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Khojabakirgan Watershed
WATERSHED PROFILE
Tajikistan - Sughd Region - B. Gafurov & J. Rasulov District
December 2023

Source: Google Earth, 2023

STREAM Sustainable | Equitable | Inclusive
acted
international alert
IMPACT Shaping practices Influencing policies Impacting lives

Contents

Data Source Disclaimer

The following report is a product of the analysis of data from the following three sources:

- Official statistical data published by the Agency of Statistics Under the President of the Republic of Tajikistan.
- Detailed desk reviews of research conducted in 2014, 2015, and 2023 by Acted under the SDC-funded, “National Water Resources Management | Tajikistan,” project.
- Open-source data on the internet, including all satellite imagery for hazard exposure analysis.

Official boundaries for Local Self- Government (LSG) administrative areas and water network data were obtained from the SDC project, and have been used in previous studies.[1]

It should be noted that the watershed boundaries for the Hydrological Watershed Analysis and Watershed Hazard Analysis differ slightly; the Watershed Analysis considers only the geologic features relevant to the Khojabakirghan river’s waterflow, while the Watershed Hazard Analysis includes settlements, land, and canals which use the water from the river in addition to its distinct geologic features.

No other proprietary data has been used. All data is presented as percentages, or otherwise presented in a way to obscure the actual original values to limit the re-printing of official data as much as possible.

This report from the project is made possible by the support of the American people through the U.S. Agency for International Development (USAID). The contents are the sole responsibility of ACTED and do not necessarily reflect the views of USAID or the United States Government.

This project is financed by Federal Republic of Germany through the PATRIP Foundation and KfW.

This document has been produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of IMPACT Initiatives and Acted and can under no circumstances be regarded as reflecting the position of the European Union.

1. Acted, Helvetas, GIZ, National Water Resources Management in Tajikistan: Summary Report on Main Findings and Conclusions of the Disaster Risk and Watershed Assessment of the Khojabakirghan/KHoja-Bakirgan Watershed, August 2015.

Executive summary

Water resource management of the Syr Darya River basin in the Fergana valley remains one of the region's greatest challenges, as the nations of Kyrgyzstan, Tajikistan, and Uzbekistan have struggled to manage the complex water systems of the Syr Darya river basin in the absence of a long-term common regulatory framework.[2] In the absence of such a framework, increasing population, greater reliance on irrigation agriculture, and the development of hydro power in the Valley have put additional strain on water resources. At the same time, water in the river basin is dwindling due to changing patterns of precipitation and melting glaciers as a result of climate change.[3]

In order to help address these challenges, in 2022, Acted, IMPACT and International Alert, with the support of USAID, launched the STREAM project to support natural resources management in local, watersheds of the greater Syr Darya River basin that passes through the Fergana Valley. The STREAM project uses an evidence-based approach to identify the watersheds most at risk to resource strain, and then seeks to develop a comprehensive understanding of the main challenges to effective resource management within the most at-risk watersheds, which is used to inform a tailored road map of intervention.

A key outcome of this project is this watershed profile, which examines key hazards to the watershed's population regarding water availability, and its impacts on agricultural and pasture lands. The profile outlines the major hazards, including natural hazards, climate change, and anthropogenic causes, alongside existing structures and methods set up by local governments and communities to manage such hazards. The research work relies on the extensive use of GIS analysis, including remote sensing hazard analysis and river basin modeling. These findings are triangulated with quantitative data from local government sources, supplemented by government statistical data and other secondary reports.

The findings have been analysed by Acted and International Alert and jointly developed into recommendations for improved watershed management to more effectively respond to climate change and other challenges, and to produce a road map outlining a plan for project implementation to address the above-mentioned key issues.

2. Global Water Partnership, Integrated water resources management in Central Asia: The challenges of managing large trans-boundary rivers, Technical Focus Paper, 2014
3. Zoinet, Environment and Security: Transforming risks into cooperation: Central Asia: Fergana / Osh / Khujand area, 2005

Analysis of water discharge data found the volume of water to have decreased 40% over the last 12 years, with water shortages reported to be more common the further down the river the community was located. The melting of the glaciers during wet seasons and associated declines in water levels during growing and harvest seasons that make up the river's source and increasingly irregular precipitation levels were reported to be the main reasons for this.

Aging and corroded water and irrigation infrastructure was reported to be the main reason for water loss in communities reliant on irrigation water. Water User Associations (WUAs) and local authorities lacked the resources to make sufficient repairs on their own. Water loss from the aging infrastructure was estimated by Acted studies under its SDC grant to be anywhere from 21% - 40%, depending on the infrastructure location.

Groundwater was used as a stop-gap to fill most of the noted gaps caused by declining or irregular surface water and precipitation levels. Groundwater was already reported to account for up to 69% of all water used for irrigation purposes in the watershed. While this is an adequate short-term solution, aquifers are projected to deplete by 2045, making more comprehensive water management solutions a major priority.

The local economy is tightly tied to agricultural output, which is primarily reliant on major cash crops like cotton, rice, and cereal grains. The proportion of the population working in agriculture increased almost 15% between 2017 and 2022 in Gafurov district, and represents 3/4th of all livelihoods in J. Rasulov district. Declines in water availability and regularity are, without sustainable solutions, likely to have major effects on the local economy and livelihoods at a macro level.

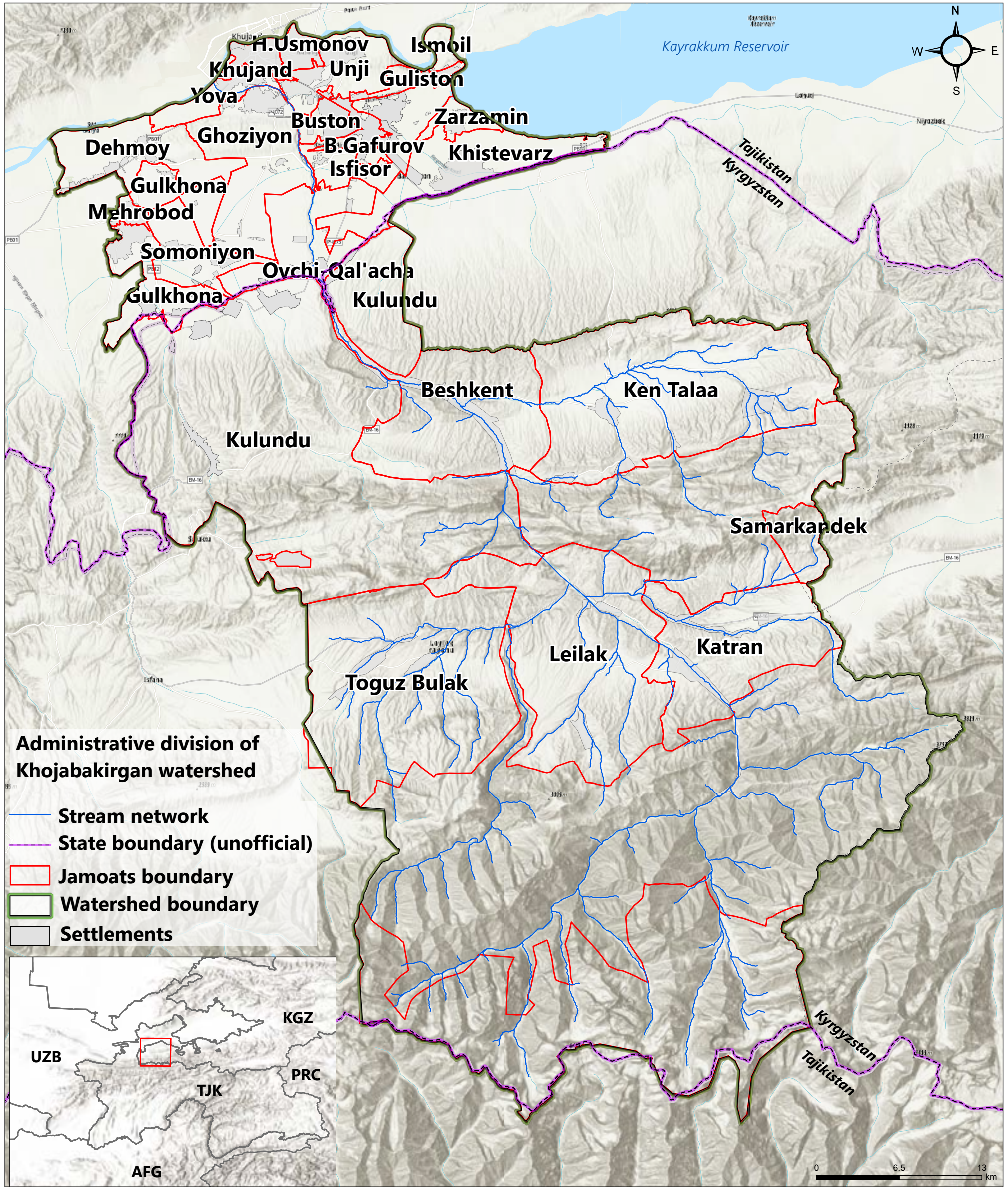
The cultivation of water intensive crops like cereal grains, rice, and cotton are likely contributing to water shortages. The shift to less resource intensive crops and adoption of water saving technologies like drip irrigation can help to reduce the overall need for large amounts of water which are likely to become unsustainable in the medium to long term.

Nearly 70% of pastureland has completely or partially degraded, and more is at risk of further degradation. This is mainly due to failures of herders to follow formal scheduling, increasing numbers of livestock overgrazing land capacity, and a shift in livestock migration patterns due to traditional pasture lands becoming inaccessible, putting greater pressure on the existing pastureland and fallow agricultural lands to meet the populations needs.

The assessment found most communities to be both vulnerable and unprepared for natural hazards like floods or drought. While awareness by local authorities and community leadership of risks is high, communities lack financing for disaster resilient infrastructure, and key pockets of the population and infrastructure are highly exposed to major natural shocks.

Women's representation in natural resource management structures was limited, but has increased as more male family members migrate outside the country for work. However, due to long-term disenfranchisement, women are less likely than men to contribute household income to or participate in local resource management processes. Increased capacity building aimed at increasing women's presence and participation in WUAs and other institutions can help to increase overall agricultural productivity and climate change resilience in the watershed. As women remain among the most affected by climate change, primarily due to their traditional roles in collecting water, this can have a major effect in improving women's livelihoods.

Map 1: Location of Khojabakirghan Watershed in the Fergana Valley, June 2023[a]



Watershed overview

Khojabakirghan watershed is a watershed located in B. Gafurov and J. Rasulov Districts, Sughd Region of Tajikistan. As of September 2023, the watershed features:

Region	Sughd	
District	**Bobojon (B.) Gafurov**	**Jabbor (J.) Rasulov**
Local Self Governments (LSGs)	11 (Dadabai Khomatov, Haidar Usmonov, Histevarz, Isfisor, Ismoil, Ovchi-Kalacha, Unchi, Yowa, Yoziyon, Zarzamin, Chashmashoor)	4 (Gulakandoz, Gulhona, Somoniyon, Dekomoy)
Villages	91	17
Oblast Capital	Gafurov	Mejrobod
Households	57,980	14,441
Individuals	408,753	81,222

Background

The Fergana Valley has one of the most complex water systems in the world.[4] Climate change, population growth, and a lack of multi-lateral resource management mechanisms have led to a situation of increased pressure for water and arable land while the resources needed to sustain them shrink.[5]

The Khojabakirghan watershed is one of the most under-stress watersheds in the valley. Located at the end of the Syr Darya river basin, the Khojabakirghan's 120km long river-source comes from snow and glacial melt in the Turkestan Mountain range. Melting and freezing cycles of the glaciers have accelerated due to climate change in recent years, disrupting seasonal water flow patterns and causing the water supply to dwindle and come later in the year.[6]

In order to improve the Natural Resource Management (NRM) of water resources in the watershed, IMPACT conducted the following assessment examining the effects of different hazards on the availability of water and associated land resources in Khojabakirghan watershed.

4. Zoinet, Environment and Security: Transforming risks into cooperation: Central Asia: Fergana / Osh / Khujand area, 2005
5. ibid.
6. Special eurasia, Kyrgyzstan and Tajikistan_ causes and analysis of an endless border dispute, 29 September 2022.

a) River data was provided by Acted from an earlier 2015 analysis by HYDROC. Watershed boundary is from HYDROC 2015, and modified by IMPACT and Acted to account for irrigated areas in the north of the watershed. Administrative LSG Boundaries are from previous Acted research conducted under SDC.

Methodology overview

The objective of this profiling assessment was to provide an in-depth understanding on the function and challenges of natural resource management. This included factors contributing to overuse or stress of natural resources and natural hazard threats in key watersheds of the Fergana Valley. This information would be used to inform the STREAM project on how to best implement infrastructure and capacity-building activities to improve NRM in the watershed.

To answer this, the following key research questions were asked:

1. What is the current exposure that populations in transboundary watershed face regarding NRM, including threats from climate change, natural hazards, and anthropogenic causes, and how are their impacts likely to affect water resources in the future?

2. How do local governance structures manage key resources, including water allocation, agricultural land use, and pasture management?

3. What are the main challenges faced by local governments to effective NRM in the watershed, in regard to resource management, conflict mitigation, and land use practices?

4. What policy recommendations and recommended road map of implementation should development actors follow to support improved natural resource management in the watershed?

To accomplish this, IMPACT, with the support of Acted and IA, used a mixed-method approach to assess each watershed:

- A satellite imagery analysis using open-source data on key risks to population and agricultural land areas from the Global Facility for Disaster Reduction and Recovery (GFDRR) was used to assess each watershed across an assortment of hazard exposure, to priority key areas.

- After the selection of the most at-risk watersheds, IMPACT conducted a detailed profiling of each watershed, to understand the population susceptibility to different hazards and their likely affects on both population and infrastructure in the watershed. This included the following:

  - Desk review based on secondary data collection, and direct data collection obtained from third parties and government, examining how resources were managed and how different hazards impacted the population.

  - Detailed GIS hydrological modeling of the watershed and satellite imagery analysis of different hazards to assess the overall susceptibility to different hazards on different areas of the watershed and environmental processes.

  - A detailed assessment of local dispute resolution by International Alert to assess contributing factors and dispute resolution for communities within the watershed for natural resource mechanisms.

Analysis overview

In order to ensure that STREAM resources were used to maximize the project's impact, IMPACT first conducted a rapid assessment of all 16 trans-boundary watersheds of the Fergana Valley. Following an extensive desk review of previous research of resource challenges within the Fergana Valley, IMPACT identified 6 main hazards that were likely to impact the availability of water and associated resources in each watershed.

All hazards were selected in line with the United Nations Office for Disaster Risk Reduction (UNDRR)[7] Hazard definition & classification review of global hazards index. Each hazard was examined on its own, and then aggregated into their respective hazard groups, defined in the UNDRR. Each hazard was given a weight to account for some hazards having a larger contribution than others to the overall impact of the hazard grouping on both population and agriculture exposure to the hazards.

Each hazard group and its population's hazard exposure were then in turn weighted based on their importance in affecting the availability of water in each watershed. This was used to calculate a single, "Water Stress Index" indicator indicating the overall level of water stress for the watershed. Ultimately, the Khojabakirghan watershed (Kyrgyzstan/Tajikistan) was selected. From this point, all assessment activities focused only on this prioritised watershed.

Hydrological Watershed Analysis

IMPACT conducted a Hydrological Watershed Analysis (HWA) modelling of the Khojabakirghan River Basin using a Soil & Water Assessment Tool (SWAT).[8] This model uses elevation, soil, meteorological, and water discharge data to build a scale model of a river basin to track and predict environmental impact of land use, land management and climate change on the watershed. IMPACT's GIS specialists developed the SWAT model using open source meteorological data (precipitation and temperature), Digital Elevation Model (DEM) data, land use data, and soil quality data. This was combined with the average monthly water discharge data recorded at key points in the watershed to produce a full model of flow, soil erosion, precipitation, and sedimentation.

Watershed Hazard Analysis

IMPACT also conducted additional remote sensing analysis of the population susceptibility to key hazards that populations and agricultural land in each watershed is vulnerable to. The exact hazards assessed are listed on Table 1 on the following page.

Specialized models using GIS and remote sensing tools for exposure to each hazard were developed by the IMPACT team based on previous research.[9] Data and methodologies used for each hazard are shown in Annex 1. Where secondary data was available, IMPACT triangulated each analysed hazard map with pre-existing risk maps to ensure accuracy.[10] The geospatial data was further triangulated with other secondary sources and

7. UNDRR, Hayard definition & classification review (Technical Report), 2020.

8. Texas A&M University, SWAT Input Data: Overview, 2023.
9. IMPACT Ukraine, Area Based Risk Assessment, Bakhmut Raion, Donetska Oblast, Eastern Ukraine, August 2020.
10. Kyrgyzstan National Water Resource Authority, Geoinformation Portal about Water of the Krygyz Republic, 2023.

primary data collection, both detailed below.

Table 1: Hazard classification according to UNDRR assessed in watershed risk analysis

Hazard group	Hazard
Climate change	Precipitation change Temperature change
Meteorological & Hydrological	Drought
Geohazards	Debris flow/Mudflows Flooding Landslides Earthquakes
Environmental	Pasture degradation
Technological	Industrial hazards
Societal	Disputes

Desk Review

In order to triangulate information from the primary data collection and geospatial analysis, IMPACT conducted an extensive desk review of existing literature. This included previous reports on NRM in the Fergana Valley, as well as academic papers and policy briefs. This was done both before, during, and after the primary data collection and geospatial analysis, both as a validation of existing data and to complete information gaps for Tajikistan. A non-exhaustive list of key resources consulted can be found in the list below, with the remainder listed in the referenced footnotes throughout the document.

Water, Peace and Security, Conflicts over water and water infrastructure at the Tajik-Kyrgyz border: A looking threat for Central Asia?
International Alert, The impact of climate change on the dynamics of conflicts in the trans-boundary river basins of Kyrgyzstan, Kazakhstan and Tajikistan, January 2022.
Centre of Development and Environment, Integrated watershed management in Tajikistan, March 2014.
Economic Commission of Europe, Strengthening Water Management and Trans-boundary Water Cooperation in Central Asia: The Role of UNECE Environmental Conventions, 2011
Blue Peace Central Asia, Climate Cryosphere-Water Nexus: Central Asia Outlook, 2018.
Zoinet, Environment and Security - Transforming risks into cooperation: the case of Central Asia, 2005.
WFP, Climate Risk and Food Security in the Kyrgyz Republic: An Overview on Climate Trends and the Impact on Food Security, 2014.
WFP, Climate Risks and Food Security in Tajikistan, 2017
Stucker, Kazebov, Yakubov, & Wegerich, Climate Change in a Small Trans-boundary Tributary of the Syr Darya Calls for Effective Cooperation and Adaptation, Mountain Research and Development, 2012.
University of Central Asia: Mountain Societies Research Institute, Sustainable Land Management in Kyrgyzstan and Tajikistan: A Research Review, 2013.
University of Central Asia: Mountain Societies Research Institute, Challenges of Social Cohesion and Tensions in Communities on the Kyrgyz-Tajik Border, 2018.

The statistical data and reports about the social and environmental aspects of the Khojabakirghan River sub-basin, obtained through previous Acted research conducted under its SDC project, were analysed. This analysis was enhanced by cross-referencing with secondary data sources and detailed maps, specifically concerning agriculture and natural hazards. This method provided valuable insights into the sub-basin's dynamics, contributing to a more comprehensive understanding for the study.

Analysis of Local Dispute Resolution

In coordination with IMPACT's primary data collection and desk review activities, International Alert also conducted an analysis of local disputes, including an analysis of gender dynamics.

To do this, International Alert conducted a detailed desk review of the context in Khojabakirghan, based heavily on a similar 2022 study on natural resource management in Central Asia.[11] The desk review was used to develop tools that were used for primary data collection.

The desk study also provided an opportunity to review the content of publications focusing resource management issues as they relate to climate, water, and environmental factors, as well as community recommendations and gender aspects of resource management and dispute mitigation.

11. International Alert, The impact of climate change on the dynamics of conflicts in the trans-boundary river basins of Kyrgyzstan, Kazakhstan and Tajikistan,January 2022

Information gaps and limitations

IMPACT and International Alert were limited in the level of analysis that they could conduct due to the availability of data and the timelines in which it could be obtained.

Primary data collection was not possible, so IMPACT instead relied on secondary data from recent studies conducted by other organizations. In particular, the research conducted by Acted was used for detailed, granular information on the watershed. Of particular use were reports obtained from SDC's project under Acted, who had collected information on B. Gafurov and J. Rasulov districts as part of an assessment on the Khojabakirghan watershed for a similar, SDC-funded project on natural resource management in the watershed.

Similarly, a limited number of hydrological and meteorological monitoring posts in each country meant that for its hydrological models, IMPACT needed to rely on limited available data from a few specific locations in the watershed, limiting the ability for IMPACT to fully calibrate the SWAT model. Given the lack of data availability, the data used in the model represents the best example of SWAT using open source data. As a result, findings drawn from the SWAT analysis should be treated as indicative, and not used alone to make key decisions on water flow. IMPACT analysed this data alongside secondary data from Acted's SDC funded studies to develop a comprehensive picture of the water situation within Khojabakirghan watershed.

Due to the length of time needed for project registration, the time frames for data collection were limited, and IMPACT needed to limit its GIS analysis to hazard analysis, and did not have time to complete the additional risk analysis before the national workshop where the preliminary findings from this report were presented on 28 November 2023.

Key terms and definitions

Hazard

Hazards refer to a “process, phenomenon or human activity that may cause loss of life, injury or other health impact, property damage, social and economic disruption or environmental degradation.”[12] A total of 6 main hazard groups were identified for the watersheds.

Exposure

Exposure is defined as the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.[13] In this assessment, the locations of population and agriculture are considered as part of the exposure component of hazard analysis of the watershed. Datasets on population and agricultural land are derived from global data sources such as WorldPop.[14]

12. Texas A&M University, SWAT Input Data: Overview, 2023.
13. WorldPop, Open Spatial Demographic Data and Research
14. UNDRR, Sendai Framework Terminology on Disaster Risk Reduction, 2023.

Glossary

Term	Definition
AAW	Average Annual Water Yield
ABRA	Area Based Risk Assessment
DEM	Digital Elevation Model
DRM	Disaster Risk Management
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information Systems
Ha	Hectares
HWA	Hydrological Watershed Analysis
IFAD	International Fund for Agricultural Development
KII	Key Informant Interview
LSG	Local Self Government
LULC	Land Use and Land Cover
MoES	Ministry of Emergency Situations
NDVI	Normalized Difference Vegetation Index
NRM	Natural Resource Management
RuVKHa	District-level Water Management Authority
SMI	Soil Moisture Index
SPI	Standard Precipitation Index
SWAT	Soil & Water Assessment Tool
TWI	Topographic Wetness Index
VCI	Vegetation Condition Index
UNDRR	United Nations Office for Disaster Risk Reduction
USAID	United States Agency for International Development
WUA	Water User Associations

1. Hydrological Watershed Analysis

Khojabakirghan Watershed
Tajikistan - Sughd Region - B. Gafurov & J. Rasulov District

Hazards to effective watershed management

Source: Google Earth, 2023

Source: IMPACT, Khojabakirghan Irrigation Canal, B. Gafurov District, October 2023

Water Management

Water management for irrigation purposes forms the foundation of natural resource management in the Khojabakirghan watershed. Surface water resources in the Tajik districts primarily come from streams, springs, and the Syrdarya River that flows through the region. These water sources, including groundwater, play a vital role in supporting agriculture, which is the main source of livelihood for most people in the area. In B. Gafurov and J. Rasulov region, the economy relies on agriculture, employing around 70% of the working age population.

Trends over the last decade show the water levels of the main river has declined over 40%, in addition to precipitation patterns becoming more extreme and less regular, disrupting harvests and harming crop yields and pasture maintenance, and leading to disputes between local communities over equitable water allocation. This is due to the combination of climate change, as well as irregularities in precipitation patterns that households depend upon for agriculture, and poor and degrading irrigation infrastructure, which has contributed to increased water loss from leaking canals.

Groundwater, which makes up approximately 69% of the water used for irrigation in the Khojabakirghan watershed, has made for an effective stop gap for supply gaps left by changing precipitation and surface water. However, recent studies have warned that the aquifers under the Khojabakirghan watershed are likely to begin to run out by 2030, and are likely to be running at a deficit of over 26 million m^3 of water by 2045, making improved groundwater management a critical issue for effective watershed management as well.

Using SWAT, IMPACT conducted basin modeling to capture the levels of surface water loss and make projections based on the expected impacts of climate change on water levels in the near term. Water levels were projected to continue to decline, and reliance on the Khojabakirghan river as the primary source for livelihoods of most households will increase, putting on the ability of key stakeholders to effectively manage natural resources in the watershed.

In Central Asia, Tajikistan contributes around 60 percent of the region's river water resources, while the country only uses 17-20% of the water resources formed on its territory. On average, over between 1985 and 2014, the annual volume of water resources used by various sectors of the country's economy ranged from 8.0 to 14.5 km^3/year.[15]

Water resources constitute Tajikistan's primary energy source, with hydroelectric power supplying over 95% of the country's electricity and accounting for 80% of agricultural production. Additionally, it serves critical functions in drinking water supply, sanitation, industrial processes, and fisheries, thereby safeguarding food security and livelihoods.

However, along with other developing countries, Tajikistan faces population growth, which in its turn increases the needs for and pressure on natural resources, particularly water each year.

From 2017 to 2022, depicted in tables 1 & 2, the population of the B. Gafurov and J. Rasulov districts has steadily grown. This growth is primarily attributed to natural growth, which compensates for the large number of people who had migrated abroad, primarily for work. On the other hand, the demand for water resources critical for food production is increasing and is aggravated further by the impact of climate change. According to Acted's September 2023 report, in Sughd region, there were 8,200 hectares of crops planted on cultivated lands, however, a portion of these crops suffered losses due to drought and a lack of water in Khojabakirghan River, which serves as the irrigation source

15. Ministry of Energy & Water Resources of the Republic of Tajikistan, 2023.

for these areas.[16]

The National Code of Tajikistan requires the creation of water councils in specific areas. These councils will include representatives from businesses and organizations involved in planning, using, and protecting water resources within that region. Water use plans will be authorized at different levels including internal water use plans, district level, inter-district level plans, and national level plans.[17]

Water management in the Khojabakirghan watershed involves multiple layers of management, including RuVKHa at the district level and WUAs at LSG (Jamoat) level. The WUAs manage on-farm irrigation systems that directly feed farms. The boundaries of these organizations and their areas of responsibility are shown in Map 2.

Additionally, the Integrated Watershed Management Initiative, funded by Switzerland since 2011, is active in Tajikistan. It encompasses projects related to Disaster Risk Reduction (DRR) and Integrated Water Resources Management (IWRM), including in the transboundary Khojabakirghan watershed, which extends across Kyrgyzstan and Tajikistan. A key aspect is knowledge management, aimed at sharing modern approaches and methods among IWRM practitioners and decision-makers. The water sector reform in Tajikistan requires to switch to basin-based water resource management. This shift is essential because the

16. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.
17. Acted, Helvetas, GIZ, National Water Resources Management in Tajikistan: Summary Report on Main Findings and Conclusions of the Disaster Risk and Watershed Assessment of the Khojabakirghan/Khoja-Bakirgan Watershed, August 2015

Table 1: Population growth in B. Gaurov District, 2011 - 2022[b]

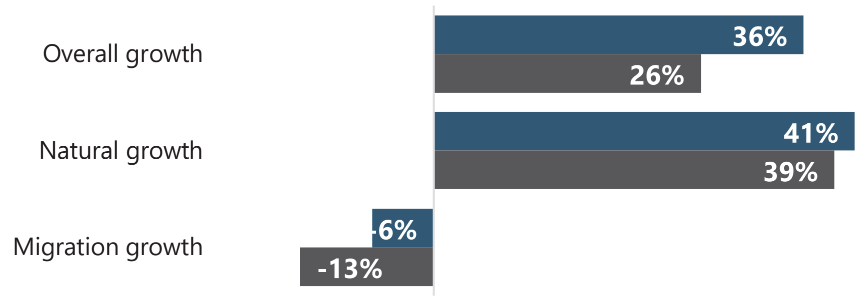
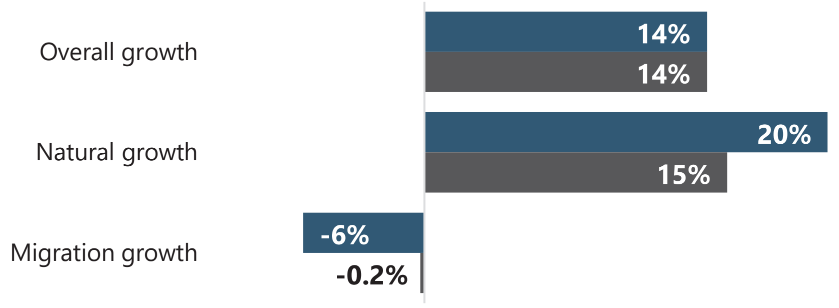


Table 2: Population growth in J. Rasulov District, 2011 - 2022[b]



current regulations do not adequately address the management of smaller tributary watersheds, which are integral components of the main river basins.[18]

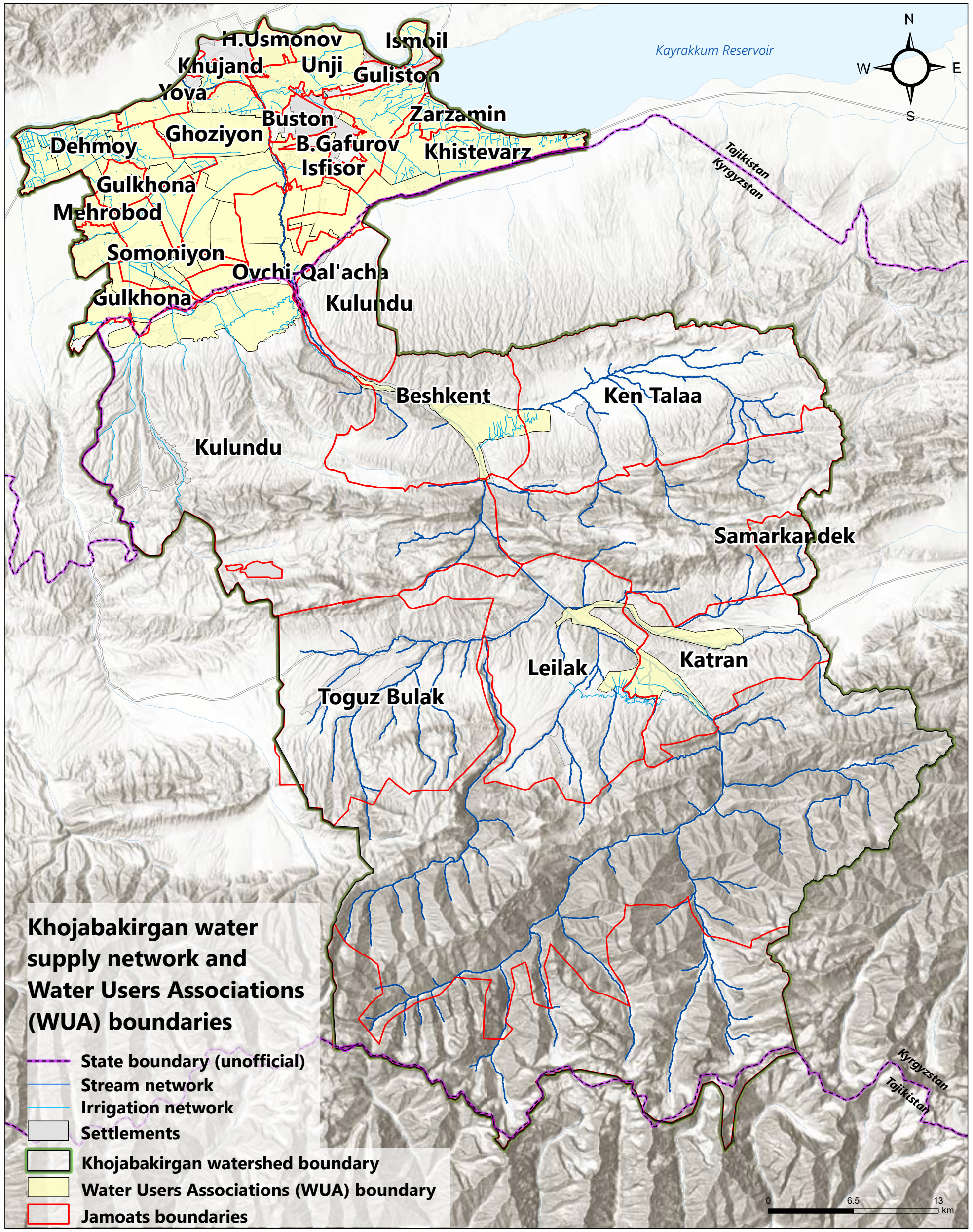
However, due to limited finances, proper management and old infrastructure there is still a need for water sector reform in Tajikistan to successfully integrate IWRM, which should emphasize knowledge sharing and involve local stakeholders in the planning of effective IWRM.[19]

Analysis from a recent survey on water infrastructure in the Khojibakirgan watershed highlighted water management issues in both districts B. Gafurov and J. Rasulov related to irrigation of agriculture. This was reported to be largely due to the malfunction of pumping stations, vertical wells, and the neglect of canal repairs and other irrigation systems. The main causes were reported to be delays in funding and the failure to maintain the drainage ditches. Water loss from the water network was reported to be 21% in B. Gafurov and between 30% and 40% in J. Rasulov, extremely high rates that highlight a need for the improvement and rehabilitation of

18. National Water resources Management Project (HELVETAS, ACTED, GIZ). Integrated Watershed Management in Tajikistan context
19. Wolfgamm B, Liniger HP, Nazarmavloev F. 2014. Integrated Watershed Management in Tajikistan. IWSM policy brief. University of Bern, Centre for Development and Environment (CDE), Berne, Switzerland.

b) Acted SDC reports, Assessment of socio-economic and environmental charactaristics of the areas of the Khojabakirgan River sub-basin, September 2023.

Map 2: Water User Association boundaries and canal networks, Khojabakirghan watershed, June 2023[b]



the canal network to reduce the loss of overall surface water.[20]

Field visits by the Acted and IMPACT STREAM staff observed that the concrete on many major canals in the Khojibakirgan water network had corroded significantly, suggesting that water loss in the network was wide-spread.

Much of the water loss is likely due to the age of the canal network; the Khojabakirghan canal was constructed in 1953 and is a 29.6 km waterway with a capacity of serving 8,069 hectares of land across B. Gafurov and J. Rasulov districts. Over time, the canal has corroded and broken down, and needs maintenance and replacement of various components, including non-functional metal shields and broken lifting mechanisms. Some villages use canal water for drinking due to a lack of other water resources.[21] The table below provides the list of canals Khojabakirghan watershed canal network. Of the canals, Khojibakirgan being the longest, 29.6 km.[22]

20. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.
21. Ibid.
22. CAWATER, Chapter 3: Khodja-Bakirghan Canal, 2011.

b) Ayil Aimak boundaries are from Ministry of Emergency Services and are obtained from Humanitarian Data Exchange. Boundaries are current as of 2021. River data was provided by Acted from an earlier 2015 analysis by HYDROC. Canal network is from National Water Resource Service Geoinformation Portal.

Table 3: Main Canals and length (km), 2011

Canal name	Canal length (km)
Khojibakirgan	29.6
Kostakoz	2.08
Navobod	1.6
Kostakoz Feeding Canal	7.2
Mashine canal	3.0
Total:	**43.48**

Suggested watershed support

- Rehabilitation of canal infrastructure is critical for reduction in water loss.
- Water gates, district-level canals, and other key infrastructure are severely corroded and need replacement and rehabilitation to allow for the effective management of the canal network.

Using the SWAT analysis described in the methodology section, water discharge was calculated using a river basin scale model developed to quantify the rate of water flow in the Khojabakirghan watershed for the years of 2017-2022. The model considers intricate data on precipitation, soil types, land cover classifications, water discharge data, temperature and elevation, which is then used to simulate the watershed's ecosystem for both current trends and projections. As shown on the map, water accumulates from glaciers in the southern Turkestan Range, collecting in the reach, or main river, before flowing north into Tajikistan.

Water discharge, shown in Map 3, is the rate at which water flows through a river, stream, or channel at a specific location, typically measured in cubic meters per second (m^3/s). The map shows an increase in overall flow of water as the river travels downstream: river flow that starts at only 0.2 m^3/s at the source reaches 116.7-815.4 m^3/s by the time water enters Tajikistan, highlighting potential exposure to flooding and inundation of water in border communities. While the map provides insights into water discharge from 2017 to 2022, it is important to consider that a lack of sufficient water monitors in the watershed limits the full calibration of the model.

The impact on aquatic ecosystems' physical, chemical, and thermal attributes varies with stream flow rate. High flow relocates sediments and debris, affecting the physical habitat, while flow rate influences water quality, temperature, and aquatic organisms. Discharge magnitude in streams and rivers is influenced by environmental factors like precipitation, slope, groundwater supply, soil type, and vegetation, as well as anthropogenic factors such as dams, urban development, and groundwater withdrawals.[23]

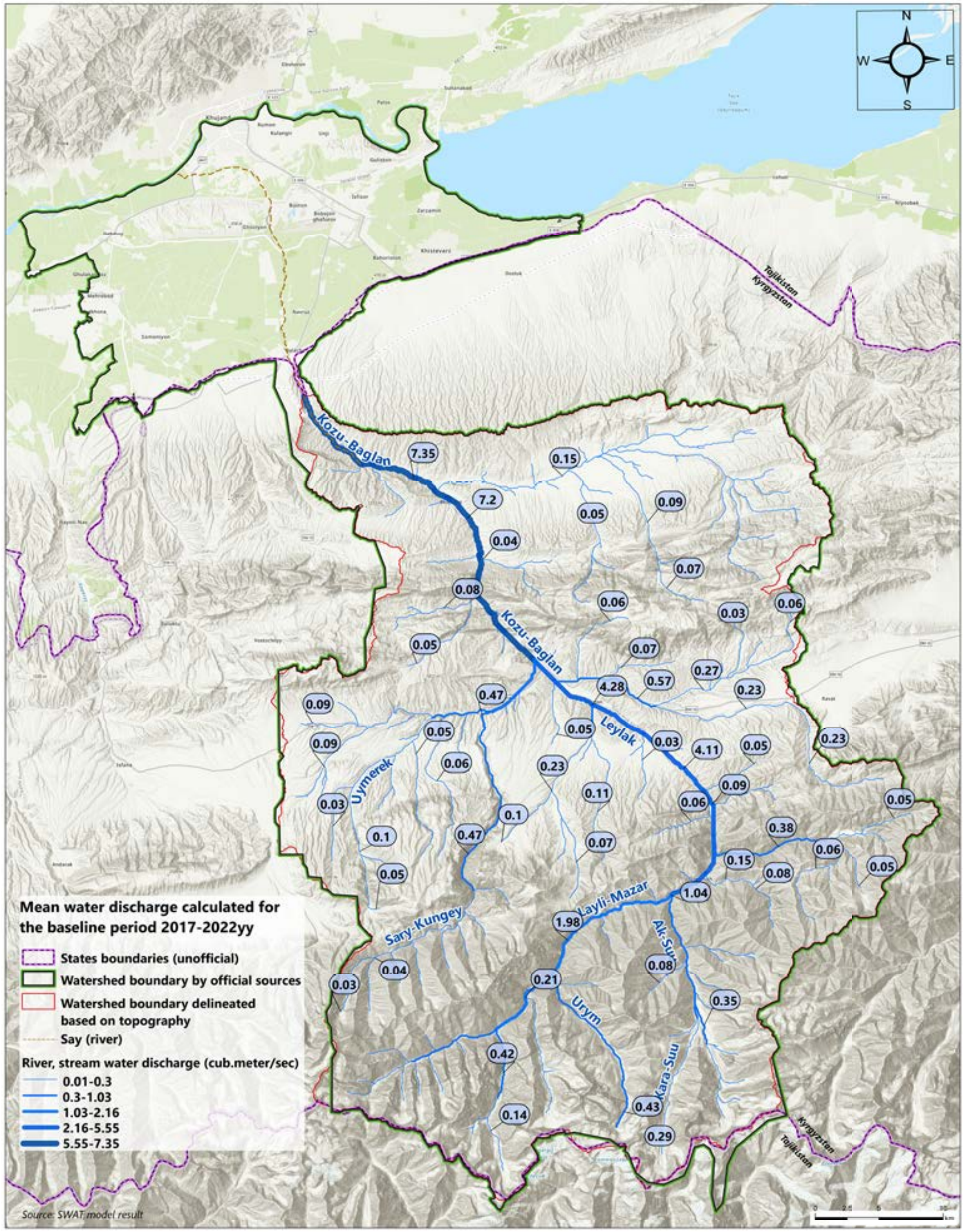
Water is Tajikistan's most abundant natural resource, forming 55% of the Aral Sea basin's annual flow. However, uneven distribution, dependence on river inputs, and a complex terrain create challenges for water usage. Tajikistan relies on a unique hydro-technical infrastructure, including pumping stations, to irrigate 40% of its lands. Nevertheless, over 140,000 hectares suffer from water deficits, requiring reservoirs and inter-basin transfers. Due to funding shortages, maintenance of the irrigation system has lagged, resulting in over 50% deterioration. This affects water supply efficiency and damages both land and agricultural water supply.[24]

Graph 1 on the next page examines the monthly trends of water discharge over the last 10 years. While water levels vary year on year, there has been a noticeable decline in water levels during the peak summer season in recent years, as well as the winter, when discharge levels have typically seen a moderate increase. In addition, water peaks has shown a pattern of gradually coming later in the year over time. Discharge levels were reported to have declined from over 200,000 km^3 in annual discharge in 2013 to less than 115,000 km^3 in annual discharge in 2022, an over 40% reduction in annual surface water. This decline can be attributed to the glacial shrinkage and fluctuations in precipitation patterns over the last decades.

The Tajikistan Government's National Development Strategy highlights that the country's water infrastructure is currently inadequate to meet the needs of the national economy and the growing

23. NEON, Hydrology & Geomorphology: Discharge, 2023.
24. Kholmatov & Pulatov, National Report on Regional Water Partnership (Republic of Tajikistan), 2005.

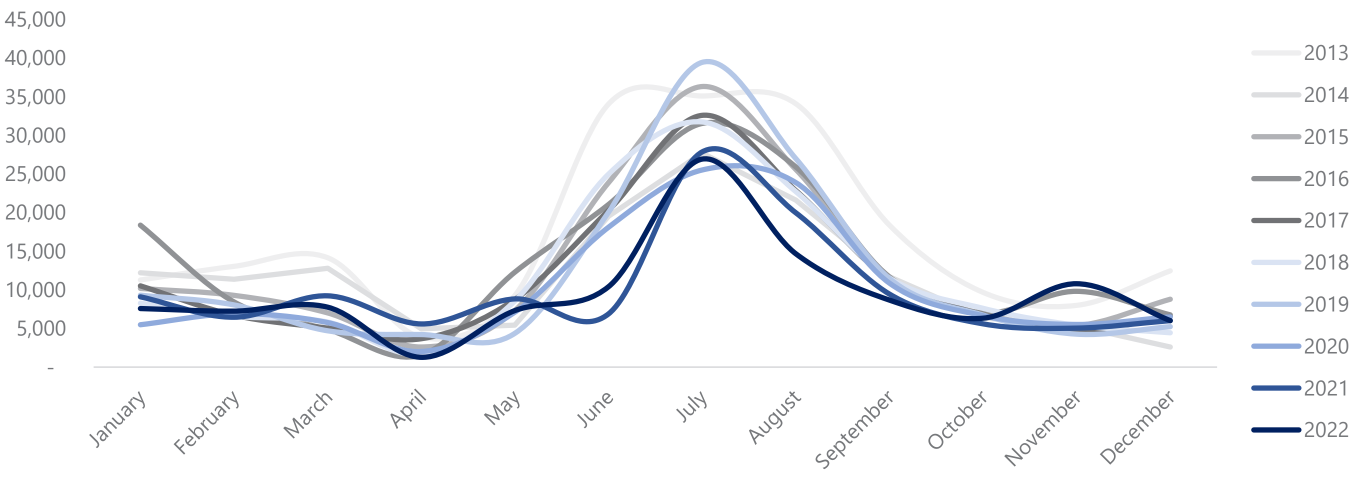
Map 3: Water discharge of Khojabakirghan watershed, 2017 - 2022



population. Tajikistan utilizes a mere 17% to 20% of its available water resources, with drinking water and sanitation demands accounting for less than 5% of the total water consumption in the country. Additionally, over half of rural areas lack centralized water supply and sewage systems, emphasizing the requirement for significant investments to improve this situation.[25]

According to recent survey analysis, one of the priorities of J. Rasulov district in the next five years is to provide the population with clean drinking water and improve access to quality drinking water. This is a critical need, as 44% of the population in J. Rasulov and 14% of the population in B. Gafurov districts still lack access to clean drinking water.[26]

Graph 1: Changes in Water discharge levels of Khojabakirghan watershed, in 1000m³, 2013-2022.



Suggested watershed support

- Flooding is likely to be a major issue within the watershed and disaster mitigation measures should be targeted accordingly.
- Water flow has declined in recent years, and is likely to continue to do so given the decrease in water supply sources, making improvement of water efficiency of the network critical.

25. Republic of Tajikistan, National Development Strategy of The Republic of Tajikistan for the period until 2030, 2016.
26. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.

As surface water has become both less reliable and available, the importance of groundwater in the irrigation network of Khojabakirghan has taken on a greater importance. The Government of Tajikistan has further highlighted groundwater as the main source with which to supplement declining surface water levels.[27] According to Acted's September 2023 study, approximately 69% of the water for irrigation in both B. Gafurov and J. Rasulov districts comes from groundwater sources.[28]

According to previous studies, the Sughd Region has 11 major underground aquifers. Of these, 4 currently risk depletion, with another 2 are at risk of depletion by 2030 if they continue to be used at current levels adjusted for population growth in the region.[29]

The Khojabakirghan watershed along with the Isfana and Aksu watershed, makes up a larger sub-basin zone that sits above the Kostakoz-Karibaam and Nau-Ispisar aquifers, which are part of the larger Suluytka-Batken-Nau-Isfara that covers most of the ground water sources along the Sughd/Batken region border.[30] Total exploitation of these aquifer reserves can be seen in Table 5.

While most of these aquifers are expected to remain exploitable for groundwater for the foreseeable future, areas of the aquifers within 7km of the border with Kyrgyzstan are projected to be at risk of depletion by 2030, making the reliance on groundwater feasible in the short term, but for the medium and long term, more sustainable groundwater practices will need to be identified in order to sustain water services for agriculture in the watershed. Given the depletion of service water, which may not have been considered in these studies, these aquifers may need to be exploited even more heavily to account for larger gaps in surface water supply. This would risk depletion at an even more rapid rate. Further analysis by HELVETAS noted that almost all aquifers in Sughd Region will be at risk of depletion by 2045.[31]

The water supply needs for the population is expected to remain roughly the same between 2020 and 2045, from 29.9 million to 30.5 million for water consumption purposes. HELVETAS's analysis on ground water also estimated that industrial growth is projected to increase the overall need for groundwater, and that the volume of industrial water extraction was expected to nearly double in 2030 compared to 2020, from 18.3 million m^3 to 36 million, and more than triple to 62.56 million by 2045, suggesting increasing pressure on underground aquifers from other industrial sectors as well.

The Nau-Ispisar aquifer in particular is at risk of over-exploitation by 2045, where the total water abstraction (300.5 million m^3) is projected to exceed total groundwater reserves (269.74 million m^3) by 2045, a deficit of over 30 million m^3 in groundwater. While the Kostakoz-Kanibadaam aquifer is not projected to be depleted, it is also expected to be too small to address the groundwater gap.

The depletion of groundwater is linked to a larger issue of aquifer depletion across Tajikistan. Many farmers in Sughd region have reportedly dealt with the issue of water shortages by drilling more boreholes, since irrigation channels cannot provide enough water, which further lowers the water table. The need to drill deeper boreholes each year has reportedly lead to tensions among farmers in the area. The increased amount of infrastructure has further reduced the available water quantity, and also degraded its quantity, thus negatively impacting the farming community.[32] As a result, the groundwater level has declined, causing problems like salinisation and water-logging, which significantly affects the productivity of agricultural lands. For instance, 56% of the total drainage network area in J. Rasulov district, which is 159 km in size, is in an unsatisfactory condition. Unfortunately, there are no specific plans or activities in place yet to address these issues, which should be monitored and implemented.

27. Dropstone, Scoping Study for a Project on Groundwater Management in the Sughd Region, Northern Tajikistan, 21 April, 2023
28. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023
29. HELVETAS, Tajikistan: Support for the Development of an Aquifer Management Plan for the Syrdarya River Basin, August 2021.
30. UNECE, Drainage Basin of the Aral Sea and Other Transboundary Waters in Central Asia, 2020.
31. ibid.
32. HELVETAS, Tajikistan: Support for the Development of an Aquifer Management Plan for the Syrdarya River Basin, August 2021.
32. ibid.

Table 4: Groundwater aquifer reserves and infrastructure in Khojabakirghan watershed area, August 2021[c]

Groundwater Aquifer	Groundwater exploitation reserves, km^3 per day	Ground water exploitation reserves, million m^3 annually	Number of operating wells
Nau-Ispisar 1 & 2	739.0	269.74	886
Kostakoz - Kanibaam	58.6	21.39	53
Total	797.6	291.13	939

Table 5: Groundwater aquifer reserves and infrastructure in Khojabakirghan watershed area, August 2021[c]

Groundwater Aquifer	Projected groundwater exploitation reserves, million m^3 annually	Projected total groundwater abstraction, million m^3 annually	Projected Groundwater deficit
Nau-Ispisar 1 & 2	269.74	300.5	-30.76
Kostakoz - Kanibaam	21.39	16.96	4.43
Total	291.13	317.46	-26.33

c) Data and Analysis from HELVETAS 2021.

Suggested watershed support

- As groundwater is the most likely alternative to address shortcomings in surface water sources, investment in effective groundwater management is critical to ensure that aquifers are not depleted within the next 20 years.
- Groundwater cannot be relied upon as the only alternative for surface water sources to address shortcomings in water sources, as these resources are already in danger of being overstressed.
- Surface water forms one of the major sources for recharge of underground aquifers in the region, and must be preserved and maintained to avoid the depletion of aquifers.

Precipitation Trends

Tajikistan has a continental climate with significant regional variability in precipitation. According to the Acted report under the SDC National Water Resources Management Project, precipitation in the Khojabakirghan sub-basin of the Syr Darya basin primarily comes from factors like orographic conditions, cyclones, and anticyclones affecting the weather. Maximum rainfall occurs in the spring during April and May.

The area is generally moisture deficient in both summer and winter. In summer, rainfall decreases as the high-altitude frontal zone moves away. Winters typically bring snow, but recent climate changes have led to occasional winter rain.

Analysis of data from weather stations in the Khojabakirghan watershed between 1981 and 2021 revealed two key findings: (1) the overall volume of precipitation has generally remained constant or increased slightly over time, and (2) the timing of precipitation patterns has begun to vary and become less predictable in the last 20 years. These fluctuations in precipitation patterns have a substantial impact on land use practices in the watershed.

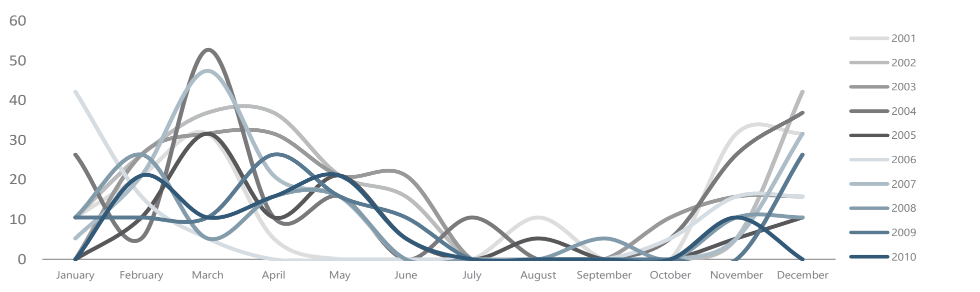
In Khojabakirghan watershed, rising temperatures are having noticeable effects.[33] This includes increased water evaporation, leading to a shortage of drinking water and resources for agriculture. Based on the precipitation data depicted in the Graphs 2-4, rainfall in Khojabakirghan has historically shown a clear and predictable pattern, with rains beginning in the late fall in October, and peaking at the beginning of spring (March), before declining steadily over the course of spring, reaching their nadir in the summer (June). More broadly, annual precipitation trends tend to follow a cyclical pattern of variability, with intense peaks of precipitation occurring approximately every five to six years.

In recent years, rainfall has increased, and is projected to continue to do so. More importantly, it has increasingly deviated from normal rain patterns as time has gone on. In Graph 2, monthly precipitation between 2001 and 2010 tends to follow the previously noted patterns. However, Graph 3, showing monthly precipitation between 2011 and 2020, shows rainfall patterns to increasingly deviate over the decade, with the rainfall peaking earlier during the fall rains in November, and later during spring rains in April. In addition, in recent years, high levels of rainfall have been observed during the summer in 2020 and 2021 (Graph 3), when flood-level precipitation events were recorded. Graph 4 shows average monthly precipitation for 2021, in which extreme deviations in precipitation were recorded, including near record lows in spring precipitation, followed by extreme precipitation in July. This was likely part of a larger 2021 drought that affected much of the Fergana Valley. While data from 2022 and 2023 was not yet available through open-source means, given reports of late rainfall in early 2023, it is likely that the observed irregular rainfall patterns have continued.

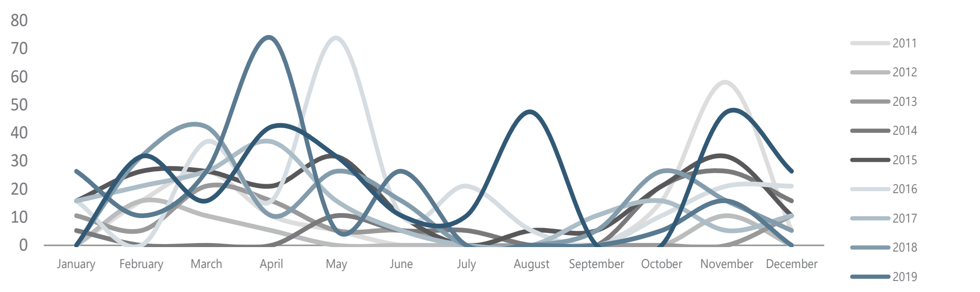
Accordingly, Map 4, covering the period 2017-2022 indicates significant variations in precipitation across the watershed. Considering the fact that the Tajik part of the watershed constitutes mainly the flat and final tail of the watershed, the irrigated plains in the lower watershed receive less than 18% of the water compared to the middle and upper watershed communities. This not only deprives the communities

33. HELVETAS, Tajikistan: Support for the Development of an Aquifer Management Plan for the Syrdarya River Basin, August 2021.
33. ibid.

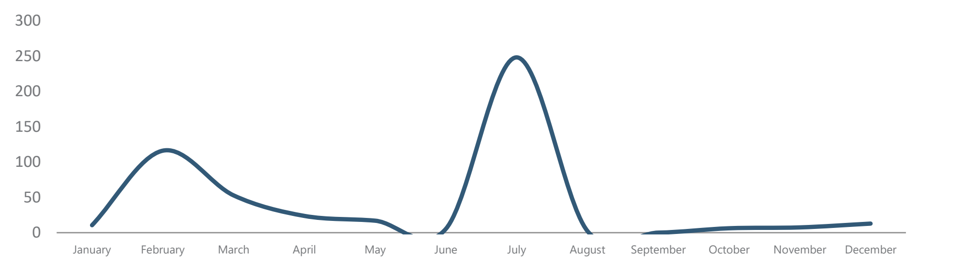
Graph 2: Monthly total of precipitation in Khojabakirghan Watershed, 2001 - 2010, in average mm per month.[d]



Graph 3: Monthly total of precipitation in Khojabakirghan Watershed, 2011 - 2020, in average mm per month.[d]

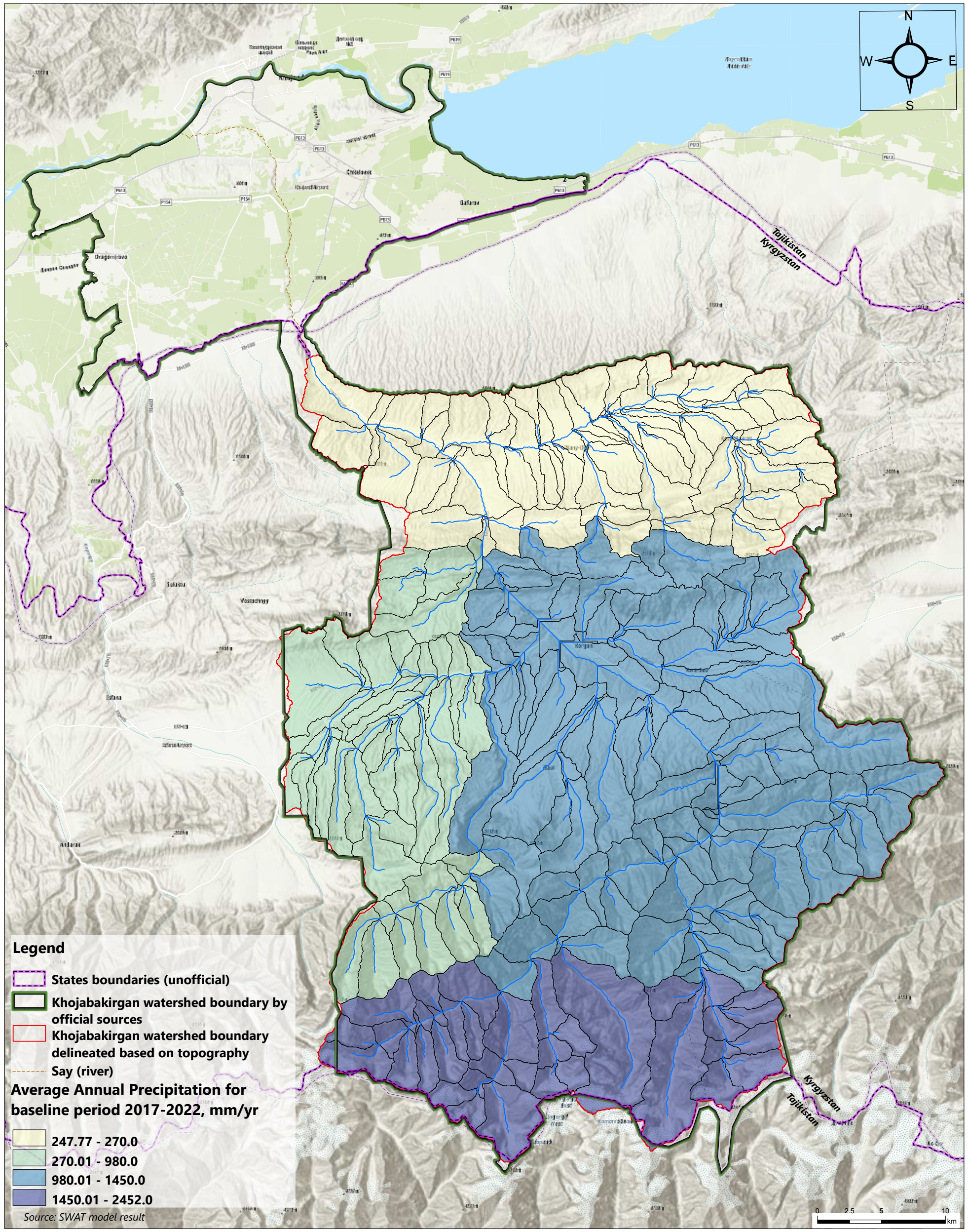


Graph 4: Monthly total of precipitation in Khojabakirghan Watershed, 2021, in average mm per month.[d]



d) Source: Data is taken from United States National Oceanic and Atmospheric Administration website.

Map 4: Precipitation levels of sub-catchments in Khojabakirghan watershed, 2017 - 2022



Source: SWAT model result

in need of water but also results in the accumulation of excess upstream water, increasing the risk of natural hazards such as landslides, flooding, mudflows, and erosion downstream. These hazards can subsequently lead to infrastructure damage and crop loss.

Suggested watershed support

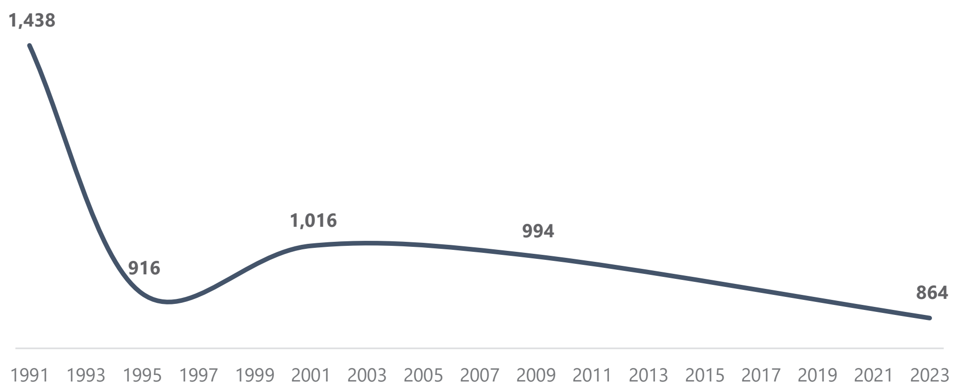
- Precipitation is likely to increase in the future, and it is also likely to occur with greater irregularity, increasing the likelihood of flooding and disrupting crops. Rainwater storage will be useful in supporting continued cultivation as weather patterns change.
- Precipitation patterns are geographically uneven, and the irrigated areas that need it the most also receive the least, increasing dependence on irrigation. Irrigation networks should be supported to reduce water loss, as communities in both countries are likely to rely on the river more for agriculture in the future. This can be done through rainwater harvesting technologies.

Glacier and snow melt are important sources for Khojabakirghan River, composing and estimated 33% and 28% of the river's total water in watersheds in the nearby Isfara watershed, which occupies a similar ecological zone.[34] This is much higher than the typical annual average of 10-20%.[35] The continued shrinkage and eventual loss of these glaciers due to climate change is likely to cause major ecological changes in the region, including loss of biodiversity, loss of irrigated land for cultivation and a reduction in livelihoods opportunities in the region, as well as lower water tables for groundwater due to less water recharging underground aquifers.[36] More directly, melting glaciers also raise the risk of Glacial Lake Outburst Floods (GLOFs) in which lakes form within depressions of glaciers, in which glacial melt can lead to sudden unforeseen flooding which destroy entire villages.[37].

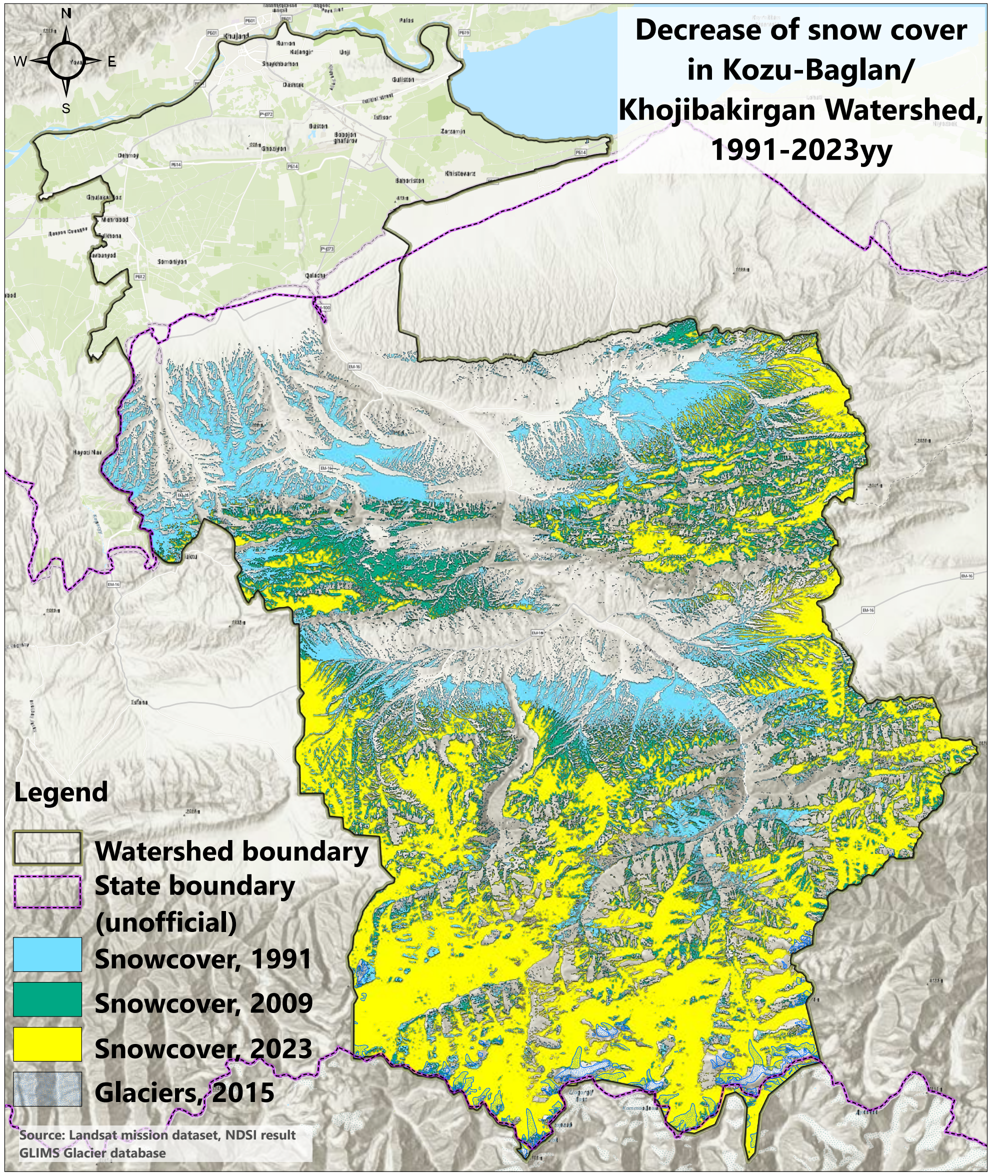
To analyse the melting of glaciers and snow melt, IMPACT conducted a geospatial analysis of the total snow and glacier coverage of the Khojabakirghan watershed using NDSI and FLDAS data. FLDAS data measures not only the area of glaciers and snow melt, but also the depth and volume of glacier formations. However, the FLDAS data was only available for the year 2000 and later, which covered three of the five time periods analysed. Given that climate change research often highlights the late 1990s as an, "inflection point" in which global warming and its associated implications began to accelerate, it was important to analyse snow melt prior to 2000. For this, NDSI data was used. This data covered the geographic area of the snow melt and glaciers, but not thickness or volume.

34. UNDP, Agro-Climatic Resources of the Batken Region of the Kyrgyz Republic", 2022.
35. Central Asian Bureau for Analytical Reporting, Why are Tajikistan's glaciers melting and how dangerous is it for us?, 2021
36. United Nations Regional Centre for Preventative Diplomacy for Central Asia, Glaciers melting in Central Asia: Time for Action, Seminar report, 11-12 November, 2014. United Nations Regional Centre for Preventative Diplomacy for Central Asia, Glaciers melting in Central Asia: Time for Action, Seminar report, 11-12 November 2014.
37. Our World, Kyrgyzstan's Glacial Floods a Growing Risk, April 2024.

Graph 5: Total area of snow accumulation in month of February of Khojabakirghan Watershed, 1991 - 2023



Map 5: Difference in snow accumulation in Khojabakirghan Watershed in month of February, 1991-2023



Graph 5 below shows the total loss in area of snow accumulation between 1991 and 2023, annual snow fall has decreased by approximately 40%, similar the recorded decrease in surface water flow of the river. This was most sharply seen in the mid-1990s, but has seen a steady decline since the early 2000s. As map 5 shows snow fall in the early 1990s covered the majority of the middle and upper portions of the Khojabakirghan watershed. However, since the 2010s, snow cover in the middle of the watershed has declined significantly, and snowfall is now only consistent in the upper watershed.

IMPACT also analyzed the melting of glaciers in the Khojabakirghan watershed between 2001 and 2023. This included both an analysis of surface area and total volume, using GLIMS and FLDAS data for both analyses, and comparing the two between 2 time periods. Over the 22-year period of assessment, the glaciers in Khojabakirghan watershed were found to have lost 4% of their area and 5% of their total volume. In addition, 26% of the nearly 100 glaciers that fed the Khojabakirghan river in 2001 were found to have disappeared.

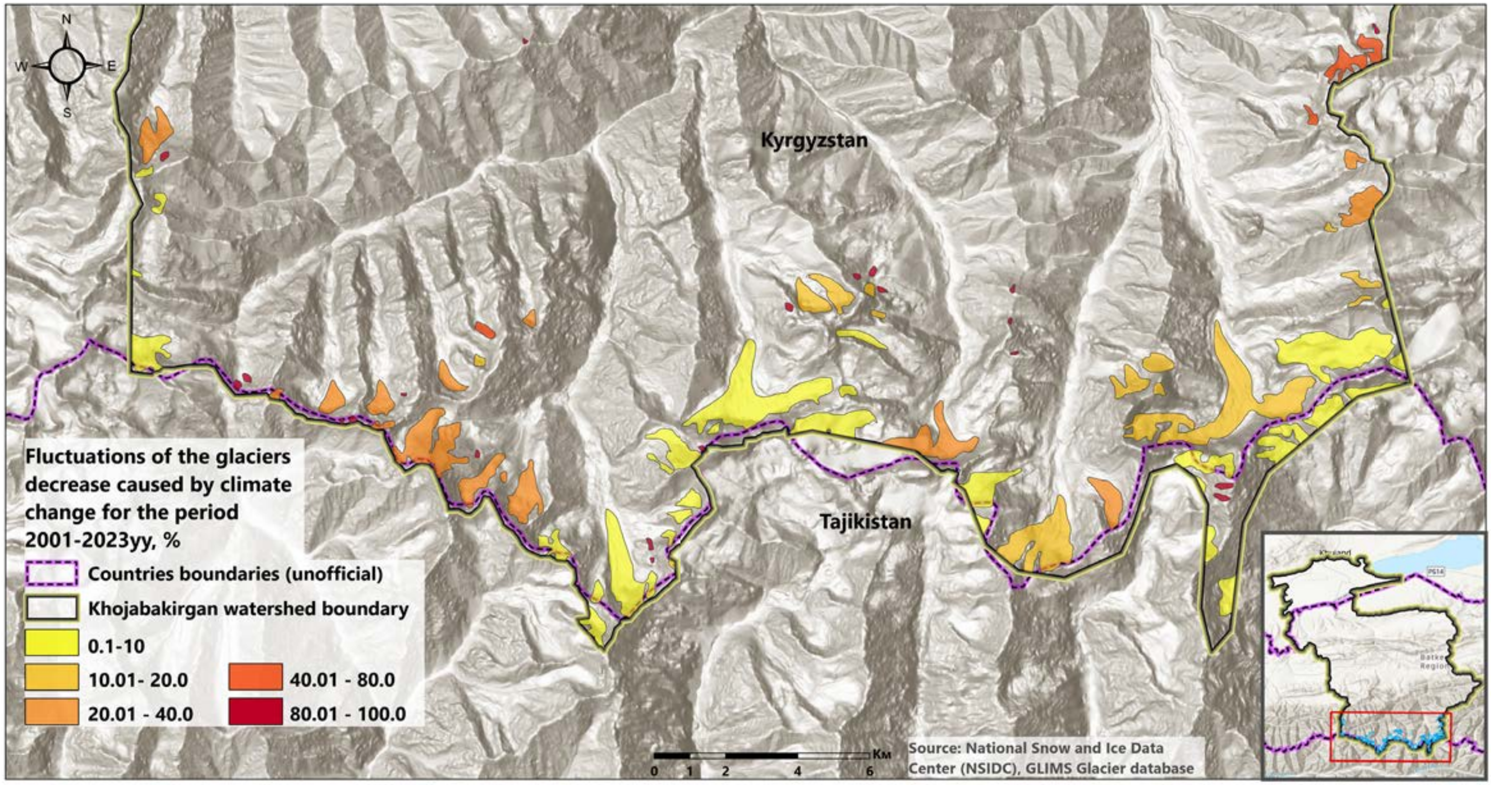
Map 6, which shows approximations of glacier size and locations in 2001, shows more severe glacier loss and shrinkage to have affected smaller glaciers, which were more likely to have lost half or more of their size. This suggests that the melting rate for small glaciers is likely similar to or higher than larger ones, and are more likely to disappear first.

As noted, the loss of snow and glacier coverage has already had implications in the overall flow of the Khojabakirghan River. While water flow can initially increase during periods of glacial melt, leading to a period known as, "peak water," it will eventually lead to a decline in total runoff, leading the river water to dry up and decrease long term. Given that most of the reduction in water discharge appears to be due to a reduction in snowfall, rather than glacial melt, it is likely that peak water has not yet been reached, and that preventative measures can still be taken to preserve water flow.

Suggested watershed support

- Measures to reduce water needed for the irrigation network is critical, as overall surface water flow is likely to decline for the foreseeable future.

Map 6: % Change in Glacier volume of Khojabakirghan Watershed, 2001- 2023



Soil erosion is a deterioration of land caused by natural forces like strong winds, abnormal rainfall, floods, and wildfires, as well as human activities such as urban expansion, overgrazing, and unsustainable farming practices.[38] This issue poses a significant threat to sustainable agriculture and contributes to landscape destruction and desertification. Much of the eroded soil, around 60% ends up in rivers and lakes, carrying pollutants, like agrochemicals, which can lead to water pollution. Also, this soil can block water flow and increase flooding, whereas, if it does not reach water bodies, can destroy land and property in nearby areas.[39]

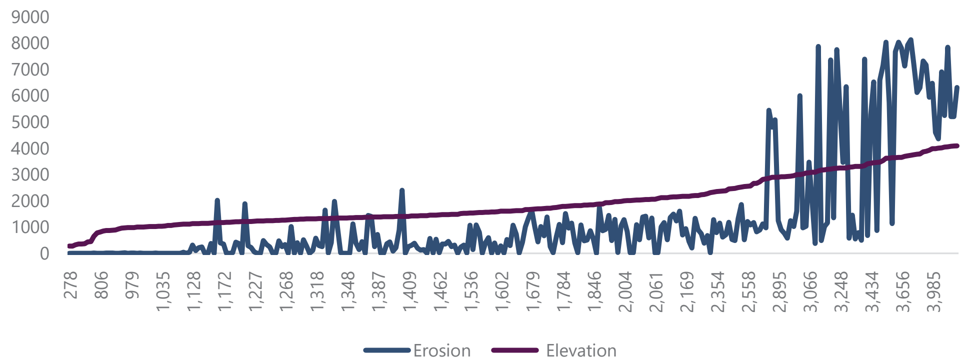
Tajikistan faces severe challenges in relation to soil degradation such as erosion, swamping, deforestation, and salinisation. These problems are both due to climate change and man-made factors. Approximately 10% of Tajikistan's population resides in areas with degraded lands, and around 70% of its arable land is impacted by soil erosion, according to the World Bank. The soil in the Tajik part of the Khojabakirghan River sub-basin consists of a variety of types and compositions, ranging from gray to brown soils.[40]

Soils with gray colour often indicate poor drainage, fostering the formation of iron and manganese compounds due to reduced oxygen levels. This association usually highlights their vulnerability to erosion, especially water erosion. Waterlogged conditions weaken soil structure, delay plant growth, promote surface crusting, and increase surface runoff, collectively making gray soils more susceptible to erosion processes. In the Sughd region, there are two types of soil observed from the FAO soil data, which are Calcisols (CL) and Technosols (TC), with Calcisols being more prevalent. Calcisols are characterized by a notable accumulation of calcium carbonate, primarily occurring in arid or semi-arid areas, whereas Technosols (TC) are human-made soils resulting from significant alterations due to human

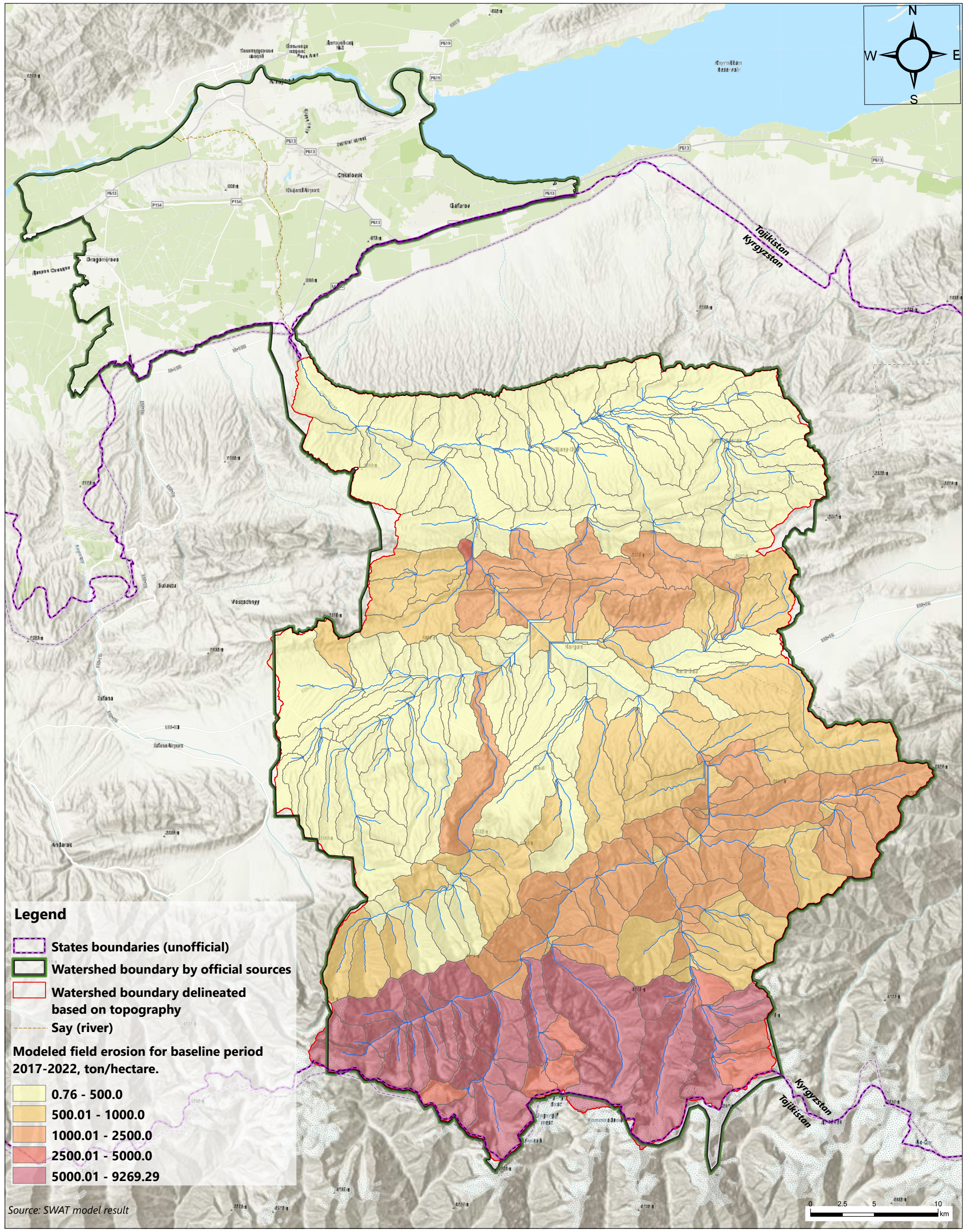
38. EOS Data Analytics, Soil Erosion Causes, Types, Ways to Reduce And Prevent, September 2022.
39. NRDC, Soil Erosion 101, June 2021.

40. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.

Graph 6: Soil Erosion and elevation relationship in Khojabakirghan Watershed 2022



Map 7: Soil Erosion in sub-catchments of Khojabakirghan watershed, 2017 - 2022



practices influencing the properties and characteristics of soil.[41]

Furthermore, the land of the B. Gafurov district was reported to be deteriorating due to multiple factors, including irrational use of water resources, inadequate agricultural practices, and improper use of fertilizers and pesticides. This makes the soil vulnerable to erosion. The failure to implement proper crop rotation, incorrect use of chemicals, and mismanagement of resources are contributing to the degradation of the land, posing a significant risk to the environment and agricultural productivity in the region.

The SWAT results of the erosion modeling conducted for the baseline period of 2017-2022 have revealed a clear trend: land erosion is more likely at higher elevations, whereas it significantly diminishes at lower and middle elevations (Graph 6). This pattern is shown more clearly on Map 7, where areas exhibiting high and very high levels of soil erosion are primarily located in rocky and mountainous terrain, steep and rugged landscapes, high mountain passes, and precipitous slopes. They are typically situated at elevations of 1,800 meters and above, away from most permanent human settlement.[42] Elevation significantly influences soil erosion with steeper slopes, often associated with higher elevations, being more susceptible to erosion. This incline of the land at higher elevations results in faster water runoff, which enhances the erosive potential of water, leading to increased soil erosion.

Low erosion areas are situated at elevations of 500 meters above sea level or below, encompassing the Tajik section of the watershed, including Ovichi-Qalacha, Ghoziyon, and Yova, which predominantly consist of irrigated farmland further contributing to their resilience against erosion. The yellow region depicted on the map within the Tajik watershed denotes areas near the river, indicating a reduced likelihood of soil erosion. As per data from Acted's SDC research, currently, over 500 hectares of agricultural land in the Shurkul region within the rural jamoat of Isfisor have experienced erosion.

Although the data does not encompass the entire sub-basin area due to data limitations, direct observations and the previous Acted reports under SDC reveal a slight deterioration of land resources in B. Gafurov districts as previously mentioned.

41. FAO, Soils Portal: Legacy Maps and Soils Databases, 2023.

42. ACTED,

Suggested watershed support

» Efforts to restore and strengthen soil through improved vegetation should be made in upper-watershed communities to reduce erosion.

Sedimentation in streams refers to the intricate interplay between the concentration of suspended sediments and the deposition of sediment onto the stream bed. According to recent studies, rivers and streams maintain an equilibrium between water discharge, slope, sediment load, and sediment size. Changes in this equilibrium can result from climate change, tectonic shifts, or human activity such as dams and irrigation, or urbanization.[43] These shifts can alter a river's flow, resulting in bank erosion and potentially increasing vulnerability to mudslide events.[44]

As part of its SWAT analysis, IMPACT modeled stream sedimentation for the 2017-2022 period. The findings of this analysis indicates that Khojabakirghan watershed suffers from a high levels of sediment accumulation, which in some places can cause floods/mudslides during heavy precipitation.

As it shown on the Map 8, sediment accumulation is highest in highly elevated areas, such as the Turkestan Ridge that makes up the river's source, exceeding 4,000 meters above sea level, exhibits elevated levels of sedimentation, with total suspended solids measuring up to 4,100 mg/L.

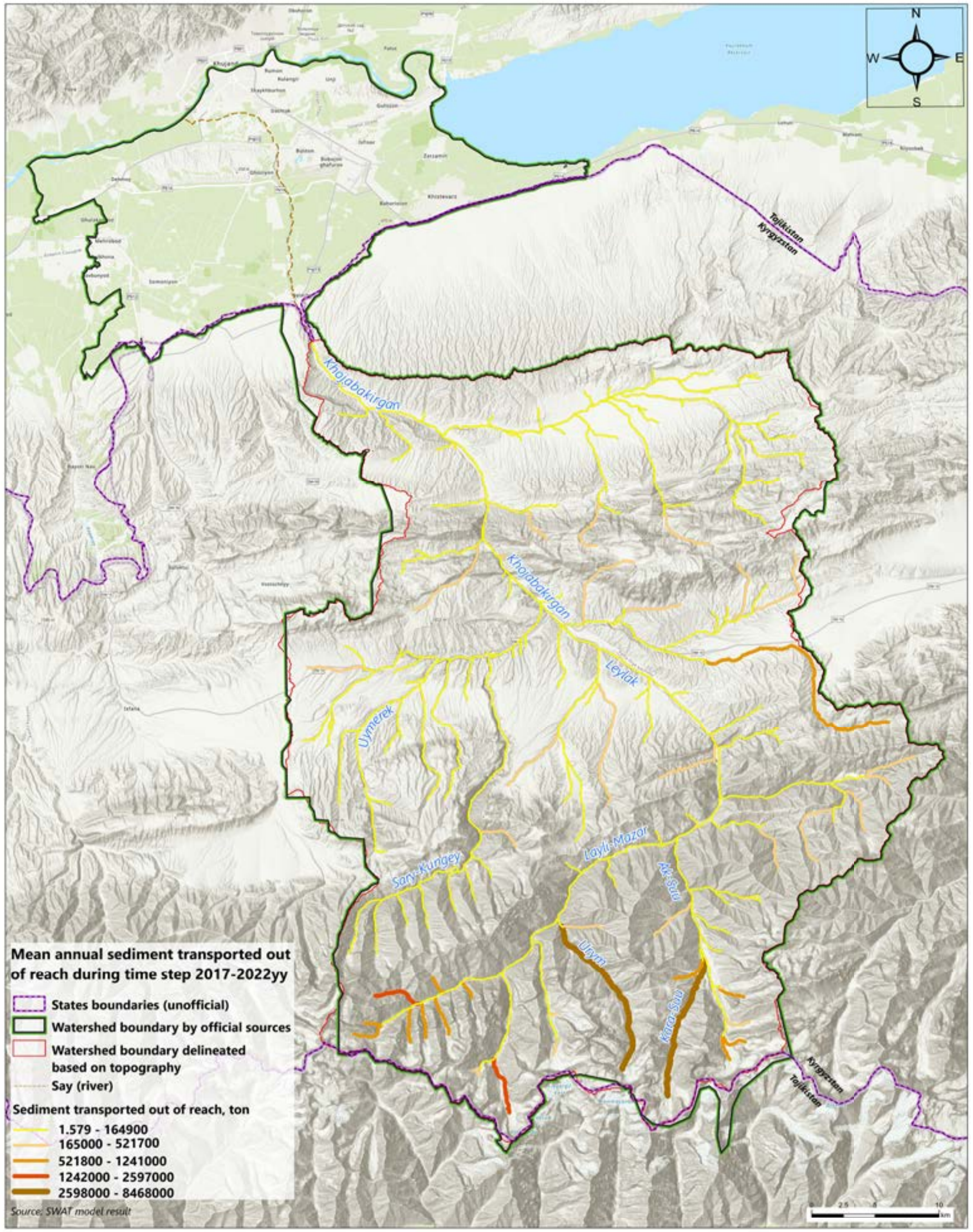
During the winter months, snow accumulates in these areas. As the warmer seasons arrive, the melting snow, along with rainfall and erosional processes (glacial erosion), can transport a variety of sediments, including stones and their smaller particles, as well as sand and gravel.

Sediment accumulation is moderately high in the southern part, especially Ovchi Kalacha. One of the reasons for this could be due to irrigation systems that can transport water across agricultural fields, and when not properly managed, can lead to the buildup of salts and sediments in irrigation channels and downstream water bodies. Similarly, poor drainage practices can result in water-logging and soil erosion.[45]

In addition, sediments can raise the level of riverbeds, increasing the risk of flooding during heavy rainfall events. According to a Hazard & Vulnerability assessment conducted by Acted in 2015,[46] mudflows were also the primary concern of communities in the watershed, which follow periods of intense rainfall and glacial melt that occurs each spring.

The report further noted that unsustainable community practices had increased the overall risk from mudflows, including: 1) uncontrolled grazing and deforestation, 2) population growth leading to construction in mudflow-prone areas, and 3) limited public finances prevent necessary preventive measures. During the period 2009-2016, the J.Rasulov district encountered 13 mudflows in the riverbeds of Isfanasoy jamoat and Gulakandoz and Tomchisoy in Somoniyon jamoat. These mudflows led to economic losses for the farms in these jamoats amounting to a total of 36.1 million somoni, with an annual average of 2.77 million somoni in damages.[47]

Map 8: Sedimentation of sub-basins in Khojabakirghan Watershed, 2017 - 2022



43. [Peter J. Wampler, Rivers and Streams-Water and Sediment in Motion,](#)
44. [Springer Link, Dealing with sediment transport in flood risk management, March 2019.](#)

45. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.

46. Acted, Helvetas, GIZ, National Water Resources Management in Tajikistan: Summary Report on Main Findings and Conclusions of the Disaster Risk and Watershed Assessment of the Khojabakirghan/Khoja-Bakirgan Watershed, August 2015

47. Acted, National Water resources Management Project. Integrated Watershed Management in

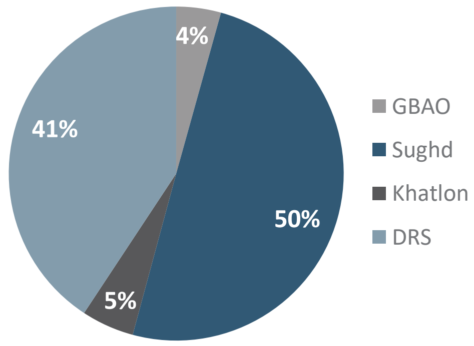
Committee of Emergency Situations and Civil Defense (CoES) records note Sughd region to be the third most vulnerable region in the country for mudflows, after Sughd and Khatlon, which a majority of these mudflows occurring in the B. Gafurov area. The area routinely is also reported by CoES to have sustained the highest amount of property damage from mudflows, emphasizing the area's vulnerability to them and need to prioritize mitigation of mudflow events and damage.[48]

According to CoES data, mudflows were most prevalent in Sughd Region. Of the approximately 14.3 Million Somoni (1.3 Million USD) in damage caused by mudflows in 2022, approximately half (50%) of the damage was in Sughd Region.

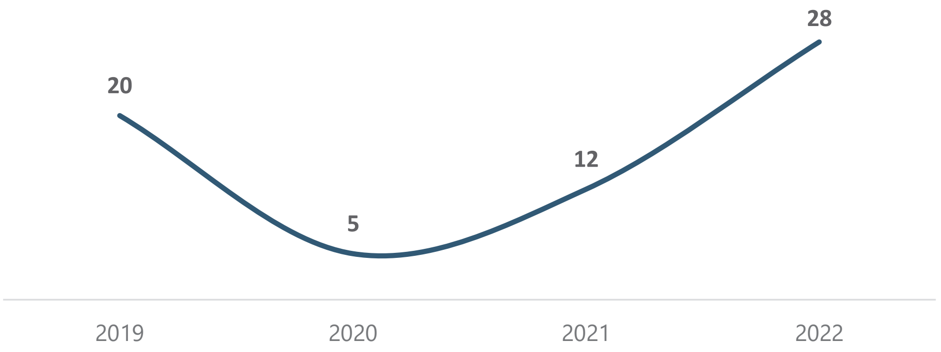
Tajikistan context, September 2023.

48. Tajikistan Committee of Emergency Situations, Overview of emergency situations in the Republic of Tajikistan, 2018 - 2022.

Graph 8: Proportion of total damage caused by mudflows, by region, 2022.



Graph 7: Mudflow Incidents in Sughd Region, 2019-2022.



Suggested watershed support

- Restoration of soils is critical for the continued health of agricultural fields in the watershed to avoid further soil erosion.
- Reforestation and pasture management initiatives can strengthen the soil and reduce the amount of erosion material that feeds mudflow events.

The climate in Khojabakirghan sub-basin, Syr Darya, is defined by its valley location. It is dry with hot summers and mild winters. The annual temperature averages 14.4°C, with January being the coldest month, with an average temperature of -0.9°C.

The average temperature has been rising since 2000, with the most significant increases occurring over the past 12 years. For example, between 1992 and 1998, temperatures were around or below the expected average. However, in the following years, they consistently exceeded the norm by 0.6 to 1.7 degrees.[49]

As part of the assessment, IMPACT conducted an in-depth analysis of various of bioclimatic variables from WorldClim. WorldClim uses the Coupled Model Intercomparion Project 6 (CMIP6) developed as part of the World Climate Research Programme (WCRP). The CMIP6 models climate change through different Shared Socioeconomic Pathways (SSPs). Each SSP corresponds to a different scenario in which macro variables, including population growth, green technological development, changes in inequality, and management of Co[2] emissions are managed globally in different ways. Of the 4 possible SSPs in the model, each representing an increasingly pessimistic scenario as the SSP number increases, with 1 representing an increasingly sustainable world, and 5 an increasingly unsustainable one.[50] Each SSP is roughly equivalent to the Representative Concentration Pathways (RCP) scenarios used under CMIP5, but include additional economic and social causal information and additional model components[51]

To conduct the analysis, IMPACT selected SSP370, which represents a middle of the road scenario, in which most current climate trends stay the same, but do

not worsen.

The analysis spanned the baseline period of 1970-2000 to the near future 2041- 2060 within Fergana valley, including the whole Khojabakirghan watershed. The analysis suggests increasing disruptions to the Fergana Valley's ecosystems due to increases in annual mean temperature and changes in precipitation patterns, which are consistent with broader climate change forecasts.[52]

As depicted in Maps 9 & 10, a rise in the average annual temperature across the Fergana Valley is expected, particularly in the southwest part of the Valley, with a projected increase in temperature as high as 4 degrees Celsius (°C) in some locations. While not as dire, the remainder of the valley is expected to see dangerous temperature increases as well.

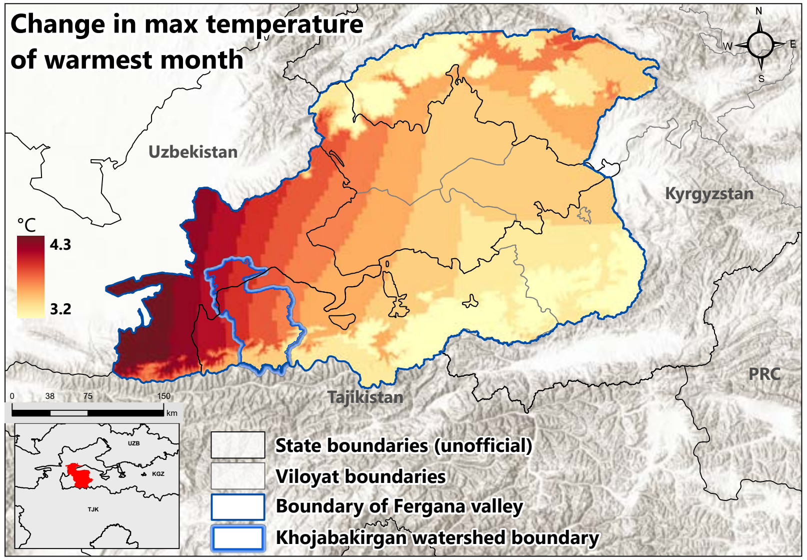
Similarly, the analysis revealed changes in precipitation patterns. Forecasts suggested an estimated increase in annual precipitation of about 40 mm within the elevated and mountainous eastern region of the Fergana Valley, while the centre and western parts of the valley are expected to see a slight decrease in precipitation.

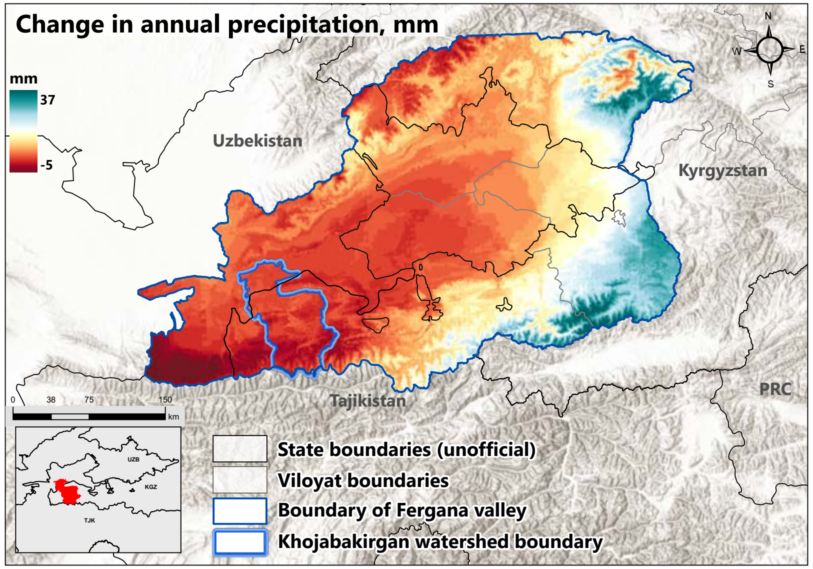
Looking at Khojabakirghan watershed specifically in Figure 1, the rise in temperature is expected to be more pronounced during the warmest quarter of the year, with less of an increase in colder months. Annual precipitation is expected to increase over time, although it is expected to decrease slightly during the summer while increasing significantly during the winter and spring.

These changes are likely to result in more frequent and intense heat waves and drought throughout the valley, as well as increased incidents of flooding, which can have adverse effects on public health and lead to reduced crop

49. ibid.
50. DKRZ, The SSP Scenarios, 2023.
51. DKRZ, The SSP Scenarios, 2023.
52. Muccione, Veruska; Huggel, Christian; Salzmann, Nadine; Fiddes, Joel; Nussbaumer, Samuel U; Novikov, Viktor; Hughes, Geoff, Climate-cryosphere-water nexus: Central Asia outlook. Châtelaine, 2018

Maps 9 & 10 : Projected changes in (a) max. temperature of warmest month and (b) precipitation of driest quarter (1970-2000 / 2041-2060), Khojabakirghan watershed





e) Including LULC. Human activities impact terrestrial carbon sinks such as forests, through land use, land-use change and forestry (LULC) activities, altering CO_2 exchange (carbon cycle) between terrestrial biosphere system and atmosphere. LULC removals are expected to have minor impacts in future in Ukraine / 2 Excluding LULC / 3 A national climate plan highlighting climate actions, including climate-related targets, policies and measures governments aims to implement in response to climate change and as a contribution to global climate action.

yields, thereby posing challenges to food security.[53]

The estimated increase in precipitation within the elevated and mountainous areas of the Fergana Valley may also cause heavy rains in the mountains leading to flooding, mudslides and erosion. According to several recent studies,[54] global warming is expected to decrease snow cover and to cause more precipitation to fall as rain rather than snow. Within the watershed area, the increase of precipitation in the wettest (usually considered as spring and autumn) and coldest periods may cause mudflows and flooding.

Additionally, the region is witnessing a growing number of natural disasters such as mudslides, landslides, and floods. These developments underline the strong link between climate change and challenges related to water resources. To address these issues, immediate action is essential to ensure access to and responsible utilization of water resources in the Khojabakirghan watershed, which is highly susceptible to the risks posed by climate change, particularly the significant increase in temperatures that jeopardize water resources.

53. Reyer, C., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., Coumou, D., Eden, A., Ludi, E., Marcus, R., Mengel, M., Mosello, B., Robinson, A., Schleussner, C., Serdeczny, O., & Stagl, J. Climate change impacts in Central Asia and their implications for development. Regional Environmental Change, 17(6), 1639–1650. 2015.

54. Muccione, Veruska; Huggel, Christian; Salzmann, Nadine; Fiddes, Joel; Nussbaumer, Samuel U; Novikov, Viktor; Hughes, Geoff . Climate-cryosphere-water nexus: Central Asia outlook. Châtelaine: Zoï Environment Network. 2018 and Ombadi, M., Risser, M. D., Rhoades, A. M., & Varadharajan, C. A warming-induced reduction in snow fraction amplifies rainfall extremes. Nature, 619(7969), 305–310. (2023b)

The consequences of these changes are likely to result in more frequent and intense heat waves and instances of drought throughout the entire valley, as well as increased incidents of flooding, which can have adverse effects on public health and lead to reduced crop yields, thereby posing challenges to food security.[55]

55. Reyer, C., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., Coumou, D., Eden, A., Ludi, E., Marcus, R., Mengel, M., Mosello, B., Robinson, A., Schleussner, C., Serdeczny, O., & Stagl, J. Climate change impacts in Central Asia and their implications for development. Regional Environmental Change, 17(6), 1639–1650. 2015.

Figure 1. Projected changes in bioclimatic variables of interest, Khojabakirghan, between 1970-2000 and 2041-2060[e]

- **+2.5°c** Annual mean temperature increase
- **+2.3°c** Change in mean temp. in driest quarter
- **-3.5mm** Decrease in precipitation of wettest quarter
- **+2.9mm** Increase in precipitation of coldest quarter
- **+2.4°c** Increase in max. temp. in warmest month
- **+2.6°c** Increase in minimum temperature in coldest month
- **+7.4mm** Increase in annual precipitation
- **-0.7mm** Decrease in precipitation in warmest quarter

Warmer temperatures and higher rainfall, particularly in the wettest and coldest months could lead to more extreme and unreliable patterns in rainfall and flooding.

Suggested watershed support

» Review crop calendars to determine crops better suited for the expected changing temperature and precipitation patterns.

» Integration of climate adaptation strategies into local development road maps.

» Climate change is expected to worsen precipitation and water discharge patterns in the near to medium term.

2. Watershed Hazard Analysis

Khojabakirghan Watershed
Tajikistan - Sughd Region - B. Gafurov & J. Rasulov District

Hazards to effective land management

Source: Google Earth, 2023

Agricultural Land Management

Agriculture is the main use for water in the Khojabakirghan watershed and forms a central focus of effective NRM. A majority of the labour force in both B. Gafurov (66%) and J. Rasulov (75%) Districts are engaged in agriculture, and this proportion has only increased in recent years. As a result, current land management practices, along with adaptation and mitigation measures taken in by communities and local authorities to address the impacts of climate change are critical to improving NRM within the Fergana Valley.

Recent trends in declining and irregular precipitation patterns, falling water discharge and rising temperatures have already had a significant impact on agriculture land and practices within the Khojabakirghan Watershed. The agricultural economy is heavily reliant on water-intensive crops like cotton, rice, and wheat, which maintain stable yields and relatively high prices. As a result, agricultural outputs are highly threatened by shifting temperatures and weather patterns due to climate change. With drought already a present hazard within the watershed, fluctuating yields and major shocks to agricultural output are likely to become more common.

Given the high reliance on the irrigation network for agriculture land, improving the capacity of the canals and irrigation schemes is critical to reducing water loss and improving the capacity Tajikistan's ability to meet their needs. Emphasizing water-saving techniques like drip irrigation, both at the household and community levels, can support the irrigation network and contribute to the preservation of rainfed lands from further deterioration.

Source: IMPACT, Cotton Crops, Kayrakum Reservaoir, B. Gafurov District, October 2023

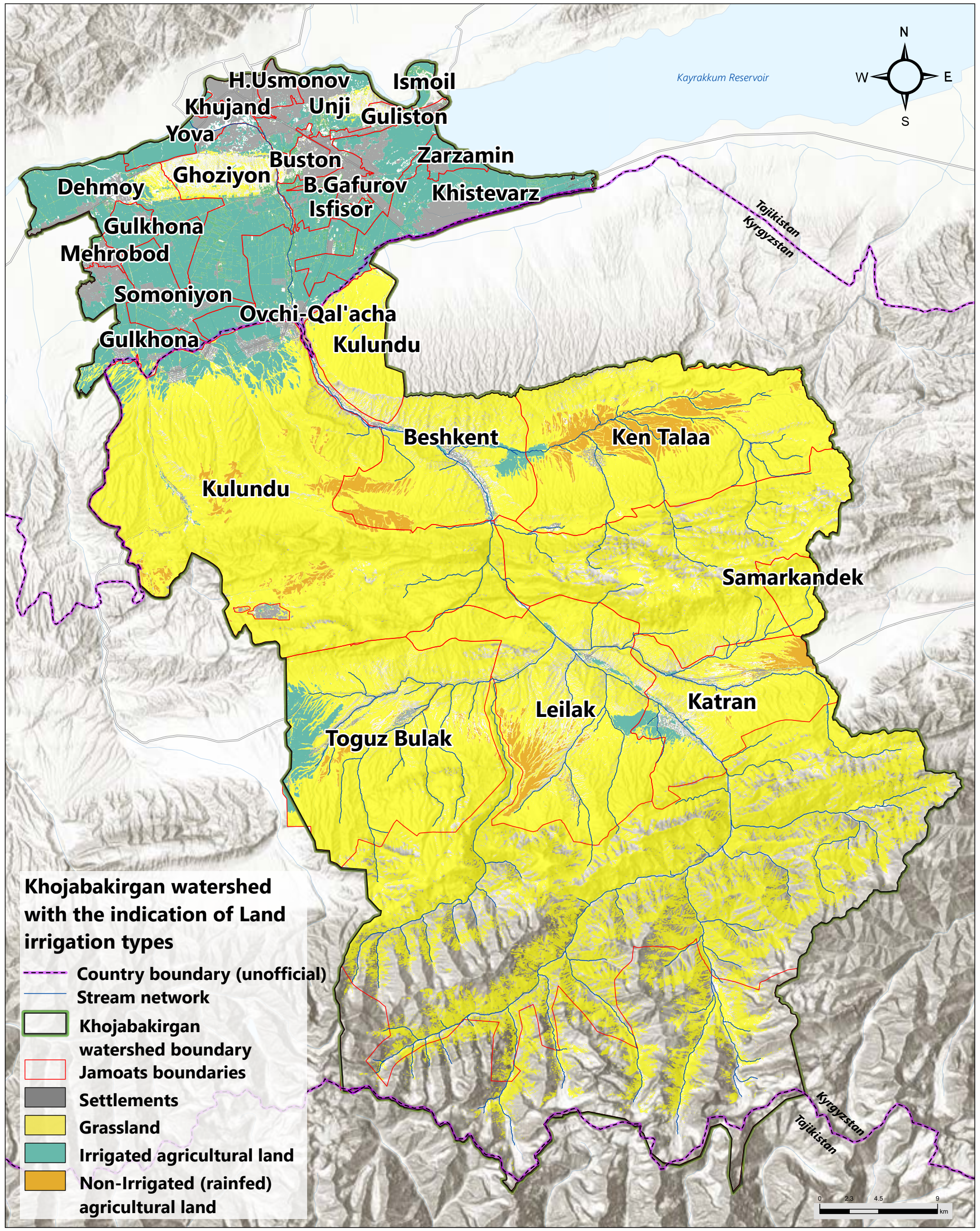
In the Central Asian countries, a significant portion of the population relies on land resources to support their way of life. Pastures, cropland, and forests play a fundamental role in ensuring food security and offering income chances for many individuals throughout the region. Approximately 72% of the population in Tajikistan resides in rural areas, directly counting on land resources and the related services provided by their ecosystems. [56] Despite the limited arable land, agriculture remains essential for livelihoods, officially providing employment for 53% of the population, even though it contributes less than 20% to the GDP. [57]

Tajikistan is a landlocked country known for its rough terrain. Its mountainous landscape means that less than 7% of the total land can be used for farming. This arable land, which is irrigated, is mainly found in the valleys of rivers. The northern Sughd region is the second prominent agricultural regions in the country, which lies in the fertile Fergana Valley, a land shared with Uzbekistan and Kyrgyzstan.

Graph 9 shows an analysis of the distribution of land use categories as a percentage of the total land area in B. Gafurov and J. Rasulov Districts. While exact numbers vary year on year, there were approximately 124,000 ha in B. Gafurov and 46,000 ha in J. Rasulov districts in September 2023. Of these, the vast majority of land in these districts is pasture land, encompassing 70-80% of the total district's productive land area. The remainder is irrigated and rainfed land. Most of the arable lands (24,902 ha in B. Gafurov and 13,754 ha in J. Rasulov) is irrigated land that is fed by the

56. Trading Economics, Tajikistan - Rural Population, 2023.
57. Hayward, & Gillin, Land Portal: Tajikistan - Context and Land Governance, 25 March 2022.

Map 11: Approximate locations of irrigated and rainfed lands in Khojabakirghan watershed, 2023



irrigation network from Khojabakirghan and the Syr Darya Rivers. 87% of arable land in B. Gafurov and 84% in J. Rasulov districts is irrigated, which the remaining 13-16% being rainfed. This represents an area much larger than Khojabakirghan watershed, where the vast majority of the watershed, shown in Map 11, is irrigated land, with small parts of the watershed being used for pasture or rainfed lands, primarily in the hilly area south of Khujand City.[58]

The same study also notes that land ownership in the area is primarily composed of Dekhan farms, which represent 60%-85% of farm ownership in B. Gafurov and J. Rasulov districts, respectively. Most of the remainder of agricultural land is owned and operated by large agricultural enterprises, with a very small minority (2%-5%) owned by individual households.

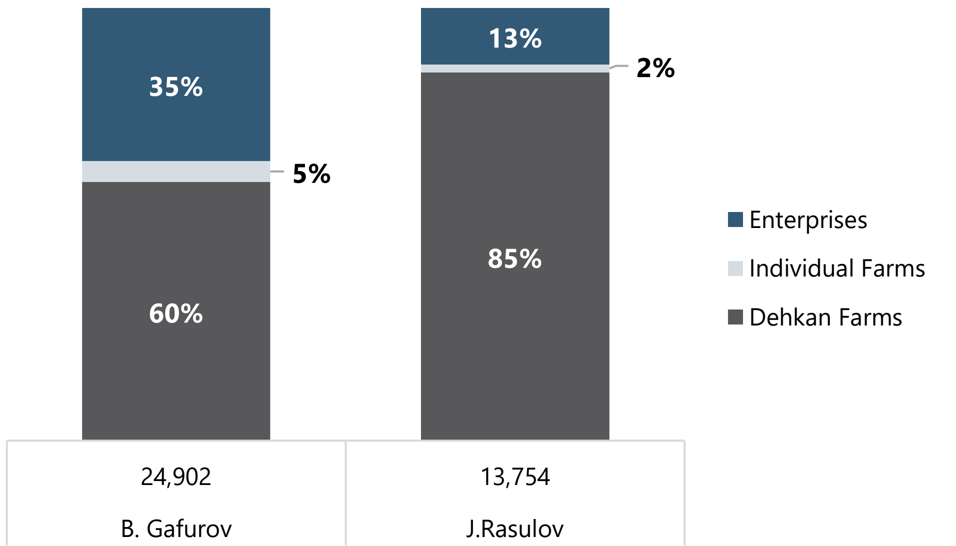
Dekhan farms are mid-sized peasant farms in which the land is leased from the state for commercial purposes. They operate functionally like privately-owned land, though they cannot be bought and sold in the same way.[59]

Over 3,000 ha (~8%) of agriculture land in both B. Gafurov and J. Rasulov were noted in previous Acted studies to be degraded, and require rehabilitation in 2018. Through various initiatives, the land is reported to be slowly being restored over time to become productive again.

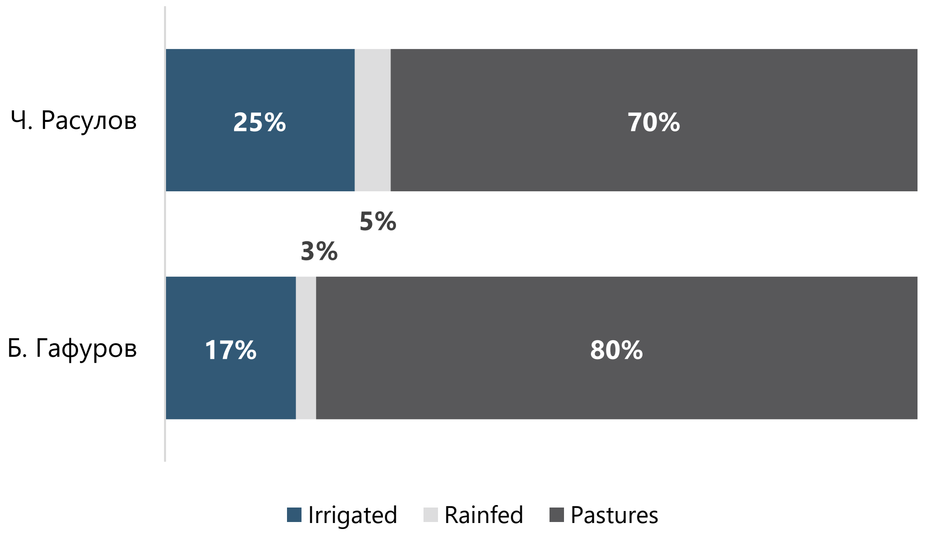
58. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.

59. USAID, Land Links: Tajikistan, April 2021.

Graph 9: Arable land by land tenure arrangement in Khojabakirghan watershed, September 2023[f]



Graph 10: Arable land by land type in Khojabakirghan watershed, September 2023[f]



f) Source: Data from previous Acted reports conducted under SDC project.

Suggested watershed support

- A significant portion of agricultural land requires restoration, and initiatives to restore fertility to soil should be made to mitigate further soil erosion and lack of agriculture productivity, which much of the population relies upon.

Tajikistan is a highly agrarian country with an estimated 75% of Tajik workers employed in the agricultural sector. The sector was modernized during the Soviet period (1922 – 1991) and remains one of the most important sectors in the country that continues to grow. During the Soviet period, Central Asia was transformed into an agricultural supplier for the whole Soviet Union mainly providing wheat and cotton crops, which remain staple crops grown in the Khojabakirghan watershed today.

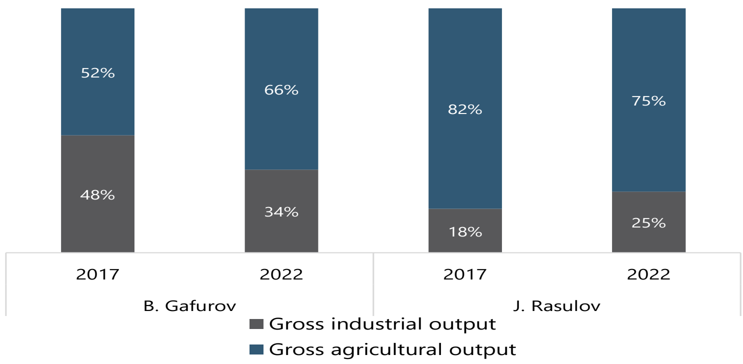
B, Gafurov and J. Rasulov districts have both both an industrial and agrarian direction of economic development. According to the data from previous Acted studies (see graph 11), between 2017 and 2022, the gross agricultural output in J. Rasulov district was between 18% and 25%, while in B. Gafurov district, reliance on agriculture increased from 52% to 66%. Suggesting an overall increasing reliance on agricultural resources as a livelihood means, and the relative vulnerability of the population to the affects of climate change.[60]

The country has 7.2 million hectares of land suitable for agriculture, primarily used for livestock pastures. Only 675,000 hectares are dedicated to crops, with 470,000 hectares being irrigated. An additional 180,000 hectares are used for orchards and vineyards. In the first half of 2023, the total value of agricultural products increased by 7.9%, driven by a 110.4% growth in plant-based products and a 102.4% increase in animal husbandry. [61]

Agriculture practices in the Khojabakirghan watershed are similar to those from the rest of the northern Sughd Region. Households in northern Sughd primarily cultivate a variety of food, cash, and fodder crops. This is mainly including rice, wheat, cotton, melons, tomatoes, cucumbers, apricots, pears, and apples. Despite high volumes of rice and some wheat production in the zone, households primarily depend on purchasing wheat flour as a major source. However, the crop varieties in this area are not distributed evenly throughout the area.[62]```

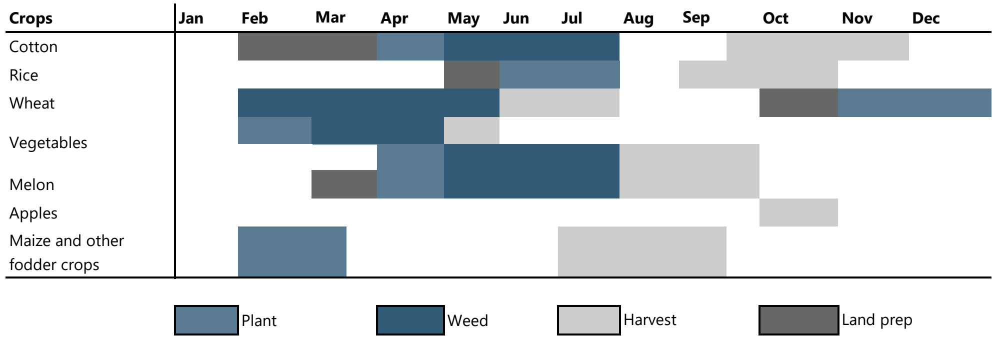
60. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.
61. Tajinvest, Agriculture Industry, 2023..

Graph 11: Sector employment of population in B. Gafurov & J. Rasulov districts, 2017 - 2022.[g]



g) Source: Data from previous Acted reports conducted under SDC project.
h) Source: FEWSNET, 2022.

Figure 2: Crop Calendar for major staple crops in North-Sughd Ago-Industrial Zone, 2011.[h]



For example, cotton and cereal grains are the two main cash crops cultivated on nearly 2/3rds of agricultural land. Cotton requires high temperatures and intensive irrigation, and it is primarily grown in hot river valleys, such as the Khojabakirghan watershed. The Fergana Valley areas of northern Sughd region contribute 30% to the cotton growing area for the entire country. The Sughd region is also the main rice production area of Tajikistan accounting for approximately 30% of annual output, with 44% of the national annual rice harvest coming from the Zerafshan and Fergana Valleys.[63]

62. FEWSNET, Livelihoods Zoning "Plus" Activity in Tajikistan, January 2011.
63. Acted, National Water resources Management Project. Integrated Watershed Management in Tajikistan context, September 2023.

Of this area, B. Gafurov district contributes almost 16% of the total cotton harvested in the Sughd Region. The area is naturally well-suited for growing crops like cotton and fruits, as well as for raising animals. According to the data collected by Acted under its SDC project, cotton yields increased significantly between 2021 and 2022, from 19.1 to 25 цс, while cereal grain yields have fluctuated, but remained largely constant. Drought conditions in the watershed in 2018 were reflected in a decrease in yields for both crops, although cotton yields were observed to be more robust.

Other crops, such as potatoes, vegetables and fruit trees, have been less affected by structural issues related to rain shortages or shortfalls in crop production. However, yields in these crops were shown to be much less stable, with yields shifting wildly between years, making them a less reliable source of income than cotton or wheat, which, despite change in output, have remained far more stable year on year.

More recently, farmers interviewed in the Sughd and the Gissar Valleys reported that cotton sowing has been delayed due to frequent rains, and greatly disrupting the local economy and livelihoods. As, the government has recognized the importance of the cotton industry for exports, this underlies the need for improved water management to ensure sustainable cotton production.

Seasonal calendars developed for the northern Sughd region by depict a schedule for planting, weeding, harvesting, and land preparation that very based on the specific requirements of each crop. Most crops undergo land preparation and planting during the winter and spring months, when rainfall is at its highest and discharge from the river water flow is at its lowest. Weeding and maintenance of cotton, fruits, and some vegetables continues throughout the summer, where crops rely highest on water irrigation from the river, and are then harvested in the Autumn and early winter as both rainfall and water discharge from the river have fallen.[64]

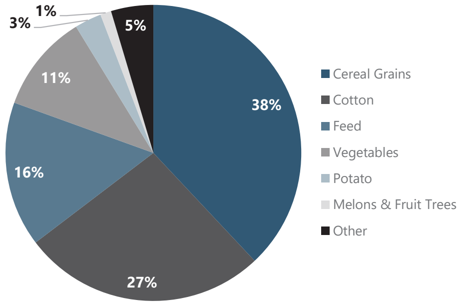
Wheat is an exception to this, as it is typically planted in the autumn, and grows throughout the winter, taking advantage of high rainfall in the area throughout the winter.

Climate change, resulting in shifting seasonal cycles and an increased frequency of extreme weather events, is expected to impact the seasonal calendars of crops, and in many ways already has, with some reports of delayed precipitation and water discharge from the river, leading to later and shortened planting seasons which have lead to stunted harvest and lower overall yields. This is likely due to changing temperatures and altered precipitation patters, which are both expected to fluctuate more and more unpredictably over time, as shown the previous climate change analysis. Due to the increasing unreliability of surface water and precipitation, farmers were reported to be increasingly reliant on groundwater, with as much as 69% of water in the irrigation network coming from groundwater. This is more expensive than precipitation and river water sources, which is likely to cause in increase in the prices of agricultural goods over time.

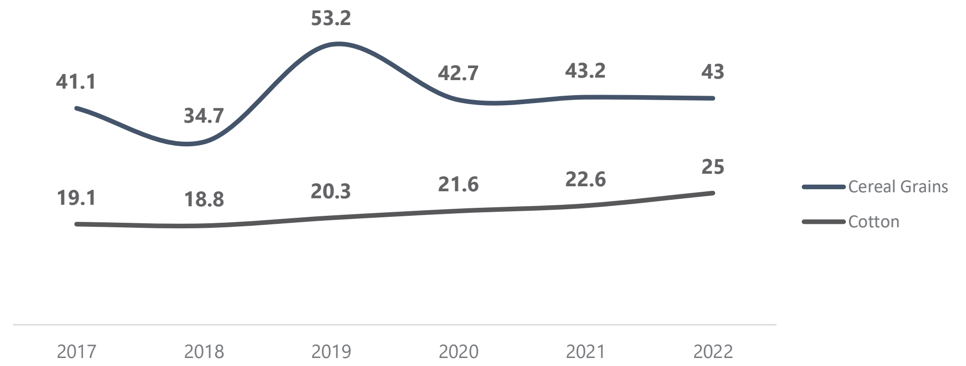
Therefore, it is important to consider the adoption of resilient crop varieties, adjustments to planting and harvesting schedules as well as promotion of sustainable farming practices to address the impacts of climate changes in crop seasonal calendar.

64. FEWSNET, Livelihoods Zoning "Plus" Activity in Tajikistan, January 2011.

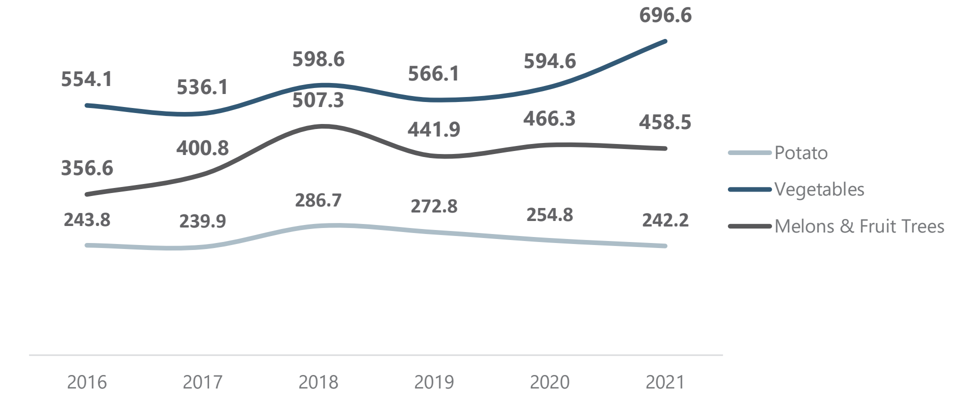
Graph 12: Proportion of ha agricultural land in Khojabakirghan Watershed by crop allocation, 2022[i]



Graph 13: Yields for cereal grains and cotton in Khojabakirghan Watershed, 2017 - 2022, (centner/ha).[i]



Graph 14: Yields for Potatoes, Vegetables, and Melons & Fruit in Khojabakirghan Watershed, 2017 - 2022, (centner/ha).[i]

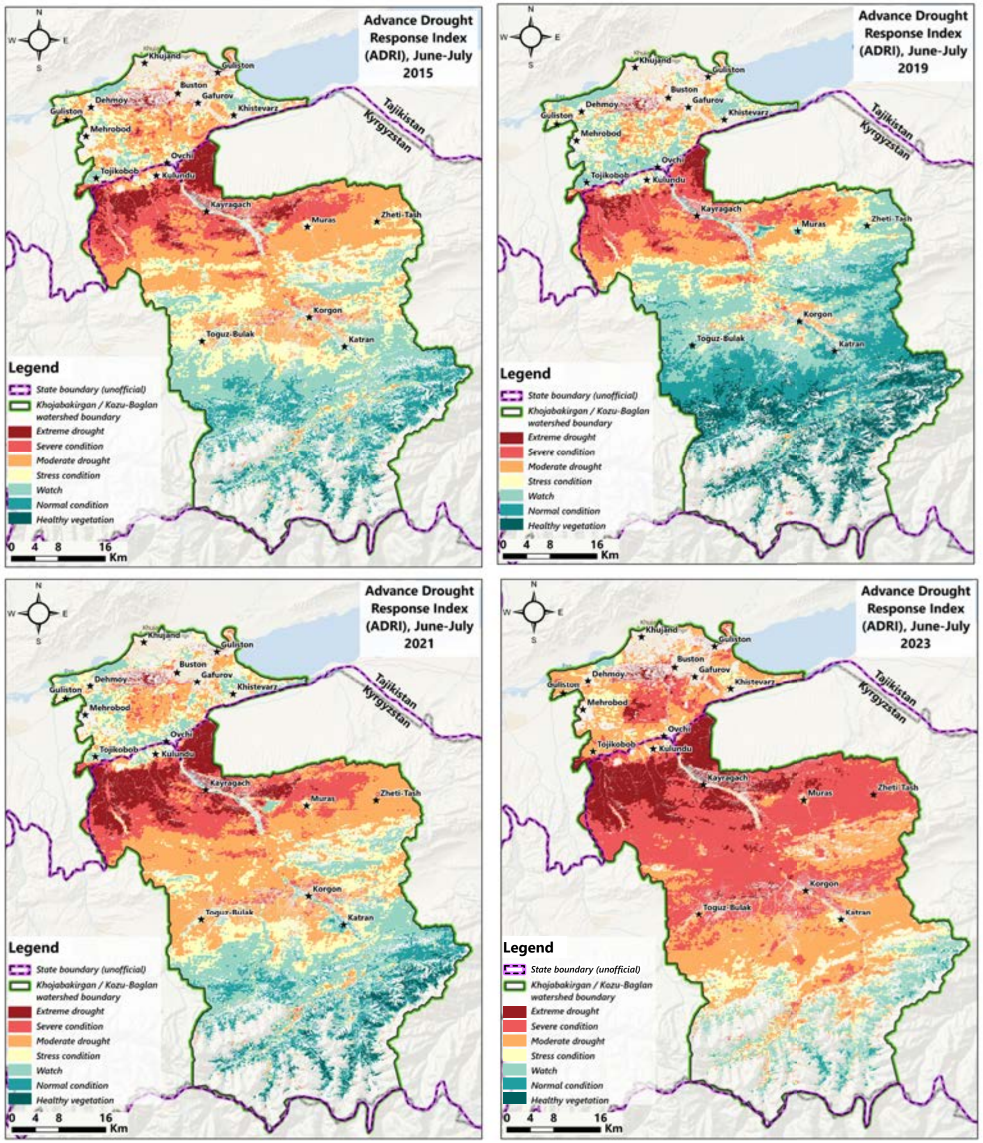


Suggested watershed support

- » Examine different crops and growing patterns, the resource inputs required to grow them, and how to adapt crops to changing climate and sowing patterns.
- » Identify crops that are more climate resilient and require lower water demands, to increase production when the watershed is under stress.
- » Implement drip irrigation and other water savng techniques to reduce water loss and efficiency of on-farm irrigation networks.

i) Source: Data from previous Acted reports conducted under SDC project.

Map 12: Drought susceptibility by LSG in Khojabakirghan Watershed, June 2022



Droughts are among the most dangerous hazards that communities in the Fergana Valley are exposed to, due to its ability to cause widespread destruction to livelihoods, and the difficulty in mitigating them at a local level. Most recently, in April 2021, a major drought across Central Asia killed over 2,000 livestock across the region.[65] The drought was amplified by dwindling water supplies due to climate change, something the Khojabakirghan watershed was reported to be vulnerable to.

A recent United Nations Food and Agriculture (FAO) study found droughts to be frequent in the Khojabakirghan watershed. Moderate droughts, causing a loss of 20% of total crop yields, were found to affect the adjacent Batken region in Kyrgyzstan every 5 years, with severe droughts, affecting 50% of yields, found to occur every 12-15 years in the nearby Isfara watershed.[66]

The Department of Agriculture in the B. Gafurov district is reported to have highlighted several likely risks to crops due to drought in the coming years. This includes approximately 2,300 hectares of rainfed lands designated for spring planting and 8,000 hectares of pastures are vulnerable to drought, approximately 10% of the both agricultural land and pastureland in the district.

The Department of Agriculture has also warned that in the likely event of temperatures exceeding 40°C between June and July, a total of 8,400 hectares of cotton crops are likely to be affected, resulting in an expected 8-10% reduction in cotton yield per hectare. This would also have an impact on the early vegetable, crop yields, affecting 250-300 hectares.

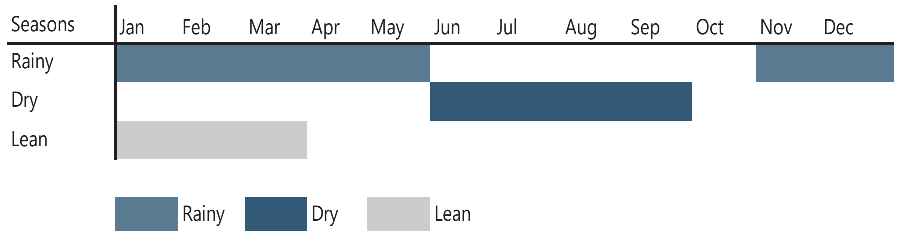
Strong winds during May-June can negatively affect around 7,000 hectares of land, leading to more than 10% of apricot trees being damaged. Additionally, in the case of heavy rainfall, cotton crops would need to be replanted on over 1,000-1,500 hectares of land.

Examining the table below, the North Sughd region has a rainy season that extends for more than half of the year, followed by a dry season in the summertime. However, recent trends in precipitation patterns indicate a potential increase in the duration of the dry season. (see section on Precipitation).

To assess drought hazards to agricultural lands in the Khojabakirghan watershed, IMPACT developed a composite model,

65. The Third Pole, Central Asian drought highlights water vulnerability, July 2021.
66. FAO, Drought Characteristics and management in Central Asia and Turkey, 2017.

Figure 3: Seasonal calendar for North Sughd Region, 2011[j]



j) Source: Data from previous Acted reports conducted under SDC project.

which combined geospatial analysis using the following indices: 1) Standard Precipitation Index (SPI), which measures rainfall, across a set period of months; 2) Vegetation Condition Index, which compares spatial data of vegetation land cover during the same periods of different years to assess change in land cover, and 3) Soil Moisture Index (SMI) which measures the estimated daily soil water content using hydrological satellite imagery data. These indicators were then averaged across each LSG in the basin to produce an estimated score of exposure to drought. The results are shown in Map 12.

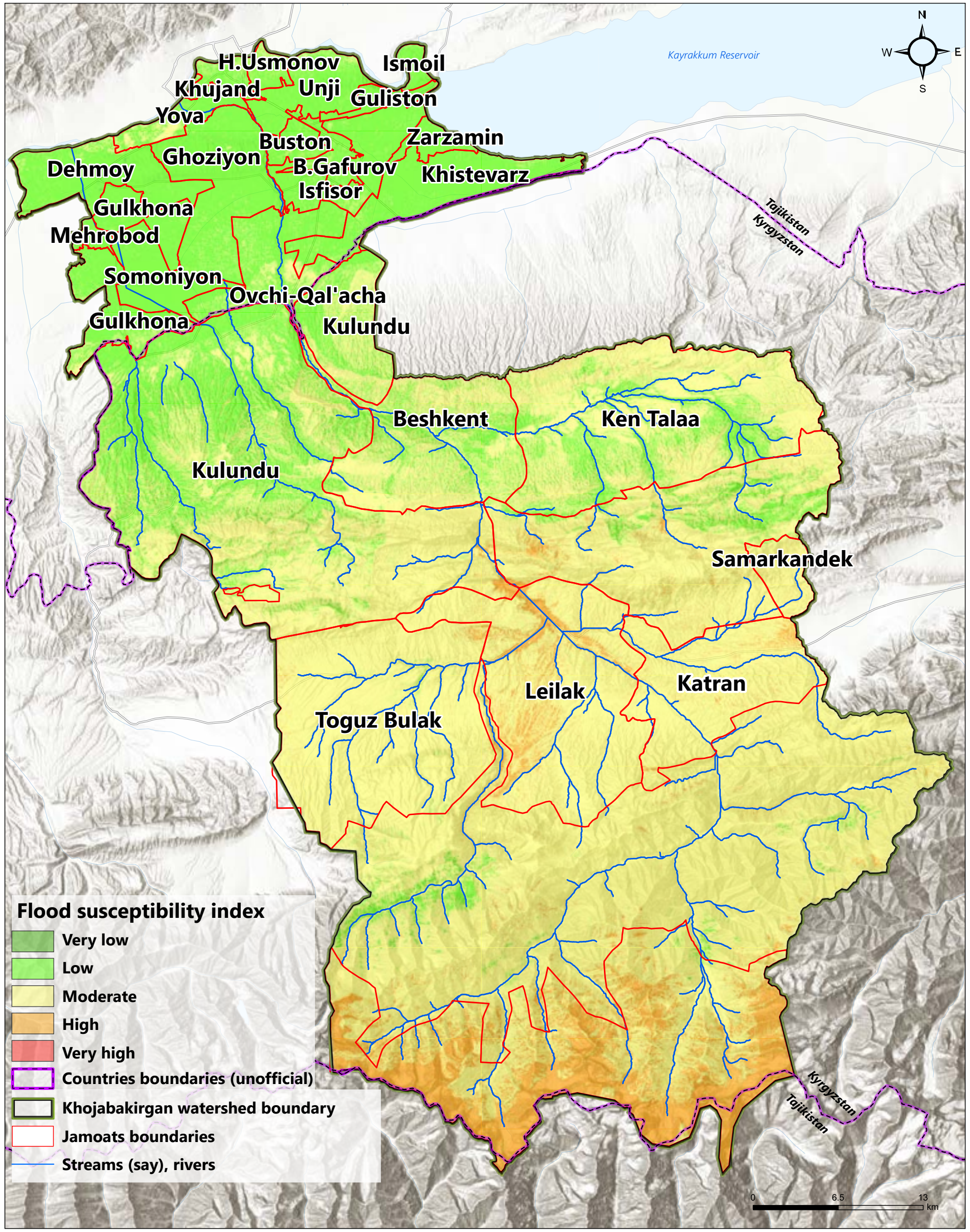
Examining the map, the jamoats in the eastern regions, including Isfisor, Zarzamin, Khistevarz, and Ismoil jamoats on the Tajik side of the watershed, are at a moderate exposure to drought, with the rest of the watershed having a low exposure to drought.

Approximately 493 ha of land in the Khojabakirghan watershed were noted in previous Acted reports under SDC to have high salinity, and nearly 8,000 ha are vulnerable to drought. The aforementioned vulnerability of the area to soil erosion raises this risk through the interlinks issues of soil degradation in the area.

Suggested watershed support

- Identification of complementary water sources, including groundwater (which will require additional assessments to understand the state of groundwater in the watershed).
- Rehabilitation of the irrigation network, particularly in upstream areas where most water loss is occurring, to improve water availability in the event of drought.
- Switching to less-water intensive crops can mitigate drought risk.
- Rainwater saving techniques can reduce the impact of drought in rain-fed areas.

Map 13: Flood hazard susceptibility in Khojabakirghan Watershed, June 2022



Floods are some of the most common hazards in the Fergana Valley and are alleged to have become more frequent and worse in recent years due to changes in precipitation and snow melt due to climate change which can result to an extensive destruction, causing fatalities and harming both individual possessions and crucial public health infrastructure.[67] The increase in water-related natural disasters highlights the strong link between water and climate change. For example, a recent report from the Emergency Situations department in Tajikistan revealed that the country now has just over 13,000 glaciers, down from over 14,000 three decades ago. The total volume of the remaining glaciers is currently 850 km^3, but this is expected to decrease by 33% by 2050.[68] This reduction in glacier volume raises the risk of GLOF-induced flash floods, highlighting a need for preventive measures.

The flood map 13 takes into account various indicators measuring exposure to flooding, including Topographic Wetness Index (TWI), elevation, slope, precipitation, Land Use and Land Cover (LULC), Normalized Difference Vegetation Index (NDVI), river and road proximity, drainage density, and soil type. Precipitation and slope are the highest-weighted indicators, as their substantial influence can trigger floods by rapidly generating runoff and overpowering inherent drainage systems. Analysis of the map shows that the areas with the greatest risk of flooding are the flat irrigated plains in the Tajikistan portion of the watershed, high mountains in the Turkestan Range that makes up the watershed's source.

Flooding was mainly due to increased or irregular precipitation in the watershed and lower and flat elevation where water collects more easily. According to the country's Committee of Emergency situations (CoES), on 19 July 2021 after a heavy rainfall, 2 people died, and 15 houses were damaged in several districts of Sughd region as a result of flooding.

As flooding in the Khojabakirghan watershed is closely linked with increased or irregular precipitation patterns, the effects of climate change are likely to cause flooding to worsen, as precipitation patterns become more extreme, leading to dryer summers and wetter rainy seasons.

B. Gafurov district faces annual flood risks, attributed to its susceptibility to climate change and its mountainous location. With over 11 mudslide-prone areas and a population residing in hazardous zones, there is a pressing need to address this issue. According to CoES, Flooding events are relatively common, with 4 reported such events occurring in Sughd district in both 2022 and 2021; this was comparable to other regions across the country.[69]

Unregulated land use, including deforestation and unchecked growth along riverbanks, exacerbates the problem, causing soil erosion and hampering natural flood control mechanisms. To mitigate flood risk, a proactive approach is required, focusing on reforestation in the mountains, tree planting with modern methods, perennial cultivation, river bank protection, and river bed maintenance. These actions are essential to safeguard both the local population and the region's agricultural land from the recurring flood hazards.

According to CAREC report, by 2050, the Sughd region may experience an increase in annual precipitation by 10-20%, which

67. World Health Organization (WFP), Floods.CoES,
68. Overview of Emergency Situations in the Republic of Tajikistan for 2022.

69. Overview of Emergency Situations in the Republic of Tajikistan for 2022.

could exacerbate the risk of sudden flooding, as well as the risk of landslides and mudslides in the more mountainous areas. Additionally, the central and southern parts of the Sughd region may face more intense daily extreme rainfall compared to historical extremes.

Suggested watershed support

- Improvement of canal infrastructure to hand water overflows will reduce downstream flooding damage.
- Digging and reinforcement of drainage ditches to allow water runoff and reduce damage to agriculture and infrastructure.
- Construction of gabion nets can reduce the impact of flooding on communities.

37 Pasture Management

Pastures play a critical role in both the economy and ecosystem of the Khojabakirghan River-Basin. Pasture resources are classified as agricultural lands, and are used by farms (state agricultural enterprises, dekhan farms and household farms) to pasture their animals for livestock production.

Pasture land in Khoiabakirghan watershed was found to have been extremely degraded, with approximately 2/3rds of total pasture land degraded. Degradation of pastureland was mainly attributed to a lack of meaningful enforcement of pasture use agreements within communities, and a lack of water and reforestation initiatives to support their restoration. The B. Gafurov district faces a pressing problem with its available pastureland. The district has 99.1 thousand hectares of pasture, which is not enough for the existing livestock. Poor pasture management and overgrazing are causing degradation and desertification which calls for actions needed to be considered and taken to manage pastures effectively, restore them, and follow established standards.

Plans are in place by local governments to improve the situation, but require collective action form the population to avoid depleting pastures through excessive unauthorized use. Additional land restoration initiatives and education on the reduction of over-use of pastures and forested areas will be critical for maintaining agro-pastoral livelihoods within the watershed.

Source: IMPACT, Cattle grazing in fallow croplands, B. Gafurov District, October 2023

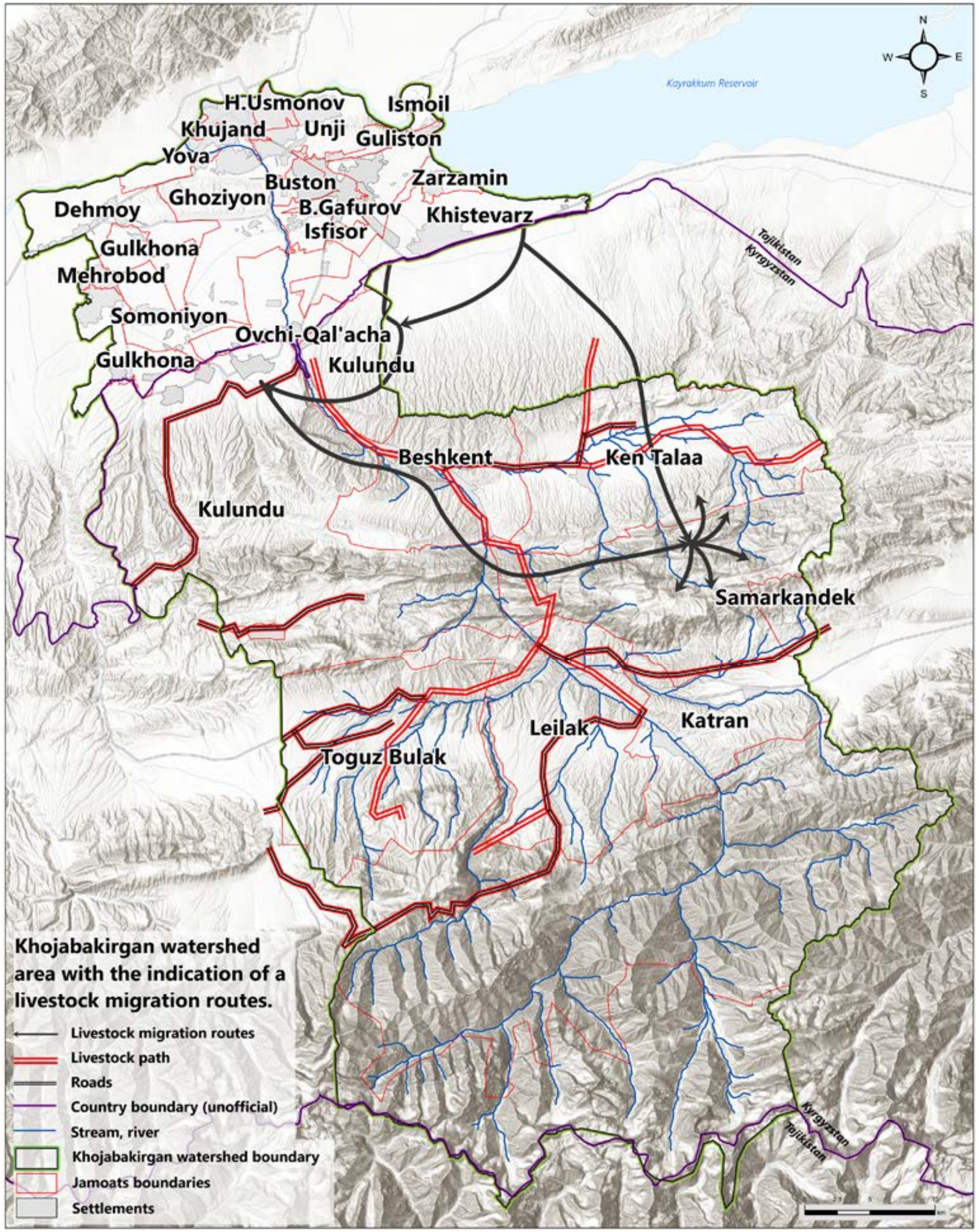
Pastures play a vital role in boosting economic development and reducing poverty in Tajikistan. Pasture land accounts for 27% of Tajikistan's total land area. In March 2013, the national parliament passed a Law on Pasture, which states that pastures are owned by the state and that allocation rights are held by the government, authorized state agencies, district government, and LSGs (jamoats). This law introduces new systems for overseeing pasture allocation and usage, alongside updated rules on pasture use fees.

Under the Land Code and land reforms, pasture distribution among different tenure types vary greatly. A report from the Asia Development Bank notes that much pasture is with private dehkan farms, around 11% in State Land Reserve, and 9% in State Forest Fund.[70] Private dehkan farms have lifetime inheritable use rights, implying that much pasture is privately held, often in larger plots. Landless households often access pasture through leases from the State Forest Fund or private landholders. In recent years, pasture lands are reported ot have degraded due to land degradation and overgrazing, despite livestock numbers rising from 4.5 million in 2005 to approximately 7.4 million in 2014.[71] This growth of over 65% is noted in the same report to be the principal cause of overgrazing.

In addition to existing institutions mentioned in the pasture management section, three more new institutions are created by the Law, which are still being in are process of structuring and specifying their functions: Pasture User Unions (PUUs), Commission on Pastures (CoP), and the Government Pasture Agency.

70. ADB, CAPE Tajikistan Linked Document 8: Assessment of Agriculture and Rural Development, 2014.
71. GIZ, Pasture Management in Tajikistan for Integrative Land Use Management Approaches (ILUMA), November 2019.

Map 14: Community herding patterns, Khojabakirghan watershed, 2023



The Ministry of Agriculture holds regulatory functions such as developing norms and methods for pasture management, overseeing utilization plans, and maintaining the state pasture inventory. It also implements state management programs and supports local communities, the Commission on Pastures (CoP), and international projects, with potential policy contributions.

The Commission on Pastures (CoP) operates at the district level under people's representatives, with a comprehensive scope encompassing regulatory, judicial, advisory, and management functions. It delineates boundaries, settles disputes, recommends lease fees, and aids in planning and monitoring. The livestock migration in the North Sughd region is primarily observed in January to mid-February and August. This migration pattern coincides with a shift in cattle movements towards Kyrgyzstan, which is driven by the lack of appropriate pasture areas on the Tajik part that prompted people to practice grazing the cattle on the fallow irrigated fields.

Pasture User Unions (PUUs) are community-based organisations working on pasture management, formed by pasture users and established at the jamoat (rural municipality) level, with members from various villages. PUUs serve a core function of informing the Minister of Agriculture, the Deputy Prime Minister, and the Executive Office of the President of Tajikistan about local pasture user union registration, their rights, and the regulations that oversee the use of pasture lands.

Suggested watershed support

- Identify alternate pasture grazing locations until traditional grazing locations are accessible again.
- Empowerment of new pasture management organizations to better hold pasture users to account and reduce collective action failure that prevent pasture restoration.

To analyse pasture degradation, IMPACT adapted a model developed by the International Fund for Agricultural Development (IFAD) to assess the degradation of pastures in Tajikistan.[72] The analysis compares the change in degraded pastures between 2000-2003 and 2019 to 2022 for the Khojibakirgan watershed. The findings of this analysis revealed a noticeable degradation across the watershed.

As shown on Map 15, the northwestern part of the map represents the lower zone of the Khojabakirghan Watershed (Tajik side), where only a small fraction of land is designated as pastures due to the predominantly flat terrain. Instead, the area is primarily devoted to irrigated agriculture.

The map illustrates that pasture degradation has affected the entire watershed area, irrespective of the elevation. The analysis revealed that approximately 67% of the pasture within the lower zone has suffered degradation. The preponderance of degraded pasturelands has been identified primarily in hilly areas outside of Khujand.

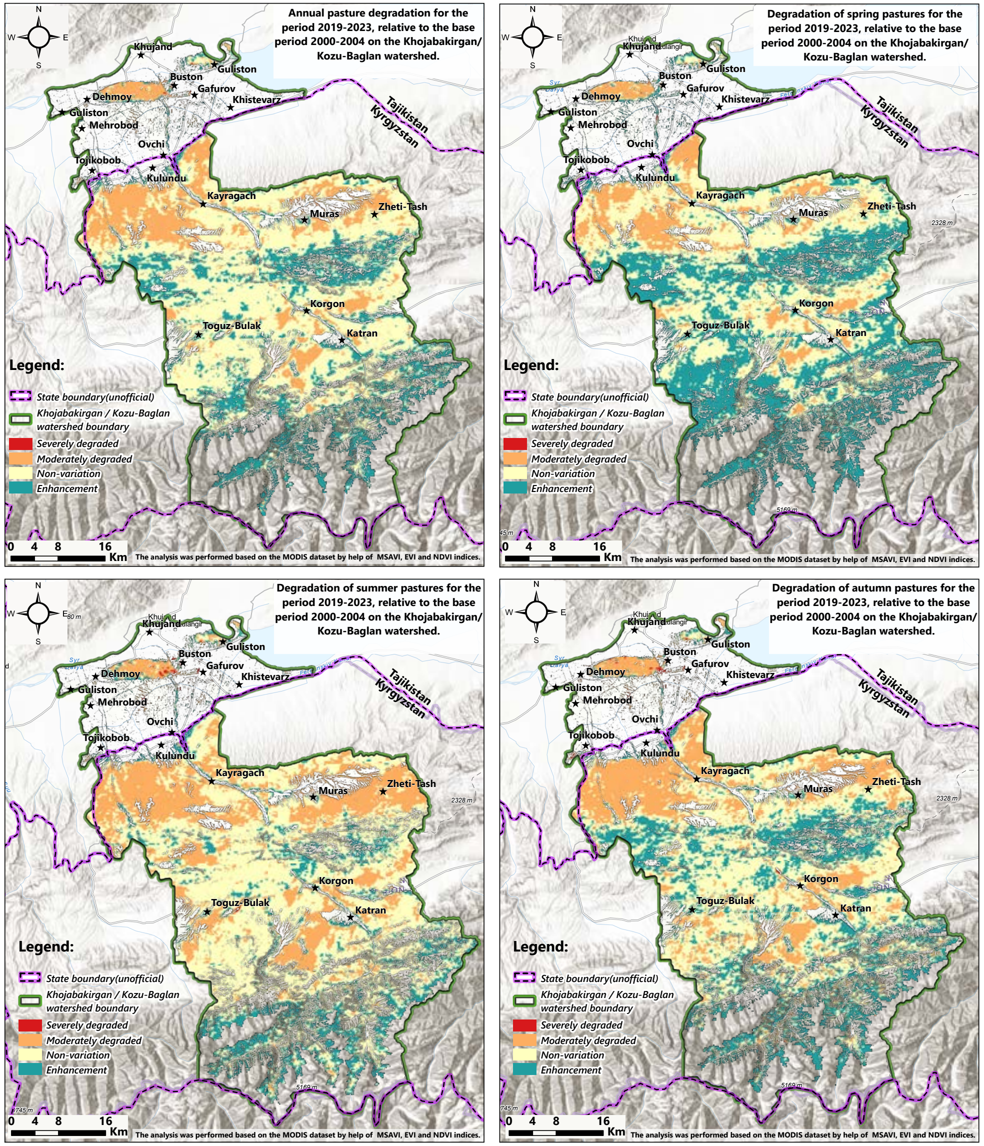
In both B. Gafurov and J. Rasulov districts, encompassing a total of 112,141 hectares of pastureland, most of which is not located in the immediate areas of the watershed and must be traveled far distances to reach. B. Gafurov district with 80,000 hectares of pastureland, has a structured grazing plan aimed at safeguarding these invaluable resources, yet annual degradation continues due to irrational utilization and excessive grazing, exacerbating desertification, mudflows, and floods.

72. International Fund for Agricultural Development (IFAD).

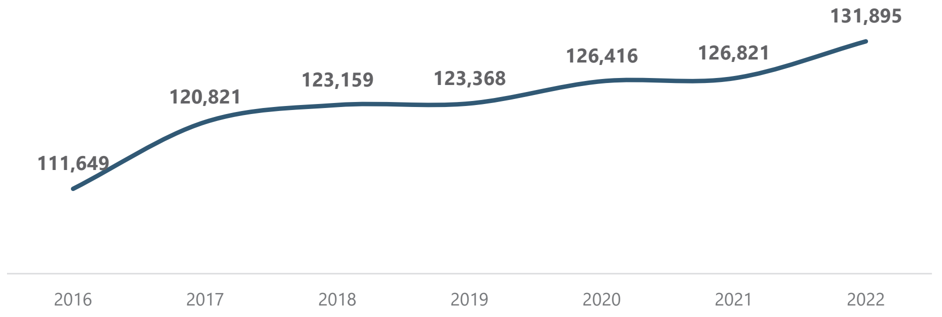
In J. Rasulov district, which has 32,141 hectares of pastureland, unauthorized use is a problem that stops the pastures from being used sustainably. To achieve sustainable pasture utilization in both districts, addressing unauthorized use and enforcing regulations is imperative.

Analysis of longitudinal data from the National Statistics Committee (Graphs 15, 16, & 17) shows cattle and sheep & goat herds to have increased slightly over time, suggesting that pressures on pastureland in the Khojabakirghan watershed are likely to continue.

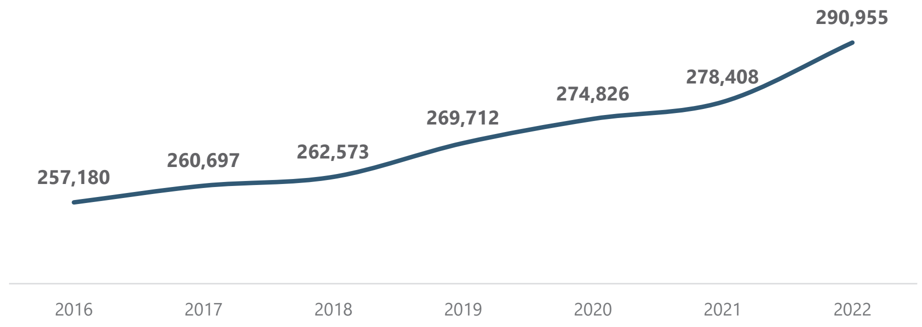
Maps 15: Pasture degradation susceptibility in Khojabakirghan watershed, between 2000-2003 and 2019-2022



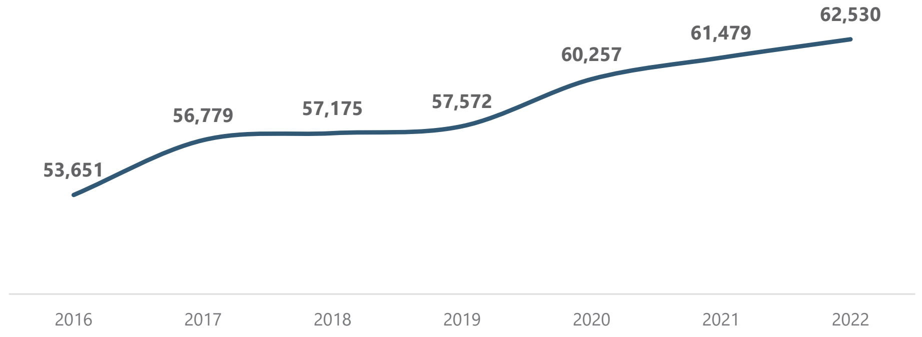
Graph 15: Number of livestock Khojabakirghan Watershed, 2012 - 2022[k]



Graph 16: Number of sheep & goats in Khojabakirghan Watershed, 2012 - 2022[k]



Graph 17: Number of cows in Khojibakirghan Watershed, 2016 - 2023[k]



Suggested watershed support

» Preservation and rehabilitation of pastures is essential to uphold ecological equilibrium and mitigate further environmental deterioration in the watershed.

» Pasture restoration is critical to maintaining livelihoods within the watershed. Restorative practices to allow land to recover and be sustainably maintained should be provided to communities.

» Government infrastructure schemes, like those to drill boreholes to provide water to pasture areas, should be supported to improve overall pasture health.

» Pastures can be restored through initiatives such as tree-planting, using alfalfa for foraging and animal feed, and drilling additional wells to improve the water supply to to improve foliage and and support livestock.

» Degradation is highest in Rukhak, the hilly area south of Khujand city. Particular efforts must be made to restore pasture health in this area due to its proximity to the city.

» Rainwater harvesting, less invasive livestock herding techniques, and tree nurseries to nourish soil can provide holistic solutions to restoring pasture lands.

k) Source: Data from previous Acted reports conducted under SDC project.

Source: IMPACT, Canal Gate, B. Gafurov District, October 2023

Disaster Risk Reduction

Disaster Risk Reduction (DRR) is a cross-cutting issue within watershed basins, as management of key hazards is a critical part of maintaining and improving the sustainability and resilience of a watershed and its associated communities.

Within the Khojabakirghan watershed, water, land, and the populations that rely on them are highly exposed to major natural hazards, particularly mudflows, flooding, landslides, and earthquakes. In addition to natural hazards, the population faces many anthropogenic hazards as well, such as conflict or industrial hazards.

Disaster risk reduction in Tajikistan involves various strategies, including transboundary cooperation, strengthening local capacities, and improving infrastructure resilience. Natural disasters such as earthquakes, mudflows, landslides, floods, and avalanches commonly affect these regions, and their impact is often amplified by practices like deforestation and overgrazing.

Based on prior assessments of the Khojabakirghan watershed's disaster risk, the findings reveal that virtually all 26 LSGs within the KB watershed have experienced various types of disasters. The most prevalent disaster by a significant margin are mudflows/debris flows, impacting 22 out of 26 communities.

The assessment found many of the longer term concerns regarding declining availability of water and it's affects on crop yields and the degradation of land to both increase the likelihood and impact of the prevalence of natural hazards, as well as be affected by them. To better understand this, an assessment of natural hazard prevalence was also conducted to support the watershed management planning process.

Earthquakes occur when a sudden slip over a fault line in the earth's tectonic plates occurs due to built-up stress overcoming friction between the plates. This releases energy as shaking waves through the Earth's crust.[73] Earthquakes are among the most destructive natural hazards in the Fergana Valley, and have in the past caused large amounts of destruction and loss of human life. While uncommon, the potential severity of damage the earthquakes can cause makes them a major focus of Tajikistan respective Ministries of Emergency Services.[74]

Of the more than 23,000 earthquakes that occur annually in Central Asia, 2,000 out of them occur in Tajikistan. The highest risks of destruction and human casualties from earthquakes of magnitude 7.3-7.5 may be in areas located in the zone of influence of the Fergana and Issyk-Ata faults. However, in the context of the Sughd region, the impacts of earthquakes have been lower, with the lowest reported annual average loss (AAL) in the country concerning earthquake damage, with a figure of 15.8 million US dollars.[75]

In B. Gafurov district, the overall overall seismic risks varies between 4 and 9 magnitude according to the Modified Mercalli Index (MMI). Preliminary findings for B. Gafurov district indicate that the annual potential financial damage from earthquakes is estimated at 52.68 thousand somoni. This number represents a minimum estimate, and the actual earthquake-related losses may include factors like economic losses, infrastructure restoration costs, lost profits, and insurance payments. The final assessment of earthquake damage is determined by the CoES, highlighting the need for further evaluation and preparedness efforts specifically related to earthquake risks in the district.

It is also important to note that earthquakes play a role in causing other natural hazards for these regions, especially landslides, mudflows, and avalanches and therefore it is crucial to prioritize measures for monitoring, prediction, and response to mitigate their response.

Map 16 illustrates the likely susceptibility of populations to earthquake impact on the watershed, indicating seismic zoning ranging from 7 to 10, showing significant exposure to earthquakes.

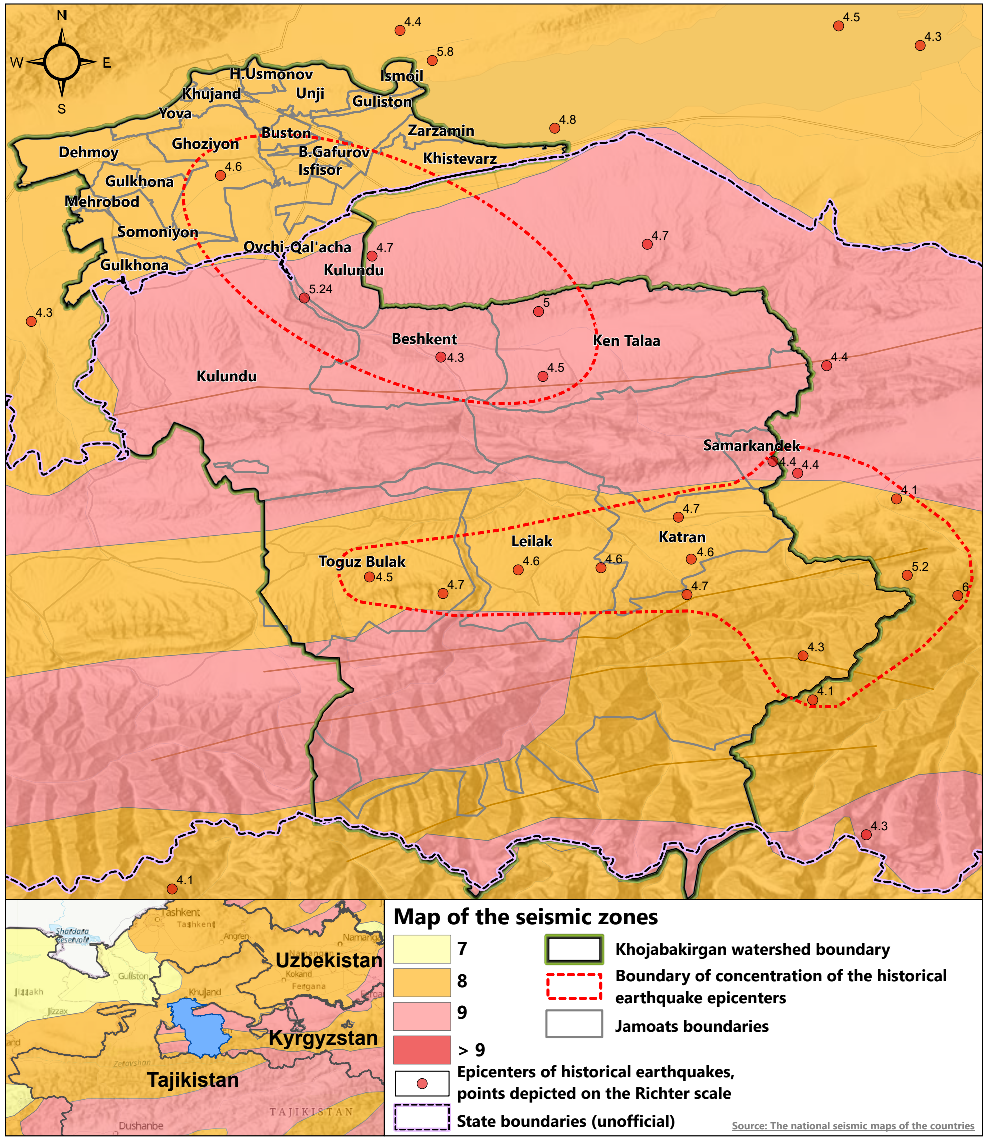
The Khojibakirgan watershed area ranges between MMI 8 and 9, some of the highest levels of risk in the region. The data was digitised from official government maps outlining major MMI shake zones, and overlaid with historical earthquake epicentres identified within the watershed. These epicentres present potential hazards to the neighbouring villages and their surroundings.

73. USGS, Earthquake Facts and Earthquake Fantasy
74. CoES, Overview of Emergency Situations in the Republic of Tajikistan for 2022.
75. CAREC, Risk Profile: Tajikistan, April 2022.

Suggested watershed support

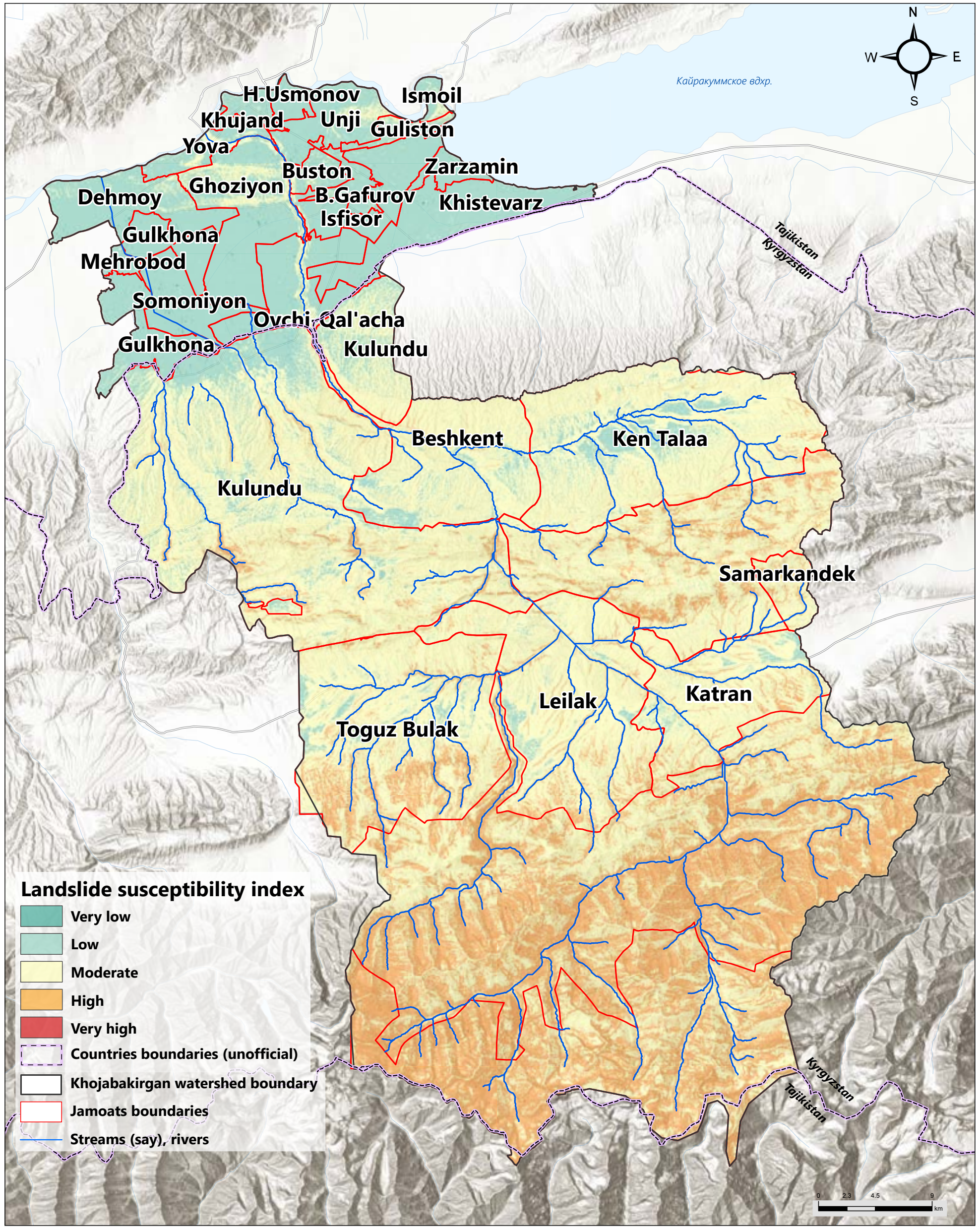
- Mainstreaming of earthquake resistant designs of shelters will reduce the likely damage of a potential earthquake.
- Prepositioning for the event of an earthquake in historical locations can improve response timing in the event of an earthquake.
- Reinforcement of irrigation network can help to reduce larger watershed NRM issues in the event of an earthquake.

Map 16: Earthquake hazard susceptibility in Khojibakirgan watershed, June 2023[I]



I) Source: Data from previous Acted reports conducted under SDC project.

Map 17: Landslide susceptibility in Khojibakirgan Watershed, 2023



Landslides involve the downward movement of rock, debris, or soil along a slope, often due to factors like slope angle, rock composition, seismic motion, and the presence of water, etc. Climate change with rising temperatures is expected to trigger more landslides, especially in mountainous areas with snow and ice.[76]

According to the World Bank, about 36% of Tajikistan is at risk of landslides and mudslides; in 2006, about 13,000 people were affected by flooding and landslides. In 2022, reported the identification of approximately 14 landslides in the country. In general, the Khojabakirghan region is not vulnerable to landslides, and in the Sughd region, they typically only occur in southern parts of the region, near Ayni.[77]

Map 17 shows the susceptibility to landslide hazards based on the index from very low to very high. The main indicators of landslide chosen for the map include NDVI, Slope, Distance from drainage, Distance from road and precipitation. The map indicates that the Tajik parts of the watershed have a lower susceptibility to of landslides. This can be due to the fact that higher slopes and less vegetation in the lower part of the map are the factors that are triggering to cause landslides most. In addition, areas close to stream are more prone to landslides due to saturated soil which is more probable to become unstable, especially during heavy rainfall even or rapid snow melt. The one exception are hilly areas to the south and east of Khujand, where animals are taken to graze.

In addition to higher slopes, a lack of overall vegetation in the mountains also increases the overall risk of landslides, contributing to greater risk. In addition, areas close to stream are more prone to landslides due to saturated soil which is more probable to become unstable, especially during heavy rainfall even or rapid snow melt. A previous study on risks in the Khojabakirghan watershed also noted that an earthquake can trigger landslides, compounding the overall susceptibility to landslide hazards.

76. NASA, "Climate Change Could Trigger More Landslides in High Mountain Asia," 11 February 2020.

77. CoES, Overview of Emergency Situations in the Republic of Tajikistan for 2022.

Suggested watershed support

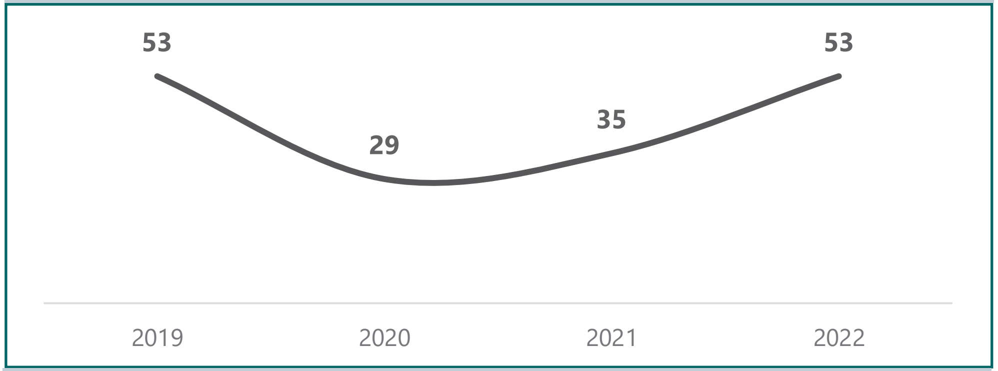
- Prepositioning of resources and assets in key villages known to be likely to be affected by landslides will improve response time and overall quality.
- Review and identification of safe relocation areas in vulnerable villages in the case a landslide occurs.

Tajikistan's landscape is mainly mountainous, with most of the country situated at altitudes above 3,000 meters, including high peaks exceeding 7,000 meters in the Pamir and Alai Mountain ranges. There are, however, low-lying regions like the Fergana Valley in the north and the valleys of the Kofarnikhon and Vakhsh rivers in the south. This varied topography plays a significant role in shaping the natural hazards faced by the country. Specifically, heavy rainfall on steep slopes in these mountainous areas frequently leads to destructive floods and landslides. In 2022, 679 disasters were recorded on the territory of Tajikistan, comprising 448 avalanches, 109-mudflows, 48 rockfalls, 22 prolonged rainstorms, 21 earthquakes, 17 inundation/water level rises in reservoirs, 14 landslides, 11 heavy winds, and 1 case of severe frost.[78]

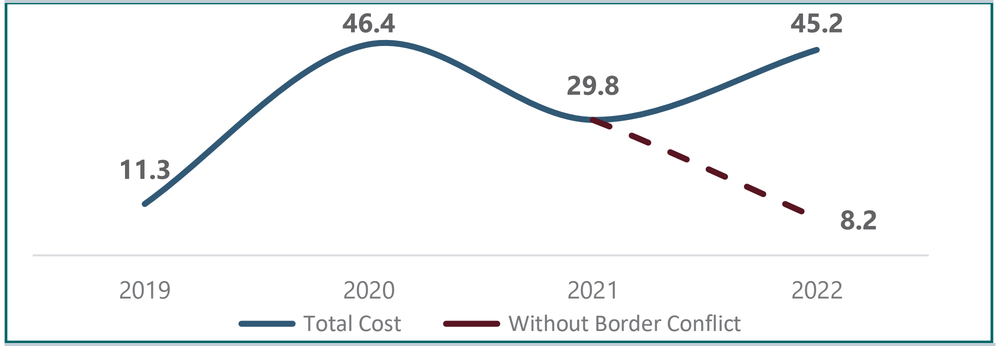
Over the past period, Tajikistan has taken significant steps to manage disaster risks and bolster its disaster risk management capabilities. In 2019, the country formulated a National Strategy for Disaster Risk Reduction to reduce risks and enhance resilience, learning from past experiences. More recently, the Untied Nations Office for Disaster Risk Reduction (UNDRR) has support CoES in improving Disaster Response processes through the Early Warning Systems for All (EW4All) Initiative. This aimed to improve resilience to natural hazard risks in Tajikistan by improving detection, observation, monitoring, analysis, and forecasting of risks.[79]

CoES annual reports indicate the number of natural disaster in Sughd to have remained stable, between 29 and 53 over the last 4 years on record.

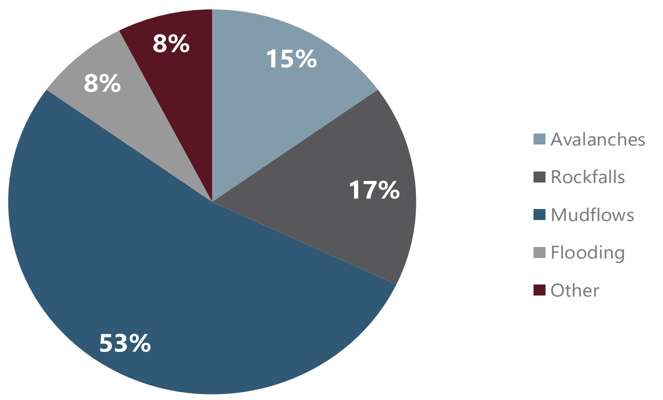
Graph 18: Total Number of Natural Disasters Catalogued by CoES in Sughd Region, 2019-2022m



Graph 19: Financial Cost of Natural Hazards in Sughd Region, 2019-2022 (in Millions of TJS, Adjusted for inflation with 2019 as a base year)m



Graph 20: Total Number of Natural Disasters Catalogued by CoES in Sughd Region, 2022m



However, the financial costs of these incidents have increased over time, from 11.3 Million TJS in 2019 to 45.2 Million TJS. In 2022 this was the most costly response of any region, over 5 times higher than the next most expensive regional response. However, it should be noted that the majority of these costs were from the responding to those affected by the border conflict. Not including these expenses, only 8.2 million TJS in damages were incurred in Sughd Region in 2022. It should be noted that this was still the most costly in damages incurred of any region in Tajikistan in 2022.

It is important to highlight that according to CoES's annual overviews of emergency response for 2022, most disaster response mechanisms are designed towards responding to disaster that have already happened, and not as much on disaster preparedness, suggesting over costs from the impacts of natural hazards could be lowered through the improvement of disaster preparation resources and planning.

Some of this has been implemented at a local level, where in J. Rasulov District in Tajikistan, an "ICOM mobile" radio station has been set up to communicated key messaging for evaluation in the event of a risk of rising water levels in the reservoir or flooding caused by dam breaches.

Disaster risk reduction in Tajikistan involves various strategies, including trans-boundary cooperation, strengthening local capacity, and improving infrastructure resilience. Natural disasters such as earthquakes, mudflows, landslides, floods, and avalanches commonly affect these regions, and their impact is often amplified

78. CoES, Overview of Emergency Situations in the Republic of Tajikistan for 2022.
79. UNDRR, UN Secretary-General's Early Warnings for All Initiative launched in Tajikistan, 29 August 2023.

m) Source: Committee of Emergency Services, 2019 - 2022.

by practices like deforestation and overgrazing. Based on prior assessments of the Khojabakirghan watershed's disaster risk, the findings reveal that virtually all 26 communities within the KB watershed have experienced various types of disasters. The most prevalent disaster by a significant margin is debris flow, impacting 22 out of 26 communities.

More specifically for the Khojabakirghan watershed area, Acted's reseach conducted under SDC recorded 2 major incidents in 2021 and 3 major incidents in 2023 related to flooding and mudflows in the watershed. Broadly, at least 1 such incident was found to occur a year, suggesting the importance of preventative measures. The largest issues identified in previous Acted SDC studies were fires, which accounted for most of the known recorded damage.

As most natural hazard risks in the watershed are linked to related water issues, like flooding and drought, much of the preventative work that has been done for reducing natural hazard risks has been related to the cleaning and maintenance of the water systems, including the cleaning 1,263 m of several riverbeds, including Khojabakirghan, which cost 377,400 TJS to implement. In addition, construction of a 9.7 km protective dam was implemented to prevent flooding from the Bahri Tojik reservoir.

Overall, the analysis highlights an interlinked need for disaster risk reduction alongside the restoration of pastures and protection of agricultural land and productivity. The main risks, by far, are to agriculture land, primary from drought. Most concerns towards building and property damage is from earthquakes, followed by flooding. As the earlier analysis on climate change demonstrated, both drought and flooding are likely to become more common in the future, making climate change mitigation and inter-linked disaster risk reduction issue, and highlighting and important emphasis on preparedness over response to natural hazards, in order to reduce their overall impact on the overall population.

Suggested watershed support

- Improve community-level trainings to incorporate a wider scope of natural hazards, and how to best respond from a community perspective. Trainings should also be conducted more frequently than twice a year, and focus on preparedness to reduce the overall effects of major natural hazards on lives and livelihoods.
- Infrastructure projects in the watershed, including canal rehabilitation and water monitoring, should mainstream disaster risk reduction approaches to reduce damage to this infrastructure in the event of a major natural hazard.
- Governments should be encouraged to take more preventative approaches to natural hazards, in order to reduce the harm to people, land, and infrastructure, and to reduce the overall damage from natural hazards.
- Concreting of river banks or installation of gabion nets may have the added benefit of reducing water loss, and should be considered for projects aimed at reducing water loss.

Traditional Gender Dynamics in the Fergana Valley

While a majority (75%-80%) of farmers operating dekhan farms in Tajikistan are male, and farm ownership by women was only 8%, women play a critical role in agriculture in Tajikistan.[80] A study by the International Water Management Institute (IWMI) on the management of dekhan farms in southern Tajikistan found that women play a dominant role in weeding fields and harvest in cotton, while a sizable minority (10%-20%) participated in purchasing agricultural inputs, marketing groups, hiring and managing labourers, and harvesting wheat.[81]

A study funded by the Asia Development Bank (ADB) found that female participation in agriculture, and particularly ownership, to have increased as more and more male members of the household have migrated abroad for work.[82] Approximately half of the households ADB surveyed were found to have had a family member who had migrated outside the country for work. The IWMI found that male family members who migrated were more inclined to delegate their physically demanding, labor-intensive tasks to women rather than to other men. However, management tasks and the operation of machinery were less likely to be passed on. As women are often not brought into Water User Association decision making, they are often left at a disadvantage for managing farm resources and are less likely to have the skills necessary to manage the dekhan farms. In recent years, this was reported to have started to change, as women have taken over more and more vacant positions in water user associations.

Productivity varies significantly between farms owned by men and women, predominantly influenced by access to agricultural inputs, with women facing notable disparities in access. For instance, fruit tree orchards demonstrate three times higher productivity on farms owned by women compared to those owned by men. Similarly, wheat and maize production shows comparable yields regardless of gender ownership, whereas cotton, other grains, and vegetable crops exhibit lower productivity on women-owned farms relative to their male-owned counterparts. This discrepancy can be attributed to the additional financial capital and labor resources required for the cultivation of these crops, which women often lack access to.

Notably, a higher percentage of the total female labor force (69%) is engaged in agriculture compared to the total male labor force (41%). This highlights the complex nature of gender dynamics within the agricultural sector, where women-owned farms excel in certain crop categories while facing challenges in others.

Interestingly, according to a previous 2012 study, women in Tajikistan were reported to be more independent and have more autonomy than any of the other surveyed countries in Central Asia.[83] Despite this, women were reported to often not be able to make household decisions directly, or require the support of women to make major decisions in land redistribution and acquiring agricultural machinery.

Women's participation in NRM

These dynamics have a major impact on women's levels of participation in NRM. As noted, women were typically excluded from participation in pasture meetings and WUAs, which, along with their often-rigid social roles and homemakers prevent them from gaining the knowledge and experience needed to meaningfully participate in these meetings.

This can have negative externalities that further degrade WUA productivity; female-run dekhan farms were reported to be 9% less likely to pay WUA fees needed to function, and 11% less likely to sign water contracts, which are needed to ensure that District offices budget the appropriate amounts of water for their communities. Women were 3% less likely to attend WUA meetings as well. While women can service in WUAs, it is very rare; as of 2020, out of a reported 416 WUAs in Tajikistan, only 13 (3%) women were reported to be the heads of water user associations.[84]

Most research on women's roles in Natural resource management and climate change in Central Asia revolves access to and acquisition of water. In Tajikistan, like other countries, women are often expected to collect water for their households, which can be difficult in many rural areas where they must travel very far from their homes to find water. This can be very dangerous if they are not escorted by a male friend or family member, as they may be seen as easy targets for criminals.[85]

This has major implications, as women are often the first group affected by climate change, which, along with the resultant lower water levels and irregular rainfall, has made water collection more difficult for these reasons.[86]

Studies also note that these restrictions in mobility can limit women's access to markets where goods can be sold for higher prices, sufficient high-quality seeds or financial assets, and other important agricultural inputs, making dekhan farm management and sustainability more difficult.

80. ADB, A Study of Women's Role in Irrigated Agriculture in the Lower Vaksh River Basin, Tajikistan. December 2020.
81. IWMI, Water Policy Brief: Strengthening participatory irrigation management in Tajikistan, June 2018.
82. ADB, A Study of Women's Role in Irrigated Agriculture in the Lower Vaksh River Basin, Tajikistan. December 2020.
83. CAWATER.info, empowering women in water resources management in Central Asia, 2012.
84. Agency for Land Reclamation and Irritation under the Government of the Republic of Tajikistan, State Support of the Water Users Associations (WUA), February 2019.
85. CAWATER.info, empowering women in water resources management in Central Asia, 2012.
86. CAKN, Practical Outlook on Gender Issues in the Water Resources Sector, "Water burden of rural women in the climate change context: case study of Shybran Village, Kyrgyzstan," Aiperi Otunchieva, 2020.

Suggested watershed support

- Trainings on the function and importance of Water User Associations and other community-level natural resource managment functions are important to increasing female particpation and financial contributions to exisiting natural resource managment organizations.

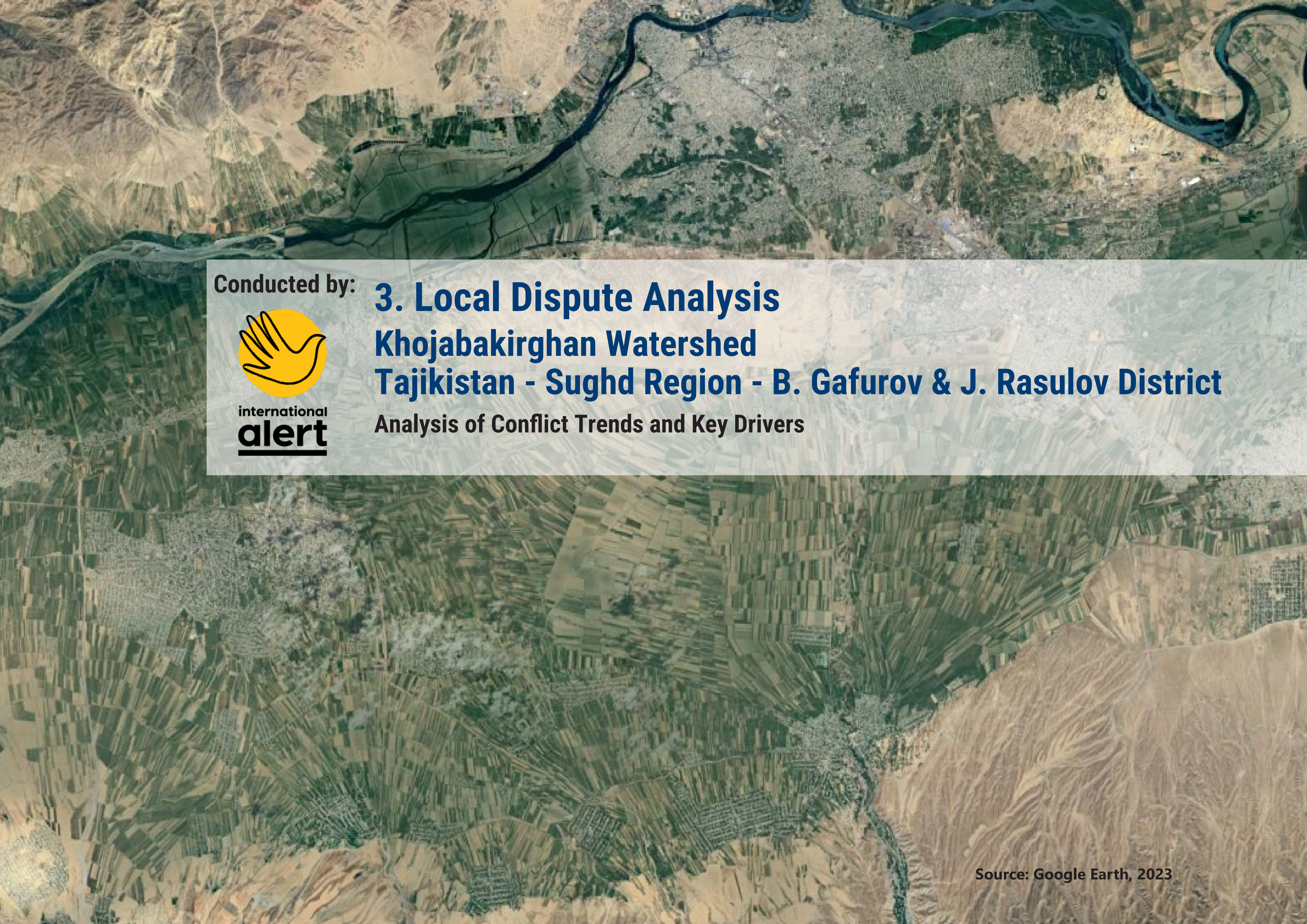
Conducted by:

international alert

3. Local Dispute Analysis

Khojabakirghan Watershed
Tajikistan - Sughd Region - B. Gafurov & J. Rasulov District

Analysis of Conflict Trends and Key Drivers



Source: Google Earth, 2023

Women are often underrepresented in trans-boundary water management, especially at higher levels of decision-making. Though the importance of including women in water management structures is beginning to receive increased recognition internationally, in practice laws and organizations seldom reflect a gendered approach.

According to the latest data from 2021, in the B. Gafurov district, 53% of the total population are women. In J.Rasulov district, 52% are women, who are mainly involved in the agriculture sector. Agriculture remains the main source of income for families in the border areas of the Khojabakirghan River Basin, notably when husbands and fathers have left their homes and migrated abroad for work.

The work in agriculture is difficult and low-paid. Often, women receive agricultural products instead of wages, which brings an additional burden to the financial condition of families.

Water is a vital resource in the region, but a scarce one, which makes it a major source of tension and conflict Lack of drinking and irrigation water provokes additional social tension in families. Some households collect rainwater for drinking, but in general, boys and girls must fetch water for drinking and sanitation from distant sources. However, boys usually stop doing this when they become teenagers. Traditionally, it is believed that collecting the water is the women's role. Thus, women are directly involved in water resources management and participate in water allocation.

In addition to difficult life conditions, when armed conflicts arise, women, children and older people remain the most vulnerable. Whereas armed conflicts usually lead to higher levels of violence against women and girls.

According to UN statistics, when women participate in peace-making processes, the resulting agreement is 35% more likely to last 15 years. The role of women in decision-making processes is underestimated and gender stereotypes still influence actors and actions on the ground, especially in rural areas.

Suggested watershed support

- Creation of a joint Basin commission with a mechanism for the distribution and use of water resources, as well as dispute settlement.
- Reform water conservation policy; develop and implement water conservation policies, considering measures like reducing water losses and ensuring equitable distribution. Engage local communities in the policy-making process to reflect their needs accurately.
- Crop diversification: promoting the cultivation of less water-intensive crops in upstream villages through awareness campaigns and education.
- Efficient water use; promoting efficient irrigation methods like drip irrigation and sprinkling, and encourage financial and technical support from governments, non-governmental organizations, and international donors to support these measures.
- Infrastructure development; investment in modern water infrastructure and irrigation canals to enhance water use efficiency and prevent water loss.
- Education and training; implementing information programs and training for farmers on water conservation and efficient agricultural practices to encourage adaption to climate change to increase crop yields.
- Strengthening local institutions; enhancing the capacity of local water management institutions (RuVKHa, WUAs) for equitable water distribution, conflict resolution, and planning for climate change impacts to ensure sustainable water management.

4. Recommendations

Khojabakirghan Watershed
Tajikistan - Sughd Region - B. Gafurov & J. Rasulov District

Key recommendations from assessment findings

Source: Google Earth, 2023

National Ministries and District Line Departments:

- Key national ministries of the Tajik Republic are recommended to develop measures to address the progressive shortage of water in the regions and changes in river hydrological regimes in response to climate change. These measures should be integrated into national policies, strategies, and planning frameworks.
- Key national ministries of the government of Tajikistan and their district and regional line departments are recommended to develop cooperation mechanisms to resolve existing issues regarding water use among different local stakeholders.
- A full stock take of the present availability of water reserves, snow and ice cover, and groundwater is recommended to better understand the total water reserves and their availability in comparison to water usage within the irrigation network for the near, medium, and long term.
- Modernization and automation of water intake from the river on irrigation channels to improve the effectiveness of water management processes within the watershed.
- Government stakeholders of the B. Gafurov and J. Rasulov districts are recommended to involve development partners who will be able to finance the modernization of hydraulic structures, hydraulic posts, the introduction of an automated information exchange systems to support the activities of the Basin Commission on the Khojabakirghan River, increasing the level of water and land productivity.
- Agreements multi-national agreements on water monitoring between different countries using the watershed are recommended.

Development Organizations:

- Consider supporting small-scale projects focused on introducing drought-resistant crops and promoting modern water-saving irrigation technologies, with the possibility for future replication within local communities.

Water & Natural Resources

- Studying and incorporating the best international practices for enhancing the natural resource management system. Skilled personnel from University hydrology departments should be engaged for this.
- Exploring the potential for extension of water accounting system to the larger canal network, which includes automatic water meters, remote reading systems, and software for data processing and analysis.
- Repairing or replacing sluice gates in the canal system is necessary to minimize losses of distributed water and increase the volume of water delivered to end users.
- Ensure the improvement natural resource management capacity of the water resources in Khojabakirghan watershed through dedicated trainings on the water infrastructure implemented under stream, as well as water management practices to more equitably distribute water between communities within the watershed.
- Repairing or replacing sluice gates in the Khojabakirghan canal system is necessary to minimize losses of distributed water and increase the volume of water delivered to end users.
- Rehabilitation of canals to reduce water loss and improve overall efficiency of the water network using water from the Khojabakirghan river for irrigation network.
- Sustainable approaches to management groundwater resources should be assessed, in order to ensure the preservation of groundwater resources and the projected depletion of Suluytka-Batken-Nau-Isfara Aquifer by 2045.
- Reduce water conflict and increase collection fees through the improvement of water counting systems via installation of water measurement devices and effective accounting systems.

Pasture Restoration

- Degraded pasture lands should be restored order to ensure more sustainable pastoral livelihoods. This should be done through a three-pronged approach of improved rainwater harvesting, vegetation restoration, and trainings on improved holistic livestock and land management in order to restore pasture ecosystems.
- Improved natural resource management of grazing areas through trainings that sensitize the population to the pasture management planning schedules and methods.
- Climate smart livestock production should be implemented, improving animal health and disease prevention through improved land management, improving feed/fodder conversation an production that is nutritionally improved, and Silvo-pastoralism initiatives to support the integration of trees and grazing livestock on the same land to support more healthy environments for livestock.
- Identification of alternative pasture lands outside of watershed area until traditional areas of pasture migration can be restored, in order ot reduce pressure on fallow agricultural lands and limited pasture lands within the Khojabakirghan watershed.
- Consider the effective reduction in livestock numbers to a more sustainable number that the watershed’s ecosystem can support through the stable keeping of livestock in adequate pasture areas.

Agriculture & Livelihoods Support

- Support to communities for climate smart agriculture to sustainably increase productivity of farmers and enhance the resilience of communities to the impacts of climate change. This includes the promotion of agricultural techniques such as drip irrigation and improved seed varieties to withstand flooding or drought, trainings on integrated pest management practices.

- Improve overall resource efficiency of household agriculture production through the reduction in usage of chemical fertilizers, improved farm equipment and maintenance of farm inputs, linked with sustainable irrigation strategies and water harvesting practices.
- Development of business models for new crop types that are less water resource intensive, with training plans and capacity-building trainings conducted to ensure adoption of new crops and growing strategies.

Disaster Risk Reduction

- Improved disaster preparation measures to reduce the impacts of natural hazards like mudflows, earthquakes, and drought on agricultural lands and irrigation infrastructure, and reduce the need for high-cost disaster response.
- Adopt an ecosystem approach to disaster risk reduction based on Integrated Watershed Resource Management model.
- Improve disaster risk management through participation in integrated natural resource management.
- Integrate disaster risk reduction with local development processes to improve their effectiveness and ensure access to financial resources.

Women & NRM

- Women's participation should be increased to a minimum of 40% in WUAs to address the imbalance in women's representation in decision-making processes within the sector.

Methodology for evaluation of hazard prevalence in Khojabakirghan watershed

Hazard	Data sources	Methodology
Earthquake	National Almanac of Seismic Belts, manually digitized from print documents, from Academy of Sciences Epicenter data is from United States Geological Survey (USGS)	Seismic belt data was manually digitized from print-based open-source maps to determine which zones were vulnerable to what Modified Mercalli Index (MMI) level of earthquakes. This was combined with epicentre point data of previously recorded earthquakes via the richter scale (1961-2023). The most vulnerable areas were demarcated based on the historical data.
Pasture Degradation	Data Sources based on IFAD Analysis of Pasture Degradation in Kyrgyzstan (2022), which are all measures taken from LANDSAT satellite imagery: Normalized Difference Vegetation Index; Enhanced Vegetation Index; Soil Adjusted Vegetation Index; Modified Soil Adjusted Vegetation Index; Normalized Difference Moisture Index; Normalized Burn Ratio; Vegetation Condition Index; Vegetation Health Index.	Following methodology outlined in the IFAD Technical Note on Pasture Condition maps in Kyrgyzstan (2022), A series of satellite imagery indexes were calculated using Landsat-based Spectral indices, comparing the period of 2000-2003 and 2019-2022. Each period was analyzed for irrigated land, rain-fed land, and pasture land, which were then compared across periods. The change in pasture areas was analysed between the 2 periods, and shows on the map. For more information, please see: here.
Flooding	Digital Elevation Model (DEM) from ALOS PALSAR (ALOS PALSAR); Road Network, Rivers, and Drainage Density data from Open Street Map (OSM); Normalized Difference Vegetation Index (NDVI) from Sentinel-2 data; Soil map of the KB watershed prepared with accordance SDC project in 2013. (as it was in PDF format in was digitized and converted into GIS format); Land Use Land Cover data from ESA WorldCover, derived from Sentinel-2	10 criteria were used for analysis. Topographic Wetness Index (TWI), Digital elevation Model (DEM), Slope (from DEM from ALOS PALSAR), Precipitation (NOAA), Land Use Land Cover from ESA WorldCover, ALOS PALSAR DEM, NDVI (Sentinel-2), Rivers and roads were taken from OSM using the euclidean distance method in ArcGIS (per metre), Drainage Density was calculated by identifying canals in OSM, and calculated using the line density function in ArcGIS, unit meter per square kilometer. Soil data was divided into 5 main texture types based on its absorption capacity (light loam, medium loam, heavy loam, clay, and rocks). The indicator values were divided into categories corresponding to a different range of values. These were re-classified to values between 1 and 5, and then each of the 5 variables was given a different weight. Topographic wetness index had the greatest weight followed by soil types and their ability to absorb water,followed by roads, slope, and vegetation.
Drought	VCI Data from MODIS EVI (2001 - 2022) SMI Data from the European Commission SPI Data from Copernicus European Drought Observatory	Overall drought hazard was calculated in Google Earth Engine based on accumulated vegetation condition index (VCI). Satellite derived vegetation health data from spring and summer months between 2001 and 2020 (MODIS EVI) was used. Methodology adapted from UN Spider. This analysis was combined with an analysis of the Standard Precipitation Index (SPI), which measures rainfall and Soil Moisture Index (SMI) which measures the estimated daily soil water content using hydrological satellite imagery data over the same time frames. These results of these indicators were broken into a 1-4 scale by severity, and then averaged across indicators to produce a final score.
Landslides	Normalized Difference Vegetation Index (NDVI) from Sentinel-2 Satellite; DEM slope data from ALOS PALSAR; Distance from Roads - Open Street Map (OSM); Distance from Streams - DEM & OSM; Precipitation: NOAA	This model used a similar approach to flooding, identifying 5 key criteria, dividing the different possible values into ranges, and giving ordinal values for each range from 1-5. Each criteria was then given a different weight based on its importance in contributing to landslides. Most important was slope, followed by precipitation, then NDVI, then distance from stream and roads.
Water Discharge **Water Yields** **Precipitation** **Soil Erosion** **Sedimentation**	All Indicators calculated through Soil and Water Assessment Test (SWAT) Modeling, developed by the University of Texas A&M, using the following data: Temperature & Precipitation data (1981 - 2021); from National Oceanic and Atmospheric Administration; Water Discharge data (2013-2022): RuVKHa & Open Sources; World Meteorological Organization; Digital Elevation Model from ALOS PALSAR; Soil Map - National Sources from FAO Land Cover Classification System (LCCS)	SWAT is based on creating a simulated model of the watershed. A digital elevation model is created, and then the boundaries of the watershed are defined. Flow direction and flow accumulation is given, and criteria are given on the area of hectares for each sub-basin of the entire watershed, which the programme computes. These sub-basins are defined as unique entities within the larger river basin in which are served by tributaries of the main river., Within each Sub-Basin, Hydrological Response Units (HRUs) are calculated. Each HRU has a specific value for LULC, soil, and slope which is uniform across the HRU. Meteorological data is put into the model, which includes temperature and precipitation per day weather data. Solar radiation, wind speed and relative humidity are also included in the model. Based on this, the model calculates discharge, which includes the water volume of all tributaries and streams. From this, calculations on the key indicators are made. Based on the information, the model simulates the potential soil erosion, sedimentation,water yields, and precipitation in each HRU. It simulates the discharge of water in the reach channel (main channel).
Snow Melt	Landsat Collection 2 Satellite data using Normalized Difference Snow Index (NDSI), 1991 - 2023	To compute the changes in snow coverage, IMPACT computed the overall areas of snow coverage using the NDSI from 1991, 1995, 2001, 2009, and 2023. These were years selected to demonstrate regular intervals over the last 30 years of glacier change, with the exact years selected by the quality of data (images with cloud coverage could not be used). All data was taken from the month of February, the hight of winter in the Fergana Valley.
Glaciers	Glacier Volume Change is from Famine Early Warning Systems Network (FEWSNET) Land Data Assimilation System (FLDAS) data provided by by NASA, Glacier Area Change is from Global Land Ice Measurements from Space (GLIMS) Datasets	Analysis for the change in glacier area compared the area of glacier location and coverage between 2001 and 2023, comparing the GLIMS satellite imagery and computing and subtracting the area of each glacier between both periods. Analysis for glacier volume was provided by the FLDAS database. This was aggregated by IMPACT and compared between 2001 and 2023.

Climate Change	Historical bio-climatic variables and model for the future 2041-2060 from WorldClim.	The analysis for climate change uses World Clim data, which is a database of high spatial resolution global weather and climate data, which uses historical climate data based on data collected over time. It does climate projections using the CMIP6 downscaled future climate projections. Four Shared Socio-economic Pathways, or climate change scenarios, are measured. IMPACT selected the 370 model for this assessment. IMPACT chose to assess the middle-near term in climate change, 2041-2060. Statistics were then calculated for the specific Khojabakirghan watershed area, including descriptive statistics, and took the average value for the watershed area. The maps show the range of the areas in total.
General datasets	Administration boundaries from Ministry of Emergency Services (MoES). Rivers, Roads, Buildings from OSM.	

As discussed in the introduction, for the initial rapid assessment, all hazards were selected in line with the UNDRR[87] Hazard definition & classification review of global hazard types. Each hazard was examined on its own, and then aggregated to their respective hazard groups, defined in the UNDRR hazard index. Each hazard was given a weight to account for some hazards having a larger contribution than others to the overall impact of the hazard grouping on population groups.

The extent of each hazard was overlayed with the population's hazard exposure, equally weighted between population density of people and the amount of agricultural land identified by satellite imagery. These were multiplied together to determine the overall risk levels to each watershed community.

Each hazard group and its population's hazard exposure was then in turn weighted based on its importance in affecting the availability of water in each watershed, which was used to calculated a single, "Water stress index" indicator indicating the overall level of water stress for the watershed. Data sources and weighting of each indicator are shown in Table T1 to the right, and the final results of the weighting are in map A1 below.

87. UNDRR, 2023.

Map A1: Prioritisation of Trans-boundary Watersheds in the Fergana Valley by Water Stress Index, March 2023

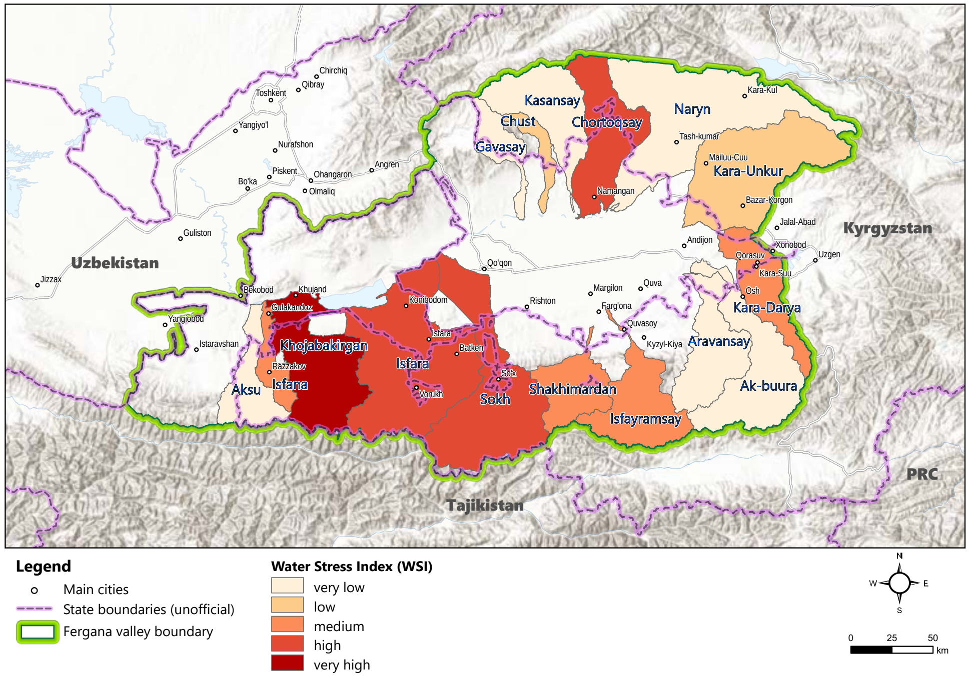


Table A1: Water Stress Index Indicators, hazard groupings, and weighting of indicators to create composite water Stress Index.

OID	Hazard Group	Weight	Hazards	Weight	Indicator	Dataset
1	Land degradation	0.1	Soil degradation	0.3	Soil salinity	Landsat-8 spectral index
2				0.4	Soil water erosion	RUSLE model: topography, soil clay component, rain erodibility, land use
3				0.3	Dust storm susceptibility - soil and wind erosion	Sentinel-5 Aerosol index; Wind speed
4	Climate change / temperature related hazards	0.1	Heatwave	0.4	Heatwave	Heatwave index - 20 year; Heatwave index change 10/10 years
5			Drought	0.6	Drought severity	VCI - 20 year[88]; Temperature changes
6	Climate change / precipitation-related hazards	0.3	Water scarcity	0.7	Water balance	Change in snow density (1961-1990 vs 1991-2020); Snow cover (current); Water availability (stream power); Precipitation yearly mean
7	Societal hazards	0.3	Conflict	1	Dispute incidents	Number of dispute incidents
8	Technological hazards	0.2	Technological hazards	1	Presence of other hazardous materials	Number of hazardous industrial facilities, mines, and radiological storage locations
9	Hazard exposure components			0.5	Agricultural land	
10				0.5	Population density	

88. UN-SPIDER, Recommended Practice: Drought monitoring using the Vegetation Condition Index (VCI), 2023.


Source: Google Earth, 2023