WEATHERING RISK

SOUTH CAUCASUS

Climate Impact Profile

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Summary for policymakers

The South Caucasus region (Armenia, Azerbaijan and Georgia) is particularly vulnerable to the impacts of climate change. This profile provides an overview of climate trends for near-term (2020–39) and medium-term (2040–59) time periods across the region under the higher-emission SSP3-7.0 scenario with regional conflicts and lower-emission SSP1-2.6 scenario with greater international collaboration, and their impacts across different sectors. Temperature and precipitation patterns across the region vary greatly depending on elevation and season. At lower elevations, both annual and monthly temperatures tend to be warmer, while higher elevations experience cooler temperatures. Precipitation generally decreases from west to east and with lower elevation. Over the last 50 years, mean temperatures have been increasing across all three countries, while observed precipitation across the region has experienced substantial interannual variation.

Climate Trends

Temperature

Mean annual and seasonal temperatures are projected to increase significantly by mid-century, rising at uneven rates across the region. Under the SSP3-7.0 scenario, Armenia sees the greatest national mean temperature increase. Under the SSP1-2.6 scenario, mean temperature rises are slightly higher in the near term but much less by mid-century. Significant temperature increases across the South Caucasus are on average expected to shift the typical climates of many subnational regions towards those currently found at lower and relatively warmer elevations, resulting in widespread changes to local climate conditions by mid-century – even if emissions are kept relatively low. The highest combined heat risks[1] under both scenarios appear in Azerbaijan's lowland plains and Caspian coast during July and August, expanding across the Kura-Aras Lowland by mid-century. Very high heat risk remains largely confined to Armenia's Ararat Valley, while in Georgia such risks are limited to Kvemo Kartli, Kakheti and the coast under SSP1-2.6, but spread throughout the Kolkheti Plain under SSP3-7.0. Mountainous regions in Armenia and Georgia face major increases in maximum daytime temperatures above 25°C under SSP3-7.0, with higher elevations seeing sharp declines in frost days.

Precipitation

Under SSP1-2.6, average annual national precipitation may slightly increase by mid-century, while SSP3-7.0 projects substantial decreases. By mid-century, SSP1-2.6 shows the largest annual precipitation rise in Azerbaijan (best estimate: +13.65 mm, range: -30.44 mm to +46.68 mm possible). In contrast, SSP3-7.0 predicts annual decreases with relatively stronger model agreement, indicating higher overall certainty (best estimate: -26.25 mm in Georgia, -21.60 mm in Armenia and -12.78 mm in Azerbaijan), though the range of possible outcomes are generally wider, as detailed in text. Under SSP3-7.0, the greatest seasonal declines are expected along the Black Sea coast by mid-century. Armenia and Azerbaijan, which are already drier than Georgia, are projected to experience significant seasonal percentage declines from historical averages over this timeframe and scenario. Under SSP1-2.6, the largest five-day precipitation events are projected to increase most in western Georgia, southern Armenia and western Azerbaijan. Despite overall declines under SSP3-7.0, precipitation intensity is expected to rise seasonally in some areas by mid-century. The frequency of the largest five-day precipitation events at 50-year and 100-year intervals is also projected to increase in northern Armenia and the Ararat Valley by mid-century.

I Combined heat risk refers to the cumulative threat posed by high temperatures, frequent and prolonged heatwaves, and their associated impacts on human health, agriculture and critical infrastructure.

Floods and Droughts

The three South Caucasus countries simultaneously face high flood and moderate-to-extreme water stress risks due to rising temperatures affecting alpine glaciers and snowpack, changes in precipitation patterns and soil moisture, growing water demand, and reduced transboundary river flows. In the longer term, depleted glacial reserves will lower runoff and change seasonal flood patterns, which vary regionally. By mid-century, 100-year riverine flood events with inundation levels greater than 1 m increase significantly under a high-emission scenario, with associated risk levels expanding across lower and middle segments of many of the region's major rivers and tributaries. Intense precipitation continues to pose flood risks, threatening settlements and infrastructure, while higher temperatures and less summer precipitation increase drought risks regionwide under both scenarios. By mid-century, SSP3-7.0 projections indicate reduced summer precipitation in the Kura-Aras Basin, increasing the risk of water shortages and hydrological droughts that could lead to conflicts over water use.

Coastal Zone and Sea-level Change

Georgia's Black Sea coastline, which is vital for trade and ecosystem services, is at significant risk from sea level rise, especially under SSP3-7.0, with many coastal locations facing a best-estimate sea level rise of 21 cm by mid-century and 60 cm likely by end-of-century (range of possible outcomes provided in text). Due to vertical land motion, the coastal town of Poti could experience even higher sea level rise than the rest of the Black Sea coastline (best estimate: 41 cm by mid-century and 1.03 m by end-of-century, with the range of possible outcomes provided in text). In contrast, the Caspian Sea is expected to experience declining water levels under both scenarios, threatening coastal infrastructure, food security and local economies.

Projected Sectoral Impacts

Human Health

Climate-related health risks – including heat stress, and vector, food and water-borne diseases – are likely to worsen over the near and medium term, and disproportionately affect the most vulnerable population groups. Under SSP3-7.0, high-to-extreme heat risks are projected in the near term for Tbilisi, Georgia's Kolkheti Plain and eastern valleys, as well as Aran, Ganja-Gazakh, the Absheron Peninsula and other lowlands in Azerbaijan. By mid-century, these risks are expected to extend further into Guba-Khachmaz, Yukhari Garabakh and the Ararat Valley. Risks of vector-borne diseases – including tularemia, Crimean-Congo hemorrhagic fever, tick-borne encephalitis, anthrax and leptospirosis – are projected to increase, with the highest risk projected for Tbilisi and Yerevan.

Food and Agriculture

Rising temperatures and shifting precipitation patterns in the South Caucasus are increasing extreme heat risks, water demand and scarcity, leading to reduced overall crop yields and threatening food security across the region, particularly for vulnerable rural populations. In addition, livestock production – a significant component of GDP in both Armenia and Georgia – is adversely affected, undermining local livelihoods, particularly in mountainous rural areas. By mid-century under SSP3-7.0, most watershed basins across the region will experience moderately high or extreme water stress, intensifying droughts, desertification and competition for water.

Critical Infrastructure and Economy

Economic activities and infrastructure in the South Caucasus are increasingly threatened by climate impacts such as extreme temperatures, droughts and flooding, which also heighten geological hazards such as landslides and mudslides. While warmer winters are expected to bring annual net energy savings due to reduced heating needs across all three countries by mid-century under SSP3-7.0, climate impacts continue to threaten critical infrastructure, for example, by straining vital hydropower capacity given lower summer precipitation yet increased cooling demand. Increasing risks from climate-driven landslides and mudslides place additional pressure on east-west rail services, and strategic oil and gas pipelines between Europe and Asia – particularly in Georgia – which could threaten energy security beyond the region.

Human Displacement

Climate-related impacts compound high levels of internal displacement in the South Caucasus resulting from years of episodic conflict and violence, leaving many households in need of additional social, economic and psychological support, and increasing the vulnerability of internally displaced persons (IDPs) living in inadequate housing, with limited services and restricted livelihood opportunities. These populations face heightened risks of flooding, droughts and resource degradation, which threaten both their safety and economic stability. Regions with the highest number of IDPs include Central Aran, Karabakh, Absheron-Khizi, Baku and much of Georgia. Due to conflicts in various areas (e.g., South Ossetia, Abkhazia and Nagorno-Karabakh), many people live in protracted displacement. Floods and geological hazards pose the greatest climate risks, with regions such as Inguri, Lower Rioni and the Kura-Aras Lowland facing increasing flood threats, while mudslide and landslide risks are rising in western Georgia, Shaki-Zaqatala, and mountainous areas of Armenia and Azerbaijan.

Ecosystems

The Caucasus Ecoregion is a global biodiversity hotspot, but both terrestrial and aquatic ecosystems in the South Caucasus are increasingly threatened by rising temperatures, droughts, wildfires and floods, with many sensitive landscapes lacking adequate protection, especially across political borders. The region's rich biodiversity – including globally unique plant species and extensive forests – faces threats such as shifting forest composition, expanding desertification, and the loss of high mountain and endemic habitats. These climate impacts are particularly acute for species that are unable to migrate to more suitable areas, highlighting the urgent need for stronger transboundary conservation and biodiversity protection efforts.

Country Overview

The South Caucasus[II] is a diverse region comprised of three countries – Georgia, Armenia and Azerbaijan – located on the Caucasian Isthmus at the crossroads between the Middle East (Türkiye to the southwest and Iran to the southeast), southeastern Europe (the Russian Federation to the north), the Black Sea (to the west) and the Caspian Sea (to the east). Azerbaijan encompasses the largest area (86,600 km^2), which the national government administered as 10 regions before 2021.[III] Georgia (69,700 km^2) comprises 12 subnational units, while Armenia (29,740 km^2) comprises 11 subnational

II This nomenclature distinguishes the region (38–44°N, 40–51°E) from the North Caucasus, which traditionally encompasses the Russian federal subjects north of the Greater Caucasus Mountain Range between the Black and Caspian seas. They include (from west to east) Krasnodar, Adygea, Karachay-Cherkessia, Kabardino-Balkaria, North Ossetia-Alania, Ingushetia, Chechnya, Dagestan and (to the north) Stavropol. This profile considers borderland areas of Türkiye and Iran part of the South Caucasus region where referenced. See UN Environment Programme (2024). *Caucasus Environment Outlook*. Second Edition. Tbilisi and Vienna: Grid Arendal. URL: https://www.grida.no/publications/946

III Due to the data limitations of the World Bank's Climate Change Knowledge Portal (CCKP), this profile analyses trends according to former economic region (iqtisadi rayon) boundaries, while referencing boundaries of the 14 new economic regions and their constituent 74 districts (rayons) and 12 cities (seher) when relevant. According to revised subdivision boundaries, the Ganja-Gazakh region split into Qazakh-Tovuz and Ganja-Dashkasan, the Absheron region split into Absheron-Khizi and Baku, and the Aran region split into Central Aran, Mil-Mughan and Shirvan-Salyan. Additionally, the borders and constituent districts of Yukhari Garabakh shifted upon incorporation of disputed Nagorno-Karabakh, with area distributed between East Zangezur (formerly Kalbajar Lachin), Karabakh and parts of the previous Aran region. One region, the exclave of Nakhchivan, governs as an autonomous republic. See UN Group of Experts on Geographical Names (2023). Report by the Republic of Azerbaijan. Accessed 27 April 2023. GEGN.2/2023/140/CRP.140. URL: https://unstats.un.org/unsd/ungegn/sessions/3rd_session_2023/documents/GEGN.2_2023_140_CRP140.pdf units (see **Figure 1**).[IV] To the north lie the Greater Caucasus Mountains, which extend 1,200 km from the northwest to southeast and shield the South Caucasus from cold northern air masses. The tallest mountain in Europe, Mount Elbrus (with an elevation of 5,642 m above sea level), lies just north of Georgia's (Samegrelo-Zemo Svaneti) border with Russia.[V] To the south lie the Lesser Caucasus Mountains, which define the northern and eastern boundaries of the Armenian Highland, a region of arid mountains and plateaus that dominate landlocked Armenia (average elevation of 1,830 m above sea level) extending into eastern Türkiye and northern Iran.[VI] Two extensive low-lying plains bisect the South Caucasus, divided by the north-south Likhi Range (under 2,500 m above sea level) in Georgia, which also demarcates western and eastern segments of the Caucasus Mountains. To the west, the humid subtropical Kolkheti Plain (under 250 m above sea level) experiences mild winters above freezing and hot summers with heavy precipitation due to the influence of the Black Sea.[VII] To the east, intermontane valleys in the rain shadow of the Likhi Range give way to the Kura-Aras Lowland in Azerbaijan, which descends to -26.5 m below sea level when it empties into the Caspian Sea, the world's largest inland body of water.[VIII] All of these complex climatic zones help shape the globally important Caucasus Ecoregion, which boasts exceptional biodiversity across its terrestrial and aquatic habitats, many of which span political boundaries and remain under-protected. Such varied landscapes provide vital ecosystem services, and hold profound cultural, spiritual and economic value for communities throughout the region. Climatic zones associated with the South Caucasus' major topo-geographic regions are further discussed in the Observed Climate section.

IV Georgia's subnational units encompass nine regions (mkhare), one municipality (the capital Tbilisi) and two autonomous republics (Abkhazia and Adjara). Georgia considers Abkhazia an occupied territory (de jure) following the 2008 Russo-Georgian War, in addition to South Ossetia (also referred to as the Tskhinvali region), an autonomous former Soviet-era oblast encompassing parts of Racha-Lechkhumi-Kvemo Svaneti, Imereti, Shida Kartli and Mtskheta-Mtianeti. The CCKP provides data for the capital Tbilisi (as its own subdivision), but not for Georgia's four other self-governing cities: Batumi (Adjara), Kutaisi (Imereti), Poti (Samegrelo-Zemo Svaneti) and Rustavi (Kvemo Kartli). Armenia's subnational units encompass 10 provinces (marzer) and the capital district Yerevan. For land surface area, see World Bank (2024). DataBank – World Development Indicators. URL: https://data.worldbank.org/

V The highest peak in Georgia is Mount Shkhara (5,068 m above sea level), located in Samegrelo-Zemo Svaneti near the border with Russia. The highest peak in Georgia east of the Likhi Range is Mount Kazbek (5,033 m), located in Mtskheta-Mtianeti near the border with Russia. The highest peak in Azerbaijan is Bazarduzu (4,466 m), located on Guba-Khachmaz's border with Russia. See Gvozdetsky, N.A., S.I. Bruk, and G.M. Howe (2024). Transcaucasia. Encyclopaedia Britannica. Accessed 3 December 2024. URL: https://www.britannica.com/place/Transcaucasia

VI The highest peak in Armenia is Mount Aragats (4,095 m above sea level), located in Aragatsotn, and more than one-third of Armenia lies above 2,000 m above sea level. In addition, the highest peak in Türkiye, Mount Ararat (5,165 m), is also located in the Armenian Highland near the border with Armenia, Nakhchivan in Azerbaijan and Iran. See Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf; Azerbaijan Ministry of Ecology and Natural Resources (2021). *Fourth National Communication to the UNFCCC*. Baku: UNDP and GEF. URL: https://unfccc.int/documents/299472

VII Despite these low-lying plains, more than half of Georgia's territory lies more than 1,000 m above sea level. See Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf

VIII Mountains dominate more than half of Azerbaijan, but many populated areas occupy lowland plains. See Azerbaijan Ministry of Ecology and Natural Resources (2021). *Fourth National Communication to the UNFCCC*. Baku: UNDP and GEF. URL: https://unfccc.int/documents/299472

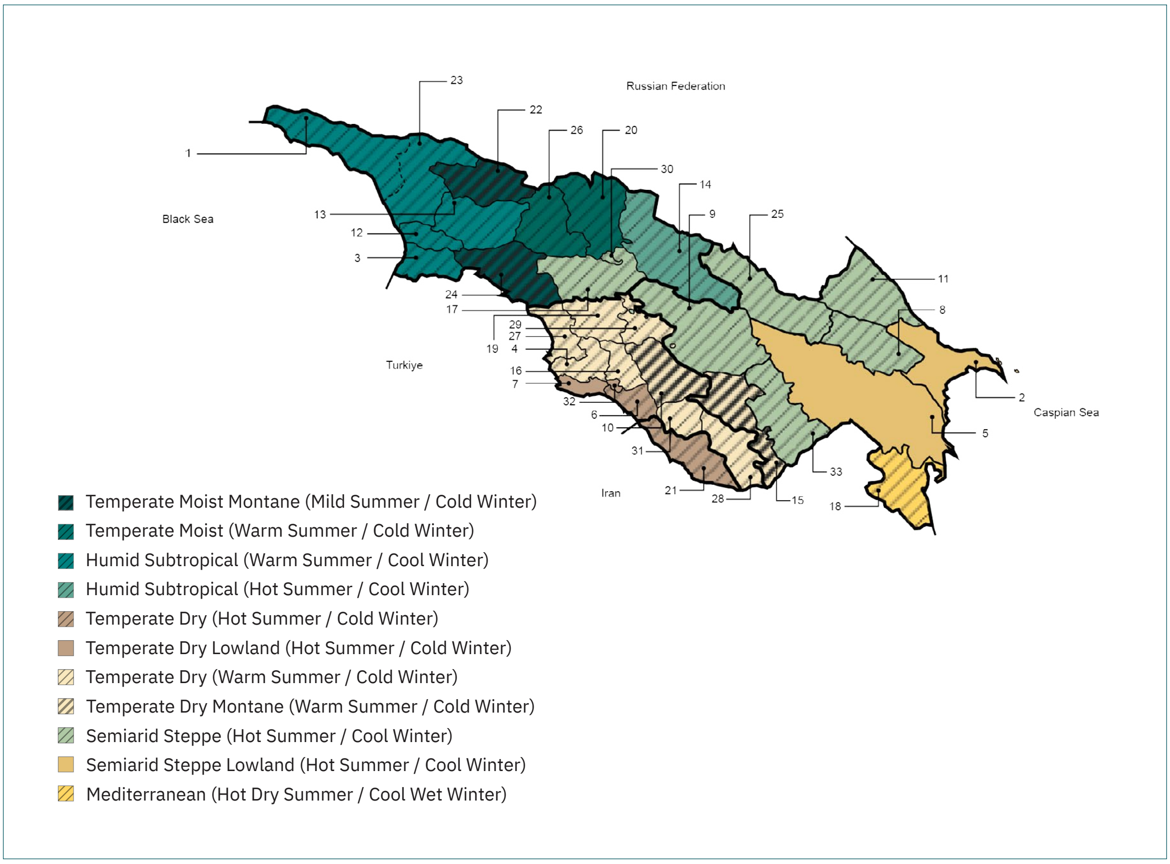


Figure 1. Map of Countries and Subnational Units in the Southern Caucasus with Dominant Topo-Climatic Zones.[IX]

IX Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Due to data limitations, Figure 1 and subsequent maps display the boundaries of Azerbaijan's former economic region (iqtisadi rayon) as of 2019. Since then, Azerbaijan fully incorporated the Nagorno-Karabakh region into its territory (see UN Map No. 3761, Rev. 10.1 Apr 2024). Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti in Figure 1 and subsequent maps, as they remain approximate and contested. Due to data limitations, the boundaries of South Ossetia, also known as the Tskhinvali region, are not displayed (see UNHCR 2025 Global Administrative Divisions). Key: 1=Abkhazia, Georgia (Kolkheti Plain / foothills / Greater Caucasus Mountains.); 2=Absheron, Azerbaijan (Caspian Lowland/ foothills); 3=Adjara, Georgia (Kolkheti Plain / foothills / Lesser Caucasus Mountains.); 4=Aragatsotn, Armenia (Armenian Highland); 5=Aran, Azerbaijan (Kura-Araks Lowland); 6=Ararat, Armenia (Ararat Valley / Armenian Highland); 7=Armavir, Armenia (Ararat Valley); 8=Daghlig-Shirvan, Azerbaijan (Kura-Araks Plain / foothills / Greater Caucasus Mountains.); 9=Ganja-Gazakh, Azerbaijan (Kura Plain / foothills / Lesser Caucasus Mountains.); 10=Gegharkunik, Armenia (Armenian Highland); 11=Guba-Khachmaz, Azerbaijan (Caspian Lowland / foothills/ Greater Caucasus Mountains.); 12=Guria, Georgia (Kolkheti Plain / foothills / Lesser Caucasus Mountains.); 13=Imereti, Georgia (Kolkheti Plain / foothills / Greater and Lesser Caucasus mountains.); 14=Kakheti, Georgia (Alazani and Iori plains / foothills / Greater Caucasus Mountains.); 15=Kalbajar-Lachin, Azerbaijan (foothills / Lesser Caucasus Mountains.); 16=Kotayk, Armenia (Armenian Highland); 17=Kvemo Kartli, Georgia (Kura Plain / foothills / Lesser Caucasus Mountains); 18=Lankaran, Azerbaijan (Caspian Lowland / foothills / Talysh Mountains); 19=Lori, Armenia (Armenian Highland); 20=Mtskheta-Mtianeti, Georgia (Kura foothills / Greater Caucasus Mountains); 21=Nakhchivan, Azerbaijan (Aras Plain / Armenian Highland); 22=Racha-Lechkhumi-Kvemo Svaneti, Georgia (Greater Caucasus Mountains); 23=Samegrelo-Zemo Svaneti, Georgia (Kolkheti Plain / foothills / Greater Caucasus Mountains); 24=Samtskhe-Javakheti, Georgia (Lesser Caucasus Mountains); 25=Shaki-Zaqatala, Azerbaijan (Alazani-Ganykh Plain / foothills / Greater Caucasus Mountains); 26=Shida Kartli, Georgia (Kura foothills / Greater and Lesser Caucasus mountains); 27=Shirak, Armenia (Armenian Highland); 28=Syunik, Armenia (Armenian Highland); 29=Tavush, Armenia (Debed and Aghstev foothills / Armenian Highland); 30=Tbilisi, Georgia (Kura foothills); 31=Vayots Dzor, Armenia (Armenian Highland); 32=Yerevan, Armenia (Ararat Valley); and 33=Yukhari Garabakh, Azerbaijan (Kura-Aras Plain / foothills / Lesser Caucasus Mountains). Topographic features in parentheses identify generalised mountain ranges (> 1,000 m above sea level), foothills (250–1,000 m) and watercourse plains (< 250 m), whereas sections below discuss more localised geographic areas of interest. As terminology for both climatic zones and placenames vary by source and language, this profile adopts terms with greatest scientific consistency and clarity. For further details on topo-climatic regions see NOAA (2023). Köppen-Geiger Climate Subdivisions. U.S. National Oceanic and Atmospheric Administration. 14 April 2023. URL: https://www.noaa.gov/jetstream/global/climate-zones/jetstream-max-addition-k-ppen-geiger-climate-subdivisions; Sayre, R., D. Karagulle, C. Frye, T. Boucher, N.H. Wolff, S. Breyer, D. Wright, M. Martin, K. Butler, K. Van Graafeiland, J. Touval, L. Sotomayor, J. McGowan, E. T. Game, H. Possingham. (2020). An Assessment of the Representation of Ecosystems in Global Protected Areas Using New Maps of World Climate Regions and World Ecosystems. Global Ecology and Conservation 21: e00860. DOI: https://doi.org/10.1016/j.gecco.2019.e00860; Access via URL: https://storymaps.arcgis.com/stories/61a5d4e9494f46c2b520a984b2398f3b

This profile highlights dominant topographic and climatic zones of subnational units since all areas, except those marked “lowland,” maintain a complex mix of elevations and climatic zones. Unless otherwise mentioned in text, the climatic zones of subnational units with mixed elevation ranges (indicated by diagonal lines and darkened for entirely montane areas) denote a combination of warmer, drier plains or foothills and cooler, wetter uplands. See Observed Climate section for further detail on local variations and seasonal temperature ranges.

As of 2023, Azerbaijan had the largest population (10.1 million people), followed by Georgia (3.8 million) and Armenia (2.8 million).[1] Each country had an urban-majority population (64% in Armenia, 61% in Georgia and 58% in Azerbaijan), principally concentrated in their capital cities, and recorded slightly positive annual population growth rates (0–1%) in 2023. However, Azerbaijan’s rate of natural increase slowed from the 2010s, while in Georgia and Armenia negative population growth due to rural outmigration began to ease after 2020.[2] Based on factors such as life expectancy, education and gross national income, the region’s overall human development ranks high and gender development equality ranks medium to high (see **Table 1**).[3] In all three South Caucasus countries, the female labour force participation rate is above average in the agricultural, forestry and fishing sectors (over 50%), though women face other social, political and economic challenges, including limited land ownership.[4] Despite reductions in poverty over the last 20 years, significant proportions of the populations in Armenia and Georgia (25% in Armenia and 16% in Georgia as of 2022) still live below their national poverty lines, with some rural populations lacking basic sanitation services.[X] By contrast, Azerbaijan had reduced national poverty to 6% by 2019, in part as a result of revenue generated from major oil and gas pipelines.[5]

Azerbaijan’s GDP, the highest in the region, topped $72.4 billion in 2023, equivalent to the economy of Serbia, and more than twice the GDP of Georgia ($30.5 billion, equivalent to the economy of Iceland) and Armenia ($24.2 billion, equivalent to the economy of Albania).[6] Despite these differences, the GDP per capita of all three countries is similar, characteristic of upper-middle-income economies (see Table 1). In Azerbaijan, the industrial sector accounts for the largest proportion of GDP, with oil and gas extraction alone generating the vast majority of exports and contributing roughly one-third of total GDP.[7] In Georgia, the service sector, including development of trade routes and tourism, accounts for the largest proportion of GDP (62% in 2023).[8] In Armenia, the service sector continues to expand, though the agricultural, forestry and fishing sectors still employed more than half of the workforce in 2022 and accounted for nearly half of total exports to Russia.[9] Russia’s invasion of Ukraine in 2022 resulted in higher short-term investment flows and migration across the South Caucasus countries, but also underscored the region’s vulnerabilities to external economic and geopolitical shocks.[10]

X The World Bank lacks an equivalent estimate for Azerbaijan during the last decade. Figures vary by source and metric, but data in Table 1 illustrates how poverty levels throughout the South Caucasus region do not rank notably high or low globally. See World Bank (2024). DataBank – World Development Indicators. URL: https://data.worldbank.org/

Human Development Index (HDI)[11]	GDP per Capita	% Population Living on < $2.15 a Day	Gini Coefficient	% Population Undernourished	ND-GAIN Vulnerability Index[12]
Armenia					
76 out of 193 (2022) *High Human Development*	104 out of 214 (2023) *$8,715.80*	97 (tied) out of 168 (2022) *0.8% (2017 Purchasing Power Parity)*	19 out of 168 (2022) *27.9 (0=Most Equal, 100=Most Unequal)*	106 (tied) out of 171 (2021) *3%*	50 out of 187 (2022) *Upper Middle Vulnerability and Adaptation Readiness*
Azerbaijan					
89 (tied) out of 193 (2022) *High Human Development*	116 out of 214 (2023) *$7,155.10*	111 (tied) out of 168 (1995–2014 avg.)[XI] *0.4% (2017 Purchasing Power Parity)*	66 (tied) out of 168 (2021)[XII] *33.7 (0=Most Equal, 100=Most Unequal)*	106 (tied) out of 171 (2021) *3%*	77 (tied) out of 187 (2022) *Upper Middle Vulnerability and Adaptation Readiness*
Georgia					
60 (tied) out of 193 (2022) *Very High Human Development*	109 out of 214 (2023) *$8,120.40*	64 out of 168 (2022) *4.3% (2017 Purchasing Power Parity)*	64 out of 168 (2022) *33.5 (0=Most Equal, 100=Most Unequal)*	106 (tied) out of 171 (2021) 3%	41 out of 187 (2022) *Upper Middle Vulnerability and Adaptation Readiness*

Table 1. Representative Fragility Indicator Rankings.[XIII]

Following the breakup of the Soviet Union in 1991, several disputed and ethnically distinct autonomous territories with de facto sovereignty continued to pose regional security challenges: Abkhazia and South Ossetia (disputed with Georgia, recognised by Russia) and Nagorno-Karabakh (disputed between Armenia and Azerbaijan). The separatist movements that erupted in South Ossetia (1991–92) and in Abkhazia (1992–93) prompted an intervention by Russia, but did not resolve hostilities.[XIV] Violence in August 2008 between Georgia and Russian-supported separatists in South

XI Since the World Bank lacks up-to-date poverty headcount data for Azerbaijan, this profile relies on 1995–2014 baseline average data reported by the CCKP and identifies where this value would rank relative to the World Bank's most recent country-level data. For further source details, see adelphi's Supplemental Information: https://weatheringrisk.org/en/publication/climate-impact-profile-supplementary-information

XII Since the World Bank lacks up-to-date Gini coefficient data for Azerbaijan, this profile relies on 2021 data from the World Population Review and identifies where this value would rank relative to the World Bank's most recent country-level data. See UN Environment Programme (2024). *Caucasus Environment Outlook*. Second Edition. Tbilisi and Vienna: Grid Arendal. URL: https://www.grida.no/publications/946

XIII Data for most recent year ranked compared to all countries and entities worldwide based on available data. Unless otherwise indicated, see World Bank (2024). DataBank – World Development Indicators. URL: https://data.worldbank.org/

XIV The Georgia-Abkhazia War resulted in roughly 30,000 casualties and displaced up to half of Abkhazia's population, mostly ethnic Georgians. The territory's current population is approximately one quarter of a million. South Ossetia, also called the Tskhinvali region after the territory's capital, previously comprised of about one-third ethnic Georgians but maintains ethnolinguistic ties to Russia's adjacent Republic of North Ossetia-Alania. South Ossetia's current population is approximately 50,000. See BBC (2024). Abkhazia Profile. BBC. 19 November 2024. URL: https://www.bbc.com/news/world-europe-18175030; BBC (2024). South Ossetia Profile. BBC. 25 October 2024. URL: https://www.bbc.com/news/world-europe-18269210

Ossetia and Abkhazia displaced at least 10,000 people and resulted in Russian military control over the territories' borders.[13] Since then, democratic backsliding and civil unrest threaten Georgia's own political trajectory.[XV] Nagorno-Karabakh, an ethnic Armenian enclave in western Azerbaijan, ignited into full-scale conflict after the autonomous Soviet oblast declared itself independent in 1991.[14] The First Karabakh War ended in 1994, with Armenia gaining control over the territory's 140,000 people and seven bordering districts.[XVI] Tensions over the following two decades continued to generate episodic violence before erupting into the Second Karabakh War in late 2020, which caused an estimated 7,000 casualties, and left tens of thousands wounded or displaced.[15] As a result of this conflict, Azerbaijan regained control of one-third of Nagorno-Karabakh and all of its surrounding regions. Following a 2022 blockade of the corridor connecting the enclave to Armenia, Azerbaijan's military retook the remaining territory in September 2023, triggering an exodus of over 100,000 people seeking refuge in Armenia.[16] Consequently, the Fragile States Index assigns Georgia and Azerbaijan an "elevated warning" status (scoring 79 and 76 out of 179, respectively), based on social cohesion, economic, political and cross-cutting indicators, while Armenia retains a "warning" status (scoring 93 out of 179).[17] All three countries maintain relatively lower vulnerability and higher adaptive capacity scores, according to the ND-GAIN Index.[XVII]

Observed Climate

Temperature Conditions

Temperatures across the South Caucasus vary by elevation and range from mild, maritime-influenced conditions year-round along the Black Sea coast to continental seasonal fluctuations across the interior of the Armenian Highland. Annual mean temperatures at the national level, including summer maximums and winter minimums, reflect the influence of average altitude. Among the three South Caucasus countries, **Azerbaijan recorded the highest national average annual mean** temperature of 12.96°C between 1991 and 2020,[18] with its **warmest monthly mean** in July (24.89°C) and coolest monthly mean in January (1.22°C). By comparison, **Armenia possessed the coolest average annual mean** temperature of 7.82°C over the same time period, with its warmest monthly mean in August (20.87°C) and **coolest monthly mean** in January (-6.40°C).[XVIII]

At the subnational level (see **Figure 1**), **warmer annual and monthly temperatures at lower elevations** (lowlands < 250 m and foothills 250–1,000 m above sea level) **generally contrast cooler temperatures at high elevations** (highlands > 1,000 m and subalpine > 2,000 m above sea level). **Interior areas with less proximity to the moderating effects of the Black Sea additionally experience greater seasonal swings between hot summers and cold winters.** Nearly all regions in Azerbaijan, the Ararat Valley in Armenia, and the eastern plains and foothills of Georgia experience hot summers (monthly means > 22°C). Subnationally, the warmest annual mean temperature occurred in low-lying Aran, Azerbaijan (15.70°C), with a July maximum of 33°C.[XIX] By contrast,

XV In Georgia, the contested results of the October 2024 national election, in which the Georgian Dream Party claimed victory and subsequently suspended the country's involvement in the EU membership process, led to mass demonstrations and a constitutional crisis. At the same time and for the third time in the last decade, a popular uprising ended the tenure of Abkhazia's leader. See Anastasijevic, M., N. Gurcov, N. Audibert, and S. Ostojic (2024). Regional Overview: Europe, Caucasus, and Central Asia November 2024. ACLED. URL: https://acleddata.com/2024/12/09/europe-caucasus-and-central-asia-overview-november-2024/#keytrends2

XVI Nagorno-Karabakh's bordering districts mostly span Azerbaijan's former Kalbajar-Lachin and Yukhari-Garabakh regions. See Landgraf, W., and N. Seferian (2024). A Frozen Conflict Boils Over: Nagorno-Karabakh in 2023 and Future Implications. Foreign Policy Research Institute. URL: https://www.fpri.org/article/2024/01/a-frozen-conflict-boils-over-nagorno-karabakh-in-2023-and-future-implications/

XVII Scores note higher risks to dam capacity in Georgia and Armenia, and agricultural risks in Azerbaijan. See Notre Dame Global Adaptation Initiative (2022). ND-GAIN Country Index Rankings. University of Notre Dame. URL: https://gain.nd.edu/our-work/country-index/rankings/

XVIII By comparison, Georgia's national-level annual mean temperature between 1991 and 2020 reached 9.01ºC. Its warmest monthly mean in August reached 20.24ºC and coolest monthly mean in January reached -2.64ºC.

XIX The subnational division with the warmest annual mean temperature in Georgia between 1991 and 2020 was the capital Tbilisi, located in the Kura (Mtkvari) River foothills (12.33ºC). Its July maximum temperature reached 30.08ºC. The subnational division with the warmest annual mean temperature in Armenia was Ararat Province (10.29ºC), which includes the Ararat Valley and featured a July maximum temperature of 30.82ºC.

moist western Georgia and the semiarid Armenian Highland experience warm summers (18–22°C monthly means). Only the most montane subnational units in Georgia experience mild summers (monthly means < 18°C). Cold winters (monthly means < -4°C) at the subnational level occur across Armenia, the Lesser Caucasus Mountains and the Greater Caucasus Mountains west of Mount Kazbegi (Mtskheta-Mtianeti). The lowest subnational annual mean temperature occurred in Racha-Lechkhumi-Kvemo Svaneti, Georgia (5.15°C), which contains the greatest subnational extent of alpine polar areas.[XX] Meanwhile, Shirak Province in the northwest Armenian Highland recorded the lowest monthly minimum in January of -14.49°C. Cool winters (monthly means from -4°C to slightly above freezing) characterise the remaining lowland and mixed-elevation regions of Georgia and Azerbaijan.

Precipitation Conditions

Several factors influence observed precipitation patterns in the South Caucasus, including changes in elevation, and exposure to tropical, temperate and polar air masses, which result in **high regional and seasonal variability. Precipitation generally decreases from west to east and with lower elevation.** At the national level, **Georgia received the greatest annual precipitation** of 1,079.52 mm between 1991 and 2020, while Armenia received 554.[39] mm and **Azerbaijan received the lowest** of 490.15 mm. **Most subnational regions contain a diverse mix of elevations, producing a blend of precipitation regimes.** In **the wettest region, Georgia's western Black Sea coast**, Samegrelo-Zemo Svaneti receives the most precipitation annually (1,501.40 mm) and **maintains high uniform rates throughout the year**, combining humid subtropical areas on the Kolkheti Plain with temperate and polar moist areas at high altitudes. In **Georgia's eastern regions and mountainous parts of Azerbaijan** (Shaki-Zaqatala and Kalbajar-Lachin), drier plains and foothills combine with moister elevations in the Greater and Lesser Caucasus to **produce relatively moderate annual precipitation totals (600–800 mm).** Most of **Azerbaijan's primarily lowland regions and Armenia's primarily highland regions experience dry annual totals of less than 600 mm.**[XXI] In the driest region, Azerbaijan's semiarid Caspian coast, Absheron receives the least annually (307.17 mm), and maintains a monthly precipitation range between 8.35 mm in July and 36.90 mm in October.[XXII] Figure 2, which charts monthly temperature and precipitation averages over the last 30 years in representative areas of the South Caucasus, illustrates the region's range of seasonal temperature extremes and variable timing, and duration of wet seasons, influenced by midlatitude jet stream patterns.

XX Racha-Lechkhumi-Kvemo Svaneti's January minimum reached -11.45ºC. The subnational division with the coolest annual mean temperature in Armenia between 1991 and 2020 was Shirak Province (5.73ºC). The subnational division with the coolest annual mean temperature in Azerbaijan was the Kalbajar-Lachin region (8.99ºC) in the country's mountainous western (Lesser Caucasus) highlands, with a January minimum of -8.92ºC.

XXI Most higher elevations (including in Armenia) tend to receive greater precipitation than areas at lower altitudes, even if annual precipitation totals do not top 600 mm annually. Only one regional outlier, the Lankaran region in southeast Azerbaijan, possesses relatively moist lowlands but dry highlands atop the Talysh Mountains, with annual totals greater than 600 mm.

XXII The driest region in Georgia, the capital Tbilisi in the eastern foothills of the country's Kura (Mtkvari) River, receives a more transitional volume of precipitation annually (646.51 mm) with a monthly minimum of 25.99 mm in December and monthly maximum of 97.68 mm in May.

Figure 2a. Samegrelo-Zemo Svaneti, Georgia
Kolkheti Plain / foothills / western Greater Caucasus Mountains (mixed humid subtropical / temperate moist, warm summer / cool winter)

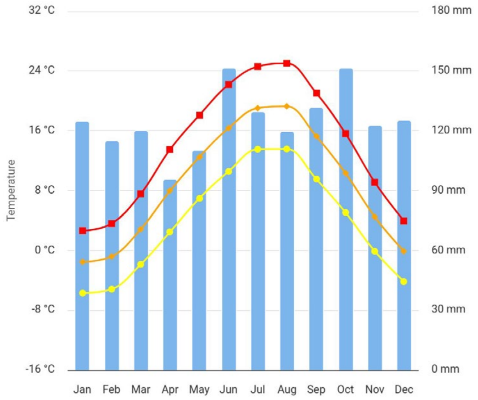


Figure 2b. Guba-Khachmaz, Azerbaijan
Caspian Lowland / foothills / eastern Greater Caucasus Mountains (mixed semiarid steppe / temperate moist, hot summer / cool winter)

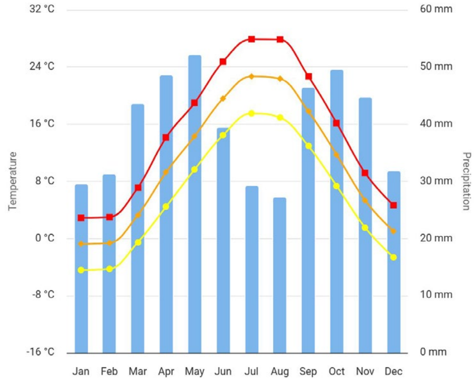


Figure 2c. Ararat, Armenia
Ararat Valley / Armenian Highland (temperate dry, hot summer / cold winter)

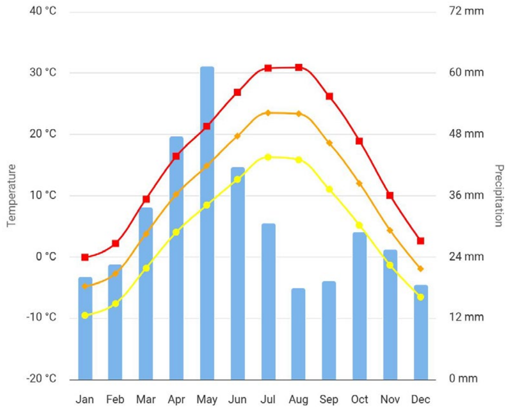
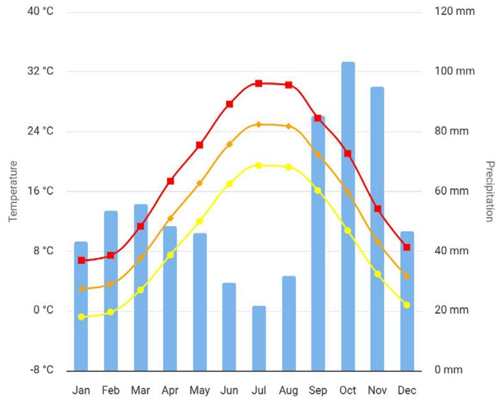


Figure 2d. Lankaran, Azerbaijan
Caspian Lowland / foothills / Talysh Mountains (Mediterranean / mixed temperate moist and dry, hot dry summer / cool winter)



Average Minimum Surface Air Temperature (˚C) | Average Mean Surface Air Temperature (˚C) | Average Maximum Surface Air Temperature (˚C) | Precipitation (mm)

Figure 2. Monthly Temperature and Precipitation Averages (1991–2020) in Samegrelo-Zemo Svaneti, Georgia (top left, 2a); Guba-Khachmaz, Azerbaijan (top right, 2b); Ararat, Armenia (bottom left, 2c) and Lankaran, Azerbaijan (bottom right, 2d).[XXIII] Note each region's climate profile possesses different y-axes for temperature (°C, left) and precipitation (mm, right): lower temperatures and uniformly wet monthly precipitation (2a); higher summer temperatures and drier annual rainfall, with two roughly equivalent wetter and drier seasons (2b); wide seasonal temperature range and drier annual rainfall, with a wetter spring (2c); higher summer temperatures, with a dry summer and wetter autumn (2d).

XXIII Monthly precipitation charts produced using World Bank (2024). Climate Change Knowledge Portal. URL: https://climateknowledgeportal.worldbank.org/

Temperature and Precipitation Trends

Observed temperature records over the last 50 years (1971–2020) indicate significantly warmer regional trends with distinct spatial and temporal patterns.[XXIV] Across all three countries during this period, the mean temperature rose 0.38°C–0.41°C per decade nationally, the minimum temperature rose 0.33°C–0.36°C per decade nationally and the maximum temperature rose 0.44°C–0.47°C per decade nationally. The annual average rate of warming in the South Caucasus during this period notably outpaced the rate of warming in most other subnational regions globally, except for interior and higher-altitude parts of Europe, the Arctic, Central Asia, and the Middle East and North Africa.

While **mean and minimum temperatures increased at similar rates subnationally**, **annual maximums increased the most** in Georgia's eastern valleys and foothills (0.65°C per decade in Tbilisi), Armenia's Ararat Valley (0.54°C per decade in Armavir) and northern Azerbaijan (0.51°C per decade in Shaki-Zaqatala). By comparison, regions along Georgia's Black Sea coast and eastern Lesser Caucasus Mountains observed the lowest annual maximum increase per decade of 0.35°C–0.38°C. **The highest maximum increases occurred during summer and winter seasons.** Tbilisi observed the highest maximum temperature increase during winter months (0.87°C per decade), followed by Ararat in Armenia (0.78°C per decade) and Nakhchivan in Azerbaijan (0.71°C per decade).[XXV] **Minimum temperatures increased** even **higher during winter months** in these and adjacent regions, with the highest in Tbilisi (1.05°C per decade), Armavir (0.82°C per decade) and Lankaran (0.72°C per decade). Similarly, summer maximum temperatures increased the most across Georgia (0.77°C per decade in Tbilisi), northern Azerbaijan (0.60°C per decade in Ganja-Gazakh), and northern and western Armenia (0.56°C per decade in Tavush). Temperature increases in other regions of the South Caucasus during this season, however, varied by up to 0.20°C per decade compared to areas with the greatest temperature increases.[XXVI] **Warmer trends,** especially in regions with wide elevation ranges**, correspond with a significant increase in the number of tropical nights** – defined as nights with minimum temperatures above 20°C – in Azerbaijan (2.89 nights per decade), and a significant decrease in the number of frost days – defined as days with minimum temperatures below freezing (0°C) – across Georgia (-4.28 days per decade), Azerbaijan (-4.25 days per decade) and Armenia (-3.53 days per decade).[XXVII]

Precipitation records over the last 50 years do not reveal clear annual trends across the South Caucasus, though several subnational regions experienced significant seasonal changes.[XXVIII] Precipitation significantly increased during spring months over western Georgia (23.60 mm per decade in Racha-Lechkhumi-Kvemo Svaneti). Meanwhile, precipitation significantly decreased during summer months in Georgia's north and east (-21.31 mm per decade in Racha-Lechkhumi-Kvemo Svaneti), Armenia's northeast (-15.29 mm per decade in Tavush), and Azerbaijan's northwest (-18.06 mm per decade in Ganja-Gazakh). Research indicates that the West Asian Subtropical Jet, which passes over the South Caucasus in summer, has weakened in June over recent decades.[19] Observed precipitation across the South Caucasus experienced notable interannual variation, but longer-term climatic patterns require more study.[XXIX] These conditions create major cross-sectoral impacts (see Floods and Droughts section).

XXIV For data sources and methodology, see adelphi's Supplemental Information: https://weatheringrisk.org/en/publication/climate-impact-profile-supplementary-information

XXV During winter months, maximum temperatures do not change significantly over western Georgia, most of the Armenian Highland (except for Tavush and the Ararat Valley) and Azerbaijan's western Aran plains.

XXVI For example, summer maximum temperatures only increased by 0.56ºC per decade in Adjara, 0.35ºC per decade in Yukhari-Garabakh, and 0.39ºC per decade in Syunik and Gegharkunik. During spring months, maximum temperature increases regionally between eastern valleys and foothills (e.g., Tbilisi), and the western coast (e.g., Samegrelo-Zemo Svaneti) also varied by 0.20ºC per decade.

XXVII For further discussion of past and projected precipitation trends at temperatures below freezing, see Floods and Droughts section.

XXVIII The only significant annual precipitation decrease occurred in Azerbaijan's Shaki-Zaqatala region, decreasing by 24.40 mm per decade.

XXIX Early evidence also indicates that, when La Niña conditions form over the Pacific Ocean, the West Asian Subtropical Jet strengthens, whereas the West Asian Subtropical Jet (and storm tracks crossing the Mediterranean Sea) shifts southward when El Niño conditions develop. The latitude of the polar front jet stream, which travels across the South Caucasus during spring and autumn months, also correlates with sea surface temperature anomalies in the North Pacific Ocean. See Alizadeh-Choobari, O., P. Adibi, and P. Irannejad, (2018). Impact of the El Niño–Southern Oscillation on the Climate of Iran Using ERA-Interim Data. Climate Dynamics, 51(7), 2897–2911. DOI: https://doi.org/10.1007/s00382-017-4055-5; Hallam, S., S.A. Josey, G.D. McCarthy and J.J.M. Hirschi (2022). A Regional (Land–Ocean) Comparison of the Seasonal to Decadal Variability of the Northern Hemisphere Jet Stream 1871–2011. Climate Dynamics, 59(7), 1897–1918. DOI: https://doi.org/10.1007/s00382-022-06185-5

HOW TO INTERPRET FUTURE CLIMATE SCENARIOS

A scenario describes a trajectory of future conditions based on key assumptions. It serves as an important tool for both climate scientists and social scientists to understand and plan for the effects of complex, unpredictable, human-non-human interactions across various timeframes. The Intergovernmental Panel on Climate Change's (IPCC's) *Sixth Assessment Report* draws upon a handful of hypothetical future scenarios (Shared Socioeconomic Pathways or SSPs) simulated by a large collection of computer models to gain insight into future societal and climate conditions. These scenarios possess a range of socioeconomic (e.g., population, economic development, technological, and governance) assumptions and associated emissions trajectories.

The Climate Impact Profiles prioritise analysis of (1) the SSP3-7.0 scenario, as it explores the effects of high-adaptation challenges under a pessimistic warming scenario and regional conflicts; and (2) the SSP1-2.6 scenario, as it explores the effects of low-adaptation challenges under an optimistic warming scenario and greater international collaboration. Where possible, analysis notes deviations compared to other scenarios in the short and medium-term.

Uncertainty in projections is indicated with the symbol throughout the profile. Additional details are specified in the corresponding text. See section on 'How to Interpret Uncertainty in Climate Change Projections' in the Supplementary Methodology for more details on the relationship between model scenarios and probability.

Projected Climate

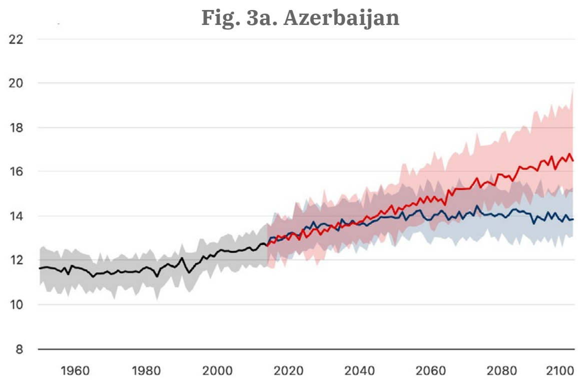
The following projections explore future effects of a lower-emission SSP1-2.6 scenario and higher-emission SSP3-7.0 scenario, referencing additional climate scenarios when appropriate, across near-term (2020–39) and medium-term (2040–59) outlooks.[XXX] Best estimates represent the middle percentile value (median) from a range of climate model projections, while the range of possible outcomes shown in parentheses indicate the lower (10th percentile) and upper (90th percentile) bounds of these projections. It is important to note that these ranges indicate the extent to which the different models agree with one another under each plausible what-if scenario, but these probabilities do not represent forecasts nor indicate the likelihood of a particular scenario occurring. As a result, dark blue text and icons guide appropriate interpretation for decision-makers. For further details regarding climate scenarios, data sources, presentation and uncertainty, see adelphi's Supplemental Information.

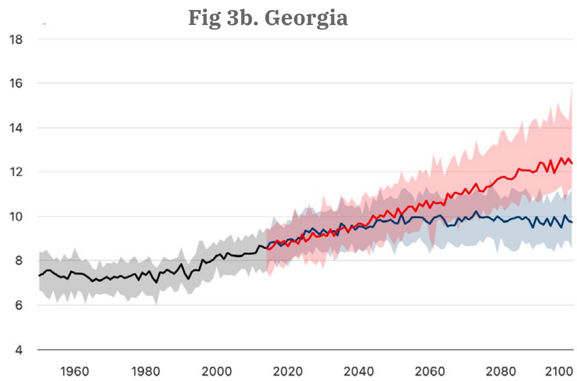
Temperature

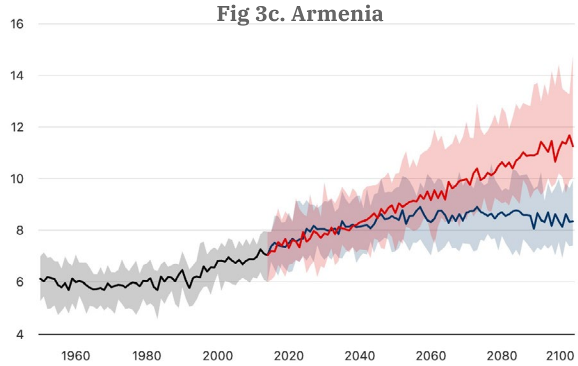
Mean annual and seasonal temperatures across the South Caucasus increase significantly by mid-century, resulting in many regions – especially those at higher elevations – experiencing a shift towards climate zones currently found in warmer relative locations. While there is high model agreement that future temperatures will increase, the extent of these increases varies according to different plausible global emission pathways. Under the higher-emission SSP3-7.0 scenario, national mean temperature increases the most in Armenia by a best estimate of 1.12°C (0.63°C and 1.91°C possible) in the near term and 2.04°C (1.37°C and 3.11°C possible) in the medium term. Mean temperatures increase at slightly lower but roughly equivalent rates in Georgia and Azerbaijan by mid-century.[XXXI] **Under the lower-emission SSP1-2.6 scenario, mean temperatures**

XXX In short, the SSP1-2.6 scenario refers to a future global trajectory of up to 2°C warming by 2100 that presumes low mitigation challenges and low adaptation challenges, realising net-zero CO_2 emissions after mid-century. The SSP3-7.0 scenario represents a future global trajectory with high mitigation and high adaptation challenges (including resurgent nationalism, regional conflict and insecurity), where CO_2 emissions double and warming exceeds 3°C by 2100.

XXXI Under SSP3-7.0, mean temperature increases in Azerbaijan 0.99°C (0.52°C and 1.79°C possible) by 2020–39 and 1.81°C (1.34°C and 2.92°C possible) by 2040–59. Georgia's mean temperature increases 0.94°C (0.57°C and 1.68°C possible) by 2020–39 and 1.84°C (1.31°C and 2.85°C possible) by 2040–59.







— Hist. Ref. Per., 1950-2014 — SSP1-2.6 — SSP3-7.0

Figure 3. Projected National Average Mean Temperature (°C) under SSP1-2.6 and SSP3-7.0 Scenarios (Ref. Period: 1995–2014) in Azerbaijan (3a, top left), Georgia (3b, top right) and Armenia (3c, bottom left). Note how both scenario trajectories increase above the overlain historical reference period but diverge during 2040–59. Each chart features a different y-axis scale.

increase at slightly higher rates over the near term, but considerably diminished rates by mid-century.[XXXII] Armenia's national mean temperature under this scenario, for example, increases by 1.26°C (0.73°C and 1.76°C possible) in the near term but only by 1.68°C (0.90°C and 2.55°C possible) in the medium term. Even though mean temperature increases in Armenia at the greatest rate, the country's best-estimate average temperature approximates Georgia's over the long term, both several degrees Celsius below that of Azerbaijan (see **Figures 3a–c).**[XXXIII]

Subnational and seasonal variations in mean temperature underscore uneven rates of future change, with the largest increases expected in Armenia. By mid-century under SSP3-7.0, the highest subnational mean annual temperature increase – 2.09°C (1.38°C and 3.16°C possible) – occurs in Armenia's capital Yerevan, with similar best-estimate increases across the Armenian Highland, eastern Georgia and western Azerbaijan. The lowest mean annual increase occurs in Absheron on the Caspian coast, increasing by a best estimate of 1.60°C (1.14°C and 2.74°C possible), with relatively similar values along the Black Sea coast. **Under both scenarios, the highest monthly mean increase by mid-century occurs in August**. Armenia's national August mean increases by 2.43°C (1.32°C and 3.49°C possible) under SSP1-2.6 and 3.19°C (1.91°C and 4.26°C possible) under SSP3-7.0, both of which exhibit very large ranges that indicate model disagreement on the magnitude of warming. The highest median subnational increase of 2.52°C (1.34°C and 3.55°C possible) under SSP1-2.6 and 3.25°C (1.92°C and 4.38°C possible) under SSP3-

XXXII By comparison, mean temperature in Azerbaijan increases 1.19°C (0.62°C and 1.64°C possible) in the near term and 1.54°C (0.84°C and 2.36°C possible) in the medium term. Georgia's mean temperature increases 1.09°C (0.65°C and 1.67°C possible) in the near term and 1.53°C (0.84°C and 2.35°C possible) in the medium term.

XXXIII Projected maximum and minimum temperature increases generally mirror the rates of mean temperature increases under each scenario.

7.0 occurs in Kotayk, Armenia.[XXXIV] **The lowest, but still significant, monthly increases across the South Caucasus occur during December, followed by March.** For example, compared to summer months, winter seasonal temperatures increase in Syunik, Armenia under SSP3-7.0 by a best estimate of 1.85°C (0.28°C and 3.21°C possible) and in Daghlig-Shirvan, Azerbaijan by a best estimate of 1.41°C (0.67°C and 2.89°C possible).

As **Figure 4** illustrates, **these large annual and seasonal mean temperature increases across the South Caucasus result in average subnational shifts to different climates by mid-century, even under a lower-emission (SSP1-2.6) scenario**. Over this timeframe and scenario, mean August temperatures in most of Georgia's western regions shift from warm to hot, reflecting an **expansion of humid subtropical conditions from the Kolkheti Plain to higher-elevation temperate moist zones**. Over the same timeframe under SSP3-7.0, this shift also occurs in Abkhazia and Samegrelo-Zemo Svaneti. In Georgia's most montane temperate moist regions (Racha-Lechkhumi-Kvemo Svaneti and Samtskhe-Javakheti), summer mean temperatures shift from mild to warm under SSP1-2.6, reflecting the same vertical shift in temperate conditions. Under SSP1-2.6, January mean temperatures shift from cold to cool in mountainous Shida Kartli and Mtskheta-Mtianeti, though summer mean temperatures additionally shift from warm to hot under SSP3-7.0. These changes reflect the **expansion of warmer temperatures across seasons surrounding the lower altitude Shida Kartli Plain**. **Notably, all provinces in high-elevation Armenia shift to hot summers characteristic of the Ararat Valley** under SSP1-2.6, **except for Shirak** in the interior northwest highland. In addition, provinces in the Ararat Valley (including Azerbaijan's Nakhchivan exclave), and the Lesser Caucasus regions of Tavush (northeast Armenia) and Kalbajar-Lachin (Azerbaijan) no longer experience cold monthly winter temperatures. This trend reflects the **expansion of hotter arid and semiarid conditions along the Aras, Debed, Aghstev and Hakari river valleys** (see Floods and Droughts section for an overview of river systems), **with mixed semiarid instead of temperate dry conditions**. While the remainder of Azerbaijan does not appear to experience widespread climate shifts, this reflects the fact that most of its regions already surpassed lower temperature thresholds, and shift instead from hot to very hot and extreme conditions (see below).[XXXV]

XXXIV Georgia's national-level August mean increases 2.18ºC (1.43ºC and 3.54ºC possible) under SSP1-2.6 and 2.94ºC (1.72ºC and 4.10ºC possible) under SSP3-7.0, with the highest subnational increase of 2.27ºC (1.39ºC and 3.71ºC possible) under SSP1-2.6 and 3.15ºC (1.89ºC and 4.33ºC possible) in Kvemo Kartli. Azerbaijan's national-level August mean similarly increases 2.13ºC (1.09ºC and 3.03ºC possible) under SSP1-2.6, but a higher increase of 2.74ºC (1.67ºC and 3.73ºC possible) under SSP3-7.0. The highest subnational mean increase during August occurs in Nakhchivan, rising 2.38ºC (1.23ºC and 3.23ºC possible) under SSP1-2.6 and 3.12ºC (1.88ºC and 4.01ºC possible) under SSP3-7.0.

XXXV Monthly summer means for some regions shift above 28ºC, making these regions very hot, while monthly winter means for some regions shift by more than 4ºC, making these regions mild instead of cool. Yukhari-Garabakh, Absheron and Lankaran shift to very hot summers under SSP3-7.0, and Aran shifts to very hot summers under SSP1-2.6 as well, though not visibly distinguished in Figure 4. In addition, Absheron and Lankaran shift to mild winters under SSP3-7.0.

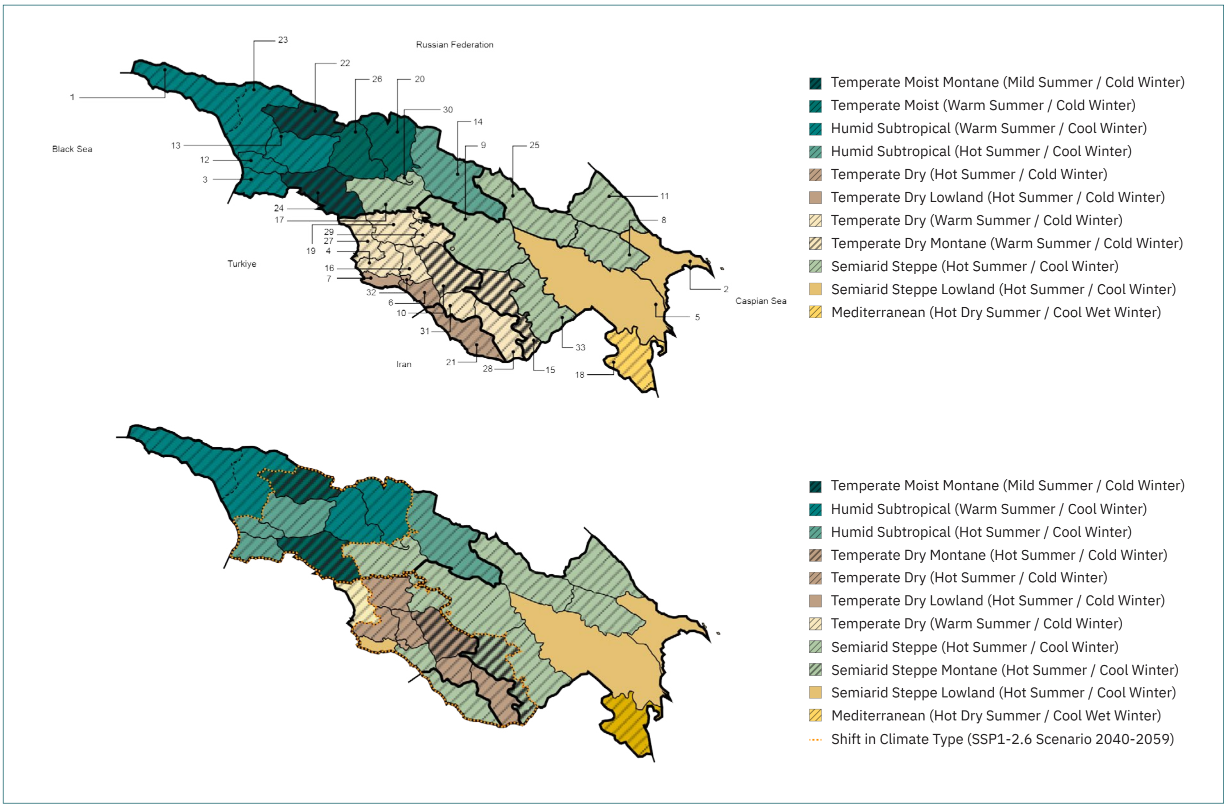


Figure 4. Projected Subnational Shifts in Climate Types (bottom) across the South Caucasus under SSP1-2.6 by 2040–59, Compared to Baseline Conditions (top).[XXXVI] Subnational units with warmer climate zones than baseline outlined in orange (see Figure 1 for baseline map details). Note that shifts document generalised trends, which incorporate multiple potential topographic and climate zones within subnational units. Some regions further shift under SSP3-7.0 by mid-century.[XXXVII]

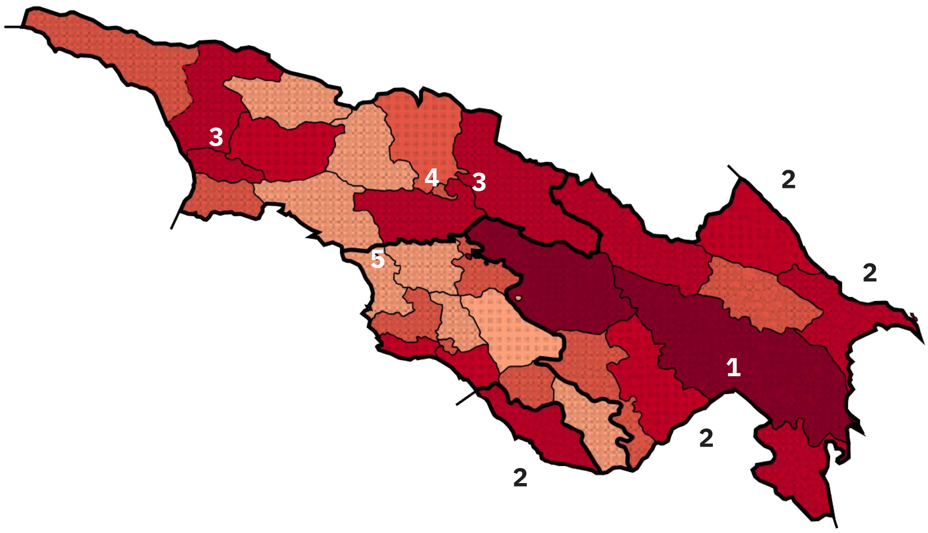
Figure 5 maps the combined effects of hot daytime temperatures and warm nighttime temperatures across the South Caucasus by subnational unit. It illustrates that **the greatest combined heat risks under both SSP3-7.0 and SSP1-2.6 scenarios – which result in serious health implications** (see Human Health section) – **occur in Azerbaijan's lowland plains and along the Caspian coast during July and August, starting in the near term (2020–39).** The projected number of hot days and warm nights annually increase regionwide, but models disagree over the magnitude of these increases. The most extreme conditions occur in the Kura River Valley downstream of the Mingachevir Reservoir (Ganja-Gazakh and Aran) during 2020–39 **and expand across the Kura-Aras Lowland by mid-century.**[XXXVIII] Under SSP1-2.6, very high combined heat risks also extend across the Absheron Peninsula and lowland areas across Azerbaijan by mid-century. Under SSP3-7.0, these risks extend further along the Aras River Valley (Nakhchivan and Yukhari-Garabakh) and Caspian coast (Guba-Khachmaz and Lankaran). **In Georgia, very high combined heat risks extend only to lowlands in**

XXXVI Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested. Since the baseline climatological period used to determine subnational-level Köppen-Geiger climate types differs slightly from the baseline period for the CCKP's climate projections, this analysis determined future subnational shifts based on whether projected mean temperature and precipitation anomalies exceeded key annual or seasonal thresholds when applied to the baseline values (ref. period 1991–2020) reflected in Figure 1. Shifts to warm summers result when mean monthly temperatures exceed 18°C, hot summers result when mean monthly temperatures exceed 22°C and cool winters result when mean monthly temperatures are above -4°C, corresponding to Köppen-Geiger classifications. Shifts from moist to dry climates result when annual precipitation is less than 800 mm.

XXXVII In Georgia, these include Abkhazia, Samegrelo-Zemo Svaneti, Shida Kartli and Mtskheta-Mtianeti, which shift from warm to hot summers under SSP3-7.0, becoming humid subtropical (hot summer / cool winter). Additionally, projected annual precipitation decreases from marginally moist to dry in Samtskhe-Javakheti and Kakheti. This results in a shift to temperate dry montane (warm summer / cold winter) in Samtskhe-Javakheti and semiarid steppe (hot summer / cool winter).

XXXVIII Hot days (maximum temperature > 35°C) by mid-century increase the most under SSP3-7.0 during summer months in Aran by 24.31 days (17.53 days and 32.00 days possible). Tropical nights (minimum temperature > 20°C) increase most annually by mid-century according to the SSP3-7.0 scenario in Yukhari-Garabakh by a best estimate of 29.84 nights (19.93 nights and 40.71 nights possible).

Kvemo Kartli and Kakheti under SSP1-2.6 by mid-century, as well as coastal areas of the Kolkheti Plain (Samegrelo-Zemo Svaneti and Guria). **However, during this period under SSP3-7.0, such conditions spread throughout the Kolkheti Plain** (including Imereti).[XXXIX] **Very high combined heat risk conditions in Armenia remain limited to the Ararat Valley under both scenarios by mid-century.**[XL]



1. Most extreme heat risk exposure in Aran and Ganja-Gazakh (Azerbaijan) over the near term, expanding to more lowland areas over the medium term
2. High and very high heat risks spread across the Absheron Peninsula and other lowlands (Lankaran, Nakhchivan) in the near term, extending to Guba-Khachmaz and Yukhari-Garabakh by mid-century
3. High and very high heat risks spread across Georgia's eastern valleys (Kvemo Kartli, Kakheti) and Kolkheti Plain (Samegrelo-Zemo Svaneti, Guria) in the near term, extending to Imereti by mid-century
4. Large populations exposed to heat risk in Tbilisi and Yerevan in the near term, becoming more certain by mid-century
5. Summer days increase in higher-elevation areas of Georgia and Armenia, starting in the near term

- Extreme Heat Areas by 2020-2039
- Very High Heat Areas by 2020-2039
- Very High Heat Areas by 2040-2059
- High Heat Areas by 2020-2039
- High Heat Areas by 2040-2059
- Moderate Heat Areas by 2020-2039
- Moderate Heat Areas by 2040-2059

Figure 5. Heat Risk by Subnational Unit under SSP3-7.0 over the Near Term (2020–39) and Medium Term (2040–59).[XLI] "Extreme," "very high," "high" and "moderate" risks are assigned when a substantial portion of a subnational unit is projected to exceed the following heat thresholds in order of moderate, high, very high and extreme risk levels: daily maximum temperatures of 30°C, 35°C, 40°C and 45°C; and nighttime minimum temperatures of 20°C, 23°C, 26°C and 29°C. Combined heat risk patterns remain broadly similar under the SSP1-2.6 scenario for both time periods.

XXXIX Hot days (maximum temperature > 30°C) increase most in Tbilisi during summer months by 25.54 days (17.34 days and 36.55 days possible) under the SSP3-7.0 scenario by mid-century. The highest mid-century increase in tropical nights (minimum temperature > 20°C) annually according to SSP3-7.0 occurs in Guria by a best estimate of 26.14 nights (15.33 nights and 39.81 nights possible).

XL Hot days (maximum temperature > 30°C) during summer months increase the most in Yerevan by 29.94 days (22.59 days and 37.34 days possible) under SSP3-7.0 by mid-century. Annual tropical nights (minimum temperature > 20°C) according to SSP3-7.0 increase most in Armavir by a best estimate of 31.37 nights (15.43 nights and 47.17 nights possible) between 2040 and 2059.

XLI Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested.

While more mountainous regions of Armenia and Georgia do not experience heat risks as extreme as in lower-altitude Azerbaijan, they do experience significant shifts in maximum daytime temperatures (summer days, maximum > 25°C) **under SSP3-7.0 by mid-century**.[XLII] The projected annual number of summer days, like the other temperature metrics discussed above, increases in key mountainous locations, though models disagree on the magnitude of this change. The annual median number of summer days increase by approximately one month across much of the South Caucasus during this period, though these shifts occur at different times of the year. In Georgia, summer days increase most by mid-century around the Kolkheti Plain and in Tbilisi by a best estimate of 33.25 days (24.08 days and 50.06 days possible) from June to September.[XLIII] In Abkhazia and Adjara, summer days primarily increase during July and August. In Armenia, summer days increase the most during July and August in the northern and southern parts of the Armenian Highland. **In addition, regions at higher elevations experience critical decreases in the number of frost days (minimum temperature < 0°C) during different seasons**.[XLIV] In Georgia, Mtskheta-Mtianeti experiences the largest best-estimate decrease of -9.05 frost days (-18.73 days and -4.40 days possible) during spring months, while Samtskhe-Javakheti experiences the largest best-estimate decrease of -9.13 frost days (-13.79 days and -3.37 days possible) during autumn months. In Armenia, Vayots Dzor experiences the largest spring decrease of -9.75 frost days (-20.21 days and -4.87 days possible), while Shirak experiences the largest autumn decrease of -10.07 frost days (-14.50 days and -3.10 days possible) over this time period. Future temperature changes under both emission scenarios significantly impact all major sectors of the three South Caucasus countries (see Projected Sectoral Impacts section).

Precipitation

Across the South Caucasus, projected precipitation (mm) amounts marginally increase nationally under the lower-emission SSP1-2.6 scenario by mid-century, but substantially decrease nationally under the higher-emission SSP3-7.0 scenario. Trends under both scenarios display uneven seasonal and regional patterns (discussed further below), and **clear directionality in near and medium-term precipitation patterns remains difficult to determine** for a host of reasons, including model uncertainty and inherent variability. Scientists believe that the behaviour of the West Asian Subtropical Jet over the South Caucasus during summer, which influences future potential drying trends, partly reflects the response to regional aerosol emissions.[20] This increases uncertainty over the direction and magnitude of change for mid-century precipitation projections under different scenarios. While planning for uncertainty is essential given wide probability ranges, analysing spatial and temporal patterns with higher relative model agreement provides valuable insights for policymakers and practitioners preparing for future climate impacts. In particular, **seasonal precipitation increases during winter or spring months under SSP1-2.6 and precipitation decreases during summer months under SSP3-7.0 exhibit relatively higher levels of model agreement regarding the direction of change.**

Under SSP1-2.6, average annual precipitation increases only slightly over the near term, as median precipitation amounts during spring months roughly offset precipitation during summer months.[XLV] **Over the medium term, annual precipitation increases most in Azerbaijan** by a best estimate of 13.65 mm, **but with wide variation in the direction of change** (-30.44 mm to +46.68 mm possible). Greater median increases over winter and spring months outweigh decreases during

XLII Summer days also increase by mid-century under SSP1-2.6, but by slightly less annually. However, in Imereti, the region with the highest increase, annual summer days still top a best estimate of one month.

XLIII Under SSP3-7.0 by 2040–59, annual summer days increase in Imereti by a best estimate of 37.47 days (27.57 days and 54.03 days possible) and in Guria by a best estimate of 34.94 days (23.85 days and 51.13 days possible).

XLIV At lower elevations, frost days decrease most during winter months. For example, by mid-century under SSP3-7.0, winter frost days decrease in Imereti by a best estimate of -12.05 days (-23.26 days and -2.90 days possible) and in Aran by a best estimate of -11.57 days (-20.86 days and -6.51 days possible).

XLV Under SSP1-2.6, precipitation over spring months increases by a best estimate of +18.40 mm (-15.27 mm and +39.37 mm possible) in Georgia, +11.04 mm (-8.47 mm and +27.93 mm possible) in Armenia and +7.60 mm (-8.34 mm and +25.38 mm possible) in Azerbaijan. However, nearly equivalent precipitation decreases occur over summer months, including a best estimate of -17.88 mm (-55.25 mm and +20.11 mm possible) in Georgia, -9.98 mm (-39.72 mm and +13.00 mm possible) in Armenia and -8.95 mm (-24.99 mm and +12.29 mm possible) in Azerbaijan.

summer months.[XLVI] However, the projected summer drying trend in Azerbaijan exhibits much lower model agreement under this scenario. By contrast, under SSP3-7.0, average annual precipitation estimates decrease nationally over the near term, with relatively higher model agreement regarding their direction of change, though not magnitude.[XLVII] By mid-century, SSP3-7.0's marginal projected increases in winter and spring precipitation do not offset summer month decreases, which are estimated at -43.47 mm in Georgia (with a very large range of -99.48 mm to -3.57 mm possible), -35.96 mm in Armenia (with a smaller range of -63.63 mm to -9.86 mm possible) and -22.39 mm in Azerbaijan (with an even smaller range of -38.75 mm to -1.36 mm possible). As a result, **annual precipitation projections under SSP3-7.0 by mid-century feature even greater relative model agreement on the trend of precipitation decreases but not magnitude of such decreases**, including best estimates of -26.25 mm in Georgia (-153.81 mm to +46.44 mm possible), -21.60 mm in Armenia (-103.55 mm to +19.27 mm possible) and -12.78 mm in Azerbaijan (-76.30 mm to +21.18 mm possible).

Monthly projected changes in national precipitation by mid-century (see **Figures 6a-c**) illustrate varied levels of model agreement between high and low-emission scenarios. However, **dominant trends could potentially exacerbate flood and drought conditions in concert with expected temperature changes** (see Floods and Droughts section). In Georgia (see **Figure 6a**), the directional trend of precipitation increases under SSP1-2.6 (blue line) exhibits greater model agreement during March and the trend of precipitation decreases under SSP3-7.0 (red line) exhibits greater model agreement during August.[XLVIII] **SSP3-7.0 projects the South Caucasus' largest median precipitation decreases along the Black Sea coast.** For example, over the medium term, Abkhazia's annual precipitation decreases by a best estimate of -62.85 mm, but the wide range of potential model outcomes (-206.18 mm to + 60.87 mm possible) indicates directional uncertainty. Adjara's summer precipitation decreases by a best estimate of -73.93 mm (-171.29 mm to + 5.99 mm possible), demonstrating a much clearer seasonal trend, especially compared to the median decrease of -45.71 mm (-121.54 mm to +36.52 mm possible), over the same timeframe under SSP1-2.6.

XLVI Under SSP1-2.6, mid-century precipitation in Azerbaijan increases by a best estimate of +11.57 mm (-0.66 mm and +23.80 mm possible) over winter months and +10.01 mm (-8.22 mm and +22.74 mm possible) over spring months, and decreases only -8.33 mm (-28.98 mm and +17.39 mm possible) over summer months.

XLVII At the national level, SSP3-7.0 projects the largest best-estimate annual precipitation decrease of -20.17 mm (-91.02 mm and +56.01 mm possible) in Georgia over the near term. Armenia's annual precipitation decreases over this timeframe by a best estimate of -18.33 mm (-89.20 mm and +36.14 mm possible) and Azerbaijan's decreases by a best estimate of -7.04 mm (-59.87 mm and +27.07 mm possible). Over this period, the largest seasonal precipitation decrease occurs during summer months by a best estimate of -22.22 mm (-84.56 mm and +8.70 mm possible) in Georgia, -22.05 mm (-57.94 mm and +12.23 mm possible) in Armenia and -13.33 mm (-33.33 mm and +9.37 mm possible) in Azerbaijan. Smaller median decreases also occur over autumn months, and relatively small median increases occur over winter and spring months.

XLVIII Georgia's greatest monthly near-term increase of +13.38 mm (-2.89 mm and +22.34 mm possible) under SSP1-2.6 occurs in March, and persists at roughly the same rate of change and level of model agreement through mid-century. Georgia's monthly near-term precipitation under SSP3-7.0 decreases in August by a best estimate of -15.20 mm (-38.17 mm and -0.35 mm possible) and generally persists by mid-century at roughly the same rate of change and level of model agreement.

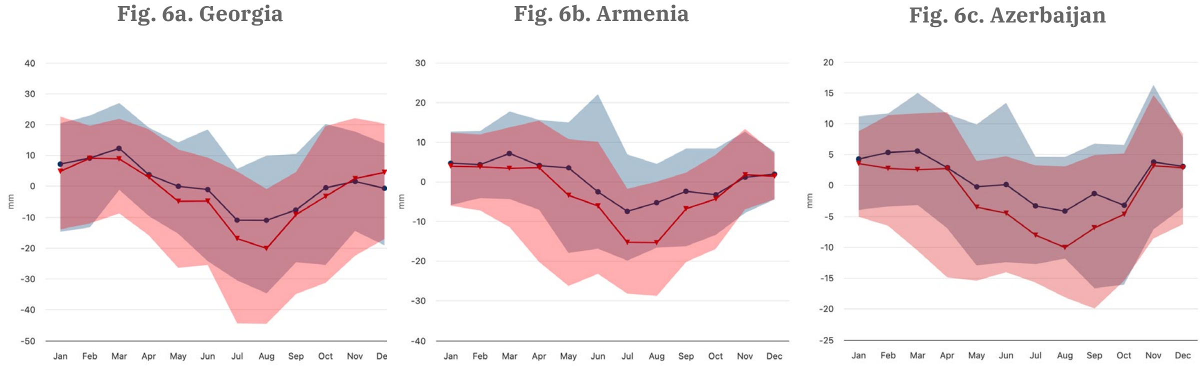


Figure 6. Projected Change in National Precipitation (mm) for 2040–59 (Ref. Period 1995–2014) under SSP1-2.6 and SSP3-7.0 in Georgia (6a, left), Armenia (6b, centre) and Azerbaijan (6c, right). Precipitation increases feature greater model agreement during March in Georgia. Precipitation decreases feature greater model agreement during July and August in Armenia, and during August in Georgia, but greatest possible (90th percentile) decrease as a percentage during August in Azerbaijan. Note the largest absolute y-axis numerical range for Georgia's precipitation change and smallest absolute y-axis numerical range for Azerbaijan's precipitation change.

In Armenia (see **Figure 6b**), the directional trend of precipitation increases under SSP1-2.6 features greater model agreement during March, while precipitation decreases under SSP3-7.0 feature greater model agreement during July and August.[XLIX] However, model uncertainty over the magnitude of these projections remains high. SSP3-7.0 projects the greatest annual decrease of -40.34 mm with a range of -142.90 mm to +14.27 mm possible in Gegharkunik, and the greatest seasonal decrease of -55.64 mm with a range of -92.28 mm to -18.24 mm possible during summer months. In Azerbaijan (see **Figure 6c**), projected precipitation under SSP3-7.0 progressively decreases during summer months by mid-century, especially in the country's north and west.[L] The greatest decrease annually occurs in Kalbajar-Lachin by a best estimate of -43.80 mm, with a wide range from -143.25 mm to + 23.93 mm possible, and during summer months by -50.37 mm, with a slightly smaller range from -83.06 mm to -7.13 mm possible and stronger directional agreement. In contrast, SSP1-2.6 projects the greatest precipitation increases during spring months by mid-century in the west.[LI] However, the dry climates of **Armenia and Azerbaijan, compared to Georgia, render the same numerical decreases more impactful.** For example, SSP3-7.0 projects summer precipitation percent changes by mid-century of -20.55% (-49.91% and -2.44% possible) in Syunik, Armenia and -29.24% (-71.01% and +6.91% possible) in Lankaran, Azerbaijan. **Large and widespread summer precipitation reductions with relatively high model agreement on the direction of change under SSP3-7.0 pose significant challenges across sectors**.

Seasonal increases in intensity present serious risks worth monitoring in some regions, though their generally lower model agreement indicates the potential for shifts in the frequency and timing of both extreme precipitation and drier conditions. Over the medium term, average largest five-day precipitation (mm) amounts increase most in western Georgia under the SSP1-2.6 scenario, with large upper bounds of intensity possible, but low model agreement on the direction and magnitude of intensity change. For example, five-day precipitation events in Racha-Lechkhumi-Kvemo Svaneti increase by a best estimate of +14.31 mm during autumn months, with a wide range of -31.68 mm to +41.43 mm possible, and by +13.99 mm during winter months, with an even wider range of -46.27 mm to +42.14 mm possible. **In southern Armenia and western Azerbaijan**, the largest increases and intensifying directional trend in winter precipitation intensity over the same

XLIX Armenia's greatest monthly near-term increase of +6.66 mm (-2.50 mm and +14.08 mm possible) under SSP1-2.6 occurs in March, and persists at roughly the same rate of change and level of model agreement through mid-century. Under SSP1-2.6, the greatest seasonal precipitation increase occurs in Lori by a best estimate of + 20.26 mm (-13.53 mm and +39.97 mm possible). Armenia's monthly near-term precipitation under SSP3-7.0 decreases in August by a best estimate of -15.33 mm (-28.73 mm and +0.03 mm possible) by mid-century.

L By mid-century under SSP3-7.0, national precipitation in Azerbaijan decreases in August by a best estimate of -10.04 mm (-18.10 mm and + 3.09 mm possible), with relatively high model agreement. Nationally, over the near term, Azerbaijan's March precipitation increases by a best estimate of +3.97 mm (-4.06 mm and +11.84 mm possible). This rate of change and level of model agreement persists over the medium term.

LI SSP1-2.6 projects Lankaran's annual mid-century precipitation increases the most by a best estimate of +24.53 mm (-25.54 mm and +64.75 mm possible), with the greatest seasonal increase during winter months of +23.01 mm (-0.09 mm and +45.36 mm possible).

time period exhibit higher model agreement. The largest five-day precipitation events increase by a best estimate of +9.36 mm (-5.49 mm to +29.62 mm possible) in Vayots Dzor and +7.57 mm (-1.46 mm to +17.29 mm possible) in Kalbajar-Lachin. **Despite generally decreasing precipitation trends under SSP3-7.0, average largest five-day precipitation intensity also increases seasonally in particular regions by mid-century, but again with high model disagreement in terms of the direction and magnitude of change.** During winter months, this intensity increases by a best estimate of +11.95 mm (-44.62 mm to +61.05 mm possible) in Abkhazia and +13.07 mm (-23.34 mm to +43.86 mm possible) during spring months. Similarly, during winter months, this precipitation intensity increases by a best estimate of +9.41 mm (-18.18 mm to +32.07 mm possible) in Lankaran.

The frequency of average largest five-day precipitation events at 50-year and 100-year intervals approximately doubles in northern Armenia and the Ararat Valley by mid-century, though without high model agreement on the direction and magnitude of change. For example, only in Armavir and Shirak do SSP1-2.6 projections for 100-year events of this intensity increase in frequency with high directional model agreement by mid-century, with the upper possible frequency exceeding the lower possible frequency by up to four times.[LII] Elsewhere in the South Caucasus, five-day precipitation events with 100-year return period events increase in frequency by a best estimate of 1.5 to 1.7 times under both scenarios, but with relatively low model agreement on their direction and magnitude of change. **Considering these trends and levels of uncertainty, decision-makers should prepare for potential shifts in the frequency and timing of extreme precipitation, as well as wetter winter and spring months, and drier summer months in the near to medium term.** Future precipitation changes significantly impact cross-sectoral activities regionally, though differ depending on the scenario (see Floods and Droughts, and Projected Sectoral Impacts sections).

Floods and Droughts

Regions within the South Caucasus face high flood risks due to the effects of increasing temperatures on alpine glaciers and snowpack, and changes in seasonal and spatial precipitation patterns. At the same time, all three countries simultaneously face at least moderate drought risks due to higher temperatures reducing soil moisture, growing water demand and reduced transboundary river flows.[LIII]

Over the last several decades, increasing mean and seasonal temperatures drove drastic rates of glacial melting in the South Caucasus. Since the 1960s, more than 70% of small glaciers (most < 10 km^2 in area) in Georgia's eastern Greater Caucasus Mountains have melted, along with nearly half of those in the western part of the country.[21] Snow and ice melt from the largest remaining glaciers in Samegrelo-Zemo Svaneti feed the Inguri and Rioni rivers, which supply the region's critical agricultural and energy sectors. However, while continued rates of glacial melting may lead to increased runoff in the near term and pose a risk of flooding due to glacial lake outbursts, **depleted reserves will lower runoff and change seasonal flood patterns over the longer term**.[LIV]

Flooding may result from many factors, including increased frequency and duration of precipitation, more intense (average largest five-day) precipitation over a short time period, increases in runoff due to temperature-related changes (i.e., a shift away from slow-melting solid precipitation), as well as localised hydrological and land use patterns, such as paved urban surfaces and poor drainage. However, **the seasonal timing of flooding in the South Caucasus varies depending on the region.**

LII The frequency of average largest five-day precipitation events at 100-year intervals increases by a best estimate of 1.99 times (0.97 times and 3.96 times possible) in Armavir and 1.87 times (0.99 times and 4.28 times possible) in Shirak by 2035–64 (centred on 2050) under SSP1-2.6. For the same return level and time period under SSP3-7.0, event frequency only increases with high directional model agreement in Shirak. This profile defines high directional model agreement for this metric when the 10th percentile change in annual exceedance probability is greater than one. The historical reference period is centred on 2000 (1985–2014).

LIII See Projected Precipitation section for levels of uncertainty in dark blue associated with linked indicators for meteorological floods and droughts.

LIV Temperature projections maintain high model agreement on the direction of change, but the rate and timing of hydrological impacts from glacier, snow and ice melt differ by scenario. See World Bank (2021). Georgia Climate Risk Country Profile. Washington DC and Metro Manila: World Bank and Asian Development Bank. URL: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15836-WB_Georgia%20Country%20Profile-WEB.pdf; USAID (2017). Azerbaijan Climate Change Risk Profile. USAID. URL: https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20Profile_Azerbaijan.pdf

Floods occur on the slopes of the Greater Caucasus in Georgia during summer, but extend earlier into **spring months in the country's Lesser Caucasus,** Likhi Mountains and **eastern plains, as well as year-round in the Kolkheti Plain**.[22] **In Azerbaijan, lowlands experience spring and autumn floods from precipitation**, but snowmelt in **alpine and subalpine** elevations contributes to flooding in **May and June**.[23] By comparison, snowmelt and runoff during **spring months produce about half of Armenia's annual river flow**.[24]

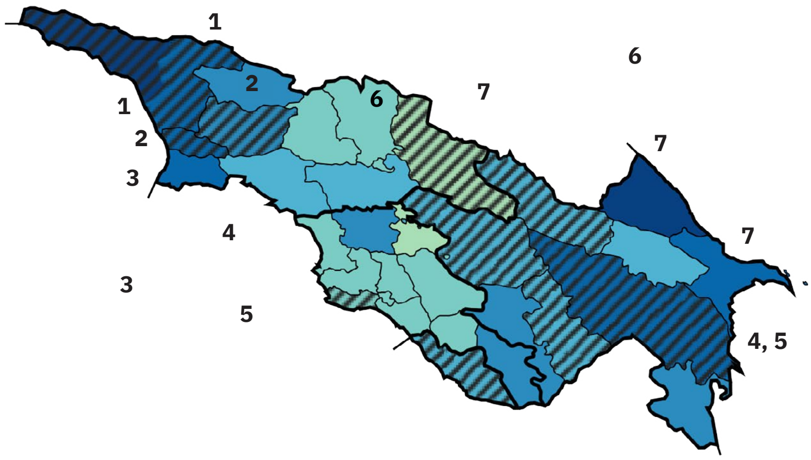
While seasonal increases in precipitation intensity generally possess high model uncertainty over the direction and magnitude of future changes, by 2040–59, SSP3-7.0 projects that average largest five-day precipitation events increase in intensity with higher directional model agreement **in the combined Rioni and Inguri river watersheds** by +8.19 mm **in March** (-17.09 mm to +34.12 mm possible) **and** by +6.94 mm **in June** (-28.89 mm to +44.69 mm possible)**. These conditions could exacerbate seasonal flood risks in Georgia and warrant close monitoring.**[LV] Elsewhere, lower model agreement on precipitation intensity indicates the potential for shifts in the frequency and timing of both extreme precipitation and drier seasonal conditions (discussed later in this section). **Nevertheless, as mentioned above, the role of non-meteorological contributors to flood risks suggests that decision-makers should prepare for both amplified seasonal floods and water shortages over the near and medium term.**

The Kura and Aras rivers not only provide water for irrigation, industry and domestic use, but also influence riverine flood risks across the region, draining nearly all of the South Caucasus (190,110 km^2),[LVI] except for watersheds such as the Rioni and Inguri west of the Likhi Mountains, which drain into the Black Sea. As illustrated in **Figure 7**, which displays **baseline and projected riverine flood exposure risk** under a high-emission scenario, areas where riverine flood risk **ranks extremely high** (> 1% of the population affected annually on average) include **Georgia's Black Sea regions, the Kura-Aras Lowland (Aran) and the Caspian coast** along the Samur-Absheron Canal (Guba-Khachmaz).[LVII] Areas where riverine flood risks rank high (0.006–1% of the population affected annually on average) include the remainder of western Georgia, the region of Lankaran, the Khrami-Debed rivers (Kvemo Kartli and Lori) in the upper Kura River Basin, regions downstream of the Kura River's Mingacevir Reservoir (Shaki-Zaqatala, Ganja-Gazakh and Aran) and regions downstream of the Aras River's Nakhchivan Reservoir (Nakhchivan, Syunik, Kalbajar-Lachin and Yukhari-Garabakh). **Future projected flood risk for 100-year riverine flood events under a high-emission scenario not only increases in areas with high extant risk, but also in areas with lower current risk such as Kakheti and Armavir. Notably, riverine flood exposure does not increase in currently high-risk areas such as along the Caspian coast and parts of the Armenian Highland**.

LV SSP1-2.6 projects stronger intensities in January of +10.88 mm (-34.23 mm and +39.26 mm possible) and June of +9.44 mm (-20.99 mm and +38.10 mm possible), but with low directional model agreement on this timeframe. Under SSP1-2.6, average largest five-day precipitation increases the most in the Kura-Aras watershed over the same time period during January by +5.18 mm (-7.97 mm and +16.41 mm possible), with a roughly similar increase and range of model agreement under SSP3-7.0.

LVI The watershed's extent spans multiple countries, including 31.5% in Azerbaijan (two-thirds of the country's area), 19.5% in northern Iran, 18.2% in Georgia (half of the country's area), 15.7% in Armenia (all of the country's area) and 15.1% in Türkiye. See Food and Agriculture Organization of the United Nations (2009). Aquastat Transboundary River Basins: Kura-Araks River Basin. Rome: FAO. URL: https://openknowledge.fao.org/server/api/core/bitstreams/76c1f173-ef42-40a2-a519-71c273f6db2e/content#:~:text=The%20Kura%2DAraks%20River%20Basin,and%2015.7%20percent%20in%20Armenia

LVII One should note, however, that riverine and coastal floods with short (10-year) return periods can still potentially affect vulnerable populations and cause damage to GDP. See UNISDR (2015). Global Assessment Report on Disaster Risk Reduction 2015. UNISDR. URL: https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2015



Regions with the highest and increasing riverine flood risk by mid-century include:
(1) **Inguri (Abkhazia),**
(2) **Lower Rioni (Samegrelo-Zemo Svaneti and Guria) and**
(4, 5) **Kura-Aras Lowland (Aran).**

Regions with lower but increasing riverine flood risk by mid-century include:
(4) **Alazani tributary of the Kura (Kakheti) and**
(5) **Middle Aras (Armavir).**

Other regions with increasing 100-year riverine flood risk include :
(2) **Middle Rioni (Imereti), and**
(4, 5) **Middle Kura and Aras segments of western Azerbaijan.**

- Extremely High Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050
- High to Extremely High Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050
- High Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050
- Medium to High Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050
- Medium Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050
- Low to Medium Riverine Flood Risk
- 100-Year Flood Inundation > 1m by 2050

Figure 7. Projected Riverine Flood Risk under High-Emission Scenario by 2050.[LVIII] Each numerical set corresponds with the source and mouth of each major river system. Annual projected risks do not differ significantly under a low-emission scenario.

LVIII Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested. Key: 1=Inguri (Samegrelo-Zemo Svaneti and Abkhazia in Georgia); 2=Rioni (Racha-Lechkhumi-Kvemo Svaneti, Imereti and Samegrelo-Zemo Svaneti in Georgia), including *Tskhenistskali* (Racha-Lechkhumi-Kvemo Svaneti, Imereti and Samegrelo-Zemo Svaneti in Georgia); 3=Chorokhi/Coruh (Bayburt, Erzurum and Artvin in Türkiye; and Adjara in Georgia); 4=Kur/Kura/Mtkvari (Ardahan in Türkiye; Samtskhe-Javakheti, Shida Kartli, Mtskheta-Mtianeti, Tbilisi and Kvemo Kartli in Georgia; and Ganja-Gazakh, Shaki-Zaqatala and Aran in Azerbaijan), including *Khrami-Debed* (Lori and Tavush in Armenia, and Kvemo Kartli in Georgia), *Aghstev* (Tavush in Armenia and Ganja-Gazakh in Azerbaijan), and *Iori-Alazani-Ganykh* (Mtskheta-Mtianeti and Kakheti in Georgia, and Ganja-Gazakh and Shaki-Zaqatala in Azerbaijan); 5=Aras/Araks/Araz (Kars, Erzurum and Igdir in Türkiye; Armavir, Ararat and Syunik in Armenia; West Azerbaijan, East Azerbaijan and Ardabil in Iran; and Nakhchivan, Kalbajar-Lachin, Yukhari-Garabakh and Aran in Azerbaijan), including *Akhuryan* (Shirak, Aragatsotn and Armavir in Armenia; and Kars in Türkiye) and Sevan-Hrazdan (Gegharkunik, Kotayk, Yerevan and Armavir in Armenia) ; 6=Terek (Mtskheta-Mtianeti in Georgia; and North Ossetia-Alania, Ingushetia and Chechnya in Russia); 7=Samur (Dagestan in Russia, and Guba-Khachmaz and Absheron in Azerbaijan). The Aqueduct 4.0 Model uses SSP3-8.5 as a "pessimistic" future scenario. Data sourced from: World Resources Institute (2023). Aqueduct 4.0 Floods. WRI. URL: https://www.wri.org/aqueduct/tools

Potentially damaging and life-threatening urban floods pose risks for most of Georgia at least once a decade, **threatening settlements and critical infrastructure**.[25] For instance, in 2015, a severe flood in Tbilisi killed more than a dozen people and resulted in $29 million in damages.[26] Annual expected urban damage from riverine floods in Georgia rises to nearly 0.8% of total urban asset value by 2050 under a high-emission scenario.[LIX] Intense flooding also **damages crops, and increases the risk of landslides and mudflows** across much of the country (see Food and Agriculture, and Critical Infrastructure and Economy sections). **Despite reduced projected river flows under both high and low-emission scenarios, flooding from intense precipitation still poses risks** in Armenia, especially in the north.[27] Average annual flood costs nationally range between $20 million and $100 million.[28] The highest average annual flood losses occur in Vayots Dzor (6.8%) followed by Lori (4.9%). However, Armavir's 100-year riverine floods are also projected to increase, disproportionately affecting people living in substandard housing.[29] In Azerbaijan's Kura-Aras Lowland (Aran), the frequency of riverine flooding has increased since the 1990s due to rising Caspian Sea levels and siltation along upstream floodplains.[30] While coastal risks may change (see Coastal Zone and Sea Level Change section for coastal flood risks), both high-emission and Middle-of-the-Road scenarios project an increase in Azerbaijan's annual GDP affected by riverine floods, rising from $490 million in 2010 to $660–670 million (0.4–0.5% of total forecast GDP) by mid-century.[LX]

At the same time, higher mean and extreme temperatures across the South Caucasus (see Figures 4 and 5), **combined with significant decreases in summer precipitation, raise the risk of droughts under high and low-emission scenarios. In fact, annual and seasonal increases in mean precipitation, such as under SSP1-2.6, do not necessarily entail more runoff due to high rates of temperature-driven evaporation.** Meteorological and agricultural droughts, often the result of low soil moisture and unmet water demand, frequently occur during the dry summer months in Azerbaijan's mountain valleys (Nakhchivan, Ganja-Gazakh and Daghlig-Shirvan) and the Kura-Aras Lowland; Armenia's Ararat Valley, surrounding provinces and south (Syunik); and Georgia's central, eastern and upper Kolkheti Plain (Shida Kartli, Kvemo Kartli, Kakheti and Imereti).[31] By mid-century under SSP3-7.0, **precipitation decreases with high model agreement on the direction of change during summer months** across the Kura-Aras Basin by -18.54%, though with a very wide range of -43.84% to -0.65% possible.[LXI] Other studies identify long-term precipitation decreases in the cross-border tributaries of the Kura-Aras Basin.[LXII] These trends **will worsen water shortages and hydrological droughts, reduce water availability for irrigation** during summer months, **and heighten the risk of competition and tensions over water use as flows decline** (see Food and Agriculture section).

LIX The Aqueduct 4.0 Model uses SSP3-8.5 as a "pessimistic" future scenario. See World Resources Institute (2023). Aqueduct 4.0 Floods. WRI. URL: https://www.wri.org/aqueduct/tools

LX The Aqueduct 4.0 Model uses SSP3-8.5 as a "pessimistic" future scenario and SSP2-4.5 as an "optimistic" future scenario. See World Resources Institute (2023). Aqueduct 4.0 Floods. WRI. URL: https://www.wri.org/aqueduct/tools

LXI By mid-century under SSP1-2.6, median summer precipitation decreases -11.60% (-26.44% and +7.73% possible) in the Kura-Aras Basin, a less extreme intensity and shorter duration compared to SSP3-7.0.

LXII These include the Khrami-Debed shared by Georgia and Armenia, the Alazani-Ganykh shared by Georgia and Azerbaijan, and the Aghstev shared by Armenia and Azerbaijan. See Shatberashvili, N., I. Rucevska, H. Jørstad, K. Artsivadze, B. Mehdiyev, M. Aliyev, G. Fayvush, M. Dzneladze, M. Jurek, T. Kirkfeldt and L. Semernya (2015). Outlook on Climate Change Adaptation in the South Caucasus Mountains. UN Environment Programme, GRID-Arendal and Sustainable Caucasus. Nairobi, Arendal and Tbilisi. URL: https://www.grida.no/publications/161

Coastal Zone and Sea-level Change

Georgia's roughly 330 km-long Black Sea coastline serves as a key trade corridor and provides critical ecosystem services, but faces multiple impacts from sea level rise if left unmitigated.[32] Factors influencing sea level rise include river runoff and sedimentation, local ground motion, and wind patterns due to atmospheric pressure differences ultimately connected to the Mediterranean Sea and North Atlantic Ocean.[33] For 2030 under SSP3-7.0, sea levels are projected to rise above the 1995–2014 baseline by a best estimate of 10 cm in Batumi (Adjara), similar to projections for the entire Georgian coast except Poti in the Rioni River Delta (Samegrelo-Zemo Svaneti).[LXIII] In Poti, high rates of subsidence due to urban development and groundwater extraction over the last century result in an effective sea level rise of twice this rate (see **Figure 8**).[34] According to the same scenario, **Batumi and most other locations on the Black Sea coast face a best estimate of 21 cm sea level rise by mid-century and 60 cm by end-of-century**.[LXIV] This surpasses the 19 cm and 43 cm best-estimate projections under SSP1-2.6 for the same time periods, respectively, illustrating longer-term scenario uncertainty over the magnitude of future sea level change.[LXV] By comparison, **under SSP3-7.0, Poti experiences significant vertical land motion, which results in a higher and more likely best-estimate sea level rise of 41 cm by mid-century and 1.03 m by end-of-century**.[LXVI]

Slow-onset sea level rise amplifies rapid-onset coastal flooding and storm surges from increasingly severe winter storm events, which can top 1–2 m in river deltas.[35] Projected riverine flooding along the Rioni's floodplain, extending upstream from the confluence of its Tskhenistskali tributary to the city of Kutaisi (Imereti), may worsen due to effects of coastal flooding and storm surge, leading to shifts and reductions in freshwater habitat in Kolkheti National Park, and the overtopping of dams, affecting low-lying agricultural land and settlements where much of the region's labour force resides.[36] After the Rioni River Delta, the areas most vulnerable to coastal flooding – according to Georgia's *Second National Communication* – include the Inguri River Delta, from Anaklia (Samegrelo-Zemo Svaneti) to hydropower facilities upstream; the Chorokhi River Delta encompassing Batumi (Adjara), which faces accelerated coastal erosion as a result of upstream dam construction in Türkiye; and the coastal zone surrounding Sukhumi (Abkhazia), where erosion contributes to landslides, and salinisation threatens local habitat and agriculture.[37] **While sea level rise particularly threatens critical infrastructure and economic activities in Batumi, such as cargo transit and oil refining, the national government reports that coastal protection efforts underway could drastically reduce exposure**.[38]

Azerbaijan's 850 km-long coastline along the Caspian Sea, the world's largest inland lake, is home to four million people, encompasses the cities of Baku and Sumgayit (Absheron), and contains three-quarters of industrial resources.[39] **Over the past century, water levels in the Caspian Sea fluctuated** due to interannual precipitation decreases and human activities in the Volga River Basin, as well as the El Niño-Southern Oscillation.[40] Temperature-driven evaporation rates played a significant role in the lake's 1.5 m decline between 1996 and 2021.[41] **However, by end-of-century, most recent studies using CMIP6 ensemble projections anticipate a best-estimate *reduction* in sea level by 8 m under the Middle-of-the-Road SSP2-4.5 emission scenario (with little difference under SSP1-2.6) and 14 m under the high-emission SSP5-8.5 scenario due to temperature-driven evaporation.[LXVII] Such a drop would seriously affect coastal infrastructure, food security and economic livelihoods,** as witnessed in Central Asia's Aral Sea, even with improved water management measures.

LXIII Probability range of 4 cm (17th percentile) and 16 cm (83rd percentile). Data from: NASA (2024). Sea Level Projection Tool. NASA Earth Data. URL: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

LXIV Mid-century probability range of 11 cm (17th percentile) and 32 cm (83rd percentile), end-of-century probability range of 33 cm (17th percentile) and 92 cm (83rd percentile) for Batumi. Data from: NASA (2024). Sea Level Projection Tool. NASA Earth Data. URL: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

LXV Probability range of 21 cm (17th percentile) and 69 cm (83rd percentile) by end-of-century, 10 cm (17th percentile) and 30 cm (83rd percentile) by mid-century under the SSP1-2.6 scenario. Ibid.

LXVI Mid-century probability range of 31 cm (17th percentile) and 53 cm (83rd percentile), end-of-century probability range of 77 cm (17th percentile) and 1.35 m (83rd percentile) under SSP3-7.0. Mid-century median of 40 cm, probability range of 30 cm (17th percentile) and 51 cm (83rd percentile) under SSP1-2.6. End-of-century median of 87 cm under SSP1-2.6, probability range of 65 cm (17th percentile) and 1.13 m (83rd percentile). Ibid.

LXVII End-of-century projections (conducted only for SSP1-2.6, SSP2-4.5 and SSP5-8.5 scenarios) possess an inter-model range of 2–15 m under SSP2-4.5 and 11–21 m under SSP5-8.5. SSP3-7.0 scenario projections would possibly fall in between these ranges. See Samant, R., and M. Prange (2023). Climate-driven 21st Century Caspian Sea Level Decline Estimated from CMIP6 Projections. Communications Earth & Environment, 4(1), 357. DOI: https://doi.org/10.1038/s43247-023-01017-8

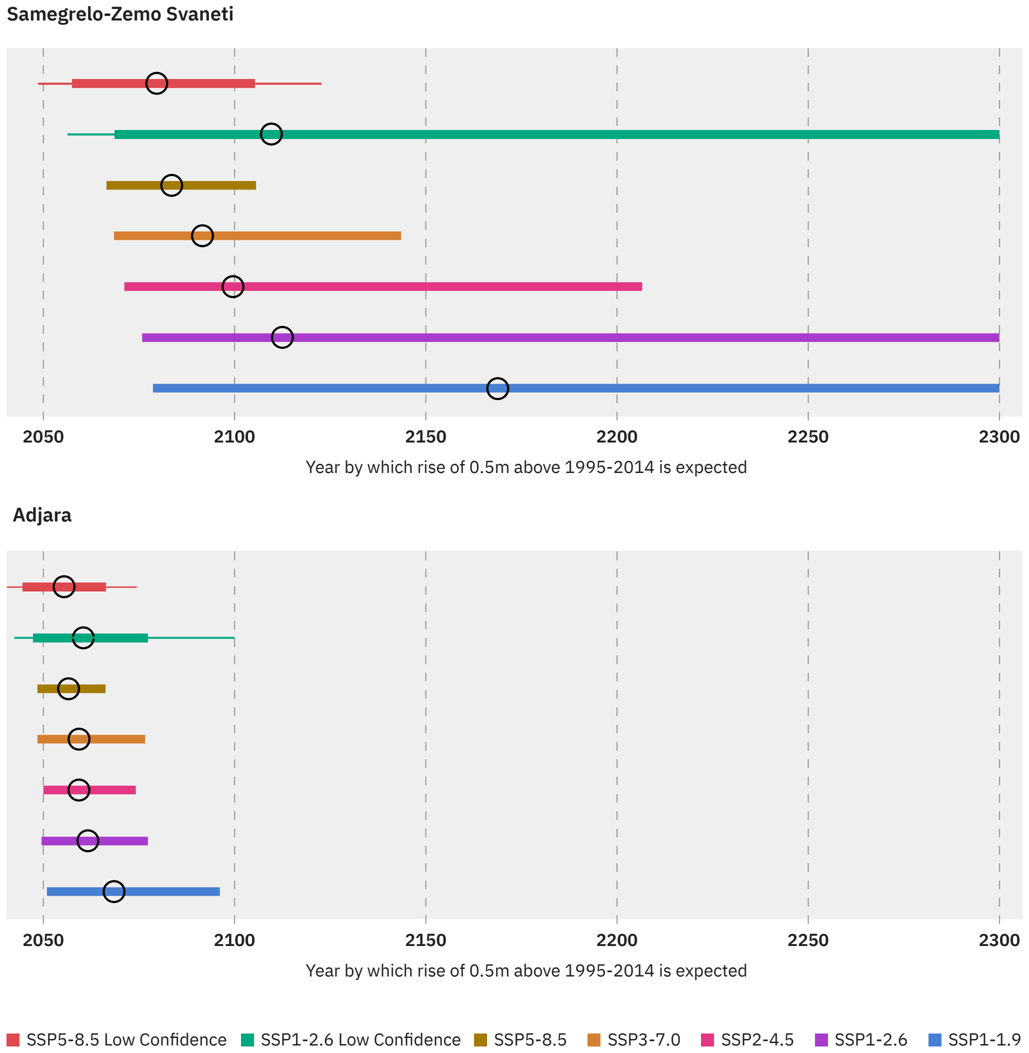


Figure 8. Year by which Sea Level Rise of 50 cm above 1995–2014 Baseline Expected in Poti (top, Samegrelo-Zemo Svaneti) and Batumi (bottom, Adjara).[LXVIII] Median years indicated by circles and 17th to 83rd percentile probability ranges indicated by bars coloured according to climate scenario. Note faster rate of sea level rise with much higher model agreement in Poti under all scenarios, slower rate in Batumi under SSP3-7.0 (orange) and lowest levels of model agreement in Batumi under SSP1-2.6 (purple; low-confidence scenario, green). Thin bars for low-confidence polar ice melt scenarios indicate fifth to 95th percentile probability ranges.

LXVIII Visuals from: NASA (2024). Sea Level Projection Tool. NASA Earth Data. URL: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

Projected Sector Impacts

The following sections outline projected climate impacts by sector considering the temperature and precipitation indicators described above, and interdisciplinary research findings – particularly as part of national governments' periodic submissions to the UN Framework Convention on Climate Change. Sector-specific metrics are further detailed in adelphi's Supplemental Methodology.[LXIX]

Human Health

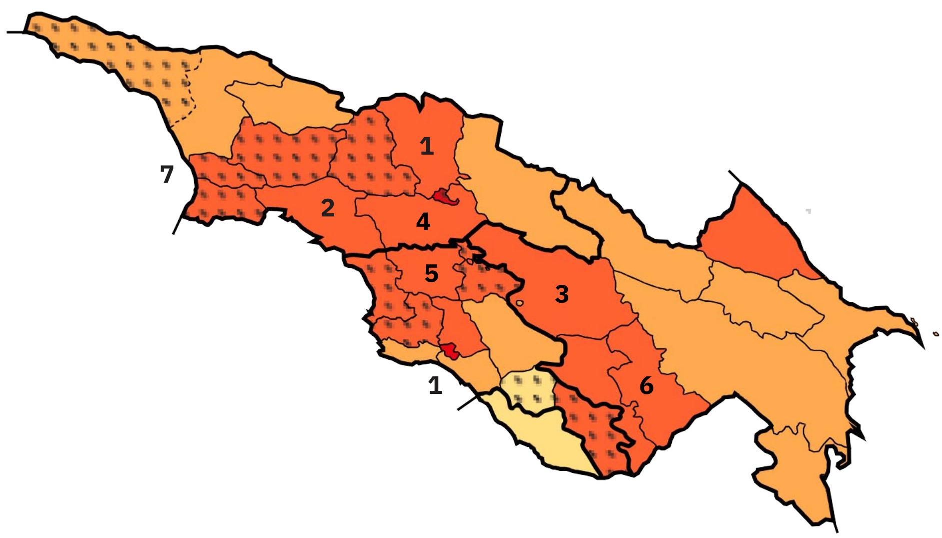
Climate-related health risks – including heat stress, vector-borne diseases, and food and water-borne diseases – are projected to worsen over the near and medium term with relatively high model agreement. Hot daytime temperatures (daily maximum > 30°C) and warm nighttime minimums (tropical nights > 20°C) – which hinder the body's ability to cool and disrupt restful sleep – increase the most **during summer months in low-elevation areas** across the South Caucasus, starting in the near term (2020–39) under both SSP1-2.6 and SSP3-7.0 scenarios (see **Figure 5**). Heat-related illnesses, including dehydration and heat stroke, **notably affect urban areas** such as Tbilisi in Georgia, Yerevan in Armenia and Baku (Absheron) in Azerbaijan, which possess dense populations and a greater concentration of heat-absorbing, moisture-deficient surfaces compared to surrounding rural areas.[42] Additionally, the national government of Georgia found Telavi (Kakheti) most vulnerable to heat waves, compared to Georgia's other major cities, due to higher rates of poverty, and a greater prevalence of cardiovascular and respiratory conditions.[43] **Disproportionate heat mortality and morbidity risks extend to outdoor agricultural workers in Georgia and Azerbaijan** (see Critical Infrastructure and Economy section), **elderly people, pregnant women, children, and people with disabilities and pre-existing health conditions.**

This profile highlights five vector-borne diseases with pronounced risks due to future climate conditions: tularemia, Crimean-Congo hemorrhagic fever, tick-borne encephalitis, anthrax and leptospirosis (see **Figure 9**).[LXX] **Warmer seasonal temperatures** (represented by summer days > 25°C), **which increase the most in parts of Georgia and Armenia by mid-century, correspond with more favourable conditions for the first four diseases**. **Meanwhile, incidents of flooding, projected to increase in western Georgia and eastern Azerbaijan by mid-century**, **correspond with greater transmission of leptospirosis, in addition to diarrheal diseases.**

Other notable bacterial infections include anthrax, leptospirosis, and food and water-borne diseases such as dysentery. Anthrax spores – which can persist in soil for more than 100 years before endangering humans, or wild or domestic animals – maintain higher future risk levels in Azerbaijan, influenced in part by local soil factors.[44] Leptospirosis, often spread by contaminated rodent urine associated with flood events, tends to cause influenza-like symptoms with many cases in riverine

LXIX For further details regarding climate scenarios, data sources and presentation, see adelphi's Supplemental Methodology: https://weatheringrisk.org/en/publication/climate-impact-profile-supplementary-information

LXX Ticks, and animal hosts such as livestock and rodents comprise the most common vectors of zoonotic diseases in the South Caucasus that transmit infections directly or indirectly to humans. However, the spread of previously unobserved mosquito populations in the South Caucasus also raises the risk of mosquito-borne diseases in the future. Ticks spread tularemia, Crimean-Congo hemorrhagic fever and tick-borne encephalitis, with habitability ranges influenced by warm seasonal temperatures, land use changes and certain agricultural practices. Infected rodents and rabbits transmit tularemia, a bacterial infection also termed "rabbit fever," which may contaminate food and water sources. Major outbreaks caused dozens of infections recently in foothill, steppe and mountain riverine areas of Georgia (Shida Kartli, 2007) and Armenia (Kotayk, 2003; Gegharkunik, 2007; and Tavush, 2017), with future risks also extending into western Azerbaijan. Less common Crimean-Congo hemorrhagic fever and tick-borne encephalitis viral infections remain important to monitor due to their symptoms (high mortality rate and potential central nervous system damage, respectively). Crimean-Congo hemorrhagic fever poses risks to adults exposed to infected domestic animals in the agricultural sector (primarily eastern Georgia and northern Azerbaijan), while tick-borne encephalitis mainly occurs as a result of tick bites in forested areas (Georgia, northern Armenia and western Azerbaijan). See Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf; Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf; Kosoy, M., P. Imnadze, L. Malania, N. Bolashvili, A. Kandaurov, C.T. Webb and K. Gilbertson (2024). Atlas of Zoonotic Diseases in the South Caucasus. Tbilisi: LEPL National Centre for Disease Control and Public Health, Georgia. DOI: https://doi.org/10.52340/9789941869020 areas of western Georgia (see Floods and Droughts section for more details on flood projections, casualties and damage). Furthermore, food and water-borne diseases stem from poor water quality, sanitation and hygiene. Azerbaijan records more than 16,000 gastrointestinal infections annually and Armenia recently registered more than 6,000 cases annually, which future floods and droughts threaten to exacerbate.[45] Diarrheal diseases significantly increased in parts of flood-prone Georgia (Adjara), for example, between 1990 and 2010.[46]



1. Highest overall vector-borne disease risk in Tbilisi and Yerevan, with greater increase in summer days projected by mid-century in Tbilisi
2. Many areas in Georgia and Azerbaijan with overall moderate-to-high disease risk experience the highest projected increases in summer days by mid-century
3. Tularemia risk high throughout most of Armenia and western Azerbaijan
4. Crimean-Congo hemorrhagic fever high across eastern Georgia and northern Azerbaijan
5. Tick-borne encephalitis risk high across most of Georgia and northern Armenia
6. Anthrax risk high across most of Azerbaijan
7. Leptospirosis risk high in the Kolkheti Plain (Georgia) and moderate in Absheron (Azerbaijan)

- High Zoonotic Disease Risk
- Increase > 30 Summer Days Annually by 2050
- Moderate to High Zoonotic Disease Risk
- Increase > 30 Summer Days Annually by 2050
- Low to Moderate Zoonotic Disease Risk
- Increase > 30 Summer Days Annually by 2050
- Low Zoonotic Disease Risk
- Increase > 30 Summer Days Annually by 2050

Figure 9. Vector-Borne Disease Risk and Projected Temperature Increase (Represented by Summer Days > 25°C) in South Caucasus by Subnational Unit.[LXXI] Based on historic cases and future risk factors, map combines five relative probabilities of human infection (anthrax, tularemia, tick-borne encephalitis, Crimean-Congo hemorrhagic fever and leptospirosis) overlayed with median projected increase of 30 or more summer days (maximum temperature > 25°C) by mid-century under SSP3-7.0. Note summer days positively increase across all of the South Caucasus during this period.

LXXI Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested. Zoonotic diseases indicate transmission from animals to humans. Data and methodology from Kosoy, M., P. Imnadze, L. Malania, N. Bolashvili, A. Kandaurov, C.T. Webb and K. Gilbertson (2024). Atlas of Zoonotic Diseases in the South Caucasus. Tbilisi: LEPL National Centre for Disease Control and Public Health, Georgia. DOI: https://doi.org/10.52340/9789941869020

Food and Agriculture

Temperature and precipitation shifts favour certain crops and agricultural activities at the expense of others, but increasing extreme heat conditions, water demand and water scarcity generate lower yields and overall food security regionwide. In Georgia's east (Kakheti), increasing temperatures prolong the growing season, and expand the number of suitable crops – including wheat, corn and tomatoes – as well as pastureland. However, this favourable shift in agricultural conditions threatens to encroach upon forestland and overlooks otherwise decreasing crop yields.[47] Recently, **high heat risk areas (maximum temperature > 30°C) paired with drought** in the eastern plains and foothills of Georgia's principal wheat-growing region **offset any increase in yields**.[LXXII] In Armenia, temperature increases by mid-century, including high heat conditions in the Ararat Valley, lead to lower fruit and vegetable yields.[48] **Rising temperatures further harm cattle, goat and sheep production, which account for a large proportion of local income in rural mountainous regions, and agricultural GDP in Armenia and Georgia.**[49] Conversely, spring frosts continue to pose risks to agriculture in the Ararat Valley, in addition to hailstorms, which caused $128 million in damage between 2014 and 2017.[50] As discussed in the Temperature section, the anticipated increases in mean seasonal temperatures and the annual number of hot days maintain high model agreement on the direction but not magnitude of future change, leaving the rate and timing dependent on the scenario.

In tandem with increasing temperatures, **all South Caucasus watershed basins (excluding those in western Georgia) are projected to experience medium-high, high or extreme annual water stress by mid-century. Figure 10** illustrates the greatest annual water stress risk in the Lower Kura-Aras Azerbaijan and Iran, followed by upstream Middle Aras regions in Armenia, Azerbaijan and Iran. Regions shifting to high annual water stress include the Samur-Absheron in Russia and Azerbaijan. Meanwhile, regions shifting to medium-high water stress include the Upper Kura in Türkiye and Georgia; Middle Aras in Armenia, Azerbaijan and Iran; and Lankaran in Azerbaijan. **The Sevan-Hrazdan (Middle Aras) in Armenia and the Lower Kura-Aras in Azerbaijan, furthest downstream, generally maintain high water stress across all seasons.**[LXXIII][51] During dry summer months and September by mid-century under SSP3-7.0, precipitation percent decreases – with relatively high model agreement in terms of the direction of change – hasten shifts to high water stress across many aforementioned river basins. But notably, **high water stress in the Alazani-Ganykh River Basin in Georgia and Azerbaijan – a key transboundary tributary along the middle segment of the Kura River – also threatens to expand** from June to September. **This pattern indicates broader shifts towards longer and more intense agricultural droughts, desertification and salinisation**.[52] For example, droughts doubled in frequency and became more prolonged in eastern Georgia, causing approximately $150 million in damages between 1995 and 2008.[53] An unusual six-month drought in 2000, which affected an estimated 700,000 people and led to a more than 5% drop in GDP, demonstrates the potential impact of future shifts.[54] Non-meteorological contributors to drought risk, from water consumption rates to transboundary resource competition, further underscore the need to prepare for water shortages, regardless of model uncertainty over seasonal precipitation magnitudes.

LXXII Despite localised increases in potential wheat cultivation (Lori, Armenia; higher-elevation Azerbaijan), wheat yields decrease in other parts of the South Caucasus by mid-century. See Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf; Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf; USAID (2017). Azerbaijan Climate Change Risk Profile. USAID. URL: https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20Profile_Azerbaijan.pdf

LXXIII Periods of drought recently expanded seasonally and spatially in Armenia, encompassing foothills and mountains outside the Ararat Valley, which align with projected ecosystem transitions in interior highlands (see Ecosystems section). Severe droughts in Armenia between 1984 and 2017 most frequently damaged crops in the surrounding provinces of Kotayk and Gegharkunik. Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf

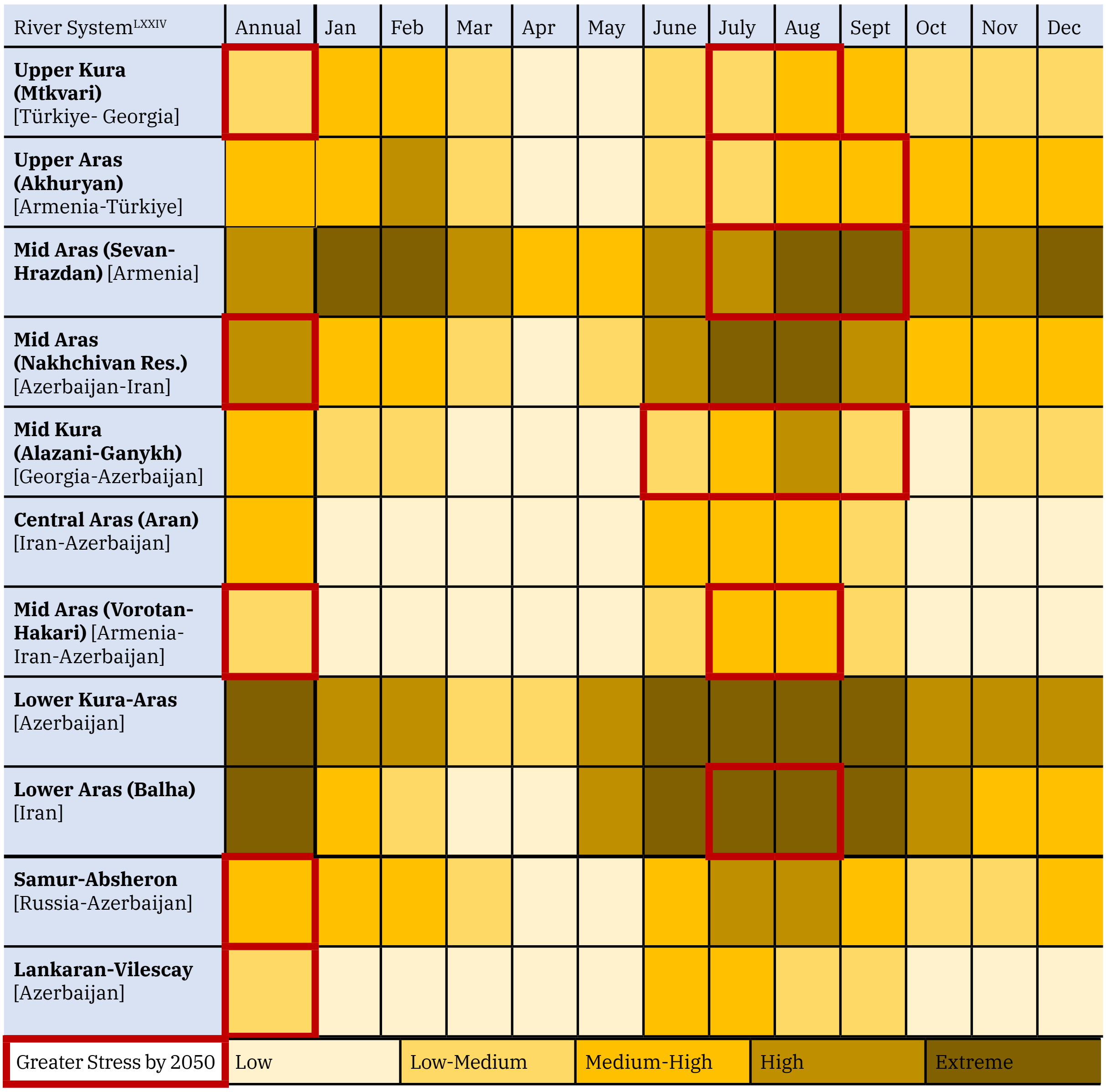


Figure 10. Current and Projected (2035–65, Ref. Period 1960–2014) Monthly Water Stress by Major River System under SSP3-7.0.[LXXV] Projected increases in monthly water stress, outlined in red, indicate precipitation percent decreases with high model agreement.[LXXVI]

LXXIV For details on river systems identified, see key for Figure 7.

LXXV Water stress is defined as the percentage ratio of total water demand for domestic, industrial, irrigation and livestock uses to available renewable surface and groundwater sources. Baseline water stress categorisations identified by the World Resources Institute's Aqueduct 4.0 Water Risk Atlas tool. Data sourced from: World Resources Institute (2023). Aqueduct 4.0 Water Risk Atlas. WRI. URL: https://www.wri.org/aqueduct/tools

LXXVI The World Resources Institute's Aqueduct 4.0 Water Risk Atlas tool projects future annual water stress risk, but only possesses monthly water stress risk for the historical baseline period. Projected precipitation percent decreases sourced from the CCKP. Under SSP3-7.0, the Upper Kura (Mtkvari) experiences greater annual water stress over the near term (2015–45) but maintains low-medium annual water stress over the medium term (2035–65). Under SSP1-2.6, annual water stress does not change, except for an increase in Samur-Absheron, and precipitation percent change only increases slightly in late winter and September. The following catchments were considered part of adjacent watersheds since greater water stress conditions impacted part or all of the river basin(s) upstream: the Aras in Türkiye as part of the Upper Aras (Akhuryan) Basin; Iori (Kakheti), Aghstev (Tavush, Ganja-Gazakh) and Shamkir (Ganja-Gazakh) tributaries as part of the Middle Kura (Alazani-Ganykh) Basin; and Aras from Ardabil (Iran) to its confluence with the Kura in Aran (Azerbaijan) as part of the Central Aran (Aras) Basin.

In Azerbaijan, projected changes in annual precipitation runoff for areas such as the Alazani-Ganykh River Basin have low model agreement. However, **high demand and competition for water across the region in 2022 already threatened the water security** of the country's 1.5 million hectares of irrigated cropland.[LXXVII]

About one-third of Armenia's surface water originates from outside its borders and at least half of Azerbaijan's runoff originates outside its borders, both of which expect future reductions in flow.[55] Lake Sevan, the largest freshwater lake in the South Caucasus, faces annual decreases in volume, straining energy, agriculture and domestic uses.[56] Other activities, such as aquaculture in Armenia's Ararat Valley, further deplete regional groundwater.[57]

Changing temperature and precipitation patterns pose high risks to food security, especially for vulnerable population groups in rural areas. Most agricultural activities in the South Caucasus take place on smallholder farms that grow fruit, vegetables, cereals, legumes, livestock, and specialty crops such as cotton, tobacco, tea and nuts.[58] Women employed in the agricultural, forestry and fishing sectors in the three South Caucasus countries remain more vulnerable to climate impacts due to lower rates of land ownership and access to financial services. Out of the three South Caucasus countries, Georgia possesses the highest prevalence of moderate and severe food insecurity, which recently decreased from 39.7% of the total population (2018–20) to 32.4% (2021–23).[LXXVIII] However, regional inequalities between urban and rural areas persist, and contribute to recent trends in migration.

Critical Infrastructure and Economy

Economic activities and infrastructure networks in the South Caucasus face increasing risks from climate impacts, such as extreme temperatures, drought and flooding, which also exacerbate the effects of geological hazards. By 2050, under the SSP3-7.0 scenario, all three South Caucasus countries face substantial GDP losses from precipitation-driven flooding (100% of GDP exposed) and extreme heat (100% of populatioZn exposed).[LXXIX] By mid-century under a high-emission scenario, Georgia experiences the largest share of annual GDP affected by riverine flooding (1.44%), while a greater number of people in Azerbaijan (approximately 59,000) are affected by riverine flooding each year on average.[LXXX] GDP losses from water stress remain high in Armenia and Azerbaijan (87% and 77% of GDP exposed, respectively), and moderate in Georgia (47% of GDP exposed), with roughly equivalent exposure to wildfire risks (74% of GDP exposed in Azerbaijan, 73% of GDP exposed in Armenia and 33% of GDP exposed in Georgia).[59] The high level of GDP exposure to water stress reflects the fact that nearly all agriculture in Azerbaijan, half in Armenia and three-quarters in Georgia relies on irrigation.[60]

LXXVII Rainfed potato and cotton crops experience the greatest decrease in future yields. See World Bank (2023). Azerbaijan Country Climate and Development Report. Washington DC: World Bank. URL: https://openknowledge.worldbank.org/handle/10986/40622; USAID (2017). Azerbaijan Climate Change Risk Profile. USAID. URL: https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20Profile_Azerbaijan.pdf

LXXVIII Using three-year averages. In Armenia, moderate and severe food insecurity decreased from 17.1% of the total population between 2016 and 2018 to only 7.8% between 2021 and 2023. The prevalence of moderate and severe food insecurity steadily increased in Azerbaijan from 5.9% of the total population between 2014 and 2016 to 12.2% between 2021 and 2023. See Food and Agriculture Organization of the United Nations (2024). FAOSTAT Suite of Food Security Indicators. Rome: FAO. URL: https://www.fao.org/faostat/en/#data/FS/visualize

LXXIX These figures do not equate to the actual loss of an entire country's GDP to a single hazard event, and exclude important factors such as local-level readiness and adaptation. In other words, these figures reflect the fact that the entire country's physical and human capital are located in regions exposed to "non-zero" hazard risk (i.e., a 1-in-100-year historical flood event depths and about six weeks of extreme heat days annually). These thresholds aim to cover the greatest plausible extent under a high-emission scenario in order to serve as a conservative, representative estimate of hazard impacts on economic production. However, because all three South Caucasus countries encompass relatively small land areas, dense economic networks, and complex topography and climatic dynamics, these national-level GDP exposure estimates are imprecise for accurately representing all dimensions of subnational-level risk exposure. Readers should, therefore, consider more localised hazard exposure estimates described later in this section and consult supplementary sources with higher-resolution analysis in order to obtain the most accurate, up-to-date subnational-level exposure risks. See Munday, P., M. Amiot, and R. Sifon-Arevalo (2023). Lost GDP: Potential Impacts of Physical Climate Risks. S&P Global. URL: https://www.spglobal.com/_assets/documents/ratings/research/101590033.pdf

LXXX However, represented as a percentage of the total expected population, the annual expected population affected by riverine flooding in Azerbaijan (0.51%) is lower than in Georgia (1.44%). The Aqueduct 4.0 Model uses SSP3-8.5 as a "pessimistic" future scenario. See World Resources Institute (2023). Aqueduct 4.0 Floods. WRI. URL: https://www.wri.org/aqueduct/tools

At the national level for each country under both SSP3-7.0 and SSP1-2.6 scenarios, best-estimate *decreases* in the annual number of heating degree days (mostly due to warmer winter and spring temperatures) outweigh best-estimate *increases* in the annual number of cooling degree days (mostly due to warmer summer temperatures).[LXXXI] **Therefore, each country will likely experience net energy savings in the near and medium term.** For example, by mid-century under SSP3-7.0, Armenia experiences the greatest net energy savings (though similar to Georgia's), with best-estimate heating degree days decreasing by -1,077.81 (-1,702.87 and -738.40 possible) and best-estimate cooling degree days only increasing by +304.92 (+187.11 and +447.07 possible). Azerbaijan's net energy balance remains relatively unchanged between 2020 and 2039 under SSP3-7.0, but it still achieves net-positive energy savings by mid-century under both SSP1-2.6 and SSP3-7.0 scenarios.[LXXXII] **However, warmer temperatures do not eliminate negative impacts on economic activities and energy infrastructure.** In Georgia, because hydropower facilities along the Rioni and Inguri rivers generate most of the electricity used for air conditioning, the energy grid remains vulnerable to lower summer runoff – even as warmer temperatures drive higher peak demand for air conditioning.[LXXXIII] Warmer temperatures also threaten winter tourism at alpine resorts in Georgia, which as a sector accounts for more than 7% of GDP.[61]

The South Caucasus acts as a vital conduit for transit and energy between Europe and Asia. However, future changes in precipitation threaten to raise the risks of geological hazards, affecting critical infrastructure and, thus, energy security also beyond the region. Currently, Georgia serves as the primary international transit node across the region, generating an estimated $5 million per one million tonnes of transported cargo.[LXXXIV] East-west rail services, and strategic oil and gas pipelines from Azerbaijan traverse Georgia en route to Türkiye and European markets, while Georgia's north-south highway and natural gas pipeline link Russia and Armenia, supporting Armenia's exports and energy security.[62] These bottlenecks remain particularly vulnerable to climate impacts and geological hazards,[LXXXV] with the potential for large economic losses. For instance, in 2014, a severe mudflow near the Dariali Gorge (Mtskheta-Mtianeti) blocked the North-South Gas Pipeline from Russia to Armenia and the heavily travelled Georgian Military Highway, circumventing the disputed territory of South Ossetia.[63]

LXXXI Cooling degree days approximate the energy required to cool a building, counting the number of degrees that the daily average temperature is above 18.3°C over a chosen timeframe. Heating degree days approximate the energy required to warm a building, counting the number of degrees that the daily average temperature is below 18.3°C over a chosen timeframe. There is high model agreement that future temperatures will increase, but different plausible global emission pathways make the magnitudes of these changes less certain.

LXXXII Under the SSP3-7.0 scenario over 2020–39, Azerbaijan's heating degree days decrease by a best estimate of -349.16 (-773.15 and -190.18 possible) units and cooling degree days increase by a roughly equivalent best estimate of +306.71 (+156.20 and +449.62 possible) units. However, by mid-century, under the same scenario, heating degree days decrease by a best estimate of -707.66 (-1,270.23 and -480.22 possible) units and cooling degree days increase +533.52 (+385.86 and +757.11 possible) units, yielding median net energy savings.

LXXXIII The drought of 2000 provides one illustration of precipitation deficits on hydropower infrastructure, lowering energy production in Georgia by 20% and causing widespread energy shortages. See USAID (2017). Georgia Climate Risk Country Profile. USAID. URL: https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID%20ATLAS_Climate%20Change%20Risk%20Profile%20-%20Georgia.pdf; Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf

LXXXIV The Nagorno-Karabakh conflict effectively shut down transit routes between Azerbaijan and Armenia, while the lack of normalised relations prevented transit connection between Armenia and Türkiye. Meanwhile, conflict in occupied Abkhazia severed Black Sea rail connection between Russia and Georgia. See De Waal, T. (2021). In the South Caucasus, Can New Trade Routes Help Overcome a Geography of Conflict? Carnegie Europe. URL: https://carnegie-production-assets.s3.amazonaws.com/static/files/de_Waal_South_Caucasus_Connectivity.pdf; Neset, S., M. Aydin, A. Ergun, R. Giragosian, K. Kakachia, and A. Strand (2023). Changing Geopolitics of the South Caucasus after the Second Karabakh War: Prospect for Regional Cooperation and/or Rivalry. CMI Report No. 4. Bergen: Chr. Michelson Institute. URL: https://www.cmi.no/publications/8911-changing-geopolitics-of-the-south-caucasus-after-the-second-karabakh-war

LXXXV Geological hazards include seismic risks. The areas of highest average annual loss due to earthquakes include Yerevan, Armenia ($44.2 million); Tbilisi, Georgia ($44.6 million) and Absheron, Azerbaijan ($64 million). Among the deadliest contemporary earthquakes, the M6.8 Spitak earthquake in 1988 caused 25,000 casualties and more than $14 billion in losses, while the M7.0 Racha earthquake in 1991 caused 270 casualties. See Silva, V., A. Calderon, M. Caruso, C. Costa, J. Dabbeek, M.C. Hoyos, Z. Karimzadeh, L. Martins, N. Paul, A. Rao, M. Simionato, C. Yepes-Estrada, H. Crowley, and K. Jaiswal (2023). Global Earthquake Model (GEM) Seismic Risk Map (version 2023.1). DOI: https://doi.org/10.5281/zenodo.8409623; URL: https://www.globalquakemodel.org/product/global-seismic-risk-map; World Bank (2017). Disaster Risk Finance Country Note: Armenia. Washington DC: World Bank. URL: https://documents1.worldbank.org/curated/en/316831526641378244/pdf/Armenia-Disaster-Risk-Finance-Country-Note.pdf

As indicated in **Figure 11**, landslide and mudslide hazard risks increase along Georgia's segments of key east-west oil and gas pipelines, as well as northern Armenia's segments of the north-south energy and transit corridor. High landslide and mudslide risk areas characterise most of Georgia and Armenia, except Tbilisi and parts of the Ararat Valley. Because percent changes in mean precipitation increase landslide risk and greater precipitation intensity raises mudslide risk, among other localised geological and environmental factors,[LXXXVI][64] Figure 11 overlays projected shifts in these metrics by mid-century under SSP3-7.0 with areas of greatest historical geological risk (see Projected Precipitation section for levels of uncertainty in dark blue associated with linked indicators for meteorological indicators). While landslide and mudslide risks increase throughout the South Caucasus, one can note:

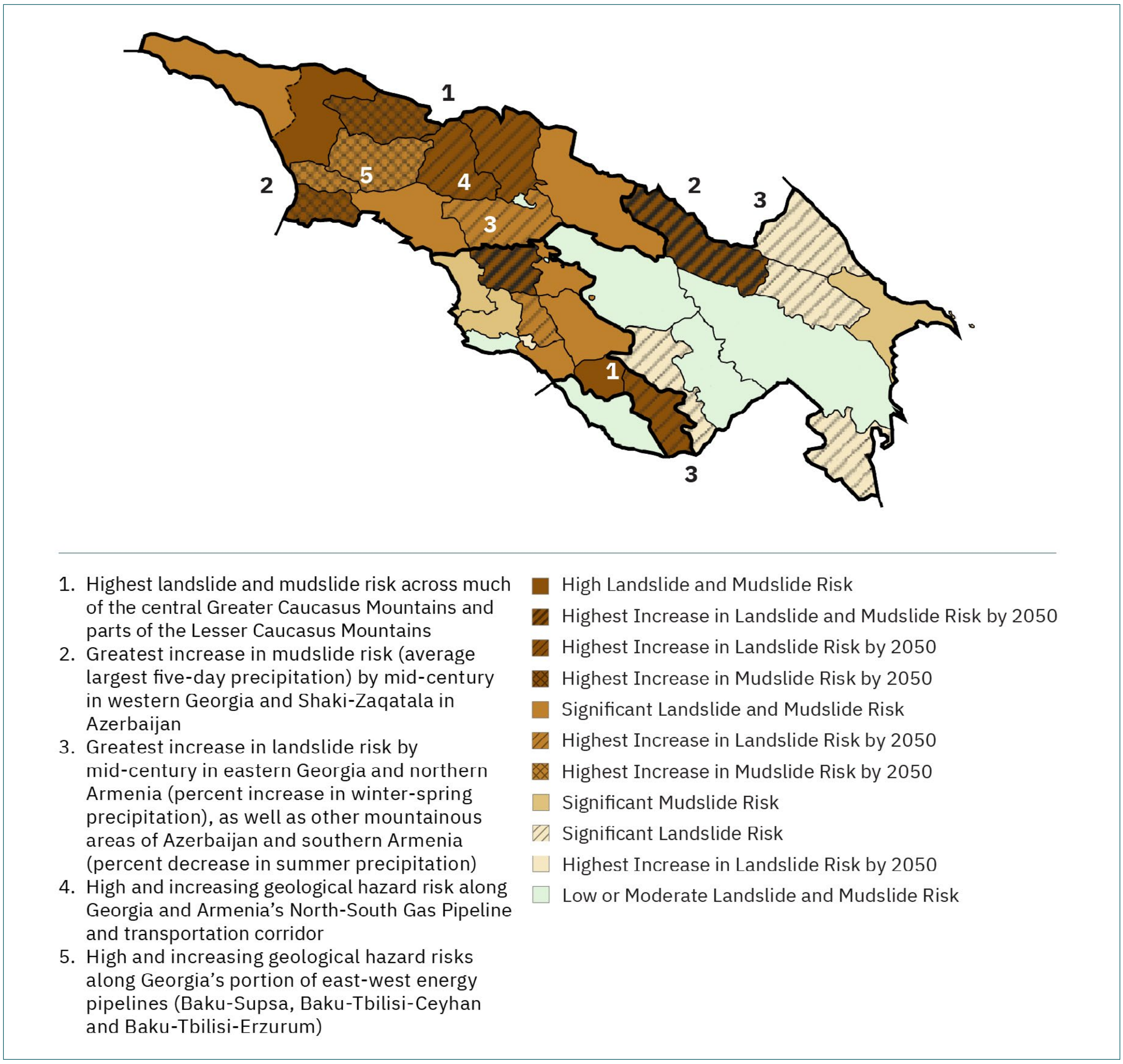


Figure 11. Landslide and Mudslide Hazard Risks, Future Change in Precipitation, and Critical Infrastructure Impacts in South Caucasus by Mid-century under SSP3-7.0.[LXXXVII] Based on historical hazard exposure and national government risk categories.[65] Largest future increase in landslide risk determined by a median percent change in seasonal precipitation of less than -20% or more than +10% under SSP3-7.0 between 2040 and 2059 (reference period 1995–2014). Largest future increase in mudslide risk determined by seasonal increase in average largest five-day precipitation (mm) between 2040 and 2059 (reference period 1995–2014), where the 90th percentile remains at least twice the absolute value of the 10th percentile, indicating stronger model agreement.

LXXXVI An increase in (solid) precipitation intensity similarly raises avalanche risk, highest in Mtskheta-Mtianeti (Georgia), and highland areas of southern and northwestern Armenia. See Georgian Ministry of Environmental Protection and Agriculture (2021). *Fourth National Communication of Georgia under the UNFCCC*. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf; Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf

LXXXVII Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested.

Human Displacement

Climate-related impacts compound high levels of internal displacement in the South Caucasus from years of episodic conflict and violence, leaving many households in need of additional social, economic and psychological support. Because IDPs often lack durable housing, adequate access to basic services and livelihood opportunities, they remain more vulnerable to climate-related impacts.[66] These impacts include damage from rapid-onset floods and flood-induced geological hazards; slow-onset disruption of water, sanitation and hygiene services during droughts; slow-onset loss of revenue from agriculture, livestock raising and forestry activities due to water shortages; shifts in productive land and ecosystems; and resource degradation.

Based on UNHCR (2020–21) data on IDPs, refugees and stateless people by subnational division, **areas with the most displaced people include Central Aran, Karabakh, Absheron-Khizi and Baku, followed by Ganja-Dashkasan and most of Georgia**.[67] However, this available subnational data does not distinguish between conflict-induced and disaster-induced displacement. In Georgia, **conflicts in South Ossetia (1991–92), Abkhazia (1992–93) and both areas (2008) resulted in 311,000 people living in protracted internal displacement as of 2023**, with at least 10,000 displaced by the last major conflict.[68] People displaced from Abkhazia settled mainly in nearby Samegrelo-Zemo Svaneti, Imereti, and the cities of Tbilisi and Batumi (Adjara), while people displaced from South Ossetia settled primarily in adjacent areas of Shida Kartli.[69] While outcomes generally improved for IDPs rehoused by the government after 2007, tens of thousands still live in housing with unsafe health conditions and receive insufficient income assistance. **The Nagorno-Karabakh conflict resulted in 658,000 people living in protracted internal displacement or in temporary housing** in Azerbaijan as of 2023, with 84,000 people displaced since late 2020.[LXXXVIII] Despite the aim of the Azerbaijani government's AZN 5.26 billion (€2.95 billion) Great Return Programme to rehouse 140,000 IDPs in reclaimed Nagorno-Karabakh, it cannot easily reintegrate occupied land due to the 1.5 million mines and unexploded remnants of war left behind by the conflict.[70] These remnants not only endanger the physical and mental health of returnees, but also degrade soil, water and biodiversity, while rendering large areas inaccessible to reconstruction efforts, and forcing many returnees to reside in Baku (Absheron) and surrounding urban areas.[71] Because floods and landslides disrupt mines, climate impacts further delay demining efforts, which are expected to take 30 years.[72] After 2020 and 2022, 7,600 people were internally displaced from Armenia's provinces of Gegharkunik, Vayots Dzor and Syunik.[73] Following the 2023 conflict, one in every 30 Armenian residents is a refugee from territory that has since been reintegrated into Azerbaijan.[74] More than half of refugees settled in Yerevan. However, because many still experience barriers to employment, climate-related shocks and stresses disproportionately affect their livelihood opportunities and income-generating activities (e.g., in the agricultural sector).

Disaster-induced displacement risks, primarily caused by flooding or geological hazards, generally increase at the subnational level, and disproportionately affect IDPs living in inadequate housing, with limited access to basic services and few income-generating opportunities (see Floods and Droughts, and Critical Infrastructure and Economy sections). Two of the largest hazard-induced displacement events in Azerbaijan were the 2010 floods and 2012 earthquake, which displaced approximately 32,000 and 36,000 people, respectively.[75] Regions with the highest and increasing riverine flood risk by mid-century include the Inguri (Abkhazia), Lower Rioni (Samegrelo-Zemo Svaneti and Guria) and Kura-Aras Lowland (Aran). Additionally, the greatest precipitation-driven increases in mudslide and landslide risks by mid-century occur in western Georgia and Shaki-Zaqatala in Azerbaijan, and eastern Georgia, northern and southern portions of Armenia, and montane regions of Azerbaijan, respectively. IDPs in western Georgia – who live in substandard housing conditions, and have limited livelihood and employment opportunities – face higher exposure to combined flood and geological hazard impacts. High and increasing flood risks across reintegrated territories of Azerbaijan, in addition to increasing landslide risks across Kalbajar-Lachin and its border areas with Syunik, further elevate mine hazard risks in areas slated for future IDP resettlement.

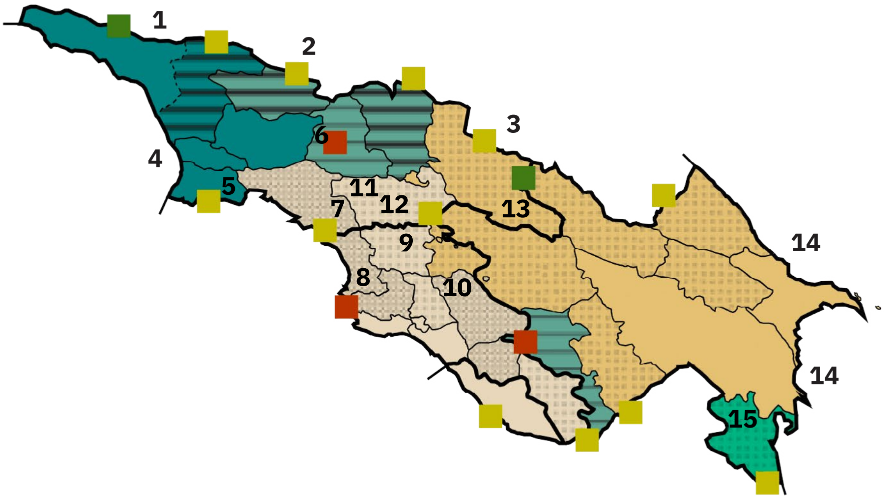
LXXXVIII Almost 4,400 displaced people returned to territory occupied by Azerbaijan in 2020. See IDMC (2023). Country Profile: Azerbaijan. Internal Displacement Monitoring Centre. URL: https://www.internal-displacement.org/countries/azerbaijan/

Ecosystems

Terrestrial and aquatic ecosystems in the South Caucasus face growing risks from warmer mean and extreme temperatures, droughts, wildfires, and floods, especially because many sensitive landscapes transverse political boundaries and lack adequate protection. The Caucasus Ecoregion, a global biodiversity hotspot spanning more than 240,000 km^2 of habitat, hosts more than 150 mammal, 400 bird, 200 fish, nearly 100 reptile and amphibian, and 6,500 vascular plant species.[LXXXIX] The region **maintains the highest levels of unique plant species for a temperate climate globally**, and is particularly important because many plant species inhabiting the Black Sea (Colchic) and Caspian (Hyrcanian) regions survived the last ice age.[76] **Forests span roughly one-fifth of the region and roughly 40% of Georgia, protecting against floods and landslides**.[XC77] The highest mountain elevations of the Greater Caucasus (> 2,000 m above sea level) are mostly in Georgia, and feature alpine meadows and sensitive glacier-fed habitat. In Armenia, the majority of forested areas (e.g., beech and oak) are located in the north, with dry shrubland, mountain steppe and subalpine meadows at higher elevations of the Armenian Highland.[78] In Azerbaijan, broadleaf forests occupy the Greater and Lesser Caucasus mountains, and the Talysh Mountains (Lankaran).[79] The Caucasus' diverse landscapes provide critical ecosystem services and economic benefits, while also offering less tangible cultural services due to their spiritual and religious, inspirational (e.g., folkloric), aesthetic, communal, medicinal, educational, and historical value.

LXXXIX The Caucasus biodiversity hotspot encompasses 13 conservation landscapes and seven bridging landscapes (defined as critical for wildlife connectivity, but not large enough to satisfy all criteria of conservation landscapes). Of the 13 conservation landscapes, three remain entirely outside the South Caucasus countries (Kuma-Manych in Russia, Sarikamish-Maku in Türkiye and Iran, and Arasbaran in Iran). Of the seven bridging landscapes, two remain entirely outside the South Caucasus countries (Sarikamish-Posof and Aras in Türkiye). See Zazanashvili, N., G. Sanadiradze, M. Garforth, M. Bitsadze, K. Manvelyan, E. Askerov, M. Mousavi, V. Krever, V. Shmunk, S. Kalem and S. Devranoğlu Tavsel, eds. (2020). Ecoregional Conservation Plan for the Caucasus: 2020 Edition. Tbilisi: WWF and KfW. URL: https://wwfeu.awsassets.panda.org/downloads/ecp_2020_part_1_1.pdf; CEPF (2004). Ecosystem Profile: Caucasus Biodiversity Hotspot. Critical Ecosystem Partnership Fund. URL: https://www.cepf.net/sites/default/files/final.caucasus.ep_.pdf

XC See Floods and Droughts, and Critical Infrastructure and Economy sections for subnational details on floods and landslides. See also Rucevska, I. (2017). Climate Change and Security in the South Caucasus: Republic of Armenia, Republic of Azerbaijan and Georgia Regional Assessment. OSCE and Grid Arendal. URL: https://www. osce.org/files/f/documents/3/1/355546.pdf CEPF (2004). Ecosystem Profile: Caucasus Biodiversity Hotspot. Critical Ecosystem Partnership Fund. URL: https://www.cepf.net/sites/default/files/final.caucasus.ep_.pdf



(2, 3) Reduction of high mountain habitat in central Greater Caucasus in Georgia
(10, 13) Expansion of desertification risk across most of Azerbaijan, Kakheti in Georgia, and Tavush in Armenia
(15) Reduction of endemic Hyrcanian forest habitat in Lankaran in Azerbaijan
(1, 13) Highest level of transboundary protection between Abkhazia and Russia, and Kakheti in Georgia and Shaki-Zaqatala in Azerbaijan
(6, 8) Greatest need for transboundary protection between Shida Kartli in Georgia and South Ossetia, northwest Armenia and Türkiye, and southeast Armenia and Kalbajar-Lachin in Azerbaijan

- High Landslide and Mudslide Risk
- Highest Increase in Landslide and Mudslide Risk by 2050
- Highest Increase in Landslide Risk by 2050
- Highest Increase in Mudslide Risk by 2050
- Significant Landslide and Mudslide Risk
- Highest Increase in Landslide Risk by 2050
- Highest Increase in Mudslide Risk by 2050
- Significant Mudslide Risk
- Significant Landslide Risk
- Highest Increase in Landslide Risk by 2050

- Some Boundary-Area Ecosystem Protection
- Inadequate Boundary-Area Ecosystem Protection
- Strict Boundary-Area Ecosystem Protection

Figure 12. Projected Subnational Shifts in Major Ecosystem Types across the South Caucasus under SSP3-7.0 by Mid-century, with Current Borderland Ecosystem Protection Statuses.[XCI] Note that shifts document generalised trends that may progress at varying timescales subnationally. Under the SSP1-2.6 scenario, such trends may experience relative delays and reduced expansion by mid-century.

XCI Sourced by author using MapChart and the World Bank's 2019 World Subnational Boundaries data catalogue. Note: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines represent Abkhazia's border with Samegrelo-Zemo Svaneti as approximate and contested. Currently dominant ecosystem types and projected shifts based on information provided by national climate communications, corroborated by CMIP6 data under the Projected Climate section, while location and relative protected statuses of priority ecoregions and corridors based on the WWF's recent assessment. Key: 1=western Greater Caucasus (Abkhazia and Russia), 2=central Greater Caucasus (Samegrelo-Zemo Svaneti, Racha-Lechkhumi-Kvemo Svaneti, Shida Kartli [South Ossetia], Mtskheta-Mtianeti and Russia), 3=eastern Greater Caucasus (Mtskheta-Mtianeti, Kakheti, Shaki-Zaqatala, Daghlig-Shirvan, Guba-Khachmaz and Russia), 4=Kolkheti (Samegrelo-Zemo Svaneti, Guria, Imereti, Adjara), 5=western Lesser Caucasus (Adjara, Guria, Imereti, Samtskhe-Javakheti, Shida Kartli and Türkiye), 6=Likhi (Imereti, Shida Kartli [South Ossetia]), 7=South Caucasus (Samtskhe-Javakheti, Kvemo Kartli, Shirak, Lori and Türkiye), 8=Aragats (Armavir, Aragatsotn), 9=Bazum (Lori), 10=eastern Lesser Caucasus (Lori, Tavush, Kotayk, Gegharkunik, Ararat, Vayots Dzor, Syunik, Nakhchivan), 11=Trialeti-Gombori (Shida Kartli, Mtskheta-Mtianeti, Kakheti), 12=Algeti-Loqi (Kvemo Kartli), 13=Iori-Mingachevir (Kvemo Kartli, Kakheti, Shaki-Zaqatala, Ganja-Gazakh, Aran), 14=Caspian (Guba-Khachmaz, Absheron, Aran, Lankaran, Russia and Iran), 15=Hyrcan (Lankaran and Iran). For sources, see Armenian Ministry of Environment (2020). *Fourth National Communication on Climate Change under the UNFCCC*. Yerevan: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf; Azerbaijan Ministry of Ecology and Natural Resources (2021). *Fourth National Communication to the UNFCCC*. Baku: UNDP and GEF. URL: https://unfccc.int/documents/299472; Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf; Zazanashvili, N., G. Sanadiradze, M. Garforth, M. Bitsadze, K. Manvelyan, E. Askerov, M. Mousavi, V. Krever, V. Shmunk, S. Kalem and S. Devranoğlu Tavsel, eds. (2020). Ecoregional Conservation Plan for the Caucasus: 2020 Edition. Tbilisi: WWF and KfW. URL: https://wwfeu.awsassets.panda.org/downloads/ecp_2020_part_1_1.pdf

As depicted in **Figure 12**, **future temperature increases threaten** to vertically shift the ranges of forest and wildlife characteristic of lower elevations, while generally drier conditions favour the expansion of thinner, more arid forests.[80] In Georgia, this entails **changes in existing forest composition and distribution at lower elevations, and an upward shift in forestland at the expense of high alpine meadows across the western Greater Caucasus.**[XCII] **Increasing mean temperatures and decreasing seasonal precipitation particularly endanger species adapted to high elevations,** at risk of further degradation from activities such as infrastructure development, unsustainable timber harvesting and overgrazing livestock.[81] In Armenia, **semidesert and steppe vegetation at the lower boundaries of forestland stand to expand in area, increasing the risk of desertification**. The expansion of drier and more heat-tolerant vegetation in regions such as Samtskhe-Javakheti and Kakheti in Georgia, as well as Tavush and Aragatsotn in Armenia demonstrates how future shifts in ecosystems coincide with subnational shifts in climate under SSP3-7.0 by mid-century in Figure 4. However, the rate and extent of processes, such as desertification and high-mountain forest succession, depend on the climate scenario and sustainability of resource-intensive activities, such as livestock grazing and fuelwood harvesting. Increasing temperatures and decreasing precipitation also endanger aquatic biodiversity in Lake Sevan (Gegharkunik in Armenia), the largest freshwater lake in the Caucasus, which already faces risks of eutrophication from agricultural and domestic wastewater pollution.[82] **However, temperature-driven changes exhibit greater model agreement than precipitation-driven changes.**

Higher temperatures and reduced precipitation – particularly in summer – raise the risk of fire weather conditions across forests not well-adapted to frequent wildfires.[83] Fires may ignite due to natural causes (e.g., lightning) or human activities (e.g., burning crop residue), and in recent years have become more frequent, burning larger areas of land. Forest fires in Armenia, which increased sixfold in number and eightfold in total area burned between 2001–09 and 2010–18, particularly threaten the provinces of Kotayk and Syunik during hotter, drier summers.[84] Similarly in Georgia, the average number of forest fires per year rose from 14 in 2007–11 to 64 in 2017–21.[85] Areas of increased wildfire, and pest and disease risks in the near and medium term include the woodlands surrounding the Likhi Range (Imereti and Shida Kartli), Borjomi-Kharagauli National Park (Samtskhe-Javakheti and Imereti), higher-elevation forests in Adjara, and more arid forests in Kakheti and eastern Kvemo Kartli.[XCIII] Many of these locations feature steep slopes and limited accessibility that may further hamper fire mitigation efforts.[XCIV]

Increasing sea surface temperatures off the Black Sea coast and fluctuating extent of the Caspian Sea additionally threaten estuaries, swamps, wetlands and migratory waterfowl.[XCV] Mean sea surface temperatures off Georgia's Black Sea coast are warmer than many other parts of the basin (approximately 17°C between 1982 and 2020) and increased by 0.65–0.70°C per decade over this period.[86] Marine heat waves, which are more frequent during El Niño events, have already led to mass die-offs of molluscs and other coastal species, impacting beach and marine tourism, and fisheries off the coasts of Poti and Batumi.[87] The Middle and South Caspian basins (north and south of the

XCII Forests along lower elevations of the Greater and Lesser Caucasus mountains currently comprise of mixed broadleaf (beech, oak, chestnut, hornbeam) and coniferous (spruce, fir) trees. Eastern Georgia and northern Azerbaijan possess subhumid pine forests, whereas juniper and pistachio woodlands occupy plains and foothills See Zazanashvili, N., G. Sanadiradze, M. Garforth, M. Bitsadze, K. Manvelyan, E. Askerov, M. Mousavi, V. Krever, V. Shmunk, S. Kalem and S. Devranoğlu Tavsel, eds. (2020). Ecoregional Conservation Plan for the Caucasus: 2020 Edition. Tbilisi: WWF and KfW. URL: https://wwfeu.awsassets.panda.org/downloads/ecp_2020_part_1_1.pdf; CEPF (2004). Ecosystem Profile: Caucasus Biodiversity Hotspot. Critical Ecosystem Partnership Fund. URL: https://www.cepf.net/sites/default/files/final.caucasus.ep_.pdf

XCIII These regional projections relied on temperature and precipitation data before the release of CMIP6 products. However, the climate trends and localised wildfire sensitivity analysis generally comport with the CCKP's latest near and medium-term trends under SSP3-7.0. See Gaprindashvili, M., E. Tsereteli, I. Megrelidze, G. Lominadze, N. Shatirishvili, M. Margvelashvili et al. (2016). The Georgian Roadmap on Climate Change Adaptation. Tbilisi: National Association of Local Authorities of Georgia. URL: https://www.researchgate.net/publication/337286978_The_Georgian_Road_Map_on_Climate_Change_Adaptation

XCIV In fact, over two-thirds of Georgia's forests occupy sloped topography (> 1,000 m above sea level). See Georgian Ministry of Environmental Protection and Agriculture (2021). Fourth National Communication of Georgia under the UNFCCC. Tbilisi: UNDP and GEF. URL: https://unfccc.int/sites/default/files/resource/4%20Final%20Report%20-%20English%202020%2030.03_0.pdf; UN Environment Programme (2024). *Caucasus Environment Outlook*. Second Edition. Tbilisi and Vienna: Grid Arendal. URL: https://www.grida.no/publications/946

XCV Notable protected areas for waterfowl and fisheries currently include the Ghizil-Agaj State Reserve (Lankaran), and Kolkheti and Kobuleti peat wetlands (Samegrelo-Zemo Svaneti, Guria, Adjara). See Zazanashvili, N., G. Sanadiradze, M. Garforth, M. Bitsadze, K. Manvelyan, E. Askerov, M. Mousavi, V. Krever, V. Shmunk, S. Kalem and S. Devranoğlu Tavsel, eds. (2020). Ecoregional Conservation Plan for the Caucasus: 2020 Edition. Tbilisi: WWF and KfW. URL: https://wwfeu.awsassets.panda.org/downloads/ecp_2020_part_1_1.pdf

Absheron Peninsula, respectively), meanwhile, feature seasonal dynamics that vary interannually. Average sea surface temperatures range from 4°C to 8°C in February moving north to south along Azerbaijan's coast, and from 24°C to 27°C in August.[88] By mid-century, annual best-estimate sea surface temperate increases above the 1995–2014 baseline by 1.33°C off the coast of Georgia and 1.61°C off the coast of Azerbaijan under SSP1-2.6, and by 1.68°C and 2.08°C, respectively, under SSP3-7.0.[XCVI] Due to generally increasing air temperatures, decreasing precipitation, and current levels of domestic, industrial and agricultural wastewater, the Caspian coast may experience increased nutrient concentrations.[89] This particularly endangers spawning areas for 90% of global sturgeon populations, prized for caviar production, and already threatened by overfishing and offshore oil activities.[90]

Climate impacts particularly threaten species and habitat without adequate protected space to migrate to more suitable areas in the future, accentuating the need for coordination across international borders. As of 2020, the Caucasus Ecoregion encompassed 362 protected areas, covering 10% of the region's total area. However, protection levels vary across sites and may not fully capture larger-scale ecological processes.[XCVII] According to the WWF, countries in the Caucasus Ecoregion (including Russia, Türkiye and Iran) offer some level of protection to 37% of key identified biodiversity areas.[91] Azerbaijan protects a larger percentage of identified key biodiversity areas (52%), compared to Armenia (36%) and Georgia (31%). However, only 6% of the entire region's key biodiversity areas possess the strictest conservation status. International and disputed border areas containing biodiverse ecoregions or corridors that benefit from the strictest protection status (see Figure 12) include those between Abkhazia and Russia, and between Kakheti in Georgia and Shaki-Zaqatala in Azerbaijan. The transboundary areas of ecological importance in need of greater protection include corridors between Shida Kartli and South Ossetia in Georgia, northwest Armenia and Türkiye, and southeast Armenia and Kalbajar-Lachin in Azerbaijan.

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XCVII Defined by the IUCN, a protected area "is a clearly defined geographical space, recognised, dedicated and managed through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values." IUCN protected area categories refer to the extent of human disturbance in an area's long-term conservation. These range from strict nature reserves with little human influence (e.g., research activities); to habitat, species or management areas, with guaranteed protection for only certain biota within a much larger area; to national parks, with a greater number of permitted activities (e.g., tourism and, sustainable economic use). See Zazanashvili, N., G. Sanadiradze, M. Garforth, M. Bitsadze, K. Manvelyan, E. Askerov, M. Mousavi, V. Krever, V. Shmunk, S. Kalem and S. Devranoğlu Tavsel, eds. (2020). Ecoregional Conservation Plan for the Caucasus: 2020 Edition. Tbilisi: WWF and KfW. URL: https://wwfeu.awsassets.panda.org/downloads/ecp_2020_part_1_1.pdf

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