CLIMATE RISK COUNTRY PROFILE

UZBEKISTAN

WORLD BANK GROUP

ADB 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).

This profile was written by Alex Chapman (Consultant, ADB), Emmet Kiberd (Consultant, ADB), William Davies (Consultant, ADB), and Ciaran Downey (Consultant). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by MacKenzie Dove (Senior Climate Change Consultant, WBG), Jason Johnston (Operations Analyst, WBG), Yunziyi Lang (Climate Change Analyst, WBG), Adele Casorla-Castillo (Consultant, ADB), and Charles Rodgers (Consultant, ADB). This profile also benefitted from inputs of WBG and ADB regional staff and country teams.

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.

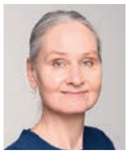
For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy 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.



Bernice Van Bronkhorst
Global Director
Climate Change Group
The World Bank Group

Preety Bhandari
Chief of Climate Change and Disaster Risk Management Thematic Group
concurrently Director Climate Change and Disaster Risk Management Division
Sustainable Development and Climate Change Department
Asian Development Bank

KEY MESSAGES

- Average temperatures are projected to rise by 4.8°C in Uzbekistan by the 2090s, above the 1986–2005 baseline under the highest emissions pathway (RCP8.5). This pace of warming significantly exceeds the projected global average.
- There is a significant 3.4°C gap between the temperature rise projected by 2080–2099 under the highest emissions pathway (RCP8.5), and the rise expected under the lowest emissions pathway (RCP2.6), indicating the large difference in outcomes for Uzbekistan achievable by reducing global emissions.
- Daily maximum and minimum temperatures are expected to warm slightly faster than average temperatures, a trend which may amplify impacts on human health, livelihoods, hydrological resources, and ecosystems.
- The annual probability of experiencing a severe drought is projected to increase significantly by the end of the century in all but the lowest emissions pathway, with severe drought conditions expected to occur in nine out of every ten years by the 2090s under emissions pathway RCP8.5.
- Increased temperatures and more rapid melting of glaciers elsewhere in the region may lead to severe water shortages along Uzbekistan's most important rivers, the Amu Darya and Syr Darya, by the 2040s and 2050s. Runoff rates are also expected to become more variable and more seasonal due to the loss of the buffer provided by glacier meltwater.
- The projected temperature rise, increases in drought frequency, and water shortages in Uzbekistan are expected to reduce the yields of the country's major crops by 25%–63% by the 2050s, relative to their 2000–2009 baseline, under emissions pathway RCP6.0.
- Increases in average temperatures pose a threat to public health in Uzbekistan via heat stress and diseases such as acute intestinal infections, bacterial dysentery and an increased risk of a resurgence of malaria.
- Without support to adapt and reduce disaster risks, climate change impacts are likely to be unequal, affecting Uzbekistan's poor and marginalized communities most.

COUNTRY OVERVIEW

The Republic of Uzbekistan is a landlocked country with a total land area of 447,400 square kilometers, situated in the heart of Central Asia, bordering Kazakhstan, Turkmenistan, Afghanistan, Tajikistan and Kyrgyzstan. It is the most populous country in Central Asia, with a population of 33.5 million in 2019. The Gross Domestic Product (GDP) of Uzbekistan grew by 5.6% in 2019,[1] making it one of the fastest growing economies in the world.[2] Primary sector products make up most of the country's exports, with the largest earnings coming from metals (gold, copper and zinc), cotton, and natural gas.[3] Strong economic growth has translated into a steady reduction in poverty levels, albeit not at the same relative pace as observed globally.[4] In, 2016 the national poverty rate was estimated at around 12% (**Table 1**).

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1 World Bank Open Data (2020). Data Retrieved October 2020. Data Bank: World Development Indicators. URL: https://databank.worldbank.org/source/world-development-indicators

2 World Bank Group (2020). World Development Indicators. URL: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=UZ

3 OEC (2019). Uzbekistan Exports, Imports and Trade Partners. URL: https://atlas.media.mit.edu/en/profile/country/uzb/]

4 World Bank Group (2016). Uzbekistan – Country partnership framework for the period FY16-20 (English). Washington, D.C.: World Bank Group. URL: http://documents.worldbank.org/curated/en/537091467993490904/Uzbekistan-Country-partnership-framework-for-the-period-FY16-20

The adaptation priorities identified in Uzbekistan's Third National Communication (NC3) to the UNFCCC (2016) include support to the understanding of climate change impacts across key sectors such as agriculture, the economy, water resource management, population health, disaster risk reduction, and energy. In Uzbekistan's Nationally-Determined Contribution (2016), additional emphasis is placed on improving the country's capacity to monitor its Green House Gas emissions and on reducing emissions and developing a population and economy more resilient to anticipated climate change.[5]

TABLE 1. Key indicators

Indicator	Value	Source
Population Undernourished[6]	2.6% (2017–2019)	FAO, 2020
National Poverty Rate[7]	11% (2019)	Uzbekistan Statistics (2020)
Share of Income Held by Bottom 20%[8]	unknown	World Bank, 2019
Net Annual Migration Rate[9]	–0.03% (2015–2020)	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)[10]	2.1% (2015–2020)	UNDESA, 2019
Average Annual Change in Urban Population[11]	1.3% (2015–2020)	UNDESA, 2018
Dependents per 100 Independent Adults[12]	51 (2020)	UNDESA, 2019
Urban Population as % of Total Population[13]	50.4% (2020)	CIA, 2020
External Debt Ratio to GNI[14]	33.9% (2018)	ADB, 2020b
Government Expenditure Ratio to GDP[15]	24.6% (2018)	ADB, 2020b

5 Centre of Hydrometeorological Service, Republic of Uzbekistan (2016). Third National Communication of the Republic of Uzbekistan Under the UN Framework Convention on Climate Change. URL: http://www.un-gsp.org/sites/default/files/documents/tnc_of_uzbekistan_under_unfccc_english_n.pdf

6 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/

7 The State Committee of the Republic of Uzbekistan on Statistics (2020). Open Data – Uzbekistan by the numbers (as of January–December 2020). URL: https://stat.uz/en/ [accessed 16/02/21]

8 World Bank (2019). Income share held by lowest 20%. URL: https://data.worldbank.org/ [accessed 17/12/20]

9 UNDESA (2019). World Population Prospects 2019: MIGR/1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]

10 UNDESA (2019). World Population Prospects 2019: MORT/1-1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]

11 UNDESA (2019). World Urbanization Prospects 2018: File 6. URL: https://population.un.org/wup/Download/ [accessed 17/12/20]

12 UNDESA (2019). World Population Prospects 2019: POP/11-A. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]

13 CIA (2020). *The World Factbook*. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/

14 ADB (2020b). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020

15 ADB (2020b). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020

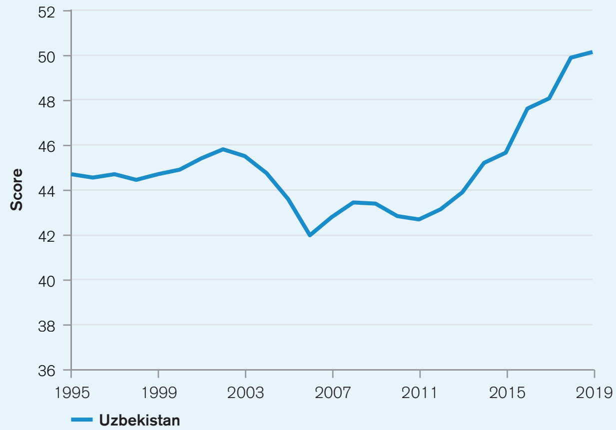
Green, Inclusive and Resilient Recovery

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 Uzbekistan. 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 Uzbekistan, 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, Uzbekistan is recognized as vulnerable to climate change impacts, ranked 83rd out of 182 countries in the 2020 ND-GAIN Index[16] The ND-GAIN Index ranks 182 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is the lower their score, while the more ready a country is to improve its resilience the higher it will be. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Uzbekistan's progress.

FIGURE 1. The ND-GAIN Index 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



[16] University of Notre Dame (2019). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

Climate Baseline

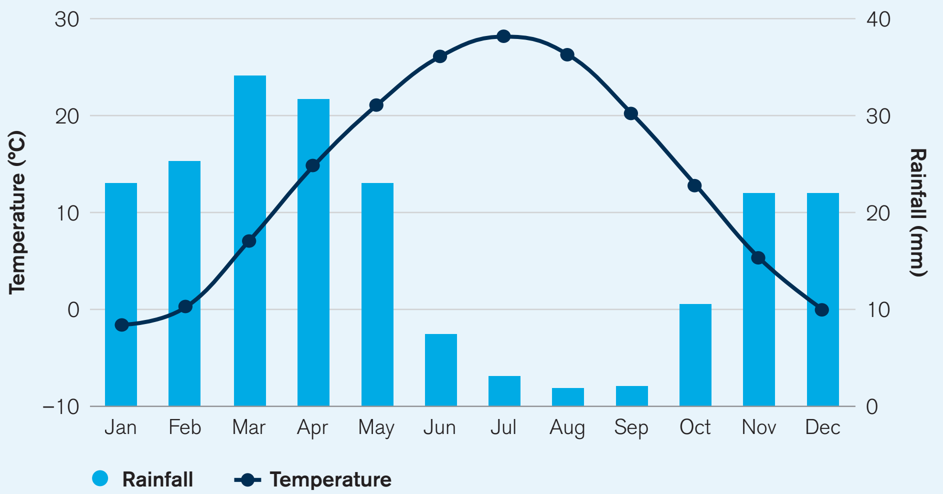
Overview

Uzbekistan has an arid and continental climate characterized by large variations in temperature within days and between seasons. Large parts of the country (79% by area) feature flat topography either in the form of semi-desert steppes or desert zones, including desert areas in the far west that have formed as a result of the drying of the Aral Sea.[17] The remaining south-eastern areas have a continental climate, including the area covering the largest cities of Tashkent and Samarkand, and contain high mountains forming part of the Tien-Shan and Gissar-Alai Ranges.

Summers are long, hot and dry, with an average monthly temperature of 27.2°C in the hottest month (July), and with an average daily maximum of 35°C in many of the major cities. Winters are cold, with average monthly temperatures of –1°C to –3°C between December and February for the latest climatology, 1991–2020, (**Figure 2**). Western areas of the country experience relatively colder winter temperatures, whereas temperatures are highest in the south, near the borders with Turkmenistan and Afghanistan. There is considerable spatial variation in precipitation levels. Many western areas receive less than 100 millimeters (mm) of precipitation per year, whereas parts of the east and south-east can receive up to 800–900 mm per year.[13] **Figure 3** shows the spatial differences of observed historical temperature and precipitation in Uzbekistan.

Annual Cycle

FIGURE 2. Average monthly temperature and rainfall in Uzbekistan, 1991–2020[18]

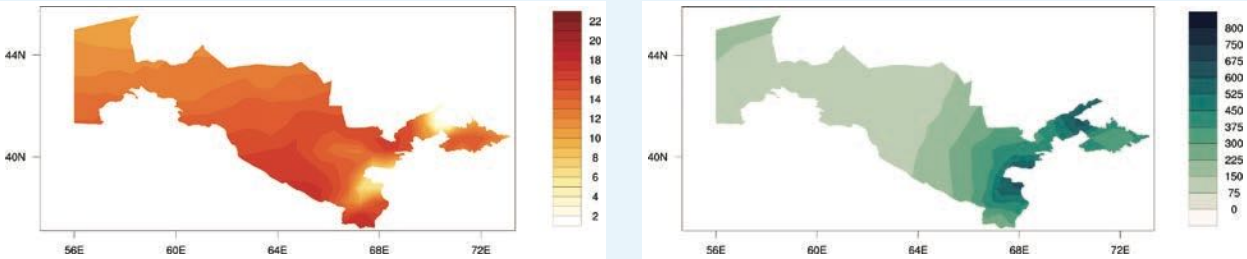


[17] Centre of Hydrometeorological Service, Republic of Uzbekistan (2016). Third National Communication of the Republic of Uzbekistan Under the UN Framework Convention on Climate Change. URL: http://www.un-gsp.org/sites/default/files/documents/tnc_of_uzbekistan_under_unfccc_english_n.pdf

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

Spatial Variation

FIGURE 3. (Left) annual mean temperature (°C), and (right) annual mean precipitation (mm) in Uzbekistan over the period 1991–2020[19]



Key Trends

Temperature

Average annual air temperatures have risen steadily and significantly in Uzbekistan over the past century, albeit with notable variation from year to year. From 1950 to 2013, temperatures rose at an average rate of 0.27°C per decade. The average annual temperature range has narrowed in Uzbekistan over the same period, with average minimum temperatures rising by 2.0°C and average maximum temperatures by 1.6°C between 1950 and 2013.[13] The drying, or 'desiccation', of the Aral Sea located at Uzbekistan's Northwestern corner has made a minor contribution to climate warming in the local vicinity.[20]

Uzbekistan's rate of warming varied considerably by region, with the steepest rises in temperature occurring in the north and in large cities (0.30°C—0.43°C per decade), and less warming occurring in mountainous areas (0.10°C—0.14°C per decade). Warming was fastest in spring (0.39°C per decade) and autumn (0.31°C), while temperature rises were relatively modest in winter (0.13°C per decade).[13]

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

[20] Sharma, A., Huang, H.P., Zavialov, P. and Khan, V. (2018). Impact of desiccation of Aral Sea on the regional climate of Central Asia using WRF model. Pure and Applied Geophysics, 175(1), pp. 465–478. URL: https://asu.pure.elsevier.com/en/publications/impact-of-desiccation-of-aral-sea-on-the-regional-climate-of-cent

Precipitation

In contrast to the clear trend in average temperatures, average annual precipitation has not shown statistically significant changes in Uzbekistan in recent decades. A slight decrease in average annual precipitation was observed between 1950 and 2013. Observations from the Tien Shan and Gissar-Alai mountain ranges exhibit some variation between seasons, with a slight increase in winter months (December to February) being offset by slight decreases in other months of the year.[13] El Niño Southern Oscillation (ENSO) has a strong influence over multi-year dry and wet climate variability.[21]

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.[22] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison 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 where RCP2.6 represents a very strong mitigation scenario and RCP8.5 assumes business-as-usual scenario. For more information, please refer to the RCP Database.

For Uzbekistan, models show a trend of consistent warming despite emissions scenario. However, projections for rainfall are highly variable with no statistically significant change over the past decades. In addition, an increase in intensity for extreme rainfall events is likely. **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.

21 Hu, Z., Chen, X., Chen, D., Li, J., Wang, S., Zhou, Q., Yin, G. and Guo, M. (2019). "Dry gets drier, wet gets wetter": A case study over the arid regions of central Asia. International Journal of Climatology, 39(2), pp. 1072–1091. URL: https://www.deepdyve.com/lp/wiley/dry-gets-drier-wet-gets-wetter-a-case-study-over-the-arid-regions-of-qR4noywkEp

22 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. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_climate-sciences

TABLE 2. Projected anomaly (changes °C) for maximum, minimum, and average daily temperatures in Uzbekistan for 2040–2059 and 2080–2099, from the reference period of 1986–2005 for all RCPs. The table is showing the median of the CCKP model ensemble and the 10–90th percentiles in brackets[23]

	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	1.5 (–0.5, 3.8)	1.5 (–0.5, 3.6)	1.4 (–0.2, 3.4)	1.3 (–0.3, 3.3)	1.4 (–0.4, 3.3)	1.3 (–0.5, 3.2)
RCP4.5	1.9 (0.1, 4.1)	2.7 (0.7, 4.9)	1.8 (0.2, 3.7)	2.6 (0.7, 4.6)	1.9 (0.0, 3.9)	2.5 (0.4, 4.7)
RCP6.0	1.8 (0.0, 3.7)	3.4 (1.4, 5.7)	1.6 (0.0, 3.5)	3.2 (1.5, 5.3)	1.6 (–0.2, 3.4)	3.0 (1.2, 5.2)
RCP8.5	2.5 (0.5, 4.8)	5.4 (3.2, 7.8)	2.5 (0.7, 4.5)	5.3 (3.3, 7.4)	2.5 (0.6, 4.6)	5.2 (3.1, 7.5)

TABLE 3. Projections of average temperature anomaly (°C) in Uzbekistan 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.[19]

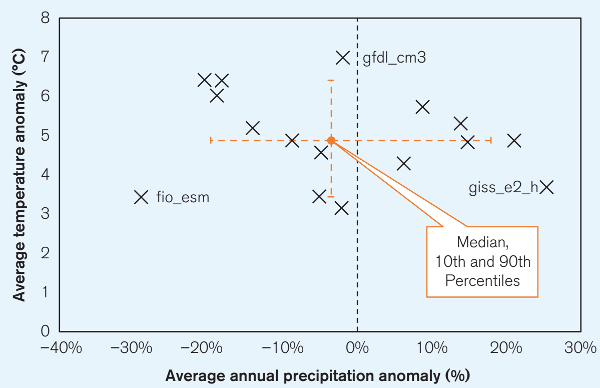
	2040–2059		2080–2099	
Scenario	**Jun–Aug**	**Dec–Feb**	**Jun–Aug**	**Dec–Feb**
RCP2.6	1.6 (–0.2, 3.6)	1.6 (–0.2, 3.9)	1.5 (–0.6, 3.5)	1.5 (–0.2, 3.7)
RCP4.5	2.1 (0.2, 2.4)	4.9 (0.2, 3.8)	2.9 (0.9, 5.2)	2.7 (1.1, 4.7)
RCP6.0	1.8 (0.3, 3.5)	1.8 (0.0, 4.0)	3.7 (1.7, 5.7)	3.3 (1.5, 5.4)
RCP8.5	2.9 (0.9, 4.9)	2.3 (0.4, 4.3)	6.0 (3.7, 8.4)	4.9 (3.3, 6.4)

[23] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Projections. URL: https://climateknowledgeportal.worldbank.org/country/uzbekistan/climate-data-projections

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).[24] 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 Uzbekistan under RCP8.5 is shown in **Figure 4**. Spatial variation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 5**.

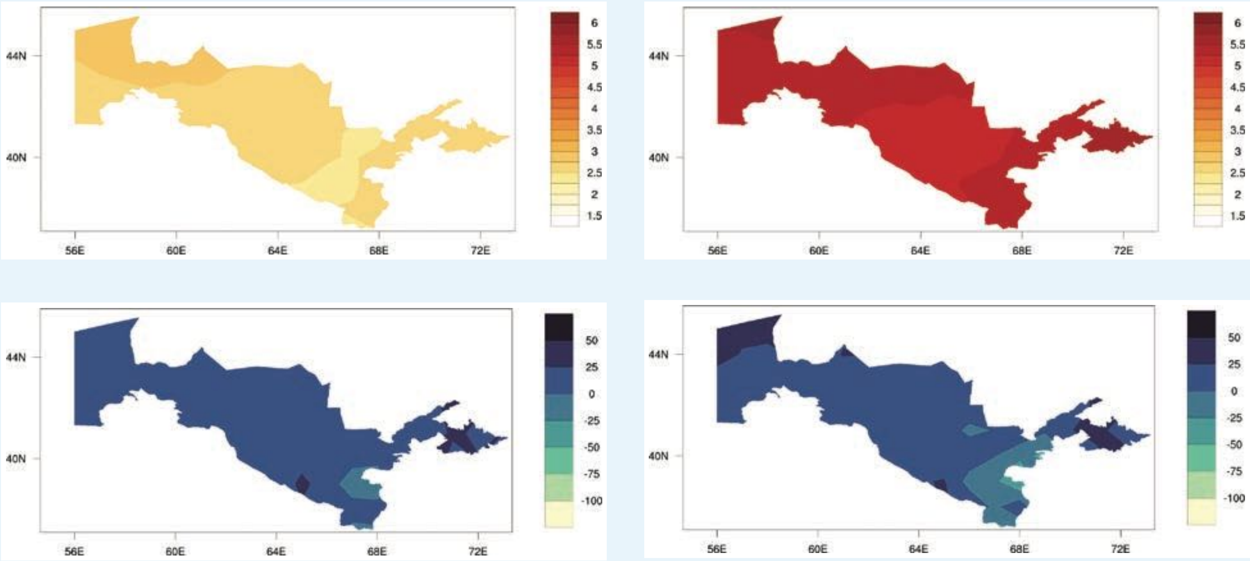
FIGURE 4. 'Projected average temperature anomaly' and 'projected annual rainfall anomaly' in Uzbekistan. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble which provide projections across all RCPs and therefore are most robust for comparison. Three models are labelled



[24] 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 5. CMIP5 ensemble projected change (32 GCMs) in annual temperature (bottom) and precipitation (top) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.5[25]



Temperature

Projections of future temperature change are presented in three primary formats. Shown in **Table 2** are the changes (anomalies) in daily maximum and daily minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 6** and **7** display the annual and monthly average temperature projections. While similar, these three indicators can provide slightly different information. Monthly/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, affecting 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.

Average temperatures in Uzbekistan are expected to rise significantly by the 2090s, under all emissions pathways, relative to their 1986–2005 baseline. The rate of warming for Uzbekistan exceeds the projected global average temperature rise. The large variation between pathways highlights the outcomes achievable through controlling global emissions. Both maximum and minimum temperatures are expected to rise more quickly than daily mean temperatures, with an increase of 5.6°C expected by the 2090s, under RCP8.5 for both indicators.

[25] WBG Climate Change Knowledge Portal (CCKP 2021). Uzbekistan Climate Data. Projections. URL: https://climateknowledgeportal.worldbank.org/country/uzbekistan/climate-data-projections

FIGURE 6. Historic and projected average annual temperature in Uzbekistan under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble.[26]

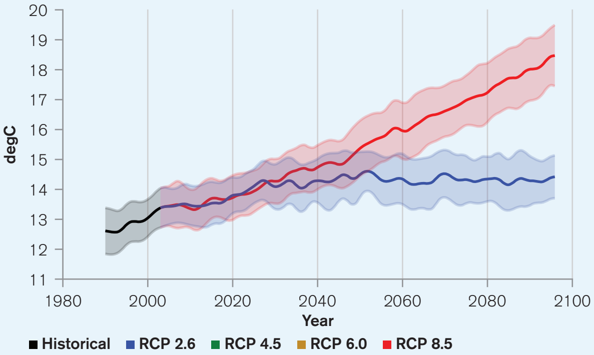
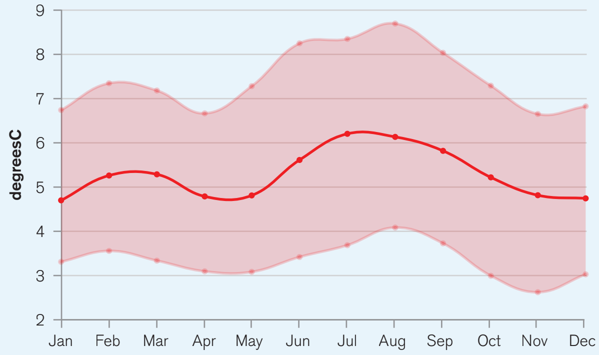


FIGURE 7. Projected change (anomaly) in monthly temperature, shown by month, for Uzbekistan for the period 2080–2099 under RCP8.5. The value shown represents the median of the model ensemble with the shaded areas showing the 10th–90th percentiles.[22]



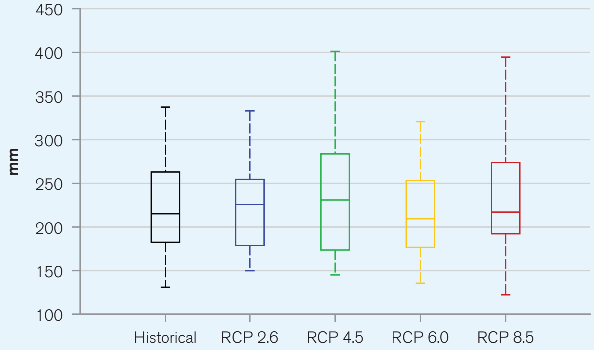
The model ensemble projects the most significant increases to occur during the summer months (June to September), with a rise as high as 6°C by the end of the 21st century under the RCP8.5 pathway. Additionally, the July daily maxima is expected to exceed 35°C in many parts of Uzbekistan, with warming of this magnitude likely to have a severe socio-economic impacts on the country as summer temperatures reach hazardous levels.

Although temperature increases are projected to be high in all parts of Uzbekistan, there is some variation in the extent of warming that is expected. Under the RCP8.5 pathway, the increase in average temperatures by the 2090s is expected to be strongest in the Fergana valley in the far east of Uzbekistan (5.6°C—5.7°C), followed by the Aralkum desert (5.5°C—5.6°C). The lowest level of warming is suggested for the central province of Bukhara (5.1°C—5.2°C).

Precipitation

The model ensemble does not tell a consistent story regarding changes in average annual precipitation over Uzbekistan. This uncertainty even in the sign of the change is evident across all four emissions pathways and at different time horizons (see **Figure 8**, below). As seen in **Figure 4**, individual climate models projections can vary between a 30% reduction in annual precipitation and a 20% increase. While considerable

FIGURE 8. The boxplot shows the projected annual average precipitation for Uzbekistan in the period 2080–2099.[22]



[26] WBG Climate Change Knowledge Portal (CCKP 2021). Uzbekistan Agriculture Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=UZB&period=2080-2099

uncertainty surrounds projections of local long-term future precipitations, some global trends are evident. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia.[27] The CCKP model ensemble also suggests that the total precipitation deposited during an extreme 5-day event in Uzbekistan could increase slightly (0%–20% depending on the emissions pathway). However, as this phenomenon is highly dependent on local geographical contexts, further research is required to constrain its impact in Uzbekistan.

CLIMATE RELATED NATURAL HAZARDS

Uzbekistan is close to the global median in disaster risk rating, with a ranking of 112 out of 191 countries (**Table 4**). The country's risk score is driven upwards by its very high exposure to earthquakes: with a score of 9.9 out of 10, Uzbekistan ranks joint 2nd highest in the world. The country also ranks in the top 20 in the world in terms of its exposure to drought. Linked to this Uzbekistan also faces a high hazard from wildfires.[28] Uzbekistan faces above-average levels of flood hazard. These scores are offset by proportionately low levels of vulnerability and moderate levels of coping capacity. The section which follows analyses climate change influences on the exposure component of risk in Uzbekistan. 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 Uzbekistan. 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)
6.3 [4.5]	0.0 [1.7]	6.6 [3.2]	1.9 [3.6]	4.0 [4.5]	3.1 [3.8]	112

27 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. URL: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014RG000464

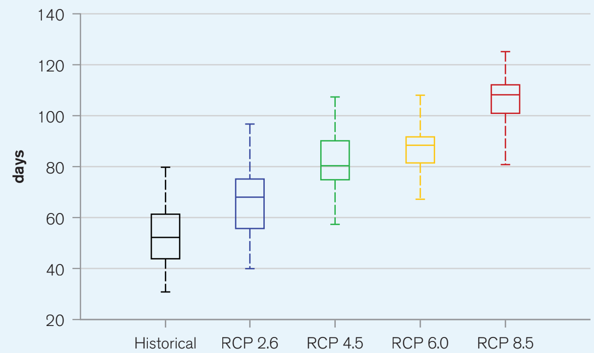
28 European Commission (2019). INFORM Index for Risk Management. Uzbekistan Country Profile. URL: https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

Heatwaves

Uzbekistan regularly experiences high maximum temperatures, with an average monthly maximum around 18.5°C, but with average July maximum of 34.9°C. The current median probability of a heat wave (defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) for Uzbekistan is around 2%. The frequency of heat waves has already risen, with the sharpest increase being observed in the northwestern areas surrounding the Aral Sea and the lower Amu Darya.[13] This has led to a rise in the number of very hot days (>40°C), which have been shown to amplify the effects of ischemic heart disease in Uzbekistan.[29]

The daily probability of a heatwave is projected to increase in Uzbekistan under all emissions pathways. This increase in heat wave probability is expected to occur as soon as the 2030s, even under the lowest emissions (RCP2.6) pathway. Primarily, increases in heatwave probability simply reflect the general increase in ambient temperatures, which constantly move away from the baseline (1986–2005) against which heat wave is measured. Another lens through which to view extreme heat is the annual frequency of days in which temperatures breach 35°C. As shown in **Figure 9,** this frequency increases significantly under all emissions pathways, and potentially doubles to over 100 days per year under the highest pathway (RCP8.5).

FIGURE 9. Historic (1986–2005) and projected (2080–2099) average annual count of days in which temperatures surpass 35°C under four emissions pathways[22]



The duration of warm spells (i.e. consecutive days on which the maximum temperature exceeds the 90th percentile of historical observations for that time of year) is expected to increase significantly by the 2030s under all emissions pathways and to continue rising in the subsequent decades, gathering pace towards the latter end of the 21st century. Considering the high average and maximum temperatures at present, and the low historical probability of a heatwave, even the lower emissions pathways suggest that temperatures that are hazardous to public health could become more common in Uzbekistan in the near future. By the 2090s, temperatures under the highest emissions pathway (RCP8.5) could also begin regularly exceeding the 35°C heat index threshold, a measure of a temperature and humidity which flags very significant risks to human health.

[29] Zunnunov Z. R. (2000). Meteopathogenic mechanisms of exacerbating ischemic heart disease in the arid zone. Issues of Balneology, Physiotherapy and Exercise Therapy, 5, 17–20. URL: https://www.ncbi.nlm.nih.gov/pubmed/11247139

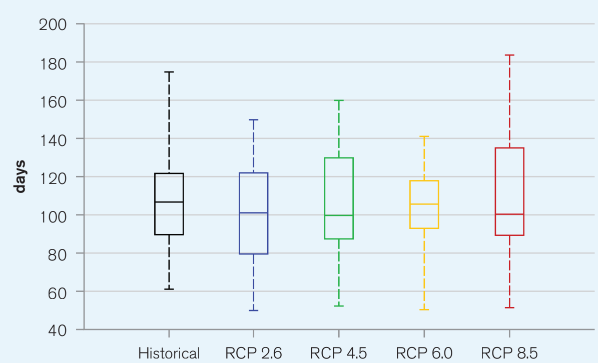
Drought

Uzbekistan's arid climate and regular high temperatures make drought an increasingly regular occurrence, with one drought every five years on average during the 1980s and 1990s and four episodes between 2000 and 2012.[30] Three kinds of drought occur in the country: *hydrological drought* (water shortages from January to March due to low precipitation in the upper watershed of key rivers), *meteorological drought* (usually associated with a precipitation deficit, and typically occurring in spring or summer), and *agricultural drought* (a lack of moisture in the soil that inhibits crop growth).[13] Hydrological drought has been occurring with increasing frequency and severity in the western areas of Uzbekistan in the past two decades, whereas the central and southern provinces have experienced the highest frequency of meteorological drought.[13]

The most severe drought of recent decades, occurred in 2000 and 2001, and resulted in severe economic and social consequences. Agricultural yields fell by 14%–17% for cereals and 45%–75% for other crops,[13] while the losses in agricultural GDP were estimated at between $38 million and $130 million.[26] There is also extensive evidence of the health impacts of the 2000–01 drought, which led to increased levels of water-related illness and malnutrition among children in western regions, iodine deficiencies, goiter, and diarrheal and respiratory diseases.[31] Naumann et al. (2018), provide a global overview of changes in drought conditions under different warming scenarios.[32] They project large increases in the duration and magnitude of droughts in Central Asia by the end of the 21st century under global warming levels of 1.5°C, 2.0°C and 3.0°C. Droughts of a magnitude that is extremely rare at present in Central Asia (100-year droughts) are projected to become 4 to 10 times more common under the same warming scenarios.

The CCKP model ensemble suggests that the annual probability of experiencing a severe meteorological drought in Uzbekistan could increase significantly by the 2090s, under all but the lowest emissions pathway. Projections indicate that severe meteorological drought could occur in 58% of all years by the 2090s under RCP4.5, whereas under RCP8.5, severe drought is projected to occur in 87% of all years. While there is some variation regionally within Uzbekistan, risks generally increase westward. Under RCP8.5, by the 2090s, parts of the western Republic of Karakalpakstan are projected to experience severe drought in 95% of years, whereas the equivalent probability in the east is 78% for Tashkent and below 67% for parts of the Ferghana valley. In effect, these projections describe a transition to a new regime of chronic meteorological drought. **Figure 10** shows the maximum number of consecutive dry days through the end of the century.

FIGURE 10. Maximum number of consecutive dry days in Uzbekistan in 2080–2099, under four emissions pathways.[22]



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[30] FAO (2017). Drought characteristics and management in Central Asia and Turkey. FAO Water Reports 44. URL: http://www.fao.org/3/a-i6738e.pdf

[31] World Bank. (2017). *The Health Dimension of Climate Change.* Washington DC: World Bank. URL: http://documents.worldbank.org/curated/en/956131484811114877/pdf/111557-WP-PUBLIC.pdf

[32] 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. URL: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL076521

Flood and Mudflow

The majority of Uzbekistan is at high risk of both river flooding and flash flooding.[24] The most severe recent flood in terms of loss of life occurred in 1998 on the Aksu and Shahimardan rivers, killing 109 people.[27] The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a baseline level of river flood exposure. As of 2010, assuming protection for up to a 1 in 25-year event, the population annually affected by flooding in Uzbekistan is estimated at 61,000 people and expected annual impact on GDP estimated at $181 million. Development and climate change are both likely to increase these figures. The climate change component can be isolated and by the 2030s is expected to increase the annually affected population by 13,000 people, and GDP impact by $143 million under the RCP8.5 emissions pathway (AQUEDUCT Scenario B).[33] Under this scenario, annual damage associated with river flood impacts alone would approach 1% of GDP. Willner et al. (2018) project that climate change could also change the number of people vulnerable to extreme flooding in Uzbekistan. The median estimate derived from an average of all four RCPs suggests that this at-risk population could increase by 5.4% by 2040s (**Table 5**).

TABLE 5. Estimated number of people in Uzbekistan 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.[34]

Estimate	Population Exposed to Extreme Flood (1971–2004)	Population Exposed to Extreme Flood (2035–2044)	Increase in Affected Population
16.7 Percentile	555,923	525,640	–30,283
Median	782,365	824,748	42,383
83.3 Percentile	1,020,578	1,094,089	73,511

A separate GFDRR study of the effects of extreme flood events[35] estimates that a flood with a 100-year return period could affect 6% of Uzbekistan's population (equivalent to 2 million people) and 5% ($4 billion) of the country's GDP. This analysis identified the far eastern provinces of Fergana and Andijan and the far western Republic of Karakalpakstan as the area most economically vulnerable to flooding.

Flash flooding and mudflows pose an increasing threat to southern and eastern parts of Uzbekistan, with 3,300 such events having occurred in the country between 1900 and 2013.[13] These phenomena typically occur between the months of March and July, fed by precipitation and potentially by melting snow. Uzhydromet estimates that 22% of the country's population lives in zones with high mudflow frequency.[13] However, uncertainty remains regarding the impacts of climate change on mudflow trends. Mudflows are known to have a complex link with atmospheric circulation patterns.[36] The potential increase in the intensity of precipitation during extreme rainfall periods flags the importance of further study. Uzbekistan is also at risk of the related natural hazard, glacial lake

[33] WRI (2018). AQUEDUCT Global Flood Analyzer. URL: https://floods.wri.org/#

[34] 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. URL: https://advances.sciencemag.org/content/4/1/eaao1914

[35] GFDRR (2016). Disaster Risk Profile: Uzbekistan. URL: https://www.gfdrr.org/en/publication/disaster-risk-profile-uzbekistan

[36] Mamadjanova, G., Wild, S., Walz, M.A. and Leckebusch, G.C. (2018). The role of synoptic processes in mudflow formation in the piedmont areas of Uzbekistan. Natural Hazards and Earth System Sciences, 18(11), pp. 2893–2919. URL: https://www.nat-hazards-earth-syst-sci.net/18/2893/2018/

outburst flooding. An assessment of lakes across the country found that 15% were susceptible to outburst,[37] and this risk may increase as the higher temperatures projected by the model ensemble serve to accelerate the melting of glaciers in Central Asia.[38]

CLIMATE CHANGE IMPACTS

Natural Resources

Water

As of 2014, 80% of Uzbekistan's water supply came from resources originating outside its borders. Uzbekistan shares the major rivers of Central Asia (Amu, Darya, Syr Darya, and Zaravshan) with its neighbors; less than 10% of Uzbekistan's water resources originates in the country.[39] This makes the country vulnerable to increased upstream river regulation from other countries, such as the new hydropower plants on the upper Zarafshan in Tajikistan or increased withdrawal of water from the Amu Darya for irrigation in Turkmenistan. In the absence of careful international coordination, the pressure on Uzbekistan's water resources may increase as climate change leads to a reduction in river runoff in the long-term.[40] Hagg et al (2013) use hydrological models to estimate the effect of climate change on the glaciers that feed the main tributary to the Amu Darya river, albeit using the previous iteration of General Circulation Models (CMIP3).[41] They project that temperature rises of between 2.2°C and 3.1°C by the 2050s in mountainous areas of Tajikistan could lead to a loss in glacial mass of 36%–45%, relative to present levels. This causes only a slight reduction in river flow by the 2050s, as the smaller glacial mass and increased evapotranspiration are partly offset by a faster glacial melt rate.[35] In Uzbekistan, the mountain headwaters of the Syr Darya Basin are primarily located in the western Tien Shan and Alai mountains, while glacial ablation contributes to runoff in the Basin, snow melt and summer precipitation are also a factor. There is potential for complete disappearance of the glaciers, however this is anticipated to have a minimal impact on availability of water sources for the Upper Syr Darya Basin; with changing precipitation patterns incurring a far more impactful role.[42]

Punkari et al (2014) use CMIP3 models to estimate the impact of climate change on the Syr Darya and Amu Darya rivers and related water supply by the 2050s.[43] They project that by mid-century inflow into downstream areas could

[37] Petrov, A. et al. (2017). Glacial lake inventory and lake outburst potential in Uzbekistan. Science of The Total Environment. 592. 10.1016/j.scitotenv.2017.03.068. URL: https://europepmc.org/article/med/28319710

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

[39] GFDRR (2019). Weather, Climate and Water in Central Asia. A guide to Hydrometeorological Services in the Region. URL: https://phase1-gfdrr-drupal8.pantheonsite.io/sites/default/files/publication/Hydromet-Atlas-ENG-27Jan2020-pages-WEB.pdf

[40] Novikov, V. & Kelly, C. (2017). Climate Change and Security in Central Asia. Geneva: ENVSEC. URL: https://www.osce.org/secretariat/355471?download=true

[41] Hagg, Wilfried & Hoelzle, Martin & Wagner, Stephan & Mayr, Elisabeth & Klose, Zbynek. (2013). Glacier and runoff changes in the Rukhk catchment, upper Amu-Darya basin until 2050. Global and Planetary Change. 110. 10.1016/j.gloplacha.2013.05.005. URL: https://pubag.nal.usda.gov/catalog/841237

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

[43] Punkari, Mikko; Droogers, Peter; Immerzeel, Walter; Korhonen, Natalia; Lutz, Arthur; Venäläinen, Ari. (2014). Climate Change and Sustainable Water Management in Central Asia. Asian Development Bank. URL: http://hdl.handle.net/11540/1296

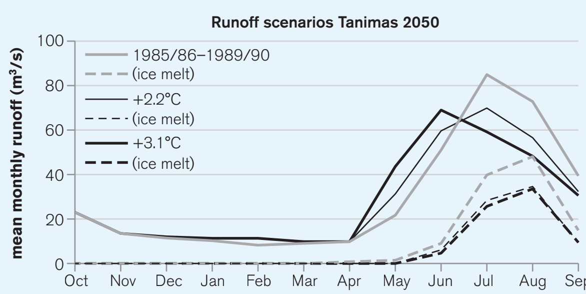
drop by 22%–28% for the Syr Darya and by 26%–35% for the Amu Darya, even as water demand rises in order to allow continued irrigation in the face of higher evaporation rates. This projection implies that by the 2050s there could be severe water shortages in the Syr Darya and Amu Darya basins, with 35% and 50% of their respective levels of demand being unmet.[36]

The Zarafshan river, another important water source for Uzbekistan, is subject to similar issues of glacial retreat. One of the main sources of this river, the Zeravshan glacier in northern Tajikistan, has seen a significant and accelerating reduction in size over the past century.[34] The Zarafshan river is currently used for extensive irrigation in the vicinity of the cities of Samarkand and Bukhara, which would be negatively affected if river flow were to weaken in the coming decades. These results are supported by additional projections undertaken by Sutton et al (2013)[44] with CMIP3 models. Under the A1B emissions scenario (most comparable to RCP6.0), they project that there could be significant water shortfalls by the 2040s in the Syr Darya East (shortfall of 51.6% of total irrigation demand), Syr Darya West (34.4%) and Amu Darya (28.9%) basins.

Although further research is needed to understand the change in runoff in the major rivers of Uzbekistan after the 2050s, models for similar glaciers in the Central Asian region (e.g. Sorg et al (2014) for the Tien Shan mountains) suggest that in the latter half of the 21st century there may be a sharp decrease in runoff as glacial mass becomes critically low.[45] This accelerated glacial melt in the latter decades of the 21st century would pose a threat to some of Uzbekistan's major water sources. However, the precise timing of this tipping point is highly uncertain and merits further work.[46]

As glaciers in the region recede, a change in the seasonal patterns of river flow is expected, with peak flow shifting from the summer to the spring in line with broader climate change impacts across central Asia.[47] Hagg et al project a mean runoff reduction of 25% during July and August for the main tributary of the Amu Darya (**Figure 11**, above),[35] and there is some evidence that the same seasonal shift is affecting the Zarafshan river.[34] If this trend were to continue, it would put pressure on Uzbekistan's irrigated cotton and grain production, which would require more water in the summer months than at present in the face of projected increases in average temperatures.

FIGURE 11. Baseline and future scenarios for Tanimas river. Total runoff (solid lines) and ice melt (dashed lines) at the basin outlet (Rukhk hydrological post) are displayed.[35]



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[44] Sutton, W.R., Srivastava, J.P., and Neumann, J.E. (2013). Looking Beyond the Horizon: How Climate Change Impacts and Adaptation Responses Will Reshape Agriculture in Eastern Europe and Central Asia. Washington, DC: World Bank. URL: http://documents.worldbank.org/curated/en/676601468249642651/pdf/Looking-beyond-the-horizon-how-climate-change-impacts-and-adaptation-responses-will-reshape-agriculture-in-Eastern-Europe-and-Central-Asia.pdf

[45] Sorg, A., Huss, M., Rohrer, M. & Stoffel, M. (2014). The days of plenty might soon be over in glacierized Central Asian catchments. *Environmental Research Letters, 9, 104018*. URL: https://iopscience.iop.org/article/10.1088/1748-9326/9/10/104018

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

[47] USAID (2018). Climate Risk Profile – Uzbekistan. URL :https://www.climatelinks.org/sites/default/files/asset/document/Uzbekistan_CRP_Final.pdf

Land and Soil

The projected reduction in glacial mass and river flow in the Amu Darya and Syr Darya basins[36] along with increased average temperatures projected by the model ensemble are likely to accelerate the desiccation of the Aral Sea. This in turn could hasten the process of desertification across the wide area of land adjoining the Aral Sea, with winds carrying sand, dust, agricultural chemicals and salt up to 300 km from the former seabed.[34] Analysis of remote sensing data for the Aral Sea area demonstrates that the area of salt-affected soils that feed the development of salt and dust storms expanded by 36% in the period 2000–2008[48]. Dust storms affect 5.5 million people in Uzbekistan and their increasing frequency, driven by desertification, has been shown to pose a risk to public health in Uzbekistan.[49] More broadly, the sharp increase in the probability of drought in Uzbekistan that is predicted by the model ensemble is likely to drive further desertification in the coming decades.[40]

It is estimated that half of all irrigated land in Uzbekistan is affected by soil salinity, with considerable spatial variation between areas along the major rivers, where less than 10% of the irrigated area is affected, and the northwestern region of Karakalpakstan, where nearly all irrigated land is affected.[50] Significant areas of land in Uzbekistan bordering the Aral Sea are affected by acute secondary soil salinization.[51] This phenomenon may be hastened by climate change, to the extent that the expected increases in average temperatures may cause increased evapotranspiration and higher water demand for irrigation.

Economic Sectors

Agriculture

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 salinization and desertification. On an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018) estimate 5% and 6% declines in global wheat and maize yields, respectively even if warming is limited to 1.5°C.[52] 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, water scarcity in Uzbekistan has also been identified as a key risk to global food trade and security.[53]

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[48] Löw, F & Navratil, Peter & Kotte, Karsten & Schöler, Heinz & Bubenzer, Olaf. (2013). Remote-sensing-based analysis of landscape change in the desiccated seabed of the Aral Sea - A potential tool for assessing the hazard degree of dust and salt storms. Environmental monitoring and assessment. 185. 10.1007/s10661-013-3174-7. URL: https://www.ncbi.nlm.nih.gov/pubmed/23564411

[49] WHO and UNDP (2011). Climate Change Adaptation to Protect Human Health: Uzbekistan. URL: https://www.adaptation-undp.org/resources/project-brief-fact-sheet/climate-change-and-human-health-adaptation-project-uzbekistan

[50] Ministry of Agriculture and Water Resources (2011). Water Resources Management Sector Project. URL: https://www.adb.org/sites/default/files/project-document/61136/40086-013-uzb-iee-05.pdf [accessed 15/01/2019]

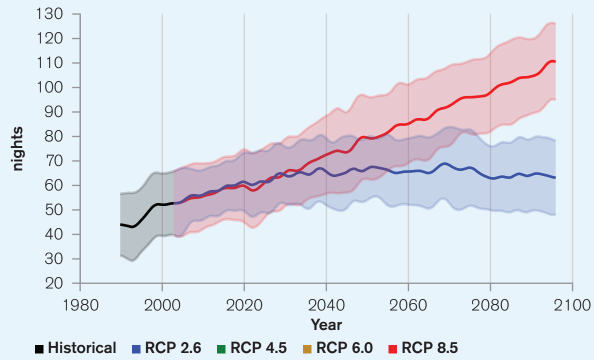
[51] Nkonya et al. (2016). Economics of Land Degredation and Improvement – a global assessment for sustainable development. URL: https://www.oapen.org/download?type=document&docid=1001884#page=660

[52] 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

[53] Zhao, H., Qu, S., Guo, S., Zhao, H., Liang, S. and Xu, M. (2019). Virtual water scarcity risk to global trade under climate change. Journal of Cleaner Production, 230, 1013–1026. URL: http://css.umich.edu/publication/virtual-water-scarcity-risk-global-trade-under-climate-change

The model ensemble projects that under RCP8.5, the number of tropical nights (with a minimum temperature of at least 20°C) could increase significantly in Uzbekistan by the 2090s, rising to approximately double the baseline level (**Figure 12**). This is likely to reduce soil moisture and consequently drive a reduction in agricultural productivity. Additionally, given that 85% of crop land in the country is irrigated, the increased temperatures, more frequent droughts and river water shortages that are projected for the country have the potential to compound this reduction in productivity.[54] The vulnerability of Uzbekistan's irrigated agriculture sector to projected declines in water availability has been identified as a major threat to the livelihoods of a large population of agricultural laborers, numbering in the hundreds of thousands.[55] In order to address this significant vulnerability,[56] studies suggest there is a high-priority need to optimize irrigation efficiency, and to address aging and poor quality infrastructure in the sector.[57]

FIGURE 12. Historic and projected annual average number of tropical nights (>20°C) 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[22].



Sutton et al. (2013) model the impact of climate change on the yields of several important crops in Uzbekistan, under the A1B emissions scenario from CMIP3 (most comparable to RCP6.0).[37] They project that, under this 'high impact' scenario and in the absence of adaptations, there are likely to be significant reductions in yields for all irrigated crops analyzed and in all parts of the country, as a result of projected higher temperatures, more variable precipitation and water shortages. Sutton et al.'s projections of declines in cotton yields are of particular significance due to the crop's major role in supporting livelihoods and the national economy of Uzbekistan. They project the following effects by crop type by the 2050s:

- Spring wheat: yield reduction of 41%–57%
- Winter wheat: yield reduction of 31%–43%
- Apples: yield reduction of 39%–63%
- Potatoes: yield reduction of 37%–57%
- Tomatoes: yield reduction of 29%–57%
- Cotton: yield reduction of 25%–49%
- Alfalfa: yield reduction of 27%–39%

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54 World Bank (2013). Uzbekistan: Overview of Climate Change Activities. Washington, DC.: World Bank. URL: https://openknowledge.worldbank.org/handle/10986/17550

55 Bekchanov, M. and Lamers, J.P. (2016). Economic costs of reduced irrigation water availability in Uzbekistan (Central Asia). Regional environmental change, 16(8), pp. 2369–2387. URL: https://link.springer.com/article/10.1007/s40333-018-0073-3

56 Aleksandrova, M., Gain, A.K. and Giupponi, C. (2016). Assessing agricultural systems vulnerability to climate change to inform adaptation planning: an application in Khorezm, Uzbekistan. Mitigation and adaptation strategies for global change, 21(8), pp. 1263–1287. URL: https://gfzpublic.gfz-potsdam.de/rest/items/item_1030912_5/component/file_2293897/content

57 Bekchanov, M., Ringler, C., Bhaduri, A. and Jeuland, M. (2016). Optimizing irrigation efficiency improvements in the Aral Sea Basin. Water Resources and Economics, 13, pp. 30–45. URL: http://www.cawater-info.net/bk/water_land_resources_use/english/english_ver/pdf/beckchanov-et-al.pdf

The likely effect of climate change on the livestock subsector, which makes up 39% of agricultural production in Uzbekistan,[40] is less clear than for crop farming. The projected increase in temperatures, and more frequent episodes of sustained exposure to extreme heat, are expected to directly reduce livestock productivity via heat stress among the animals.[13] This is a concern, as the model ensemble estimates that the duration of warm spells could increase significantly in Uzbekistan as soon as the 2030s under all emissions pathways. On the other hand, the indirect effects (via the impact of climate change on pasture yields) are not expected to be as severe. There may be some benefits to pasture growth, as higher temperatures may allow the growing season to begin earlier, which in turn would benefit from the higher monthly precipitation that is typically observed in March and April.[13] This is only expected to increase pasture yields in wetter than average years, however.

The warmer temperatures projected by the model ensemble are also likely to have a negative effect on agricultural productivity in Uzbekistan by increasing the sector's exposure to pests and diseases. Farmers in the country have identified an increase in the number of pests and diseases,[37] while higher temperatures have also been linked to increased propagation of locusts and increases in animal diseases.[13]

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) 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 the 2050s under the highest emissions pathway.[58] The increase in the number of days in which temperatures surpass 35°C in Uzbekistan (**Figure 9**) also highlights potential productivity issues for the agricultural labor force. In combination, it is highly likely that the above processes could have considerable impact on national food consumption patterns both through direct impacts on internal agricultural operations, and through impacts on the global supply chain.

Urban and Energy

Research has established a reasonably well constrained relationship between heat stress and labor productivity, household consumption patterns, and (by proxy) household living standards.[59] In general, 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.

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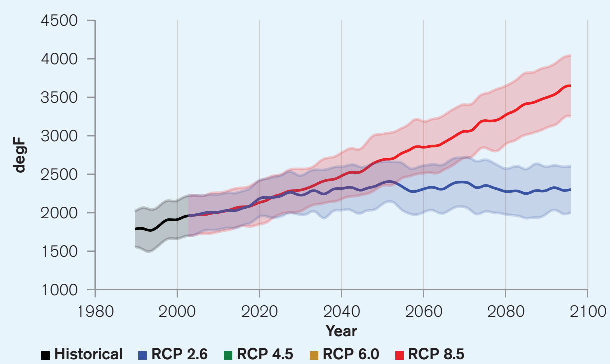
58 Dunne, J. P., Stouffer, R. J., & John, J. G. (2013). Reductions in labor capacity from heat stress under climate warming. Nature Climate Change, 3(6), 563–566. URL: http://www.precaution.org/lib/noaa_reductions_in_labour_capacity_2013.pdf

59 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

The effects of temperature increase and heat stress in urban areas are increasingly compounded by the phenomenon of the Urban Heat Island (UHI) effect. Dark surfaces, residential and industrial sources of heat, an absence of vegetation, and air pollution[60] 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.[61] As well as impacting on human health (see Communities) the temperature peaks that could result from combined UHI and climate change, as well as future urban expansion, are likely to damage the productivity of the service sector economy, both through direct impacts on labor productivity, but also through the additional costs of adaptation.

Research suggests that on average, a one-degree change in ambient temperature can result in a 0.5%–8.5% increase in electricity demand.[62] Notably this serves business and residential air-cooling systems. 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. The number of annual cooling degree days (when such cooling systems would be required) is projected to increase significantly by the 2090s under RCP8.5, to approximately double its current level (**Figure 13**).

FIGURE 13. Historic and projected annual cooling degree days in Uzbekistan (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.[22]



While most of the energy produced in Uzbekistan comes from fossil fuels (90%), hydroelectric power generation also plays a significant role in the country's generation capacity. Hydropower accounted for 10% of the country's domestic power generation in Uzbekistan in 2020, having risen in prominence since the 1990s.[63] Natural gas accounts for 82 percent of the power mix in Uzbekistan. Hydro and coal account for 10 percent and 8 percent, respectively. The Government has target to reduce the share of fossil fuels in power mix to 51% by 2030 in line with the Government roadmap on "A Carbon Neutral Electricity Sector in Uzbekistan by 2050".[64] The government has plans to construct additional hydro power plants in the coming years.[65] The flow reduction projected for its major rivers by the middle of the century[37]

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60 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

61 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://www.researchgate.net/publication/263283084_Surface_urban_heat_island_in_China's_32_major_cities_Spatial_patterns_and_drivers

62 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://www.semanticscholar.org/paper/On-the-impact-of-urban-heat-island-and-global-on-of-Santamourisa-Cartalisb/17f86e9c161542a7a5acd0ad500f5da9f45a2871

63 IEA (2019). Electricity generation by fuel: Uzbekistan 1990 – 2016. URL: https://www.iea.org/statistics/?country=UZBEKISTAN&year=2016&category=Key%20indicators&indicator=ElecGenByFuel&mode=chart&dataTable=ELECTRICITYANDHEAT

64 Ministry of Energy of the Republic of Uzbekistan (2021). A Carbon Neutral Electricity Sector in Uzbekistan. URL: http://minenergy.uz/en/lists/view/131

65 PWC (2016). CAREC: Study for Power Sector Financing Road Map. URL: https://www.carecprogram.org/uploads/CAREC_TA8727_CountryReport_Uzbekistan.pdf

has the potential to limit Uzbekistan's capacity to generate energy in this way, especially during summer and autumn months,[40] when energy demand for cooling could be higher. Future hydropower potential will also depend on the development and adaptation plans of upstream nations such as Tajikistan in regards to water management as well as the implementation of energy sector reforms to create enabling environments.

Communities

Poverty and Inequality

Many of the climate changes projected are 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.[66] Poorer businesses are least able to afford air conditioning, an increasing need given the projected increase in cooling days. Additionally, poorer farmers and communities are least able to afford local water storage, irrigation infrastructure, and technologies for adaptation. The agriculture sector in Uzbekistan has a lower than average level of productivity, accounting for 27% of employment but only 18% of GDP,[67] meaning that many of those who work in the sector make up the poorer segments of the population. The projected impacts of climate change on agricultural yields - via higher temperatures, more frequent droughts, growing water shortages and an increased threat of desertification and soil salinization is therefore likely to disproportionately affect the living standards of parts of Uzbekistan that are already poor. Households in Uzbekistan spend a relatively high proportion of their income on food, 47.3% in 2016,[68] compared with an average of 38.6% across a representative sample of 92 developing countries,[63] leaving poorer groups relatively exposed to rises in food prices.

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.[69] The FAO have explored some of the intersections between gender and vulnerability to climate change and natural hazards in Uzbekistan, highlighting in particular to ensure women are represented in key institutions managing environmental change and their needs and views are integrated into policies tackling climate impacts. However, a lack of data and analytical understanding of gendered issues in Uzbekistan remains a barrier in urgent need of addressing.[70]

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66 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://www.ncbi.nlm.nih.gov/pubmed/26989826

67 USAID (2018). Climate Risk Profile – Uzbekistan. URL: https://www.climatelinks.org/countries/uzbekistan

68 Uzbekistan (2017). The State Committee of the Republic of Uzbekistan on Statistics. URL: https://www.stat.uz/en/

69 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

70 FAO (2019). Gender, agriculture and rural development in Uzbekistan. Food and Agriculture Organization of the United Nations. URL: http://www.fao.org/3/ca4628en/ca4628en.pdf

Human Health

Nutrition

The World Food Programme estimates that without adaptation, the risk of hunger and child malnutrition on a global scale could increase by 20% respectively by 2050.[71] Springmann et al. (2016) assessed the potential for excess, climate-related deaths associated with malnutrition.[72] The authors identify two key risk factors that 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 24 climate-related deaths per million linked to lack of food availability in Uzbekistan by the 2050s under RCP8.5.

Uzbekistan has made significant improvements in its nutrition and food security over the past decade, so that the country currently has a more secure and adequate supply of food at the national level.[73] Nonetheless, given that 85% of crop land in the country is irrigated, the increased temperatures, more frequent droughts and river water shortages that are projected for have the potential to sharply reduce the yields of most crops,[37] which would threaten Uzbekistan's food security.[47] Households in Uzbekistan spend a relatively high proportion of their income on food, 47.3% in 2016,[74] compared with an average of 38.6% across a representative sample of 92 developing countries;[75] leaving Uzbekistan relatively exposed to rises in food prices.

Heat-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.[76] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. Climate change could push global temperatures closer to this temperature 'danger zone' both through slow-onset warming and intensified heat waves.

Honda et al. (2014) utilized 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.[77] The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[78] Qualitative research by the Ministry of Health found that a high proportion of respondents had experienced overheating or sunstroke during summer months, and that 10% had experienced reduced ability to work due to high humidity.[13]

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[71] WFP (2015). Two minutes on climate change and hunger: A zero hunger world needs climate resilience. The World Food Programme. URL: https://docs.wfp.org/api/documents/WFP-0000009143/download/

[72] 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. URL: https://www.ncbi.nlm.nih.gov/pubmed/26947322

[73] Musaev, D., Yakhshilikov, Y., and Yusupov, K. (2010). Food Security in Uzbekistan. URL: http://www.iprcc.org.cn/English/Index/down/id/3909.html [accessed 21/02/2019]

[74] Uzbekistan (2017). The State Committee of the Republic of Uzbekistan on Statistics -Analysis of the Development of Living Standards and Welfare of the Population in the Republic of Uzbekistan. URL: https://stat.uz/en/435-analiticheskie-materialy-en1/2078-analysis-of-the-development-of-living-standards-and-welfare-of-the-population-in-the-republic-of-uzbekistan

[75] World Bank (2010). Global Consumption Database. URL: http://datatopics.worldbank.org/consumption/

[76] 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.full

[77] 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: https://www.ncbi.nlm.nih.gov/pubmed/23928946

[78] 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://www.ncbi.nlm.nih.gov/pubmed/30319715

Disease

There is strong evidence of a relationship between higher temperatures and cases of food and water-borne disease in Uzbekistan. Acute intestinal infections are positively correlated with air temperature both in Tashkent and the country as a whole,[13] whereas the incidence of bacterial dysentery is three times higher during summer months than at other times of the year.[40] This suggests that, in the absence of careful adaptation measures, the prevalence of enteric diseases in Uzbekistan is likely to rise in line with projected temperature increases. The increased temperatures that are projected by the model ensemble may create conditions more conducive to the spread of mosquito-borne diseases, increasing the risk of a resurgence of malaria[40] and parasitic diseases such as leishmaniasis.[13]

Respiratory disease is the most common cause of death among children younger than 14 in Uzbekistan and 2010 evidence from Nukus, the capital city of the northwestern area of Karakalpakstan, shows a positive correlation between dust concentration in the air and cases of respiratory disease.[13] The risk of this disease may increase in the coming decades, as climate change is likely to drive increased desertification and accelerate the desiccation of the Aral Sea, leading to more frequent dust storms.

POLICIES AND PROGRAMS

National Adaptation Policies and Strategies

TABLE 6. Key national adaptation policies, strategies, and plans

Policy/Strategy/Plan	Status	Document Access
National Communications to the UNFCCC	Three submitted	Latest: February, 2016
Nationally Determined Contribution (NDC) to Paris Climate Agreement	Submitted	November, 2018

Climate Change Priorities of ADB and the WBG

ADB Country Partnership Strategy

The Asian Development Bank agreed a Country Partnership Strategy (CPS) (2019–2023) with Uzbekistan to strengthen the country's disaster management and climate change resilience capabilities. The CPS specifically addressed climate change issues as a cross-cutting theme. ADB will integrate environmental and climate change considerations into its sector operations in order to address Uzbekistan's unique environmental challenges, which include deteriorating water quantity and quality, high carbon-intensive energy use, weak implementation capacities of climate change and environmental agencies, and high risk to climate impacts with low adaptive capacity. ADB will also help to build government capacity for climate risk management practices and facilitate access to climate change financing. Support for clean energy and energy efficiency will cut greenhouse gas emissions and mitigate climate change impacts, as will assistance for transport sector modernization that will reduce fuel use and vehicle emissions. Urban environment improvement will be supported through assistance for water supply and sanitation and solid waste management projects. Support for irrigation projects will promote greater availability of water and sustainable agricultural practices to reduce environmental degradation in rural areas.

WBG Country Partnership Framework

The World Bank Group agreed a Country Partnership Framework (CPF) (2016–2020)[79] with Uzbekistan. Climate change is identified as a cross-cutting area of engagement. WBG activities for increased climate resilience focus on three areas, 1) support to agriculture to increase resilience by diversification to less water-intensive crops, introduction of water saving techniques, and modernization of irrigation systems; 2) ensuring all infrastructure investments, including clean and renewable energy deployment would be screened both in terms of physical resilience to likely climate change and of economic returns if climate change considerations were fully costed; 3) the continued promotion of the collection of better data on climate change and water flows in the Syr Darya and Amu Darya basins and in support of increased consultation by riparian to manage water resources for mutual benefit.

[79] Adjustment through the Performance and Learning Review (PLR; Report number: 126078-UZ dated June 26, 2018), which has extended the CPF (Report number: 105771-UZ dated June 14, 2016) by one year.

CLIMATE RISK COUNTRY PROFILE

UZBEKISTAN

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK