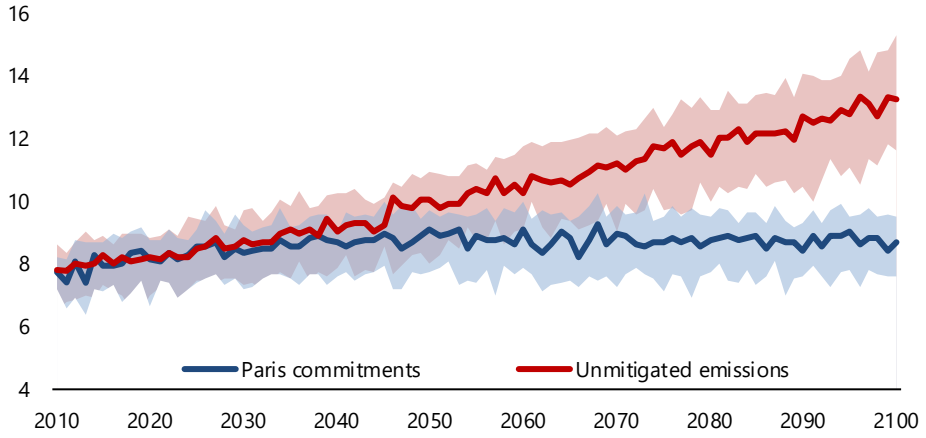
I. CLIMATE CHANGE AND ARMENIA

A. Climate Change Risks in Armenia[1]

1. The average temperature in Armenia has already increased by 1.2 degrees Celsius[2] since the 1990s and is projected to continue rising by more than the global average. Under the Representative Concentration Pathway (RCP) 8.5 or 'unmitigated' emissions scenario,[3] Armenia's average annual temperature is projected to rise by around 5.6 degrees above the 1990s average by the 2090–2100 decade (Figure 1), placing it in the third quartile of temperature rises by country. This would also be around 4.1 degrees higher than the RCP 2.6 scenario where commitments under the Paris Agreement are met. Even under the more modest RCP 6.0 scenario, the average annual temperature is projected to rise by around 3.5 degrees, which is equivalent to the projected rise in the global average temperature under the unmitigated scenario. Under the unmitigated scenario, the number of summer days is projected to increase, and the number of frost and ice days are expected to fall, in both cases substantially, by 2100.

Figure 1. Annual Average Temperature Projections for Armenia
(Degrees Celsius)



Source: World Bank Group, Climate Change Knowledge Portal.
Note: Shaded area covers the 10 to 90 percentile band.

2. The impact of climate change on temperatures and precipitation in Armenia is projected to be variable across seasons. This reflects historical experience; between 1966 and

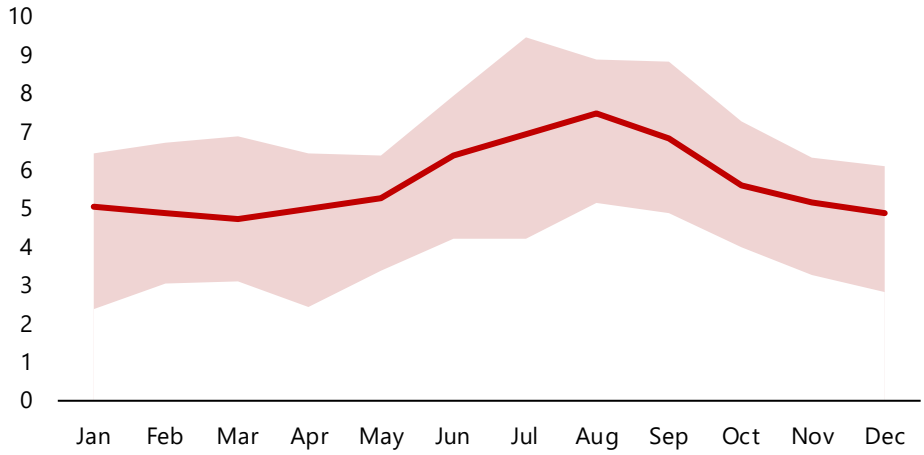
[1] In this report, weather refers to atmospheric conditions over short periods of time (e.g., temperature and precipitation) and climate refers to the long-term average and variability of weather. Climate change is a shift "in the state of the climate that can be identified (e.g., via statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2014).

[2] The temperature projections and history are drawn from the World Bank's Climate Knowledge Portal, and specifically the Coupled Model Intercomparison Project 5 Multi-Model Ensemble Projections.

[3] A Representative Concentration Pathway or RCP is a GHG concentration trajectory that is published by the Intergovernmental Panel on Climate Change and used by climate change research and policy institutions. Different RCPs describe different climate futures, all considered possible depending on the volume of GHG emitted in the years to come. The RCP 8.5 scenario is considered an extreme emissions scenario which is associated with fast global economic growth and carbon intensive energy use.

2016, the average summer temperature rose by around 1.3 degrees, with extremely hot summers observed in 2000, 2010, and 2015, whereas over the same period, winter temperatures only rose by 0.4 degrees. Under the unmitigated scenario, the average summer temperature is projected to be 7 degrees higher in 2090-2100 than the 1990s, whereas the average winter temperature is projected to be around 5 degrees higher (Figure 2). This more extreme rise in summer months is also observed on projections under the RCP 6.0 scenario.

Figure 2. 2080–2100 Average Temperature Increase Above 1990–2000 Baseline
(Degrees Celsius)



Source: World Bank Group, Climate Change Knowledge Portal.
Note: Shaded area covers the 10 to 90 percentile band.

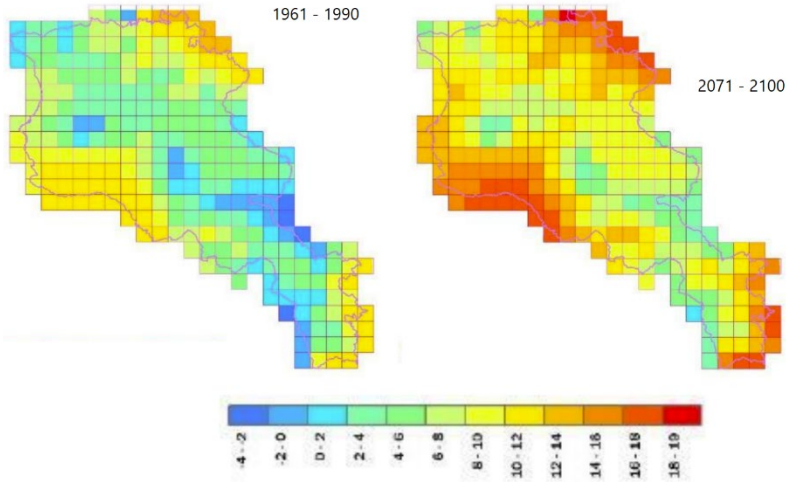
3. While the rise in temperature is projected to be fairly consistent across the country, different marzes (regions) are projected to experience varying reductions in precipitation. The temperature increase under the unmitigated scenario is projected to be slightly higher in Ararat, Vayots Dzor, and Syunik than in other marzes, although the average annual temperature in the key agricultural marzes of Ararat, Tavush and Syunik valleys is projected to rise from 10–14 degrees to 16–18 degrees, with greater increases in summer (Figure 3). The largest projected falls in precipitation in the unmitigated scenario are in Ararat, Kotayk, and Gergharkunik (the immediate catchment area for Lake Sevan), but precipitation is projected to fall in all marzes (Figure 4). Increased temperatures and reduced precipitation in these agricultural valleys would exacerbate aridity and be a threat to the viability of the sector.

4. Climate change is likely to reduce water flows in some rivers and lead to a fall in the level of Lake Sevan. Most rivers in Armenia do not have a constant flow and dry out in the summer, with around 55 percent of the total annual river flow formed by snowmelt and precipitation in spring. The projected fall in precipitation under the unmitigated scenario would lead to a higher reduction in water flow of as much as 39 percent by 2100. Water flows into Lake Sevan would fall by a third, and the flow into some reservoirs would fall by more than half.[4]

[4] Armenia's Fourth National Communication on Climate Change (2021). https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf.

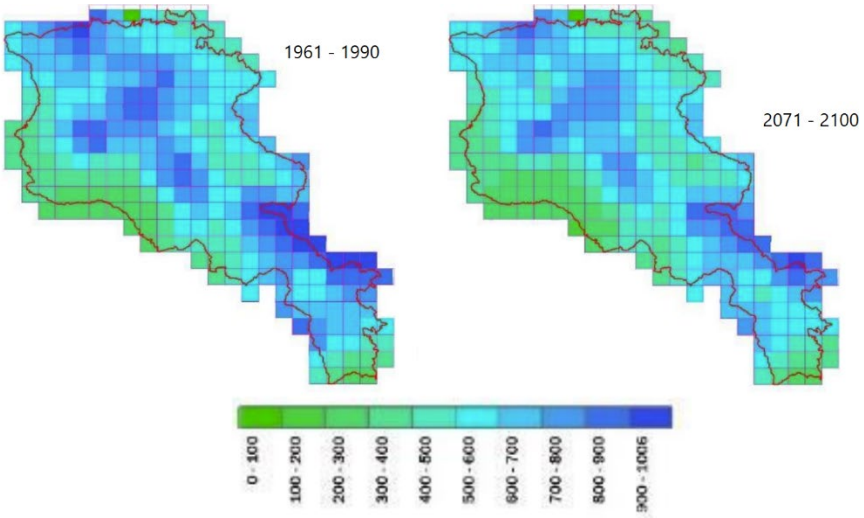
While water flows are expected to fall across the country, some rivers may see more stability or even an increase in water flow. The Vorotan and Voghji river basins are two examples where an increase in precipitation is possibly outweighing faster rates of evaporation.[5]

Figure 3. Temperature Changes in the Unmitigated Scenario



Source: Armenia's Fourth National Communication on Climate Change (2021).

Figure 4. Precipitation Changes in the Unmitigated Scenario



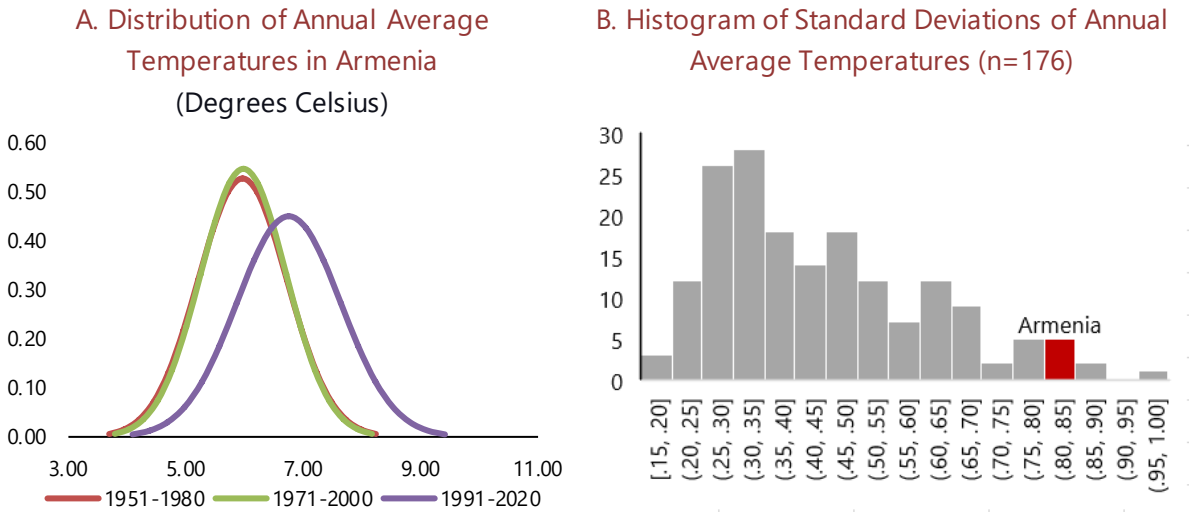
Source: Armenia's Fourth National Communication on Climate Change (2021).

5. Temperature variations from year to-year in Armenia are high compared to other countries, and variability has been rising. Temperature variability is an important predictor of income loss under climate change scenarios because this variability increases the likelihood of

[5] Stanton, et. al, (2008), "The Socio-Economic Impact of Climate Change in Armenia", Stockholm Environment Institute. https://www.undp.org/armenia/publications/socio-economic-impact-climate-change-armenia,

extreme events (the right tail of the distribution reaches higher temperatures) and because it makes it more difficult for firms and households to plan. Between 1971–2000 and 1991–2020, both the mean and standard deviation of average annual temperatures have risen (Figure 5, Panel A). Only three countries have a reported higher variance of temperatures than Armenia (Figure 5, Panel B).

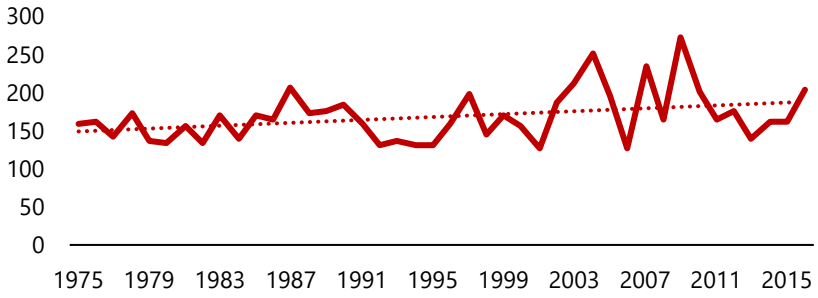
Figure 5. Variance in Annual Average Temperatures



Source: World Bank Group, Climate Change Knowledge Portal and Kahn et. al (2021).
Note: Red highlighted group in Panel B includes Armenia.

6. The frequency of climate-related natural disasters has been rising in Armenia (Figure 6). The most observed hazardous phenomena in Armenia during the period of 1975–2016 were frost, hailstorms, strong winds and extremely heavy rainfalls. The length of droughts each year has increased by 33 days over the period between 2000 and 2017, with the boundary of the drought zone expanding to now also include mountainous areas (UNFCC). From 1935 to 2016, average annual precipitation decreased by 9 percent.

Figure 6. Frequency of Climate-Related Natural Disasters in Armenia

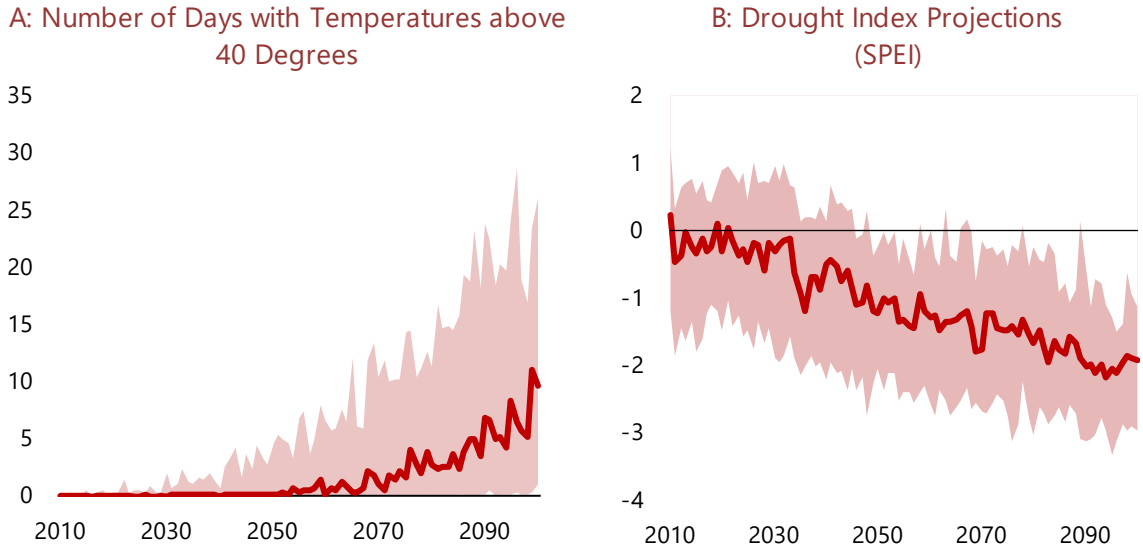


Source: Armenia's Fourth National Communication on Climate Change (2021).

7. With increased temperatures and rising temperature volatility, Armenia will see an increase in climate-related natural disasters. The most serious effects of climate change in Armenia are expected to be an increase in severe drought, and an increase in extreme

precipitation events, leading to more mudslides and landslides. Under the unmitigated scenario, Armenia is projected to become substantially drier, with the SPEI[6] index reaching -2 (or severe drought conditions) by the end of the century (Figure 7.A). The high and increasing year-to-year variation (Figure 7.B) is also likely to lead to an increase in extreme weather events at the right tail of the distribution, increased health problems, lower productivity, drought related water and food shortages, damage to infrastructure, and disruption in supply chains.

Figure 7. Extreme Temperatures and Droughts
(Unmitigated scenario)



Source: World Bank Group, Climate Change Knowledge Portal
Note: SPEI is the Standardized Precipitation Evapotranspiration Index. Negative (positive) values are increasingly dry (wet) conditions. Shaded area covers the 10 to 90 percentile band.

8. International indices suggest Armenia is in the mid-to-high range of exposure to climate-related risks. The European Commission's INFORM Risk Index[7] (which rates broad disaster-related risks) ranks Armenia as a high-risk country, while the Notre-Dame Global Adaptation Initiative Index (ND-GAIN)[8] ranks Armenia 52nd least vulnerable out of 181 countries, with above-average readiness. The ND-GAIN index notes Armenia is anticipating mounting challenges in managing the impact of increased climate-related weather events on water resources, infrastructure, and climate-sensitive industries like tourism, but that it is well-placed to adapt to these challenges noting recent improvements in regulatory quality, the rule of law, the control of corruption, and an improving business environment.

[6] Standardized Precipitation Evapotranspiration Index.

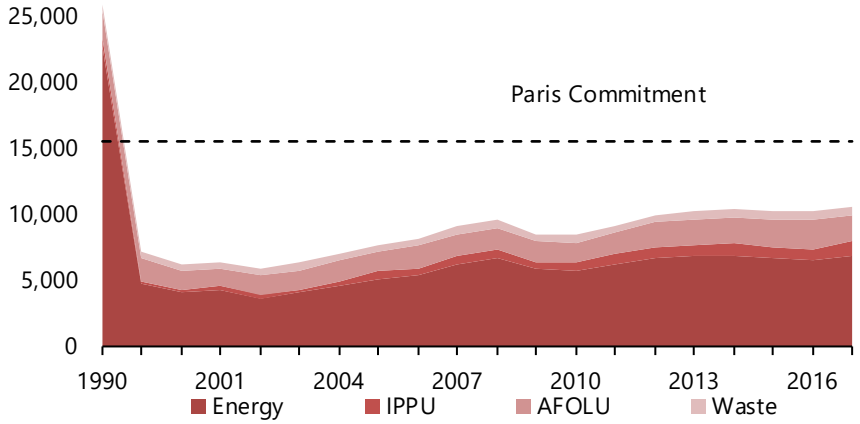
[7] https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Country-Risk-Profile.

[8] Notre Dame Global Adaptation Initiative, ND-Gain Index: https://gain.nd.edu.

B. Climate Change Commitments and Framework

9. Armenia has pledged to reduce emissions to 40 percent below the emission levels in 1990 by 2030, though emissions have been well below this level for the past twenty years.[9] Total greenhouse gas (GHG) emissions in the 1990 were 25.9 million GHG CO_2 equivalent tons. In 2017, total GHG emissions were 10.6 million GHG CO_2 equivalent tons, or around 60 percent below the emissions level of 1990, and well below the target for 2030 (Figure 8). This largely reflects the sharp reduction in GHG emissions following the deindustrialization, emigration, and structural change in Armenia following the break-up of the Soviet Union in the early 1990s. GHG emissions have been growing by an annual average rate of 3.2 percent per year since 2000.

Figure 8. Mitigation Target and GHG levels – 1990 to 2017
(GHG CO_2 equivalent tons ,000s)

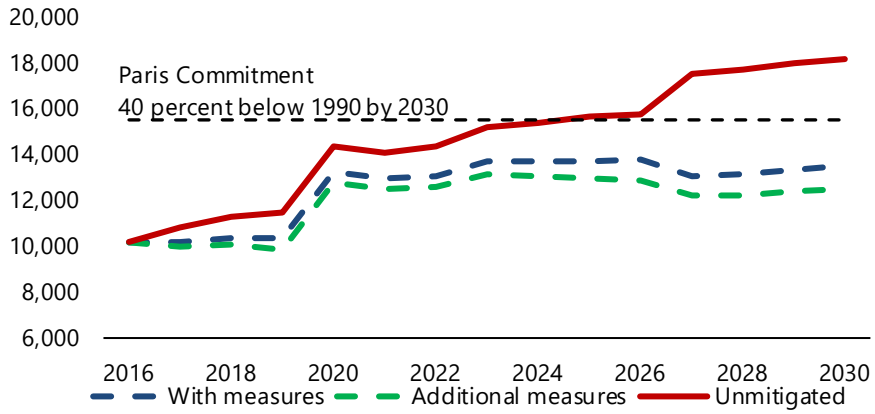


Source: National Greenhouse Gas Inventory Report of Armenia 1990-2017.
https://unfccc.int/sites/default/files/resource/NIR_2017_Armenia.pdf
Note: IPPU is Industrial Processes and Product Use. AFOLU is Agriculture, Forestry and Other Land Use.

10. GHG emissions are dominated by those from the energy sector, which are forecast to rise further in the coming years. In 2018, 65 percent of primary energy supplies came from natural gas, and another 10 percent came from oil products. The energy sector produced over 95 percent of all CO_2 emissions in 2017 (or 66 percent of all GHG emissions), reflecting the high emissions volume from thermal power plants in the country. Energy emissions are expected to have risen in 2020 with the installation of a large new thermal power plant, and are projected to rise in the coming years with the increasing demand. To mitigate these emissions, Armenia is planning the construction of a new nuclear power plant as well as smaller hydroelectric power plants across the country. If these measures are not taken, Armenia is likely to exceed its GHG target under the Paris Agreement (Figure 9).

[9] Nationally Determined Contribution 2021-2030 of the Republic of Armenia to the Paris Agreement.
https://www4.unfccc.int/sites/NDCStaging/Pages/Party.aspx?party=ARM&prototype=1

Figure 9. Projection of GHG Emissions with Energy Mitigation Scenarios
(GHG CO_2 equivalent)



Source: National Greenhouse Gas Inventory Report of Armenia 1990-2017, Armenia's Fourth National Communication on Climate Change (2021), and Staff estimates.

11. Armenia produced its first National Adaptation Plan in 2021, but this plan remains limited in scope, providing only an overview of institutional actions to build resilience to climate change across the country. The National Adaptation Plan lists 26 measures to (a) introduce and enhance the National Adaptation Plan process in Armenia and (b) enhance institutional and technical capacity for the National Adaptation Plan process, with an assessed cost of AMD560m (0.01 percent of gross domestic product (GDP)). However, the plan does not contain any specific actions to build resilience and adapt to climate change. Instead, the plan focuses on the early processes of establishing the technical capacity to assess risks and needs. Among these actions, several have relevance for fiscal risk management, including (a) Action 2.1: The development of the guideline on integration of climate-related risk management considerations into sectoral and regional development strategies; and (b) Action 2.4: The mapping and development of a database on climate-change related risks. Both of these actions were originally due to be completed in early 2022 but have been delayed and are not expected to be completed until 2023.[10]

[10] Republic of Armenia National Adaptation Plan, 2021. https://unfccc.int/sites/default/files/resource/NAP_Armenia.pdf.

II. FISCAL RISKS FROM CLIMATE CHANGE

A. The Nature of Climate Change Fiscal Risks

12. Climate change can affect the main drivers of economic growth by causing both supply and demand side vulnerabilities. A persistent rise in temperature, changes in precipitation patterns and more volatile weather events can have long-term macroeconomic effects by adversely affecting labor productivity, slowing capital accumulation, and damaging human health (Kahn et al. 2021 – see Box 1).[11] Supply side vulnerabilities include potential impacts of climate change on productivity, land, capital, and labor. Table 1 provides examples of transmission channels as used by the European Commission to analyze the potential impact of climate change on debt sustainability. The demand side could be impacted via consumption, investment, and trade effects. Some demand side effects will be temporary, but others may also persist via an ongoing reallocation of resources from productive capital to adaptation investment, which would mean less consumption. Supply side effects may result in positive developments because of an increased availability of resources, such as higher agricultural yields following on innovation stimulated by new climate-resilient technologies.

Table 1. Armenia: Transmission Channels to Supply Side

	Land	Capital	Productivity	Labor volume
Extreme weather event	Landslides resulting in production input shortages.	Infrastructure degradation.	Deterioration in population health.	Human life losses/mortality rates
Gradual transformation of the environment	• Land degradation with reduction in agricultural potential. • Scarce land resources in some regions.	• Faster depreciation of machinery equipment. • Reallocation of resources from productive capital to adaptation investment	• Health care issues • Reduced human performance due to higher temperature. • Resource reallocation to new technologies.	• Loss of hours worked due to extreme temperatures. • Employment and social impacts of climate change policies, resource reallocation.

Source: European Commission (2020): Debt Sustainability Monitor 2019, institutional paper 120

[11] Kahn M.E., Mohaddes K., Ng R.N.C., Pesaran M.H., Raissi M., and Yang J-C, 2019, *Long-Term Macroeconomic Effects of Climate Change: A Cross-country Analysis*, Energy Economics, 104, pp. 105624/1–13

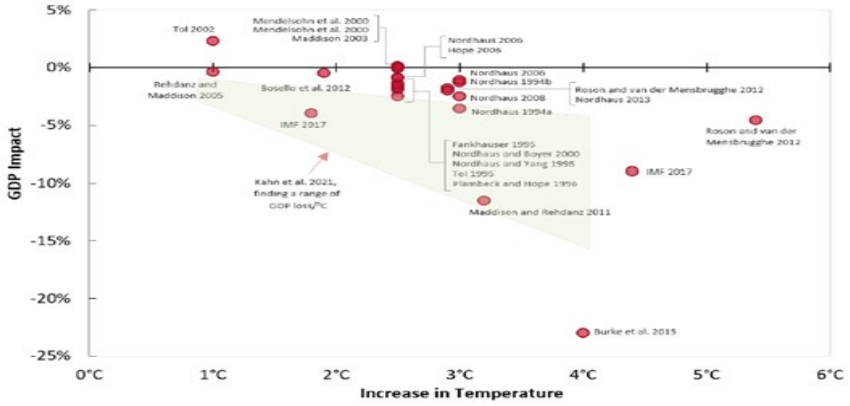
Box 1. Summary of Kahn et al (2021)

The authors estimate the long-term effects of weather patterns transformed by climate change on economic activity across countries. They begin with a theoretical growth model that links "deviations" of temperature and precipitation (that is, weather) from their long-term moving-average historical norms (that is, climate) to growth in real GDP per capita. This theoretical model is then estimated by using data from 174 countries over 1960–2014. Their econometric technique allows for dynamics, nonlinearity, an implicit model for adaptation to climate change, and accounts for the effects on economic activities of changes in the distribution of weather patterns—that is, both averages and variability of temperature and precipitation. They further explore the efficacy of adaptation by tracking the elasticity of per capita GDP to climate variables over time. The key findings include the following.

- Per-capita real output growth is adversely affected by persistent changes in the temperature above or below its historical norm.
- A persistent increase in average global temperature by 0.04 degrees Celsius per year, in the absence of mitigation policies, reduces world real GDP per capita by more than 7 percent by 2100.
- The estimated losses would increase to 13 percent globally if country-specific variability of climate conditions were to rise commensurate with annual temperature increases of 0.04 degrees Celsius.
- Abiding by the Paris Agreement goals, thereby limiting the temperature increase to 0.01 degrees Celsius per year, reduces the loss substantially to about 1 percent.
- While adaptation to climate change can reduce these negative long-run growth effects, it is highly unlikely to offset them entirely.

Figure 10 compares the authors' results with other loss estimates from rising temperatures.

Figure 10. Estimates of GDP Impact from Increases in Temperature



Source: Kahn M.E., Mohaddes K., Ng R.N.C., Pesaran M.H., Raissi M., and Yang J-C, 2019, *Long-Term Macroeconomic Effects of Climate Change: A Cross-country Analysis*, Energy Economics, 104, pp. 105624/1–13.

Annual estimates of GDP losses for each of the countries to 2100 under three different scenarios — the Paris, the unmitigated (with different speed of adaptation), and the volatile scenario —are key inputs in the spreadsheet-based framework used to quantify climate change fiscal risks.

13. Potentially as important as economic impacts, the effects of climate change on public finances can also be expected to materialize via various direct and indirect transmission channels. Direct impacts may occur via increased public spending on subsides, relief measures, repairing or replacing damaged infrastructure and indirect impacts may occur via disruption of economic activity after a major disaster or the materializing of contingent liabilities affecting distressed (non-) financial public and private institutions. Table 2 provides some examples of climate change-related impacts on public finances.

Table 2. Armenia: Climate Change Related Impacts on Public Finances

Non-discretionary impact *Exogenously driven by climate phenomenon*	**Discretionary impact** *Endogenously driven by policies and investments*
Direct • Public spending to replace damaged infrastructure or buildings. • Social transfers to households affected by the natural disaster. • Materialization of explicit contingent liability, e.g., insurance schemes backed by state guarantees.	• Public investments and subsidies to mitigate climate change • Public investments and subsidies to adapt to climate change • Natural disaster emergency spending, compensation financial losses, and repairing and rebuilding assets. • "Rainy days" funds
Indirect • Reduction of tax revenue due to a reduction in economic activity. • Increase of health care spending due to more diseases. • Materialization of implicit contingent liabilities, e.g., support to financial institutions in distress. • Impact on sovereign capacity to pay debt payments obligations over the medium-term, e.g., due to budgetary funds reallocation towards recovery and reconstruction.	

Source: IMF staff &European Commission (2020): Debt Sustainability Monitor 2019, institutional paper 120.

14. Fully fledged climate change fiscal risk analysis should include long-term fiscal sustainability considerations. Usually, fiscal sustainability reports focus on demography-driven spending such as pensions, health care, social assistance, and education. However, the effects of climate change can be expected to affect the ability of a government to sustain its spending and tax in the long run without threatening government solvency or defaulting on any of its liabilities.

B. Approaches to Quantifying Climate Change Fiscal Risks

15. Quantifying the magnitude and the probability of a climate change fiscal risk supports governments to understand the potential fiscal impact and calibrate the response. Countries can draw on a range of complementary techniques to quantify the climate change fiscal risks. These approaches include:

- **Analyzing the long-run effect of climate change on the economy and the consequences for the fiscal position.** This approach identifies the transmission channels of climate change

through to the economy and draws on this analysis to model scenarios of climate change on the economy and fiscal position. This allows a government to establish a view on the scale of adjustment that might be needed under various climate change scenarios. The development of the approach usually starts with the design of a simplified long-run framework that is then gradually developed and refined as new research and information become available. Box 2 presents examples of this approach applied in the United Kingdom and Georgia.

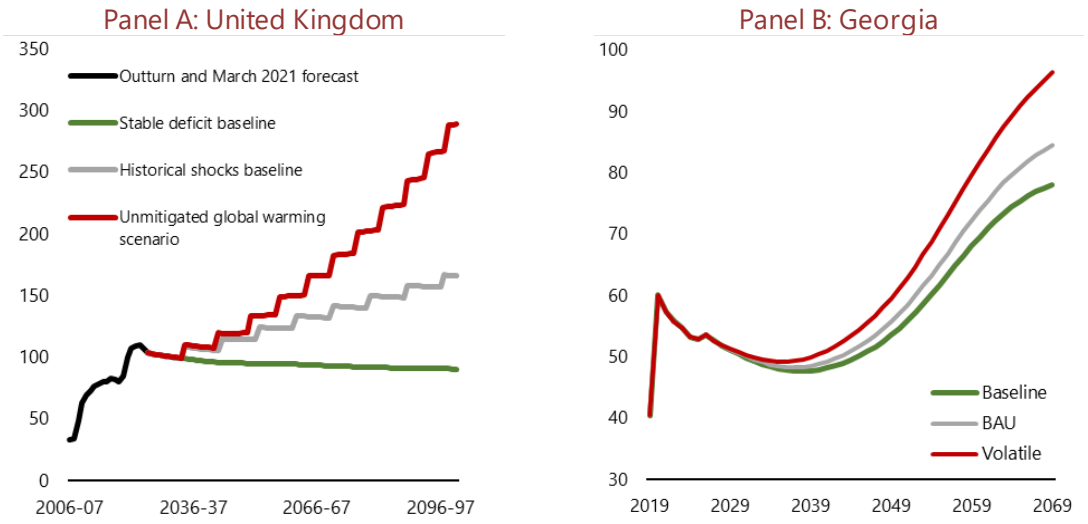
- **Analyzing the potential fiscal impact of climate-change related natural disasters.** When natural disasters, such as flooding or drought, materialize, they tend to (i) reduce fiscal revenue due to lower tax collection resulting from the impact on economic sectors, and (ii) require government spending for post-disasters recovery and rebuilding efforts. Government can quantify the potential impact by analyzing historical and projected vulnerabilities to natural disasters and affiliated economic and budgetary costs.
- **Analyzing other discrete fiscal risks related to climate change.** Governments can analyze the potential impact of climate change on specific vulnerabilities within the government budget. For example, by analyzing the potential budgetary implications of reduced power-generating capacity of hydropower installations because of drought or reduced river flows.
- **Because climate change also affects government assets and liabilities, governments can also quantitively analyze the impact of climate change on their balance sheets.** Natural disasters and gradual changes in the environment, e.g., droughts, could damage or destroy public assets, requiring increased expenditure on maintenance but also increased deprecation rates for public assets because of shorter life cycles.

Box 2. Climate Change Fiscal Risk Analysis in the United Kingdom and Georgia

In its 2021 Fiscal Risk Report, the United Kingdom's Office of Budget Responsibility (OBR) outlines the fiscal implications and fiscal risks related to climate change. The OBR began by creating a simple long-term fiscal baseline for the budget deficit called the 'stable deficit baseline'. Based on historical experiences in the United Kingdom and worldwide, the additional impact of periodic fiscal risks was layered on top of that baseline, creating the "historical shocks baseline." The OBR then added an "unmitigated global warming scenario", which builds on the RCP8.5-scenario and assumes the cost of adaptation to be 0.3 percent of GDP a year. It also assumes the cost of natural disasters is twice as large and natural disasters occur twice as frequently (Figure 10) This simple framework provides illustrative scenarios that illustrate the potential fiscal scale of climate change risks in the United Kingdom.

In Georgia, the Ministry of Finance drew in IMF technical assistance to assess the fiscal impact of climate change from three complementary perspectives. They first examined the growing impact of higher temperatures on the macroeconomy and the consequences for the public finances. They then modelled the fiscal cost of more frequent and severe natural disasters, particularly floods, landslides, and droughts which Georgia is already predisposed to. Third, they qualitatively reviewed climate change-related discrete fiscal risks such long-run power contracts, guarantees and on-lent loans to state-owned enterprises (SOEs) that may be affected by changing weather patterns. Their analysis found that climate change could reduce GDP per capita by 13 percent by the end of the century, and increase public debt levels by 18 percent of GDP, both relative to the baseline.

Figure 11. Illustrative Long Run Fiscal Sustainability Analysis with Climate Change
(percent of GDP)



Source: OBR (2021), Fiscal Risk Report July 2021, and Harris, J., et. al, (2022), "Georgia: Updating the Balance Sheet and Quantifying Fiscal Risks from Climate Change", IMF Technical Assistance Report.

III. QUANTIFYING CLIMATE CHANGE FISCAL RISKS IN ARMENIA

A. Climate Scenarios

16. This report focusses on three key climate scenarios for assessing fiscal risks, while noting that there is a broad range of climate scenarios that can be applied for such analysis. Table 3 summarizes key fiscal indicators under these scenarios over time.

- **The Paris agreement scenario**, where international commitments from the 2015 Paris summit are met. The Intergovernmental Panel on Climate Change describes this scenario as RCP2.6, and its models suggest this is consistent with limiting temperature warming to below 2 degrees Celsius above pre-industrial levels. For Armenia this translates to a 0.5 degree Celsius increase in temperature by the end of this century compared to the 1990s.
- **The unmitigated scenario**, where global GHG emissions continue to increase throughout the century. This scenario would lead to a temperature increase of around 5.5 degrees over the average 1990s level by 2090–2100. This is widely considered to be an extreme warming scenario, rather than a likely scenario, which is appropriate when considering fiscal risks.
- **The unmitigated scenario with high temperature variability, or the volatile scenario**, where the economic impacts of the increased climate volatility is explicitly modelled. That is, the volatile scenario aims to capture the effects of not just a hotter planet that is expected in the unmitigated scenario, but also the higher volatility of weather and increased numbers of

extreme weather events that are likely to occur with climate change. As discussed above, climate volatility is already acute in Armenia, and its effects on economic activities will likely worsen significantly with climate change.[12]

Table 3. Armenia: Key Fiscal Indicators Under Different Climate Scenarios

KEY FISCAL INDICATORS (% of GDP)	2022	2032	2052	2072
Primary Net Lending / Borrowing				
Baseline	-1.0	-0.5	-0.5	-0.5
Paris		-0.5	-0.5	-0.5
Unmitigated		-0.5	-0.8	-1.3
Volatile		-0.8	-2.6	-4.8
Debt				
Baseline	63.7	48.5	40.3	46.7
Paris		48.5	40.3	46.6
Unmitigated		48.7	44.2	61.8
Volatile		49.5	66.0	139.7

Source: IMF staff estimate.

17. Armenia's public finances are likely to gradually worsen over the next half century with climate change. In the unmitigated scenario, the debt-to-GDP ratio reaches 62 percent in 2072, compared with the baseline projection of 47 percent. In contrast, absent any policy change, public finances would be on an unsustainable trajectory over the coming decades with debt reaching 140 percent of GDP by 2072. Exploring such an extreme scenario is useful for fiscal risk analysis as it helps to define a boundary of worst case but plausible possibilities.

18. These results reflect simulations in an analytical framework that links econometric estimates of changing climate patterns on the real economy and with long run fiscal projections. In the baseline scenario (Subsection IIB), nominal GDP growth reflects projections for demography, productivity, and prices. Results from a cross-country econometric estimate of changing climate on the real economy are applied to this baseline under different climate scenarios (Subsection IIIC). Fiscal projections in different climate scenarios reflect lower revenue collections due to slower economic growth, which (in conjunction with assumptions on expenditure) raise net borrowing requirements and debt over time. Further refinements and possible policy implications are explored in Subsection IIID, followed by a discussion on discrete fiscal risks (Subsection IIIE).

19. These scenarios represent a starting point for climate change fiscal risk analysis and are possibly conservative. The results are stylized, albeit based on cross-country empirical

[12] By allowing the variability of temperature to increase commensurately with high average temperature. That is, by keeping the coefficient of variation unchanged, and therefore by setting the standard deviation of annual temperature over 2014-2100 equal to the standard deviation of annual temperature over 1960-2014 times the ratio of average projected temperature over 2014-2100 divided by the realized average temperature over 1960-2014.

evidence. Importantly, the scenarios and their economic impacts reflect historical relationships between changing climate patterns and economic outcomes across the globe. However, there is potential for impacts to be significantly higher in future as climate change can lead to tipping points that have non-linear impacts in excess of past experience.

20. There is scope for significant refinement and improvement to the analysis. Some refinements and improvements are suggested at the end of this section. The IMF's Climate Macroeconomic Assessment Program (CMAP) could be used to further this analysis, including by incorporating mitigation and adaptation policies more fully. The framework and scenarios described below were the subject of a series of hands-on workshops, at the end of which the authorities were provided with the framework.

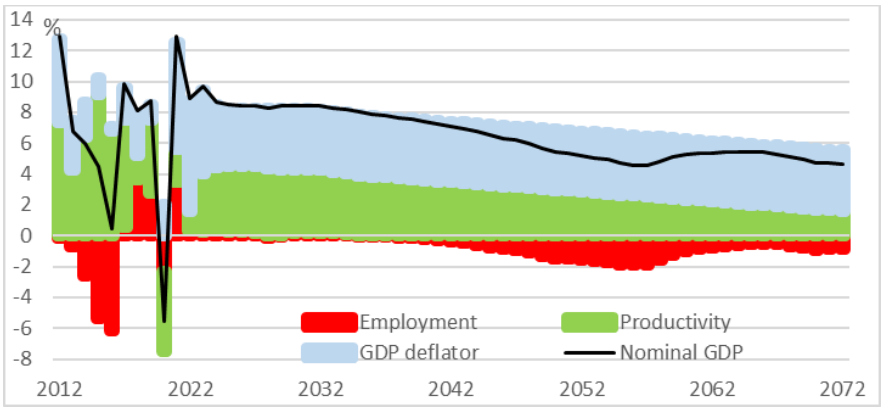
B. Baseline Scenario

21. The Baseline scenario demonstrates how the long-term fiscal situation may evolve based on current policies in the absence of climate change. In the Baseline scenario, annual real GDP growth is projected to slow from 4.5 percent in 2027 to 0.6 percent by 2072. This incorporates the impact of population decline, convergence of labor productivity growth towards the OECD average, and stable and cautious fiscal policy. This translates into a four-fold increase in real GDP per capita over the next 50 years. The debt-to-GDP ratio remains in line with the existing fiscal rules over the next half century, despite the gradual slowing in GDP growth. A primary deficit of 0.5 percent of GDP is projected for 2072, when the debt-to-GDP ratio is expected to be 47 percent of GDP.

22. The baseline nominal GDP projection is derived from projected growth in employment, productivity, and the GDP deflator. Nominal GDP growth over time can be decomposed into real GDP growth and growth in the GDP deflator. Real GDP growth, in turn, reflects growth in employment and labor productivity, where the latter is defined as real GDP per person employed.[13] The IMF World Economic Outlook (WEO) April 2022 database is used for historical and medium term (until 2027) projections. Beyond that, nominal GDP growth reflects annual growth in the GDP deflator consistent with the central bank's inflation target of 4 percent, an assumed productivity trajectory, and employment growth equaling the growth in working age (15-64) population as projected by the United Nations (UN) (Figure 12).

[13] Formally, let N represent nominal GDP. $N = Y * P$ where Y is real GDP and P is the GDP deflator. Taking the log difference yields the familiar result that the growth in nominal GDP is approximately the sum of the growth in real GDP and the growth in GDP deflator. Let E be employment and L be labor productivity, defined as $L = Y / E$. That is, $Y = E * L$, and the growth in real GDP is approximately the sum of the growth in employment and the growth in labor productivity.

Figure 12. Nominal GDP Growth and its Drivers (2012–72)

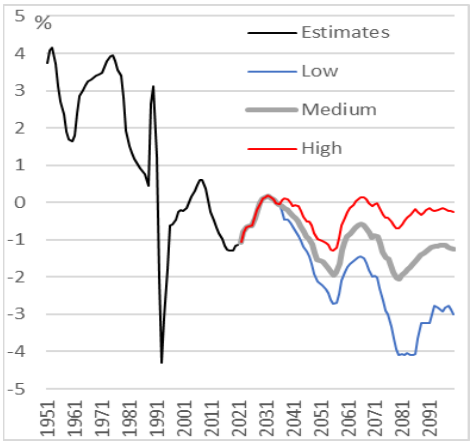


Source: IMF WEO, April 2022; ArmStatBank; IMF staff estimate.

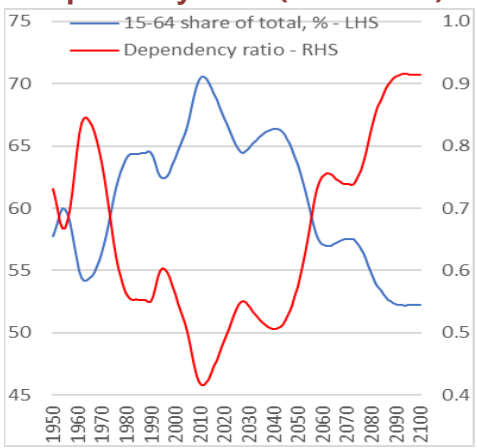
23. Employment growth is expected to detract from GDP growth in the longer term, reflecting the bleak demographic projection. Employment is projected to decline from the mid-2030s, in line with the declining working age population in the UN's medium variant population projections. Figure 13 shows the projected decline in working age population and the rise in the dependency ratio in Armenia. Conceptually, employment growth reflects the stage of the business cycle and the unemployment rate in the near term, changes in the participation rate in the medium term, and a country's demographic structure in the long term. The participation rate is assumed to remain unchanged from 2020, with slight increases in employment in the medium term reflecting drops in unemployment as projected by the IMF. Employment is assumed to remain unchanged as a share of the 15–64 population from 2027.

Figure 13. Demographic Trends and Projections

A. Growth in 15-64 Population (1951-2100)



B. Share of 15-64 Population and the Dependency Ratio (1950-2100)

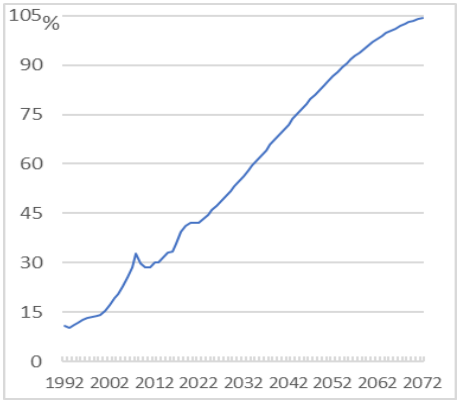


Source: UN Population Projections, 2022.

Note: The dependency ratio is the sum of children (14 and below) and the elderly (65 and above) divided the working age (15-64) population.

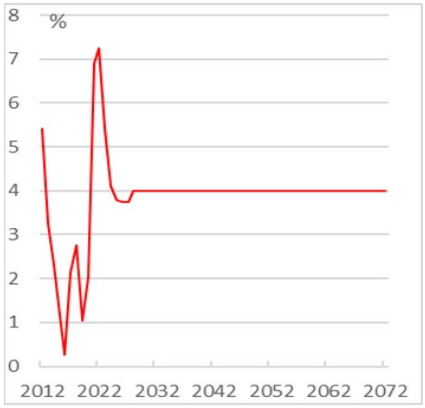
24. Growth in labor productivity, defined as GDP per person employed, is assumed to converge towards the OECD average growth in the long term. In the past three decades, labor productivity in Armenia had been converging towards the OECD average level.[14] The average Armenian worker was around 40 percent as productive as their OECD peer in 2021. The Armenian economy is set to stage a recovery in the medium term according to the April 2022 WEO, with implied productivity growth of 4.3 percent in 2027. Labor productivity growth is then assumed to decelerate over the long term to the OECD average rate of 1.2 percent by the late 2070s.[15] This translates into annual average productivity growth of 3 percent over the 2022–72 period. Figure 14 shows Armenia's labor productivity relative to the OECD average.

Figure 14. Labor Productivity Level Relative to OECD (1992–2072)



Source: World Bank World Development Indicators; IMF staff estimates.

Figure 15. Growth in GDP Deflator (2012–72)



Source: IMF WEO, April 2022; IMF staff estimates.

25. Long term fiscal projections are set such that debt remains relatively stable as a share of GDP. A strong fiscal consolidation is predicted in the April 2022 WEO, with primary net lending of 1.4 percent of GDP in 2027 on the back of record high revenue relative to GDP. This is partly unwound in 2027–30, and constant primary net borrowing of 0.5 percent of GDP is projected thereafter. Crucially, both revenue and primary expenditure are held constant relative to GDP. This likely underplays the expenditures pressures that will build over this period as a result of Armenia's rapidly ageing population.

26. Assessing the fiscal risks emanating from demographic pressures from health and pensions spending is critical for Armenia. Public finances are likely to worsen with ageing population, with expenditures on health, aged care, and pensions are likely to rise, while the revenue base may erode. These effects are likely to be particularly acute in Armenia as the

[14] Analysis of Armenia's past productivity trends is complicated by measurement issues (including the prevalence of a large informal sector and structural breaks in the labor market data) and significant adverse shocks (including a construction boom and bust cycle and the effects of geopolitical conflicts in the region).

[15] According to the World Bank World Development Indicators, labor productivity growth in the OECD averaged 1.2 percent a year in the three decades to 2021.

demographic transition to an ageing population has already commenced. This mission did not attempt to quantify the fiscal effects of ageing but suggests that the authorities build on the analytical framework to assess the fiscal risks from demographic pressures.

27. The average nominal interest rate is assumed to be 4.6 percent in the long run. This is in line with the average interest rate implied by the WEO projections over 2022–27. Underpinning the projected interest rates are assumptions on: the share of domestic currency denominated debt (30 percent); implied nominal interest rate on domestic debt (10 percent); and implied nominal interest rate on foreign currency denominated debt (2.3 percent). These assumptions are consistent with the authorities' macroeconomic models, medium- term projections, and debt strategy.

28. Long-term fiscal projections are highly sensitive to the interest rate assumptions, and there are considerable uncertainties around them. The interest rate used in these scenarios is kept constant over time, though this reflects some trends that could be analyzed further:

- Around three-fifths of the foreign currency denominated debt are concessional, reducing the implied interest rate paid by the government below the market rate. As Armenia develops, the share of concessional loans will likely decrease, resulting in upward pressure on the implicit interest rate.
- In the long run, the real interest rate tends to gradually decline in line with slower productivity growth. While productivity growth is assumed to slow over the long-term projection horizon, the real interest rate is assumed to remain unchanged.
- The rest of the foreign currency denominated debt may be subject to significant risk premia, reflecting geopolitical uncertainties in the region.

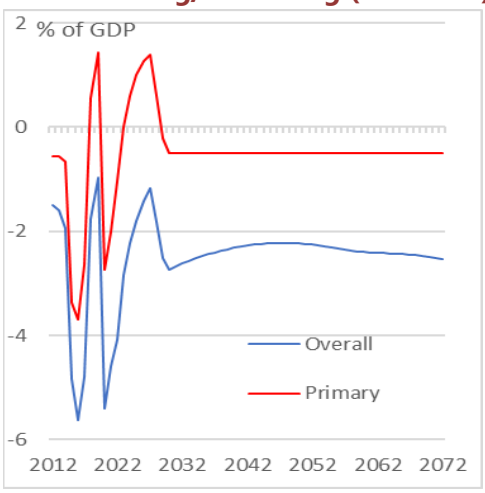
29. Under the Baseline scenario, debt-to-GDP ratio is projected to reach 47 percent of GDP in 2072 (Figure 16), well within Armenia's fiscal rules. The assumed primary net borrowing, in conjunction with the WEO projected stock of debt as of 2027 and the interest rate assumptions, are used to derive the baseline projection of the debt-to-GDP ratio.[16] Debt is projected to fall relative to GDP into the 2040s because of strong economic growth on the back of faster productivity growth. As productivity growth slows, debt starts rising relative to GDP from the 2050s. Further, the echoes of different cohorts of workers leaving the workforce are also evident in the changing slopes of the debt-to-GDP ratio.

[16] Given nominal GDP growth of G, a nominal interest rate of I, and primary net lending/borrowing (as percentage of nominal GDP) of pb, the debt-to-GDP ratio (D) evolves according to:

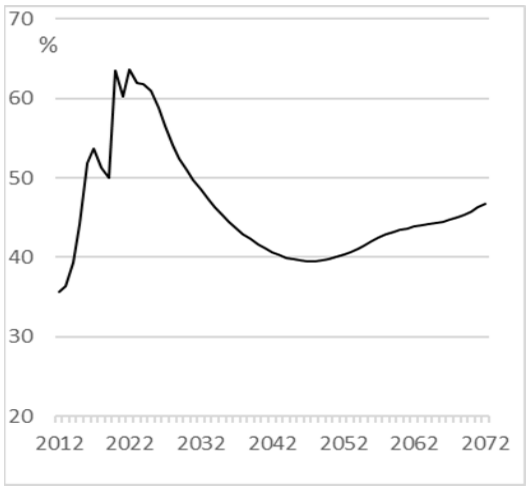
$$D_{t+1} = D_t * [(1+ I) / (1+G)] - pb_t .$$

Figure 16. Baseline Fiscal Projections

A. Net Lending/Borrowing (2012–72)



B. Debt-to-GDP Ratio



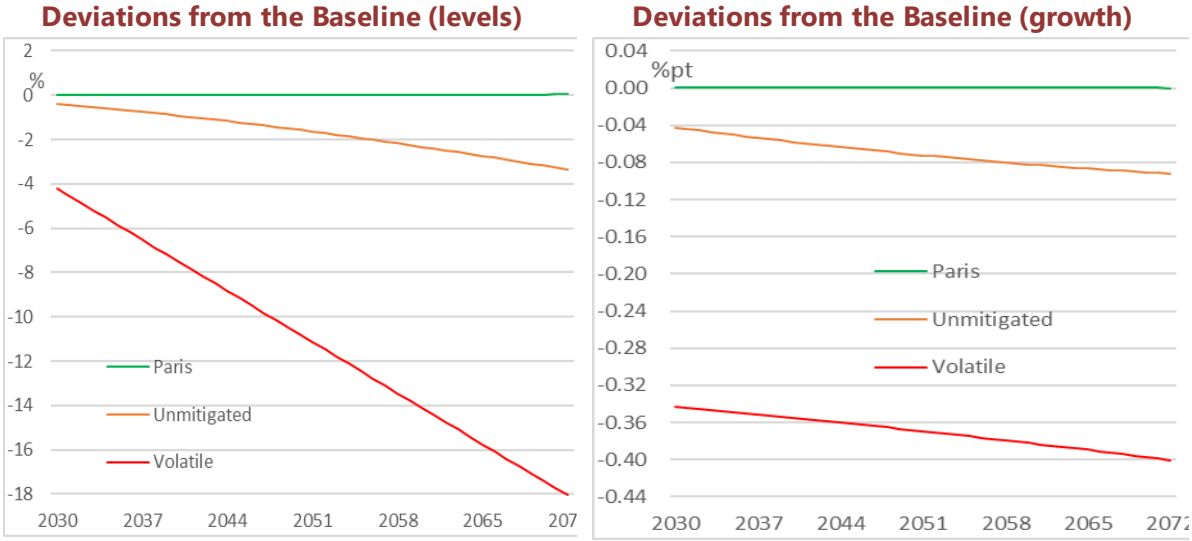
Source: IMF WEO, April 2022; IMF staff estimates.

C. Integrating Climate Change Scenarios into Fiscal projections

30. The effects of climate change on the macroeconomy are taken from the estimates of Kahn et al (2021) —see Box 1 above**.** The authors estimate the long-term macroeconomic effects of climate change using data from 174 countries over the period 1960–2014. According to their estimates, a persistent increase in average global temperature by 0.04 degrees Celsius per year, in the absence of mitigation policies, would reduce world real GDP per capita by more than 7 percent by 2100. The loss in real GDP per capita could increase to 13 percent globally if country-specific variability of climate conditions were to rise commensurate with annual temperature increases of 0.04 degrees Celsius.

31. Three different scenarios are explored: the Paris scenario of strong global climate change mitigation; the unmitigated scenario; and the volatile scenario where the effects of increased climate volatility under the unmitigated scenario are explicitly modelled. Figure 17 compares the deviations from baseline in productivity and real GDP growth and levels under various scenarios. Armenia's economy is hit particularly hard in the volatile scenario, with the economy 18 percent smaller in 2072 relative to the baseline. In contrast, the Paris scenario presents a benign climate outlook for Armenia, which is broadly in line with the baseline scenario, and for simplicity is not elaborated on in what follows.

Figure 17. Macroeconomic Effects of Climate Change



Source: Kahn et al (2021); IMF staff estimates.

- **The effect of climate change on real GDP growth is captured in the analytical framework as a slowdown in labor productivity growth.** The econometric estimates of Kahn et al (2021) establishes a link between changing climate and GDP per capita growth, but does not explicitly elaborate on transmission channels through which the former affects the latter. However, other empirical estimates and qualitative assessments point to a number of mechanisms that are likely to be relevant for Armenia.[17]
- **Higher depreciation of the public and private capital stock.** Higher and more volatile temperatures will erode the capital stock in an ongoing manner. For example, higher average temperatures and changing precipitation will degrade roads, rail tracks and machinery and equipment. Additionally, more volatile temperatures and precipitation will lead to greater risks of snowfalls, landslides, and other discrete weather events that will damage or destroy assets. Finally, increased volatility will make it more difficult to plan and schedule repair and maintenance activities.
- **Reduced hours worked and effort.** There is international evidence that hotter days can reduce productivity. For example, Somanathan et al (2021) find that each degree Celsius rise in temperature leads to a 2 percent decline in annual output in the Indian manufacturing sector. The construction sector, particularly important for Armenia, is likely to be vulnerable to extreme weather events. Due to extreme weather, employees may face a decrease in days or hours they are able to work effectively. Higher temperatures may also result in worsening health outcomes and an increased number of absentee days.

[17] Somanathan E, Somanathan R, Sudarshan A, and Tiwari M, 2021, *The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing*, Journal of Political Economy, vol 129, no 6.
Cevik S and Miryugin F, 2022, *Climate Change and Firm Performance*, IMF Working Paper 2022/102.

- **Reduced firm level total factor productivity.** Climate change will likely hinder firms' ability to perform their production or business processes effectively. For example, Cevik and Miryugin (2022) find that nonfinancial firms operating in countries with greater vulnerability to climate change tend to experience difficulty in access to debt financing even at higher interest rates, while being less productive and profitable relative to firms in countries with lower vulnerability to climate change. Increased climate volatility will likely make it even harder for firms to perform their activities effectively. Further, while firms can adjust to different climate norms, unexpected variations in temperature and/or precipitation will make such adaptation more costly.
- **More frequent and severe climate related natural disasters.** Historically, Armenia has experienced drought and other meteorological natural disasters, but they have left limited macroeconomic or fiscal footprints.[18] However, this may well change with increased climate volatility. The most pressing natural disaster currently facing Armenia is earthquake, which is unrelated to climate change, and therefore, not incorporated in this analysis. Nevertheless, the authorities can use FAD's Natural Disaster Shock Module for the Fiscal Stress Test (Box 3) to incorporate earthquake risks into their fiscal risk analysis.
- **Adverse effects on the external and monetary sectors.** In addition to the gradual dampening of productivity growth, climate change is likely to make Armenia more vulnerable to imbalances in the external and monetary sector. For example, the risk premium faced by the country may well rise with increased climate volatility, affecting the country's capital accounts and exchange rates. Another possibility is that supply chain disruptions caused by climate volatility lead to inflation, which causes a depreciation of the exchange rate.
- **Other longer term effects on the economy**. In addition to the channels described above, climate change could well affect the structure of the Armenian economy. For example, in a relatively worse climate scenario, certain industries such as high value-added agriculture or niche tourism are less likely develop. Further, extreme climate volatility may exacerbate Armenia's demographic pressures by inducing emigration of highly skilled population.

32. With inflation assumed to remain unchanged, the decline in labor productivity directly reduces nominal GDP. As noted above, climate change could cause spikes in inflation through natural disasters and other supply chain disruptions. Further, climate change may also affect Armenia's external balances, presenting another potential inflation risk.

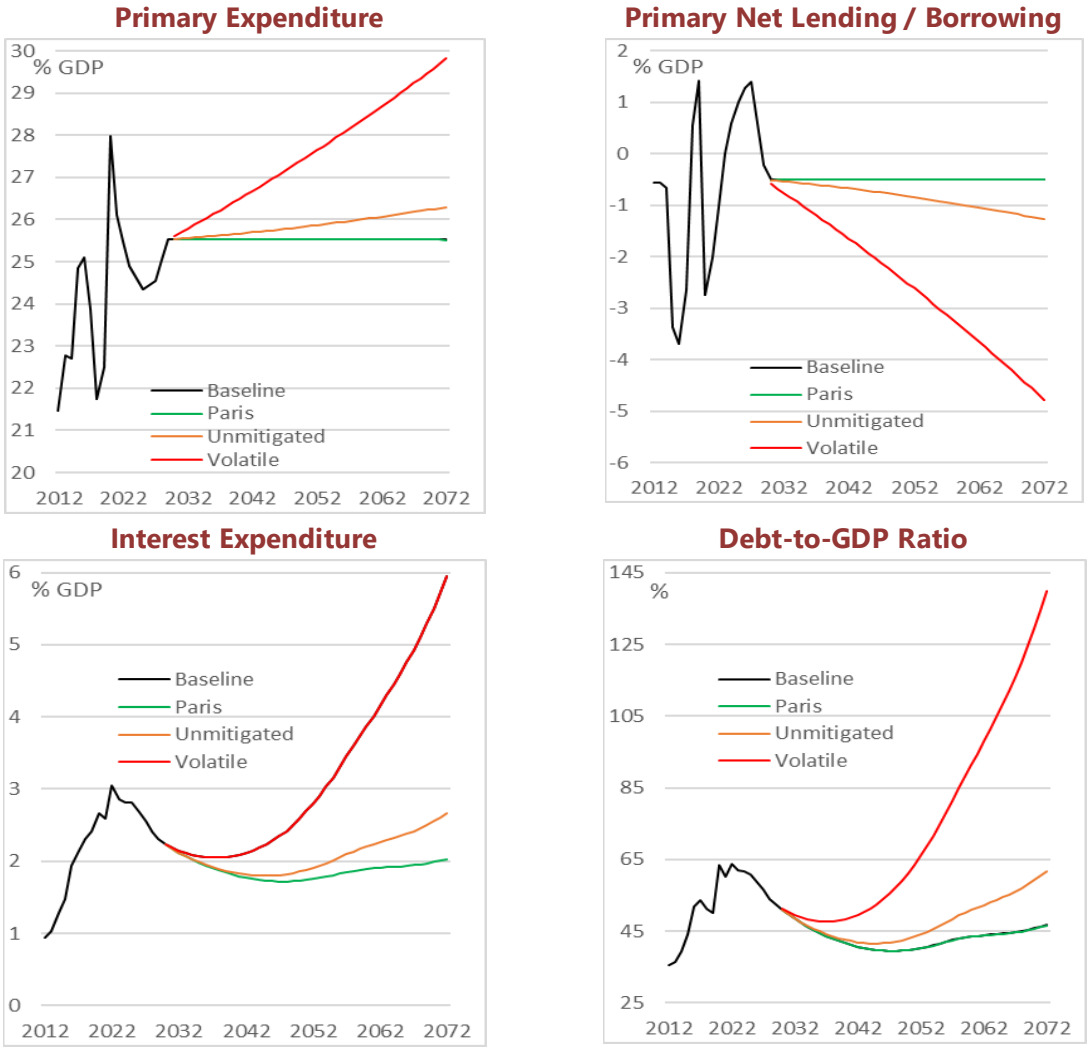
33. The fiscal implications of alternative climate scenarios are initially reflected in the revenue side of the budget. Under each of the climate change scenarios, revenue is assumed to decline in line with nominal GDP, so revenue-to-GDP ratios are held constant. On the other hand,

[18] Over the past quarter century, the meteorological event with the largest macroeconomic impact was a drought in 2000 that likely caused around ½ percent of GDP damages with fiscal effect of around ¼ percent of GDP.

primary expenditure is assumed to be rigid, and held unchanged in Armenian dram terms from the baseline.

34. Slower economic growth and worsening primary net borrowing result in gradual but significant increases in debt-to-GDP ratio over time. This is most acutely visible in the volatile scenario, where the increasing primary net borrowing requirements lead to a sharp ramp up in debt-to-GDP ratio as well as interest expenditures by the 2040s. under the volatile scenario, Armenia's public finances would be on an unsustainable trajectory without a fiscal adjustment. However, even in the unmitigated scenario, primary net borrowing requirements are 0.8 of a percentage point larger relative to the baseline in 2072, leading to a 15 percentage points higher debt-to-GDP ratio. The fiscal effects of climate change under different scenarios are illustrated in Figure 18.

Figure 18. Effects of Climate Change on Fiscal Projections (2012–72)



Source: IMF staff estimates.

Box 3. Summary of the Disaster Module

The Natural Disaster Shock Module for the Fiscal Stress Test (the Module) allows country authorities to assess the impact of different scales and magnitudes of natural disasters on macroeconomic and fiscal outcomes. The Module simulates the impact of a supply side disaster shock—pandemic, as well as flood, drought, earthquake, and severe storms—on economic activities. This module is currently being piloted, and will be available on the IMF's Fiscal Risk Portal in 2023.

The Module can be used at the onset of a disaster, or for medium to long term scenario analysis, to analyze:

- the impacts of a disaster on individual sectors of the economy,
- how these impacts will feed into tax, expenditure, and deficit/financing/debt changes; and
- what this means for the macroeconomy and public finances overall.

The Module has an option to record discretionary fiscal policy in response to the disaster being analyzed or materialization of contingency liabilities because of the disaster. A simple production function underpins the Module. However, the analysis is partial equilibrium in nature, in the sense that the external and monetary sectors are assumed to be exogenous.

The Module automatically generates a range of macroeconomic and fiscal scenarios in response to changes in a pair of variables describing the intensity of the disaster being simulated: the severity of the disaster — a measure of how damaging the disaster is; and preparedness of the country — the degree to which a country's policy settings, institutions, and public agencies are ready to respond to, and ameliorate, the impact of the disaster.

The Module is designed to be adapted to country circumstances. It requires the use of national macroeconomic and fiscal data, to which some global impacts are applied as the starting point of analysis. Authorities are strongly encouraged to amend the scale and nature of these impacts to reflect their particular national circumstances.

D. Expenditure Rigidity, Adaptation, and Policy Implications

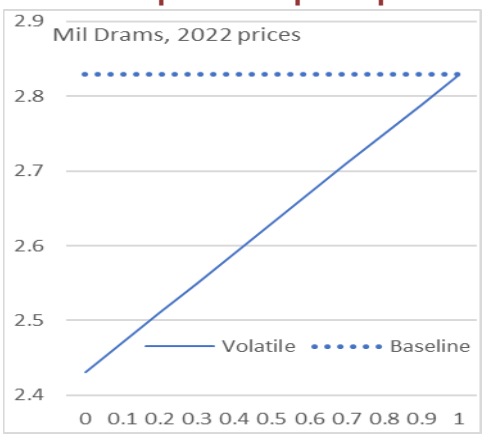
Expenditure Rigidity

35. The above projections are based on a strong assumption that spending under the climate scenarios remains at the same levels as the baseline path. This assumption implies that the policymakers do not adjust fiscal settings in response to the climate induced economic slowdown. This likely overstates the effects of climate change on fiscal sustainability as policymakers may well recalibrate primary expenditure as growth slows and revenues decline.

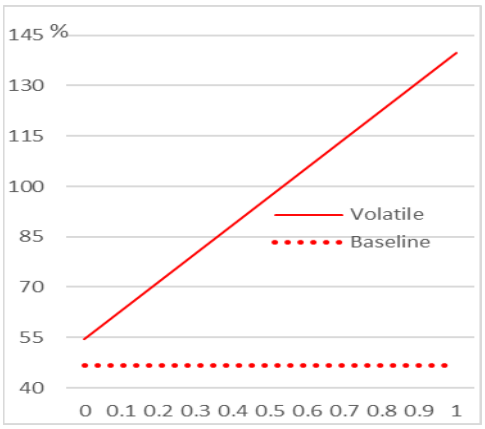
36. The possibility of expenditure recalibration is built into the analytical framework through a parameter that allows for different degrees of spending flexibility. That is, it allows the expenditure rigidity assumption to be relaxed. This parameter varies between 0 (fully flexible) and 1 (completely rigid). As primary expenditure becomes more flexible (the parameter approaches 0), real primary expenditure per capita reduces to a point where the expenditure to GDP ratio is held constant, and primary expenditure is significantly lower than the baseline. This is illustrated in Figure 19 with respect to the volatile scenario.

Figure 19. Effects of Expenditure Rigidity (Volatile Scenario, 2072)

Real Expenditure per Capita



Debt-to-GDP Ratio

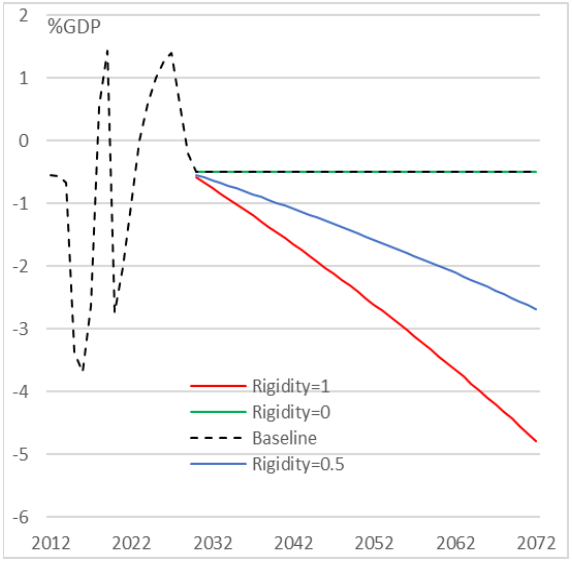


Source: IMF staff estimates.

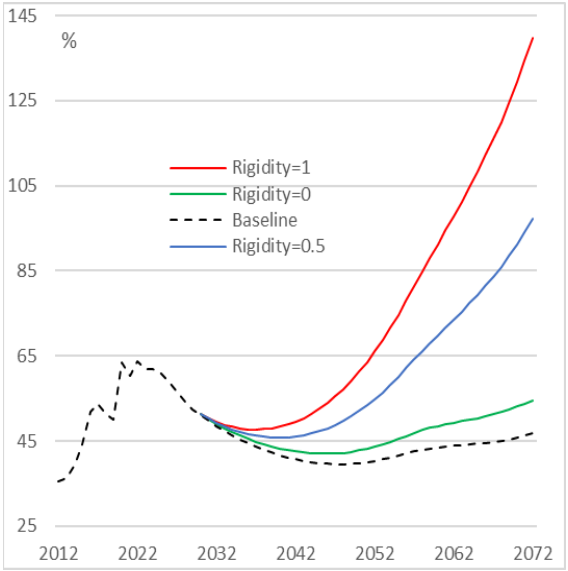
37. In the volatile scenario, if primary expenditure is reduced in line with revenue, debt-to-GDP ratio rises by only 8 percentage points relative to the baseline in 2072. To achieve this outcome, real primary expenditure per capita needs to be 14 percent lower relative to the baseline in 2072. However, this still translates into a 2.5 percent a year increase in real primary expenditure per capita over the five decades to 2072. That is, an early recalibration of fiscal policy in the face of looming climate change can avert more drastic adjustments later. The effects of full (rigidity of 1), partial (0.5) and no (0) expenditure rigidity on fiscal projections in the volatile scenario are presented in Figure 20.

Figure 20. Effects of Expenditure Rigidity, Volatile Scenario (2012–72)

Primary Net Lending / Borrowing



Debt-to-GDP Ratio

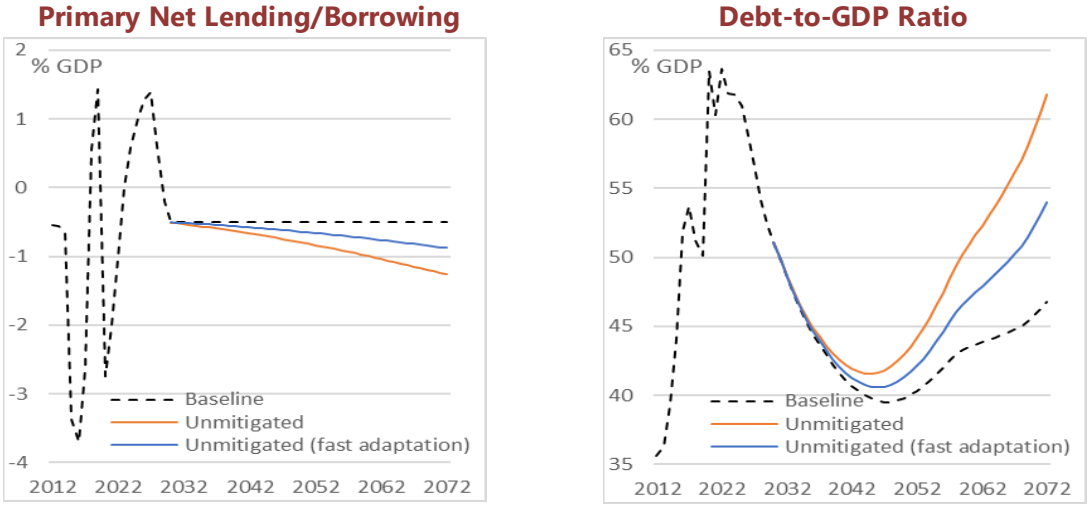


Source: IMF staff estimates.

Faster Adaptation

38. Faster adaptation to climate change can ameliorate, the long term macroeconomic and fiscal effects of climate change. Implicit in the Kahn et al (2021) empirical framework is an adaptation parameter (*m*) that assumes countries will adapt to higher temperatures over the course of 30 years. This parameter can be adjusted, with a lower value reflecting faster adaptation, which reduces the macroeconomic impact. Setting this parameter to 20 (that is, countries adapt to higher temperature in 20 years rather than 30) in the unmitigated scenario reduces the net primary borrowing requirements by 0.4 of a percentage point in 2072 and reduces debt by 8 percent of GDP compared with the central adaptation scenario (Figure 21).

Figure 21. Effects of Faster Adaptation, Unmitigated Scenario (2012–72)



Source: IMF staff estimates.

39. Faster adaptation to climate change is likely to require significant public and private investment. Global public adaptation needs in 2030 are estimated in the literature at around ¼ percent of world GDP per year (Aligishiev and others). There is as yet no econometric analysis linking adaptation investment with macroeconomic and fiscal outcomes. However, IMF analysis suggests that while adaptation investment may be more costly than traditional public investment, in the longer run it could reduce the fiscal impacts of natural disasters by making the country more resilient.[19] Not all adaptation measures involve public expenditure. For example, changing work hours to avoid times of extreme heat may be achieved through regulations. Other measures, such as switching agricultural output to fruits and vegetables that are more resilient to volatile weather patterns, may require upfront investment. There is currently no detailed quantitative analysis of climate adaptation investment in Armenia.

[19] For example, see: Duenwald et al, 2022, *Feeling the Heat: Adapting to Climate Change in the Middle East and Central Asia*, IMF Departmental Paper, DP/2022/08.

Implications for Fiscal Policy Settings

40. Simulations such as the above can be used to quantify the potential impact of climate change fiscal risks on fiscal rules and fiscal sustainability. For example, whereas fiscal consolidation of 0.5 percent of GDP is required to stabilize debt-to-GDP ratio in 2072 in the Baseline scenario, in the unmitigated scenario the required consolidation is 1.3 percent of GDP, and in the volatile scenario the task rises to 5.3 percent.

41. The analytical framework introduced in the mission can be used, in conjunction with other estimates, to assess fiscal policy trade-offs in the face of climate change. A fiscal policy setting that is sustainable under the baseline scenario may cease to be so with climate change. As climate change unfolds, the authorities could improve long term fiscal aggregates by investing in climate adaptation and appropriately recalibrating fiscal policies. For example, in the unmitigated scenario, faster adaptation to climate change may raise debt in 2072 by 7 percent of GDP relative to the baseline instead of a 15 percent increase in the central adaptation scenario. In addition, if primary expenditures were to decline in line with revenues, debt-to-GDP ratio would be less than one percentage point higher in this scenario compared to the baseline. Indeed, even in the volatile scenario, if primary expenditure evolves in line with revenue, debt would be around 8 percentage points higher in 2072 relative to the baseline.

E. Discrete Fiscal Risks of Climate Change in Armenia

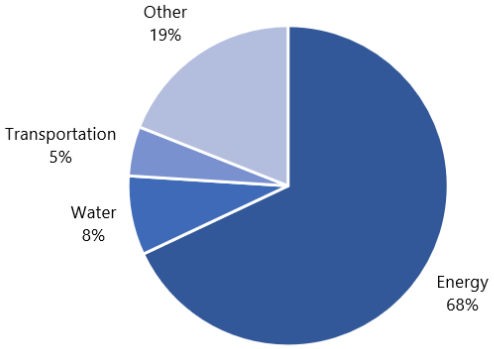
42. Discrete fiscal risks arise from direct exposure of government assets and contracts to climate change. There are two general types of discrete fiscal risk related to climate change: direct physical risks to the assets (increasing temperature, reduced precipitation and water flow, and increased natural disasters); and transition risks (related to changing policy, technology and international commitments) that affect the viability of assets and contracts. Public private partnerships (PPPs), SOEs, government guarantees, government projects are all potential channels for these types of climate change-related fiscal risks. Assets and contracts in Armenia are exposed to both of these risks, but particularly physical risks given the exposure of key SOEs and PPPs to higher and more volatile temperatures, reduced rainfall, and natural disasters.

43. SOEs and PPPs in Armenia are concentrated in the energy, water, and transport sectors (Figure 22). More than 60 percent of the assets of SOEs (equivalent to around AMD473bn or 7.0 percent of GDP) are concentrated in the energy sector. Another 6 percent of assets are in the water sector, and 4.5 percent in the transportation sector. The liabilities of energy sector SOEs are particularly high at around AMD400bn (5.7 percent of GDP). The government is also exposed to around AMD256bn (3.6 percent of GDP) in broad contingent liabilities from power-purchase agreements in the energy sector and AMD87bn (1.2 percent of GDP) in contingent liabilities from a PPP in the water sector.

Figure 22: SOE Assets and PPP/PPA Contingent Liabilities

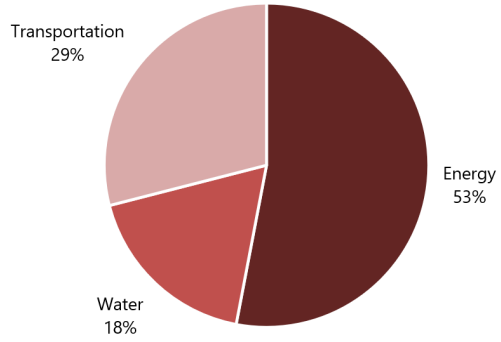
Panel A: SOE Assets

(Total assets of AMD702bn, 10.0 percent of GDP)



Panel B: PPP & PPA Contingent Liabilities

(Total CLs of AMD482bn, 6.9 percent of GDP)



Source: Republic of Armenia, (2022), 2023-2025 Medium Term Expenditure Framework.

44. These sectors are also where climate-related risks are concentrated. Increasing temperatures, extreme temperature events, reduced water flows, increased wildfires, and landslides all present significant risks to assets in these sectors. Reduced water flow through rivers and to reservoirs that drive hydroelectric power could reduce the provision of such power. Climate change-related natural disasters could damage infrastructure and generate force majeure events for PPP contracts. Higher temperatures can compromise the efficiency of thermal power plants and the distribution network. Table 4 provides an example of some of these channels and the assets and contracts that could be at risk from climate-change related events. This analysis should be deepened as part of the process to better identify and assess climate-related fiscal risks; this process is already under way in the Ministry of Finance, with the inclusion of initial disclosures of those risks in the FRSs and the intention to expand these disclosures progressively in the future, with the continuing support of the Asian Development Bank.

45. Climate change also presents risks to existing infrastructure and the pipeline of investment projects. The exposure of existing infrastructure to climate change risks should be quantified and understood, and risks to new investment projects assessed and considered in the appraisal and selection of projects. The new public investment management system is intended to systematize all stages and elements of project management consistent with the recommendations of the 2018 PIMA. However, this system is not yet operational. Thus, the incorporation of climate change risks assessment and management in public investment management is currently likely to be insufficiently systematic. Box 4 below summarizes how the Akhouryan irrigation project feasibility study incorporated climate change risks.

Table 4. Armenia: Examples of SOEs and PPP Climate Change Risk Exposures

Climate impact	Sector	Exposed SOEs and PPPs	Exposure
Reduced water flow in rivers and lower reservoirs	**Energy:** Hydro power plants compromised by lower water levels and flow, and possible limits on thermal and nuclear power plant cooling capacity.	Yerevan Thermal Power Center CJSC Armenian Nuclear Power Plant CJSC Contour Global Hydro Cascade CJSC	SOE assets: AMD327bn (4.6% of GDP) PPA CLs: AMD102.1bn (1.5% of GDP)
	Water: Reduced water available for domestic distribution.	Veolia Jur CJSC	PPP CLs: AMD 87bn (1.2% of GDP)
Increase in large precipitation events, landslides, and mudslides	**Energy:** Hydro power limitations during excessive rainfall, and damage to transmission lines.	High Voltage Electric Networks CJSC Armpower CJSC, PPA Contour Global Hydro Cascade CJSC	SOE assets: AMD129bn (1.8% of GDP) PPA CLs: AMD231bn (3.3% of GDP)
	Transportation: Damage to road, railway, and airports	Karen Demirchyan Yerevan Metro CJSC South-Caucasian Railways CJSC Armenia International Airports CJSC	SOE assets: AMD15bn (0.2% of GDP) PPP CLs: AMD139bn (2.0% of GDP)
Increase in wildfires	**Energy:** Damage to transmission lines	High Voltage Electric Networks CJSC Armpower CJSC, PPA	SOE assets: AMD 129bn (1.8% of GDP) PPA CLs: AMD129bn (1.8% of GDP)
Increasing temperatures and extreme temperature events	**Energy:** Thermal power efficiency falls, and transmission lines are compromised by extreme heat.	Yerevan Thermal Power Center CJSC High Voltage Electric Networks CJSC Electro Power System Operator CJSC Armpower CJSC, PPA	SOE assets: AMD280bn (4.0% of GPD) PPA CLs: AMD129bn (1.8% of GDP)
	Transportation: Damage to road, railway and air infrastructure.	Karen Demirchyan Yerevan Metro CJSC South-Caucasian Railways CJSC Armenia International Airports CJSC	SOE assets: AMD15bn (0.2% of GDP) PPP CLs: AMD139bn (2.0% of GDP)

Source: Republic of Armenia, (2022), "Assessment of Fiscal Risks Related to the Activities of the Organizations Operating in Infrastructure and Other Sectors" and Staff estimates. Medium Term Expenditure Framework 2023-2025, Assessment of Fiscal Risks.

Box 4. Akhouryan Irrigation Project Feasibility Study Climate Change Risk Assessment

The Kaps dam on the Akhouryan River near Gyumri, Armenia's second largest city, was started but not completed due to the economic situation after the 1988 earthquake and the 1991 collapse of Soviet Union. The uncompleted dam is a hazard as the river diversion might not cope with extreme floods, which could have serious consequences to downstream areas, including Gyumri. A 2014 feasibility study for the Akhouryan Irrigation Project envisaged the reconstruction of the dam and the gravity supply of irrigation currently supplied by pumps or not irrigated. At the time the updated feasibility study was prepared, the assessment of climate change impacts was relatively new.

The study identified several climate change factors that impacted the project:

- Around 80 percent of the land plots in Armenia were characterized by desertification processes and various levels of land degradation. More than half of cultivated lands were irrigated, and their share in crops production was 70 percent. As result of temperature rise and decrease in precipitation, the areas in Armenia needing irrigation will expand, and increased evaporation from the soil could result in the secondary salinization. Moreover, heavy rainfall and floods will intensify water erosion, and droughts and southern winds will cause further wind erosion.
- Irrigation was the largest user of water in the Akhouryan basin, and its use efficiency was very low, resulting in high losses. The reduction of the overall irrigation water demand by increasing the system efficiency would be a way of combating the effects on runoff by climate change. From this perspective, the project was a climate change adaptation project.
- The project was also a climate change mitigation project. The study assessed the reduction of emissions resulting from changing irrigation water supply from energy intensive pumping to gravity flow. Moreover, the project was designed to enable the generation of renewable electricity by small hydropower plants.
- Climate change will reduce water quality in the basin. This, together with the project, would have significant impacts on the ecology of the Akhouryan basin which would need further detailed assessment.

Notably, the study incorporated forecasts of the impact by 2100 of increased temperatures (4-6 degrees) and reduced precipitation (22 percent) and river flow (37 percent). It also incorporated designs of facilities to cope with increasing hydro-meteorological hazardous events, including floods and mudslides.

Major project risks for the project noted by the study include the capacity of farmers to adapt their practices, including to invest in on-farm facilities, and the regulatory and policy environment. However, it did not include analyses of the possible impacts of different climate and macroeconomic scenarios.

Source: Republic of Armenia (2014), Construction of Kaps Reservoir and Gravity Irrigation System: Final Feasibility Report, December 2014.

46. However, climate-related risks are not equally distributed in these sectors. For example, under the unmitigated scenario, overall water flows are projected to fall by as much as 40 percent, potentially compromising the hydroelectric power plants that rely on this water flow to generate power. The distribution of the impact of climate change varies across rivers and reservoirs and while water flows will drop sharply for some hydroelectric critical rivers, they may increase in others (Table 5). For example, the largest project (The Vorotan Cascade) is projected to see a large increase in river flow in this scenario. This demonstrates the importance of taking a specific approach to the analysis of the effect of climate change on systemically important SOEs, large contracts, and projects rather than just a broad sectoral review.

Table 5. Armenia: Projected Hydroelectric Losses from Climate Change

	Power generated in 2007 *(million kWh)*	Projected Change in River Flow in 2100 *(from baseline)*	Projected 2100 Power Generation *(million kWh)*	Decrease from Current Generation *(million kWh)*
Vorotan HPPs Cascade	1,030	45%	1,030	0
Sevan-Hrazdan HPPs Cascade	521	-36%	334	188
Dzora HPP	86	-25%	64	21
Small Scale HPPs	216	-24%	164	52
Total	1,853		1,592	261

Source: Stanton, et. al, (2008), "The Socio-Economic Impact of Climate Change in Armenia", Stockholm Environment Institute. https://www.undp.org/armenia/publications/socio-economic-impact-climate-change-armenia,
Note: HPP is Hydroelectric Power Plant.

47. It would be useful to undertake a Climate Public Investment Management Assessment to assess how climate change risk management is incorporated in its PIM system and the priorities for improvement. For example, environmental and social impact studies that are undertaken in the feasibility and appraisal stage of projects could be required to include analysis of the risk of climate change on the project, as well as the risk the project presents to meeting Armenia's mitigation targets. For example, the Environmental and Social Impact Study for the Yerevan 2 CC Power Plant ArmPower CJSC provides a detailed assessment of the expected CO2 emissions from the operation of the plant and the consistency of those projections with Armenia's NDC commitments.

48. There is a range of other sources of climate change-related fiscal risks that should be regularly and carefully evaluated. For instance, the scheme for compensating landowners during droughts should be assessed in the context of increasing severity and regularity of droughts in Armenia. Climate-related fiscal risks stemming from the financial sector should be considered and assessed; central banks are increasingly examining climate-related risk management.[20] In Armenia, the Ministry of Finance should continue to carefully track the liabilities under the agricultural insurance system and project future subsidy requirements under different climate scenarios. The subsidy component of this scheme (which covers agricultural losses under extreme weather events and wildfires) was AMD256m in 2020, or around 50 percent of the insured premia, and was doubled to AMD500m in 2021.[21] Insurance programs can be an effective way to distribute risk, but the exposure of the government to these programs should be carefully assessed in the context of increasing climate change-related events.

[20] 6 Example activities of central banks can be found at the website of the European Central Bank (https://www.ecb.europa.eu/ecb/climate/html/index.en.html) and the Bank of England (https://www.bankofengland.co.uk/climate-change).

[21] Republic of Armenia, (2022), "Assessment of Fiscal Risks Related to the Activities of the Organizations Operating in Infrastructure and Other Sectors".

IV. FUTURE WORK PROGRAM

49. The results and analysis presented above provides a preliminary, broad brushed analysis of the macro-fiscal risks from climate change, which should continue to be refined. The mission has provided the analytical framework and simulations to the Ministry of Finance, who should continue to improve the analysis over the remainder of 2022 before presenting the results in the next FRS.

A. Refinements and Extensions

50. Some suggestions for improvement to the macro-fiscal analysis and quantification are:

- **The input data used for the analysis should be updated.** The analysis presented above uses the WEO data. These should be replaced with Armenia's medium term fiscal framework. This task can be performed in the next few months.
- **Reassess the productivity convergence assumptions.** In the Baseline scenario above, productivity growth is assumed to converge in the long run to the Organization for Economic Cooperation and Development's (OECD) historical average. Instead of the entire OECD, countries that have successfully transitioned from centrally planned to market economy might provide a more appropriate convergence benchmark. The authorities could perform a productivity analysis for Armenia in the next few months to appropriately set the productivity convergence assumption in the analytical framework.
- **Reassess the interest rate assumptions.** In the analysis above, the interest rate is assumed to be 4.6 percent. While this is consistent with the authorities' medium-term assumptions and the medium term WEO projections, multiple factors are likely to weigh in on the interest rates in the long run. These include: possible loss of concessional loans as Armenia becomes a richer country; risk premia; and the effect of slowing productivity growth. The authorities could perform a detailed analysis of long-term interest rates in the coming months.
- **Assess Armenia's climate adaptation needs and quantify fiscal effects.** The analysis provided above suggests that adaptation to climate change will be important for Armenia. Working across relevant parts of the government, analysis of adaptation policies should begin in the next few months. In the initial stages, it would involve a qualitative assessment, to be followed by quantification of costs and benefits, and ultimately financing options and strategies.
- **Incorporate the effect of ageing on expenditure.** As noted above, Armenia is already experiencing the demographic transition towards an ageing population. However, the baseline assumptions presented above abstract away from the effect of ageing on the expenditure path. The analytical framework can be amended to incorporate the effect of ageing on expenditure, particularly healthcare and pensions but also possibly others. Assuming that the Baseline scenario is recalibrated with the Armenian medium term fiscal framework and the appropriate adjustments are made to the productivity assumptions in the next six months, this task can be performed in the first half of 2023.

- **Assess the sustainability of revenue base in various demographic and climate scenarios.** The analysis presented above assumes that revenue-to-GDP ratio remains constant in the long term in the face of climate change. This is also the standard initial assumption for the long-term analysis of the fiscal effects of ageing. However, both climate change and ageing could affect the revenue base. Assuming that the other tasks mentioned above are completed by then, the authorities could explore the long run trend in Armenia's revenue base in late 2023.
- **Include external and monetary shocks.** The analysis could explore the effects of external and monetary shocks emanating from climate change, ageing, natural disasters, or geopolitical events on the long-term fiscal projections. For example, climate change could raise Armenia's risk premia, supply chain disruptions triggered by geopolitical events could lead to inflation, causing a depreciation of the exchange rate. Because the majority of Armenia's public debt is denominated in foreign currency, both situations would present a significant fiscal risk. A qualitative discussion of these issues could be included in the next FRS, followed by various quantification approaches, including possibly using the Ministry of Finance's (MoF) macroeconomic model, could be explored in 2023.
- **Analyze the effect of climate change on the capital stock.** Using historical national accounts data and parameter values from the economic growth literature, the labor productivity projections could be disaggregated into capital-labor ratio and total factor productivity. This would allow authorities to examine, initially in a stylized way, but eventually with more robustness, the effect of climate change on the capital stock. This work could begin in 2023.

51. In addition to the analysis presented above, the FRS could also provide additional analysis of discrete risks associated with climate change. To support this analysis, the Fiscal Risk Unit should carefully examine discrete climate change-related fiscal risks, including vulnerabilities of the government budget to climate change risks, such as those relating to power purchase agreements (PPAs), other major long-term contracts, and contingent liabilities. This should also include analysis of the impact of transition risks (related to possible changes in policy to mitigate and adapt to climate change). The Ministry of Finance should also participate in the National Adaptation Plan Action 2.4 (the mapping and development of a database on climate-change related risks) and further map these risks into the Ministry of Finance's database of fiscal risks.

B. Broader Fiscal Risk Work Program

52. The work on quantifying fiscal risks from climate change comes amidst a broader work program which is seeing distinct improvements in Armenia's fiscal risk analysis and reporting. The Ministry of Finance's Fiscal Risk Management Department has been reinvigorated and is now focused on preparing analysis and advice on policy measures that can be taken to mitigate risks in addition to its current role of preparing the annual FRSs.

53. The 2018 Fiscal Transparency Evaluation (FTE) assessed Armenia's fiscal risk reporting and management as being reasonably good, but with a number of clear areas of improvement. Some of the stronger areas were reporting and analysis of risks stemming from macroeconomic, guarantees, financial sector, sub nationals and public corporations. However, there were a number of areas of improvement identified, including standardizing, and collecting the various strands of risk analysis into a single document, the development of long-term demographic related risk analysis and environmental risks.

54. Since 2018, there has been substantial improvement in the FRSs in response to the main recommendations of the 2018 FTE. These include:

- Expanding the reporting and assessment of fiscal risks to include natural disasters, including climate change and government risk mitigation and adaptation policies, other environmental risks, litigation risks, financial sector risks and biological risks.
- Expanding the discussion around government financial assets, in particular the on-lending portfolio.
- More detailed and comprehensive assessments of PPP fiscal risks.

55. There are a range of high-level improvements that can be incorporated in future FRSs including the roadmap prepared by the Asian Development Bank in the context of their support and having regard for the FTE. These include:

- Providing a clear upfront summary and guidance as where the major fiscal risks lie, their size and probability. This will help policymakers and readers understand where the focus of concern should be, and where to direct risk mitigation efforts
- Broadening the fiscal risk statement to include key summaries of risk assessments that are published elsewhere, such as the macroeconomic risk assessment published separately in the medium-term expenditure framework, and assessments of debt fiscal risks.
- Incorporating areas that are still missing in terms of the FTE categorization, including demographic and natural resources fiscal risks, and use of key risk mitigation measures such as reserves.
    - Further expansion standardization and clearer descriptions of risks. In some areas, clear and high quality analysis is presented, allowing the reader to understand the importance, size and major risk factors around the specific risks. In others, the discussion can be characterized as collections of facts and observations that do not form a coherent analysis.
    - Linking individual risks to specific management and policy measures that can be taken to reduce risks or react to them in light of their crystallization.
    - Publication of special chapters, that provide deep one-off pieces of analysis on particular areas of concern, such as:

- climate change fiscal risks from a macro-fiscal perspective, as exemplified in this report and the UK's Office of Budget Responsibility's July 2021 report;
- Demographic fiscal risks, as exemplified in long-term fiscal sustainability statements published in several countries, including Kazakhstan starting in 2022 and Georgia planned to start in 2023.