3,9
Trade & commerce	62	197	388	252283	1,9
Services	10	19	54	9932585	75,2
Financial Services	4	1	41		
Other spheres	1	22			
Total:	266	3833	6143	13212485	100

Source: State executive authority of Muminabad district, 2015

This sector represents a huge resource for the development of the district. SMBs (small & medium businesses) play an important role in such sectors as agriculture, trade and manufacturing and mixed activities, in the provision of consumer services to the population.

According to official data, 4,099 entrepreneurs were registered in Muminabad district in 2014, including 266 legal entities and 3,833 individuals.

Most of the SMBs of the district are engaged in agriculture (90%) and trade (6%), transport and communication (1%) and others in other areas.

According to official data, in recent years, the number of entrepreneurs is constantly growing, which make a significant contribution to the creation of new jobs and the saturation of the consumer market in the district of Muminabad. According to the analysis, it was found out that in 2014 the total number of legal entities and individuals increased on average by 31.8% and 21.1% respectively compared to 2012 and 2013. As a result, 2,000 new jobs were created. It should be noted that 12% of income and 88% of employment in the SMB sector is only in agriculture.

The lack of development in many types of entrepreneurships in the sphere of services and production is related to:

- the lack of financial capabilities of entrepreneurs
- low qualification in preparation of business plans, marketing of sales
- unstable inflation rate
- high fuel prices and high costs of exporting products to foreign markets

Improvement of skills and knowledge of entrepreneurs, provision of necessary information about markets for goods and products and changes in its conjuncture, as well as provision of preferential loans to entrepreneurs, will give a new impulse to the development of the SME sector.

15.3.3. Agriculture

Agriculture is the main focus of economic development of Muminabad district and it plays an important role in the economic life of the district. The main part of working-age population (85%) is engaged in agriculture and for the majority of the population it is considered as the only source of income. The main sectors of agriculture are crops, animal husbandry and horticulture. In Muminabad district, the main producers of agricultural products are collective farms (8%), individual farms (30%) and the local population (62%). The share of these farms is huge in the total production of agricultural products, particularly in the production of potatoes and vegetables. Individual farms are involved in the production of wool, meat, milk, eggs, honey, grains and fruits.

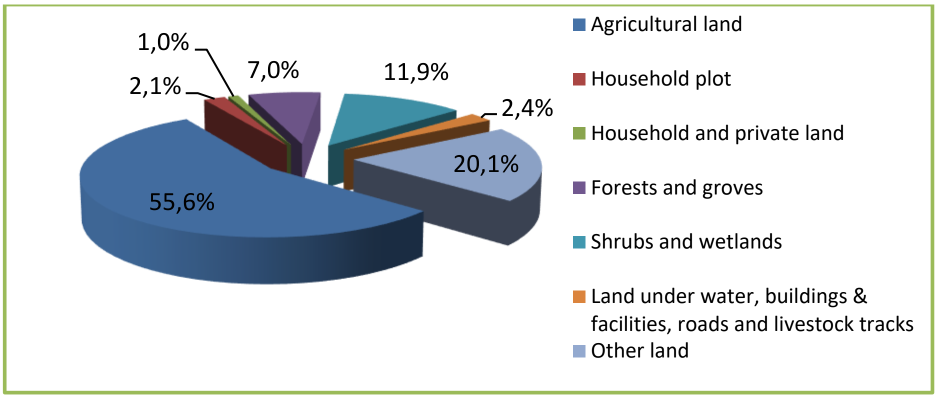
In 2014, the share of products produced by Muminabad district farms was 5.8 percent of the total agricultural output of the region (including cereals - 9.1 percent, vegetables - 21.6 percent, potatoes - 24 percent, fruits - 14.8 percent, milk - 21.5 percent, meat - 13.2 percent, eggs - 7.2 percent, honey - 17.1 percent and wool - 12.8 percent).

The population of Muminabad district is engaged in cultivation of grain crops (wheat, beans and barley), vegetables, potatoes, fruits, animal feed (clover and sainfoin) and cattle breeding. Most of the population of the villages derives their income from the sale of agricultural and animal products. There are 4,980 individual farms, 155 commercial cooperatives, 1 scientific farm named after Sh. Zarif and a forestry farm are operating in Muminabad district. The number of households is 10,811, of which 84.2 percent are households consisting of more than 5-6 people. Out of the total number of individual farms, 1,017 are managed by women. Agricultural activities are mainly carried out by women, as the majority of men of working age are in labour migration

Land use

Dekhkan farms are delegated the major share of agricultural lands, including arable fields and other areas. However, practice indicates that not all of the are allotted to them or to private subsidiary farms are utilised for the intended purpose. The area may be crossed by a main road or canal, or it may be unsuitable for planting and producing agricultural goods. For example, due to a lack of irrigation (FAO, 2019). According to official data as of January 1, 2015, the total area of the district is 121,479 hectares, and the number of registered land owners is 14,716 people. Of the total land area, 67,555 hectares are agricultural lands, 2,576 hectares are homestead lands (413 hectares are irrigated), 1 thousand 189 hectares are personal subsidiary lands (50 hectares are irrigated), 18 hectares are reserve fund, 8,451 ha - forests and groves, 14,19 ha - bushes, 1,423 ha - land under water, 715 ha - land for roads and livestock tracks, 717 ha - land for buildings and facilities, streets and squares and 24,834 ha - other lands. The area of land suitable for agricultural enterprises is 102,377 hectares (of which 4,687 hectares are irrigated).

Figure 15-11 Structure of total agricultural land use (in %)

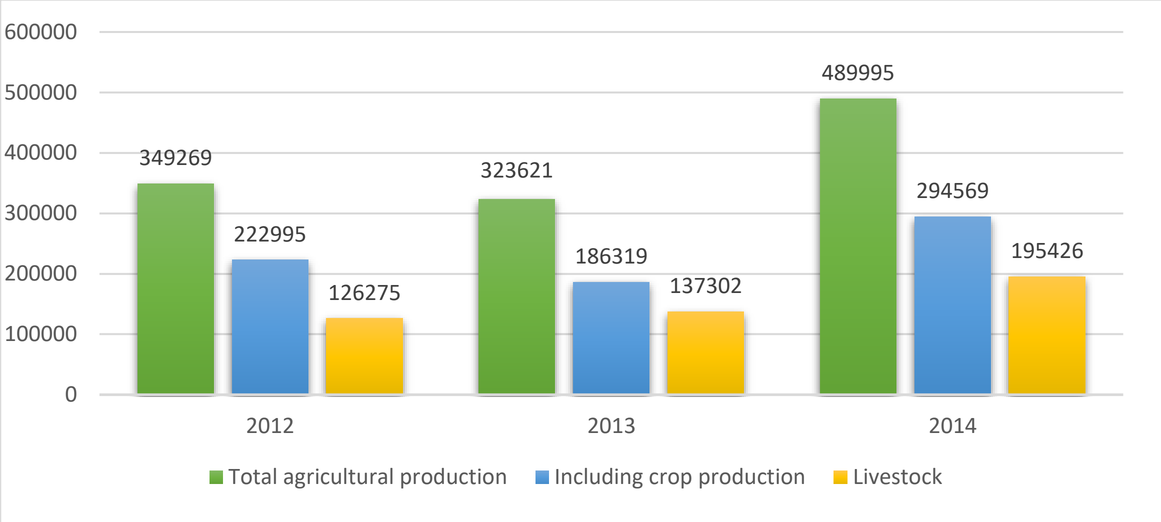


Source: State executive authority of Muminabad district, 2015

Out of the total area of perennial trees - 2,328 ha are orchards (433 ha irrigated), 632 ha - vineyards (1 ha irrigated), 37 ha - mulberry trees (12 ha irrigated) and 3 ha - nurseries for growing seedlings (3 ha irrigated). Irrigated land is mainly used for sowing potatoes, vegetables, melons, cereals and fodder crops.

In 2014, the agricultural enterprises of Muminabad district, taking into account all forms of farming, produced 489.9 million TJS, of which 294.6 million TJS were in crop production (60.1%) and 195.4 million TJS in livestock production (39.9%). According to official statistics, in 2014 there were 322 kg of grain, 138 kg of fruits, 197 kg of vegetables, 249 kg of potatoes, 75 kg of grapes, 37 kg of melons, 131 litres of milk, 98 kg of meat and 19 eggs for every resident of Muminabad district.

Figure 15-12 Agricultural production in Muminabad district by all forms of farming for 2012-2014 (in comparative prices) (thousand somoni)



Source: State executive authority of Muminabad district, 2015

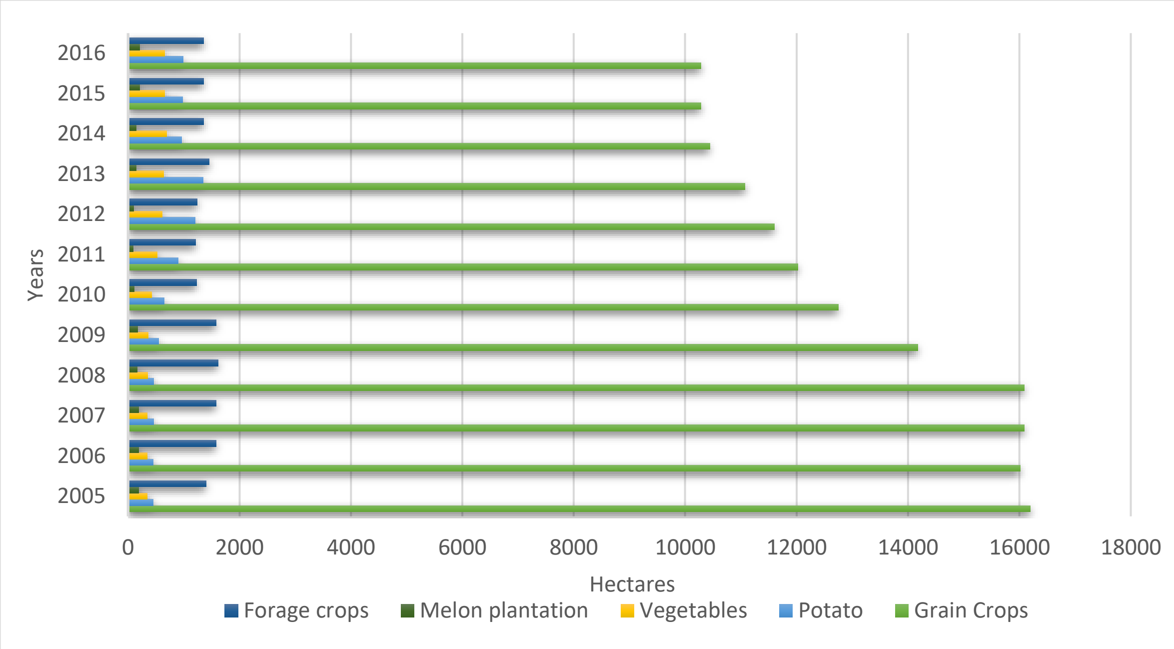
The volume of agricultural production in 2014 compared to 2012 increased by 140.6 million somoni, or 40.3 percent. The volume of produced products, including potatoes, vegetables and fruits can meet the internal demand of the district and be exported. However, the area of land suitable for sowing is insufficient to fully provide the population of the district with all types of agricultural products. In current conditions in Muminabad district, taking into account available capacities such as use of fallow lands and improvement of meliorative condition of lands at the expense of repair and rehabilitation of water supply systems, organization of drip irrigation, effective use of existing lands, development of fallow lands, there is a possibility to develop 310 ha of new irrigated lands

Farmers in Muminabad responded that they usually decide when and what to plant, but government specialists (Ministry of Agriculture) also provide recommendations. Usually the farmers (household head) decide the price of the commodities they sell. They receive price data from other farmers (word of mouth). Women are also participating in the farming decision-making process at any stage and according to the farmers, there are around 70% of those employed in the farmers sector are women. Men are more engaged in planting and harvesting seasons and women usually contribute in the growing season. The harvesting and planting workload might be physically challenging for women (World Food Programme, 2016)

Crop production

Crop production is the main part of the agricultural sector in Muminabad district. Its production accounts for 60.1 percent in the structure of gross agricultural output of Muminabad district. Agricultural enterprises of the district grow cereals (wheat, barley, beans), potatoes, vegetables (cabbage, carrots, onions, tomatoes, cucumbers, beans, etc.) and animal feed (clover and sainfoin).

Figure 15-13 Sowing areas of agricultural crops in all categories of farms for Muminabad



Source: Agency on Statistics under the President of the Republic of Tajikistan, n.d.

In the area for 2011-2014 there was an increase in the production of all types of agricultural products, except for cereals, the main reason for this is the reduction of the area of sowing cereals. In turn, at the expense of the reduction of the area of this type of culture the area of sowing of other types of crops, including vegetables has increased by 31.8 percent, potatoes by 7.2 percent and animal feed by 11.5 percent

Table 15-16 Crop production in Muminabad district

№	Indicators	Unit of measurement	2011	2012	2013	2014	2014 in comparison with 2010 (in %)
	Cereals	ton	27641	27744,7	28916	27214	98,5
	Crop area	hectare	12055	11599	11078	10442	86,6
1.	Yield	centner/ha	22,9	23,9	26,1	26	113,5
	Vegetables	ton	12261	13520	13485	16624	135,6
	Crop area	hectare	525	615	635	692	131,8
2	Yield	centner/ha	235	219	227	240	102,1
	Potato	ton	18721	24126	28761	21004	112,2
	Crop area	hectare	900	1200	1350	965	107,2
3	Yield	centner/ha	208	201	213	218	104,8
	Fruits	ton	10338	10644	11249	11639	112,6
4	Yield	centner/ha	87	89	90	92	105,7
	Animal food	ton	36262,8	36263	46057	50183	138,4
	Crop area	hectare	1216	1243	1459	1356	111,5
5	Yield	centner/ha	29,8	29,9	31,5	36,9	123,8

Source: State executive authority of Muminabad district, 2015

There is an opportunity to increase the volume of agricultural production in the area by putting into agricultural turnover of rainfed lands (fallow lands - 126 ha, of which 1 ha is irrigated). One of the directions of the Program is to put these lands into agricultural turnover.

To saturate the domestic market with fresh fruit in 2014, 313 hectares of new apple, apricot, pear and cherry orchards were created in the district on the sites of rural Jamoats Childukhtaron, Dehibaland and N. Nazarov. In addition, in 2014, apple orchards, 15 hectares of cherry trees, 10 hectares of vineyards and other types of fruits were restored in the villages of Savzakpoja, Sayod and Childukhtaron on the area of 86 hectares at the expense of own funds of agricultural enterprises and foreign investments of “Caritas” organization.

One of the main problems observed in this direction is the low level of processing of fruits and vegetables. Due to the lack of fruit processing enterprises in Muminabad district, most of the fruit is spoiled and used as animal feed, which brings financial losses to horticulture farms.

In the framework of this program, one of the priority tasks of the sector will be to organize a reception point for dried fruits and the construction of a small shop for the processing of fruits and vegetables.

On the basis of scientific achievements, the organization of protection of orchards from diseases and insect pests will increase the yield and production of fruits. Consequently, in the medium term, another important direction of development of the industry will be the organization of protection, storage and processing of agricultural products by attracting funds from all possible sources.

Livestock. Animal husbandry along with other sectors of agriculture is one of the main sectors, the specific weight of which in the gross agricultural product is 39.9 percent. In 2014, livestock farms of the district produced products worth 195.4 million somoni, which is 54.7 percent more compared to 2012.

Table 15-17 The volume of livestock production for 2011-2014

List of products	**Unit of measurement**	**Years**				**2014 in comparison with 2011 (%)**
		2011	**2012**	**2013**	**2014**	
Meat	ton	5966,4	6549,6	7105,2	8323	139,5
Milk	ton	9144	9836	10645	11075	121,1
Eggs	thousand pieces	1260,4	1363,1	1456,2	1590	126,2
Honey	ton	99,4	145,9	173	106,1	106,7
Wool	ton	375,3	379,7	383,1	394	105

Source: State executive authority of Muminabad district, 2015

During 2011-2014 there was a significant progress in the livestock industry, as well as growth of results for all types of products. During the analysed period, the production of major livestock products, including meat (live weight) increased by 39.5 percent, milk by 21.1 percent, eggs by 26.2 percent, honey by 6.7 percent and wool by 5 percent.

According to official statistics, a total of 3,607 head of large animals and 1,3986 small animals were registered in the district as of January 1, 2015. An increase of 7.3 percent and 9.8 percent, respectively, compared to 2011.

Table 15-18 Production volume of livestock production for 2011-2014

№	**List**	**Years**				**2014 in comparison with 2011 in %**
		2011	**2012**	**2013**	**2014**	
1.	Large animals	32245	32604	33574	34607	107,3
	Out of them – cows	15499	18184	19372	19683	127,0
2.	Goats & sheep	103771	104673	109573	113986	109,8
3.	Poultry	83898	84583	94336	100886	120,2
4.	Horses	3084	3132	3249	3293	106,8

Source: Agency on Statistics under the President of the Republic of Tajikistan, n.d.

The district has good conditions for the development of animal husbandry, as the total area of pastures is 52713 hectares, which is equal to 78% of the total area of agricultural land. The current situation in the livestock industry of the district requires serious improvements. Necessary measures to withdraw the industry from the current situation: increasing the area of sowing and strengthening the forage base of animals, increasing the number of breeding animals, information-explanatory work among the population to improve the breeding qualities of personal animals, the timely implementation of necessary measures related to the prevention of diseases among animals, etc.

Poultry farming

The development of poultry farming will bring great benefits to the district, since the district has all the conditions for this - a moderate climate, favourable for poultry farming. Before the collapse of the Soviet Union, a poultry factory operated in the district, which provided not only the district, but also other parts of the district with eggs and cheap poultry meat. After the collapse of the Soviet Union, the poultry factory did not function for many years. Subsequently, with the support of the Government of the Republic of Tajikistan and the executive body of the regional and district authorities, the factory resumed its activities in 2010. In 2012, the poultry factory CJSC "Yakar-cha" produced 75 tons of poultry meat and sold it in the markets of the country. According to the available data, in 2014 there were 113986 birds in all sectors in the district, this figure is higher than in 2012 by 27533 birds.

Table 15-19 The main indicators of the sphere in collective and dehkan farms for 2012-2014

№	List	Unit of measurement	Years		
			2012	2013	2014
1	Bird population	head	86453	109573	113986
2	Egg production	thousand pieces	1363,1	1456,2	1590

Source: State executive authority of Muminabad district, 2015

Analysis shows that in 2014 compared with 2012, the main indicators of the industry, including the number of birds and egg production increased by 31.8% and 16.6%, respectively.

The main problems of the industry, first of all, are lack of funds, lack of conditions for the production of nutritious combined feed (for example: fish meal, bones, meat, premixes, vitamins, amino acids, enzymes, macro and microelements), lack of permanent electricity, lack of preferential loans, etc. Due to the lack of production facilities such products are not produced in the area. For this purpose, farms have to import them from abroad separately or as supplements with protein and vitamins, which requires large funds.

The development of poultry farming will create new jobs, reduce poverty, protect the population from the spread of infectious diseases and prevent the importation of low-quality products from abroad.

To achieve the set goals and sustainable development of the poultry industry it is necessary to solve the following problems:

- Organization of the feeding base and its rational use in terms of scientific achievements and best practices by allocating funds and preferential loans in order to create enterprises for the production of combined fodder for birds;
- Creation of a factory of breeding birds producing a lot of eggs and organization of breeding works;
- Creation of joint ventures, restoration of the activity of poultry factories by means of using the bank credits and attracting foreign investments;
- Providing veterinary protection for birds;
- Providing poultry farms with regular power supply;
- Equipping poultry farms with new and modern equipment

Beekeeping

Beekeeping and honey production is considered a low-cost and profitable sector of agriculture. Climatic conditions of the area are favourable for the development of bee-keeping. Existing resources containing nectar plants, allow increasing the number of bee families and doubling the production. In order to develop beekeeping in the district, a Beekeepers' Association was created, which has provided assistance in solving certain problems of the sector, including the elimination of certain signs of infectious diseases, providing beekeepers with necessary materials, purchase and sale of bee products.

Table 15-20 Main indicators of beekeeping for 2012-2014

Years	Bee family	Honey production (ton)
2012	5200	67,6
2013	5500	71,5
2014	7531	106,1

Source: State executive authority of Muminabad district, 2015

The sale of beekeeping products (honey, wax, propolis, flower pollen, royal jelly, bee venom, etc.) within and outside the district brings a large income, provides a huge inflow of funds and improves the living standards of the district population.

There are conditions and opportunities for the implementation of the Program for the restoration and further development of beekeeping.

The provision of long-term loans with low interest rates for the support of beekeeping farms can become a favourable ground for the development of this industry. In the framework of the Program of development of the district one of the strategic objectives of the development of this sphere is an increase in the number of bee families in 2020 to 9126 families and the production of honey to 154 tons.

In Muminabad, the main challenges they face are expensive fertilizer and low-quality seeds. As a solution, farmers advocate for long-term credit and a better irrigation system. The two main challenges for farmers are the changing climate and the high costs of agricultural inputs (i.e., fertilizers). Farmers also shared that they have experienced weather/climate hazards with too high temperature for potato, dust for floral products, and heavy rain for fruits. Bee-keepers, livestock owners and farmers are the most affected ones. In response to the hazards, farmers tend to sell more livestock, plant fast growing produces or ultimately migrate to the Russian Federation for better job opportunities. (World Food Programme, 2016)

Agricultural businesses of Muminabad district are sufficiently provided with new agricultural machinery, the number of which in the enterprises, to date, is 496 units. In 2014, Muminabad district received 53 units of wheeled tractors, including 12 units are on the balance of Tojikagroleasing SUE. At present, each imported tractor accounts for 220 hectares of arable land, 57.5 hectares of orchards and vineyards, and in total for each tractor 226 hectares of land. Availability of modern machinery plays an important role in the development of agriculture. Out of the 496 items of machinery and equipment on the balance of farms, 79 percent are in working condition (153 units of tractors, 15 units of combines, 130 units of tractor ploughs), the remaining 21 percent are out of order. From the total number of machinery and equipment, 80 percent are arable tractors (153 units), 81 percent are tractor plows (160 units). Lands of limited area and stony areas are mainly ploughed with a working bull. However, the funds provided for repair and restoration of machinery and equipment in farms are insufficient, which makes it impossible to repair and restore machinery at the expense of farms.

Table 15-21 Information on agricultural machinery

№	List of tractors	Total	Ready	% of readiness
1	Arable tractors	153	122	80%
2	Cars	73	55	75%
3	Mini-harvesters	15	13	87%
4	Tractor Trailers	89	69	78%
5	Mowers	-	-	-
6	Heymakers	2	2	100%
7	Baler	1	1	100%
8	Sowers	-	-	
9	Cultivators	3	2	67%
10	Tractor plows	160	130	81%
	Total:	496	394	79%

Source: State executive authority of Muminabad district, 2015

The main problems that farms face are:

- weak technical basis
- weak financial position of farms
- lack of spare parts
- shortage and high prices for fuel and lubricants
- partial wear and tear of agricultural machinery and equipment
- shortage of highly qualified personnel.

15.3.4. Forestry

In the district, the issues of protection, care and creation of new areas of forests is handled by the "Forestry section of Muminabad district". It has 4 permanent workers (1 inspector and 3 jaegers), as well as 12 seasonal workers. The district forestry annually produces up to 1.5 tons of dried fruits, 0.7 tons of nuts, 9 tons of animal feed and 0.9 tons of rose hips, more than 240 cubic meters of firewood are exported for sale. The total area of forests and groves of Muminabad district is 407 hectares. In the forests of the district, mainly apple trees, apricot tree, willow, silver poplar, rose hips, nut tree and almond grow. The main problem of the industry is the lack of an administrative building of the Forestry Department, machinery and workshop for the processing of rosehip and fruit in the forestry

Adaptation strategies

- Regional strategies in context of national adaptation strategies
- Adaptation plan
- Investments
- Expectations

Financing of the "Program of social and economic development of Muminabad district for 2016-2020 years" is provided from the funds of the local budget, the state budget, domestic investment (domestic entrepreneurs) and from extrabudgetary sources. Extrabudgetary sources that are attracted for financing of this Program include the following:

- Target payments from profits of organizations interested in the implementation of the Program;
- Bank loans;
- Funds from foundations and public organizations;
- Funds of foreign investors interested in the implementation of the Program or its individual activities;
- Funds of labour migrants outside the Republic, who are interested in the implementation of the Program.

In the process of developing this Program, the requirements of the Law of Republic of Tajikistan "On the State Forecasts, Concepts and Programs Socio-economic development", "Methodological guidelines for the formulation and the guidelines for the formulation and implementation of the programs on socio-economic development of cities and districts of the Republic of Tajikistan" (approved by the Ministry of Economic Development and Trade of the Republic of Tajikistan), important strategic documents (Millennium Development Goals, "National Development Strategy of the Republic of Tajikistan until 2015, "Welfare Improvement Strategy of Tajikistan for 2013-2015") and sectoral and regional programs.

The main goal of the Program is to ensure sustainable growth of the real economy based on the use of local raw materials, to improve social services and enhance the quality of life of the district's population. As the main document, the present Program determines the priorities and future policies of the social and economic development of the district for the medium-term period. The District Development Program includes 182 projects amounting to 163262 thousand somoni, out of which 60 projects for the amount of 65757 thousand somoni are related to the economic sector, 42 projects for the amount of 48145 thousand somoni are related to social sphere and 44 projects for the amount of 49745 thousand Somoni are implemented.

Table 15-22 Distribution of funds of the "Program of socio-economic development of Muminabad district for 2016-2020" by sectors from all sources of funding (thousand somoni)

Sector	Total (thousands somoni)	2016	2017	2018	2019	2020
Agriculture	18702	1040	4240	3822	2320	1900
Industry	7170	82	438	1350	2100	3200
Small and medium business	3555	1231	956	956	406	6
Construction	36330	8030	12880	7420	4300	3700
Total, economic sector	65757	10383	18514	13548	9126	8806
Education	20760	2100	5310	4650	3200	5500
Healthcare	12830	3405	4145	4040	1240	0
Culture, sport & tourism	14555	5857	6218	2480	0	0
Total, social sector	48145	11362	15673	11170	4440	5500
Provision of drinking water	16141	1481	3194	4419	4495	2552
Housing & communal services	8315	1035	1666	2099	2210	800
Electricity	8365	1443	2184	2675	1428	635
Transport & roads	10736	2537	2000	2570	1719	1910
Communication & information	585	60	235	190	100	
Total, infrastructure	44142	6556	9279	11953	9952	5897
Environment protection	240	70	80	90	0	0
Emergency prevention	4908	1992	1402	1514	0	0
Resource provision	70	0	50	20	0	0
Total	163262	30363	44998	38295	23518	20203
Including the budget of the republic	81420	18928	26652	16410	11730	7700
Regional budget	920	80	280	280	280	
Local budget	799	207	166	379	30	17
Own funds of entrepreneurs, population, organizations & institutions	24883	5826	7789	7876	3086	306
Foreign investments	18949	1013	4249	5334	4483	3870
Projects with uncertain sources of funding	36291	2990	6060	7140	4699	8310

Source: State executive authority of Muminabad district, 2015

15.4. Shaartuz district

15.4.1. Socio Demographic conditions

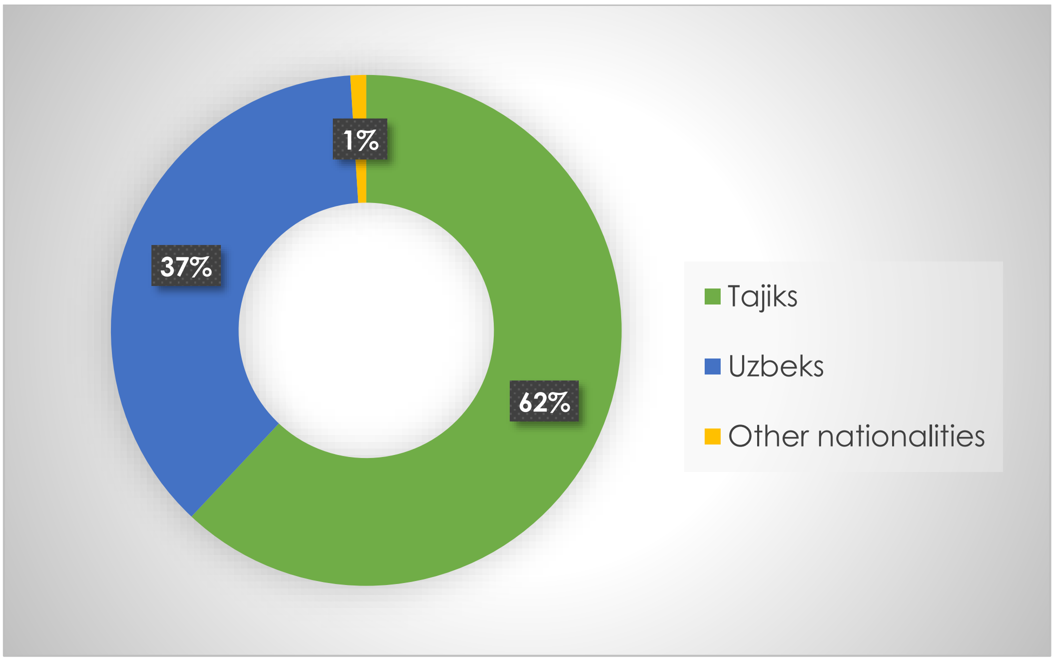
Shaartuz district is in the southern part of the republic. The area of Shaartuz district is 1.52 km². As of January 1, 2020, the population of the Shaartuz district is 130 thousand people (Agency on Statistics under the President of the Republic of Tajikistan, 2022).

Of the total population, 48.8 percent (52.6 thousand people) are men and 51.2 percent (55.1 thousand people) are women. The annual population growth rate is 2.3 percent, and the population density is 71.3 people per 1 km² (from 2013 data).

By its specifics, the district is agrarian, 93.7 percent of the population lives in the village and 6.3 percent in the village.

The ethnic composition of the population of the Shaartuz district consists of Tajiks, Uzbeks, and other nationalities.

Figure 15-14 Ethnic composition of the population of Shaartuz district (data from 2013)



Source: Executive body of the state authority of Shaartuz, 2013

Table 15-23 Population of rural jamoats of Shaartuz district

Jamoats	Number of villages	Number of households (from 2013 data) UNDP in Tajikistan	Population (from 2015 data) [II]Jambi data
township Shaartuz	1	2259	15800
Kh. Kholmatov	12	5198	31654
Sayod	7	3039	15858
Obshoron	3	1326	8648
Juma Nazarov	5	2500	17808
Pakhtaobod	8	3424	21270
Total:	35	17746	111 038

Source: UNDP based on Jambi data, 2021

In the age structure of the population, the number of children under the age of 14 is 50%, the middle-aged (working age) population is 51.2% and the retirement and elderly population is 6.8% (from 2012 data).

Table 15-24 Age structure of the population of Shaartuz district in 2012

Population	Total	Of them, girls	Percentage of girls
Teenagers under 14 (children)	43350	21690	0,5
middle age population	60258	30877	0,512
Retirement population (63 men/58 women) and older people	4124	2520	0,611
Total:	107732	55087	0,511

Source: Executive body of the state authority of Shaartuz, 2013

The population growth of Shaartuz district over the past three years amounted to 1,766 people, and the average annual population growth was 1.7 percent (from 2013 data)

Table 15-25 Demographic growth of the population of Shaartuz district

Years	Number of weddings	Number of deceased	Birth rate	Natural population growth	Population growth in %	Total population
2010	1507	417	2251	3964	102,5	102671
2011	1332	370	2464	4443	101,6	104227
2012	1418	361	2402	4659	102,1	105430

Source: Executive body of the state authority of Shaartuz, 2013

According to estimates, life expectancy among the population of the area is 62-56 years on average, including 55-62 years for men and 66-73 years for women.

Table 15-26 Indicators of the forecast of demographic growth of the population in the Shaartuz district for 2014–2016

Indicators	**2012 report**	**2013 assessment**	**Forecast parameters**			**2016 in % by compared to 2012**
			2014	**2015**	**2016**	
Main general economic indicators						
Average annual population (thousands of people) - total	104235	106284	108410	110578	112789	108%
Including:						
urban	14202	14457	14746	15041	15342	108%
rural	90033	91827	93663	95536	97447	108%

Source: Executive body of the state authority of Shaartuz, 2013

More than 93 percent of the region's able-bodied population lives in rural areas and is mainly engaged in agricultural activities.

15.4.2. Economic issues

Shaartuz district is subvention, almost 23.5% of the funds go to the local budget at the expense of the republican budget. There are 8 industrial enterprises operating in the district, whose contribution to the total volume of production in the district is 3.5 percent (from 2013 data).

Another industry that plays a paramount role in the development of the region's economy is agriculture. More than half of the district's population receive income from the production and sale of agricultural products.

The main areas of agriculture in the region are crop production, animal husbandry and horticulture. The farms of the district are engaged in the production of cotton, grain, vegetables, melons, fruits, milk, meat, and eggs.

According to official figures, the unemployment rate was 2.5 percent in 2012.

Table 15-27 Unemployment rate in Shaartuz district

Indicators	**Years**		
	2010	**2011**	**2012**
Working-age population	38794	39580	39850
Unemployed (registered)	897 (2,3 %)	1083 (2,7%)	765 (1,9%)

Source: Executive body of the state authority of Shaartuz, 2013

Table 15-28 Population employed in the economic sphere of the district

№	Sectors	In 2012, people	The ratio of industries in % terms	The number of employed populations, people	The ratio of industries in % terms	Number of employed workers compared to those listed in %
1	Total, including	17554	100	9614	100	54,7
2	In the field of production of material goods	13766	78,4	5978	62,2	43,4
3	Agricultural industry	12729	72,5	5222	54,3	41,0
4	Forestry	136	0,77	20	0,20	14,7
5	Industry	616	3,5	492	5,1	79,8
6	Infrastructure	26	0,14	21	0,21	80,7
7	Construction	53	0,30	46	0,47	86,7
8	Trade	160	0,91	142	1,47	88,7
9	Transport and communications	46	0,26	35	0,36	76,1
10	In the field of production of intangible goods	3788	21,5	3636	37,8	95,9
11	Financial activities	148	0,84	130	1,3	87,8
12	Government agencies	234	1,33	215	2,2	91,8
13	Education	2443	13,9	2383	24,7	97,5
14	Healthcare	813	4,6	768	7,9	94,4
15	Other communal, social, and personal services	150	0,8	140	1,4	93,3

Source: Executive body of the state authority of Shaartuz, 2013

The analysis shows that in the economy of the region 59.4% of the able-bodied population is mainly employed in the field of agriculture and 30.6% of the able-bodied population of the region in the field of education.

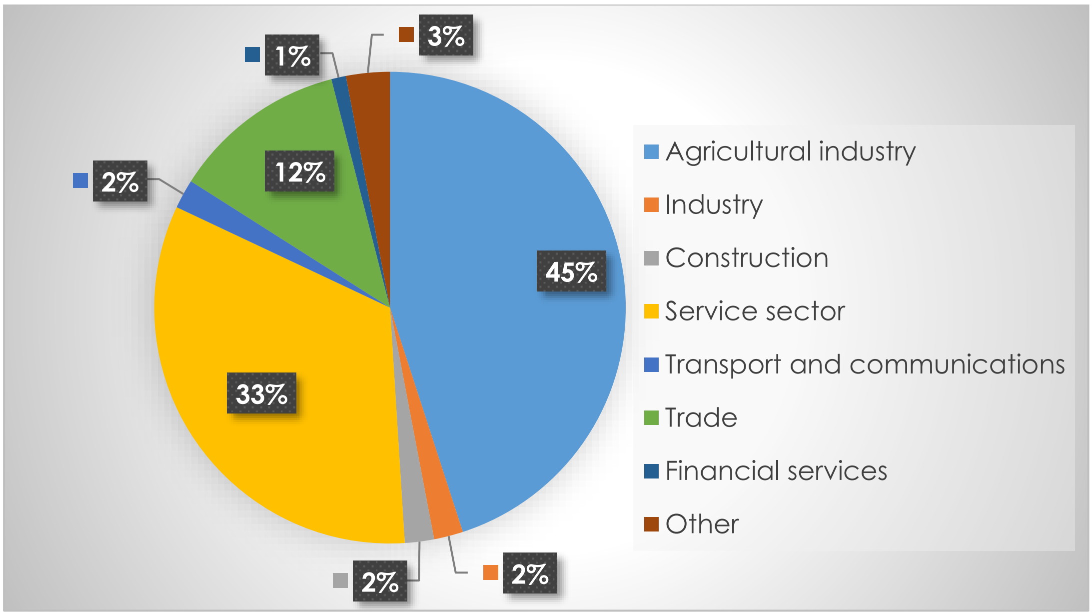
However, there are several social issues in the district, in particular issues in the field of labour, such as a high degree of income classification of the population, low wages of workers in the social sphere, agriculture, communications, budgetary organizations, and high wages of workers in the banking sector. services, construction, and industry.

As a result, civil servants annually leave their jobs due to low wages and engage in commercial activities and choose external labour migration or get jobs in construction and industrial enterprises. The lowest average wage is in agriculture. After the transition to new forms of farming, the profitability of most dehkan farms decreased, which had debts to the relevant authorities. In these farms, recruitment methods and procedures are not properly established.

In addition, each farm manager individually sets the wages of his employees, who in most cases do not comply with the requirements stipulated by the Labour Code of the Republic of Tajikistan. It is necessary to emphasize the development of small and medium enterprises of the region, which is a paramount sign of changes in the transition period to a market economy, and which is aimed at increasing the efficiency of enterprises and their cooperation in ensuring financial normalization, providing the population with new jobs, and expanding the consumer market.

The number of persons engaged in entrepreneurship and small and medium-sized businesses in the Shaartuz district is increasing from year to year.

Figure 15-15 The volume of production and services of small and medium enterprises in the sectors of the national economy of the Shaartuz district



Source: Executive body of the state authority of Shaartuz, 2013

The main part of the small and medium businesses of the district is engaged in agriculture and compared with other industries, is 77.1%, or 1875 people (from 2012 data).

The receipt of funds to the local budget of the district in 2012 from small and medium businesses engaged in agriculture amounted to 1126.0 thousand somoni, which is 47.7% of the total revenues to the local budget from small and medium enterprises.

Table 15-29 The role of small and medium businesses in the provision of jobs and the formation of the revenue side of the budget of the Shaartuz district by industry

Branches of the economy	**Number of registered small and medium businesses**			**Number of workers**	**Funds received by the budget, thousand somoni**
	Total number	legal entities	individuals		
Agriculture, including processing	1312	-	1312	1875	779063
Industry	127	3	124	492	1489799
Construction	5	-	5	46	617345
Transport and communications	23	3	20	35	1087653
Trade	1601	1	1600	142	1049967
Services	134	-	134		469091
Banks and credit organizations	9	3	6	49	236851
Other	134	1	133	215	754446
Total:	2891	358	1290	2854	23437824

Source: Executive body of the state authority of Shaartuz, 2013

15.4.3. Agriculture

Agriculture is considered the main branch of development of the Shaartuz district, which plays a primary role in the development of the region's economy. More than half of the able-bodied population of the region is engaged in agriculture (44%), which is the only source of income for the majority of the population of the region.

The main areas of agriculture in the region are plant growing, animal husbandry and horticulture. The main producers of agricultural products are households and dehkan (farm) enterprises. The share of dehkan farms in the total volume of agricultural production is high in the production of grains and fruits, and family farms in the production of vegetables, potatoes, milk, meat, eggs, and wool.

Almost all types of ornamental and fruit-bearing trees grow in the region (apple, pear, plum, cherry, apricot, peach, persimmon, pomegranate, fig, grape, mulberry, cherry, and almond), steppe and forest plants. The soil in the region is yellowish and sandy, in some places there is black soil, in the mountains the soil is red (pottery), which is suitable for growing agricultural products.

In 2012, considering all forms of management, the farms of the district produced products worth 363.1 million somoni, of which 274.6 million somoni accounted for crop production (75.6%) and 88.4 million somoni for the livestock industry (24.4%).

In the production of agricultural products, the share of households and dehkan farms amounted to 30 percent.

In 2012, in the Shaartuz district, out of the total volume of agricultural production per person, there were 25.8 kg of cereals, 30.6 kg of vegetables, 5.9 kg of potatoes, 57.8 kg of fruits and grapes, 25.2 litres of milk and 1 .7 kg of meat.

Table 15-30 Agricultural production in Shaartuz district

№	Indicators	unit of measure ment	2000	2006	2007	2008	2009	2010	2011	2012
	Volume of agricultural products	thousand /TJS*	68940	131985	138891	144301	162004	175884	311806 ,4	363174,5
	Including: Crop production	thousand /TJS	51459	101016	105979	109284	118713	129626	233761 ,5	274674,6
	Animal husbandry	thousand /TJS	17481	30970	32912	35017	43291	46258	78044, 9	88499,9
1	Cereals	ton	7067	18924	18950	19787	25591	30164	27305	30315
	Cultivated lands	ha	5262	3967	3739	4055	5370	6083	4725	5140
	Yield	cent/ha	13,4	47,7	50,6	48,7	47,6	49,5	57,7	58
2	Cotton	ton	6479	13256	13824	11851	90004	6292	11265	11666
	Cultivated lands	ha	5632	6351	6760	6216	4284	3107	5350	5200
	Yield	cent/ha	11,5	20,9	20,4	19,1	21	20,3	21,0	22,4
3	Vegetables	ton	7455	19004	20067	22512	23309	25610	34633	39933
	Cultivated lands	ha	875	798	884	869	904	998	1033	1236
	Yield	cent/ha	85,2	238,1	227,0	259,0	257,8	256,6	335,2	323,0
4	Potato	ton	4361	6406	6874	6988	7451	9187	34633	11075
	Cultivated lands	ha	681	370	387	390	359	370	397	442
	Yield	cent/ha	67	173,1	174,3	179,3	207,5	248,4	146,3	250,0
5	Fruit	ton	1795	1425	1429	1788	2515	2866	3292	3521
	Yield	cent/ha	29,9	30,2	28	29	39,2	42,9	47,9	48,9
6	Viticulture	ton	1245	1337	1509	1567	2257	2460	2783	2782
	Yield	cent/ha	22,1	22,8	27	34	44,9	49	49,8	49,8
7	Forage crops	ton	3117	3549	3636	4097	7000	7551	8249	7454
	Cultivated lands	ha	1370	1319	1031	746	564	689	466	351
8	Melons	ton	3109	12195	14197	19427	28890	41453	28003	31609
	Cultivated lands	ha	270	329	347	401	919	1128	556	572
	Yield	cent/ha	115,1	370,6	409,1	484,4	314,3	367,4	503,6	552,6

Source: Executive body of the state authority of Shaartuz, 2013

Table 15-31 Production of livestock products

№	Indicators	unit of measure ment	2000	2006	2007	2008	2009	2010	2011	2012
Production of livestock products										
1	Meat	ton	832	1842	1962	2128	2980	3165	3468,3	3846
2	Milk	ton	3798	6427	6802	7142	7712	8399	9249	9814
3	Egg	Thousan d/ pieces	364	1576	1599	1644	2010	2141	2302,6	2406,1
4	Honey	ton	-	5	10	12	14	15	14,6	15
5	Cocoons	ton	47	59	65	60	39	32	38,1	34,6

Source: Executive body of the state authority of Shaartuz, 2013

Regardless of the increase in agricultural output, farm incomes have declined in recent years. Manufactured products are not able to satisfy the internal needs of the region.

In accordance with the forecast plan in 2016, the volume of agricultural production is provided for at actual prices at 41.4 million somoni, and at prices in 2012 at 35.9 million somoni, of which 17.5 million somoni falls on crop production and 17.9 million somoni somoni for the livestock industry.

In 2016, compared with 2012, the growth rate of the total volume of agricultural products will be 11.6%, and the production of agricultural products per capita, including cereals - 88.4 kg, vegetables - 4.0 kg, potatoes - 75.2 kg and milk - 13.9 kg.

In case of irrigation of 334 hectares of fallow lands, the district will be able to increase the volume of agricultural production by 5.1%.

According to the forecast plan for the development of agriculture, the growth rate of the total volume of agricultural production in 2016 at actual and comparative prices in 2012 is projected to be within 21.2% and 15.3%, respectively.

The main goal of the development of the agricultural sector is to improve the reclamation state of irrigated lands over the next five years, expand the area of orchards at the expense of rainfed lands, develop animal husbandry, beekeeping, and fish farming.

Forms of activity in the agricultural sector

In Shaartuz district, 32 subsidiary farms, 12 collective dehkan farms, 156 individual dehkan farms, 5 fish farms and more than 1,830 households operate. Out of 1,998 dehkan farms operating in the district, 703 farms are headed by women.

The lack of sufficient knowledge about agriculture has a negative impact on the development of the industry (more than 80 percent of the sector's employees have no work experience and knowledge about agriculture, 90 percent have no experience in management, and 92 percent of dehkan farms do not have proper accounting).

Other problems that have a negative impact on agricultural production are the poor state of the material and technical base due to insufficient financial resources on farms, lack of access to spare parts, rising prices for fuel and lubricants, and depreciation of most of the agricultural machinery and equipment located on balance of existing farms.

One of the main reasons for the decline in farm incomes is the lack of agricultural machinery.

Agricultural enterprises of the region are experiencing a shortage of new modern equipment. In recent years, 17 units of new tractors have been purchased for the farms of the region. For each imported tractor, there are 188 hectares of arable land, 166 hectares of orchards, 40 hectares of vineyards, and in general, each tractor accounts for 680 hectares of land. The provision of modern technology plays an important role in the development of the agricultural industry.

Of the 179 units of machinery and equipment on the balance of agricultural enterprises, 65.4 percent are in working condition (117 units) and 34.6 percent (62 units) are in non-working condition.

Table 15-32 Information about agricultural machinery

№	List of equipment	Total units	In working order	% completed
1	Tractors	179	117	65,4
	Including: tracked	26	5	19,2
	Wheeled	-	-	-
2	Trucks	93	-	-
3	Combine harvesters	3	1	33
4	Trailers	134	74	55,2
5	Mowers	-	-	-
6	Hay harvesters	-	-	-
7	Baler	-	-	-
8	Seeders	49	18	36,7
9	Cultivators	67	23	34,3
10	Tractor plow	42	25	59,5

Source: Executive body of the state authority of Shaartuz, 2013

Most of the tractors were manufactured in the 80th of the last centuries and are not able to meet current needs. Farms do not have the financial resources to purchase modern equipment.

In addition, the lack of spare parts, fuel, lubricants (high cost) and the poor condition of local roads have led to an increase in the cost of agricultural products. Therefore, dehkan farms are not interested in exporting products outside the region.

This situation creates obstacles to the further development of the agricultural sector.

Due to the low level of profitability of production, a decrease in production and technical potential is observed in the farms of the region.

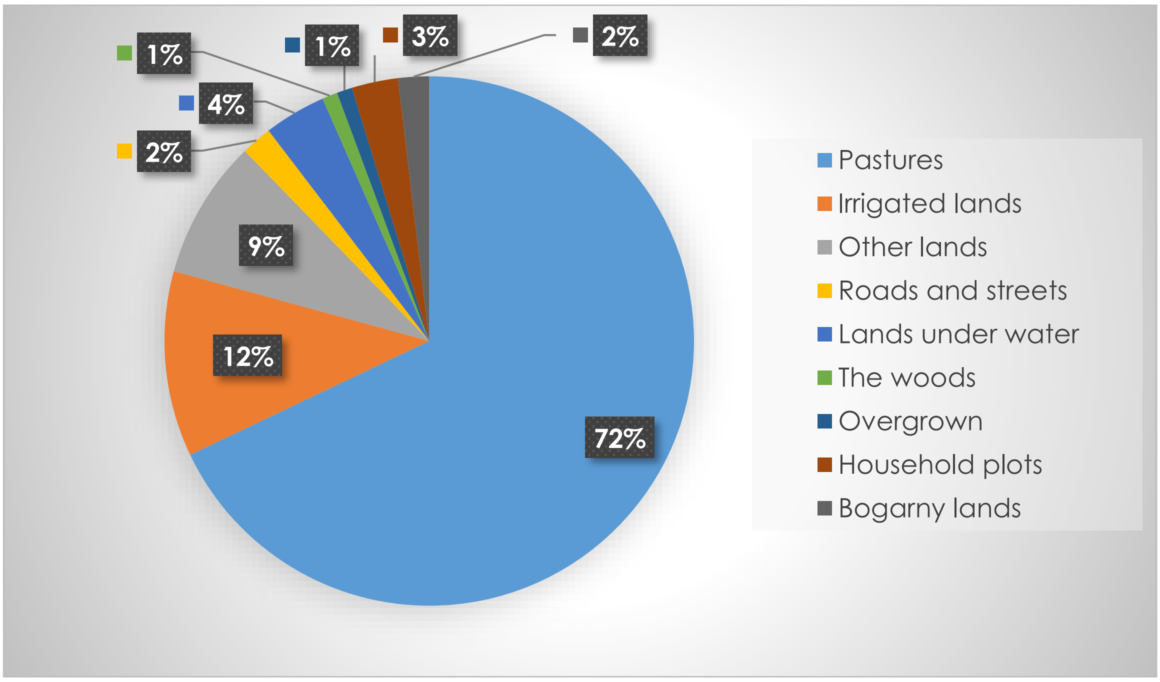
It is worth emphasizing that during 2014, 9108 hectares of the total area of arable land (considering all forms of management, population, and household plots) were fully sown, of which 4034 hectares fall on cereals, potatoes - 747 hectares, vegetables - 529 hectares, gourds - 21 hectares, industrial crops (mahsar*, flax) 631 hectares, animal feed - 3146 hectares.

*Herbaceous essential oil plant from the family of compound flowers

Land use

As of January 1, 2013, the total area of agricultural land in the Shaartuz district is 121,873 hectares, of which 14,216 hectares are irrigated lands.

Figure 15-16 The structure of common land use (in %)



Source: Executive body of the state authority of Shaartuz, 2013

Of the total land area, 80 percent (121,873 hectares) are agricultural enterprises, 2.9 percent (4,541 hectares) are used as household plots, 0.5 percent are private lands (712 hectares), and 9 percent (14,101 hectares) are other lands. Of the 121,873 hectares of land under agricultural use, 91.2 percent is assigned to dehkan farms.

Irrigated lands are mainly used for sowing cotton, potatoes, vegetables, cereals, and fodder crops.

Of the total agricultural land area, 9349 ha are arable land (including 9321 ha irrigated arable land), 1680 ha perennial trees, 107556 ha pasture and 3288 ha rainfed land.

Table 15-33 Communication land use

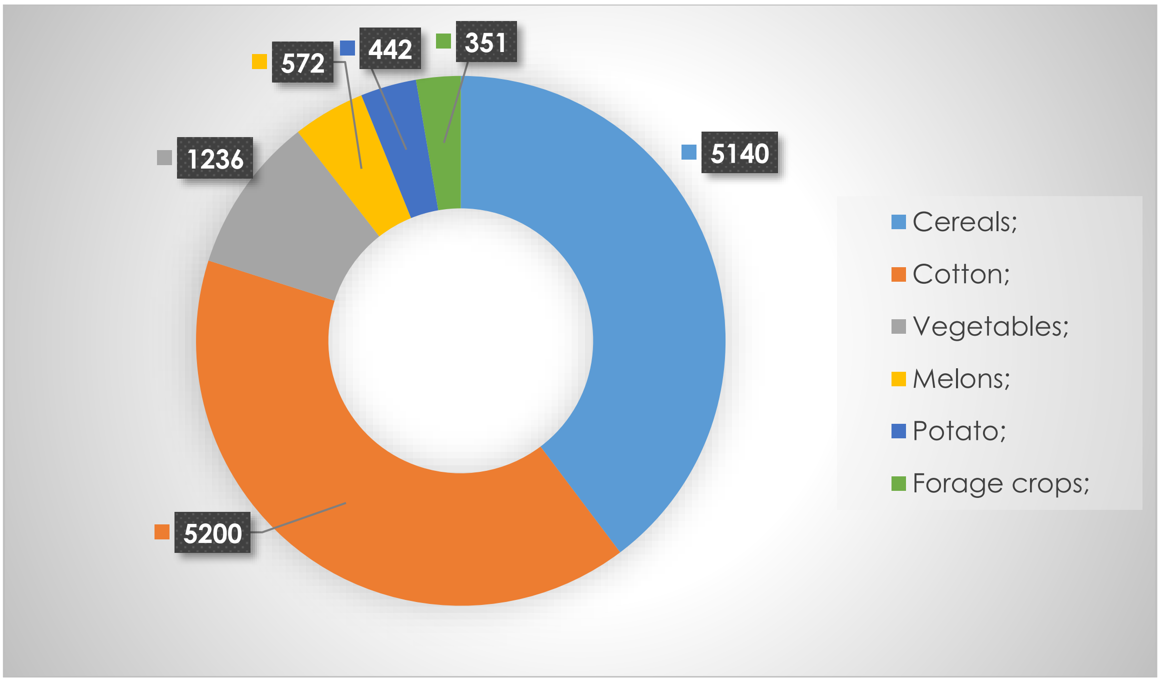
	№	Land use	Area, ha as of 01.01.2013
		Number of land users (persons)	1988 farms (17045)
	1	Total land area	152537
	1.1	Including: irrigated lands	18470
	2	Arable land	9349
	2.1	Of these, irrigated land	9321
	3	Perennial trees	1680
	3.1	Of these, irrigated land	1675
	3.2	Gardens	1029
		Including: irrigated lands	1024

№	Land use	Area, ha as of 01.01.2013
3.3	Vineyards	478
	Including: irrigated lands	478
3.4	Mulberry trees	147
	Including: irrigated lands	147
3.5	Forest planting, nurseries (all irrigated)	5
4	Bogarny lands	3288
4.1	Of these, irrigated land	3220
5	Meadows	-
6	Pastures	107556
6.1	Of these, summer pastures	351
6.2	Spring and autumn	-
6.3	Year-round	107205
	Total agricultural land:	121873
	Of these, irrigated land	14216
	Number of households	14628
1	Household plots	4541
	Of these, irrigated land	3503
1.2	Arable land	3206
	Of these, irrigated land	3013
1.3	Perennial fruit - bearing trees	517
	Including: irrigated lands	490
1.4	Buildings and other lands	818
2	Farm or private land	712
2.1	Including: irrigated lands	712
3.	Forests and groves	1245
3.1.	Among them: an area with trees	146
3.2	An area without trees	328
3.3.	Nurseries	29
3.4.	Protective forests and groves	42
3.5.	Other protective trees	700
	Of these, irrigated land	73
4.	Overgrown	845
5.	Wetlands	145
6.	Lands under water	5910
6.1.	Including: rivers and canals	2466
6.2.	Lakes and seas	7
6.3.	Storage reservoir and reservoirs	2
6.4.	Canals, ditches, drainage canals	3435
7.	Roads and trails for animals to cross	1646
8.	Land for buildings and objects, streets and squares	1519
9.	Other lands	14101
9.1.	Sandy places	3304
9.2.	Cliffs	93
9.3	Landslide and pebble	3234
9.4.	Glaciers	-
9.5.	Other land not used for agriculture	7470

Source: Executive body of the state authority of Shaartuz, 2013

In 2012, the area under crops under all types of farms per capita amounted to 0.09 hectares, which decreased by 0.01 hectares compared to 2010. In general, over the past five years, the area under crops has increased by 2%.

Figure 15-17 Land use by crops in 2012 (in ha)



Source: Executive body of the state authority of Shaartuz, 2013

In 2013, due to the reserves of arable land available in the region (considering all forms of management), crops were sown on an area of 12,941 hectares, which is 414 hectares more than last year. Of the total sowing area, cereals were sown on an area of 5,140 hectares, cotton was sown on an area of 5,200 hectares, potatoes were sown on an area of 442 hectares, vegetables were sown on an area of 1,236 hectares, melons were sown on an area of 572 hectares, and fodder crops were sown on an area of 351 hectares.

The program provides for the development of new lands, considering the geophysical and meliorative-chemical state of the land (except for lands with a slope of more than 20%).

Plant growing

In 2012, the total volume of crop production produced in the Shaartuz district in all categories of farms amounted to 274.6 million somoni, which is 9.4% more than in 2011.

In general, in recent years, there has been a tendency in the region to increase the volume of crop production, and the yield per hectare of land has also increased relatively (except for grain crops). In addition, in 2012, compared with 2011, the volume of grain production increased by 11% (30,315 tons) and potato production (11,075 tons) by 8.3%. The share of households engaged in wheat production was 30.1 percent

Table 15-34 *Production of plant growing*

№	Indicators	In kind (ton)		
		2010	**2011**	**2012**
1	Cereals	30164	27305	30314,7
2	Vegetables	25610	34633	39932,9
3	Potato	9187	10229	11075
4	Fruit	2866	3292	3521,4
5	Animal feed per feed unit	7551	8249	9249

Source: Executive body of the state authority of Shaartuz, 2013

The farms of the district are engaged in the cultivation of cereals (wheat, barley, peas, corn), cotton and other industrial crops (flax, sesame), potatoes, other vegetables (cabbage, carrots, onions, tomatoes, cucumbers, etc.), melons (watermelon and melon) and animal feed. Over the past five years, the area sown with potatoes has increased by 14%, vegetables by 16.1%, melons by 66.3 times due to the reduction in the area under grain and fodder crops, and 182 hectares of new orchards have been created (91% plan).

There is a possibility in the region to increase agricultural production by expanding the area of orchards and vineyards and improving the reclamation state of irrigated lands. The analyses confirm that if the grain production is 20 centners more per hectare, the farms will be able to cover their expenses and receive additional income.

In recent years, due to the lack of irrigation water, the deterioration of the reclamation state of irrigated lands, the drying up of orchards and vineyards, and the deterioration of irrigation networks, farms cannot get the desired harvest. In case of repair and restoration of the Iskra pumping station and cleaning of drainage channels, the volume of agricultural production can be increased up to 11.4 percent.

In accordance with the forecast plan, in 2016 compared to 2012, the total area under crops will increase by 2%, including cotton by 15%, cereals by 0.4%, vegetables by 6.5% and potatoes by 4.0%, and crop production will increase by 8.0 percent.

Cotton growing

Cotton growing is the main branch of agriculture. In recent years, the yield per hectare of cotton land has increased by almost 1.1%.

Even though cotton growing is the main branch of agriculture, the documents indicate the general indicators in the cotton growing sector over the past 7 years. More detailed information regarding cotton growing in the region for the reporting period is not available.

Table 15-35 *Indicators in the cotton sector of the Shaartuz district*

Years	Area (ha)	Yield, cent. /ha	Production, ton
2006	6351	20,9	13256
2007	6760	20,4	13824
2008	6216	19,1	11851
2009	4284	21	90004
2010	3107	20,3	6292
2011	5350	21,0	11265
2012	5200	22,4	11666

Source: Executive body of the state authority of Shaartuz, 2013

Potato growing

Potato growing is considered one of the profitable sectors among the district's farms, the profitability of which has increased in recent years from 17.3% (in 2010) to 28.4% (in 2012). In 2012, agricultural enterprises of the district planted potatoes on an area of 103 hectares, which is almost 70% more than in 2010.

Gardening

Gardening is one of the priority and profitable areas of the region. This area also has a strategic character since it plays an important role in saturating the domestic and foreign markets with fresh fruits and is a source of exports and providing the population with permanent jobs.

The climate of the region allows expanding the area of orchards with high-yielding seedlings (in particular, subtropical fruits) and fully satisfying the demand of domestic and foreign markets for fresh fruits. The daily growing demand for fruit and building materials, for wood (due to the planting of barren trees), requires the acceleration of the solution of the social and economic problems of the village and the further development of horticulture.

Table 15-36 Information on the number of fruit-bearing and ornamental trees planted during 2010–2012

№	Unit of measurement	Types of seedlings	2010	2011	2012
1	wood	apple	-	-	-
2	wood	almonds	60	65	65
3	wood	apricot	205	98	100
4	wood	peach	23	12	12
5	wood	cherries	1	2	2
6	wood	mulberry	-	-	-
7	wood	nut	-	-	-
8	wood	cherry	-	-	-
9	wood	Mirabelle	-	-	4
10	wood	vine	-	-	6
11	wood	hawthorn	-	-	-
12	wood	pomegranate	400	1800	-
13	wood	jida	3000	2500	3300
14	wood	rosehip	-	-	-
		Total fruit-bearing trees	3690	4479	3496
15	wood	Silver poplar	2000	1800	2200
16	wood	Coniferous trees	12000	7600	4100
17	wood	Acacia	-	-	-
18	wood	Decorative	5500	5200	2200
		Total:	23190	19079	11996

Source: Executive body of the state authority of Shaartuz, 2013

According to the efforts of local authorities, 172.4 hectares of old orchards and vineyards were restored during 2010-2012, 92.6 thousand cuttings of ornamental and shady trees and 19.3 thousand seedlings were planted. In general, as of January 1, 2012, considering all forms of management, new gardens on an area of 394 hectares and vineyards on an area of 56 hectares were created in the district.

Animal husbandry

Along with other industries, animal husbandry is one of the main areas of agriculture in the district, whose share in gross agricultural production is 24.4%. In 2012, the livestock farms of the district produced products worth 88.49 million somoni.

Table 15-37 The volume of livestock production in 2011–2012

Product List	Unit of measurement	Years		2012 compared to 2011 (%)
		2011	2012	
Meat, live weight	ton	3468,3	3845,9	110%
Milk	ton	9249	9214	99%
Egg	thousand / pieces	2302,6	2499,7	108%
Honey	ton	14,6	15	102%
Wool	ton	132,8	136,3	102,6%
Fish	ton	11	31,5	286,3%

Source: Executive body of the state authority of Shaartuz, 2013

According to official data, until January 1, 2013, only 35,154 heads of cattle and small cattle were registered in the district.

Table 15-38 The total number of animals in all forms of management (heads)

№	Indicators	2007	2008	2009	2010	2011	2012
1	Cattle	28427	32209	33103	33488	34146	35154
2	Small cattle	53449	54669	54626	58407	59493	19590
3	Birds	94892	103191	106088	106103	106173	61897
4	Horses	1009	1011	1015	1016	1016	1016
5	The Bee family	1022	1022	1100	916	916	916

Source: Executive body of the state authority of Shaartuz, 2013

In the district, 44 percent of sales of animals and birds occur through households. In general, the sale of cattle is common among households in the area. In the district, 57% of households are engaged in the sale of cattle, the sale of goats and sheep - 36.8% and 34.7% of households, respectively.

There are good conditions for the development of animal husbandry and the creation of a forage base in the Shaartuz district. The total area of pastures is 107,556 ha, but the pastures are not used effectively. Of the 56 livestock farms, only 12 are assigned winter and summer pastures, other livestock farms do not have access to pastures.

In recent years, animal husbandry has become unprofitable for some farms in the region. To solve this problem in the field, it is necessary to take a number of measures, including increasing and saturating land for sowing fodder crops, increasing the sowing of oil crops in farms for the production of animal feed, improving animal breeds and creating a base of breeding animals in specialized farms, providing winter and summer pastures, an increase in the number of animals in those farms where the number of livestock is reduced, the creation of favourable conditions for the development of animal husbandry and the provision of additional pastures for small cattle.

Of the total livestock, households account for 98.1 percent of cattle (including 98.9 percent of cows), 87.5 percent of goats and sheep, 99.5 percent of birds and 90.1 percent of horses.

Beekeeping

Beekeeping is one of the low-cost and profitable branches of agriculture since the climatic conditions of the area are suitable for the development of the beekeeping industry. The existing plant reserves of the region allow increasing the number of bee families (1107 families) and doubling its production.

Over the past five years, bee colonies have increased by almost 4 times, and honey production by 9 times. Compared to 2011, honey production increased from 14.6 tons to 15 tons.

According to experts in this field, for the further development of this industry, it is necessary to organize retraining courses and create an association of beekeepers. The creation of such a centre can contribute to solving the problems of the industry, including eliminating pathogens of infectious diseases, providing beekeepers with the necessary materials, and assisting in the purchase and sale of manufactured products

15.4.4. Forestry

Of the 17,500 ha of the total area of existing forest areas in the district, 130 ha consist of thickets of juniper, which significantly affects the global process of climate change. In recent years, many trees have been cut down in forests and hills, without restoring their number, which negatively affects the environment. To prevent this situation, it is necessary to provide the population with coal in a timely manner or introduce a procedure for the public use of forests.

This procedure provides for the attachment of forest plots to the population of the nearest villages on a contractual basis. If this procedure is implemented, the population will be given the opportunity to use land for grazing livestock, in compliance with established rules, use trees and dried branches, as well as restore forests by planting fast-growing trees.

Table 15-39 Territory of activity of the forestry of the Shaartuz district

Indicators	Unit of measurement	Land plot
Total area of forest borders	ha	17500
Free Forest Fund	ha	-
Irrigated lands	ha	27
Pasture	ha	16000
Forest	ha	900
Flooded	ha	20
Covered by road	ha	54
Built-up (buildings, structures)	ha	95
Other lands	ha	400

Source: Executive body of the state authority of Shaartuz, 2013

The state enterprise "Forestry of the Shaartuz district", in accordance with the budget plan, is engaged in sowing forests, preparing juniper seeds, collecting medicinal herbs, mountain artisanal fruits, as well as biotechnical activities. The company has 21 employees. 17,500 hectares of land, 3 residential buildings, 1 passenger car and 2 non-working trucks are on the balance sheet of this enterprise. Of the 2 units of existing tractors, only one MTZ tractor is in working order.

According to local authorities, a lot of work has been done in recent years to plant new forest areas. As a result, 40 ha of saxaul were planted in the village of Ayvach, 20 ha of pistachio in the Ok-Madjit plot, and 10 ha of forest plots were restored in the Obshoron and Jura Nazarov jamoats and 4.17 ha of new orchards were created in the Obshoron and Nazarova jamoats (from the data year 2013).

The organization of processing of forest products, such as wild rose, medicinal plants, sea buckthorn, mountain almonds, etc., can affect the increase in income and the creation of new jobs in this industry, since more than 40 species of medicinal plants grow in the forest areas of the region.

Within the framework of the "Forestry Development Program of the Republic of Tajikistan for 2006-2015", it was envisaged to solve the problems of forestry, as well as its main directions to increase the economic level and improve environmental conditions.

15.5. Gissar district

15.5.1. Socio Demographic conditions

The demographic situation of the district as of January 1, 2022 is 329,952 people, including 163,415 head of livestock and 166,537 women. More detailed information provided in the table above. Of the total number of employees, 43% are employed, 14% are in migration and 22% are unemployed. The number of unemployed registered with the employment authorities as of January 1, 2021 amounted to 1,238 people. Of the registered unemployed, 725 are women. Tajiks, Uzbeks and others live in the region. 83% of the population are Tajiks, 11% are Uzbeks and 6% are representatives of other nationalities. (TAJSTAT, 2021)

Table 15-40 Main population indicators of Gissar district

Main Indicators	**Units of measurement**	**as of January 01, 2022**
The date of founding of the district		03.03.2016
The total area of the Gissar district	км2	975,1
Number of the urban and rural jamoats	Number	12
Including: Urban Jamoats	Number	2
- Rural Jamoats	Number	10
Number of the populations in the urban and rural jamoats (as 01.01.2021)	people	329952
Including: - Males	people percentage	163415 49,6
- Females	People Percentage	166537 50,4
Number of the populations in the urban areas	People Percentage	46995 14,2
In rural areas	People Percentage	282957 85,8
Population growth	People	7519
Population growth	Percentage	2,3
1. Jamoat city Gissar	people	30989
Females	People	16083
2. Jamoat city Sharora	People	18797
Females	People	9344
3. Rural Jamoat Almosy	People	24950
Females	People	12849
4. Rural Jamoat Khonaqohi Kuhi	People	32906
Females	People	16235
5. Rural Jamoat Somon	People	33775
Female	People	17065
6. Rural Jamoat Navobod	People	31650
Female	People	15968
7. Rural Jamoat Mirzo Rizo	People	32551
Females	People	16201
8. Rural Jamoat Mirzo Tursunzoda	People	24888

Females	People	12725
9. Rural Jamoat Dehqonobod	People	24467
Females	People	12054
10. Rural Jamoat Durbat	People	24679
Female	People	12583
11. Rural Jamoat Gissar	People	39457
Female	People	19948
12. Rural Jamoat Oriyon	People	10843
Female	People	5482

Source: TAJSTAT, 2021

15.5.2. Agriculture

Rural households are the main economic sector of the district, cultivation crops, cotton, vegetables, potatoes, melons, animal feed, animals and bees. District farms grow more wheat and cotton. More than 45% of the total labour force is employed in agriculture sector of the district. According to the research conducted by the agricultural sector, 8 collective farms, 3 educational and practical farms, 3 breeding farms, 76 agriculture companies and 1200 individual dekhkan farms have been created in the region.

In 2010, agricultural enterprises of the region, taking into account all categories of farms, produced products worth 291.7 million somoni, of which 72% falls on crop production and 28% on animal husbandry. (Anon., 2012) The total volume of agricultural production for January-December 2021 amounted to 163866.6 thousand somoni on the collective farm, 374657.2 thousand somoni on the dekhkan farm and 374657.2 thousand somoni on subsidiary farms. (TAJSTAT, 2021)

The main problems of the agro-industrial complex are the lack of modern technologies, the lack of high-quality seeds and fertilizers.

Table 15-41 The total volume of agricultural production in January-December 2021

	Thousand Somoni (In current price)	**Comparison in %**	
		Previous year	**Total**
Total in the District	827552,3	105,3	100,0
Collective Farms	163866,6	111,7	19,8
Dehqan Farms	289028,6	110,1	34,9
Household Farms	374657,2	99,6	45,3

Source: TAJSTAT, 2021

The total volume of agricultural production in January-December 2021 for all categories of farmers amounted to 827552.3 thousand somoni. Compared to the previous year 2020, more by 41852.3 thousand somoni, which is 105.5%, including the volume of crop production 606674.9 thousand somoni and livestock production 220877.4 thousand somoni. (TAJSTAT, 2021)

Table 15-42 Total agricultural production

(Thousand Somoni)	**The total volume of agricultural production in January-December 2021**	**January - December 2021 in % comparing to January - December 2020 in %**	**Ratio, in percentage**		
			Collective Farms	**Dehqan Farms**	**Household farms**
Total agricultural production	827552,3	105,3	19,8	34,9	45,3
Including:					
Crop production	606674,9	107,2	16,0	47,0	37,0
Livestock production	220877,4	100,6	30,3	1,6	68,1

Source: TAJSTAT, 2021

Crop cultivation is one of the main branches of agriculture in the region. The growth of the sector has a great impact on the income of the district farm; therefore, a big attention is paid to this sector.

Table 15-43 Production and yield of crop products for January 2022

Name of indicators	January - December 2020	January- December 2021				January- December 2021 in comparison to January-December 2020 in Percentage (%)
		Collective Farms	Dehqan Farms	population	Total	
Total harvested grain crops (ha)	8410	3192	2542	2440	8173	97,1
Yield (cent)	234922	90088	74483	61334	225905	96,2
Yield from 1ha (cent)	27,9	28,2	29,3	25,1	27,9	100,0
Including Wheat (ha)	6180	2433	1930	1677	6040	97,7
Yield (cent)	151667	55165	52583	38571	146319	96,5
Yield from 1ha (cent)	24,5	22,7	27,2	23,0	24,2	98,8
Technical crops (ha)	1510	386	634,4	411	1431	94,7
Yield (cent)	9626	1535	3911	3916	9362	97,3
Yield from 1ha (cent)	6,4	4,0	6,2	9,5	6,5	101,6
Cotton (ha)	1214	928	280		1208	100,0
Yield (cent)	26600	21611	5683		27294	102,6
Yield from 1ha (cent)	21,9	23,3	20,3		22,6	103,2
Potato (ha)	626,6	125	202	460	787	125,6
Yield (cent)	90686	19900	41570	60000	121470	133,9
Yield from 1ha (cent)	144,7	159,2	205,8	130,4	154,4	106,7
Vegetables (ha)	2259	153	800	1223	2176	96,3
Yield (cent)	567402	44974	269734	255652	570360	100,5
Yield from 1ha (cent)	251,2	293,6	337,2	209,0	262,1	104,3
Malon plantation	133,5	10,2	66,0	40	116,0	87,0
Yields (cent)	28072	2214	18572	8700	29486	105,0
Yield from 1ha (cent)	210,3	217,1	283,5	217,5	254,2	120,9
Fruits (ha)	3551	777	1618	1123	3818	107,5
Yield (cent)	200376	15410	101624	101500	218534	109,1
Yield from 1ha (cent)	56,4	18,8	62,8	90,4	61,9	109,7
Grape (ha)	4205	1210	1945	1050	4205	100,0
Yield (cent)	278613	50479	189207	98602	338288	108,2
Yield from 1ha (cent)	66,3	41,7	97,3	93,9	80,4	121,3

Animals feed (forage crops) (ha)	6291	2797	2222	1280	6299	100,2

Source: TAJSTAT, 2021

Land use

The number of land users is 1805, 125250 hectares of land have been transferred to them. Of the total amount of land, 75,919 hectares are used by agricultural enterprises, 987 hectares - a populated area, 1,565 hectares - other industries, 1,994 hectares - forestry. Arable irrigated land is mainly used for cotton, crops, potatoes, vegetables and animal feed. (Anon., 2012) This source provides information for 2012. The table below provides information on land plots for 2021.

Table 15-44 Land characteristics

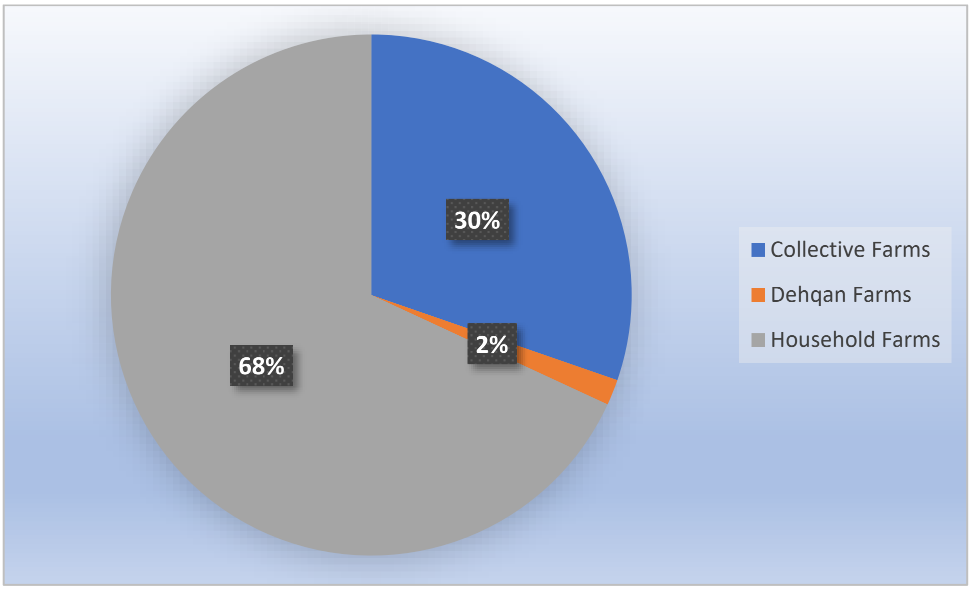
The total amount of land in the district	**Hectares**	**97514**
Of it Irrigated	Hectare	14308
Total amount of arable lands	Hectare	11907
Of it Irrigated	Hectare	7488
Gardens	Hectare	3834
Of it Irrigated	Hectare	2473
Vineyard	Hectare	3566
Of it Irrigated	Hectare	897
mulberry lands	Hectare	198
Of it irrigated	Hectare	194
Citrus and subtropical	Hectare	81
Of it irrigated	Hectare	65
Tree planting	Hectare	11
Pastures	Hectare	37739
Total amount of agricultural lands	Hectare	57344
Of it irrigated	Hectare	11131
Subsidiary private lands	Hectare	7779
Of it irrigated	Hectare	2736
Auxiliary farms lands (Presidential)	Hectare	1721
Of it irrigated	Hectare	441
Forests	Hectare	242
shrub land	Hectare	1683
Flooded lands	Hectare	2202
Under the ways	Hectare	1699
Under the buildings	Hectare	2064
Other lands	Hectare	22780

Source: TAJSTAT, 2021

Livestock Production

The total volume of livestock production for January-December 2021 amounted to 220877.4 thousand somoni, which is 100.6% more than in the previous year or 1245.1 thousand somoni.

Figure 15-18 Total livestock production by categories of farms in the district in %



Source: Executive body of the state authority of Gissar, 2020

As of January 1, 2022, there are 72,293 heads of cattle in all categories of farms, which is 472 heads more than in the previous year, including the cows (females) amounted to 41381 heads, which is compared to this period of the past year is more than 106 heads. The number of sheep and goats amounted to 125884 heads, which is 4853 heads more than last year. The number of poultry amounted to 209768 heads, which is 52722 heads less than last year. There are 4811 bee colonies in the district, which is 19 colonies more than last year. And the number of horses amounted to 3032 heads, which is 208 heads more than last year. (TAJSTAT, 2021)

Table 15-45 Total amount of livestock and poultry in all categories of farms *(Heads)*

	January-December		**January 2022 in comparison to 2021 in Percentage (%)**	**January 2022 in comparison to 2021 in Percentage (%)**	**January 2022 in comparison to 2021 in heads**
	Year 2020	Year 2021			
Cattle	71821	72293	100,7	100,7	472
Collective Farms	3976	4103	103,2	103,2	127
Dehqan Farms	36	341	9,4	9,4	305
Household Farms	67809	67849	100,1	100,1	40
Including cow (Female)	41275	41381	100,3	100,3	106
Collective Farms	1473	1458	99,0	99,0	-15
Dehqan Farms	2	90	5,1	5,1	88
Household Farms	39800	39833	100,1	100,1	33
Sheep and goats	121031	125884	104,0	104,0	4853
Collective Farms	18393	14996	81,5	81,5	-3397
Dehqan Farms	8636	16852	195,1	195,1	8216
Household Farms	94002	94036	100,0	100,0	34
Poultry	262490	209768	79,9	79,9	-52722
Collective Farms	198280	145514	73,4	73,4	-52766
Dehqan Farms	-	-	-	-	-
Household Farms	64210	64254	100,1	100,1	44
Horses	2944	3032	103,0	103,0	208
Collective Farms	225	186	82,7	82,7	-39
Dehqan Farms	208	335	161,1	161,1	127
Household Farms	2511	2511	100,0	100,0	-
Beez family	4792	4811	100,4	100,4	19
Collective Farms	257	257	100,0	100,0	-
Dehqan Farms	-	16	-	-	16
Household Farms	4535	4538	100,1	100,1	3

Source: TAJSTAT, 2021

15.5.3. Forestry

The total area of forest land in the Hisar region is 1990 hectare or 0.2% of the total land area of the region. Of the total area of forest land in the district, 1 ha is intended for growing trees, 2 ha - for perennial trees, 1879 ha - for pastures and 108 ha - for other lands. (TAJSTAT, 2021)

Auxiliary forestry enterprises of the district in January-December 2021 produced products by 269.5 thousand somoni, which is 163.6 thousand somoni more than the indicators of this time in the previous year (TAJSTAT, 2021)

Table 15-46 Production activities of forestry

	Unit of measurement	January-December 2020	January-December 2021	January-December 2021 in comparison to 2020 in percentage (%)
Total product of agriculture	Thousand somoni	105,94	269,5	256
Including: Crop production	Thousand somoni	74,3	224,2	302
fruit trees, shade trees and flower trees	Thousand pieces	20,2	20,7	102,5
Other products	Ton	20	29	145
Fruits	Ton	64,45	82,6	128,1
Of it pistachio	Ton		0,34	
Apple	Ton	64	81,6	127,5
Almonds	Ton		0,1	
Nut	Ton		0,1	
Other fruits	Ton		0,8	
Dry fruit	Ton		3	
Grape	Ton	0,45	6,2	1377
Meat	Ton	5,36	5,36	100
Honey	Ton		0,4	
Sheep and goat	Heads	237	155	65,4
Poultry	Heads			
Horse	Heads	24	23	95,8
Bee family	Heads	125	125	100
Total tractors	Number			-
Of this number works	Number			
On – board vehicles	Number	1	1	100

Source: TAJSTAT, 2021

15.6. Kuhistoni Mastchoh district

15.6.1. Economic issues

Table 15-47 Volume of manufactured products, works and services in the district in January-December 2021.

Economy sector	**Amount of produced product**			**difference between 2021 and 2020 (+, -)**	**Production in percent**
	Year 2020	**Year 2021**	**Percentage**		
Industry sector	261,7	290,7	106,7	29,0	9,0
Agriculture	785,7	827,5	105,3	41,8	25,6
Construction	84,4	130,0	154,0	45,6	4,0
Trade	1650,6	1817,2	110,1	166,6	56,3
Service	160,5	164,6	102,6	4,1	5,1
Total in the District	2942,9	3230,0	109,8	287,1	100,0

Source: TAJSTAT, 2021

The average monthly wage of nominal labour paid to employees in January-November 2021 amounted to 1080.2 somoni, which is 73.9 somoni or 7.3% more than the previous year. The lowest average monthly wage was in January-November 2021 in the real sector of the type of economic activity in agriculture and amounted to 699.4 somoni. The highest average monthly salary was in January-November 2021 in the real sector of the financial sector and amounted to 2879,3 somoni. (TAJSTAT, 2021)

Table 15-48 Salary by sector

	Number of employees (people)		Calculated salary (Thousand somoni)		Average salary per worker (thousand somoni)			payroll loan
	2020	2021	2020	2021	2020	2021	difference %%	Total
Agriculture	3506	3580	9476,7	13556,1	606,3	699,4	115,4	33,0
Industry sector	897	1061	9130,9	11788,1	1498,3	1528,7	102,0	
Water supply	236	250	2026,8	2243,2	794,2	825,6	103,9	
Construction	427	463	6761,4	7473,3	1568,0	1606,1	102,4	
Trade and total amount	693	768	6227,9	5974,4	928,1	847,3	91,3	
transport and communication	68	76	306,7	310,5	961,4	973,2	101,2	
Finance activity	295	315	8188,1	9691,9	2611,8	2879,3	110,2	
Service	1009	475	2664,8	772,0	832,5	694,8	83,4	
Government agencies	893	914	10120,3	10811,6	1063,6	1137,6	106,9	
Education	6269	6514	67233,1	77274,8	991,3	1094,7	110,4	
Healthcare	2349	2418	20375,0	22258,9	858,3	904,2	105,3	
Other organizations	149	147	2439,5	2413,0	1928,5	1741,0	90,3	
Total:	16791	16990	150686,6	171287,8	1006,3	1080,2	107,3	33,0

Source: TAJSTAT, 2021

15.6.2. Socio - Demographic characteristics

As at 01 January 2021, the population of Kuhistoni Mastchoh district was 25920. Men - 13115, women – 12805. The entire population lives in the villages. The population density of the area is 6.9 people per km².

Table 15-49 No. Of households

	2582	15004	7629	7375
	1739	10916	5486	5430

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

The entire population is Tajiks. Population growth over the past three years is shown in the following table:

Table 15-50 Population growth

	23762	560	635	75
	24462	543	587	44
	24600	415	454	39

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

By age category, people under 14 years old make up 32.4%, the middle age - 60.3% and the elderly - 7.1%.

Table 15-51 Population composition in 2019

Young people under the age of 14	8258	4008	48,8
Middle age	15336	7619	49,6
Elderly (63 male)/58 (female) and over	1819	874	48,0
Total:	25413	12501	49,1

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Population growth in 2025 is projected to be 14.1 compared to 2019.

Table 15-52 Indicators of population growth in 2021-2025

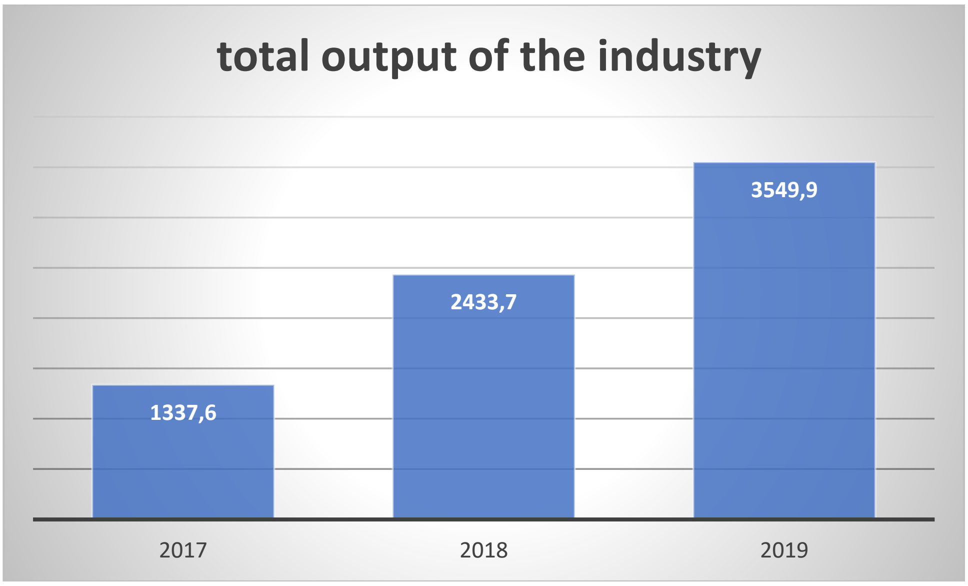
	2019	2020	2021	2022	2023	2024	2025	
Average population per year, total (thousand people) including:	25,4	25,9	26,6	27,2	27,8	28,4	29,0	114,1
city	-	-	-	-	-	-	-	-
Villages	25,4	25,9	26,6	27,2	27,8	28,4	29,0	114,1

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

15.6.3. Economic characteristics

Industry is one of the new sectors of the district's economy, whose total production in 2019 was 3,549.9 thousand somoni, an increase of 45.8% compared to 2018. Analysis shows that over the past three years, the total output of the industry has increased by 265.3%.

Figure 15-19 Growth of total industry output



Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

The Kuhistoni Mastchoh area is one of the most remote areas of the country that began to develop after 1996. The main sector of the district's economy is agriculture, which employs 73.3 percent of the district's population. The main positions in the agricultural sector of the district are potato growing, crop production, horticulture and animal husbandry. The type of agricultural farms is mostly individual dekhkan farms.

Analysis of the economy in agriculture shows that potato growing, horticulture, tree growing, and beekeeping are developing. Despite the increase in agricultural production, farmers' profits are not so high due to high costs. Industry in the area develops every year. It should be noted that the district's budget is limited and insufficient to provide for the district.

Table 15-53 SWOT analysis of the Kuhistoni Mastchoh district

Strengths	Weakness
Availability of fertile lands **Beautiful nature and fresh weather** **Availability of the** labour **force** **Hard working population** **Availability of the natural** resources (**Coal, gold, marble, water etc.);** **Availability of** the medical **bunker and schools** **Availability of useful plants** **Availability of the banks** **Availability of the industry companies**	one of the most remote areas of the country Deficit of highly qualified personal Ways need to be reconstructed Slow growth of entrepreneurship Lack of public transport; Limited budget of the district. Not enough INTERNET network. Deficit of the electricity; Imperfect system of the drinking water Lack of tourism infrastructure Lack of agriculture machinery. Lack of qualified medical personal and modern medical equipment
Opportunity	**Threat**
Implementation of developing program for the district **Organization of beekeeping and honey** **Organization farms of animal husbandry** **organization of poultry farms** **Organization of fruit processing companies** **Organization of intensity and fertile orchards**	Natural disasters (mudflow, Avalanche, Washing the shores, Droughty); Pests. Climate change Inflation Increase of fares on the ways. Negative impact of the economic crises. Increase of the migration to outside of the district Increase on price of electricity.

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Average wages in 2017-2019 in the education sector 104.83 somoni or 16%, health sector 64.05 somoni or 11.1%, industry sector 542.5 somoni or 2.8 times, agriculture sector 70.7 somoni or 17.3% and other sectors 96.86 somoni or 14.5% increased.

Table 15-54 Average wages in the sectors (somoni)

Sectors	2017	2018	2019	2019 compared to 2017 in %
budget organizations	644,67	659,18	738,53	114,5
Agriculture	406,67	433,85	477,42	117,3
Industry	297,5	340,0	840	282,3
Healthcare	572,81	574,23	636,86	111,1
Education	651,78	644,11	756,62	116,0

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Table 15-55 Major unemployment indicators in 2017-2019 years

Indicators	Years		
	2017	2018	2019
Total labore force	15519	16009	16533
Registered unemployed	117	102	86
Unemployment rate **(in %)**	0,75	0,63	0,52

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

It should be noted that these statistics are not the real number of unemployed, because only part of the unemployed are registered at the employment agency, the real unemployment is very high.

15.6.4. Agriculture

Agriculture is the main sector of the district, with cultivation of potatoes, grain, animal feed, horticulture, etc. 97.2% of the district's total production and services are in the agricultural sector, and 76.3% of the district's workforce is employed in this sector.

Structure of the district's farms

As a result of land renewal in the agricultural sector, 994 individualized dehkan farms were created, which have 4197 shareholders. As of 01.01.2020, there are 22 dekhkan collective farms in the district with 1,687 shareholders.

One of the indicators affecting the development of the sector is technical support. Currently, due to the poor condition and aging of technical equipment, agriculture is unable to provide technical support to the industry. There are currently 312 tractors in the area. There are also 738 different vehicles in the district.

Contribution of the international company is big in the agriculture sector. Including Agro Action Germany, which has been working in the area in recent years. Thanks to them, the Kuhistoni Mastchoh Potato Association was established in the district, as well as a company that supplies seeds and fertilizers to the district.

Land use

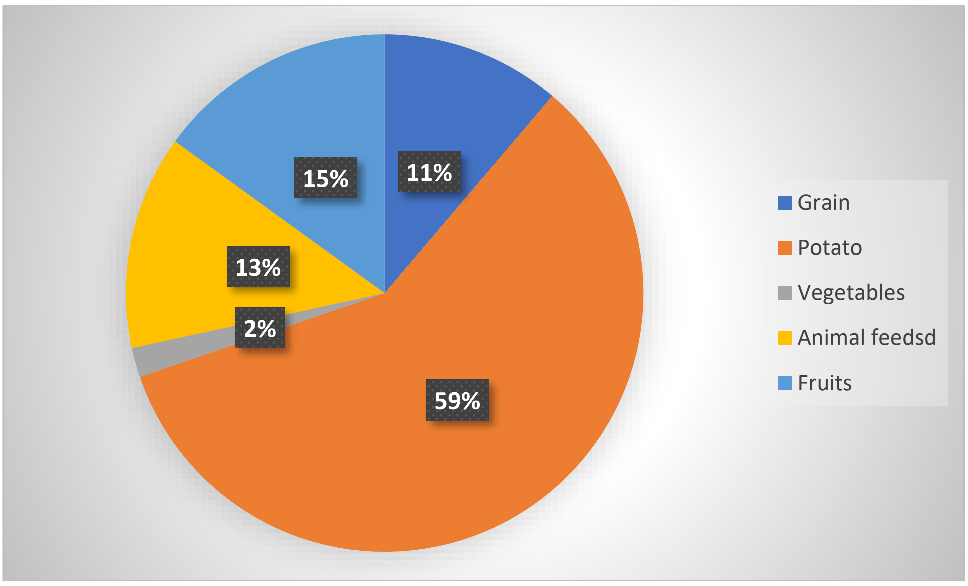
Of the total land area of 94,274 hectares, only 3463.9 hectares are used in the agricultural sector. Of these, 2,571 hectares are arable and irrigated land, of which 13 hectares are nourishing land, 550 hectares are orchards, and 7,910 hectares are pastures. Arable and irrigated land is mainly used to grow potatoes, vegetables, and animal feed. The total area of homestead lands is 1,223 hectares, of which 67.3% are homestead lands and 32.7% are presidential land.

Table 15-56 Structure of the lands in 2019 (ha)

Type of Lands	ha
arable lands	2571
Gardens	550
pasture	79310
Forest (wooded)	8147
shrubs	8548
Lands under the water	2997
lands under roads	342
Under buildings	111
other lands	264506

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Figure 15-20 Use of the agriculture land in 2019



Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

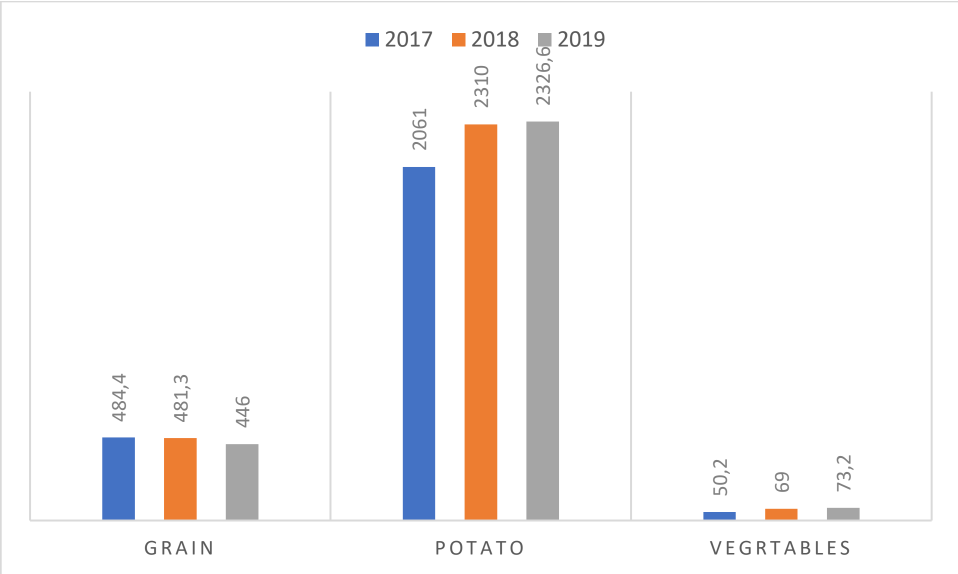
Table 15-57 The area of lands according to land use in 2014

№	Type of lands	area (ha)
1.	Presidential lands	400
2.	homestead lands	823
3.	Dehkan Farms	2230,8
	Total:	3435,8

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

In recent years, the area under grain crops and animal feed has been decreasing, while the area of potatoes, vegetables and fruits has been increasing. The main reason for the reduction in acreage sown to grain crops and animal feed is the increase in potato production in the district.

Figure 15-21 Planted areas by type of crops in years 2017-2019 (ha)

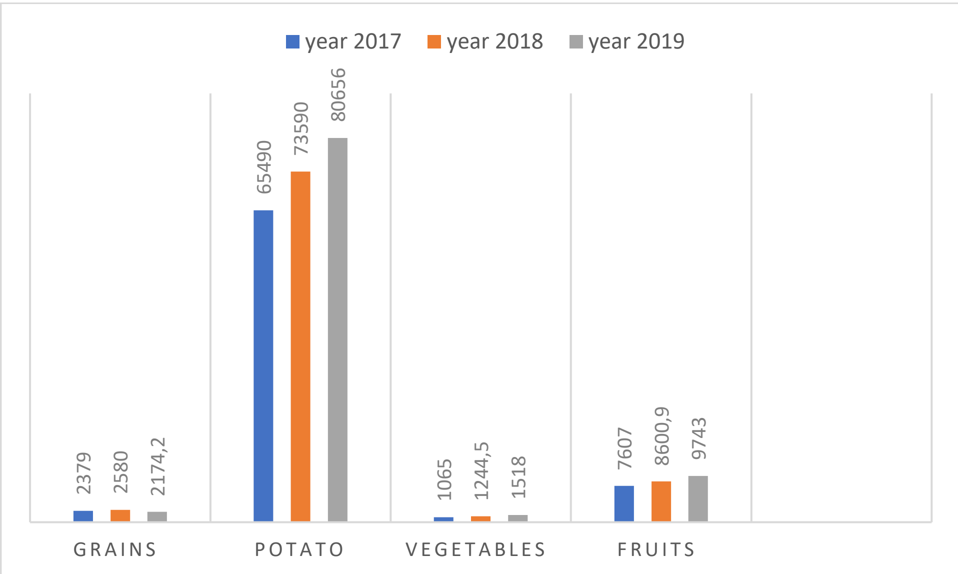


Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Crop Cultivation

The total volume of agricultural production in 2019 amounted to 264279.7 thousand somoni, of which 78.5% are the products of crop production. Of the crop types, potatoes are in first place, accounting for 74% of.

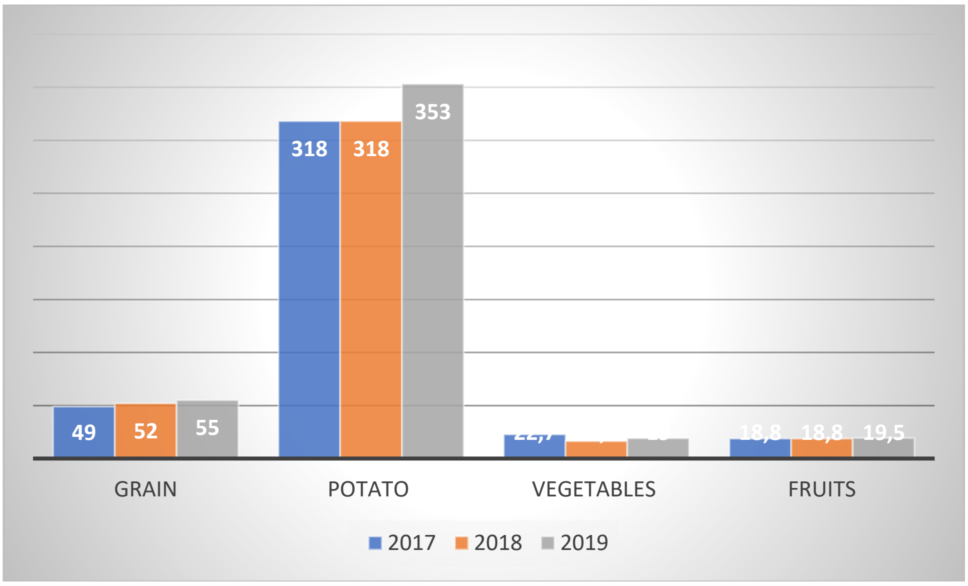
Figure 15-22 Total crop production in 2017-2019 (in tons)



Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Analysis shows that potato production increased in 2017-2119, this is due to the fact that the state of the district is favourable for potato growing. With the help of development partners, high-quality seed material is brought into the district year after year, which affects the growth of potato production. It should be noted that for the development of this sector in the area it is necessary to build farms to grow seeds.

Figure 15-23 Productivity of major crops in 2017-2019 (centners/hectare)



Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

Land irrigation

To date, more than 4 thousand lands in the area are not irrigated. On these lands there is an opportunity to irrigate them and engage in agriculture. This requires the provision of an irrigation system and the creation of more irrigated canals. The construction of canals and drains in the district (in Oburdon, Mujdif, Padask, Yesiz-Poyon, Guzn, Hadishahr, Istoshon, Samjon, Pastishav, Vitkon, Comdon villages) makes it possible to irrigate more than 2,000 hectares of land.

Livestock husbandry

Animal breeding in the area is mainly engaged by households. The productivity of this sector has also been growing in recent years.

Table 15-58 Total production of animal husbandry in 2017-2019

		2017	2018	2019
Meat	Tonna	1834	1784,5	1798,8
Milk	Tonna	6422	6650	6758
Egg	Thousand pieces	622	627	630
Honey	Tonna	35,2	40,1	41,1
Wool	Tonna	42	164,2	142,9

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

The livestock sector is getting better and better every year. Through updating animal breeding in the district, the quality of the animals got better and production of meat raised.

Table 15-59 Total number of animals in 2018-2019

Indicators	2018		2019	
	Dehkan Farms	Household Farms	Dehkan Farms	Household Farms
Cattle	581	14615	583	15038
Including cows (female)	126	7594	126	8384
Sheep and Goats	18675	101765	18756	102643
Horse	14	211	14	228
Poultry	-	7415	-	7620
Honeybee (family)	-	1994	-	2008

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

The development of animal husbandry depends on the prevention of infectious diseases. Causes of the disease are lack of technology, lack of qualified personnel, lack of animal drugs and veterinary pharmacy. Despite the fact that the number of livestock increases every year, there are no enterprises in the district for the processing of wool, meat, leather, etc.

Table 15-60 Indicators of forecast productivity of major crops and animals in the agricultural sector in 2014-2020 years

Indicator	**2019**	**2020**	**Prediction**					
			2021	**2022**	**c.2023**	**2024**	**2025**	**2025 compared to 2019(%)**
crop yields								
Grain – c/ha	34,1	34,4	34,6	34,9	35,2	35,5	35,9	105,3
Including – c/ha	49,2	49,4	49,5	49,8	49,9	50,1	50,2	102
Potato- c/ha	374,8	374,8	374,8	374,9	375,0	375,2	375,5	100,2
Vegetables - c/ha	325	330,4	335,9	337,4	340,4	341,3	342,4	105,3
Fruits -c/ha	103,5	102,9	103,2	103,3	103,6	104,1	104,5	101
Agriculture production								
Grain – 8/ton	2,2	2,2	2,2	2,3	2,3	2,4	2,5	113,6
Wheat – thousand/ton	1,2	1,2	1,2	1,3	1,3	1,4	1,5	125
Potato –thousand/ton	56,8	56,9	56,9	57,1	57,5	59,0	61,4	108,1
Vegetables – thousand/ton	0,65	0,69	0,74	0,78	0,82	0,86	0,96	147,7
Fruits – thousand/ton	5,7	5,7	5,7	5,8	5,9	6,5	7,3	128
Total number of Livestock and Poultry								
Cattle thousand/head	13	13	13,1	13,2	13,2	13,3	13,4	103
Cow (female)– thousand/head	6,2	6,3	6,2	6,3	6,4	6,5	6,6	106,4
Sheep and goat – thousand/ head	92,3	92,3	92,3	92,4	92,5	92,6	92,7	100,4

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

In 2025, potato yields are projected to increase by 8.1%, wheat yields by 13.6% and fruits by 28% compared to 2019.

Table 15-61Forecast of production agricultural products in 2016-2020 (million TJS)

Indicators	2019 report	2020 estimation	Prediction					
			2021	2022	c.2023	c. 2024	c.2025	2025 Compared to 2019(%)
Production of agricultural products	160,2	162,67	164,9	167,4	169,59	173,14	176,04	109,8
Including: Crop cultivation	130,2	130,9	131,5	132,4	132,9	134,8	135,9	104,3
Animal husbandry	30,04	31,77	33,4	35,02	36,64	38,34	40,14	133,6

Source: Executive body of the state authority of Kuhistoni Mastchoh, 2020

15.7. Kanibadam district

15.7.1. Socio Demographic conditions

The population of Kanibadam at the beginning of 2014 amounted to 197.5 thousand people, including 99.7% women. 50.6 thousand people live in the city or 25.6% of the population of the district are urban and 146.9 thousand or 74.4% of people are rural.

Table 15-62 Population of Kanibadam in the context of jamoats and city (from 2014 data)

City/Jamoats	Number of households	Population	As a percentage
Kanibadam city	11921	50,5	25,6
Patar	3167	18,2	9,2
Pulatan	4985	32,4	16,4
Ortikov	4553	24,1	12,2
Hamroboev	4570	27,1	13,7
Sharipov	4147	24,3	12,3
Lohuti	3499	20,9	10,6
TOTAL:	*36842*	*197,5*	*100*

Source: Executive body of the state authority of Kanibadam, 2015

Table 15-63 Prospects for population growth in Kanibadam in 2016–2020

Indicators	**2014 reporting year**	**2015 assessment year**	**Forecast parameters**				
			Indicators 2014 report 2015 evaluation 2016	**2017**	**2018**	**2019**	**2020**
Average annual population, total (thousand people) Including:	197,5	200,1	202,5	204,9	207,3	209,7	212,2
urban	50,6	51,2	51,8	52,5	53	53,5	53,8
rural	146,9	148,9	150,7	152,4	154,3	156,2	158,4

Source: Executive body of the state authority of Kanibadam, 2015

Most of the Lahoti city's population (83.3%) are Tajiks, the rest of the population are Uzbeks and representatives of other nationalities.

The gender and age structure of the population is dominated by 27.2% children under 14 and 64.4%, middle-aged people, people of retirement age 8.3%.

Table 15-64 Gender and age structure of the population of Kanibadam in 2014

	Total	**including girls/women**	**% girls/women**
Teenagers under 14 years old (children)	53,9	27,0	50,1
Middle-aged people 15-62	127,1	66,	52,1
People of retirement age (63 husbands/58 wives) and older	16,5	8,3	50,3
TOTAL:	197,5	101,3	51,3

Source: Executive body of the state authority of Kanibadam, 2015

The city is experiencing demographic growth.

Table 15-65 Demographic situation of 2012-2014

Years	**Number of births**	**Number of deaths**	**Natural population growth**	**Natural population growth in %**	**Total population**
2012	4614	1010	3604	1,89	189,7
2013	4781	1010	3771	1,95	192,8
2014	4871	985	3529	1,78	197,5

Source: Executive body of the state authority of Kanibadam, 2015

According to official data, as of January 1, 2015, 36,585 of the city's population are in labour migration, of which 33.4% are women. Labour migration is an important source of income for the population. Due to labour migration in 2014, according to official data, the population received 114,022 thousand US dollars.

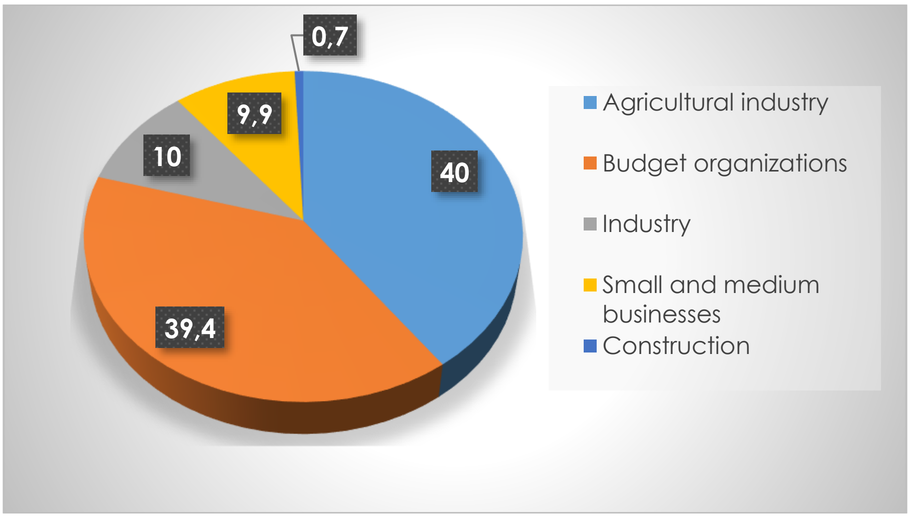
15.7.2. Economic issues

The basis of the economy of the city of Kanibadam is agriculture, it is also the most important area that provides the population with food, jobs, and a source of income. Mostly agricultural land is allocated for cotton, orchards, and fodder crops.

The gross volume of agricultural production in 2014 amounted to 322.9 million somoni. 66.5% of agricultural production in the field of crop production is accounted for by the private sector. Animal husbandry, along with other sectors of the agricultural sector, is one of the most important sectors, and its comparative share in the total volume of agricultural production is 33.5%.

In recent years, the city has seen a decline in the yield of cotton, vegetables, fruits, the main reason for which is the unsatisfactory reclamation condition of the land, improper crop rotation, low level of material and technical resources, poor quality of planting and seed materials, insufficient land allocated for fodder crops, lack of points for artificial insemination of animals, limited winter and summer pastures, poor organization of veterinary stations, lack of points for receiving and processing wool and leather, lack of a special point for slaughtering livestock and waste, lack of information and advisory support for dekhkan farms, as well as issues related to the change climate.

Figure 15-24 Employment by industry (in percentages), 2014



Source: Executive body of the state authority of Kanibadam, 2015

Table 15-66 The total volume of manufactured products in the context of the main industries in 2014 in (thousand somoni and in percentage terms)

№	Indicators	2014	in %
1	Total volume of manufactured industrial products (comparative)	114035,1	12,9
2	Investment and other contributions from all available funding sources (total)	27605,7	3,1
3	Retail turnover (comparative)	257463,9	28,9
4	Money services (comparative)	166141,2	18,7
5	Total agricultural production	322986	36,4
	TOTAL:	*888231,9*	*100*

Source: Executive body of the state authority of Kanibadam, 2015

There are 22 industrial enterprises in the city, where the production of goods is mainly based on local raw materials. In 2014, the total volume of industrial production tended to increase and, in relation to 2013, was 100.7%. The development of the industrial potential of the city is facilitated by the presence of railway approaches and branches, proximity to the Dushanbe – Khujand – Kanibadam highway, common borders with Uzbekistan and Kyrgyzstan.

Table 15-67 Industrial enterprises by category (from 2014 data)

№	Sector name	Number of operating enterprises
1	Mechanical engineering	2
2	Light industry	7
3	Food industry	8
4	Chemical industry	1
5	Oil refining industry	1
6	Printing industry	1
7	Construction industry	2
	TOTAL:	*22*

Source: Executive body of the state authority of Kanibadam, 2015

In 2014, the total volume of industrial production tends to decrease, which is 3.83% less compared to 2012, for example, in 2010, the total volume of industrial production tended to increase, which, compared to 2008, amounted to 25.9 %.

The industrial enterprises of the city employ 1,963 people, which is 3.0% of the total number of employed (65,486 thousand people), including 20% of women. The main employer among industrial enterprises is LLC "Toj", JSC "Habib", JSC "Resmon", JSC "Kanibadam", Carriage Repair Plant.

In the industrial enterprises of the city of Kanibadam, there is a shortage and leakage of qualified specialists, including in the light engineering and processing industries, due to low wages. The average level of wages in industrial enterprises as of January 1, 2015, amounted to 530.19 somoni.

In the sectoral structure, a prominent place is occupied by the cotton processing industry, oil refining, the engineering industry (including the repair of wagons and the production of spare parts for cars and agricultural mechanisms), and the production of food products.

After the collapse of the USSR and the independence of the Republic of Tajikistan, many enterprises lost economic ties with suppliers and markets for their products. Large enterprises like Shveymestprom No. 2 (now LLC "Toj", where 4 thousand women were employed), JSC "Brake Equipment Plant" a subsidiary of Gorky Automobile Plant (now JSC "Bodom"), Cannery Kanibadam (now LLC "Kanibadam"), Carriage Repair Plant were forced to reduce production volumes and significantly reduce the number of employees, which significantly affected the overall level of employment and socio-economic status of Kanibadam.

In recent years, small and medium businesses have been one of the key positions providing the population with jobs. The main problems hindering the development of small and medium businesses are characterized by a lack of coordination of entrepreneurs, a low level of their legal literacy on business organization and marketing, a high level of interest rates on bank loans, a lack of sustainable institutions providing legal support services, and capacity building

The analysis shows that small and medium businesses are represented in industries, agriculture, trade and services, transport, communications, and construction.

Table 15-68 The role of small and medium businesses in providing employment by industry (from 2014 data)

Sectors of the economy	**Number of registered entities**		**Employment**
	Legal entities	***Individuals***	***Total number of jobs***
Agriculture (including processing)	49	6154	7549
Transport and communication	11	209	250
Trade	9	95	441
Service sector	15	236	431
Industry (small and medium enterprises)	22	--	976
Construction	7	--	134
Financial services	8	2	334
TOTAL:	*121*	*6696*	*10115*

Source: Executive body of the state authority of Kanibadam, 2015

In recent years, small and medium businesses have become an important sector in providing the population with jobs. So, in this area in 2014, 10115 people were employed. As of January 1, 2015, 121 small legal entities and 6696 individuals are registered in the district.

According to statistics in the total volume of manufactured products by small and medium businesses, agriculture and trade occupy a special place, which form 56.9% of the total volume of manufactured products of the city.

The current stage of development of the city of Kanibadam is due to a high level of unemployment, pronounced social inequality, limited economic opportunities for the main part of the population of the city and villages, although official data show a completely opposite picture.

Table 15-69 Unemployment rate

Indicators	Years		
	2012	2013	2014
Employable population thousand people	108,3	109,3	112,4
Non-working (officially registered, pers.)	837	951	996

Source: Executive body of the state authority of Kanibadam, 2015

To provide financial support to the unemployed, the Agency for Social Protection and Employment of Kanibadam allocates small interest-free loans to create new jobs, mainly for the organization of small and medium businesses. The volume of concessional loans issued has increased significantly in recent years.

Table 15-70 Interest-free lending to the unemployed (somoni)

	Years		
	2012	**2013**	**2014**
Number of loan recipients (pers.)	91	73	81
For total cost	257656	272800	291000

Source: Executive body of the state authority of Kanibadam, 2015

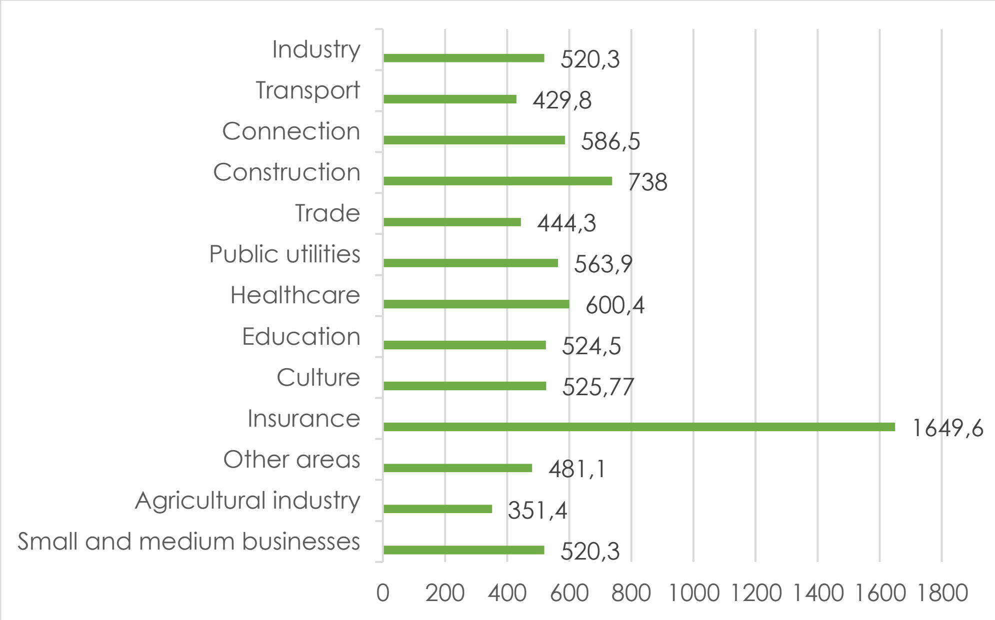
Table 15-71 Forecast parameters of the labour resources of the city of Kanibadam (thousand people)

Indicators	**2014 reporting year**	**2015 assessment year**	**Forecast parameters**			**2018 in % to 2014**
			2016	**2017**	**2018**	
Human Resources	112,4	108,6	109,3	109,9	112,5	100,0
Number of people employed in the economy	65,4	64,4	64,8	65,2	65,5	100,0
including:						
in material production	57,7	57,5	57,6	57,8	58,1	100,7
in the non-manufacturing sector	7,7	6,9	7,2	7,2	7,4	96,1
Number of people employed in the economy – total	47,0	44,2	44,5	44,7	47,0	100
Work migration						
Number of labour migrants who left the republic (thousand people)	36,5	33,3	32,8	32,5	32,1	87,9

Source: Executive body of the state authority of Kanibadam, 2015

Nominal wages in the city of Kanibadam as of 01.01.2015 amounted to 531.19 somoni. At the same time, there is a difference between the level of wages of workers in different sectors. The lowest wages were recorded in the public sector and in the agricultural sector.

Figure 15-25 Wage level by sector (in somoni), as of January 2015



Source: Executive body of the state authority of Kanibadam, 2015

According to the data of the Social Protection Department of the city of Kanibadam in 2014, the total number of pensioners was 16,253 people, of which 5.5% continue to work due to the low pension. The average pension in Kanibadam is 208 somoni 94 dirams.

Table 15-72 Composition of pensioners (from 2014 data)

№	Composition of pensioners	number of persons
1	By age	11795 pers.
2	By disability	1614 pers.
3	Loss of the breadwinner	1023 pers.
4	Many years of work	183 pers.
5	Pensioners for merits of RT	52 pers.
6	Social pensions	1561 pers.
7	Disabled WWII	9 pers.
8	WWII participants	3 pers.
9	Families of WWII Participants	3 pers.
10	Disabled people of the Chernobyl nuclear power plant	32 pers.
11	Disabled Afghans	5 pers.
12	Home front workers	22 pers.
13	Lonely	21 pers.
14	Working pensioners	430 pers.

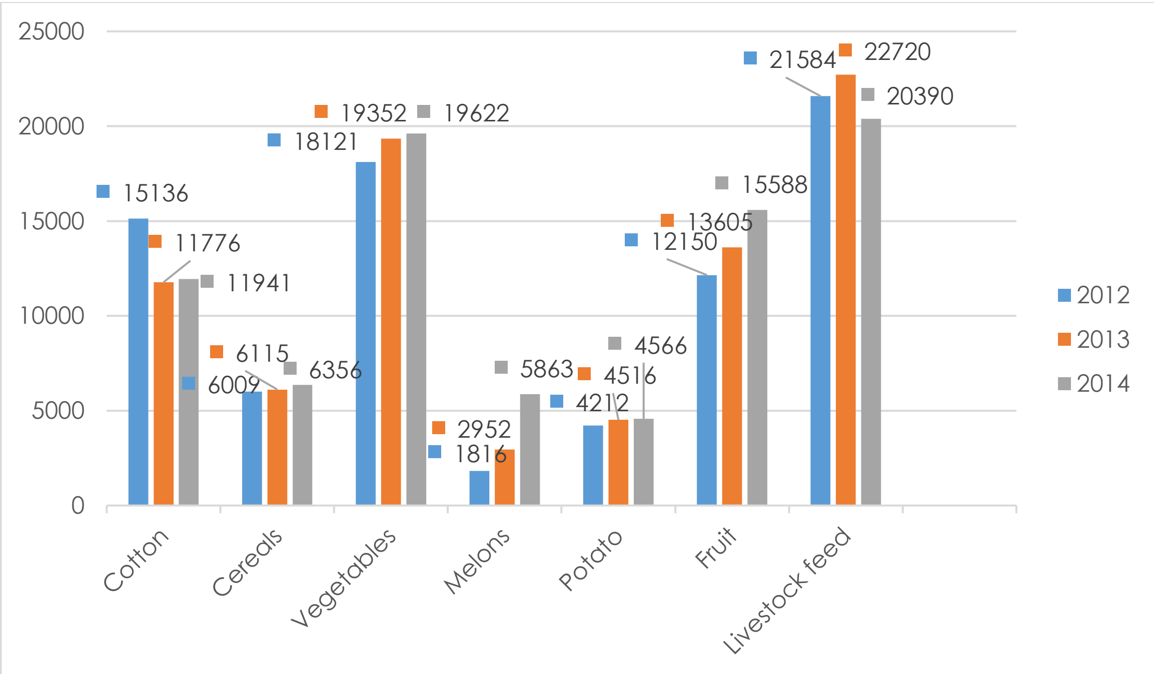
Source: Executive body of the state authority of Kanibadam, 2015

15.7.3. Agriculture

Agriculture in Kanibadam is the most important area that provides the population with food, jobs, and a source of income. More than 70% of the able-bodied population of the region is engaged in agriculture, which is the main source of income for most of the population of the region. In the city of Kanibadam, 6 thousand people are employed in the agricultural sector, of which 55% are women. The gross volume of agricultural production in 2014 amounted to 323 million somoni (including the share of crop production is 66.5% and livestock 33.4%).

It should be emphasized that the share of agriculture is 36.4% of the total production. According to official data, more than 40% of households are employed in agriculture (mainly in horticulture, vegetable growing and growing melons and gourds). 87% of crop production comes from the private sector (family and individual households, households, and presidential plots), while 13% is from the public sector (collective households).

Table 15-73 Gross volume of crop production for 2012–2014 (in tons)



Source: Executive body of the state authority of Kanibadam, 2015

The analysis shows that the growth in the volume of agricultural production occurs mainly due to an increase in the area allocated for crops, although in some cases the increase in volume also occurs due to an increase in productivity, mainly in the areas of horticulture, growing potatoes, melons, and fodder crops.

Table 15-74 Crop yields for 2012–2014 (c/ha)

Yield c/ha	2012	2013	2014
Cotton	21,3	17,5	19,7
Cereals	24,4	25,3	24,4
Vegetables	179,3	183,2	202,3
Melons	79,0	99,0	103,6
Potato	208,3	210,1	216,4
Fruit	19,3	19,0	20,5
Livestock feed	84,7	78,6	88,3

Source: Executive body of the state authority of Kanibadam, 2015

In recent years, the city's farms have seen a decline in vegetable crop yields by 7.6% and 7.9% compared to 2010 and 2011, against the background of an increase in vegetable production. The increase in production is mainly due to the extensive method of introducing agriculture, that is, by increasing the area under vegetable crops. The decline in yields is also observed in the field of cotton growing.

The reasons for the decline in productivity in agriculture, in particular in the cultivation of cotton, are primarily associated with the unsatisfactory reclamation state of the land, improper crop rotation, low level of material and technical resources, poor quality of planting and seed materials, low soil fertility, lack of highly qualified specialists , fragmentation of individual households, lack of modern agricultural technologies, high prices for fuels and lubricants, high prices for mineral fertilizers and pesticides, lack of agricultural equipment and inadequate quality of agrotechnical measures, lack of information and advisory support and climate change issues.

Other obstacles to the development of cotton growing in recent years have been high debts of cotton farms to the water management enterprise, tax authorities, fluctuations in cotton prices, and because of reduced profitability and lack of incentive for farms. The development of the industry was facilitated by the cancellation of debts of cotton farms in 2007, in accordance with the Decree of the Government of the Republic of Tajikistan No. 111, and the recent increase in cotton prices.

According to the data for 2015, in recent years there has been a significant increase in the production of melons, which is due to an increase in the area under crops by 182.1% and an increase in yield by almost 104.6%. The growth of melon production is often associated with economic profitability and the presence of demand for this product. The main problem of this industry is caused by inadequate water resources management and poor ameliorative condition of agricultural lands, lack of integrated pest management, etc.

Forms of activity in the agricultural sector

As a result of the land reform in 2009–2014. instead of the former collective farms that previously existed in the region, namely, from 120 collective dekhkan farms and 8 associations and joint-stock companies, more than 6 thousand 154 dekhkan farms were created. They have been allocated more than 86.4% of the total land for lifetime use.

In recent years, new effective forms of management have been introduced in the field of agriculture that meet the new economic conditions. Currently, the process of uniting individual farms into associations is underway (2 such associations are registered in the city), according to experts, these associations relate to the demand of the time, especially in the economic efficiency of economic entities (dekhkan farms).

One of the key problems of agriculture in the city of Kanibadam is the inadequate state of mechanization of agricultural production.

After the privatization of the state institution "Agropromtechsnab" in the city of Kanibadam, all available agricultural equipment was transferred to the balance of collective dehkan farms. Unsatisfactory activity of collective dekhkan farms, lack of highly qualified personnel, limited financial resources, depreciation of repair shops, poor quality of fuels and lubricants, lack and high cost of spare parts caused the deterioration of the existing agricultural equipment belonging to collective dekhkan farms.

In the city, there is mainly a shortage of arable, forage harvesting equipment, as well as plant protection equipment, etc. Currently, there are 319 units on the balance sheet of collective dekhkan farms, 128 units of industrial, construction and infrastructure enterprises and 356 units of agricultural tractors in the private sector and cars. 84% of tractors on the balance sheet of collective dekhkan farms are in working condition, while private sector tractors are 85–90% efficient. In recent years (data as of 01.01.2015), collective dekhkan farms in Kanibadam purchased 18 tractors MTZ "Belarus", of which 3 units were purchased on a leasing basis, 5 in the form of a grant due to technical assistance provided by an international organization "ACTED". To improve the mechanization of agricultural production in 2009 on the territory of the collective dekhkan farm named after Nazarov D.KH. "Kushkak" created the first machine and tractor station on the balance sheet, which has 4 tractors, as well as relevant agricultural mechanisms. It should be noted that the machine and tractor station does not have a modern repair base. For the city of Kanibadam, an acute problem is the lack of a repair base for agricultural machinery that meets modern requirements, which has all the conditions for the maintenance of agricultural machinery (with stands and other means of monitoring the health of agricultural machinery).

Table 15-75 State of agricultural machinery (as of January 1, 2015)

Name of agricultural machinery	Unit. Measurements.	Total	In working order	In working order in %
Tractors	Unit	319	268	84
including arable	Unit	34	26	76,5
Trucks	Unit	87	49	56,3
Harvesting equipment	Unit	3	1	33,3
Seeders	Unit	59	55	93,2
Mowers	Unit	4	4	100
Hay pickers	Unit	-	-	-
Loaders	Unit	-	-	-
Forage harvesters	Unit	2	2	100
Silage harvesters	Unit	1	-	-
Potato harvesters	Unit	-	-	-
Planter	Unit	85	74	87,1
Plows	Unit	74	67	90,5
Baler	Unit	2	2	100

Source: Executive body of the state authority of Kanibadam, 2015

Along with the depreciation of agricultural machinery, the lack and high cost of spare parts, fuel and lubricants leads to an increase in the costs of agricultural production.

Table 15-76 Forecast parameters for the growth of agricultural production in Kanibadam for the period 2016–2020 (in monetary terms, in thousand somoni)

Indicators	2014 reporting year	2015 assessment year	Forecast parameters				
			2016	2017	2018	2019	2020
Volume of agricultural production	322986	323241	330429	330942	342126	353687	364298
including:							
Crop production	214915	214384	220641	220330	230427	240986	248216
Animal husbandry	108071	108856	109788	110612	111699	112701	116082

Source: Executive body of the state authority of Kanibadam, 2015

According to the given program parameters, the total volume of agricultural production in 2020 should increase by 34.9% compared to the indicators of 2015 (86153.0 thousand somoni), including crop production 40.2% (or 75334.0 thousand somoni) mainly due to the intensification of agricultural production (reduction of sown areas and increase in productivity) and livestock 18.1%.

Table 15-77 Forecast parameters for the growth of agricultural production in Kanibadam for the period 2016–2020 (in kind million somoni)

Indicators	2014 reporting year	2015 assessment year	Forecast parameters				
			2016	2017	2018	2019	2020
Crop production:							
Cereal crops – ton	5640	6325	6651	6971	7238	7515	7740
including wheat – ton	3195	3254	3524	3625	3690	3756	3793
Cotton – ton	11941	14000	14500	14500	15000	15000	15000
Potato – ton	4566	4620	4796	4840	4995	5154	5310
Melon crops – ton	5674	5775	5985	6300	6300	6350	6375
Vegetables – ton	15579	16812	17480	18220	19850	20247	20500

Source: Executive body of the state authority of Kanibadam, 2015

Table 15-78 Forecast parameters of the yield of the main agricultural crops in the city of Kanibadam for the period 2016–2020

Indicators	2014 reporting year	2015 assessment year	Forecast parameters				
			2016	2017	2018	2019	2020
Crop production:							
Cereal crops – c/ha	24,4	25	25,8	26	26	26,1	26,2
including wheat – c/ha	26,6	27	29	30	30	30	30
Cotton – c/ha	19,7	20	20,2	20,3	20,5	25	25
Potato – c/ha	216	216	218	220	222	229	230
Melon crops – c/ha	103,6	105	105	105	110	105,8	106,2
Vegetables – c/ha	202,3	202,7	206	210	210	238,2	241,2
Fruit – c/ha	20	20	20,2	20,2	20,3	20,3	20,5

Source: Executive body of the state authority of Kanibadam, 2015

Table 15-79 Forecast parameters of livestock production in the city of Kanibadam for the period 2016–2020 (in kind)

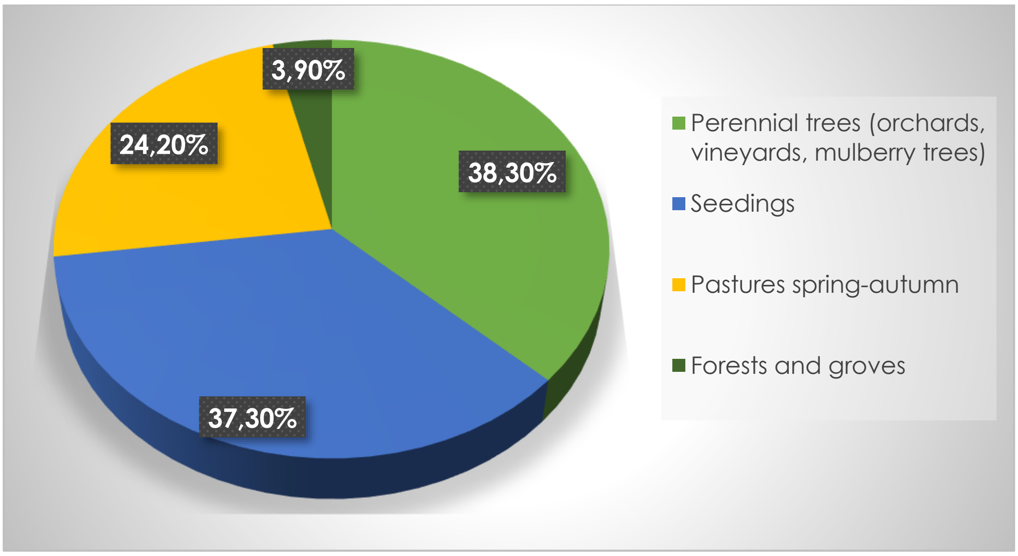
Indicators	2014 reporting year	2015 assessment year	Forecast parameters				
			2016	2017	2018	2019	2020
Animal husbandry:							
Livestock and poultry in live weight - ton	2749	2780	2800	2820	2850	2880	2960
Milk – ton	19964	19964	20076	20188	20300	20412	20615
Eggs – thousand pieces	600	600	630	680	750	830	920
Wool in physical weight - tons	44,6	44,6	47,1	48,9	50,4	51	52
Silkworm cocoons - tons	126,5	127	128	129	130	132	135
Honey - tons	21	21,2	21	22	22,3	22,4	22,5

Source: Executive body of the state authority of Kanibadam, 2015

Land use

As of January 1, 2015, in the land fund of Kanibadam with a total area of 82,894 hectares, 32% or 26,469 hectares are allocated for agricultural land, which are completely irrigated.

Figure 15-26 Structure of land use (in % ratio)



Source: Executive body of the state authority of Kanibadam, 2015

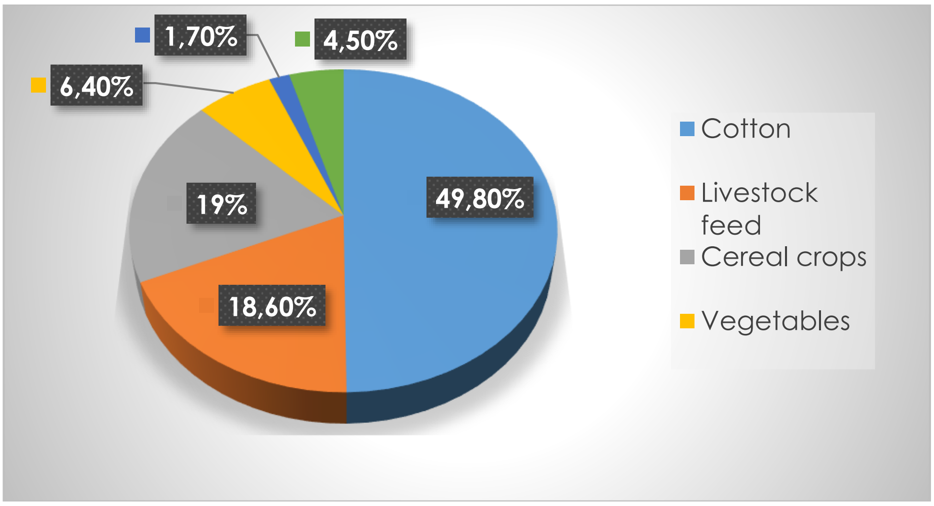
The total area of land allocated for personal plots is 3857 hectares, of which 82.3% is irrigated land. Household plots make up 14.5% of cultivated agricultural land. In the city, 11 thousand 600 families are provided with 10 acres of subsidiary lands.

Table 15-80 Land category

№	Land category	Number of hectares
1	Agricultural land (including pastures)	26563
2	Household plots	3857
3	Presidential lands	1153
4	Forests and groves	1051
5	Lands under water	26096
6	Roads and livestock roads	1216
7	Land for buildings and objects, streets, and squares	1636
8	Other lands	21322
TOTAL:		*82894*

Source: Executive body of the state authority of Kanibadam, 2015

Figure 15-27 Use of sown areas (in % ratio)



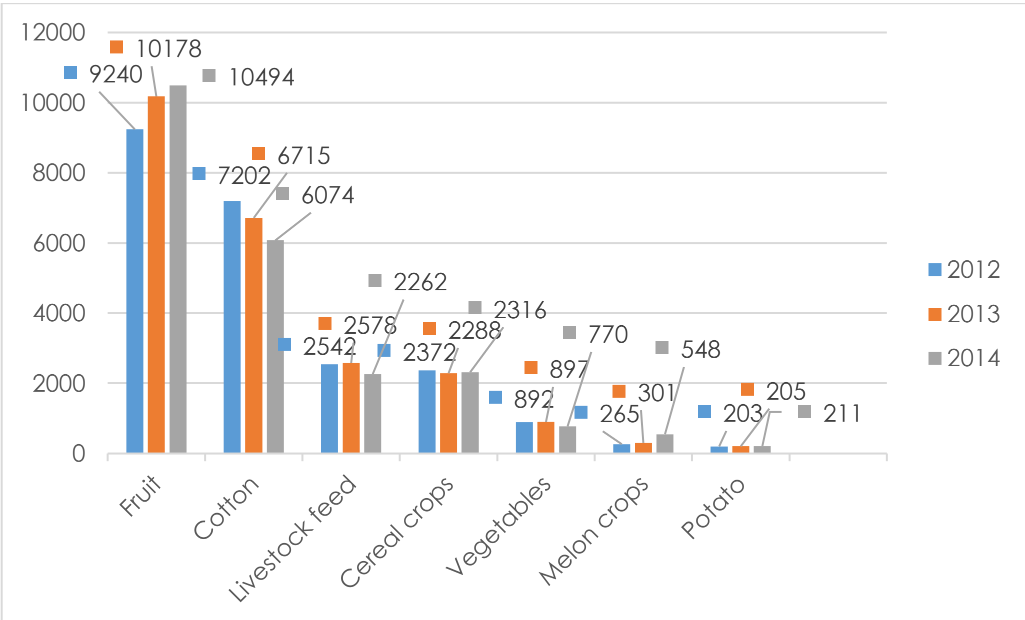
Source: Executive body of the state authority of Kanibadam, 2015

Most of the agricultural land is devoted to cotton, orchards, and fodder crops.

In recent years, the proportion of areas allocated for cotton and fodder crops has decreased, while the area for orchards, cereals, vegetables, and melons has increased.

The reason for the decrease in the area under cotton crops is primarily due to the low level of cotton prices in 2013–2014. in the world markets, as a result, there was a low profitability of production, as well as a decrease in productivity due to the unsatisfactory reclamation state of agricultural land (high level of waterlogging and soil mineralization, erosion).

Figure 15-28 Dynamics of changes in the use of sown areas for 2012–2014 (ha)



Source: Executive body of the state authority of Kanibadam, 2015

Gardening

According to local authorities, within the framework of the “Targeted State Program for the Development of Horticulture and Viticulture and the Growing of Fruit-bearing Saplings and Ornamental Trees in the Republic of Tajikistan for 2007–2010” and Decree of the President of the Republic of Tajikistan dated August 27, 2009, under No. 683 “On additional measures to develop the horticulture and viticulture industry in the Republic of Tajikistan for 2010-2014” in recent years, more than 2067 hectares of new orchards have been created on the territory of the city, of which 751.8 hectares are stone fruit trees, which in the future should lead to an increase in fruit production by 1200 tons (with a yield of 12.3 c/ha), which in terms of fulfilling the task is 103%.

Of the total area of 10,183 ha under perennial trees, 9,726 ha are orchards, 68 ha are vineyards, and 385 ha are mulberry fields. Of the household plots, 1683 ha consist of perennial trees. Along with crop production and viticulture, the cultivation of apricots is of particular importance for the farms of the city of Kanibadam, 90% of the city's existing orchards are apricot plantations.

From time immemorial, the city of Kanibadam was famous for its apricot plantations, the harvest from which supplied to India, Russia, and Europe. This tradition continues to this day. At present, the produced apricot exported to Russia, Kazakhstan, Ukraine, and other CIS countries, as well as to the Baltic countries.

In 2014, the city of Kanibadam produced 15,588 tons of various varieties of fruits, including apricots: 14,123 tons. Of the total apricot crop produced, only a third of the apricots grown processed. To increase farmers' incomes, the USAID funded Productive Agriculture Project launched a program to train farm managers in Kanibadam on Turkish apricot post-harvest technology, which includes the process of harvesting and drying the crop using the modern technology.

An important moment in the development of horticulture and agriculture in general for the city is the introduction of "solar dryers" for drying fruits, including apricots. This experience already used in other districts of the Sughd region, such as Spitamen, Jabbor Rasulov and other districts of the republic.

The construction of energy-efficient greenhouses and greenhouses can be a priority in this sector, which will help increase the safety of the crop, the income of the local population, households and contribute to the economic development of the city.

The main problems affecting success in the fruit and vegetable sector and leading to product losses are high prices for fuels and lubricants and pesticides, lack of effective pest control methods, limited sales markets, obsolete technology of existing processing enterprises, lack of agricultural machinery and poor quality of agrotechnical measures. , unsatisfactory ameliorative condition of orchards, low level of awareness of dekhkans on the issues of processing and drying fruits and vegetables.

There are no organizations providing consulting agricultural services in the city. Advice to dekhkan farms on agricultural production provided by specialists from existing associations, which does not meet modern requirements.

The market providing services for the provision of agricultural inputs non-existent. A key factor influencing the development of the agricultural sector is the low level of access of farms to preferential long-term loans.

Animal husbandry

Animal husbandry, along with other sectors of the agrarian sector of the city, is one of the most important industries, and its share in the total volume of agricultural production is 28%.

Table 15-80 Production of livestock products

Product List	Unit	2011	2012	2013	2014
Meat (poultry)	tons	1682	1689	1844	2749
Milk	tons	18561	18598	19852	19964
Eggs	thousand pieces	2466	2568	2645	2895
Wool	tons	34,8	36,4	37,0	38,0
Honey	tons	20,4	21,0	21,0	21,0

Source: Executive body of the state authority of Kanibadam, 2015

In the city, according to the re-registration of private households, there are 38.6 thousand heads of cattle, as well as 31.1 thousand heads of small livestock, 238 heads of horses and 60.4 thousand chickens. However, it is worth noting that the number of livestock and the production of livestock products relative to the existing needs of the population for products are at a low level.

Table 15-81 Livestock in all forms of management (heads)

Indicators	2011	2012	2013	2014
Cattle	38365	38643	38662	38643
Goats and sheep	27461	30742	30790	31040
Chickens	49000	60123	59010	60440
Horses	215	218	235	238

Source: Executive body of the state authority of Kanibadam, 2015

The analysis shows that in recent years there has been a slight increase in the number of animals. In 2014, compared to 2011, the number of cattle increased by 0.7%, goats and sheep by 13.0%, chickens by 23.3%. The increase in the number of animals in the private sector, as well as the disappearance of livestock farms, has led to a decrease in the profitability of the livestock industry.

The main problems of this industry are due to the lack of land allotted for fodder crops, especially for sowing oilseeds, provided for livestock feed, the lack of points for artificial insemination of animals, the limited winter and summer pastures, the poor organization of veterinary stations, the lack of points for receiving and processing wool and skin, the absence of a special point for slaughtering livestock and waste.

Individual cases of brucellosis, rabies, foot-and-mouth disease, polyarthritis, tuberculosis and other diseases among cattle and small cattle, as well as pseudo-plague among poultry have registered in livestock farms.

There is one city veterinary hospital, one veterinary pharmacy and 8 veterinary stations in Kanibadam. There is no point for decontamination of animals (for burning and washing animals, especially in cases of outbreaks of infectious diseases).

To increase the production of livestock products, as well as to implement the program for the development of livestock breeding and improvement of animal breeds, in accordance with the Decree of the Government of the Republic of Tajikistan under No. 501 dated October 1, 2007, as well as the "Program for the development of livestock breeding and improvement of breeds in Kanibadam", 7 points of artificial insemination were organized in the city animals.

In recent years, the development of the beekeeping industry has observed on the territory of Kanibadam. On this basis, a beekeeping association has been organized in the city, uniting over 15 beekeepers with a total of more than 400 bee families.

Now, the main problem of beekeepers is the lack of high-performance queens, low access to preferential long-term loans.

15.7.4. Forestry

According to the official data of the local authorities, as of January 1, 2015, the total area of forests and groves in the city is 1051 hectares.

16. Appendix 4. Methodology of interviews and focus groups

16.1. Methodology

The structure of the focus groups

The focus groups aim to assess the following

- How the local communities perceive the climate change in the area, how communities see climate change in the future
- How climate change is changing life in the area in terms of economic, environmental, social, how communities respond to climate change, how they foresee their future in the context of climate change, focus on agriculture, forestry, water management (primarily irrigation rather than drinking water quality)
- What adaptation measures have been taken in the area, and what have been the results
- What adaptation measures should be undertaken first in the future, what will they help with
- How does the community assess the cost-effectiveness of specific climate change adaptation measures and strategies?

The participants of the interviews and focus groups are presented in the appendix

The structure of the interviews

1. How do you view economic and social situation of Tajikistan and/or 6 specifics districts?
2. How would you comment the shape of agriculture, water management, forestry, local ecosystems?
3. How do you perceive the change in climate in the districts?
4. What are the effects of climate change on forestry, water management, local ecosystems, agriculture, economy, and social life in districts?
5. What is done to prevent that? What were the projects, results, and experiences?
6. Which national/international organizations are active in the districts? Which projects they are conducting? What are the results?

7. The interviewer summarizes the national strategy for climate adaptation in the region. How do you characterize the national strategy to combat the climate change in particular districts?

8. What you think should be done to combat climate change and/or adapt to climate changes? Which strategies you find most important? Most urgent?

9. Which specific policies or projects you recommend for particular districts, why? How the projects or policies will help the region?

10. What will happen is nothing is done? Please consider economic and social well-being, access to drinking water, in- and out- migration within the country and outside, health effect

11. What will be the effects if the projects you suggest are successful?

12. Can you rank the adaptation measures you propose according to your perception of cost effectiveness?

The participants of the focus groups and interviews

In this report we do not present information about the participants of the focus groups is order to save the anonymity and confidentiality. The names and the contact information stay with the authors of this study and can be presented only upon a reasonable request.

16.2. Gissar

Methodologically this assessment relies on one focus group in the field and one focus group with the experts in the university, and several expert interviews with the representatives of relevant organizations such as the agency of forestry, the representatives of water management (association of water users) and the local representatives of agriculture.

The selection of jamoat

As the results of the focus group were meant, to an extent, to represent the whole region, the aim was to choose the most representative jamaat as opposed to the most vulnerable one. The group was selected to represent both farmer and expert communities, including the local government representatives.

Selection criteria

- Population
- Area of irrigated land and availability of pastures
- Availability of drinking and irrigation water
- Forest and forest plantation areas
- Area and productivity of agricultural crops
- Livestock (provision with livestock)

Selection method

- Statistical data
- Expert interview

Table 16-1 The statistical description of jamoats in Gissar region

Name of Jamoat	Name of the Association of Water Users	Number of households	Average number of people in a household	Total person	Irrigated land, Ha					Number of WUA** members		Number of dehkan farms on the territory of the WUA				The area of irrigated land		
						including												
					Total	Arable land area	President's lands	Household plots	Other lands *	Total	Women	Total	Headed by women	<30ha	>30ha	Total	<30ha	>30ha
Sharora	No WUA	2800	6	16800														
Gissar	No WUA	1987	7	13909														
Mirzo – Rizo	Obi rahmat	3792	8	29332	1610	1199	21	390	0	210	7	271	7	267	4	1199	546	653
Navabad	Chashmai umed	3005	8	23033	2150	1618	125	407	0	133	8	246	9	243	3	1618	1077	541
M.Tursunzoda	Obi umed	3223	7	21071	1189	845	57	287	0	365	12	524	170	523	1	845	670	175
Somon	Chashmai mekhr	3623	8	28675	1199	816	30	353	0	105	5	440	106	436	4	816	386	430
Durbat	Chashmai zamzam	2081	4	21526	1011	482	63	313	93	86	21	83	25	80	3	337	235	101
Dekhkanabad		3542	4	19090	971	428	72	398	133	93	36	141	43	137	4	573	401	173
Oriyon	Rudhona	2118	5	11279	1082	891	8	183	0	64	9	64	11	58	6	891	479	412
Gissar	Shumon	5662	6	33972	2269	1768	74	427	0	101	18	175	39	172	3	1768	453	1315
Almasi	No WUA																	
Gornaya Hanaka	No WUA																	
Total			7	187978	11481	8047	450	2758	226	1157	116	1944	410	1916	28	8047	4247	3800

* seed farming, fish farming, research institutes, etc., **WUA - Water User Association

Source: Institutional data from the WUA of Hissar region (2020).

The first two and the last two jamoats have no irrigation area. They are located closer to river flows. They are closer to water sources and more dependent on rainfall. They have good conditions of rainfed land. Sufficient area for cattle breeding. However, these two jamoats are smaller and cannot be considered representative.

According to these parameters, Mirzo-Rizo jamoat was selected as the largest and most representative jamoat in the district.

Figure 16-1 The location of Mirzo-Rizo jamoat on the map of Tajikistan

Source: Karte Creative Commons by-sa-3.0

Description of jamoat

- The most densely populated jamoat
- The jamoat is located in the difficult-to-reach area as for water availability, at the tail of the water sources. Susceptible for drought.
- The area suffers from lack of water for agriculture and pastures. The total irrigated area amounts to 1610 ha. In addition, the jamoat occupies a rainfed area of over 3000 ha. In case of drought, 2/3 of the area cannot be used.
- Due to insufficient access to water, little soil is available for farming and pastures. The average number of livestock is lower than the average for Tajikistan - in Mirzo

Rizo jamoat, the average number of cows per family is one or two, while the average for a well-to-do family in Tajikistan is three cows per family.

- The supply of drinking water is problematic
- According to agro landscape, the territory suffers from insufficient precipitation
- The territory has forested territories and plated forests
- Has areas of degraded soil (erosion) due to difficult terrain conditions, higher slopes
- The region suffers from a significant level of outmigration

Water use.

Table 16-2 Volume of irrigation water according to the plan of contracts and the level of payment collection for water delivery by the WUA of Gissar region (2020)

Name of Water Users Association (WUA)	Planned water volume, according to contracts, thousand m3	Actual water volume, thousand m3	Level of water supply, % of planned	Planned costs of irrigation water, according to contract thousands somoni	Cost of actual water volume, thousand somoni	Level of payment for water delivery to supplier, thousand somoni	Payment, as % of planned
Obi rahmat	6050,0	4800,0	79,7	115,9	84,9	59,5	70,1
Chashmai umed	5379,0	3365,0	62,6	95,2	59,6	35,8	59,9
Obi umed	9339,0	5025,0	53,8	165,3	88,9	66,9	75,3
Chashmai mekhr	4943,5	2900,0	58,6	87,5	51,3	43,3	84,4
Chashmai zam-zam	4569,4	3350,0	73,2	80,9	51,1	64,4	125,9
Rudhona	5610,0	4519,5	80,5	89,2	89,2	64,0	71,7
Shumon	8152,0	4300,0	52,7	144,3	76,1	33,9	44,5
Total	44043,0	28259,9	65,9	778,2	501,2	367,8	73,3

Source: Institutional data from the WUA of Gissar region (2020).

According to table 16 - 2, the whole Gissar region suffers from insufficient water supply where the actual water volume is much lower than planned. On the other hand, the payments for water are also lower than planned and approximately correspond to the proportion of actual water supply as computed to planned (with one exception of Chashmai zam-zam). According to these characteristics, Mirzo-rizo, as represented by "Obi rahmat" WUA, approximately correspond to the average for the region. The source of water supply in the jamoat is the Honako River; its length is 70 km, the source of the river is about 25 km. There are also some efforts to build local wells. Most of these wells are approximately 40-50 m deep. Thus, they take the water from the layers that are still renewable from the rain and snow.

Crop yields

Table 16-3 Area and yield of agricultural crops (WUAs).

Name of jamoat	Name of WUA	Main crops																	
		Cotton		Wheat		Vegetables		Melons		Corn for grain		Maize for silage		Alfalfa		Gardens and vineyards		Rice	
		Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha	Area, ha	Yield t/ha
Mirzo – Rizo	Obi rahmat	55	3,2	159	4	31	22	25	23	67	4,6	163	7,8	80	11,2	325	8,7	0	0
Navabad	Chashmai umed	400	3,2	125	4	87	19	5	23	60	4,6	100	7,8	68	12,7	246	9,1	1	5,2
M.Tursunzoda	Obi umed	40	3,7	103	4	39	19	10	23	30	4,6	103	8,1	120	12,7	328	8,3	0	0
Somon	Chashmai mekhr	40	3,1	150	4	74	17	38	23	34	4,6	250	7,8	50	9,8	170	7,8	0	0
Durbat/ Dekhkanabad	Chashmai zam-zam	300	3,6	196	4	77	22	3	23	30	4,6	100	8,2	131	11,8	84	8,7	1	4,8
Oriyon	Rudhona	80	3,5	300	4	3	16	2	23	1	4,6	1	7,8	3	9,2	66	6,7	32	3,1
Gissar	Shumon	40	3,5	98	4	46	19	9	23	30	4,6	98	8,1	36	10,8	103	7,2	16	5,2
Total by irrigation zones		955	3,4	1131	4	357	19,1	92	23	252	4,6		7,9	488	11,1	1322	8,1	50	2,6

Source: Institutional data from the WUA of Hissar region (2020).

From the table 16-3 follows that all the main crops except rice are planted in all the jamoats, however, the overall yields are rather low according to international standards.

16.3. Kuhistoni Mastchoh

Methodology

Jamoat selection

Selection criteria

- Population (more populous)
- Transport accessibility
- Agricultural production.
- Livestock small ruminants
- Availability of water (mountain springs, canals, wells)

Table 16-4 Area, population of jamoats in Kuhistoni Mastchoh district

№	Jamoats	Area, km2	Population, thousands of persons	Population density, per 1 km2 persons
1	Ivan Tajic	18,8	15,487	823,8
2	Langar	19,2	11,514	599,7

Source: passports of jamoats in Kuhistoni Mastchoh District

Table 16-5 The land balance in jamoats of Kuhistoni Mastchoh district, as of 01.01.2022 (ha)

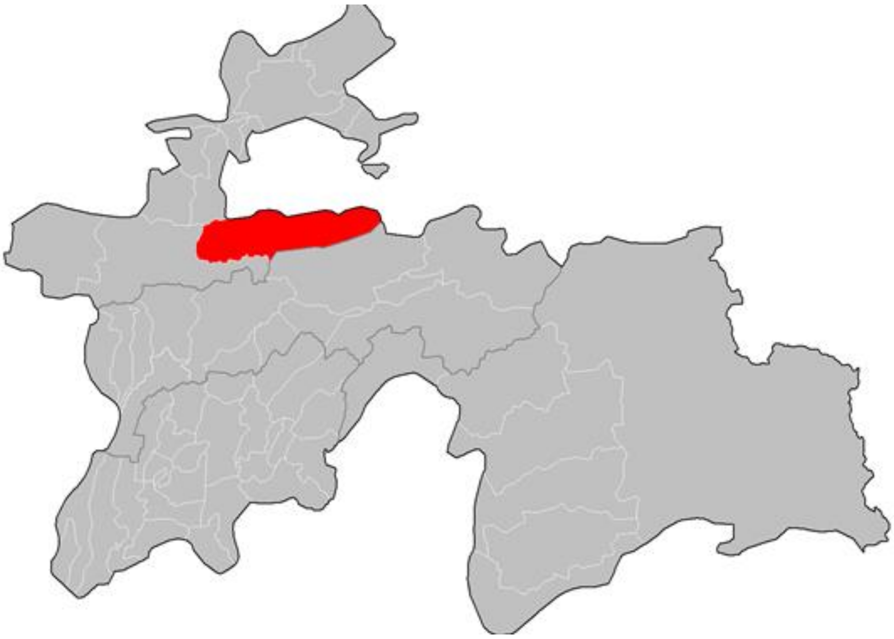
Indicators	Ivan Tajic	Langar
Total land area	1880	2339
Arable area	1409	1965
Irrigated arable land	1409	1965
Gardens	419	168
Household plots	224	180,04
Auxiliary lands of population	180	194

Source: Passports of Jamoats of Kuhistoni Mastchoh district

For the agricultural production see appendix 3. According to the indicators presented in tables 16-4 and 16-5 the jamoats are approximately equivalent. The choice was based primarily on the transport accessibility.

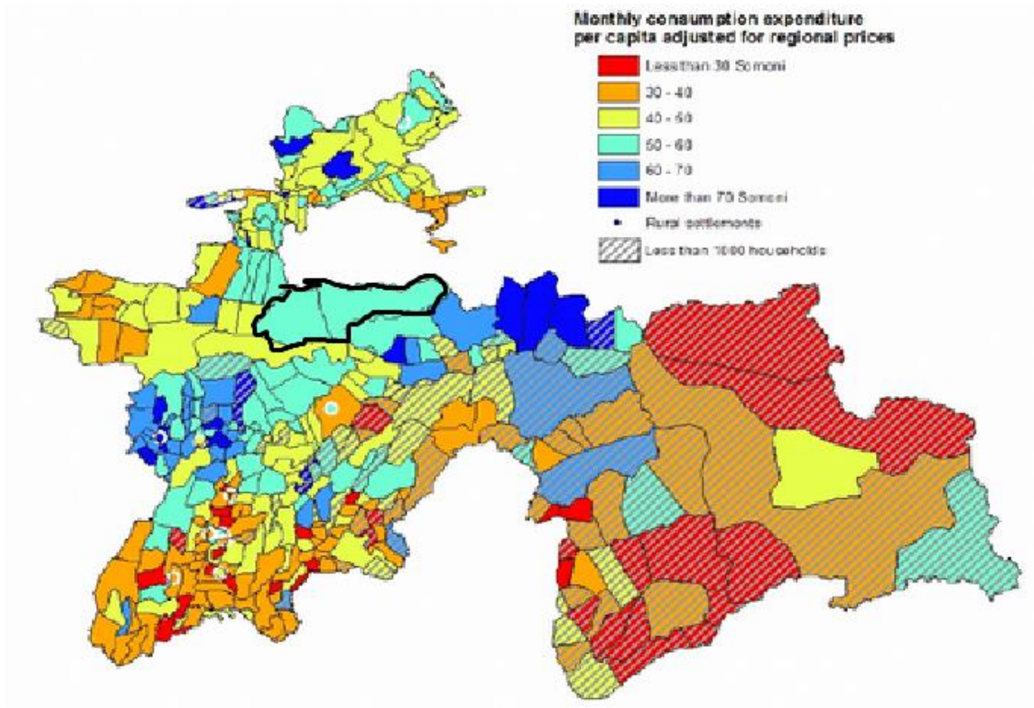
According to the criteria above the jamoat Ivan Tajic was chosen.

Figure 16-2 Kuhistoni Mastchoh district on the map of Tajikistan.



Source: CC BY-SA 3.0.

Figure 16-3 The poverty map of Tajikistan. The Kuhistoni Mastchoh district is one of the poorest districts with monthly consumption expenditures per capita between 50-60 somoni



Source: Baschieri and Falkingham, (2005).

According to the maps above, the district belongs to the middle to low-income districts in the region. Both of the jamoats fall approximately to the same income group. Thus, the selection needs to be based on the criteria other than income, such as described above.

16.4. Muminabad

Methodology

Methodologically this assessment relies on one focus group in the field and several expert interviews with the representatives of relevant organizations such as the agency of forestry, the representatives of water management (association of water users) and the local representatives of agriculture

The methodology of the focus group in the Muminabad district. The selection of jamoat

Selection criteria

- Population (most populous)
- Drainage and collector networks of the district
- Type of natural disaster that threats the jamoat
- Availability of irrigation water
- Area and productivity of agricultural crops
- Livestock (provision with livestock)

- Transport accessibility.

Selection method

- Statistical data
- Expert interview

According to these criteria the Nuralisho Nazar Jamoat was selected. The lists of participants of focus groups and interviews are presented in Appendix 4.

The statistical tables are presented below.

Table 16-6 Administrative division of the district.

№	Name of Jamoat	Number of villages	Distance to the regional centre (km)	Population (people, 2015)	Number of households
1	Jamoat Muminabad	18		13400	1815
2	N. Nazarova	28	5	15840	2171
3	Childukhtaron	47	25	6498	842
4	Dekhibaland	16	5	14362	1933
5	Boggai	16	12	11931	1410
6	Sh. Shohin	17	27	10769	1275
7	Balhobi	14	50	11500	1365

Source: Jamoat-level basic indicators, United Nations Development Programme in Tajikistan

Table 16-7 Drainage and collector networks of the district

№	List of Jamoats	Total, drainage and collector networks, km	Including			
			On the balance of water supply institutions in the district, km	Including cleaned, km	In rural jamoats, km	Including
						Open, km
1	Dehibaland	17,4	10,4	4,3	7,0	17,4
2	**N. Nazarova**	**15,22**	**9,6**	**3,9**	**5,6**	**15,3**
3	Boggai	10,58	6,0	3,5	4,6	10,58
4	Sh. Shohin	8,3	2,0	1,2	3,6	8,3
5	Balhobi	2,5	1,0	0,5	1,5	2,5
6	Muminabad	2,3	-	-	2,3	2,3
7	Childukhtaron	-	-	-	-	-
	Total:	56,3	29,0	13,4	27,3	56,3

Source: Program of socio-economic development of Muminabad region for 2016-2020.

Table 16-8 List of natural disasters threatening villages

Rural jamoats	Village	Type of threatening process
Jamoat Muminabad	S. Nazarova Street	Mudflow
	D. Rumi Street	Mudflow
	A. Firdavsi Street	Mudflow
	A.Rakhimov Street	Mudflow
Jamoat N. Nazarova	Gesh	Mudflow and landslides
	Sadbargo	Mudflow
	Margaki Ubara	Mudflow and landslides
	Lichaki bolo	Mudflow
	Tichoro	Mudflow and landslides
	Kulchashma	Mudflow
	Momandiyon	Mudflow
	Dehlolo	Mudflow and landslides
	Guliston	Mudflow
Jamoat Childukhtaron	Chavzodara	Mudflow
	Degrez	Mudflow and landslides
	Safedband	Landslides
Jamoat Boggai	Khuchai Nur	Landslides
	Shaimiri	Mudflow
	Sarsiblock	Landslides
	Yakkachinor	Mudflow
	Chorvodor	Mudflow
	Sanghdrai ubara	Mudflow
	Chukkurak	Landslides
Jamoat Sh. Shohin	Obodon	Mudflow
	A. Rudaki	Mudflow
	Tutu	Mudflow
	Chashmai Chushon	Mudflow
	Sanghdarai bolo	Mudflow
	Sangdarai poyon	Mudflow
Jamoat Balhobi	Balhobi	Mudflow
	Momirak	Mudflow
	Tuto	Mudflow
	Bogi Habib	Mudflow
	Tebalai	Mudflow
	Garabdara	Mudflow and landslides
	Shululu	Mudflow and landslides
Jamoat Dehbaland	Fayzabad	Mudflow
	Hanatarosh	Mudflow
	Sarmaidon village	Mudflow
	Shulduk	Mudflow
	Dehbaland	Mudflow

Source: Program of socio-economic development of Muminabad region for 2016-2020.

16.5. Shaartuz

Methodology

Methodologically this assessment relies on expert focus group and expert interviews. The interview took place in the building of the executive authority (Hukumat) of Shaartuz district. 19.03.2022. The list of participants is presented in appendix 4.

Criteria for selecting jamoats

- In order to assess the costs and benefits of adaptation to climate change in agriculture, forestry and water management in Tajikistan, we selected in each district (Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad) according to a certain methodology structured interview, for example one pilot jamoat, which is considered the most representative (characteristic) settlement with accessible means of transport at district level. In the course of the analysis the following main indicators and criteria were taken into account:
    - ✓ The most populated jamoat;
    - ✓ Area of irrigated land and availability of pastures;
    - ✓ Availability of drinking and irrigation water;
    - ✓ Forest and forest plantation strips and areas;
    - ✓ Area and yield of crops;
    - ✓ Number of farms and average area per farmer;
    - ✓ Number of sharecroppers per farm;
    - ✓ Level of livestock production.

Methods for selecting jamoats

- Statistics;
- Expert interviews;
- Focus group interviews;

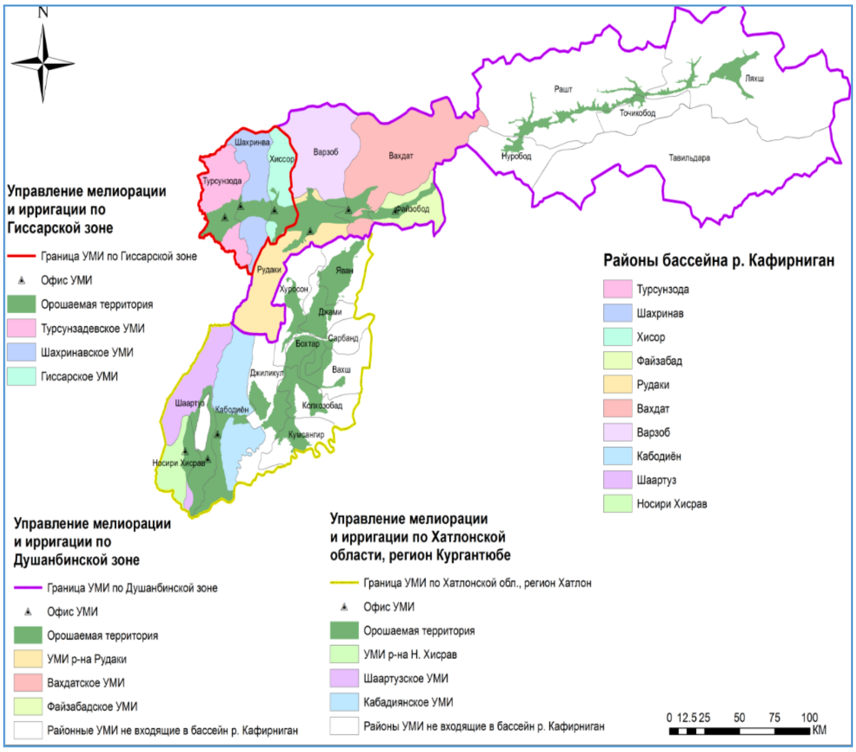
Structured interviews, questionnaire

- Interviews in each district were conducted with representatives of: 1) farms; 2) Forestry; 3) Land Reclamation and Irrigation Agency (management and use of water resources); 4) Water Users Association; 5) Chairman of Village Jamoats; 6) Representatives of Committee on Environment; 7) Committee on Emergency Situations and Civil Defence; 8) Experts of district weather station, also representatives of NGOs, agricultural communities, ministries, etc.

Geographic location and climate

Shaartuz district is located in the valley of the Kafirnigan River, the right tributary of the Pyandj. In the north it borders with Surkhandarya region of Uzbekistan, in the east - with Kubodiyon district, in the west - with Nosiri-Khusrav district of Khatlon region of Tajikistan, in the south - with the district of Khulm of Balkh province of Afghanistan.

Figure 16-4 Map of the location of land reclamation and irrigation departments in the Kafirnigan River basin (source BRL report, vol. 3, 2017)



Preliminary selection criteria, as well as analysis and evaluation of jamoats are shown in Table 16-9. From the data in Table 16-9 on the above selection criteria of jamoats show that more appropriate jamoat at the level of Shaartuz district is jamoat "Ayvanj".

Table 16-9 Institutional data (profile) of the Shaartuz WUA

No	Name of Jamoat	Name of WUA	Households ' number	Average number of people in household	Number of households led by women	Total population	Irrigated land. Ha					Number of members of WUA		Number of derghan farms on the territory of WUA				Irrigated area (derghan farms)		
							Total	including												
								Area under crops	Presidential lands	Household plots	Other lands (seed growing, fish farming, research institutes, etc.)	Total persons	From which women	Total	Total headed by women	<30ha	>30 ha	total	<30 ha	>30 ha
1.	X. Kholmatov	Navruz	3460	6	23	20760	2098	1384	198	498	18	196	8	196	8	189	7	1384	1137	247
2.	**<u>У. Aivodzh</u>**	**<u>Nazarov</u>**	**<u>3190</u>**	**<u>5</u>**	**<u>7</u>**	**<u>15950</u>**	**<u>1304</u>**	**<u>1278</u>**	**<u>10</u>**	**<u>16</u>**		**<u>156</u>**	**<u>12</u>**	**<u>156</u>**	**<u>12</u>**	**<u>151</u>**	**<u>5</u>**	**<u>469</u>**	**<u>320</u>**	**<u>149</u>**
3.	X. Kholmat	Khochai Chom	2130	6	21	12780	1270	854	94	307	15	151	17	151	17	147	4	854	729	125
4.	Sayyod	Sayyod	2270	5	19	11350	1556	985	217	354	0	196	37	196	37	190	6	985	573	412
5.	Ч. Nazarov	Dusti	1560	5	25	7800	1413	624	72	224	493	101	5	101	5	98	3	624	500	124
6.	Obsharon	Vatan - 1	2310	4	12	9240	1335	1100	54	87	94	158	3	158	3	152	6	1247	1058	189
7.	X. Kholmatov	Karakul	1380	5	14	6900	717	554	103	60		94	3	94	3	85	9	501	350	151
8.	Pakhtaobod	Tartki	1050	5	10	5250	743	420	45	151	127	164	8	164	8	159	5	480	308	172
9.	Pakhtaobod	Karashuvok	3000	4	13	12000	1400	1200		200		416	3	416	3	403	13	1180	755	425
10.	Pakhtaobod	Sultonobod	2310	6	3	13860	709	500		85	124	131	12	131	12	124	7	520	303	217
	Total		**22660**	**5**	**147**	**115890**	**12545**	**8899**	**793**	**2732**	**871**	**1763**	**108**	**1763**	**108**	**1698**	**65**	**8244**	**6033**	**2211**

Table 16-10 Water use. Volume of irrigation water according to the plan of contracts and the level of collection of funds for water delivery by WUA in Shaartuz district (2021)

Name of WUA	**Water volume, thousand m3**		**Water supply level, %**	**Cost of irrigation water volume, according to the contract plan,**	**Cost of actual volume of water, thousand somoni**	**The level of payment for water supply to the supplier,**	**Payment from the plan the cost of water,**
	Plan, according to agreements	Actual volume		thousand somoni		thousand somoni	%
Navruz	16727	7981	48	334,5	159,6	55	34
Ajvodzh	11910	3136	26	238,2	62,7	44	70
Hochai Chom	9928	5523	56	198,6	110,5	39	35
Sajyod	10905	5675	52	218,1	113,5	45,2	40
Dusti	8706	4182	48	174,1	83,6	38	45
Vatan - 1	4683	2599	55	93,7	52	38,2	73
Karakul	8625	4233	49	172,5	84,7	23	27
Tartki	8227	4159	51	164,5	83,2	36,2	44
Karashuvok	12400	5576	45	248	111,5	56,2	50
Sultonobod	6615		48	334,5	159,6	55	34

It should be noted that at present in each district the main indicators are the activities of WUAs and all projects from the first to assess their activities before implementation to determine the nature of employment for sustainable agriculture and water resources management.

Table 16-11 Indicators of agricultural crop yields in the Aivanj jamoat, Shaartuz district for 2000-2020

Year	Cotton			Wheat			Vegetables			Melons			Corn grain			Forage			Orchards and vineyards			Rice		
	Area, ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha	Area , ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha	Area, ha	Production amount, ton	Yield, t/ha
2000	695	1946	2,8	120	300	2,5	90	2088	23,2	185	6586	35,6	80	896	11,2	35	94,5	2,7	25	70	2,8	26	65	2,5
2001	750	1875	2,5	118	259,6	2,2	95	2451	25,8	213	8179,2	38,4	68	775,2	11,4	32	96	3	26	80,6	3,1	22	61,6	2,8
2002	758	1819,2	2,4	125	350	2,8	98	2381,4	24,3	215	7869	36,6	89	1121,4	12,6	35	98	2,8	30	81	2,7	26	75,4	2,9
2003	765	1606,5	2,1	132	356,4	2,7	96	2716,8	28,3	208	8798,4	42,3	76	1185,6	15,6	33	95,7	2,9	33	105,6	3,2	28	86,8	3,1
2004	780	1404	1,8	136	353,6	2,6	100	3540	35,4	206	9393,6	45,6	78	1224,6	15,7	38	117,8	3,1	35	98	2,8	24	72	3
2005	785	1805,5	2,3	115	322	2,8	102	3692,4	36,2	200	8920	44,6	85	1360	16	36	115,2	3,2	40	132	3,3	23	64,4	2,8
2006	745	1639	2,2	112	291,2	2,6	110	4213	38,3	215	9954,5	46,3	83	1369,5	16,5	31	102,3	3,3	40	140	3,5	23	66,7	2,9
2007	740	1554	2,1	116	313,2	2,7	113	4779,9	42,3	216	9849,6	45,6	75	1222,5	16,3	32	112	3,5	43	163,4	3,8	21	67,2	3,2
2008	730	1460	2	118	330,4	2,8	115	5209,5	45,3	234	11442,6	48,9	80	1136	14,2	36	129,6	3,6	43	180,6	4,2	21	69,3	3,3
2009	610	1403	2,3	123	344,4	2,8	118	5758,4	48,8	248	12697,6	51,2	95	1596	16,8	30	135	4,5	44	211,2	4,8	18	63	3,5
2010	550	1540	2,8	112	347,2	3,1	120	5232	43,6	350	18305	52,3	93	1348,5	14,5	38	159,6	4,2	45	225	5	18	64,8	3,6
2011	735	1837,5	2,5	132	382,8	2,9	123	6297,6	51,2	270	13716	50,8	90	1512	16,8	31	127,1	4,1	45	234	5,2	20	68	3,4
2012	725	1885	2,6	118	377,6	3,2	125	6325	50,6	260	12558	48,3	88	1496	17	35	133	3,8	46	220,8	4,8	25	82,5	3,3
2013	700	1960	2,8	116	371,2	3,2	128	6054,4	47,3	235	10927,5	46,5	85	1326	15,6	33	118,8	3,6	46	197,8	4,3	25	75	3
2014	715	2145	3	115	368	3,2	117	5300,1	45,3	225	10170	45,2	85	1241	14,6	34	119	3,5	48	187,2	3,9	23	78,2	3,4
2015	723	2024,4	2,8	108	334,8	3,1	118	5262,8	44,6	220	9306	42,3	80	1136	14,2	37	118,4	3,2	48	220,8	4,6	29	95,7	3,3
2016	728	1747,2	2,4	113	327,7	2,9	122	5270,4	43,2	218	9112,4	41,8	82	1131,6	13,8	35	108,5	3,1	50	235	4,7	30	93	3,1
2017	720	2232	3,1	114	342	3	120	4944	41,2	210	8400	40	83	1128,8	13,6	36	108	3	50	225	4,5	28	89,6	3,2
2018	715	2002	2,8	120	336	2,8	118	4531,2	38,4	213	8221,8	38,6	80	1040	13	34	95,2	2,8	55	214,5	3,9	31	89,9	2,9
2019	713	1782,5	2,5	117	292,5	2,5	123	4083,6	33,2	208	7425,6	35,7	79	1003,3	12,7	35	94,5	2,7	58	243,6	4,2	33	89,1	2,7
2020	718	1866,8	2,6	116	278,4	2,4	125	3950	31,6	205	6724	32,8	75	937,5	12,5	35	87,5	2,5	58	208,8	3,6	29	75,4	2,6

Source: Annual reports of Shaartuz district Agricultural Department

Table 16-12 Characteristics of the existing irrigation and collector-drainage network and their specific indicators in Shaartuz district

№	Name	Unit	Shaartuz Districts
1.	Land reclamation and irrigation management:		
	Total employees	person	70
	including: management personnel	person	18
	Irrigated area	ha	18504
	line staff	person	52
2.	Hydrographic production areas		
	Amount	pcs	3
	Workers	person	23
3.	Water User Associations		
	amount	pcs	10
	Irrigated area served by WUA	ha	13932
4.	Pumping stations		
	Amount	pcs	4
	Irrigated area	ha	4608
	Workers	person	26
5.	Inter-farm channels		
	Length	meter	291620
	Specific length	meter/ha	21,86
	Irrigated area	ha	18504
6.	On-farm channels		
	length	meter	431811
	Specific length	meter/ha	32,37
	Irrigated area	ha	18504
7.	Collector-drainage network		
	Length	meter	222222
	Specific length	meter/ha	19,66
	Drained area	ha	11303

Table 16-13 Characteristics of existing irrigation and collector-drainage network and their specific indicators in rural Jamoat "U. Nazarov" WUA "Ayvonj" Shaartuz district

Jamoat name	WUA name	Length, km		Quantity, pcs	
		On-farm irrigation network	KDS	GTS	Irrigation pumping stations
H. Holmatov	Navruz	70,4	3,7	33	3
U. Nazarov	Ajvodzh	28,4	59,7	40	4
H. Holmat	Hochai Chom	71,4	12,5	38	1
Sajyod	Sajyod	60,9	58,51	123	5
CH. Nazarov	Dusti	29,1	89,7	35	

Jamoat name	WUA name	Length, km		Quantity, pcs	
		On-farm irrigation network	KDS	GTS	Irrigation pumping stations
Obshoron	Vatan - 1	126,3	76,26	216	
H. Holmatov	Karakul	72,5	17,7	42	
Pahtaobod	Tartki	51	7,2	25	1
Pahtaobod	Karashuvok	37,6	21,3	30	3
Pahtaobod	Sultonobod	49	0	20	5
Total		596,6	346,57	602	22

Comparative analysis of the indicators of our pilot jamoat "U. Nazarov" shows that their irrigated area varies from 1072 to 1304 ha, the total length of irrigation canals is 28.4 km, the number of collector drainage networks is 8-17 pieces, and their total length is 59.7 km.

For example, in WUA "Sultonobod" rural Jamoat "Pakhtabod" Shaartuz district, where irrigated area is 709 ha, number of irrigators is 66 pcs or 67 pcs/1000 ha, total length of irrigators is 49 km or 41.01 m/ha. From the conducted comparative analysis, it follows that where the irrigated area is 2.5 times less, for the specific indicators of the length of irrigators is about two times higher. This shows that the uniform water distribution is very low.

Analysis of the data in Table 16-13 shows that the number of hydraulic structures located in the area does not depend on the size of the irrigated area.

WUA's aims and objectives WUA was established in order to control conservation, use of on-farm irrigation and drainage systems under joint and individual use, equitable, effective, timely water distribution among its members and other water users, collection of water supply payment, resolution of disputes between members and other water users on water distribution and use.

The main tasks of WUA are:

- ● monitoring contractual relations with water management departments to supply water to WUA' service areas from sources;
- ● participation in management of irrigation systems in WUA' service area and water distribution on contractual terms between members of WUA and those who are not members.
- ● monitoring and control over maintenance, rehabilitation, repair and improvement of irrigation systems in the WUA' service area;
- ● control over acquisition, installation, replacement and maintenance of hydrotechnical equipment in the WUA' service area;
- ● Participation in accounting of volume and quality of used water, submission of statistical reports to authorized state bodies on regulation and use of water

- ● control over water saving and prevention of water pollution within WUA' service areas implementation of measures on effective use, protection and improvement of land reclamation state;
- ● participation in organization of training of members and other water users in water saving methods of irrigation and use of new irrigation technique and technology;
- ● Settlement of disputes arising during water use between WUA's members and other water users.

16.6. Kanibadam

Methodology

For the qualitative assessment was based on one focus group and semi-structured interviews. The lists of participants are presented in Appendix 4.

Jamoat selection

Selection criteria

- Population (more populous),
- Population density
- Territory
- Agricultural production.
- Soil types
- Irrigation options
- Climatic and geographical conditions (mountains, valleys and coastal locations)

According to these selection criteria, the jamoat Kuhandiyor was chosen.

Characteristics of jamoats.

Table 16-14 General characteristics of rural jamoats in Kanibadam district

№	Name of jamoats	Territory, km²	Population, thousand people.	Population density per 1 km ² man	Watering			Soil (in %)		Features of jamoats
					Channel system Watering (in %)	Pumping, approximate Watering (in %)	Well, pcs.	rocky	clay	
1	Patar	33.1 km²	20,6	622,4	78	22	16	13	87	Border Jamoat (bordering Uzbekistan)
2	Pulloton	59.9 km²	35,7	595,9	70	30	16	18	82	The most densely populated jamoat, located near the city of Kanibadam
3	Firuzoba	100.2 km²	27,2	271,5	90	10	44	28	72	Irrigation of the jamoat is totally dependent on irrigation water coming from mountain springs (via the Isfara River to the Ferghana Grand Canal
4	P. Khamraboev	101.02 km²	30,2	299	60	40	36	46	64	Jamoats are located in the middle of the district, have all types of soil and irrigation technology
5	Kuhandiyor	59.0 km²	27,6	467,8	45	55	18	43	67	
6	Lochut	61.6 km²	22,4	363,6	20	80	12	45	55	Jamoat is located near the Bakhri Tojik (Kayrakkumskoe) reservoir

Source: Passports of the jamoats of Kanibadam district

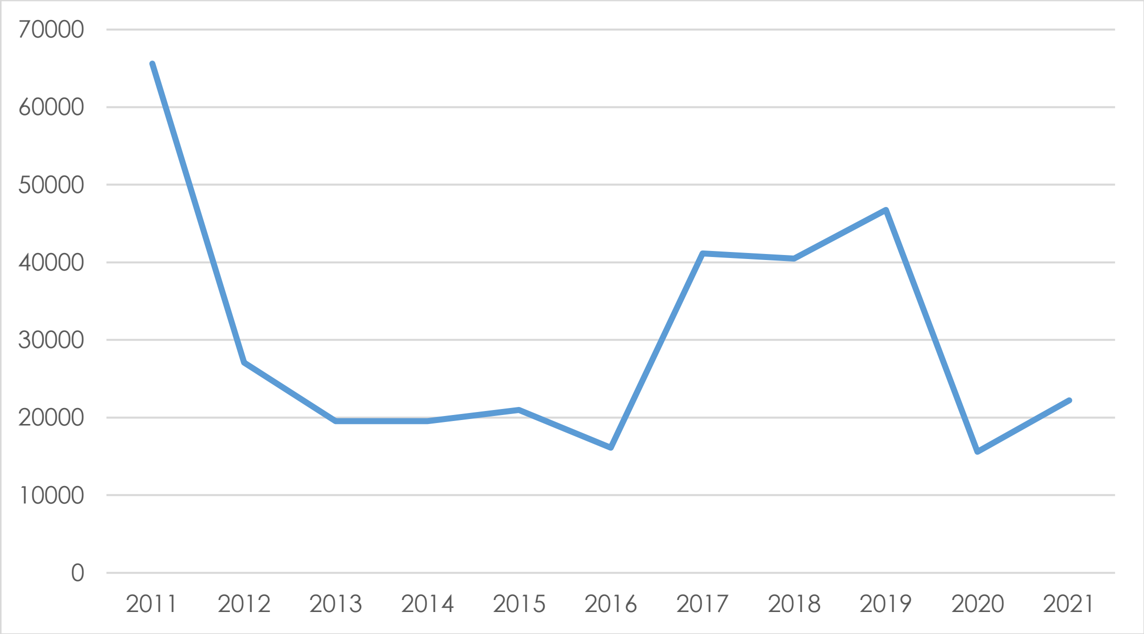
Kuhandiyor, brief description

The jamoat is located in the Middle of the district, have all types of soils and irrigation technologies. Channel and mechanized irrigation (pumps) technologies are represented approximately 50x50 %. However, the irrigation with pumps suffers from the low voltage electricity in summer. Similarly, to the whole district, forests are insignificant and virtually non-existent (see section The Impact of the Climate Change on Forestry in Tajikistan). Area with no irrigation is virtually non-existent and forms only 5% of the area. The most frequent natural disasters that cause damage to farmland include mudflows, abnormal frosts and heat waves. The extreme winds create dust storms.

While agricultural production forms the most important part of income for inhabitants, part of the agricultural land has been taken out of use due to the increase salinity of the land. According to the soil structure the region represents all the soil types present in the district.

Water for irrigation comes from two main sources: Karakum reservoir and Big Fergana Canal. If unavailable, wells are being built. However, the water from wells increases soil salinity and leads to making land unusable for agricultural production. Moreover, the wells run very deep (up to 120-140 m), where the water does not recover from precipitation. Thus, after water in exhausted, the wells necessarily shut down.

Figure 16-5 Water supply through the Big Fergana Canal to Kanibadam district (thousand m3)



Data source: Yearbooks of Kanibadam district.

The main problem of the agriculture in jamoat and district is the lack of irrigation water. In the times of drought, the water supply from the Fergana Canal decreases. In part this is caused by drought. The other part is caused by increased water use in Kyrgyzstan, leaving Tajikistan less water resources. The water from the Karakum reservoir is not sufficient for the district, neither it is distributed to the whole district.

The Water User Association is created in the district, however, when water is scarce, it does not perform its duties effectively, as farmers have significant incentive to cheat and use the water without permit.

The districts possess significant amounts of spare land, however, these lands could hardly be used for agricultural production as it is drying up and no additional water is available.

Table 16-15 Information on the land use by jamoat in Kanibadam district, as of 01.01.2022 (ha)

Indicators	**Patar**	**Pulloton**	**Firuzoba**	**P. Khamraboev**	**Kuhandiyor**	**Lochuti**	**Total**
Total land area	2047,17	6170,93	8521,78	10154,78	8761,46	3312,58	38968,7
Including: arable land	906,43	1153,56	2218,17	1859,46	1964,09	638,39	8740,1
Perennial plantations	699,67	3502,18	1355,21	1948,07	2007,51	2243,66	11756,3
Including: Stone Fruit	690,04	3385,59	1355,21	1880,94	1985,19	2127,29	11424,26
Vineyard	0,78	13,04	1,45		6,96	54,8	77,03
Mulberry	7,97	101,55	17,97	66,72	14,46	61,07	269,74
Subtropics				0,41		0,5	0,91
Under the deposits		2					2
Other perennial plantings	0,88				0,63		1,51
Pastures			1661,01	1005,54	1337,3	60	4063,85
Total agricultural land	1606,1	4655,74	5234,39	4813,07	5308,9	2942,05	24560,25
Woodland and bushland	2,44	13,25	2,28	6,27	6,57		30,81
Open drains underwater land	253,38	385,24	500,21	495,49	437,09	128,45	2199,86
Roads	35,22	120,05	82,62	42,35	74,84	39,51	394,59
Land for construction	8,92	117,79	94,77	24,61	23,44	16,1	285,63
Other lands	141,11	325,68	2607,51	4772,99	2910,51	186,47	10944,27

Source: Annual reports of the Kanibadam District Agricultural Department

Table 16-16 Yields of main crops by jamoat in Kanibadam district (c/ha)

№	Name of jamoats	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cotton												
1	Patar	22,2	23,4	22,3	15,7	16,9	15,6	21,2	17,3	21,3	25,0	13,2
2	Pulloton	23,8	19,8	24,8	21,0	8,3	4,4	22,1	27,3	22,9	29,6	16,7
3	Firuzoba	21,0	22,9	24,9	18,5	16,6	17,6	25,9	20,6	27,6	28,5	17,7
4	P. Khamraboev	20,2	24,6	24,2	17,9	22,4	21,6	24,3	22,4	22,8	21,8	16,2
5	Kuhandiyor	15,2	23,2	17,7	22,5	20,9	11,6	22,1	18,1	20,3	20,4	12,8
6	Lochutií	18,7	18,7	15,3	14,4	12,9	13,0	19,5	17,1	22,9	22,3	11,4
Wheat												
1	Patar	22,2	20,3	22,9	30,0	33,8	32,0	36,0	38,3	40,3	39,0	40,0
2	Pulloton	30,7	21,8	25,4	30,0	32,0	34,9	35,3	40,0	42,0	45,0	46,0
3	Firuzoba	24,2	20,2	23,8	32,7	30,0	29,7	35,4	40,3	37,5	35,6	46,9
4	P. Khamraboev	24,2	22,1	27,5	30,0	-	30,3	34,8	38,1	39,9	41,3	47,0
5	Kuhandiyor	21,3	20,1	20,8	26,7	28,0	33,0	35,4	35,7	38,0	38,2	39,3
6	Lochuti	24,9	26,0	18,5	20,0	25,9	34,0	35,0	35,0	38,0	39,8	39,3
Stone fruits												
1	Patar	5,8	3,8	4,4	6,0	5,7	20,0	0	11,7	28,0	27,7	11,3
2	Pulloton	28,3	8,6	8,9	27,2	31,0	25,8	27,3	21,7	29,1	29,4	14,9
3	Firuzoba	7,8	6,2	5,6	8,4	22,8	39,5	0	37,6	29,7	28,1	25,1
4	P. Khamraboev	6,3	8,8	9,7	7,9	10,1	16,5	22,8	30,4	22,4	22,4	22,4
5	Kuhandiyor	16,1	18,2	10,7	9,4	16,1	21,9	22,5	18,0	18,4	30,1	15,
6	Lochuti	9,3	13,0	9,0	11,8	9,7	20,7	17,3	22,7	28,2	26,3	6,4

Source: Annual reports, Kanibadam District Agricultural Department. In 2021 the crops were heavily affected by floods and mudflows.

Table 16-17 Dynamics of natural disasters affecting Kanibadam district (mudflows, abnormal frosts and heat waves that have damaged farmland)

№	Name of jamoats	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	Patar	3	-	-	-	1	4	-	2	1	2	1
2	Pulloton	2	-	4	2	3	5	-	2	-	3	-
3	Firuzoba	-	1	4	-	4	-	1	5	2	2	3
4	P. Khamraboev	1	-	3	5	-	5	1	2	-	4	2
5	Kuhandiyor	-	-	2	2	2	4	3	2	2	2	4
6	Lochuti	-	-	1	4	3	3	2	4	-	1	2

Source: According to the Kanibadam district office of the Ministry of Emergency Situations

Table 16-18 Dynamics of water supply through the Big Fergana Canal to Kanibadam district (thous. m³)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total for the district	65615	27111	19563	19538	20994	16112	41141	40483	46770	15598	22242
Patar	5851	7731	610	3289	963	3304	4772,4	5424,7	7483,2	2807,6	3892,3
Pulloton	6042,	6360	4274	5156	3710	4994,7	11684,0	7934,7	9494,3	3431,6	4670,8
Firuzoba	10003	5184	2599	2188	4562	3786,3	8063,6	8299,0	8746,0	3041,6	4137,0
P. Khamraboev	7459	4346	3134	4577	4756	3593	10902,4	11335,2	11926,3	3681,1	5871,9
Kuhandiyor	5003	1519	3856	3918	4890	386,7	5183,8	4250,7	6267,2	1497,4	2290,9
Lohuti	6294	599	3573	410	341	48,3	5348	3238,3	2946,5	1138,6	1379,0
Digar						-	-	-	-	-	-

Source: Annual reports of the Kanibadam District Mellerage and Water Authority, all sites.

Table 16-19 Water availability in Kanibadam district through the Grand Fergana Canal (in %)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total for the district	73,2	73,0	64,4	64,0	48,5	66,1	59,3	52,7	46,7	60,4
Patar	78,9	75,5	74,7	70,6	69,8	71,2	72,6	70,9	68,6	75,5
Pulloton	82,5	80,0	92,5	90,0	71,0	84,4	88,0	77,5	53,2	60,0
Firuzoba	90,0	85,6	77,4	78,5	60,0	65,6	70,1	54,4	57,4	63,3
P. Khamraboev	74,6	71,5	70,0	69,4	45,4	54,5	60,6	43,5	40,9	43,5
Kuhandiyor	45,5	50,7	46,7	45,7	34,0	40,9	44,5	50,9	51,3	52,5
Lochuti	27,8	24,0	25,5	30,0	11,0	14,5	20,0	18,9	8,9	15,6

Source: Calculations based on annual reports from the Department of Melling and Water Management and the Kanibadam Land Committee

Table 16-20 Ranking of jamoats in Kanibadam district by geography

	Population (area seat)	**Territory (area seat)**	**Gustan population**	**Hydro irrigation options**	**Soil properties and structure**	**Level of infrastructure development**	**Climatic and geographical Coverage of the region (mountains, valley and reservoir coastline)**	**Total**
Patar	6	6	1	2	3	3	4	25
Pulloton	1	4	2	4	4	1	3	19
Firuzoba	3	5	3	5	5	5	5	31
P. Khamraboev	2	1	5	3	2	4	2	19
Kuhandiyor	4	2	6	1	1	2	1	17
Lochuti	5	3	4	6	6	6	6	36

Note: the rank corresponds to the place if the jamoat in the district according to the criteria above.

According to the points in the table above Kuhandiyor jamoat was selected for the focus group analysis.

16.7. Fayzabad

Methodology

Methodologically this assessment relies on focus group conducted by the authors of the current study in rural jamoat "Buston" of Fayzabad district, 12.04.2022. The focus group was conducted in the building of the jamoat of Fayzabad district. In addition, we rely on a number of expert interviews, and the results of a focus group with farmers conducted by the World Food Program (2016) and the local representatives of agriculture. The lists of the respondents are presented below

Criteria for selecting jamoat

In the course of the analysis the following main indicators and criteria were taken into account:

- The most populated jamoat;
- Area of irrigated land and availability of pastures;
- Availability of drinking and irrigation water;
- Forest and forest plantation strips and areas;
- Area and yield of crops;
- Number of farms and average area per farmer;
- Number of sharecroppers per farm;
- Level of livestock production.

Methods for selecting jamoats:

- ✓ Statistics;
- ✓ Expert interviews;
- ✓ Focus group interviews;

Structured interviews

Interviews in each district were conducted with representatives of: 1) farms; 2) Forestry; 3) Land Reclamation and Irrigation Agency (management and use of water resources); 4) Water Users Association; 5) Chairman of rural Jamoats; 6) representatives of the Committee on Environment; 7) Committee on Emergency Situations and Civil Defence; 8) specialists of the district weather station, as well as representatives of NGOs, agricultural communities, ministries, etc.

Geographical position and climate

Territory of the region amounts to 1171.5 sq.km. According to the existing administrative-territorial division, Fayzabad district is part of the Rayons of Republican Subordination of the Republic of Tajikistan. Fayzabad district is located in the Rasht valley, 60 kilometres east of Dushanbe. It borders with Vahdat district in the north and west, with Rogun district in the east, and with Nurek district of Khatlon region in the south.

Fayzabad district belongs to the districts of republican subordination of Tajikistan and is located in the central part of the country. Its northern part is spread out in the Gissar valley, while the rest of the territory is occupied by the Gissar range. The Vakhsh River serves as the border with Khatlon Province. Through the district passes the East Pamir highway, which leads from Dushanbe to Gorno-Badakhshan Autonomous Oblast.

Nature

At 50 kilometres east of Dushanbe is located Booston rural jamoat. It should be noted that the area covers an area of 1.17 thousand sq. km. and is located within the Rashtan valley, the eastern part of the district is located in the foothills of the Karategin range. Climatic conditions in the area are sharply continental and arid. Significant remoteness from large water masses predetermines the increased dryness of air during the whole calendar year.

Table 16-21nstitutional data on rural jamoats Fayzabad district

№	Name of jamoat	Population, thousand	Area (ha)	Number of derkhan farms	Irrigated area (ha)
1	Fayzabadskij gorodok	12327			
2	Dustmurod Aliev	15355	8043	799	589
3	Buston	9947	2138	568	940
4	Mekhrabad	13501	4525	611	364
5	Vashgird	6578	2111	91	116
6	Dzhavonon	15087	5276	476	544
7	Kal'ai Dasht	13586	7565	275	622
8	Chashmasor	8812	2970	574	189
9	Miskinabad	19333	2451	297	106

The climate of rural jamoat "Buston" is sharply continental, arid with large values of solar radiation and temperature variations. The average annual air temperature in the western part of the jamoat (valley) is 14°C, and in the eastern part (foothills) 7.6°C. Absolute maximum air temperature is observed in July (30°-39.2°C), minimum is observed in January (-19°C). There are sharp diurnal fluctuations in air temperature. The amplitude of the annual fluctuations of absolute air temperatures reaches 58°C. This indicates that the climate of the territory is distinctly continental. Winters in the territory of the jamoats are short and rather mild, but there are severe frosts that reach up to 26°C. The average height of snow cover is 16-26 cm, the maximum is 30 cm, and in the eastern part of the area reaches up to 70 cm. The average duration of the period with negative temperatures does not exceed 40-50 days per year. Distribution of atmospheric precipitation by seasons of the year is uneven. The rainiest month is March, the driest month is August. The average annual amount of precipitation is 700-1370 mm. Relative humidity is 40% on average, rising to 70-80% in February and May. Humidity deficit reaches up to 20-22 mbar in summer and decreases to 3-6 mbar in winter. Snow cover is retained for 2-3 months and reaches a maximum height of 0.5 m. Snow falls between October and February.

17. References

1. Alford, D., Kamp, U. & Pan, C. (2015). Europe and Central Asia - Assessment of the role of glaciers in stream flow from the Pamir and Tien Shan mountains. *World Bank*, GWADR, Report No ACS12128, Washington D.C.

2. Aliev, F. (2016). Agricultural production, welfare and food security under climate change in Tajikistan. *Institute of Agricultural Development in Transition Economies (IAMO) Samarkand Conference 2016, November 2-4, Samarkand, Uzbekistan*. https://ideas.repec.org/p/ags/iamc16/250089.html

3. Ambinakudige, S., & Joshi, K. (2015). Multi-decadal changes in glacial parameters of the Fedchenko Glacier in Tajikistan. *International Journal of Advanced Remote Sensing and GIS*, *4*(1), 911.

4. Bann, C., R. Shukurov, L. Boziev, and D. Rakhmatova (2012). *The Economics of Land Degradation for the Agriculture Sector in Tajikistan – A Scoping Study*. United Nations Development Programme and United Nations Environment Programme.

5. Beck, H., Zimmermann, N., McVicar, T. (2018). Present and future Köppen-Geiger climate classification maps at 1-km resolution. Sci Data 5, Article 180214. https://doi.org/10.1038/sdata.2018.214

6. Beniston, M. (2003). Climatic change in mountain districts: a review of possible impacts. *Climatic Change*, 59, 5–31.

7. Bobojonov, I., & A. Aw-Hassan (2014). Impacts of Climate Change on Farm Income Security in Central Asia: An Integrated Modeling Approach. *Agriculture, Ecosystems and Environment*, 188, 245–55. DOI: http://doi.org/10.1016/j.agee.2014.02.033

8. Broka, S. (2016). *Tajikistan: Agricultural Sector Risk Assessment*. World Bank Group. http://documents.worldbank.org/curated/en/395161468196164557/pdf/103077-WP-TJ-P154004-Box394863B-PUBLIC-ASRA.pdf

9. CABAR - Central Asian Bureau for Analytical Reporting (2021). *Why are Tajikistan's glaciers melting and how dangerous is it for us?* https://cabar.asia/en/why-are-tajikistan-s-glaciers-melting-and-how-dangerous-is-it-for-us

10. CAREC (2013). *Adapting to Climate Change in Most Vulnerable Sectors of Central Asia: Water and Agriculture*. Regional Environmental Centre for Central Asia under Asia Pacific Adaptation Network. http://www.asiapacificadapt.net/sites/default/files/resource/attach/apan-carec-policy-brief-adapting-to-cc-in-vulnerable-sectors-feb-2013.pdf

11. CBR - The Central Bank of the Russian Federation (2016). *Bank of Russia Annual Report for 2015*. http://www.cbr.ru/collection/collection/file/8315/ar_2015_e.pdf

12. CCKP (2020) *Country: Tajikistan. Climate Change Knowledge Portal for Development Practitioners and Policy Makers*, World Bank Group. https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

13. Christmann, S., & Aw-Hassan, A. (2011). Should agricultural research in Central Asia and Caucasus (CAC) re-prioritize its agenda with view to climate change. *Agriculture, ecosystems & environment*, 140,314–316

14. Christmann, S., & Aw-Hassan, A. A. (2015). A participatory method to enhance the collective ability to adapt to rapid glacier loss: The case of mountain communities in Tajikistan. *Climatic Change*, *133*(2), 267-282.

15. Climate change knowledge portal (2022). *Tajikistan*. https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-projections

16. Climate Risk Country Profile: Tajikistan (2021). *The World Bank Group and the Asian Development Bank*. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-09/15919-WB_Tajikistan%20Country%20Profile-WEB.pdf

17. Closset, M., Dhehibi, B. B. B., & Aw-Hassan, A. (2015). Measuring the economic impact of climate change on agriculture: A Ricardian analysis of farmlands in Tajikistan. *Climate and Development*, 7(5), 454–468. https://doi.org/10.1080/17565529.2014.989189

18. CRED (2022). EM-DAT. The international disasters database. https://www.emdat.be/

19. CRG-NAST - Center for Research of Glaciers of the National Academy of Sciences of Tajikistan (2022). The necessity to protect and preserve glaciers in modern times. Department for Monitoring glaciers, Cryosphere, Glaciology and GIS technology, https://www.cryosphere.tj/en/2022/02/09/the-necessity-to-protect-and-preserve-glaciers-in-modern-times/

20. DGRT - Decree of the Government of the Republic of Tajikistan (2019). *National strategy for adaptation to climate change of the Republic of Tajikistan for the period up to 2030*. http://extwprlegs1.fao.org/docs/pdf/taj190980.pdf

21. Duulatov, E., Chen, X., Amanambu, A.C., Ochege, F.U., Orozbaev, R., Issanova, G. and Omurakunova, G. (2019). Projected Rainfall Erosivity Over Central Asia Based on CMIP5 Climate Models. *Water*, 11(5), p. 897. DOI: https://doi.org/10.3390/w11050897

22. EM-DAT (2022). *CRED - The international disasters database*. https://www.emdat.be/

23. FAO - Food and Agriculture Organization of the United Nation (2008). *Climate Change and Food Security: A Framework Document* http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf

24. FAO - Food and Agriculture Organization of the United Nation (2018). *Small Family Farming in Tajikistan - a country specific outlook*. http://www.fao.org/family-farming/detail/en/c/1128092
25. FAO - Food and Agriculture Organization of the United Nation (2021). *The Environmental Land Management and Rural Livelihoods Project in Tajikistan*. https://www.Fao.org/in-action/epic/projects/ex-act-past-projects/tajikistan/en/

26. Fay, M., R. I. Block, and J. Ebinger (2010). *Adapting to Climate Change in Eastern Europe and Cental Asia*. Washington, DC: World Bank. DOI: http://doi.org/10.1596/978-0-8213-8131-1

27. Food and Agricultural Organization. (2022). *Food Balances* (2010-). Food Balances (2010-). https://www.fao.org/faostat/en/#data/FBS

28. Food and Agriculture Organization of the United Nations. (2017*). ClimAfrica: Climate change predictions in Sub-Saharan Africa : impacts and adaptations*.

29. Food Security and Poverty (2018). *Statistical Agency under President of the Republic of Tajikistan* 3-2018. https://www.stat.tj/en/welfare-of-the-population

30. Gan, R., Luo, Y., Zuo, Q., & Sun, L. (2015). Effects of projected climate change on the glacier and runoff generation in the Naryn River Basin, Central Asia. *Journal of Hydrology*, *523*, 240-251.

31. Government of Tajikistan (2012). *Programme for Reforming the Agriculture Sector of the Republic of Tajikistan for 2012–2020*. http://moa.tj/wp-content/Program_Taj_Rus_Eng_ready.pdf

32. Government of Tajikistan (2016). *National Development Strategy of the Republic of Tajikistan for the Period up to 2030*. Dushanbe: Government of Tajikistan. https://nafaka.tj/images/zakoni/new/strategiya_2030_en.pdf

33. Gulahmadov, N., Chen, Y., Gulakhmadov, A., Rakhimova, M., & Gulakhmadov, M. (2021). Quantifying the relative contribution of climate change and anthropogenic activities on runoff variations in the central part of Tajikistan in central Asia. *Land*, *10*(5), 525. DOI:10.3390/land10050525

34. Heltberg, R., & M. Bonch-Osmolovskiy (2011). Mapping Vulnerability to Climate Change. Policy. *World Bank*, Article 5554, DOI: http://doi.org/10.1596/1813-9450-5554 http://documents.worldbank.org/curated/en/884801468330915595/pdf/WPS5554.pdf

35. Heltberg, R., and M. Bonch-Osmolovskiy (2011). Mapping Vulnerability to Climate Change. *Policy Research Working Paper No. 5554*. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/884801468330915595/pdf/WPS5554.pdf DOI: http://doi.org/10.1596/1813-9450-5554

36. Heltberg, Rasmus, Anna Reva, and Salman Zaidi (2012). *Tajikistan – Economic and Distributional Impact of Climate Change*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/10047

37. Hijioka, Y., (2014). *Asia.* In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, M. Chatterjee, et al. (eds.), 1327–70. Cambridge: Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap24_FINAL.pdf

38. Huang, J., Ji, M., & Xie, Y. (2016). Global semi - arid climate change over last 60 years. *Climate Dynamics*, 46(3), 1131–1150. https://link.springer.com/article/10.1007/s00382-015-2636-8

39. Huang, J., Yu, H., Guan, X., Wang, G., & Guo, R. (2016). Accelerated dryland expansion under climate change. *Nature Climate Change*, 6(2), 166–171. https://www.nature.com/articles/nclimate2837

40. IFAD. (2019). CARD - *User guide* (2019). IFAD. https://www.ifad.org/documents/38714170/41085512/Card_usermanual_W.pdf/e867a16c-e581-8038-aa6f-1767a10629a3?t=1554123066000

41. IMF - International Monetary Fund (2005). *Republic of Tajikistan: Selected Issues and Statistical Appendix*. IMF Country Report No. 05/131. DOI: http://doi.org/10.5089/9781451837056.002

42. IMF - International Monetary Fund (2010). *Republic of Tajikistan: Poverty Reduction Strategy* Paper. Washington, DC: International Monetary Fund.

43. Inouye, D. (2009). The effects of climate change on the phenological interactions of plants and pollinators. *Nature Proceedings*, 1-1. DOI:10.1038/npre.2009.3583.1

44. International Food Policy Research Institute (IFPRI). (2019). *IMPACT Projections of Food Production, Consumption, and Hunger to 2050, With and Without Climate Change: Extended Country-level Results for 2019* GFPR Annex Table 5 [Data set]. Harvard Dataverse. https://doi.org/10.7910/DVN/BMPQGN

45. Jägermeyr, J., & Frieler, K. (2018). Spatial variations in crop growing seasons pivotal to reproduce global fluctuations in maize and wheat yields. *Science Advances*, 4(11), eaat4517. https://doi.org/10.1126/sciadv.aat4517

46. Kayumov, A., & V. Novikov (Eds) (2014). The Third National Communication of the Republic of Tajikistan under the UN Framework Convention on Climate Change. State *Administration for Hydrometeorology, and Committee on Environmental Protection under the Government of the Republic of Tajikistan.* https://unfccc.int/sites/default/files/resource/tjknc3_eng.pdf

47. Khakimov, P. & Aliev, J. & Thomas, T. & Ilyasov, J. & Dunston, S., (2020). Climate Change Effects on Agriculture and Food Security in Tajikistan, *Silk Road: A Journal of Eurasian Development* 2(1), p.89–112. doi: https://doi.org/10.16997/srjed.33

48. Khakimov, P. (2015). *The Impact of Changes in Macroeconomic Conditions on the Agricultural Sector of Tajikistan*. Gottingen: Cuvillier Publishing House.

49. Khakimov, P., and M. Mahmadbekov (2009). *Republic of Tajikistan: Environmentally Induced Migration – Case Study Report*. Bonn: United Nations University Institute for Environment and Human Security.

50. Khakimov, P., Aliev, J., Timothy S., Ilyasov, J., & Dunston, S. (2020). Climate change effects on agriculture and food security in Tajikistan. *Silk Road: A Journal of Eurasian Development*, 2(1), 89–112. https://doi.org/10.16997/srjed.33

51. Kure, S., Jang, S., Ohara, N., Kavvas, M. L., & Chen, Z. Q. (2013). Hydrologic impact of regional climate change for the snowfed and glacierfed river basins in the Republic of Tajikistan: hydrological response of flow to climate change. *Hydrological Processes*, *27*(26), 4057-4070. DOI: 10.1002/hyp.9535

52. Kure, S., Jang, S., Ohara, N., Kavvas, M. L., & Chen, Z. Q. (2013). Hydrologic impact of regional climate change for the snowfed and glacier fed river basins in the Republic of Tajikistan: hydrological response of flow to climate change. *Hydrological Processes*, 27(26), 4057-4070. DOI: 10.1002/hyp.9535

53. Leng, G., & Hall, J. (2019). Crop yield sensitivity of global major agricultural countries to droughts and the projected changes in the future. *Science of The Total Environment*, 654, 811–821. https://doi.org/10.1016/j.scitotenv.2018.10.434

54. Lerman, Z., and Wolfgramm, B. (2011). Vulnerability to Risk among Small Farmers in Tajikistan: Results of a 2011 Survey. *The Center for Agricultural Economic Research Discussion Paper No. 8.11*. Jerusalem.

55. Li, Z., Chen, Y., Li, W., Deng, H., & Fang, G. (2015). Potential impacts of climate change on vegetation dynamics in Central Asia. *Journal of Geophysical Research: Atmospheres*, 120(24), 12345–12356. DOI: https://doi.org/10.1002/2015JD023618

56. Liu, B., Asseng, S., Müller, C., Ewert, F., Elliott, J., Lobell, D. B., Martre, P., Ruane, A. C., Wallach, D., Jones, J. W., Rosenzweig, C., Aggarwal, P. K., Alderman, P. D., Anothai, J., Basso, B., Biernath, C., Cammarano, D., Challinor, A., Deryng, D., Zhu, Y. (2016). Similar estimates of temperature impacts on global wheat yield by three independent methods. *Nature Climate Change*, 6(12), 1130–1136. https://doi.org/10.1038/nclimate3115

57. Loboda, T. V, Giglio, L., Boschetti, L., & Justice, C. O. (2012). Regional fire monitoring and characterization using global NASA MODIS fire products in dry lands of Central

Asia. *Frontiers of Earth Science*, 6(2), 196–205. https://link.springer.com/article/10.1007/s11707-012-0313-3

58. Luo, Y. (2018). Contrasting streamflow regime induced by melting glaciers across the Tien Shan – Pamir – North Karakoram. *Nature – Scientific Reports*, 8. Article 16470. https://www.nature.com/articles/s41598-018-34829-2

59. Main Administration on Hydrometeorology and Environmental Pollution Monitoring & Ministry for Nature Protection of the Republic Tajikista*n* (2003). *NAPRT - National Action Plan of the Republic Tajikistan for Climate Change Mitigation.* https://unfccc.int/resource/docs/nap/tainap01e.pdf

60. Makhmadaliev, B.A. (2008). *The Second National Communication of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change*. Dushanbe: State Agency for Hydrometeorology of the Committee for Environmental Protection. http://unfccc.int/resource/docs/natc/tainc2.pdf.

61. Met Office Hadley Center, and WFP (2019). *Food Insecurity & Climate Change*. https://www.metoffice.gov.uk/food-insecurity-index/
62. Müller, C., & R. D. Robertson (2014). Projecting Future Crop Productivity for Global Economic Modeling. Agricultural Economics 45(1), 37–50. DOI: http://doi.org/10.1111/agec.12088

63. NAPRT (2003). *National Action Plan of the Republic Tajikistan for Climate Change Mitigation.* Main Administration on Hydrometeorology and Environmental Pollution Monitoring & Ministry for Nature Protection of the Republic Tajikistanhttps://unfccc.int/resource/docs/nap/tainap01e.pdf

64. Orlov, A., Daloz, A. S., Sillmann, J., Thiery, W., Douzal, C., Lejeune, Q., & Schleussner, C. (2021). Global Economic Responses to Heat Stress Impacts on Worker Productivity in Crop Production. *Economics of Disasters and Climate Change*, 5(3), 367–390. https://doi.org/10.1007/s41885-021-00091-6

65. OSCE - Organization for Security and Co-operation in Europe (2021). *Overview of emergency situations in the republic of Tajikistan for 2020.* https://www.osce.org/files/f/documents/4/5/503953.pdf

66. OSCE (2010). *Climate Change Survey in Tajikistan*. Dushanbe: Organization for Security and Co-operation in Europe.

67. Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). *Climate change 2007-impacts, adaptation, and vulnerability: Working group II contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

68. Pfefferle, N., Zolly, M., Bierkandt, R. (2020). Climate Change Profile: Tajikistan. *Deutsche Gesellschaft für Internationale Zusammenarbeit*. https://reliefweb.int/report/tajikistan/climate-change-profile-tajikistan

69. Pritchard, H. D. (2019). Asia's shrinking glaciers protect large populations from drought stress. *Nature*, *569*(7758), 649-654.

70. Rasmus, H., and Bonch-Osmolovskiy, M., (2011). Mapping Vulnerability to Climate Change. *Policy Research*, Article 5554. World Bank. http://documents.worldbank.org/curated/en/884801468330915595/pdf/WPS5554.pdf DOI: http://doi.org/10.1596/1813-9450-5554

71. Rasmus, H., Reva, A., & Zaidi, S. (2012). *Tajikistan – Economic and Distributional Impact of Climate Change*. World Bank. https://openknowledge.worldbank.org/handle/10986/10047

72. Reyer, C. P. O., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M, Stagl, J. (2017). Climate change impacts in Central Asia and their implications for development. *Regional Environmental Change*, 17(6), pp. 1639–1650. DOI: https://doi.org/10.1007/s10113-015-0893-z

73. Rosegrant, M. W., & the IMPACT Development Team (2012). *International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description*. International Food Policy Research Institute.

74. SNC-TJK (2008). *The second national communication of the Republic of Tajikistan under the United Nations framework convention on climate change*. The Government of the Republic of Tajikistan, The State Agency for Hydrometeorology Committee for environmental protection under the Government of the Republic of Tajikistan [http://unfccc.int/resource/docs/natc/tainc2.pdf

75. Sommer, R., M. Glazyrina, T. Yuldashev, A. Otarov, M. Ibraeva, L. Martynova (2013). Impact of climate change on wheat productivity in Central Asia. *Agriculture, Ecosystems & Environment*, 178, 78–99. https://geoagro.icarda.org/downloads/publications/papers/Sommer_et_al_2013_Impact_of_climate_change_on_wheat_productivity_in_Central_AsiaR.pdf

76. Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). *Nature Climate Change*, 2(10), 725-731.

77. Stat.tj. (2022b). *Foodstuff consumption per capita*, 1991-2020. https://stat.tj/en/database-real-sector

78. TajStat (2009). *Labor Force Survey*. Agency on Statistics under the President of the Republic of Tajikistan. https://www.stat.tj/en/

79. TAJSTAT (2009). *Labour Force Survey* Dushanbe: Agency on Statistics under President of the Republic of Tajikistan.

80. TajStat (2010). *Agriculture Sector in Tajikistan*. Agency on Statistics under the President of the Republic of Tajikistan. https://www.stat.tj/en/

81. TajStat (2015a). *Agriculture Sector in Tajikistan*. Agency on Statistics under the President of the Republic of Tajikistan. https://www.stat.tj/en/

82. TajStat (2015b). *Labor Market in Tajikistan*. Agency on Statistics under the President of the Republic of Tajikistan. https://www.stat.tj/en/

83. TAJSTAT (2018). *Food Security and Poverty No.3 2018.* Statistical Agency under President of the Republic of Tajikistan. https://www.stat.tj/en/

84. TajStat (2022). *Statistical Agency under the President of the Republic of Tajikistan*. https://www.stat.tj/en/

85. The State Agency for Hydrometeorology Committee for environmental protection under the Government of the Republic of Tajikistan (2008). *SNC-TJK The second national communication of the Republic of Tajikistan under the United Nations framework convention on climate change*. http://unfccc.int/resource/docs/natc/tainc2.pdf

86. The World Bank Group and the Asian Development Bank (2021). *Climate Risk Country Profile: Tajikistan*. https://www.adb.org/publications/climate-risk-country-profile-tajikistan

87. UNDESA (2015). *World Population Prospects: The 2015 Revision*. New York: Population Division, Department of Economic and Social Affairs of the United Nations.

88. UNECE (2012). *Environmental Performance Reviews: Tajikistan (Second Review)*. New York and Geneva: United Nations Economic Commission for Europe. https://www.unece.org/fileadmin/DAM/env/epr/epr_studies/TajikistanII.pdf (accessed 30 October 2020).

89. UNFCCC (2022). *The updated NDC of The Republic of Tajikistan* https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Tajikistan%20First/NDC_TAJIKISTAN_ENG.pdf

90. USAID (2016). *Tajikistan-Property Rights and Resource Governance Profile*. https://www.land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Tajikistan_Profile.pdf

91. Water for Life Conference (2015). General Information about Tajikistan. *Water for Life Conference, 8–10 June 2015, Dushanbe*, Tajikistan.

92. World Bank (2007). *Integrating Environment into Agriculture and Forestry: Tajikistan Country Review*. Washington, DC: World Bank.

93. World Bank (2016). *The World Development Indicators.* Washington, DC: World Bank. http://datatopics.worldbank.org/world-development-indicators/wdi-archives.html

94. World Bank (2019). *Tajikistan Data Set*. Open Data Platform. https://data.worldbank.org/country/tajikistan

95. World Bank (2022). *Agriculture, forestry, and fishing, value added (% of GDP) - Tajikistan* https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=TJ

96. World Bank Group – CCKP (2020). *Country: Tajikistan.* Climate Change Knowledge Portal for Development Practitioners and Policy Makers. https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

97. World Bank Group, & Asian Development Bank. (2021). *Climate Risk Country Profile: Tajikistan*. World Bank.

98. World Bank. (2019). Open Data Platform. *Tajikistan Data Set*. https://data.worldbank.org/country/tajikistan

99. World Bank. (2021). *Tajikistan Agrifood Sector and Public Expenditure Review*. World Bank. https://doi.org/10.1596/35972

100. World development indicators (2022). https://databank.worldbank.org/source/world-development-indicators

101. Zaripova, M. (2018). *Tajikistan Disaster Risk Profile*. Emergency and Disaster Reports, 5(3), 2-46 https://dialnet.unirioja.es/servlet/articulo?codigo=7912140

102. Zhang, G., Biradar, C. M., Xiao, X., Dong, J., Zhou, Y., Qin, Y., Thomas, R. J. (2018). Exacerbated grassland degradation and desertification in Central Asia during 2000–2014. *Ecological Applications*, 28(2), 442–456. URL: https://pubmed.ncbi.nlm.nih.gov/29205627/

103. Zholdosheva, E., Ruchevska, I., Semernya, L., Dairov, I., Kozhakhmetov, P., Barieva, A. , Maskaev, A., Mitrofanenko, T., Alekseeva, N. (2017). *Adaptation to climate change in the mountainous regions of Central Asia. Series of Reviews on Adaptation in Mountain Areas*. UN Environment, GRID-Arendal, RSCA. Nairobi, Vienna, Arendal, Bishkek. www.unep.org

104. Zhou, Y., Zhang, L., Fensholt, R., Wang, K., Vitkovskaya, I., & Tian, F. (2015). Climate Contributions to Vegetation Variations in Central Asian Drylands: Pre- and Post-USSR Collapse. *Remote Sensing*, 7(3), 2449–2470. https://doi.org/10.3390/rs70302449