CLIMATE RISK COUNTRY PROFILE

TAJIKISTAN

WORLD BANK GROUP

ASIAN DEVELOPMENT BANK

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ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles that are jointly developed by the World Bank Group (WBG) and the Asian Development Bank (ADB). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Veronique Morin (Senior Climate Change Specialist, WBG), Ana E. Bucher (Senior Climate Change Specialist, WBG) and Arghya Sinha Roy (Senior Climate Change Specialist, ADB).

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Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

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FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group (WBG) and the Asian Development Bank (ADB) are committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

Both institutions are investing in incorporating and systematically managing climate risks in development operations through their individual corporate commitments.

For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

For the Asian Development Bank (ADB): its Strategy 2030 identified "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability" as one of its seven operational priorities. Its Climate Change Operational Framework 2017–2030 identified mainstreaming climate considerations into corporate strategies and policies, sector and thematic operational plans, country programming, and project design, implementation, monitoring, and evaluation of climate change considerations as the foremost institutional measure to deliver its commitments under Strategy 2030. ADB's climate risk management framework requires all projects to undergo climate risk screening at the concept stage and full climate risk and adaptation assessments for projects with medium to high risk.

Recognizing the value of consistent, easy-to-use technical resources for our common client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group and ADB's Sustainable Development and Climate Change Department have worked together to develop this content. Standardizing and pooling expertise facilitates each institution in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For common client countries, these profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

We hope that this combined effort from our institutions will spur deepening of long-term risk management in our client countries and support further cooperation at the operational level.

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KEY MESSAGES

- Tajikistan is projected to experience temperature rises significantly above the global average. Under the highest emissions pathway (RCP8.5), warming could reach 5.5°C by the 2090s, compared with 1986–2005 baseline.
- Warming trends are projected to be even stronger for maximum and minimum temperatures, which could adversely impact on human lives, livelihoods, and ecosystems.
- There is a high likelihood that temperatures in Tajikistan will more regularly surpass 40°C, particularly in lowland regions. This can have result in increased consequences to human health
- Increased temperatures, paired with increased likelihoods for aridity and drought incidence can cause the expansion of arid land for some areas, which could also affect agricultural yields.
- The potential for decrease of the country's mountain glaciers is likely to reduce the regularity of waterflows, and may result in the drying of some watersheds. Simultaneous flooding issues and associated hazards such as landslides and mudslides are expected to intensify, impacting lives and livelihoods.
- Tajikistan has a strong reliance on hydroelectric power production and potential drying may impact regularity of flows, which may increase variability of hydropower generation.
- Without needed adaptation efforts and disaster risk reduction preparedness and planning, the effects of climate change, and particularly heat and drought, may result in severe loss and damage in Tajikistan.

COUNTRY OVERVIEW

The Republic of Tajikistan is a landlocked country lying between latitudes 36°40'N to 41°05'N and longitudes 67°31'E to 75°14'E with an area of 143,000 kilometers square (km^2). Tajikistan shares borders with Kyrgyzstan and Uzbekistan in the north and west, China to the east, and Afghanistan to the south. Mountains occupy about 93% of the terrain, with altitudes ranging from 300 meter (m) to 7,000 m. Nearly 50% of Tajikistan's territory is at least 3,000 m above sea-level. Tajikistan has approximately 1,300 lakes, and the two principal rivers of Central Asia, the Amu Darya and the Syr Darya, both flow through the country. Other major rivers are the Pyanj, Vakhsh and the Kofarnihon, which are tributaries of the Amu Darya.[1] 93% of the country is covered in mountains, with many glaciers, primarily in the eastern regions of Tajikistan.[2] These serve an important function by retaining water, controlling flows, and regulating the climate. Glaciers, snowmelt and permafrost are important sources of water recharging the Aral Sea river basin. Geographically, Tajikistan is divided into four zones: Northern Tajikistan, Southern Tajikistan, Central Tajikistan, and the Pamirs. The western part of the country is occupied by foothills and steppes; lowland areas are found along river valleys in southwestern Tajikistan. The Pamir mountains in the east are sparsely populated, with extremely cold winters, considerable snow cover, and short summers.[3]

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[1] FAO (2012). Country Profile – Tajikistan. FAO AQUASTAT Reports. URL: http://www.fao.org/3/ca0369en/CA0369EN.pdf

[2] GIZ (2020). Climate Change Profile: Tajikistan. URL: https://www.preventionweb.net/files/73805_73805gizclimatechangeprofiletajikis.pdf

[3] Khakimov, P., Aliev, J., Thomas, T., Ilyasov, J., and Dunston, S. (2020). Climate Change Effects on Agriculture and Food Security in Tajikistan. *Silk Road: A Journal of Eurasian Development.* 2(1). pp. 89–112. DOI: https://doi.org/10.16997/srjed.33

Tajikistan's population and agricultural activities are concentrated in the valleys and in the western part of the country. As of 2020, agriculture (including forestry and fishing) contributed approximately 23.8% to national GDP, services 35.3% and industry 32.8%.[4] Agriculture remains the largest employer, accounting for about 43% of the workforce in 2016. Tajikistan's major agricultural products are cotton and cereals. The country has significant natural resources such as water, coal, mercury, gold, silver, salt, limestone, marble, and clay. Water resources are used to irrigate agriculture, supply industrial and domestic needs, and generate about 95% of all electricity. Tajikistan is one of the most impoverished nations in Central Asia (**Table 1**).

TABLE 1. Key Indicators

Indicator	Value	Source
Population Undernourished[5]	Unknown (2017–2019)	FAO, 2020
National Poverty Rate[6]	26.3% (2019)	Tajikistan, 2021
Share of Income Held by Bottom 20%[7]	7.4% (2015)	World Bank, 2019
Net Annual Migration Rate[8]	–0.22% (2015–2020)	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)[9]	2.9% (2015–2020)	UNDESA, 2019
Average Annual Change in Urban Population[10]	2.62% (2015–2020)	UNDESA, 2018
Dependents per 100 Independent Adults[11]	68 (2020)	UNDESA, 2019
Urban Population as % of Total Population[12]	27.5% (2020)	CIA, 2020
External Debt Ratio to GNI[13]	67.7% (2018)	ADB, 2020
Government Expenditure Ratio to GDP[14]	30.8% (2019)	ADB, 2020

4 World Bank (2021). World Development Indicators. DataBank. [accessed 15 March 2021]. URL: https://databank.worldbank.org/source/world-development-indicators
5 FAO, IFAD, UNICEF, WFP, WHO (2020). The state of food security and nutrition in the world. Transforming food systems for affordable healthy diets. FAO. Rome. URL: http://www.fao.org/documents/card/en/c/ca9692en/
6 TajStat (2021). National Statistics. URL: https://www.stat.tj/en/
7 World Bank (2019). Income share held by lowest 20%. URL: https://data.worldbank.org/ [accessed 17/12/20]
8 UNDESA (2019). World Population Prospects 2019: MIGR/1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
9 UNDESA (2019). World Population Prospects 2019: MORT/1-1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
10 UNDESA (2019). World Urbanization Prospects 2018: File 6. URL: https://population.un.org/wup/Download/ [accessed 17/12/20]
11 UNDESA (2019). World Population Prospects 2019: POP/11-A. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
12 CIA (2020). The World Factbook. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/
13 ADB (2020). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020
14 ADB (2020). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020

Given the Tajikistan's dependence on natural resources and high social vulnerability, the nation faces significant risks from climate change. Tajikistan has signed and ratified the Paris Climate Agreement and submitted its Third National Communication (TNC) to the UNFCCC in 2014. Tajikistan's National Adaptation Plan continues to be under development, coordinated by the Committee for Environmental Protection under the Government of Tajikistan. Tajikistan has also submitted its first Nationally Determined Contribution (NDC) to the UNFCC in 2017. An updated version of the NDC is currently being prepared.

Green, Inclusive, and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

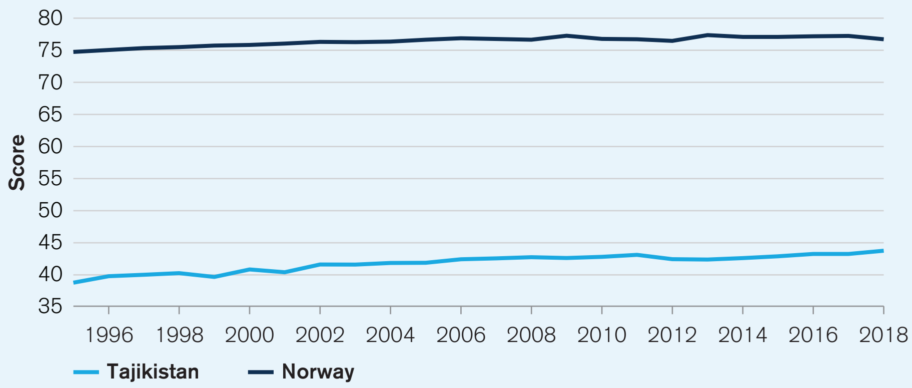
This document aims to succinctly summarize the climate risks faced by Tajikistan. This includes rapid onset and long-term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of Tajikistan, therefore potentially excluding some international influences and localized impacts. The core data presented is sourced from the database sitting behind the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG and ADB staff to inform their climate actions. The document also aims and to direct the reader to many useful sources of secondary data and research.

Due to a combination of political, geographic, and social factors, Tajikistan is recognized as vulnerable to climate change impacts, ranked 100th out of 182 countries in the 2020 ND-GAIN Index.[15] The ND-GAIN Index ranks 182 countries using a score which calculates a country's vulnerability to climate change and other global challenges as

[15] University of Notre Dame (2020). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

well as their readiness to improve resilience. The more vulnerable a country is the lower their ND-GAIN score, while the more ready a country is to improve its resilience the higher it will be. The higher the score, the higher the rank. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Tajikistan's progress, in comparison to Norway.

FIGURE 1. The ND-GAIN Index Score (out of 100) summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead.



CLIMATOLOGY

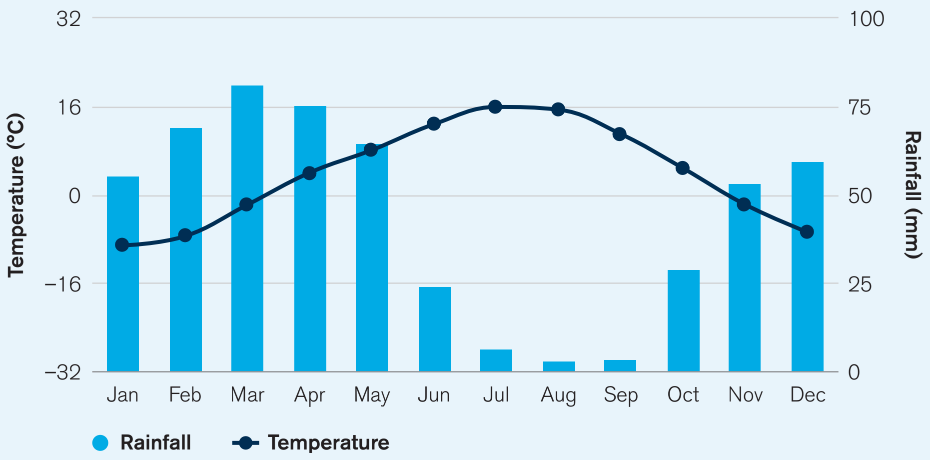
Climate Baseline

Overview

Aridity, extreme temperatures, and significant intra-annual), inter-annual and regional variability are predominant characteristics of Tajikistan's climate. **Figure 2** shows the seasonal cycle for the latest climatology, 1991–2020. Variability is driven by Tajikistan's position at the intersection of atmospheric circulations from the tropics to the southeast and Siberia to the north. Annual mean temperatures vary from 17°C in the south to –6°C in the lower Pamirs. Maximum temperatures are typically observed in July and minimum in January. In East Pamir, minimum temperatures below –50°C have been recorded, whereas in the south, maximum surface air temperature can exceed 40°C. The annual precipitation in lowland, hot deserts of northern Tajikistan, and cold mountain deserts of east Pamir averages from 70 millimeters (mm) to 160 mm, whereas in central Tajikistan precipitation can exceed 1,800 mm per year. The nation receives negligible precipitation during the months of July, August, and September, contributing to frequent droughts. **Figure 3** shows observed spatial variation for temperature and precipitation across Tajikistan.

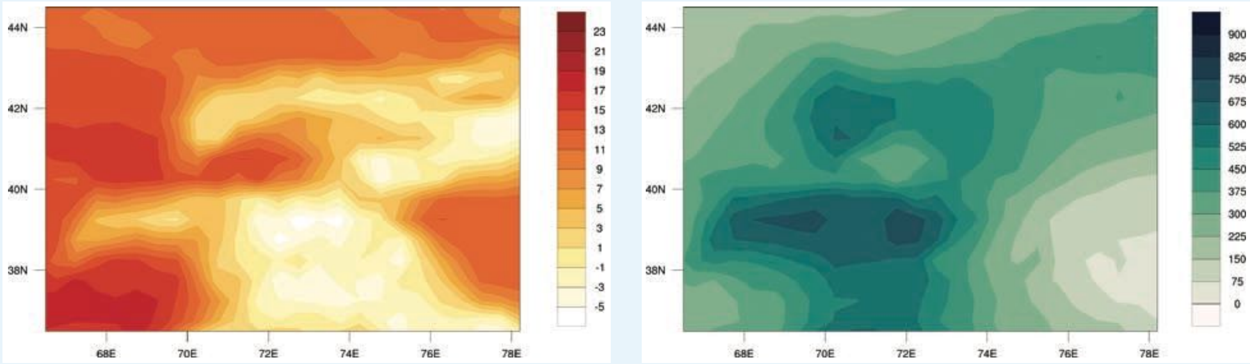
Annual Cycle

FIGURE 2. Average Monthly Temperature and Rainfall in Tajikistan, 1991–2020.[16]



Spatial Variation

FIGURE 3. Annual Mean Temperature (°C) (left), and Annual Mean Rainfall (mm) (right) in Tajikistan over the period 1991–2020.[17] Maps present the coordinates of Tajikistan: latitude 67°18′25″E–74°50′35″E and 36°54′40″N–41°01′58″N.



Key trends

Temperature

The decade 2001–2010 was the hottest since instrumental records began in Tajikistan (**Figure 4**). Lowland areas experienced a temperature rise of approximately 1°C over the long-term average, mid-altitude regions warmed 0.8°C and uplands by 0.2°C. Between 1930–2010 temperatures rose at an average rate of 0.1°C per decade.[18]

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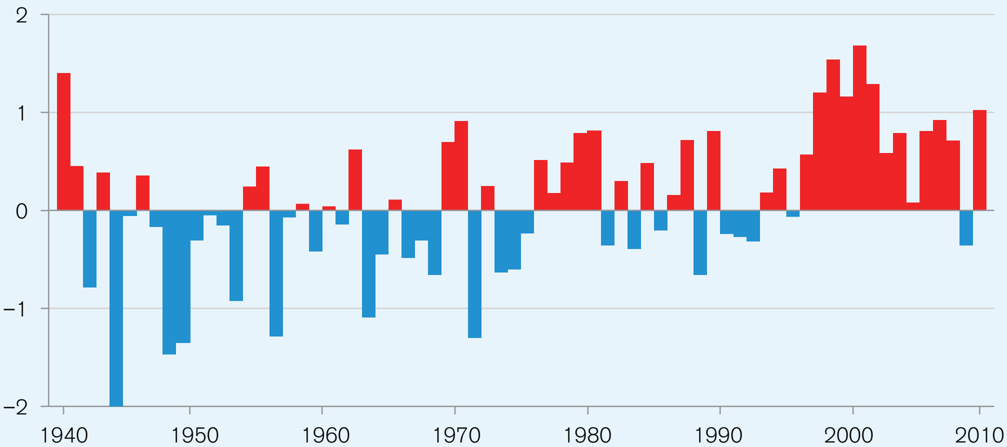
[16] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

[17] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

[18] Aalto, J., Kämäräinen, M., Shodmonov, M., Rajabov, N., & Venäläinen, A. (2017). Features of Tajikistan's past and future climate. International Journal of Climatology, 37(14), 4949–4961. URL: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.5135

Weather remains very unstable from year-to-year, primarily as a result of atmospheric circulation processes which bring unusually hot or cold air. Across the last century, temperature rises have been strongest in the autumn and winter months (i.e. minimum temperatures) and less pronounced in spring and summer.

FIGURE 4. Annual Mean Temperature Anomalies from the long-term average (1961–1990) for the period 1940–2010



Source: Tajikistan Third National Communication to the UNFCCC (2014)

Precipitation

Trends in precipitation are highly uncertain and subject to considerable variation depending on micro-climates and period of record. Overall, Tajikistan's Third National Communication to the UNFCCC suggests there has been an increase in average annual precipitation of approximately 5–10%. However, this increase is primarily associated with higher intensity of extreme precipitation events, and in some areas the frequency of days with precipitation has in fact declined. This has led to some recent extremely dry years: notably 2000, 2001, and 2008 when precipitation was 30–50% below average. One study identifies a general trend of drying over the arid regions of Central Asia linked strongly to ENSO trends.[19]

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated.[20] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

[19] Hu, Zengyun, Xi Chen, Deliang Chen, Jianfeng Li, Shuo Wang, Qiming Zhou, Gang Yin, and Meiyu Guo. (2019). "Dry gets drier, wet gets wetter": A case study over the arid regions of central Asia." International Journal of Climatology 39, no. 2: 1072–1091. URL: https://www.deepdyve.com/lp/wiley/dry-gets-drier-wet-gets-wetter-a-case-study-over-the-arid-regions-of-qR4noywkEp

[20] Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO2 emission budgets caused by permafrost carbon release. Nature Geoscience, 11, 830–835. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_climate-sciences

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal is the Coupled Model Intercomparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus; RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes business-as-usual scenario. For more information, please refer to the RCP Database.

Tables 2 and **3** below provide information on temperature projections and anomalies for the four RCPs over two distinct time horizons, presented against the reference period of 1986–2005. In subsequent analysis, RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus. RCP2.6 assumes rapid and systemic global action, achieving emissions reduction throughout the 21st century enough to reach net zero global emissions by around 2080. RCP8.5 assumes annual global emissions will continue to increase throughout the 21st century. Climate changes under each emissions pathway are presented against a reference period of 1986–2005 for all indicators.

TABLE 2. Projected Anomaly (changes °C) for Maximum, Minimum, and Average Daily Temperatures in Tajikistan for 2040–2059 and 2080–2099, from the Reference Period of 1986–2005 for all RCPs. The table shows the median of the CCKP model ensemble and the 10th–90th percentiles in brackets.[21]

	Average Daily Maximum Temperature		Average Daily Temperature		Average Daily Minimum Temperature	
Scenario	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**
RCP2.6	1.7 (–0.2, 4.1)	1.7 (–0.4, 4.2)	1.5 (–0.1, 3.8)	1.5 (–0.3, 3.8)	1.6 (–0.4, 3.9)	1.5 (–0.6, 3.8)
RCP4.5	2.2 (0.2, 4.4)	3.1 (1.0, 5.5)	2.0 (0.2, 4.1)	2.8 (0.9, 5.1)	2.1 (–0.1, 4.4)	2.8 (0.5, 5.2)
RCP6.0	1.9 (0.2, 3.9)	3.9 (1.9, 6.5)	1.8 (0.1, 3.7)	3.6 (1.8, 5.9)	1.8 (–0.4, 3.9)	3.6 (1.4, 5.8)
RCP8.5	2.8 (0.7, 5.2)	6.0 (3.6, 8.8)	2.7 (0.9, 4.8)	5.8 (3.7, 8.1)	2.8 (0.6, 4.9)	5.8 (3.2, 8.2)

21 WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Projections. URL: https://climateknowledgeportal.worldbank.org/country/tajikistan/climate-data-historical

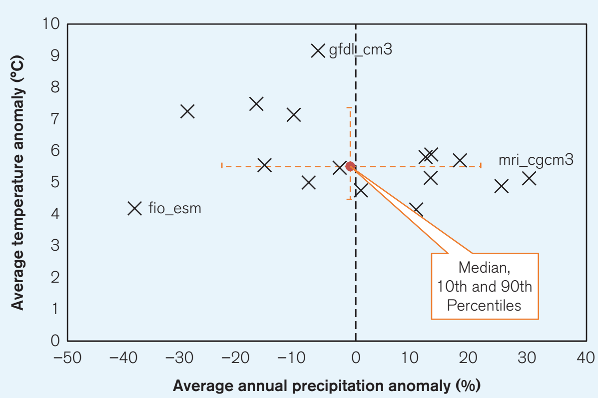
TABLE 3. Projections of Average Temperature Anomaly (°C) in Tajikistan for different seasons (3-monthly time slices) over different time horizons and emissions pathways, showing the median estimates of the full CCKP model ensemble and the 10th and 90th percentiles in brackets[21]

Scenario	2040–2059 Jun–Aug	2040–2059 Dec–Feb	2080–2099 Jun–Aug	2080–2099 Dec–Feb
RCP2.6	1.9 (0.0, 4.2)	1.5 (–0.6, 3.9)	1.8 (–0.6, 4.5)	1.4 (–0.6, 3.9)
RCP4.5	2.3 (0.4, 4.6)	1.8 (–0.1, 4.3)	3.2 (1.1, 5.7)	2.8 (0.8, 5.2)
RCP6.0	2.0 (0.4, 3.8)	1.7 (–0.4, 3.8)	4.0 (2.3, 6.1)	3.6 (1.3, 6.1)
RCP8.5	2.9 (1.1, 5.2)	2.6 (0.5, 4.8)	6.1 (3.9, 8.5)	5.6 (3.5, 8.2)

Model Ensemble

Climate projections presented in this document are derived from datasets available through the CCKP, unless otherwise stated. These datasets are processed outputs of simulations performed by multiple General Circulation Models (GCM) (for further information see Flato et al., 2013).[22] Collectively, these different GCM simulations are referred to as the 'model ensemble'. Due to the differences in the way GCMs represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs, this is particularly the case for rainfall related variables and at national and local scales. The range of projections from 16 GCMs for annual average temperature change and annual precipitation change in Tajikistan under RCP8.5 is shown in **Figure 5**. Spatial representation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 6**.

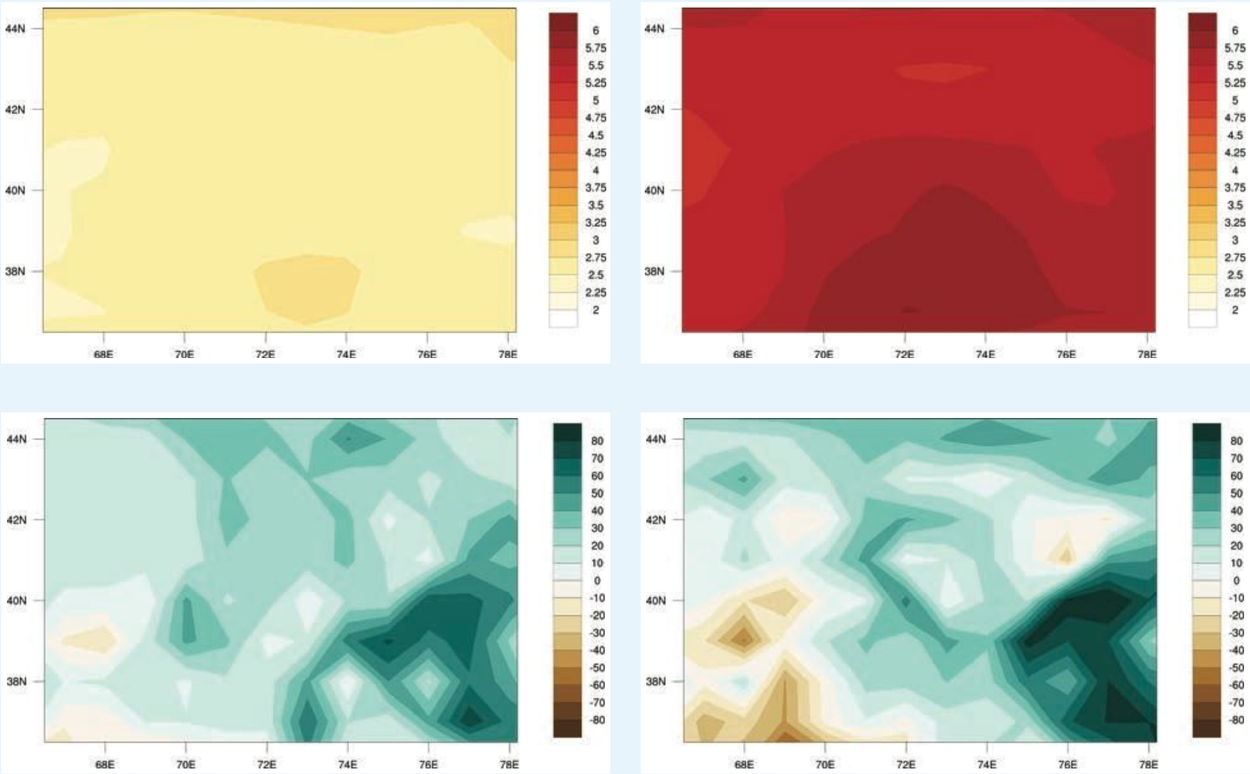
FIGURE 5. Projected Average Temperature Anomaly and Projected Annual Rainfall Anomaly in Tajikistan. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble which provide projections across all RCPs and therefore are most robust for comparison.[21] Three models are labelled.



[22] Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., . . . Rummukainen, M. (2013). Evaluation of Climate Models. Climate Change. (2013). The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 741–866. URL: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Spatial Variation

FIGURE 6. CMIP5 Ensemble Projected Change (32 GCMs) in Annual Temperature (top) and Precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.5.[23] Maps present the coordinates of Tajikistan: latitude 67°18′25″E–74°50′35″E and 36°54′40″N–41°01′58″N.



Temperature

Projected temperature changes are presented in three primary formats. **Table 2** shows the changes in maximum and minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 7** and **8** display the annual and monthly temperature projections. While similar, these three indicators can provide slightly different information. Monthly and annual average temperatures are most commonly used for general estimation of climate change, but the daily maximum and minimum can explain more about how daily life might change in a region. For instance, effects on key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes.

[23] WBG Climate Change Knowledge Portal (CCKP 2021). Tajikistan. Climate Data. Projections. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=TJK&period=2080-2099

FIGURE 7. Historic (grey) and Projected Average Annual Temperature in Tajikistan under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble.[24]

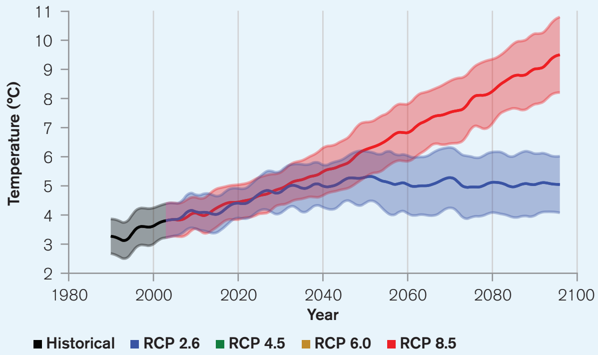
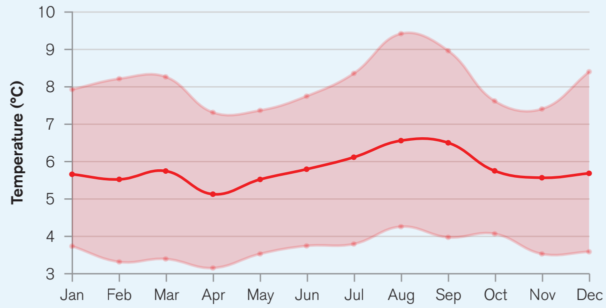


FIGURE 8. Projected Change (anomaly) in Monthly Temperature, shown by month, for Tajikistan for the period 2080–2099 under RCP8.5. The value shown represents the median of the model ensemble with the shaded areas showing the 10th–90th percentiles.[24]



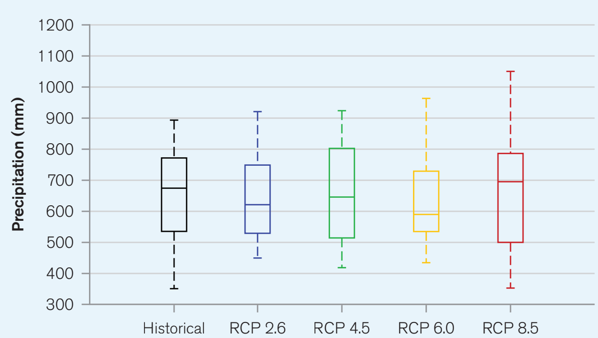
There is good agreement among model projections that Tajikistan could experience rates of warming considerably above the global average. By the 2090s, the ensemble projects 5.8°C of warming under the highest emissions pathway (RCP8.5) compared with a global average rise of 3.7°C. The warming projected in maximum and minimum temperatures, while minor, is greater than the rise in average temperature. Under the lowest emissions pathway (RCP2.6) warming for maximum temperatures reaches 1.7°C above the 1986–2005 baseline, in the 2050s. This highlights the very significant influence potential global emissions reductions could have over warming trends in Tajikistan.

The seasonality of future temperature rises is somewhat uncertain, but under higher emissions pathways (**Figure 7**) projections from the CCKP model ensemble indicate warming trends will be stronger in the summer months of August and September.

Precipitation

Considerable uncertainty surrounds projections of local long-term future precipitation (**Figure 9**). Disagreement between models on the direction of change is considerable (**Figure 5**) and few conclusions can be drawn. Further research is urgently required to constrain the possible futures. Analysis in Tajikistan's National Communication suggests that even if an

FIGURE 9. Projected Average Annual Precipitation for Tajikistan in the period 2080–2099[24]



[24] WBG Climate Change Knowledge Portal (CCKP 2021). Tajikistan. Climate Data. Projections. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=TJK&period=2080-2099

increase in average precipitation rates results this increase is likely to be offset by concurrent and more significant rises in the evaporation rate. Some more recent downscaling studies have pointed to a general reduction in precipitation during the summer months and a slight increase in precipitation during the winter.[25] Overall, it currently seems unlikely that there will be any material increase in the freshwater available for human and ecosystem use due to future changes in annual precipitation, but that shifts in the rainfall regime are likely.

Changes in the precipitation regime seen over the 20th century match with global trends. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia.[26] Projections suggest a continuation of this trend into the future. However, as this phenomenon is highly dependent on local geographical contexts, further research is required to constrain its impact on micro-climates in Tajikistan.

CLIMATE RELATED NATURAL HAZARDS

Tajikistan faces relatively high disaster risk, ranked 64th out of 191 countries in the INFORM 2019 Index for Risk Management (**Table 4**). This risk is driven most significantly by exposure to drought, for which Tajikistan ranks 8th in the world. Risk is also enhanced by moderate levels of flood exposure and relatively low levels of coping capacity. The implications of climate change for exposure to natural hazards are discussed below. The following section analyses climate change influences on the exposure component of risk in Tajikistan. As seen in **Figure 1**, the ND-GAIN Index presents an overall picture of a country's vulnerability and capacity to improve its resilience. In contrast, the Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response, and a country's overall risk management.

TABLE 4. Selected indicators from the INFORM 2019 Index for Risk Management for Tajikistan. For the sub-categories of risk (e.g. "Flood") higher scores represent greater risks. Conversely the most at-risk country is ranked 1st. Global average scores are shown in brackets.

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
5.4 [4.5]	0.0 [1.7]	7.6 [3.2]	3.3 [3.6]	5.1 [4.5]	4.5 [3.8]	64

25 Luo, M., Liu, T., Meng, F., Duan, Y., Bao, A., Frankl, A. and De Maeyer, P., 2019. Spatiotemporal characteristics of future changes in precipitation and temperature in Central Asia. International Journal of Climatology, 39(3), pp. 1571–1588. URL: https://biblio.ugent.be/publication/8617398

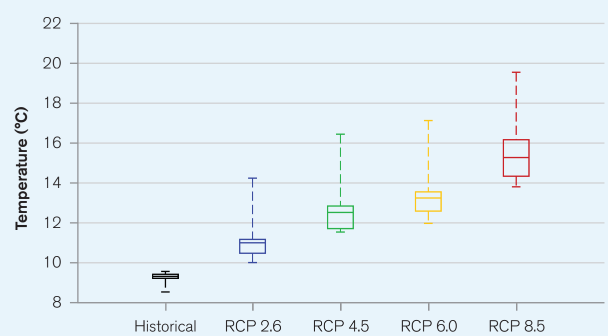
26 Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., Roberts, N. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. DOI: https://doi.org/10.1002/2014RG000464

Heatwaves

Tajikistan regularly experiences high maximum temperatures. While nationally averaged maximum temperatures are biased by extremely cold high-altitude regions, most lowland regions experience multiple days exceeding 35°C on an annual basis[24]. The current median probability of a heatwave (defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 3%. The probability of heatwave conditions is projected to increase dramatically under all emissions pathways, reaching 7%–23% by the 2090s. This is primarily a result of continual rising temperatures, which pull the ambient temperature away from the baseline period (1986–2005) and increase the likelihood of heatwave conditions.

Another indicator through which to examine the heat threat is the annual maximum of daily maximum temperatures. **Figure 10** shows that Tajikistan as a whole is projected to experience a sharp rise in annual maximum temperatures. From a historical baseline (1986–2005) of around 30°C, maximums are projected to approach, and in the case of RCP8.5 exceed, 35°C by the 2090s. These national average increases are likely to translate into even more extreme temperatures in Tajikistan's lowlands. The occurrence of days exceeding 40°C could shift from a rarity to an annual event and may expand from the southwest of the country where such temperatures have historically occurred. One study has suggested that the largest temperature increases are likely to be seen during the winter months of December to February when temperatures are lower. As such the rise in summer temperatures may be slightly less extreme.[27] Nonetheless, Tajikistan is likely to experience life-threatening temperatures on a far more regular basis in future.

FIGURE 10. Historical (1986–2005) and Projected (2080–2099) Annual Maximum Daily Maximum Temperatures under four emissions pathways averaged across Tajikistan's full spatial extent[24]



Drought

Two primary types of drought may affect Tajikistan, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins).[28] At present, Tajikistan faces an annual median probability of severe meteorological drought of around 3%,[24] as defined by a standardized precipitation evaporation index (SPEI) of less than –2. The smoothing effect of the glacier and snow meltwater contribution to runoff has historically provided some protection against hydrological drought.[29]

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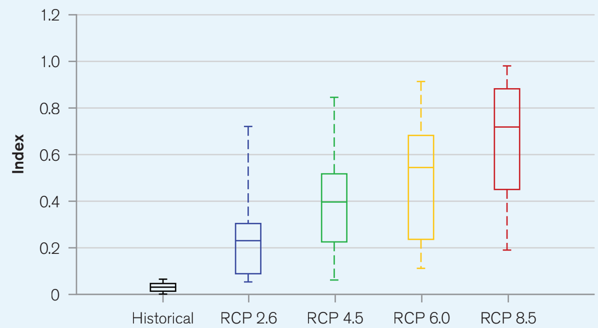
27 Altinsoy, H., Ozturk, T., Turkes, M., & Kurnaz, M. L. (2013). Simulating the Climatology of Extreme Events for the Central Asia Domain Using the RegCM 4.0 Regional Climate Model. In C. G. Helmis & P. T. Nastos (Eds.), Advances in Meteorology, Climatology and Atmospheric Physics (pp. 365–370). Berlin, Heidelberg: Springer Berlin Heidelberg. DOI: https://doi.org/10.1175/JCLI-D-16-0269.1

28 White, C., Tanton, T., and Rycroft, D. (2014). The Impact of Climate Change on the Water Resources of the Amu Darya Basin in Central Asia. Water Resource Management. 28: 5267–5281. URL: https://link.springer.com/article/10.1007/s11269-014-0716-x

29 Pritchard, H.D. (2019). Asia's shrinking glaciers protect large populations from drought stress. Nature, 569(7758), p. 649. URL: https://www.nature.com/articles/s41586-019-1240-1

Naumann et al. (2018)[30] provide a global overview of changes in drought conditions under different warming scenarios. The work suggests the Central Asian region could be among the most significantly affected by climate change influences on drought probability. What would previously have been a 1-in-100-year drought event is projected to occur around once every 15 years under 2°C of global warming, a threshold which is likely to be surpassed under both RCP6.0 and RCP8.5. This view is supported by the CCKP model ensemble projections for Tajikistan, which suggest very significant increases in the annual probability of meteorological drought, increasing from 3% to over 25% under all emissions pathways by the 2050s (**Figure 11**). The sharp projected rise in meteorological drought conditions reflects the transition of parts of Tajikistan to chronically drought affected areas (i.e. towards considerably more arid environments).

FIGURE 11. Annual Probability of Experiencing a 'Severe Drought' in Tajikistan (–2 SPEI index) in 2080–2099 under four emissions pathways[24]



Flood and Landslide

The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a baseline level of flood exposure. As of 2010, assuming protection for up to a 1-in-25-year event, the population annually affected by river flooding in Tajikistan is estimated at 20,000 people and the expected annual impact on GDP at $39 million. UNISDR estimate the average annual losses to all types of flood at $48 million.[31] Socio-economic development and climate change are both likely to increase these figures. The climate change component can be isolated and by 2030 is projected to increase the population annually affected by river flooding by 5,000 people (based on present day populations figures), and the impact on GDP by $30 million under the RCP8.5 emissions pathway (AQUEDUCT Scenario B).[32] In comparison to other Asian nations, these projected increases are proportionately small. The same can be said for the changes projected for the future impact of extreme flood events. By 2035–2044, the number of people affected by an extreme river flood is projected to increase by around 6,000–7,000 people, less than 4% (**Table 5**). Nonetheless, increases in flood risk are material, and other categories of flood also demand consideration.

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[30] Naumann, G., Alfieri, L., Wyser, K., Mentaschi, L., Betts, R. A., Carrao, H., . . . Feyen, L. (2018). Global Changes in Drought Conditions Under Different Levels of Warming. Geophysical Research Letters, 45(7), 3285–3296. DOI: https://doi.org/10.1002/2017GL076521

[31] UNISDR (2014). PreventionWeb: Basic country statistics and indicators. URL: https://www.preventionweb.net/countries [accessed 14/08/2018]

[32] WRI (2018). AQUEDUCT Global Flood Analyzer. URL: https://floods.wri.org/# [Accessed: 22/11/2018]

TABLE 5. Estimated Number of People in Tajikistan Affected by an Extreme River Flood (extreme flood is defined as being in the 90th percentile in terms of numbers of people affected) in the historic period 1971–2004 and the future period 2035–2044. Figures represent an average of all four RCPs and assume present day population distributions.[33]

Estimate	Population Exposed to Extreme Flood (1971–2004)	Population Exposed to Extreme Flood (2035–2044)	Increase in Affected Population
16.7 Percentile	242,350	248,955	6,605
Median	271,219	281,372	10,153
83.3 Percentile	293,088	303,026	9,938

Tajikistan also faces significant risks from flash floods, and notably glacier lake outburst floods (GLOFs), which occur when moraine dams holding back accumulated meltwater in high altitude areas are breached. These events can also happen as a result of, or cause, landslides and dangerous mudflows.[34]

The Central Asian region is known to be a hotspot of vulnerability to GLOFs. One study reports 6,300 deaths due to GLOFs in the region since approximately 1940,[35] but this is likely an underestimate due to a lack of available records. Risks are believed to be highest in the Pamir region of Tajikistan, but remain poorly understood. One study which aimed to classify lakes by hazard level identifies many lakes presenting low to moderate levels of potential outburst hazard, and a small minority presenting high hazard levels.[36] However, glacial retreat and the potential for increased glacial melt due to climate change-induced warming is likely to result in the formation of new;[37] this situation requires close, ongoing monitoring and further research into the potential impacts this could have for downstream water resources as well as potential disaster risk.

Also demanding disaster risk reduction attention are the projected increases in extreme rainfall intensity and frequency. Flash flooding and associated land and mud slides have persistently affected Tajikistan over recent years, with significant infrastructure and livelihood damage, and loss of life reported to UNOCHA almost every year between 2000–2018.[38] It has been reported that up to 36% of Tajikistan's land area may be at risk of landslides, and climate changes are projected to compound this risk.[39] A similar proportion of the nation faces high risk of

[33] Willner, S., Levermann, A., Zhao, F., Frieler, K. (2018). Adaptation required to preserve future high-end river flood risk at present levels. Science Advances: 4:1. DOI: 10.1126/sciadv.aao1914
[34] GFDRR. (2017). Disaster Risk Profile: Tajikistan. URL: https://www.gfdrr.org/sites/default/files/Tajikistan.pdf
[35] Carrivick, J. L., & Tweed, F. S. (2016). A global assessment of the societal impacts of glacier outburst floods. Global and Planetary Change, 144, 1–16. URL: https://linkinghub.elsevier.com/retrieve/pii/S0921818116301023
[36] Gruber, F. E., & Mergili, M. (2013). Regional-scale analysis of high-mountain multi-hazard and risk indicators in the Pamir (Tajikistan) with GRASS GIS. Natural Hazards and Earth System Sciences, 13(11), 2779–2796. URL: https://nhess.copernicus.org/articles/13/2779/2013/
[37] Mergili, M., Müller, J. P., & Schneider, J. F. (2013). Spatio-temporal development of high-mountain lakes in the headwaters of the Amu Darya River (Central Asia). Global and Planetary Change, 107, 13–24. URL: https://agris.fao.org/agris-search/search.do?recordID=US201500208678
[38] Reliefweb (2018). Tajikistan country profile. URL: https://reliefweb.int/country/tjk [accessed 08/01/2019]
[39] World Bank (2017). A rocky future? Ensuring Central Asia's mountains are climate and disaster resilient. World Bank. URL: https://www.worldbank.org/en/news/feature/2017/12/11/ensuring-central-asias-mountains-are-climate-and-disaster-resilient [accessed 08/01/2019]

mudflows, and the majority of the country faces some level of exposure.[40] Research focused on the Central Asian region has highlighted that the erosive capacity of rainfall is likely to increase under all emissions pathways, likely increasing the risk of landslide and exacerbating issues of soil erosion.[41]

CLIMATE CHANGE IMPACTS

Natural Resources

Water

In the middle of the 20th century, around 6% of Tajikistan's surface area was covered by glaciers. By the early 21st century this was believed to have declined to 5%. Simultaneously, the volume of ice mass found in Tajikistan's glaciers is reported in its Third National Communication to the UNFCCC to have reduced by 30% over the same period. By the end of the century, glacier mass loss is projected in the region of 50%–70% over the Central Asian region, dependent on the emissions pathway.[42] Glacial melting is likely to have a very significant impact in the primary river basins encompassing most of Tajikistan, that of the Amu Darya and Syr Darya. An estimated 50% of the runoff of the Amu Darya river is believed to derive from glacier meltwater (a lower percentage is estimated for the Vakhsh river),[43] with similarly high dependence seen in most of Tajikistan's rivers.[44] Additional research is required on the impacts from increased temperatures on the country's glacial melt scenarios and subsequent flow rates over the short-term and long-term.

Glacier and snow melting typically provides regulation of flows, ensuring water resources are available all year round. The ongoing melting of glaciers is already delivering slightly increased runoff (typically less than 10%) in many of Tajikistan's rivers, as reported in its TNC, but uncertainty in precipitation and snowfall projections surrounds future runoff trends. One study has suggested that the increase in runoff due to accelerated melting could peak in the Naryn basin by around 2040.[45] As smaller glaciers disappear entirely, the runoff of smaller tributary rivers can fall dramatically. The cumulative effects of glacier loss are likely to grow over the longer-term future, dependent on global emissions reductions, potentially leading to significant declines in runoff. As these processes unfold the runoff regime is likely to shift, increases in the variability of flows are projected, amplifying the April-June peak

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[40] ADRC (2006). Tajikistan: Country report for Asian Disaster Reduction Center. URL: https://www.adrc.asia/countryreport/TJK/2005/english2.pdf [accessed 14/08/2019]

[41] Duulatov, E., Chen, X., Amanambu, A.C., Ochege, F.U., Orozbaev, R., Issanova, G. and Omurakunova, G. (2019). Projected Rainfall Erosivity Over Central Asia Based on CMIP5 Climate Models. Water, 11(5), p. 897. DOI: https://doi.org/10.3390/w11050897

[42] Reyer, C. P. O., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., . . . Stagl, J. (2017). Climate change impacts in Central Asia and their implications for development. Regional Environmental Change, 17(6), pp. 1639–1650. DOI: https://doi.org/10.1007/s10113-015-0893-z

[43] Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). Nature Climate Change, 2, 725. URL: https://www.nature.com/articles/nclimate1592

[44] WBG (2015). Assessment of the role of glaciers in stream flow from the Pamir and Tien Shan Mountains. GWADR – Europe and Central Asia. URL: http://documents1.worldbank.org/curated/en/663361468283187700/pdf/AralBasinGlaciers-FinalReport-May-2015.pdf

[45] Gan, R., Luo, Y., Zuo, Q., & Sun, L. (2015). Effects of projected climate change on the glacier and runoff generation in the Naryn River Basin, Central Asia. Journal of Hydrology, 523, 240–251. URL: https://core.ac.uk/download/pdf/206078904.pdf

and reducing late summer and autumn flows.[46] In combination with the projected increase in the frequency of meteorological drought climate change is likely to present major water supply challenges. If flow rates and related water availability does reduce, there is potential challenges for the sharing of water resources among riparian zones.

Another major route through which climate change could affect Tajikistan's water resources is through its impact on evaporation rates and crop water demands. Both factors are likely to increase, leading to significantly greater irrigation water demand.[47] Studies have suggested that on a basin scale, irrigation demand may no longer be satisfied by available runoff during even low-intensity, high-frequency, drought events by 2070–2099.[48] Deficits of this nature are likely to have knock-on effects such as increased competition for water, both between sectors and potentially between regions. For example, more than 95% of Tajikistan's electricity generation is sourced from hydropower. Changes to the annual runoff regime which could reduce its stability, may also reduce the reliability of energy generation. This in turn, could incentivize the development of more water storage capacity to harvest summer inflows for winter hydropower generation, which could have negative effects for downstream communities.[49] However, with increased temperatures, electricity demand for winter heating could reduce, mitigating impact of altered flow rates and generation capabilities. Additional research is required.

Through indirect impacts on agriculture and power, and direct impacts on potable water supply the increasingly drought-affected future expected under climate change is likely to negatively impact some of Tajikistan's poorest communities. As of 2015, only 74% of the nation's population was estimated to have access to at least a basic water supply[50] and Tajikistan's water security is shown to be vulnerable across several sectoral measures, including household water security, in ADB's 2016 Asian Water Development Outlook 2016.[51]

Land, Soil, and Biodiversity

Historical warming has already had an impact on largescale vegetation health across Central Asia and locally in Tajikistan. Over the period 1992–2011, rising air temperatures were associated with significant loss of 'greenness'[52]. These losses have been linked to increased water deficits driven primarily by greater evapotranspiration which can result in stunted plant growth and desiccation. Tajikistan's lowlands are also among the areas already being

[46] Kure, S., Jang, S., Ohara, N., Kavvas, M. L., & Chen, Z. Q. (2013). Hydrologic impact of regional climate change for the snowfed and glacierfed river basins in the Republic of Tajikistan: hydrological response of flow to climate change. Hydrological Processes, 27(26), 4057–4070. URL: https://doi.org/10.1002/hyp.9535

[47] Nikanorova, A. D., E. V. Milanova, N. M. Dronin, and N. O. Telnova. (2016). Estimation of Water Deficit under Climate Change and Irrigation Conditions in the Fergana Valley of Central Asia." Arid Ecosystems 6, no. 4: 260–267. URL: https://link.springer.com/article/10.1134/S2079096116040053

[48] White, C. J., Tanton, T. W., & Rycroft, D. W. (2014). The Impact of Climate Change on the Water Resources of the Amu Darya Basin in Central Asia. Water Resources Management, 28(15), 5267–5281. DOI: 10.1007/s11269-014-0716-x

[49] Siegfried, T., Bernauer, T., Guiennet, R., Sellars, S., Robertson, A. W., Mankin, J., . . . Yakovlev, A. (2012). Will climate change exacerbate water stress in Central Asia? Climatic Change, 112(3), 881–899. URL: https://orbit.dtu.dk/en/publications/will-climate-change-exacerbate-water-stress-in-central-asia

[50] Water Aid (2018). The Water Gap - The State of the World's Water 2018. URL: https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/The%20Water%20Gap%20State%20of%20Water%20report%20lr%20pages.pdf

[51] ADB (2016). Asian water development outlook 2016: Strengthening water security in Asia and the Pacific. Mandaluyong City, Philippines: Asian Development Bank, 2016. URL: https://www.adb.org/sites/default/files/publication/189411/awdo-2016.pdf

[52] Zhou, Y., Zhang, L., Fensholt, R., Wang, K., Vitkovskaya, I., & Tian, F. (2015). Climate Contributions to Vegetation Variations in Central Asian Drylands: Pre- and Post-USSR Collapse. Remote Sensing, 7(3), 2449–2470. URL: https://doi.org/10.3390/rs70302449

affected by increased aridity,[53] as reported in the nation's TNC. Persistent drought periods degrade grassland areas, causing transition to sparsely vegetated lands and shrubs. Indeed, over the Central Asian region, an estimated 8% of grasslands and 10% of forest land converted to shrubland between 2000–2013.[54]

The Central Asia region is identified as a hotspot of potential dryland expansion under future climate change.[55] Desertification may also be a risk, but evidence from 2017 suggested Tajikistan contained most of the land that is immediately vulnerable.[56] The future of land and soil health in Tajikistan will depend strongly on local land management and development practices, such as biomass burning and soil conservation,[57] but sustainability challenges are likely to be exacerbated by climate change. Issues such as the projected increase in the erosive capacity of rain, and its impact on soil quality, will increase the pressure on key ecosystem functions.[41] These changes, in combination with issues such as glacial melt and drought will likely result in significant shifts in species' viable ranges (both in natural ecosystems and for agricultural purposes).[58] Modelling is increasingly reinforcing the likely 'upslope' (movement to higher altitudes) and northwards shifts ranges and the resulting declines in viable ranges this will bring for many species in Central Asia.[59]

Economic Sectors

Agriculture

Tajikistan has a large and diverse agricultural sector employing an estimated 43% of the workforce in 2016. Key crops in production include wheat, potato, vegetables (particularly onion), melon and other fruits. Food is primarily produced to satisfy national consumption. Nonetheless, around 120,000 tons of food products are exported each year, constituting about 2%–3% of total exports by volume.[60] Climate change could influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation and temperatures. Indirect effects include through impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to desertification.

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[53] Huang, J., Ji, M., & Xie, Y. (2016). Global semi - arid climate change over last 60 years. Climate Dynamics, 46(3), 1131–1150. URL: https://link.springer.com/article/10.1007/s00382-015-2636-8

[54] Li, Z., Chen, Y., Li, W., Deng, H., & Fang, G. (2015). Potential impacts of climate change on vegetation dynamics in Central Asia. Journal of Geophysical Research: Atmospheres, 120(24), 12345–12356. DOI: https://doi.org/10.1002/2015JD023618

[55] Huang, J., Yu, H., Guan, X., Wang, G., & Guo, R. (2016). Accelerated dryland expansion under climate change. Nature Climate Change, 6(2), 166–171. URL: https://www.nature.com/articles/nclimate2837

[56] Zhang, G., Biradar, C. M., Xiao, X., Dong, J., Zhou, Y., Qin, Y., . . . Thomas, R. J. (2018). Exacerbated grassland degradation and desertification in Central Asia during 2000–2014. Ecological Applications, 28(2), 442–456. URL: https://pubmed.ncbi.nlm.nih.gov/29205627/

[57] Loboda, T. V, Giglio, L., Boschetti, L., & Justice, C. O. (2012). Regional fire monitoring and characterization using global NASA MODIS fire products in dry lands of Central Asia. Frontiers of Earth Science, 6(2), 196–205. URL: https://link.springer.com/article/10.1007/s11707-012-0313-3

[58] Luo, Y. at al. (2018). Contrasting streamflow regime induced by melting glaciers across the Tien Shan – Pamir – North Karakoram. Nature – Scientific Reports. (2018) 8:16470. URL: https://www.nature.com/articles/s41598-018-34829-2

[59] Ashraf, U., Peterson, A. T., Chaudhry, M. N., Ashraf, I., Saqib, Z., Rashid Ahmad, S., & Ali, H. (2017). Ecological niche model comparison under different climate scenarios: a case study of Olea spp. in Asia. Ecosphere, 8(5), e01825. DOI: https://doi.org/10.1002/ecs2.1825

[60] TajStat (2018). Food Security and Poverty No.3 2018. Statistical Agency under President of the Republic of Tajikistan. URL: https://www.stat.tj/en/

On an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018)[61] estimate 5% and 6% declines in global wheat and maize yields respectively even if the Paris Climate Agreement is met and warming is limited to 1.5°C. Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway. Notably, Tajikistan depends on significant imports of wheat (650,000 tons in 2017, equivalent to more than 50 kg per capita),[60] exposing the country to global supply chain pressures under climate change.

The outlook projected for agricultural production in Tajikistan is mostly negative. One study suggests yield declines are likely for several key crops including wheat, barley, maize, vegetables, and fruits, typically in the order of 5%–10% by 2050. Rice, potato and cotton yields are projected to experience small (<5%) yield gains over the same period.[62] Taken together these changes could reduce national food security and community well-being. There is some disagreement over the outlook for wheat, a key staple crop. Studies have suggested that rising temperatures may, over the long-term, improve conditions for wheat growth, increasing achievable yields by up to 12%.[63] However, such projections should be treated with extreme caution because models typically assess the compatibility of average climate conditions with plant physiology and do not capture the impact of climate extremes. In addition, over the longer-term future, there is concern that loss of glacier and snow cover could significantly reduce the available water resource, potentially leading to major water shortages for irrigation purposes.[42]

With projections of considerably increased drought and heat wave probability, agricultural production is likely to become less stable, and net production may suffer. Studies have suggested that household income security in Tajikistan's more arid regions may decline while households in the more humid regions may experience gains.[64] However, modelling which averages across the country's different ecological zones and their respective farming communities suggests that the net revenue change as a result of climate changes is likely to be negative.[65] This shift in fortunes is likely to penalize the poorest groups, with least access to agricultural technologies, infrastructure, and lowest adaptive capacity, the most. Notably, a lack of access to credit and agricultural inputs are identified as key barriers to adoption.[66]

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61 Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48

62 Aliev, F. (2016). Agricultural production, welfare and food security under climate change in Tajikistan. Institute of Agricultural Development in Transition Economies (IAMO) Samarkand Conference 2016, November 2-4, Samarkand, Uzbekistan. URL: https://ideas.repec.org/p/ags/iamc16/250089.html

63 Sommer, R., Glazirina, M., Yuldashev, T., Otarov, A., Ibraeva, M., Martynova, L., . . . de Pauw, E. (2013). Impact of climate change on wheat productivity in Central Asia. Agriculture, Ecosystems & Environment, 178, 78–99. URL: https://geoagro.icarda.org/downloads/publications/papers/Sommer_et_al_2013_Impact_of_climate_change_on_wheat_productivity_in_Central_AsiaR.pdf

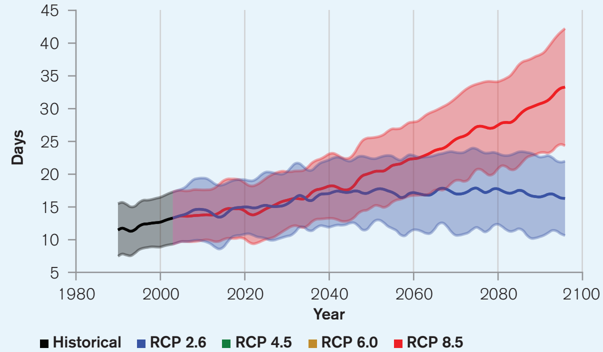
64 Bobojonov, I., & Aw-hassan, A. (2014). Impacts of climate change on farm income security in Central Asia: An integrated modeling approach. Agriculture, Ecosystems and Environment, 188, 245–255. URL: https://www.sciencedirect.com/science/article/pii/S0167880914001170

65 Closset, M., Dhehibi, B.B.B. and Aw-Hassan, A. (2015). Measuring the economic impact of climate change on agriculture: a Ricardian analysis of farmlands in Tajikistan. Climate and Development, 7(5), pp. 454–468. URL: https://ccafs.cgiar.org/resources/publications/measuring-economic-impact-climate-change-agriculture-ricardian-analysis

66 Mirzabaev, A. (2018). Improving the Resilience of Central Asian Agriculture to Weather Variability and Climate Change. In D. Zilberman, R. Goetz, & A. Garrido (Eds.), Climate Smart Agriculture (pp. 477–495). Springer/FAO. URL: http://www.fao.org/3/a-i7931e.pdf

A further, and perhaps lesser appreciated influence of climate change on agricultural production is through its impact on the health and productivity of the labor force. Dunne et al. (2013)[67] suggest that global labor productivity during peak months has already dropped by 10% as a result of warming, and that a decline of up to 20% might be expected by 2050 under the highest emissions pathway (RCP8.5). Both humans and crops are highly vulnerable to temperatures over 35°C. Under the highest emissions pathway (RCP8.5), these conditions are projected to more than double in frequency by the late 21st century (**Figure 12**). In combination, it is highly likely that the processes discussed above will have a considerable impact on national food consumption patterns in Tajikistan both through direct impacts on internal agricultural operations, and through impacts on the global supply chain.

FIGURE 12. Historic and Projected Annual Average Number of Hot Days (>35°C) under RCP2.6 (blue) and RCP8.5 (red). The values shown represents the median of 30+ GCM model ensemble with the shaded areas showing the 10–90th percentiles.[24]



Urban and Energy

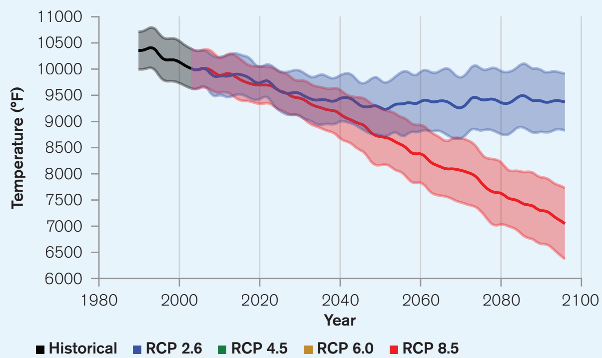
The population of Tajikistan has been steadily urbanizing, but the proportion is still relatively low at around 27.5% in 2020 (**Table 1**). The links between climate, the urban and energy sectors, and by proxy the service sector in Tajikistan are complex. The nation has developed adaptations to extremes of both hot and cold, but every year there is considerable need for both cooling and heating. Research has established a reasonably well constrained relationship between temperature and labor productivity, household consumption patterns, and (by proxy) household living standards.[68] In general terms, the impact of an increase in temperature on these indicators depends on whether the temperature rise moves the ambient temperature closer to, or further away from, the optimum temperature range. The optimum range can vary depending on local conditions and adaptations.

[67] Dunne, J. P., Stouffer, R. J., & John, J. G. (2013). Reductions in labour capacity from heat stress under climate warming. Nature Climate Change, 3(6), 563–566. URL: http://www.precaution.org/lib/noaa_reductions_in_labour_capacity_2013.pdf

[68] Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., Mosier, T. (2018) South Asia's Hotspots: The Impact of Temperature and Precipitation changes on living standards. South Asian Development Matters. World Bank, Washington DC. URL: https://openknowledge.worldbank.org/handle/10986/28723

In many of Tajikistan's cold-stressed, higher altitude regions temperature rises could result in a net improvement in human temperature-related health outcomes and productivity as the number of heating days decline (**Figure 13**). However, in lower altitude regions, such as the nation's capital Dushanbe, which are generally more densely populated and urbanized, extreme summer heat may intensify and create new health challenges. These challenges may be compounded by the Urban Heat Island phenomenon (UHI). Dark surfaces, residential and industrial sources of heat, an absence of vegetation, and air pollution[69] can push temperatures higher than those of the rural surroundings, commonly anywhere in the range of 0.1°C–3°C in global mega-cities.[70] As well as impacting on human health (see Communities) the temperature peaks that will result from combined UHI (including likely future urban expansion) and climate change, may damage the productivity of the service sector economy, both through direct impacts on labor productivity, or through the additional costs of adaptation.

FIGURE 13. Historic and Projected Annual Heating Degree Days (cumulative degrees above 65°F) under RCP2.6 (blue) and RCP8.5 (red). The values shown represent the median of 30+ GCM model ensemble with the shaded areas showing the 10–90th percentiles.[24]



Research suggests that on average, a one degree increase in ambient temperature results in a 0.5%–8.5% increase in electricity demand for cooling.[71] Notably, this serves business and residential air-cooling systems. In the summer periods, this increase in demand places strain on energy generation systems which is compounded by the heat stress on the energy generation system itself, commonly due to its own cooling requirements, which can reduce its efficiency.[72] Additionally important is the impact rising temperatures have on winter temperatures. Increases in ambient temperatures in colder periods may have an impact in heat requirements (**Figure 13**). In Tajikistan, where hydropower is prevalent, there are varying projections regarding how future flow changes could affect energy generation potential,[42] and further research is required.

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[69] Cao, C., Lee, X., Liu, S., Schultz, N., Xiao, W., Zhang, M., & Zhao, L. (2016). Urban heat islands in China enhanced by haze pollution. Nature Communications, 7, 1–7. URL: https://www.nature.com/articles/ncomms12509

[70] Zhou, D., Zhao, S., Liu, S., Zhang, L., & Zhu, C. (2014). Surface urban heat island in China's 32 major cities: Spatial patterns and drivers. Remote Sensing of Environment, 152, 51–61. URL: https://europepmc.org/article/agr/ind605450314

[71] Santamouris, M., Cartalis, C., Synnefa, A., & Kolokotsa, D. (2015). On the impact of urban heat island and global warming on the power demand and electricity consumption of buildings—A review. Energy and Buildings, 98, 119–124. URL: https://doi.org/10.1016/j.enbuild.2014.09.052

[72] ADB (2017). Climate Change Profile of Pakistan. Asian Development Bank. URL: https://www.adb.org/publications/climate-change-profile-pakistan

Communities

Poverty, Inequality and Vulnerability

Tajikistan has achieved remarkable poverty reduction in recent years, though it remains among the poorest countries in Europe and Central Asia.[73] Some key features of society in Tajikistan have been identified which may amplify the impacts of climate change on the poorest groups. Two causes for concern include the high proportion of income spent on food, believed to be between 70%–80%,[74] and the large proportion of food which is imported from international markets and therefore exposed to price fluctuation.[42] Ultimately, these factors contribute to very high food insecurity. These factors mean that environmental shocks which impact on local and international agricultural production are likely to drive up poverty and malnutrition in Tajikistan, both of which already sit at relatively high levels (**Table 1**).

Increases in the intensity and frequency of drought stand out as some of the most significant risks associated with climate change. There is strong evidence that these risks will disproportionately impact the poorest groups in Tajikistan. At present, the poorest quintile are estimated to be more than twice as likely to be exposed to droughts in comparison with other groups.[75] Rain-fed and subsistence-level agricultural operations are likely to be the worst affected as poorer farmers and communities are least able to afford and access technologies for adaptation.

Other climate changes projected are also likely to disproportionately affect the poorest groups in society. For instance, heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress[76] and poorer businesses are least able to afford air conditioning, an increasing need given the projected increase in cooling days. These considerations are perhaps most pertinent in Tajikistan's hotter, more densely populated, lowland and urban areas. In the nation's uplands and more remote areas the poorest are also likely to be the most exposed and least able to cope with other hazards which may be exacerbated due to climate change such as flash flooding, landslides, and disease outbreaks. Key issues hindering coping capacity include a lack of health and transportation infrastructure and public services,[77] and poor early warning and disaster preparedness systems.

At the national scale disasters are known to have significant economic consequences. A minimum level of average annual loss has been established by UNISDR at around 1%–2% of GDP,[31] but this figure likely misses a large number of lower intensities, or localized, events which may accumulate into much larger annual losses. The economic cost of disasters, alongside their human consequences, slows the broader progress which is needed in Tajikistan to

[73] World Bank (2020). Poverty & Equity Brief – Tajikistan. [October 2020]. URL: https://databank.worldbank.org/data/download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/AM2020/Global_POVEQ_TJK.pdf

[74] UNOCHA (2016). Tajikistan: Food security monitoring bulletin, Issue 17 (June 2016). Department for International Development, World Food Programme, UN Children's Fund. URL: https://reliefweb.int/report/tajikistan/tajikistan-food-security-monitoring-bulletin-issue-17-june-2016 [accessed 08/01/2019]

[75] Winsemius, H. C., Jongman, B., Veldkamp, T. I. E., Hallegatte, S., Bangalore, M., & Ward, P. J. (2018). Disaster risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts. Environment and Development Economics, 23(3), 328–348. DOI: https://doi.org/10.1017/S1355770X17000444

[76] Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. (2016). Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. Annual Review of Public Health: 37: 97–112. URL: https://pubmed.ncbi.nlm.nih.gov/26989826/

[77] Barbone, L., Reva, A., Zaidi, S. (2010). Tajikistan: Key priorities for climate change adaptation. World Bank Policy Research Paper 5487. URL: https://openknowledge.worldbank.org/handle/10986/3969

alleviate the multiple dimensions of poverty experienced by communities. Processes linked to climate change are already hindering progress in this regard, but intensification of these changes, and new challenges are almost certain to emerge over the 21st century. Many of the potential routes to damage and loss remain poorly understood and therefore are not captured herein; potential factors include the arrival of new pests and diseases and unexpected or abrupt shifts in the hydrological regime.

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.[78]

Human Health

Nutrition

The World Food Programme (2015) estimate that without adaptation action the risk of hunger and child malnutrition on a global scale could increase by 20% respectively by 2050.[79] According to the FAO between 2014–2016 over 30% of Tajikistan's population were undernourished and over 80% of households experienced at least marginal food insecurity.[74] Climate factors make a major direct contribution to this insecurity, through harvest failure, as do indirect climate-linked factors such as crop pests and disease. Springmann et al. (2016) assessed the potential for excess, climate-related deaths associated with malnutrition.[80] Two key risk factors are expected to be the primary drivers: a lack of fruit and vegetables in diets and health complications caused by increasing prevalence of people underweight. The authors' projections suggest there could be approximately 13 climate-related deaths per million population linked to lack of food availability in Tajikistan by the year 2050 under RCP8.5. The World Health Organization estimated future stunting of growth in children under five years of age attributable to climate change through loss of nutrition in the Central Asian Region (for detailed assumptions of the study follow reference).[81] Their ensemble mean projection under the base case scenario was a 1.2% increase in moderate stunting and 0.8% in severe stunting by 2030.

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78 World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf

79 WFP (2015). Two minutes on climate change and hunger: A zero hunger world needs climate resilience. The World Food Programme. URL: https://www.wfp.org/publications/two-minutes-climate-change-and-hunger

80 Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., . . . Scarborough, P. (2016). Global and regional health effects of future food production under climate change: a modelling study. The Lancet: 387: 1937–1946. DOI: 10.1016/S0140-6736(15)01156-3

81 WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization. URL: https://www.who.int/globalchange/publications/quantitative-risk-assessment/en/

Temperature-related mortality

Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[82] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. A study conducted in Tajikistan in an urban setting, and reported in its TNC, showed that complications in pregnancy are correlated with temperatures over 33°C. Climate change could push global temperatures closer to this temperature 'danger zone' both through slow-onset warming and intensified heat waves. The number of days during which temperatures exceed 35°C is projected to increase under all emissions scenarios, reaching at least 15 per year, and potentially over 30 under higher emissions pathways.

Honda et al. (2014) used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0) to estimate that without adaptation, annual heat-related deaths in the Central Asian region, could increase 139% by 2030 and 301% by 2050.[83] The World Health Organization[81] also estimated future heat-related mortality attributable to climate change in the Central Asian Region, assuming population growth based on the UN's 2010 revised projections.[84] An ensemble mean estimate of 1,752 excess deaths was projected for the year 2030, and 4,886 by 2050. The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[85]

As temperature rises will also be felt during winter months, Tajikistan may also benefit from a reduction in cold-related mortality during winter months. Tajikistan currently faces major issues providing the necessary energy to meet heat demand during the winter.[86] Warming may slightly alleviate these issues, but this gain must be seen in the context of the significant potential threat to Tajikistan's hydroelectric power generation.

Disease

Progress on the eradication of vector-borne disease has been inconsistent in Tajikistan. In the late 1990s and early 2000s, the deadliest form of malaria returned to Southern Tajikistan. While political and development factors are believed to have been the main cause of this return, changes to the climate, including warmer winters, are believed to have contributed[87]. Most studies suggest it should be possible to eradicate malaria from the Central Asian Region, but future climate changes may improve conditions for its survival, thereby potentially increasing the challenge involved in achieving eradication.[81]

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[82] Im, E. S., Pal, J. S., & Eltahir, E. A. B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances, 3(8), 1–8. URL: https://advances.sciencemag.org/content/3/8/e1603322

[83] Honda, Y., Kondo, M., McGregor, G., Kim, H., Guo, Y-L, Hijioka, Y., Yoshikawa, M., Oka, K., Takano, S., Hales, S., Sari Kovats, R. (2014). Heat-related mortality risk model for climate change impact projection. Environmental Health and Preventive Medicine 19: 56–63. URL: 10.1007/s12199-013-0354-6

[84] UN (2019). World Population Prospects: the 2010 revision. New York: United Nations. URL: https://population.un.org/wpp/

[85] Mitchell, D., Heaviside, C., Schaller, N., Allen, M., Ebi, K. L., Fischer, E. M., . . . Vardoulakis, S. (2018). Extreme heat-related mortality avoided under Paris Agreement goals. Nature Climate Change, 8(7), 551–553. URL: https://pubmed.ncbi.nlm.nih.gov/30319715/

[86] Fields, D., Kochnakyan, A., Stuggins, G. and Besant-Jones, J. (2013). Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives. The World Bank. URL: https://openknowledge.worldbank.org/handle/10986/15795

[87] Lioubimtseva, E., & Henebry, G. M. (2009). Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. Journal of Arid Environments, 73(11), 963–977. DOI: https://doi.org/10.1016/j.jaridenv.2009.04.022

The World Health Organization[81] explored changes in the incidence of several key diseases under future climate changes in the Central Asian Region. Notably, an 11% rise in the number of deaths due to diarrhoeal disease in children under 15 was projected by 2030 and attributed to climate change, and a 16% rise by 2050 in the region. Two known interactions are likely to drive transmission of diarrhoeal disease, namely increasing temperatures and increases in flooding frequency and extent.[88]

POLICIES AND PROGRAMS

National Adaptation Policies and Plans

Policy/Strategy/Plan	Status	Document Access
Nationally Determined Contribution (NDC) to Paris Climate Agreement	Submitted	March, 2017
National Communications to The UNFCCC	Three submitted	Latest: December, 2014
National Disaster Risk Management Strategy for 2010–2015	Enacted	March, 2010

Climate Change Priorities of ADB and the WBG

ADB — Country Partnership Strategy

ADB have agreed a Country Partnership Strategy (CPS) with the Government of Tajikistan covering the period 2021–2025. Climate change is addressed under the third focus area of the CPS, *Fostering better livelihoods through investment in a land-linked economy* where ADB will respond to climate change to address food security and inclusive growth in rural areas. As a crosscutting issue, the CPS also addresses climate change by continuing the following interventions: (i) climate proofing and carbon reduction, such as by investing in low-carbon renewable energy; (ii) expanding and modernizing climate-proofed infrastructure; (iii) building climate risk management capacity, including meteorological monitoring, impact assessments, resource management, and climate mainstreaming in government policy and institutions; and (iv) developing and introducing innovative technologies for climate resilience. ADB operations will address flood and drought risk management and its modernization, and improved delivery of quality hydrometeorological and climate services to support Tajikistan's Nationally Determined Contributions. Advanced technologies to manage climate risks and optimize resource efficiency can be promoted. Systematic integration of climate data and information services through improved institutional collaboration with the State Agency for Hydrometeorology of Tajikistan will be pursued.[89]

[88] Levy, K., Woster, A. P., Goldstein, R. S., & Carlton, E. J. (2016). Untangling the Impacts of Climate Change on Waterborne Diseases: a Systematic Review of Relationships between Diarrheal Diseases and Temperature, Rainfall, Flooding, and Drought. Environmental Science & Technology, 50(10), 4905–4922. URL: 10.1021/acs.est.5b06186

[89] ADB (2021). Tajikistan: Country Partnership Strategy (2021–2025). URL: https://www.adb.org/sites/default/files/institutional-document/728136/taj-cps-2021-2025.pdf

WBG — Country Partnership Framework

The WBG agreed a Country Partnership Framework (CPF) the Government of Tajikistan covering the period 2019–2023. Climate change is identified as one of three cross-cutting themes. This CPF supports efforts and opportunities to address climate change vulnerabilities and seize low-emissions growth opportunities, for instance: private sector-led growth—more efficient use of energy resources (resilience and mitigation); social inclusion, sustainable land and water practice in rural areas (e.g., improved efficiency and resilience of irrigation systems and management, reduced erosion and flood/mudflow risk), better disaster risk management, improved sanitation (mitigation co-benefits of wastewater treatment); regional connectivity—rehabilitation of road sections taking into account climate variability, and a new regional program for climate resilience (to design systematic and coordinated approach for efficient and scaled-up response to regional climate challenges).[90]

[90] WBG (2019). Tajikistan – Country Partnership Framework for the Period of FY19–FY23. URL: http://documents1.worldbank.org/curated/en/962981557781100857/pdf/Tajikistan-Country-Partnership-Framework-for-the-Period-of-FY19-FY23.pdf

CLIMATE RISK COUNTRY PROFILE

TAJIKISTAN

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK