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ASSESSMENT OF THE POTENTIAL IMPACT OF NATURAL HAZARD EVENTS ON DEBT SUSTAINABILITY OF ARMENIA, KYRGYZSTAN, AND TAJIKISTAN

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Disclaimer:

This Working Paper was prepared based on statistical data as of 1 July, 2023.

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Abbreviations

ADB	Asian Development Bank
ADRC	Asian Disaster Reduction Centre
CAREC	Central Asia Regional Economic Co-operation
CMIP	Coupled Model Intercomparison Project
CRED	Centre for Research on the Epidemiology of Disasters
DesInventar	Disaster Inventory System
DSA	Debt Sustainability Analysis
ECB	European Central Bank
EDB	Eurasian Development Bank
EFSD	Eurasian Fund for Stabilization and Development
EM-DAT	Emergency Events Database
GDP	gross domestic product
GEM	Global Earthquake Model Foundation
GRP	gross regional product
HPP	hydro power station
IMF	International Monetary Fund
KR	Kyrgyz Republic
LSM	least square method
NOAA	National Oceanic and Atmospheric Administration
NSC KR	National Statistical Committee of the Kyrgyz Republic
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PPP	purchasing power parity
QPM	Quarterly Projection Model
RA	Republic of Armenia
RT	Republic of Tajikistan
SA RT	Statistical Agency under the President of the Republic of Tajikistan
SC RA	Statistical Committee of the Republic of Armenia
SSP	Shared Socioeconomic Pathway
UNDRR	United Nations Office for Disaster Risk Reduction
WBG	World Bank Group
WCRP	World Climate Research Programme
WGCM	Working Group of Coupled Modelling

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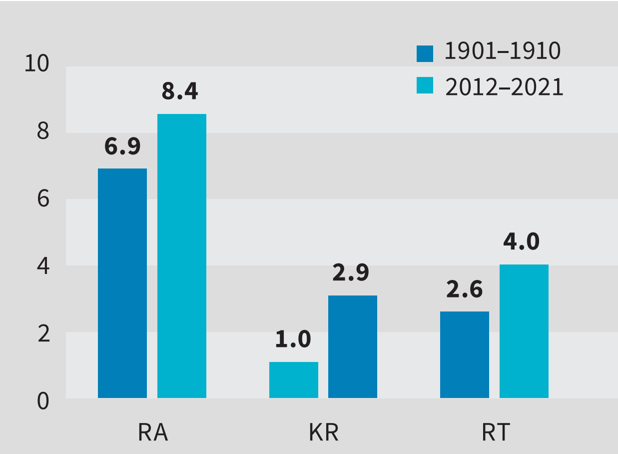
Executive Summary

Since the beginning of the 20th century, most regions of the planet have experienced significant climate change. According to the WBG Climate Change Knowledge Portal, Armenia, Kyrgyzstan, and Tajikistan have experienced temperature increases of 1.6, 1.9, and 1.4°C, respectively, based on averages for 1901–1910 and 2012–2021 (Figure A).

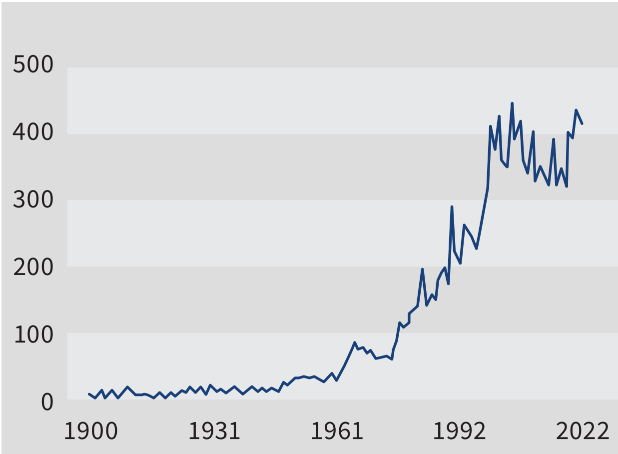
Many countries are suffering from more frequent and intense natural hazard events related to global climate change. According to EM-DAT, during the period from 1900 to 2022, the annual frequency of natural hazard events (geophysical, meteorological, hydrological, and climatological) has been growing exponentially (Figure B).

Figure A. Average Temperature, °C



Source: WBG Climate Change Knowledge Portal.

Figure B. Annual Frequency of Natural Hazard Events



Source: authors' calculations based on EM-DAT data.

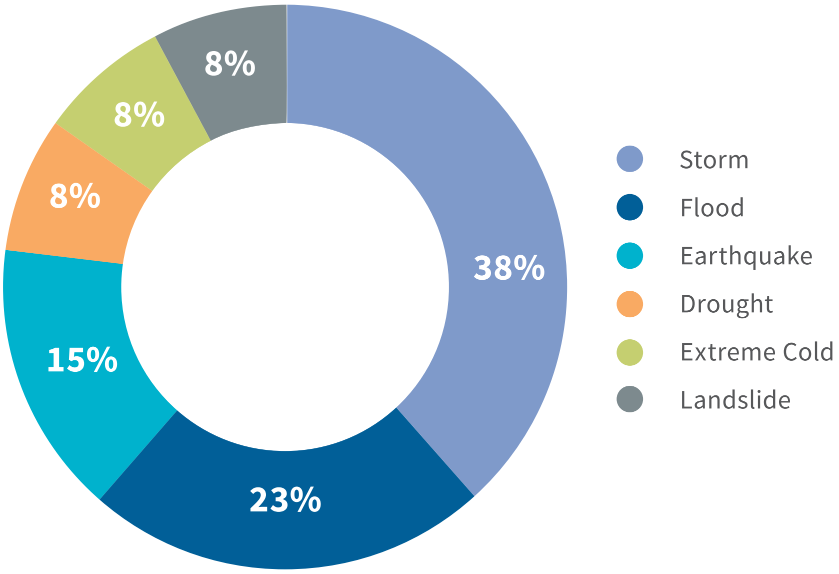
Armenia, Kyrgyzstan, and Tajikistan have relatively low risk compared to other countries, yet losses from certain natural hazard events can be significant.

In Armenia, earthquakes and droughts are the main natural hazard events that may strongly impact economic stability. In 1992–2023, the most widespread natural hazard events were storms (38%) and floods (23%) (Figure C), but the heaviest damage was caused by the 2000 drought ($170 million in 2022 prices) and the 1988 Spitak earthquake ($34.6 billion in 2022 prices).

Direct losses from earthquakes in Armenia could reach $2.4 billion (12.3% of the 2022 GDP). The south of the Lori Province is the most vulnerable region (Figure D).

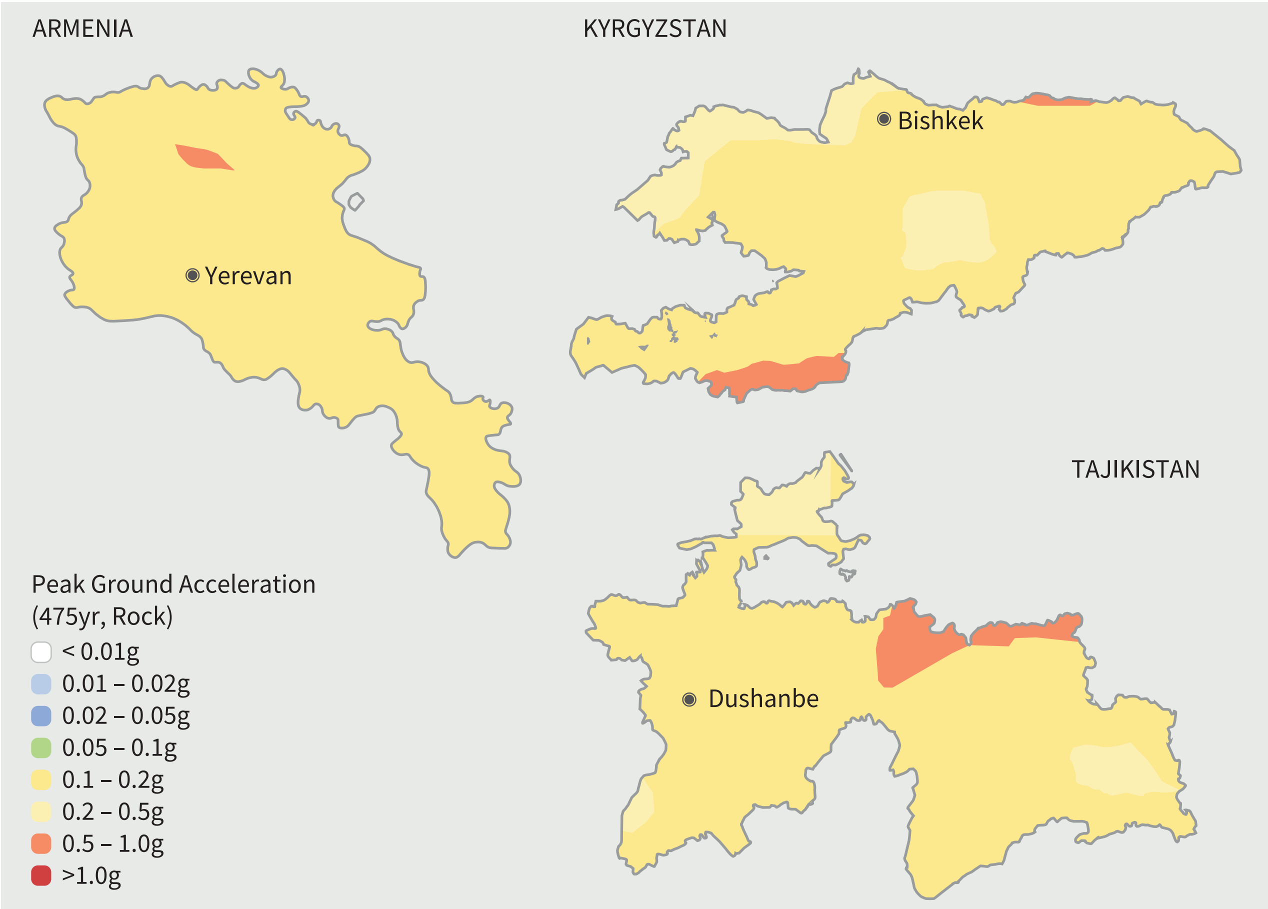
In the event of an extreme drought, Armenia's economic losses may amount to 4–5% of GDP. This estimate assumes complete loss of crops in the most vulnerable regions (Ararat, Armavir, and Aragatsotn), and partial decline of output of livestock products.

Figure C. Rate of Occurrence of Significant Natural Hazard Events in Armenia in 1992–2023



Source: authors' calculations based on EM-DAT data.

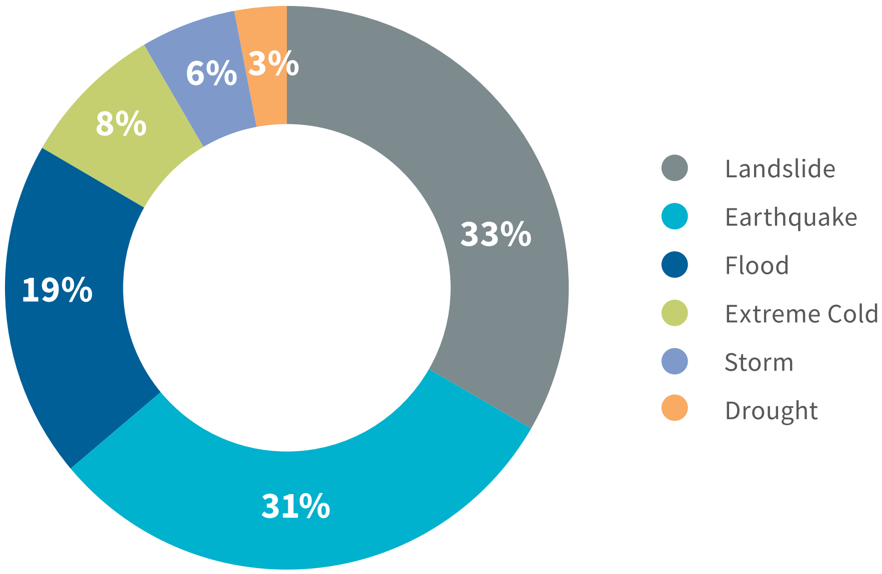
Figure D. Seismic Hazard, Peak Ground Acceleration (PGA) as a Fraction of g=9.81 m/s² (Return Period: 475 Years)



Source: GEM (2023b–d).

In Kyrgyzstan, earthquakes and floods are the main types of natural hazard events which may have an adverse impact on economic stability. In 1992–2023, the most widespread natural hazard events were landslides (33%), earthquakes (31%), and floods (19%) (Figure E), but the heaviest damage was caused by the 1992 earthquake ($271 million in 2022 prices) and the 1994 landslide ($71 million in 2022 prices).

Figure E. Rate of Occurrence of Significant Natural Hazard Events in Kyrgyzstan in 1992–2023



Source: authors' calculations based on EM-DAT data.

Direct losses from earthquakes in Kyrgyzstan may reach $2.6 billion (23.9% of the 2022 GDP). The most vulnerable regions are in the south-west and north-east of the country (Figure D).

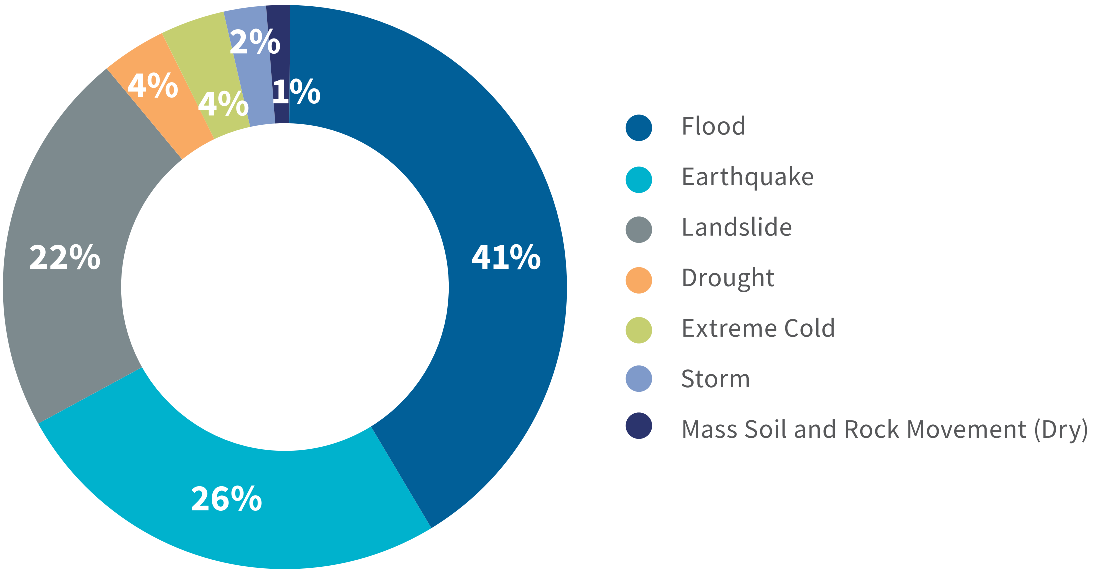
Direct losses of Kyrgyzstan in case of floods can reach 6.4% of the 2022 GDP. According to JBA Risk Management, average annual flood-related damage in Kyrgyzstan amounts to $73.3 million. The most damage is registered in Chüy Region, Jalal-Abad Region, and Osh Region. These regions account for about 50% of the country's population, and are crossed by its two longest rivers, the Naryn and the Chu.

In Tajikistan, earthquakes and floods are the main natural hazard events which may have an adverse impact on economic stability. In 1992–2023, the most widespread natural hazard events were floods (41%), earthquakes (26%), and landslides (22%) (Figure F). The most damage was caused by the 2008 cold wave ($1.1 billion in 2022 prices), the 1992 flood ($0.6 billion in 2022 prices), the 1985 Kayrakkum earthquake ($0.5 billion in 2022 prices), and the 1993 landslide ($0.3 billion in 2022 prices).

Direct losses from earthquakes in Tajikistan may be as high as $2.8 billion (26.7% of the 2022 GDP). The most vulnerable areas are in the north of the regions of republican subordination and the Gorno-Badakhshan Autonomous Province (Figure D).

Direct losses that Tajikistan may suffer from floods may reach 5.2% of the 2022 GDP. According to JBA Risk Management, average annual flood-related damage in Tajikistan amounts to $60.8 million, with the most damage registered in Khatlon Region.

Figure F. Rate of Occurrence of Significant Natural Hazard Events in Tajikistan in 1992–2023



Source: authors' calculations based on EM-DAT data.

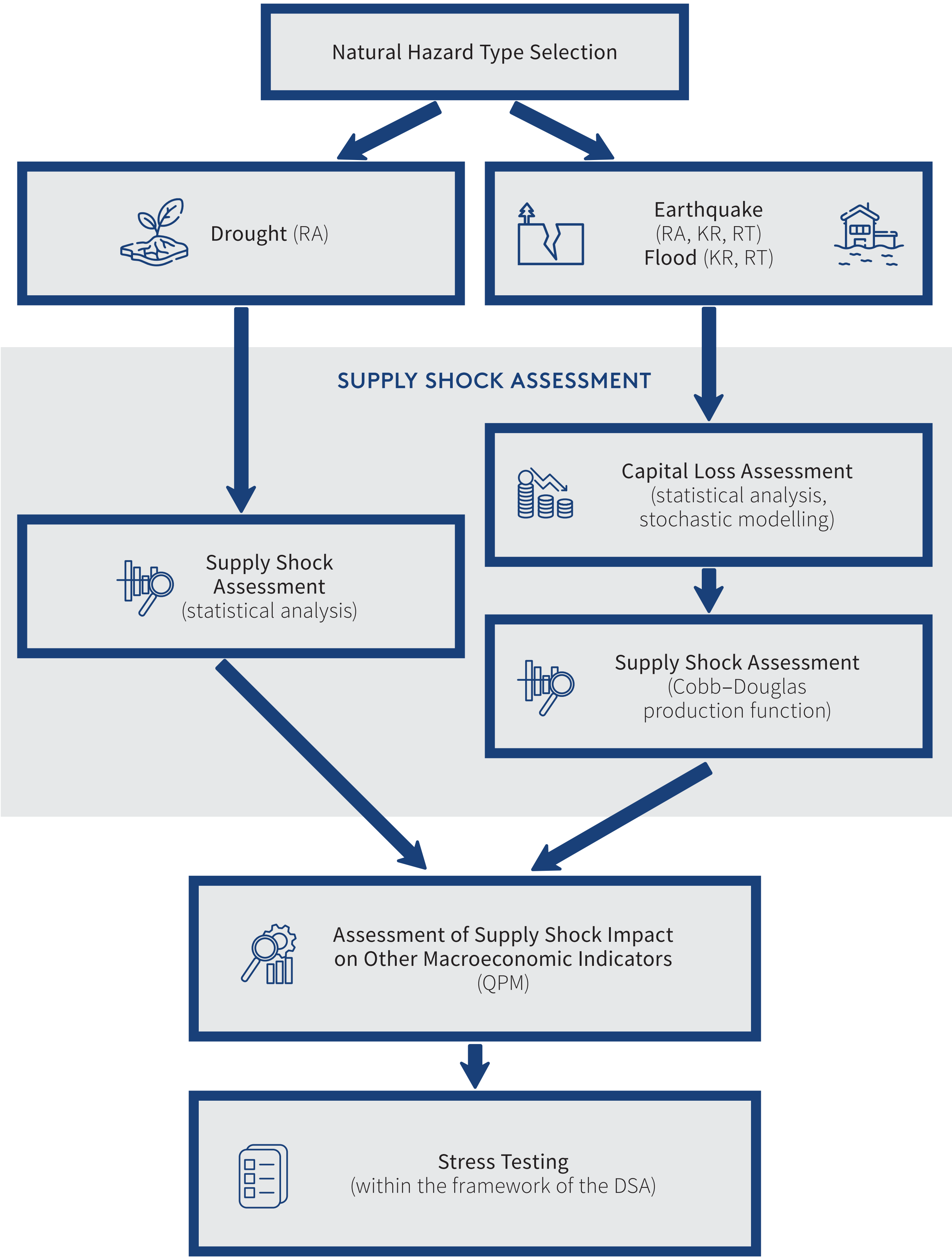
The authors estimated the impact that loss of capital in Armenia, Kyrgyzstan, and Tajikistan may have on potential GDP. Reduction of capital in these countries by 1% results in a decrease in their potential GDP by 0.35%, 0.4%, and 0.4%, respectively.

The authors also designed an approach to assessment of the potential impact of natural hazard events on the debt sustainability of the three countries (Figure G). The approach is based on the IMF and World Bank methodology used within the framework of the Debt Sustainability Analysis (DSA) system. Additionally, it measures the impact of natural hazard events on various macroeconomic indicators (real and potential GDP, inflation rate, exchange rate of the national currency to the US dollar, key rate of the central bank).

A forecast of changes in public debt and financing needs shows that **if Armenia, Kyrgyzstan, and Tajikistan lose 10% of their vulnerable capital due to earthquakes/floods, they will not be able to fully recover those losses** due to their inability to generate sufficient primary budget surpluses in the future to repay their outstanding debt. That will force the governments to prioritise their decisions about recovery of industrial, commercial, and residential buildings.

The research findings can be used to design fiscal strategies and natural hazard mitigation strategies to reduce vulnerability of the countries under review to potential adverse events. That, in turn, will improve the quality of financial risk management, and generally ensure steady economic growth.

Figure G. Stages of Construction of the Shock Scenario for DSA Stress Testing



Source: developed by the authors.

Introduction

Many countries are suffering from increasingly frequent and intense natural hazard events related to climate change. The trend is taking an ominous turn, and climate risks are becoming critical. According to EM-DAT, a comparison of the global average annual frequency of natural hazard events measured for 1900–1929 and 1993–2022 shows that that indicator has increased more than 40-fold (from 8 to 348 per year).[1] The most intensive rate of increase was in the second half of the 20th century.

In this Working Paper, a "natural hazard" is defined as a destructive natural and/or natural-anthropogenic phenomenon or process of significant scale which may result, or has resulted, in a threat to human life and health, destruction or annihilation of material values or natural environment components.[2]

There are several types of natural hazards:

- geophysical (earthquakes[3], volcanic eruptions, etc.),
- meteorological (storms, droughts, etc.),
- hydrological (floods, tsunamis, etc.),
- climatological (fires, etc.),
- biological (epidemics, etc.), and
- extra-terrestrial (geomagnetic storms, etc.).

Resilience of countries to natural hazard-related risks underpins the activity of international institutions providing development financing. As certain major climate risks materialise, it may be necessary to promptly offer an assessment of their impact on macroeconomic indicators (GDP reduction, decrease in budget revenues and increase in budget expenditures, acceleration of inflation, depreciation of the national currency) and, possibly, to develop a national bailout plan. Qualitative assessment of the macroeconomic impact of climate risks makes it possible to more effectively streamline any applicable fiscal and BoP support programmes.

Due to their geographical location, relatively small territory, and highly concentrated economies, climate risks can have a significant impact on the macroeconomic performance of EFSD member states such as Armenia, Kyrgyzstan, and Tajikistan. It is therefore important to quantify this impact in order to monitor the debt sustainability of these countries.

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1 The analysis covered geophysical, meteorological, hydrological, and climatological natural hazards. The figure may be overstated due to possible lack of quality statistical information for the first half of the 20th century.

2 State Standard GOST 22.0.03-97. Safety in Emergencies. Natural Emergencies. Terms and Definitions, paragraph 3.1.6.

3 While there is no evidence of a direct link between climate change and an increase in earthquake frequency and intensity (NASA's Global Climate Change, 2019), this Working Paper further examines this type of natural hazard to assess its potential impact on the debt sustainability of the analysed countries.

The purpose of this Working Paper is to assess the potential impact of natural hazard events on the debt sustainability of Armenia, Kyrgyzstan, and Tajikistan.

To achieve that purpose, it is necessary to:

- develop country profiles which contain a description of the natural hazard events occurring in the countries under review;
- identify the main natural hazard events which may have a significant impact on the debt sustainability of the countries under review;
- assess the potential adverse effect of natural hazard events on the key macroeconomic and debt indicators of the countries under review; and
- develop proposals for ways to improve stress testing tools used to analyse the debt sustainability of the countries under review.

For the purposes of such research, it is necessary to have access to quality statistical information describing the consequences of natural hazard events in the countries under review. However, the data quality problem remains unresolved because global databases are compiled from multiple official sources using different measurement methods.

There are currently several international sources of data on the consequences of natural hazard events, such as EM-DAT, DesInventar, ADRC, ReliefWeb, and NOAA National Centers for Environmental Information.

EM-DAT is the most frequently used database. It is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) operating under the Université Catholique de Louvain (Belgium). Each record contains information on the number of deaths and affected people, and the estimated amount of direct economic damage sustained by infrastructure facilities and assets. However, to be included in the EM-DAT, a natural hazard event must meet one or more of the following criteria: at least 10 deaths, at least 100 affected people, a call for international assistance, or an emergency declaration (Centre for Research on the Epidemiology of Disasters, 2023). Those criteria restrict the EM-DAT coverage of natural hazard events.

The other sources listed above offer limited information (for example, the NOAA National Centers for Environmental Information maintains only earthquake records), or contain no information on the EFSD recipient states (DesInventar).

In addition, several ratings (indices) were developed to measure the risk related to natural hazards in various regions of the world, including the National Risk Index (for US states) and the WorldRiskIndex (covering 193 countries in 2022).

Taking into consideration the scope of information available on the countries under review, this Working Paper uses the annual WorldRiskIndex data published in the WorldRiskReport by Bündnis Entwicklung Hilft jointly with the Institute for International Law of Peace and Armed Conflict at Ruhr-Universität Bochum (Germany). The main advantage of this index is that it covers not only the risks directly linked to the frequency and intensity of natural hazard events, but also the risks associated with the social, political, and economic situation in each country.

That makes it possible to identify problems related to the country's vulnerability to natural hazards, and to develop effective mitigation measures.

This Working Paper has the following structure. Section 1 describes international research dedicated to the impact of natural hazard events on the key macroeconomic and debt indicators of the countries under review. Section 2 features country profiles of the EFSD recipient states, containing general information on those states (geography, climate, demography, economy), and a review of the natural hazard events that have occurred in their territories. Section 3 details the results of an assessment of direct economic losses caused by natural hazard events which may have material impact on the economic stability of Armenia, Kyrgyzstan, and Tajikistan. The last section presents the proposed approach to assessment of the potential impact of natural hazard events on the debt sustainability of the countries under review.

1. Literature Review

Any assessment of the impact of natural hazard events on the debt sustainability of the countries under review requires an in-depth analysis of several matters. In particular, it is necessary to:

- determine the main types of natural hazards which may inflict material economic damage on the countries under review;
- design tools to measure the potential economic damage attributable to natural hazards;
- design tools to assess the impact of the economic damage attributable to natural hazards on changes in the key macroeconomic indicators and debt sustainability of the countries under review.

At this time, there are several reports, working papers, and research publications dedicated to these matters.

Arazyan (2020) describes the main types of natural hazards characteristic of Armenia. The author notes that, because of its geography, the country is exposed to numerous natural hazards and catastrophes, including earthquakes, floods, hail, landslides, mudslides, droughts, soil erosion, and desertification, which have, for a long time, been the cause of huge societal upheavals and economic damage. The paper contains a detailed account of one of the most significant natural hazard events, the 1988 Spitak earthquake. In addition, the author points out that Armenia does not have sufficient capacity (ability) to manage the risks associated with natural hazards.

Reports published by the WBG and the ADB (2021a; 2021b; 2021c) are dedicated to probable climate warming scenarios and their impact on the intensity of natural hazard events in Armenia, Kyrgyzstan, and Tajikistan, respectively. According to the proposed stress scenario, by 2090 potential warming in those countries relative to the baseline period (1986–2005) may amount to 4.7–5.5 °C. Accordingly, the authors mention a number of problems, including droughts (for all the countries); stronger floods and related hazards, such as landslides and mudslides (for Kyrgyzstan and Tajikistan); and stronger fluctuation of hydro power generation in Tajikistan due to drought-triggered river runoff fluctuations.

CAREC reports (2022a; 2022b) describe country risk profiles for Kyrgyzstan and Tajikistan, respectively. The authors note that earthquakes, floods, and mudslides caused by abundant precipitation and/or rapid snowmelt are the most dangerous phenomena in those two countries. The reports also present data on the actual average annual economic losses related to earthquakes and floods, and their potential scope, depending on specific natural hazard return periods.

Wouter Botzen et al. (2019) offer a detailed review of research papers on the assessment of economic consequences of natural hazard events, both direct (e.g., material damage) and indirect (e.g., impact on GDP, trade). The authors distinguish the following types of models used for simulation and quantitative assessment of projected consequences of natural hazard events: catastrophe models, input-output models, general equilibrium models, and due diligence models.

Below we list several noteworthy research papers on modelling of the macroeconomic impact of natural hazard events.

In the Working Paper published by Nishizawa (2019), assessment of the impact of natural hazard events on the budget relies on the panel VAR approach by capturing the linear interdependencies between government revenues and government expenditures. Natural disasters are treated as exogenous shocks with contemporaneous and lagged macro-fiscal impacts. The model is based on statistical data for the Pacific island countries. According to the calculations performed for the countries of that region, a severe natural disaster is likely to increase government expenditures by 13.8–20.6% of GDP over a three-year period. In the disaster year, government expenditures are likely to increase by 6.4%, and two years after the disaster, government expenditures tend to further increase by 6.8%. It is also noted that a severe natural disaster would cause the country about a 2% decrease in real GDP growth in the disaster year.

Cantelmo et al. (2019) use a dynamic stochastic general equilibrium model (DSGE model) to describe the channels through which natural disaster shocks affect macroeconomic outcomes and welfare in disaster-prone countries. The paper shows that relative to non-disaster-prone countries, on average, these shocks cause a welfare loss equivalent to a permanent fall in consumption of 1.6%. The authors also note that it is more cost-effective for donors to contribute to the financing of resilience before disasters occur, rather than to disburse aid afterwards.

Bayoumi et al. (2021) analyse the impact of natural disasters on per-capita GDP growth. Using quantile regression, their paper examines the impact of disasters on the distribution of growth. The authors conclude that countries that have disaster preparedness mechanisms in place and lower public debt have a lower probability of a significant drop in growth as a consequence of a natural disaster.

Hallegatte et al. (2022) describe a macrostructural model for Türkiye which includes several adaptations designed to analyse the impact of natural disasters on economic activity, subject to the nature of the resultant capital loss. The authors (1) make a distinction between infrastructure and non-infrastructure capital, (2) conduct separate modelling for reconstruction investment solutions used in the private and public sectors, (3) present the impact of the shock on productivity of unaffected capital, and (4) consider realistic constraints on the reconstruction rate.

Kabundi et al. (2022) investigate how climate shocks affect consumer prices in a broad range of countries over a long period, using local projection methods. The researchers established that the impact of climate shocks on inflation depends on the type and intensity of shocks, country income level, and monetary policy regime. Specifically, droughts tend to have the highest overall positive impact on inflation, reflecting rising food prices. Interestingly, floods tend to have a dampening impact on inflation, pointing to the predominance of demand shocks in this case.

Maldonado et al. (2022) describe the methodology proposed for integrating the potential impact of natural disasters in the Debt Sustainability Analysis (DSA) system designed by the IMF and the World Bank (IMF, 2018; IMF, 2021). The methodology envisages several scenarios: under the first scenario ("Physical Risk Scenario"), the country experiences a climate catastrophe; under the second scenario ("Green Transition Scenario"), it resolves to invest in adaptation to a green economy, thus improving its resilience to climate risks; the third scenario is a combination of the first two.

The approach presented in this Working Paper for estimating the potential impact of natural hazards on macroeconomic indicators and debt sustainability differs from those used in the studies described above and is based on the integration of:

- the estimation of potential direct economic damage (capital loss) due to natural hazards provided by the Global Earthquake Model Foundation and JBA Risk Management;
- the estimation of the impact of capital loss on GDP change, which is done using the Cobb-Douglas production function (Cobb et al., 1928; Hallegatte et al., 2016; Hallegatte et al., 2022);
- quarterly projection models (QPMs) adapted to natural hazards shocks for the countries analysed (EDB, 2016); and
- the Debt Sustainability Analysis (DSA) framework (IMF, 2018; IMF, 2021). A feature of the approach presented here is the use of QPM models, while in global practice DSGE models are used to solve this problem (Hallegatte et al., 2022).

2. Country Profiles

2.1. Armenia

2.1.1. Country Review

Geography

Armenia is a landlocked country in the Caucasus with a total area of about 29,800 km^2, of which more than 90% is mountainous terrain more than 1,000 m above sea level.

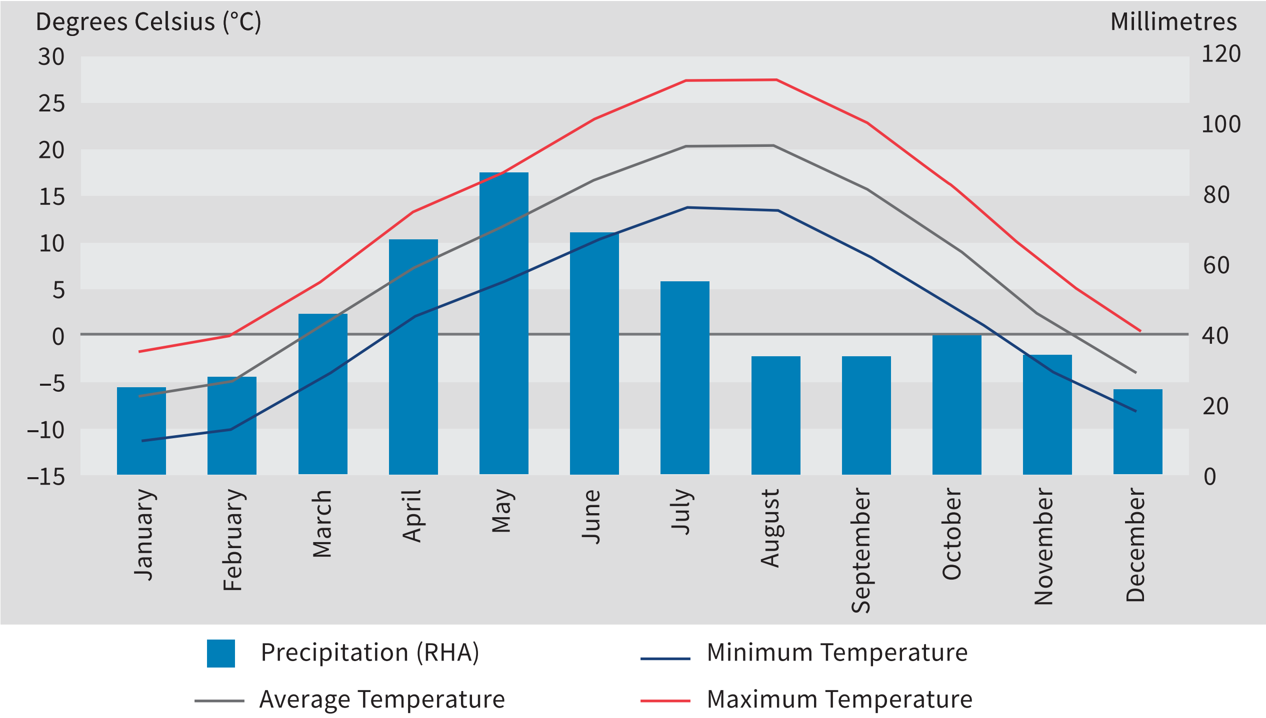
Armenia is divided into ten regions and the City of Yerevan (Figure 2.1).

Climate

Armenia lies in the subtropical zone, but a subtropical climate is observed only in the south of the country (in the vicinity of the city of Meghri). Other areas have highland and continental climate, with a large temperature difference between summer maximums occurring from June to August and winter minimums occurring from December to February (Figure 2.2).

Figure 2.1. Armenia: Regions and City of Yerevan

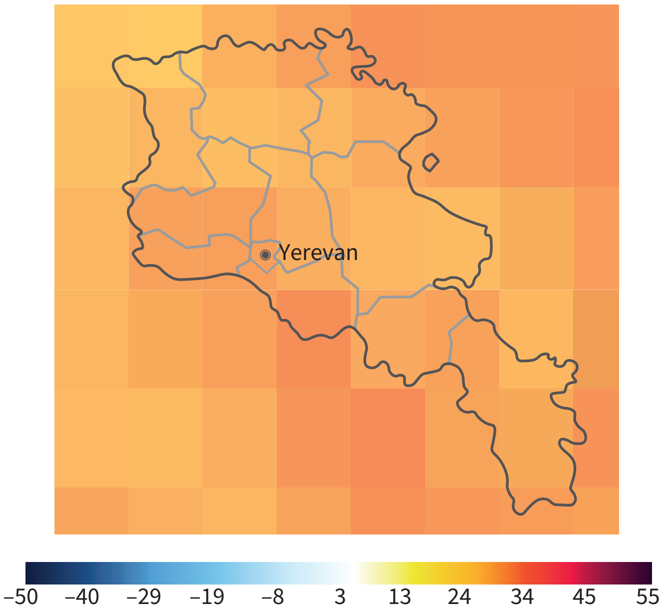
Figure 2.2. Average Monthly Temperatures and Precipitation in Armenia in 1991–2020



Source: WBG Climate Change Knowledge Portal.

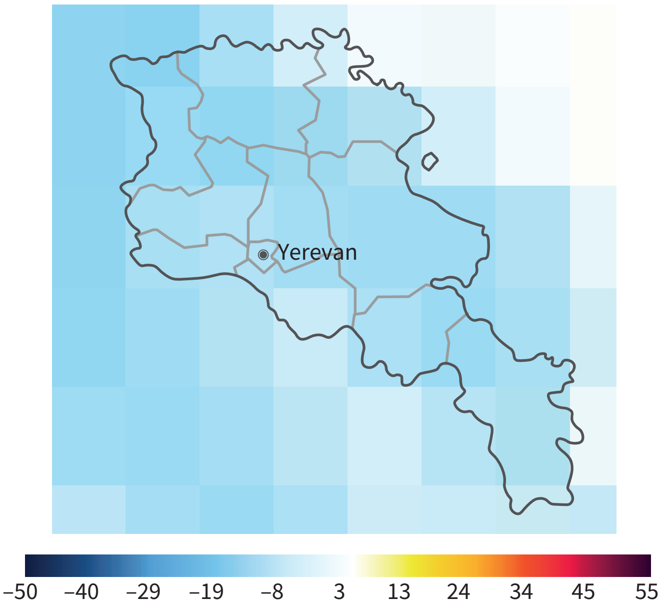
In Armenia, spatial distribution of temperatures and precipitation is determined by the height above sea level. Minimum temperatures are usually observed around Armenia's mountain ranges, while maximum temperatures are typical for the plains (e.g., near Ararat, Armavir, and Aragatsotn) (Figures 2.3 and 2.4).

Figure 2.3. Seasonal Maximum Temperatures in Armenia (June–August) in 1991–2020



Source: WBG Climate Change Knowledge Portal.

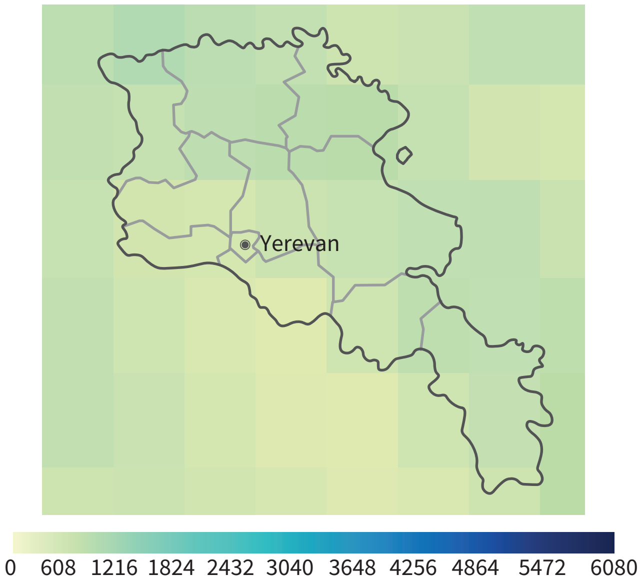
Figure 2.4. Seasonal Minimum Temperatures in Armenia (December–February) in 1991–2020



Source: WBG Climate Change Knowledge Portal.

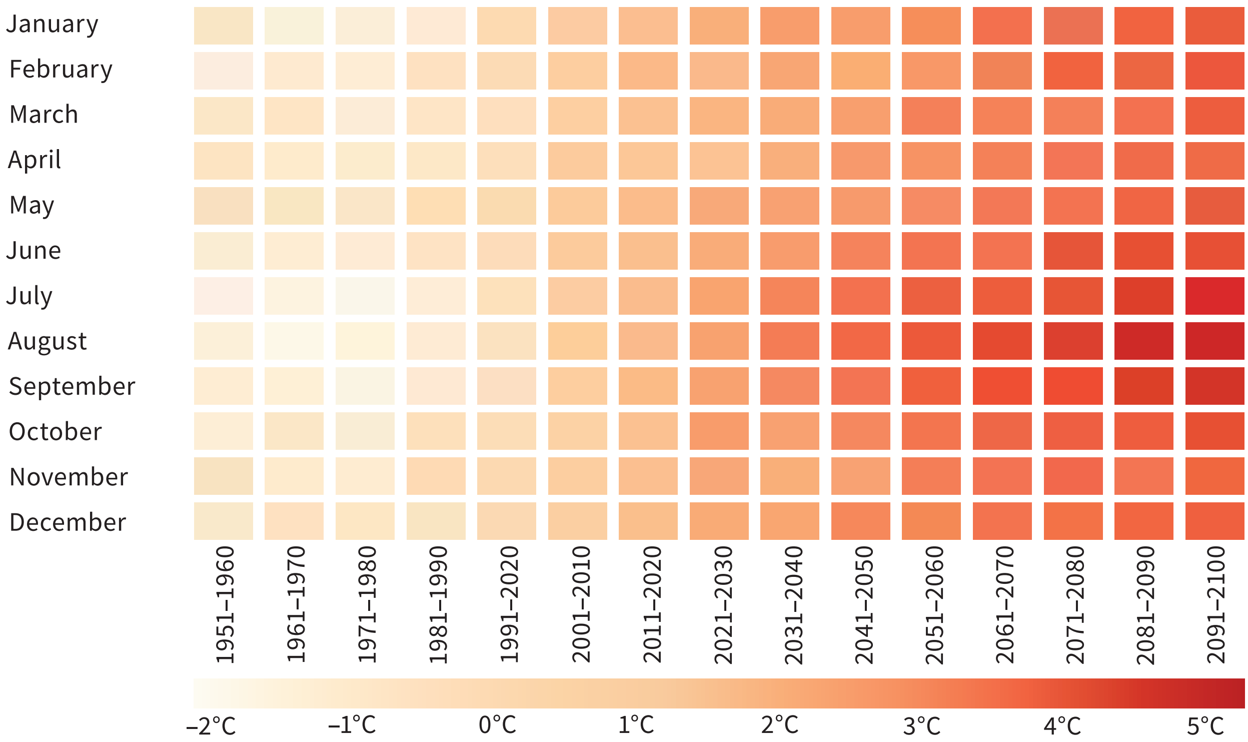
Similarly, annual precipitation in the vicinity of Armenia's highest mountain peaks may be as high as 1,000 mm, while in the plains it may reach merely 200 mm (Figure 2.5).

Figure 2.5. Average Annual Precipitation in Armenia in 1991–2020



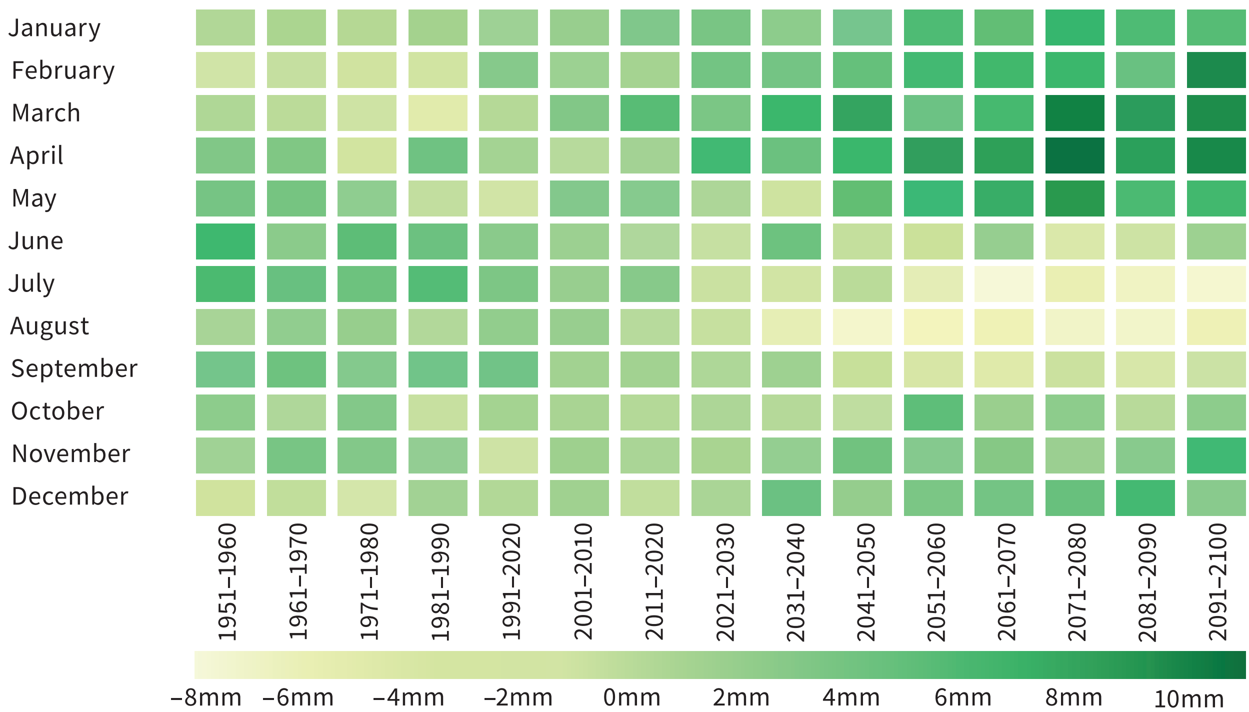
Source: WBG Climate Change Knowledge Portal.

Figure 2.6. Projected Average Temperature Anomaly in Armenia under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

Figure 2.7. Projected Precipitation Anomaly in Armenia under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

A comparison of the 1901–1910 and 2012–2021 averages based on the data available at the WBG Climate Change Knowledge Portal[4] shows that temperature in Armenia has increased by 1.6 °C, while precipitation has decreased by 4.7%. The observed temperature increase triggered a rapid shrinking of glaciers in the mountainous regions of Armenia: they are receding at the rate of about 8 m per year (Shahgedanova et al., 2009).

Under the moderate scenario presented in Phase 6 of the Coupled Model Intercomparison Project (CMIP),[5] in the future Armenia is expected to experience steady warming during all seasons (Figure 2.6). Average annual precipitation is likely to remain close to its current level, but precipitation rates are expected to go up in February–May and down during the summer months (Figure 2.7). Regions in the east and south will have the least precipitation.

Demography

According to SC RA, at the end of 2022, the resident population of the country was estimated at 3.0 million people. Almost two thirds live in cities.

As of 1 January 2022, the largest shares of the resident population lived in the City of Yerevan (36.9%), and in the provinces of Armavir (8.9%), Ararat (8.7%), and Kotayk (8.5%). Vayots Dzor was the least populated province (1.6%).

Economy

In 2022, Armenia's GDP amounted to $19.5 billion. According to 2020 data, GRP figures (as GDP percentages) were as follows:

- City of Yerevan — 60%,
- Ararat — 7%,
- Kotayk — 7%,
- Syunik — 6%,
- Armavir — 6%,
- Lori — 3%,
- Shirak — 3%,
- Gegharkunik — 3%,
- Aragatsotn — 2%,
- Tavush — 2%, and
- Vayots Dzor — 1%.

In 2022, the following sectors accounted for the largest shares of the gross value added:

- Manufacturing and Mining — 16.8%,
- Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles — 12.9%,

[4] Resource developed by the World Bank.

[5] CMIP is a project realised by the Working Group of Coupled Modelling (WGCM) under the World Climate Research Programme (WCRP). In this Working Paper, the term "moderate scenario" refers to Scenario SSP2-4.5, assuming that the world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns.

- Agriculture, Forestry and Fisheries — 11.6%,
- Finance and Insurance Activities — 8.9%,
- Real Estate — 8.8%, and
- Construction — 7.6%.

Total electricity generation in Armenia in 2022 was 8.9 billion kWh, with thermal power plants, the Armenian Nuclear Power Plant, and hydro power plants accounting for 44%, less than 32%, and 22%, respectively.

Armenia's key social and economic indicators are presented in Table 2.1.

Table 2.1. Key Indicators of Armenia

Indicator	Period	Value	Source
Resident population, million people	2022 EoY	3.0	SC RA
Population density, people per 1 km^2	2022 EoY	100.1[6]	SC RA
Fertility rate, number of births per woman	2021	1.58	World Bank
Urban population, % of total population	2022	63.6	World Bank
GDP (in current prices), $ billions	2022	19.5	World Bank
GDP per capita (PPP, in current prices), $	2022	18,941.5	World Bank
Electricity generation, billion kWh	2022	8.9	SC RA

2.1.2. Natural Hazards

In WorldRiskReport–2022 (Bündnis Entwicklung Hilft, 2022), Armenia was ranked No. 127 among the 193 rated countries (the higher the position, the lower the risk), and classified as a low-risk country (Figure 2.8).

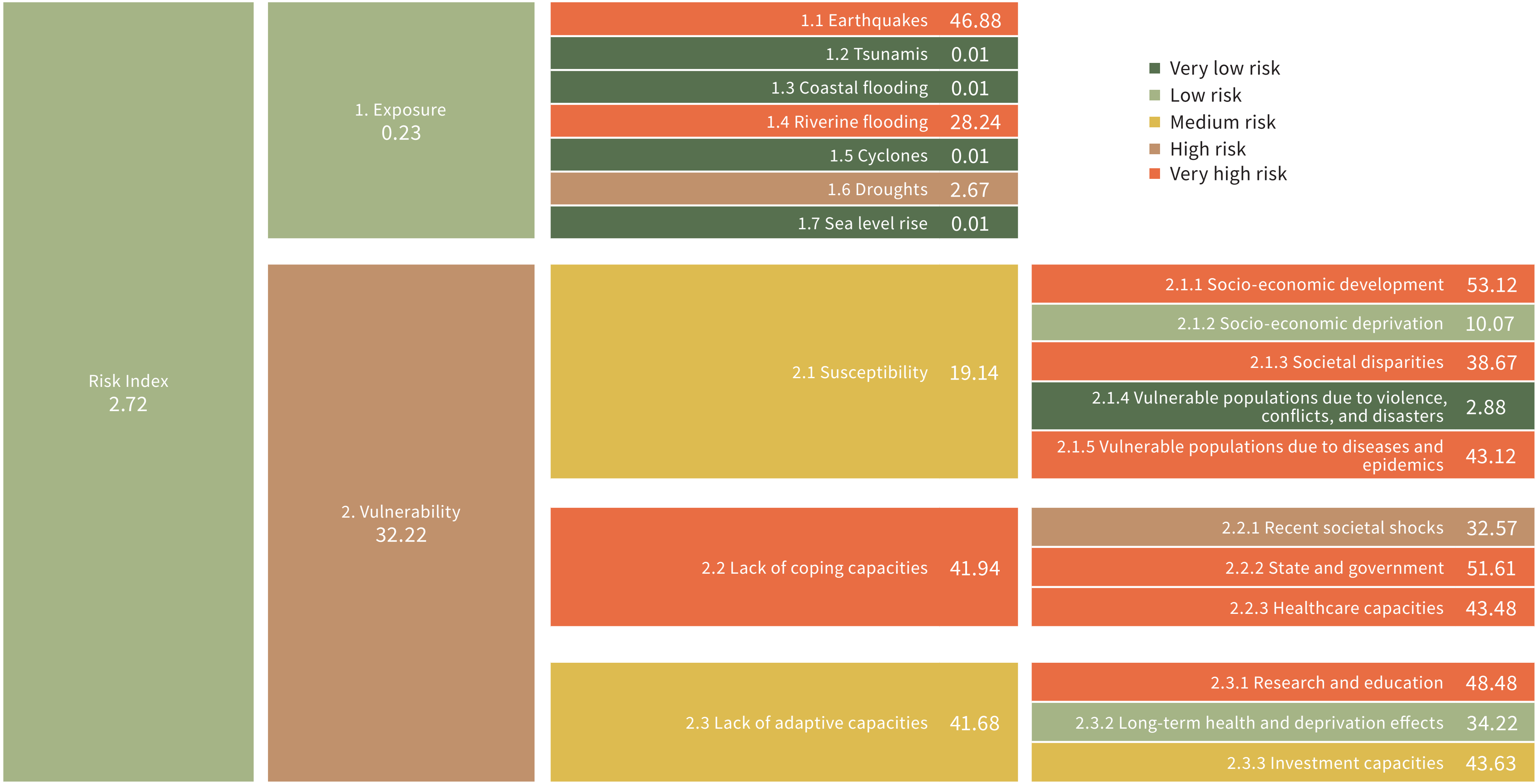
That low level of risk can be explained by Armenia's low exposure to natural hazards: of the seven types of natural hazards analysed in WorldRiskReport–2022, the country is exposed to only three: earthquakes, floods, and droughts.

At the same time, Armenia is characterised by high vulnerability due to its:

- medium susceptibility: insufficient socio-economic development, high societal disparities; high vulnerability of the population to diseases and epidemics;
- low coping capacities: severe societal shocks, low government effectiveness, health care problems; and
- medium adaptive capacities: low research activity, low investment capacities (Figure 2.8).

[6] Author's calculations based on SC RA data.

Figure 2.8. Armenia: Risk Index and Its Components



Source: authors' calculations based on WorldRiskReport (2022).
Note: for a description of the WorldRiskIndex calculation methodology, see WorldRiskReport (2022).

Table 2.2 presents data on natural hazard events that occurred in Armenia in 1992–2022.

It should be noted that international databases that contain information on natural hazard events prior to 1992 do not have separate records for Armenia, as it was part of the Soviet Union. Finding detailed statistical data for that period is a challenging task; accordingly, our analysis covers only events from 1992 to the present.[7]

Table 2.2. Natural Hazard Events in Armenia in 1992–2023

Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
1997	Earthquake	N/A	15,000	33	61
1997	Flood	4	7,000	8	15
1998	Flood	N/A	144	0	0
1998	Earthquake	N/A	N/A	N/A	N/A
2000	Drought	N/A	297,000	100	170
2004	Flood	1	N/A	N/A	N/A
2013	Storm	N/A	64,000	60	75
2013	Extreme Cold	N/A	12,000	N/A	N/A
2016	Landslide	N/A	750	N/A	N/A
2018	Storm	N/A	9,900	2	2
2019	Storm	N/A	11,700	N/A	N/A
2020	Storm	N/A	2,836	N/A	N/A
2023	Storm	N/A	18,000	N/A	N/A

Source: EM-DAT with confirmation from other sources, including ADRC, ReliefWeb, NOAA National Centres for Environmental Information.

Notes: 1. Total damage — economic losses directly or indirectly related to the natural hazard event.

2. The classification of natural hazard events used in this table is described in EM-DAT Documentation (2023).

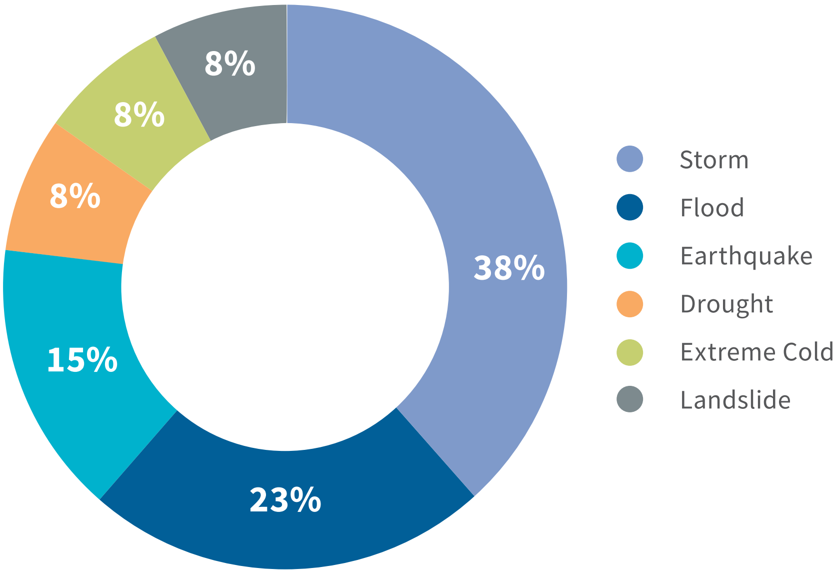
According to the data presented in Table 2.2, the most widespread natural hazard events in 1992–2023 were storms (38%) and floods (23%) (Figure 2.9).

An analysis of the economic impact of natural hazards in 1992–2023 shows that the heaviest damage was caused by droughts ($170 million in 2022 prices). The 1988 Spitak earthquake deserves special mention, as total damage caused by that event amounted to $34.6 billion (in 2022 prices), while total deaths and total affected persons stood at about 25,000 and 1.6 million, respectively.

Based on our analysis of the frequency of, and damage caused by, natural hazard events, we come to the conclusion that **earthquakes and droughts** are the main types of natural hazard events capable of producing a significant impact on the economy and, as a consequence, on the debt sustainability of Armenia.

[7] The same is true for Kyrgyzstan and Tajikistan (as described below).

Figure 2.9. Rate of Occurrence of Significant Natural Hazard Events in Armenia in 1992–2023



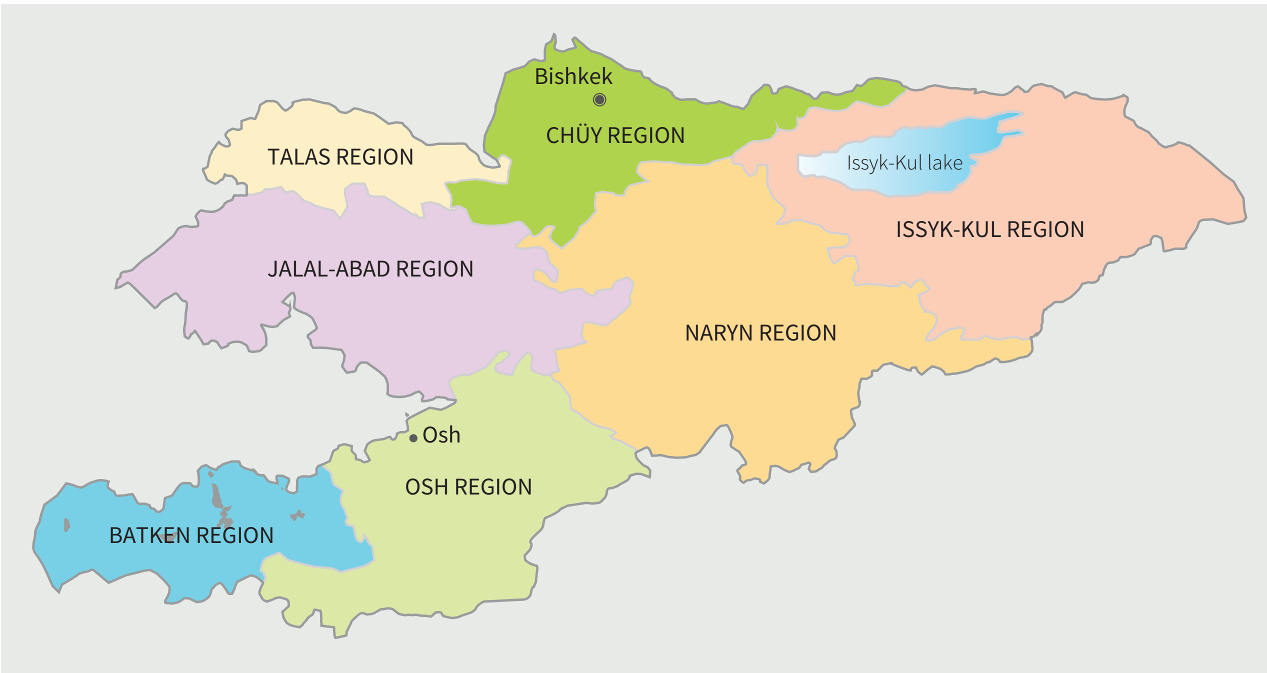
Source: authors' calculations based on EM-DAT data.

2.2. Kyrgyzstan

2.2.1. Country Review

Geography

Figure 2.10. Kyrgyzstan: Regions and Cities of Republican Subordination



The Kyrgyz Republic is a landlocked country in Central Asia situated in the western and central parts of the Tian-Shan mountain system and in the Pamir-Alay mountain system. The total area is about 200,000 km^2, of which more than 75% is occupied by mountains.

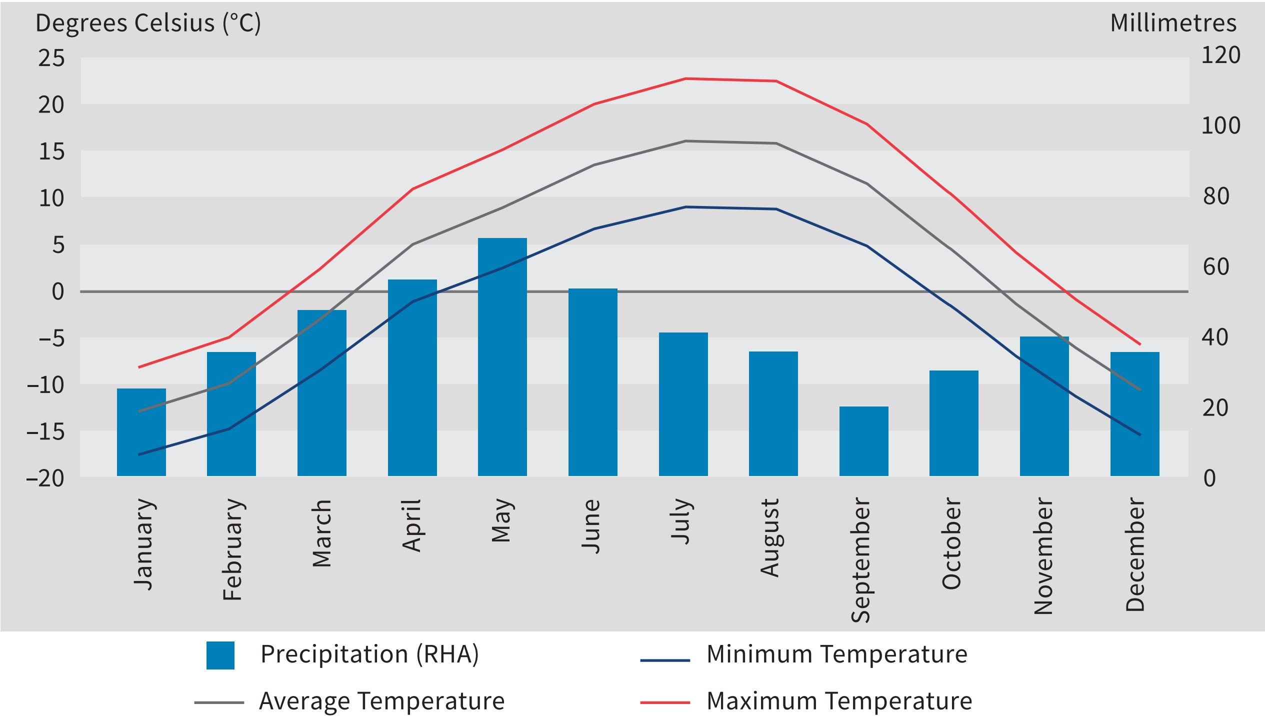
Kyrgyzstan is divided into seven regions and two cities — Bishkek and Osh — have a special status. (Figure 2.10).

Climate

Kyrgyzstan has a continental climate. Most of the country is arid territory characterised by partly cloudy conditions and precipitation patterns shaped by the mountainous terrain.

The climate is determined by the country's position in the northern hemisphere, in the middle of the Eurasian continent, as well as its remoteness from oceans and proximity to deserts. It is characterised by relatively high intra-annual (Figure 2.11) and spatial variability: maximum temperatures are observed in the northern and western lowlands (Figure 2.12), minimum temperatures — in high mountain areas (Figure 2.13).

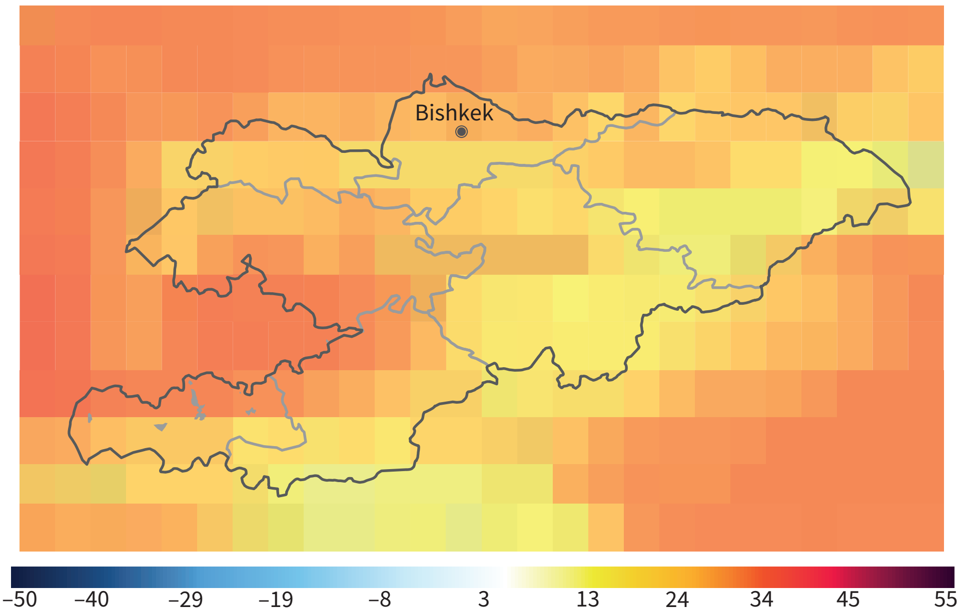
Figure 2.11. Average Monthly Temperatures and Precipitation in Kyrgyzstan in 1991–2020



Source: WBG Climate Change Knowledge Portal.

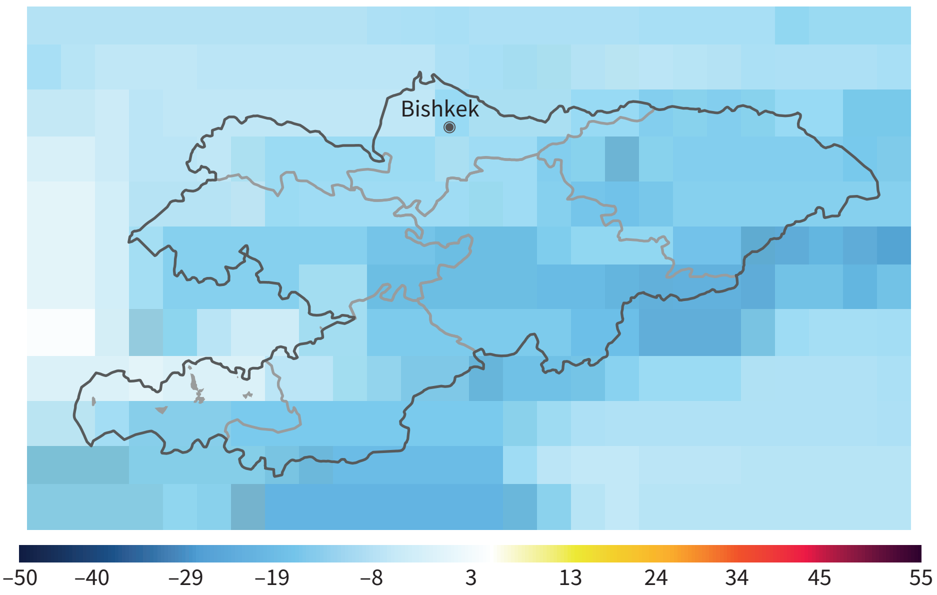
According to the data available at the WBG Climate Change Knowledge Portal, in 2021, average precipitation in the country was 342.1 mm; precipitation levels vary strongly from region to region, with the most precipitation recorded in Jalal-Abad region (Figure 2.14). Approximately 24% of the country's territory is more than 3,500 m above sea level, and that area is under perennial snow cover (Kyrgyz Republic, 2016).

Figure 2.12. Seasonal Maximum Temperatures in Kyrgyzstan (June–August) in 1991–2020



Source: WBG Climate Change Knowledge Portal.

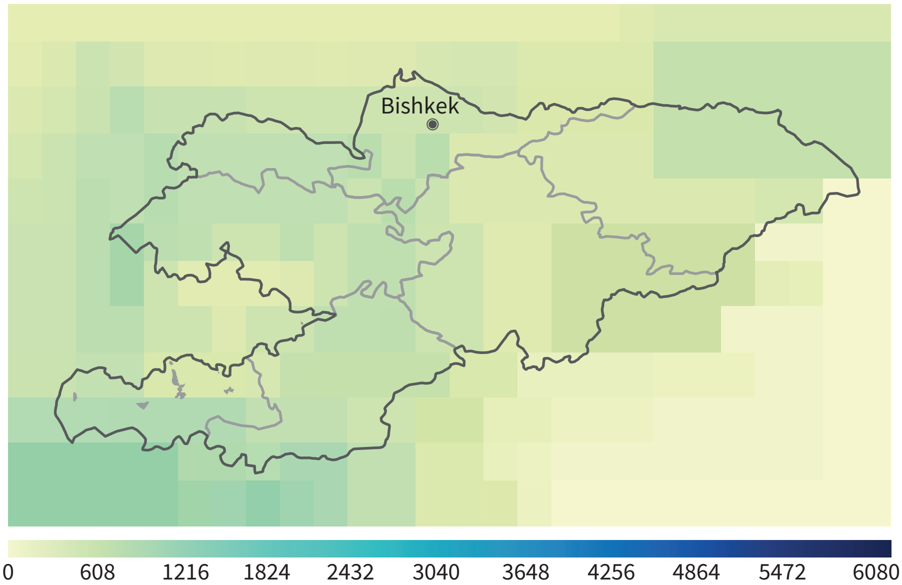
Figure 2.13. Seasonal Minimum Temperatures in Kyrgyzstan (December–February) in 1991–2020



Source: WBG Climate Change Knowledge Portal.

A comparison of the 1901–1910 and 2012–2021 averages based on the data available at the WBG Climate Change Knowledge Portal shows that the temperature in Kyrgyzstan has increased by 1.9°C, while precipitation has decreased by 5.2%. Warming trends were noted in all regions of Kyrgyzstan, and at all heights above sea level (Kyrgyz Republic, 2016). Warming is most pronounced from November to March.

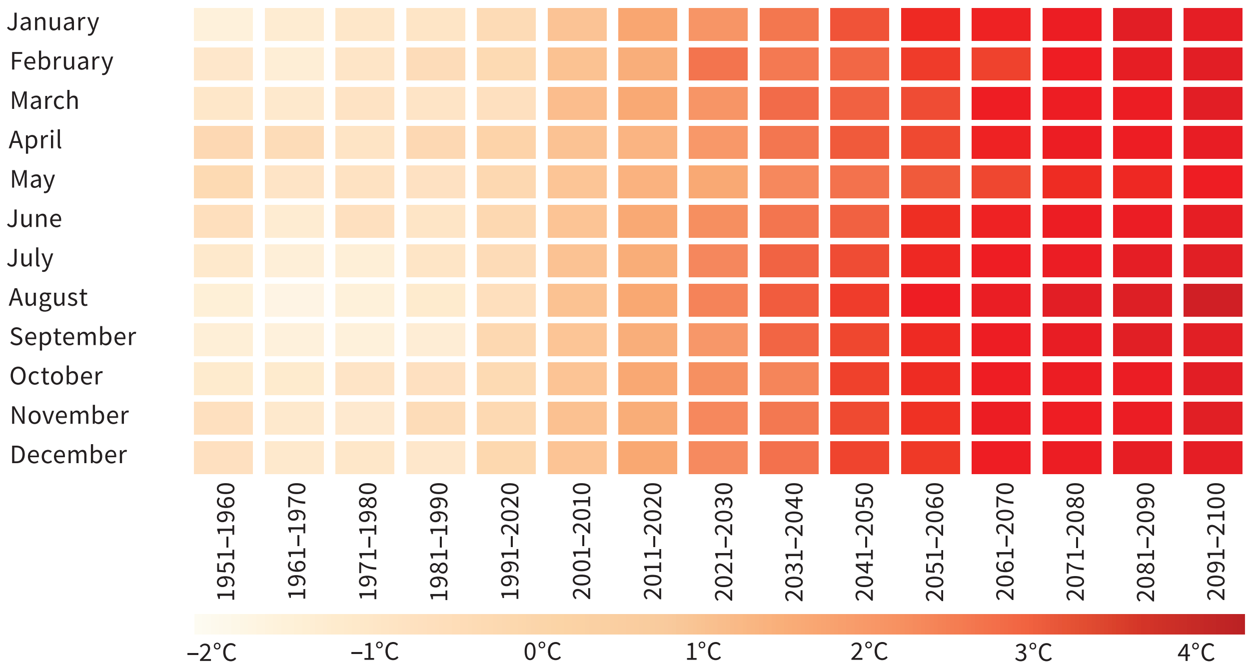
Figure 2.14. Average Annual Precipitation in Kyrgyzstan in 1991–2020



Source: WBG Climate Change Knowledge Portal.

Under the moderate scenario,[8] in the future Kyrgyzstan is expected to experience steady warming during all seasons (Figure 2.15). On the other hand, precipitation projections for Kyrgyzstan are less certain. It is expected that precipitation intensity may increase in January–April and in November–December (Figure 2.16).

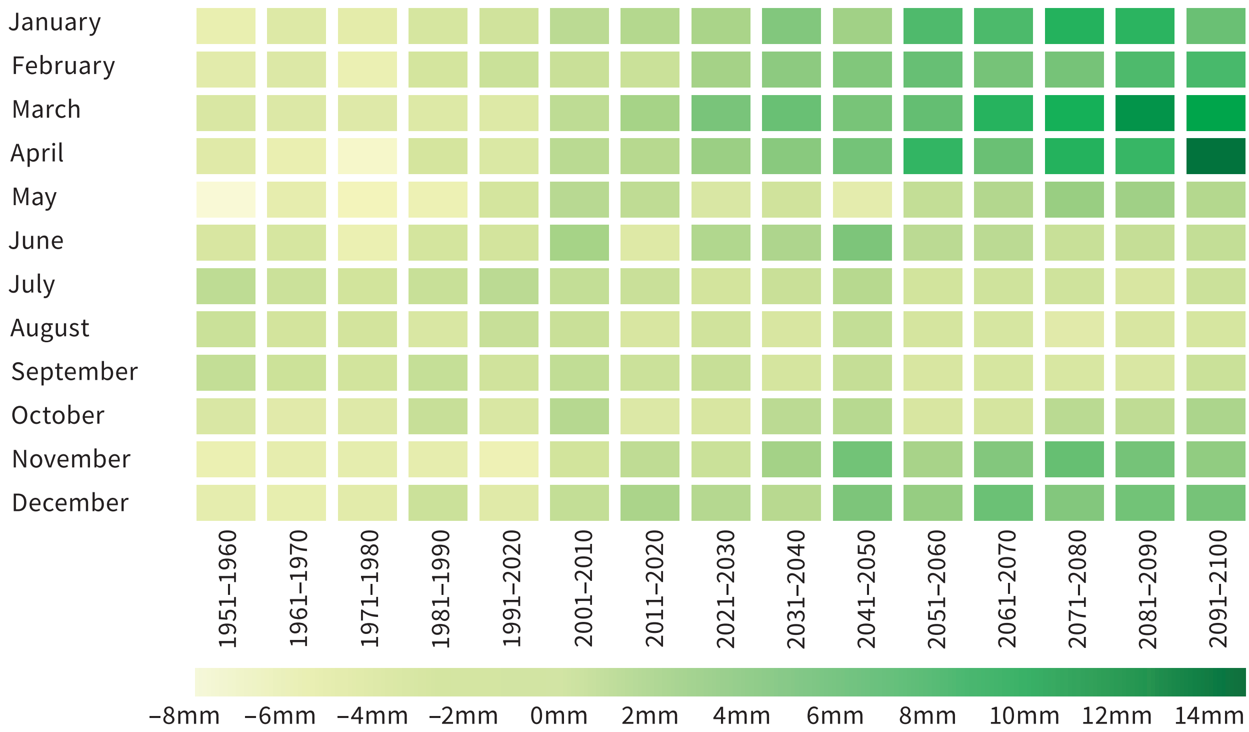
Figure 2.15. Projected Average Temperature Anomaly in Kyrgyzstan under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

8 According to CMIP Phase 6 results.

Figure 2.16. Projected Precipitation Anomaly in Kyrgyzstan under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

Demography

According to NSC KR, as of 1 January 2023, the resident population of the country was estimated at 7.0 million people. The largest shares live in Osh Region (20.8%), Jalal-Abad Region (18.6%), and Chüy Region (15.2%), as well as in the City of Bishkek (16.3%, including villages and suburbs). The urban population is only about one third of the total population.

Economy

In 2022, Kyrgyzstan's GDP amounted to $10.9 billion. According to 2021 data, GRP figures (as GDP percentages) were as follows:

- City of Bishkek — 40%,
- Chüy Region — 15%,
- Jalal-Abad Region — 11%,
- Issyk-Kul Region — 11%,
- Osh Region — 8%,
- City of Osh — 5%,
- Talas Region — 4%,
- Batken Region — 3%, and
- Naryn Region — 2%.

The following sectors had the largest shares in the country's GDP (2022):

- Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles — 17.5%,
- Manufacturing — 12.4%,
- Agriculture, Forestry, and Fisheries — 12.1%,
- Construction — 7.4%,
- Education — 6.9%, and
- State Administration and Defence, Obligatory Social Insurance — 6.4%.

Total electricity generation in Kyrgyzstan in 2021 was 15.1 billion kWh, with hydro power plants accounting for 86%, and thermal power plants for the remaining 14%.

Kyrgyzstan's key indicators are presented in Table 2.3.

Table 2.3. Key Social and Economic Indicators of the Kyrgyz Republic

Indicator	Period	Value	Source
Population, million people	2022 EoY	7.0	NSC KR
Population density, people per 1 km^2	2022 EoY	35.2[9]	NSC KR
Fertility rate, number of births per woman	2021	2.89	World Bank
Urban population, % of total population	2022	37.5	World Bank
GDP (in current prices), $ billions	2022	10.9	World Bank
GDP per capita (PPP, in current prices), $	2022	6,132.5	World Bank
Electricity generation, billion kWh	2021	15.1	NSC KR

2.2.2. Natural Hazards

According to WorldRiskReport–2022 (Bündnis Entwicklung Hilft, 2022), Kyrgyzstan was ranked No. 142, and classified as a low-risk country (Figure 2.17).

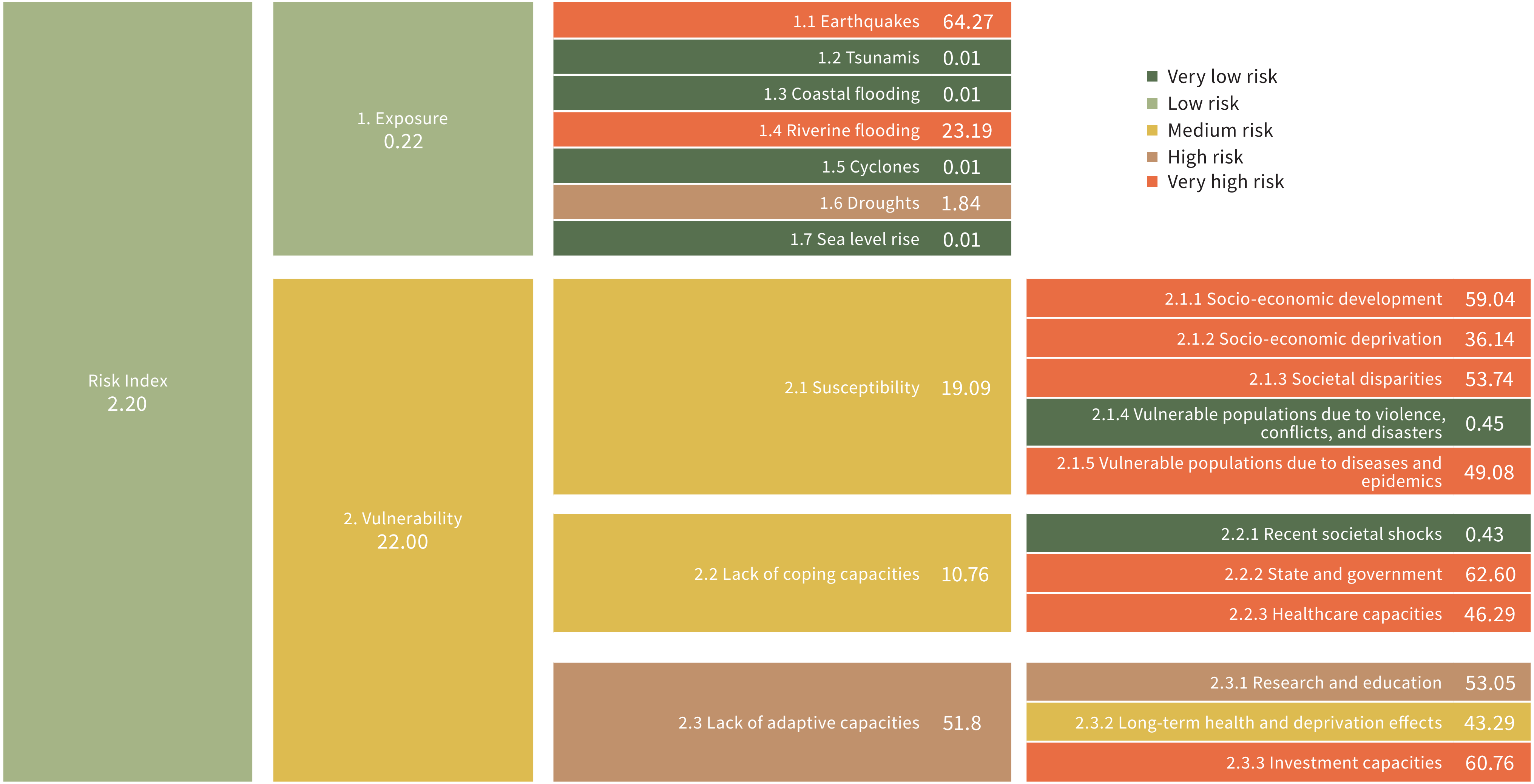
That low level of risk can be explained by Kyrgyzstan's low exposure to natural hazards: of the seven types of natural hazards analysed in WorldRiskReport–2022, the country is exposed to only three: earthquakes, floods, and droughts.

Kyrgyzstan is characterised by medium vulnerability due to its:

- medium susceptibility: weak socio-economic development, high socio-economic deprivations and societal disparities; high vulnerability of the population to diseases and epidemics;
- insufficient coping capacities: low government effectiveness, poor state of the health care system;
- weak adaptive capacities: low research activity, low investment capacities (Figure 2.17).

[9] Authors' calculations based on NSC KR data.

Figure 2.17. Kyrgyzstan: Risk Index and Its Components



Source: authors' calculations based on WorldRiskReport (2022).
Note: for a description of the WorldRiskIndex calculation methodology, see WorldRiskReport (2022).

Table 2.4 presents data on natural hazard events that occurred in Kyrgyzstan in 1992–2022.

Table 2.4. Natural Hazard Events in Kyrgyzstan in 1992–2023

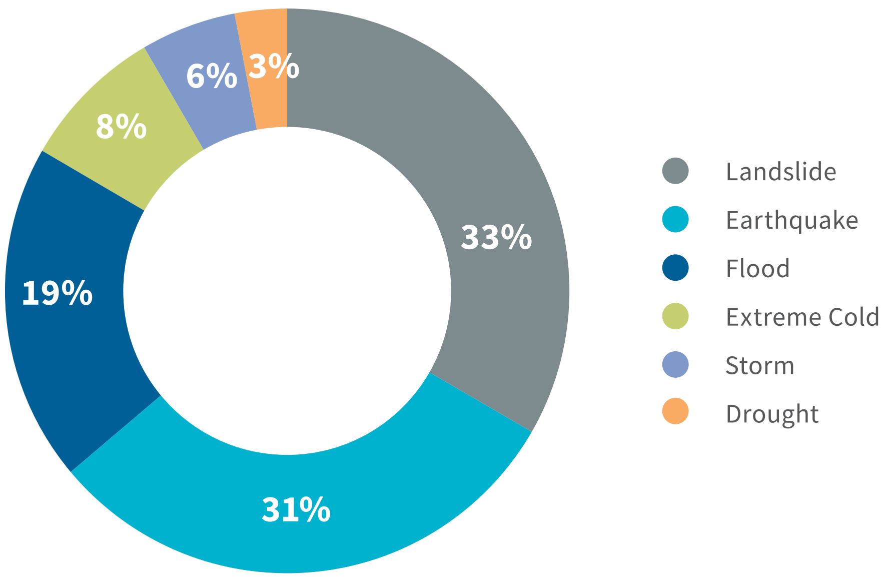
Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
1992	Earthquake	54	86,806	130	271
1992	Earthquake	4	50,000	31	65
1994	Landslide	111	58,500	36	71
1994	Landslide	51	N/A	N/A	N/A
1997	Earthquake	N/A	1,230	2	4
1998	Flood	1	7,728	2	4
2000	Extreme Cold	11	N/A	N/A	N/A
2002	Earthquake	N/A	N/A	N/A	N/A
2002	Landslide	N/A	1,002	2	2
2003	Landslide	38	211	N/A	N/A
2004	Landslide	11	2	N/A	N/A
2004	Landslide	4	N/A	N/A	N/A
2004	Landslide	5	N/A	N/A	N/A
2004	Landslide	33	96	N/A	N/A
2005	Flood	3	2,050	3	4
2006	Storm	4	9,075	N/A	N/A
2006	Earthquake	N/A	12,050	N/A	N/A
2007	Earthquake	N/A	N/A	N/A	N/A
2007	Flood	N/A	845	0	0
2008	Earthquake	N/A	3,000	N/A	N/A
2008	Earthquake	74	1,197	N/A	N/A
2009	Landslide	16	N/A	N/A	N/A
2009	Drought	N/A	2,000,000	N/A	N/A
2010	Landslide	N/A	8,350	N/A	N/A
2011	Earthquake	N/A	N/A	N/A	N/A
2012	Flood	N/A	N/A	N/A	N/A
2012	Flood	N/A	11,000	N/A	N/A
2012	Extreme Cold	16	50	N/A	N/A
2014	Storm	N/A	N/A	N/A	N/A

Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
2015	Earthquake	N/A	16,780	12	15
2017	Earthquake	N/A	5,000	N/A	N/A
2017	Landslide	24	55	N/A	N/A
2021	Landslide	15	N/A	N/A	N/A
2021	Flood	N/A	N/A	N/A	N/A
2022	Extreme Cold	N/A	13,850	N/A	N/A
2023	Flood	N/A	N/A	N/A	N/A

Source: EM-DAT with confirmation from other sources, including ADRC, ReliefWeb, NOAA National Centres for Environmental Information.

According to the data presented in Table 2.4, the most widespread natural hazard events in 1992–2023 were landslides (33%), earthquakes (31%), and floods (19%) (Figure 2.18). It should be noted that most landslides are caused by earthquakes and floods (according to EM-DAT (Annex 1) and CAREC research (2022)).

Figure 2.18. Rate of Occurrence of Significant Natural Hazard Events in Kyrgyzstan in 1992–2023



Source: authors' calculations based on EM-DAT data.

An analysis of the economic impact of natural hazards in 1992–2023 shows that the heaviest damage was caused by the 1992 earthquake ($271 million in 2022 prices), and the 1994 landslide ($71 million in 2022 prices).

Based on the foregoing, we come to the conclusion that **earthquakes and floods** are the main types of natural hazard events capable of producing a significant impact on the economy and, as a consequence, on the debt sustainability of Kyrgyzstan.

2.3. Tajikistan

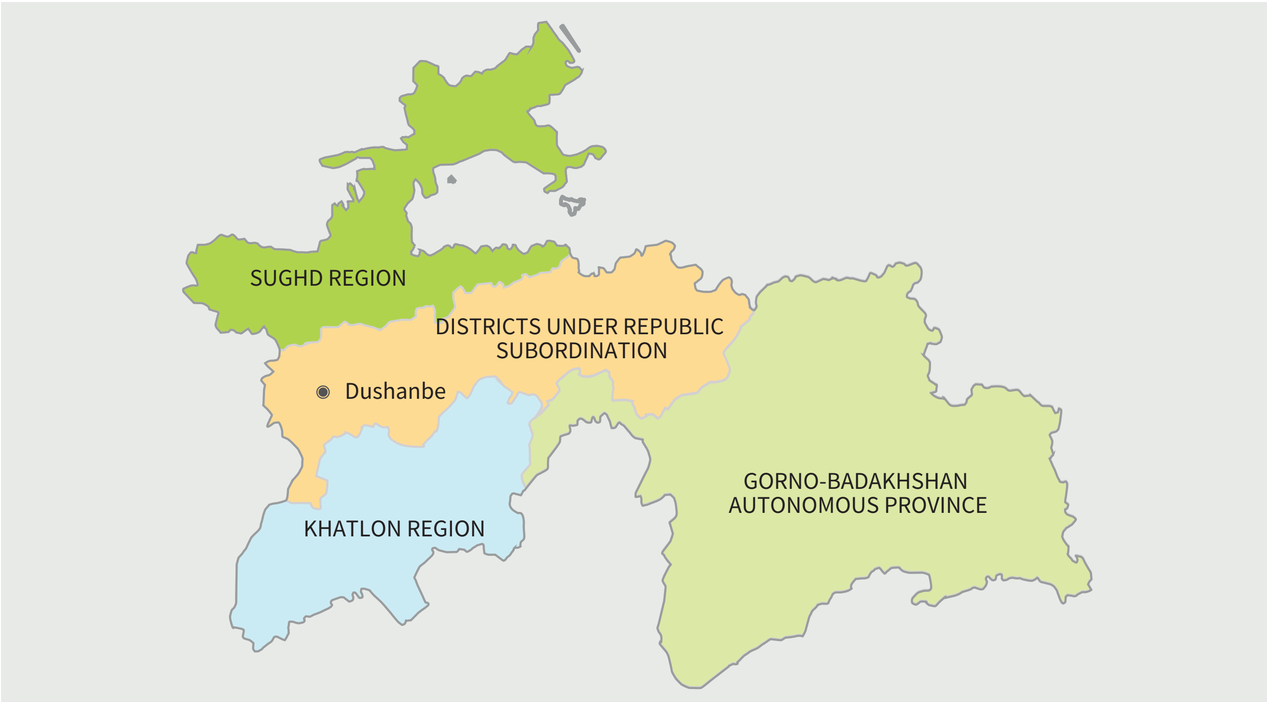
2.3.1. Country Review

Geography

Tajikistan is a landlocked country in Central Asia situated in the foothills of the Pamir mountains. The total area is 141,400 km^2, of which 93% is occupied by mountains.

Tajikistan is divided into three regions, one city, and several districts of republican subordination (Figure 2.19).

Figure 2.19. Tajikistan: Regions and the City of Dushanbe



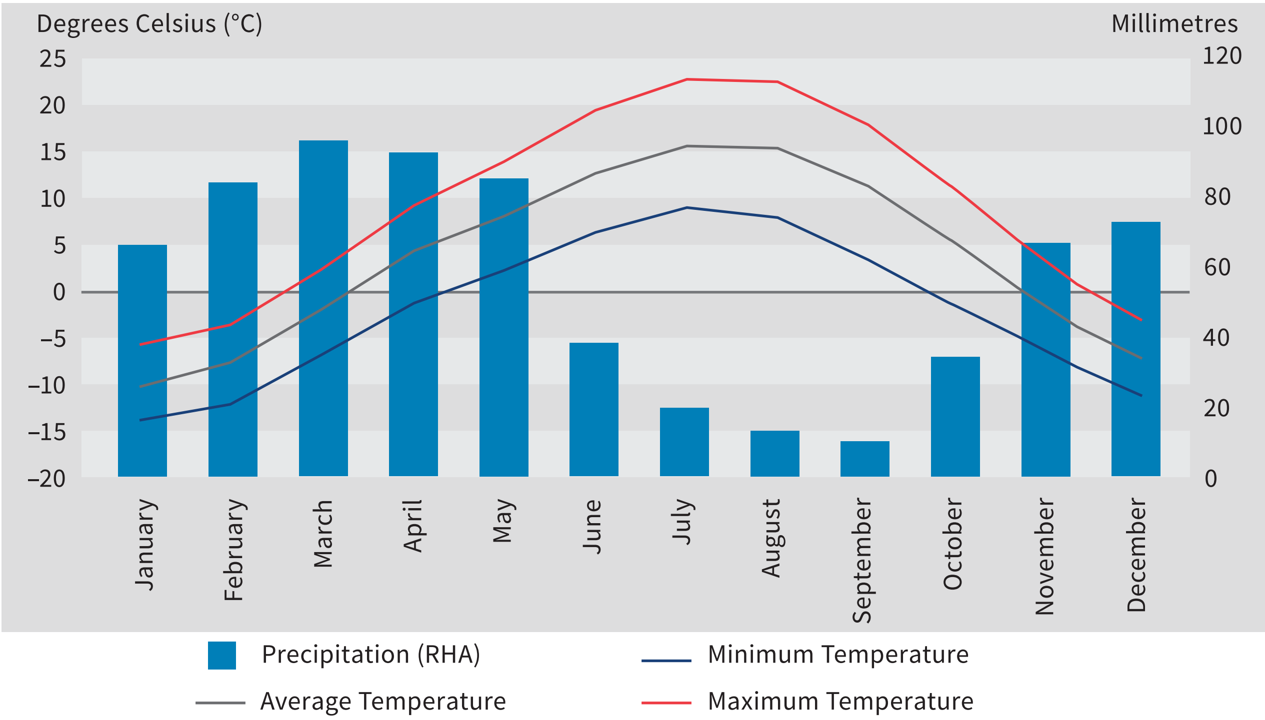
Climate

Tajikistan has a continental climate characterised by significant daily and seasonal fluctuations of air temperature and scarce precipitation (Figure 2.20).

Maximum temperatures are observed in the south of Khatlon Region and in the north of Sughd Region (Figure 2.21), minimum temperatures — in the Pamir mountain system (Figure 2.22).

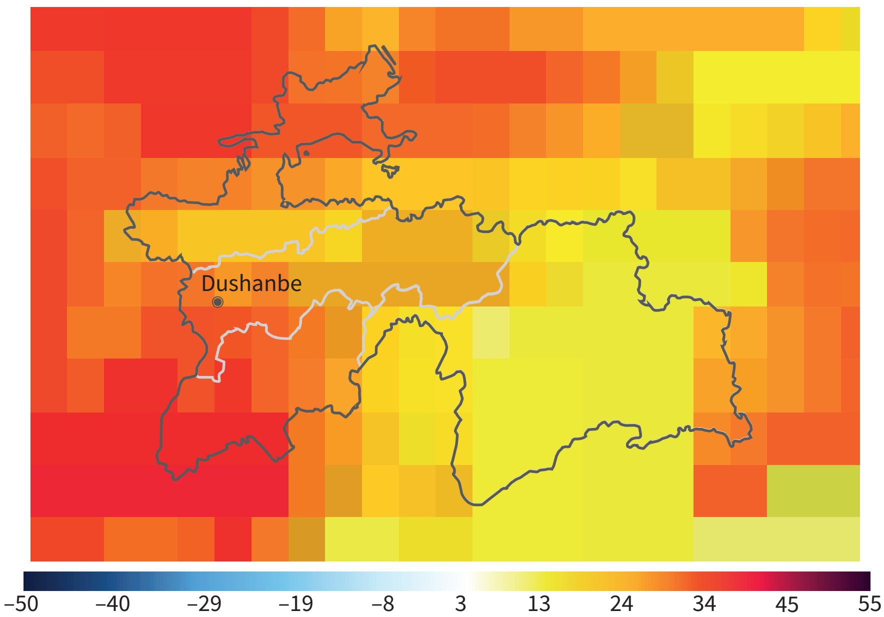
Average annual precipitation in the hot flatland deserts in the north of Tajikistan and in the cold mountain deserts in the east of the Pamir mountains can range from 70 to 160 mm per year, while in Central Tajikistan precipitation may exceed 1,800 mm per year (Figure 2.23). Precipitation in July, August, and September is insignificant, which frequently leads to droughts.

Figure 2.20. Average Monthly Temperatures and Precipitation in Tajikistan in 1991–2020



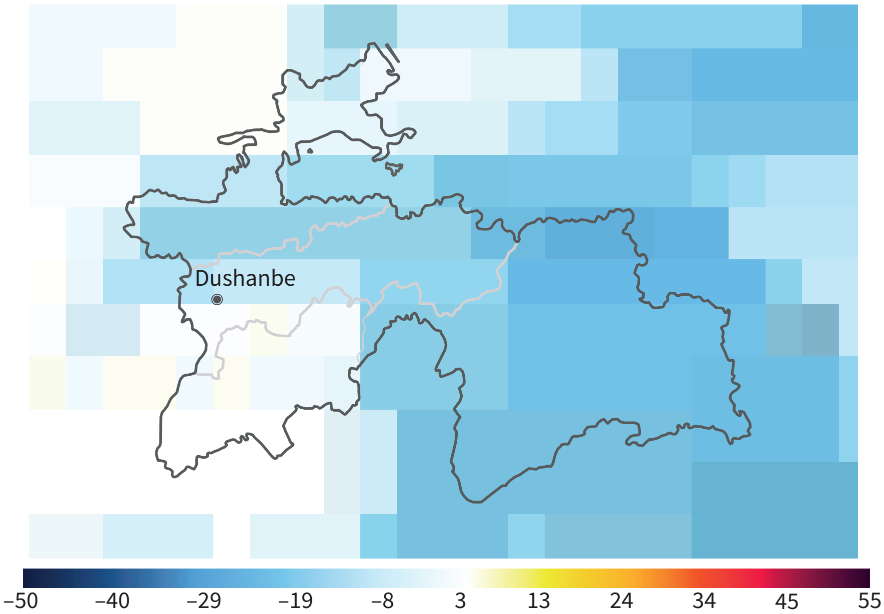
Source: WBG Climate Change Knowledge Portal.

Figure 2.21. Seasonal Maximum Temperatures in Tajikistan (June–August) in 1991–2020



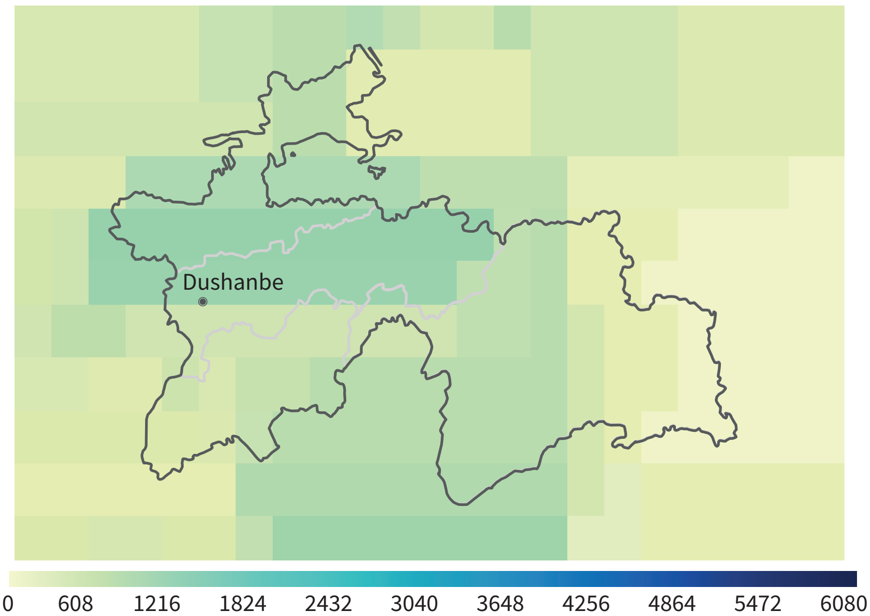
Source: WBG Climate Change Knowledge Portal.

Figure 2.22. Seasonal Minimum Temperatures in Tajikistan (December–February) in 1991–2020



Source: WBG Climate Change Knowledge Portal.

Figure 2.23. Average Annual Precipitation in Tajikistan in 1991–2020



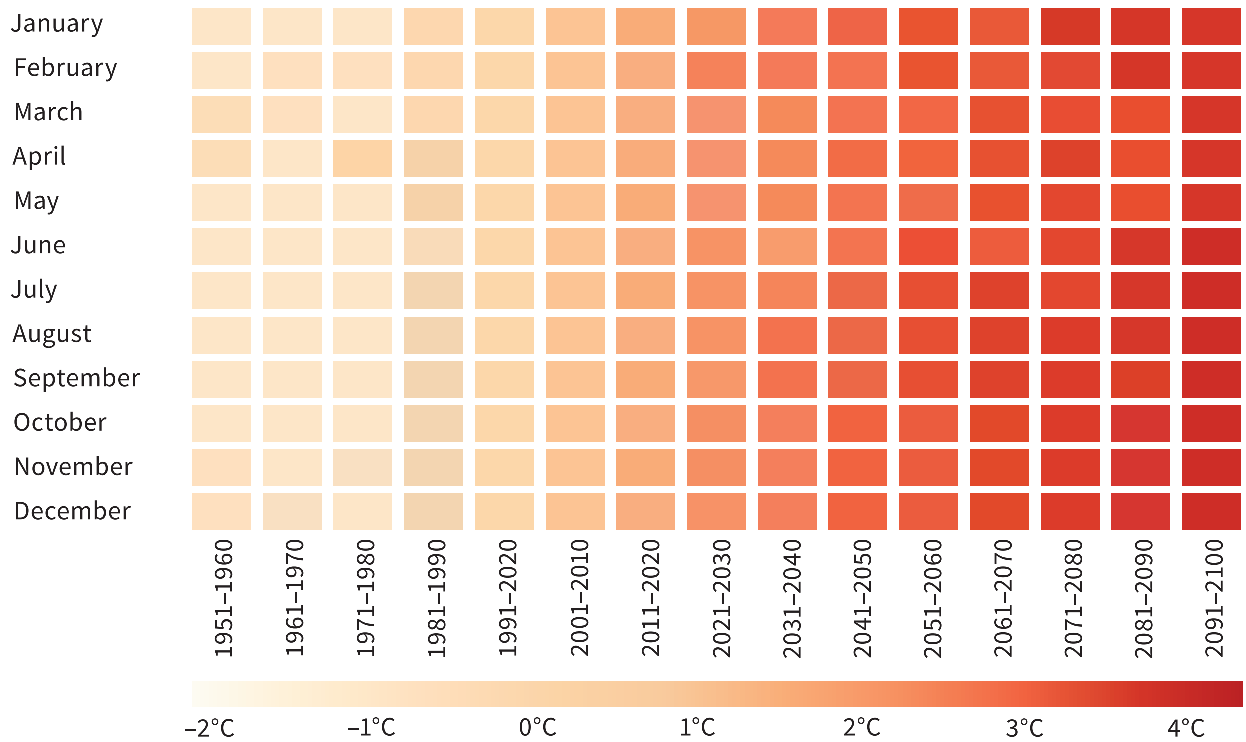
Source: WBG Climate Change Knowledge Portal.

A comparison of the 1901–1910 and 2012–2021 averages based on the data available at the WBG Climate Change Knowledge Portal shows that the temperature in Tajikistan has increased by 1.4 °C and precipitation has increased by 3.3%.

Under the moderate scenario,[10] in the future Tajikistan is expected to experience steady warming during all seasons (Figure 2.24). Projected precipitation will also slightly increase due to higher intensity in January–April (Figure 2.25).

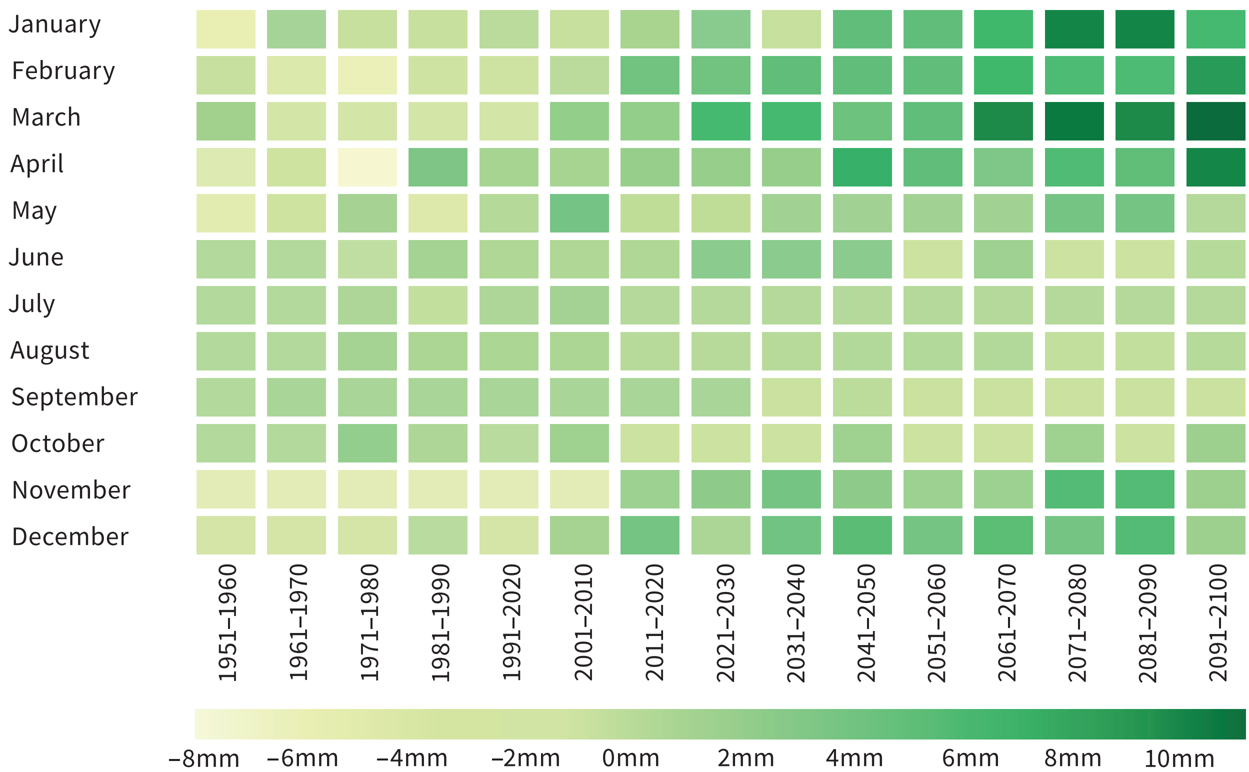
[10] According to CMIP Phase 6 results.

Figure 2.24. Projected Average Temperature Anomaly in Tajikistan under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

Figure 2.25. Projected Precipitation Anomaly in Tajikistan under the Moderate Scenario (Reference Period: 1995–2014)



Source: WBG Climate Change Knowledge Portal.

Demography

According to SA RT, as of 1 January 2023, the resident population of the country was 10 million people. At the beginning of 2022, 36% of the population lived in Khatlon Region, 29% in Sughd Region, 21% in the districts of republican subordination, 12% in the City of Dushanbe, and 2% in Gorno-Badakhshan Autonomous Province. The urban population is less than one third of the total population.

Economy

In 2022, Tajikistan's GDP amounted to $10.5 billion. According to 2022 data, GRP figures (as GDP percentages) were as follows:

- Khatlon Region — 29.2%,
- Sughd Region — 27.6%,
- City of Dushanbe — 19.5%,
- Districts of republican subordination — 16.5%, and
- Gorno-Badakhshan Autonomous Province — 1.2%.

The following sectors had the largest shares in the country's GDP (2022):

- Agriculture, Forestry and Fisheries — 24.6%,
- Industry — 17.0%,
- Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles, Hotels and Restaurants — 14.3%,
- Transport Operations and Storage of Cargoes, Information and Communications — 9.3%,
- Construction — 7.9%, and
- Other Services — 17.7%.

Table 2.5. Key Indicators of Tajikistan

Indicator	Period	Value	Source
Population, million people	2022 EoY	10.0	SA RT
Population density, people per 1 km^2	2022 EoY	70.0[11]	SA RT
Fertility rate, number of births per woman	2021	3.19	World Bank
Urban population, % of total population	2022	28.0	World Bank
GDP (in current prices), $ billions	2022	10.5	World Bank
GDP per capita (PPP, in current prices), $	2022	4,885.1	World Bank
Electricity generation, billion kWh	2022	20.6	SA RT

[11] Author's calculations based on SA RT data.

Total electricity generation in Tajikistan in 2022 was 20.6 billion kWh. Hydro power plants accounted for the bulk of total generation (92%), while thermal power plants produced 8%, and solar power plants a small fraction of the total.

Tajikistan's key indicators are presented in Table 2.5.

2.3.2. Natural Hazards

According to WorldRiskReport–2022 (Bündnis Entwicklung Hilft, 2022), Tajikistan was ranked No. 137, and classified as a low-risk country (Figure 2.26).

At the same time, Tajikistan is characterised by high vulnerability due to its:

- high susceptibility: weak socio-economic development, high socio-economic deprivations and societal disparities; high vulnerability of the population to diseases and epidemics;
- insufficient coping capacities: low government effectiveness, poor state of the health care system;
- weak adaptive capacities: low research activity, low investment capacities (Figure 2.26).

Table 2.6 presents data on natural hazard events that occurred in Tajikistan in 1992–2022.

Table 2.6. Natural Hazard Events in Tajikistan in 1992–2023

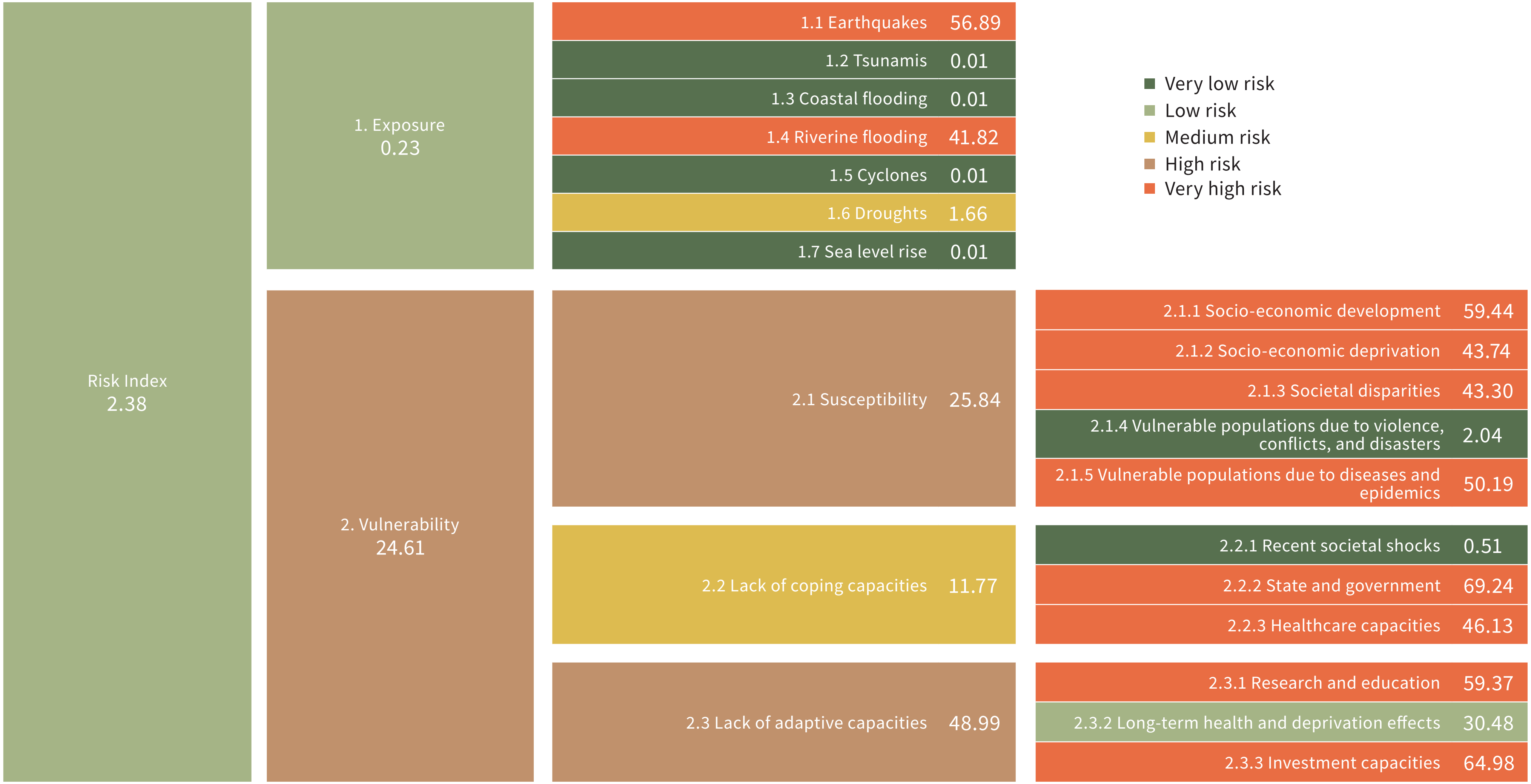
Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
1992	Mass Soil and Rock Movement (Dry)	12	N/A	N/A	N/A
1992	Landslide	243	N/A	24	50
1992	Flood	1,346	63,500	300	626
1993	Landslide	5	75,357	149	302
1994	Flood	N/A	6,051	N/A	N/A
1996	Flood	N/A	180,000	N/A	N/A
1997	Landslide	40	N/A	N/A	N/A
1998	Flood	51	40,974	66	118
1998	Landslide	11	N/A	N/A	N/A
1998	Flood	N/A	916	N/A	N/A
1999	Flood	27	9,392	6	11
1999	Storm	N/A	1,500	0	0
2000	Earthquake	N/A	6,000	N/A	N/A
2000	Drought	N/A	3,000,000	57	97
2001	Landslide	1	165	1	1
2001	Flood	N/A	2,190	N/A	N/A

Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
2001	Storm	N/A	830	0	0
2001	Drought	N/A	N/A	N/A	N/A
2002	Flood	24	1,713	3	5
2002	Flood	8	1,500	N/A	N/A
2002	Earthquake	3	1,050	N/A	N/A
2002	Earthquake	N/A	500	N/A	N/A
2002	Flood	N/A	630	N/A	N/A
2002	Flood	N/A	408	N/A	N/A
2002	Landslide	5	N/A	N/A	N/A
2002	Earthquake	N/A	N/A	N/A	N/A
2002	Earthquake	50	N/A	N/A	N/A
2003	Landslide	N/A	181	N/A	N/A
2003	Flood	6	1,755	20	32
2003	Landslide	1	6,000	41	65
2004	Flood	N/A	400,000	12	19
2004	Earthquake	N/A	180	N/A	N/A
2005	Landslide	16	1,953	N/A	N/A
2005	Flood	N/A	1,890	50	75
2005	Flood	8	3,222	N/A	N/A
2005	Flood	N/A	N/A	N/A	N/A
2006	Landslide	1	13,000	N/A	N/A
2006	Earthquake	3	15,427	22	32
2006	Landslide	21	728	N/A	N/A
2006	Earthquake	N/A	N/A	N/A	N/A
2007	Earthquake	11	7,003	N/A	N/A
2007	Flood	1	17,184	N/A	N/A
2007	Landslide	16	N/A	N/A	N/A
2007	Landslide	14	N/A	N/A	N/A
2007	Earthquake	N/A	N/A	N/A	N/A
2007	Flood	21	125	N/A	N/A
2007	Earthquake	10	N/A	N/A	N/A
2008	Drought	N/A	800,000	N/A	N/A
2008	Extreme Cold	N/A	2,000,000	840	1,142
2009	Flood	21	15,000	1	1

Year	Type of Natural Hazard Event	Total Deaths, people	Total Affected, people	Total Damage, $ millions	Total Damage (in 2022 Prices), $ millions
2010	Flood	73	6,708	204	274
2010	Earthquake	N/A	7,840	2	2
2010	Flood	2	1,914	N/A	N/A
2011	Earthquake	N/A	N/A	N/A	N/A
2011	Flood	N/A	2,130	N/A	N/A
2012	Flood	N/A	5,556	1	1
2012	Landslide	1	N/A	N/A	N/A
2012	Earthquake	2	2,531	N/A	N/A
2012	Extreme Cold	1	N/A	N/A	N/A
2013	Extreme Cold	N/A	2,500	N/A	N/A
2013	Earthquake	N/A	N/A	N/A	N/A
2014	Landslide	13	N/A	N/A	N/A
2014	Flood	20	7,438	2	2
2014	Flood	N/A	5,785	N/A	N/A
2015	Flood	N/A	5,401	N/A	N/A
2015	Flood	N/A	5,401	N/A	N/A
2015	Earthquake	2	7,976	5	6
2015	Landslide	10	N/A	N/A	N/A
2016	Earthquake	N/A	155	N/A	N/A
2016	Flood	4	12,750	N/A	N/A
2017	Flood	N/A	700	N/A	N/A
2017	Landslide	13	N/A	N/A	N/A
2017	Earthquake	N/A	N/A	N/A	N/A
2018	Flood	6	5,725	N/A	N/A
2019	Flood	4	6,750	N/A	N/A
2020	Flood	2	2,690	N/A	N/A
2021	Flood	7	25,010	9	10
2021	Earthquake	5	100	N/A	N/A
2021	Landslide	12	N/A	N/A	N/A
2021	Earthquake	N/A	N/A	N/A	N/A
2023	Flood	21	N/A	N/A	N/A
2023	Earthquake	N/A	2,205	N/A	N/A

Source: EM-DAT with confirmation from other sources, including ADRC, ReliefWeb, NOAA National Centres for Environmental Information.

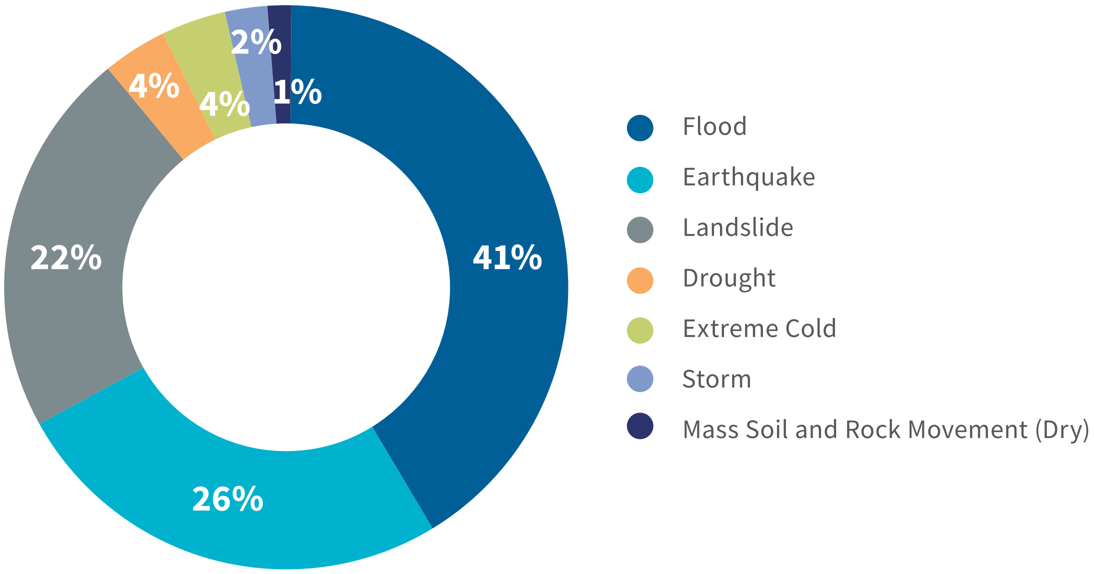
Figure 2.26. Tajikistan: Risk Index and Its Components



Source: authors' calculations based on WorldRiskReport (2022).
Note: for a description of the WorldRiskIndex calculation methodology, see WorldRiskReport (2022).

According to the data presented in Table 2.6, the most widespread natural hazard events in 1992–2023 were floods (41%), earthquakes (26%), and landslides (22%) (Figure 2.27). It should be noted that, like in Kyrgyzstan, most landslides are caused by earthquakes and floods.

Figure 2.27. Rate of Occurrence of Significant Natural Hazard Events in Tajikistan in 1992–2023



Source: authors' calculations based on EM-DAT data.

An analysis of the economic impact of natural hazards in 1992–2023 shows that the heaviest damage was caused by:

- extreme cold in 2008 ($1.1 billion in 2022 prices),
- flood in 1992 ($626 million in 2022 prices), and
- landslide in 1993 ($302 million in 2022 prices).

The 1985 Kayrakkum earthquake deserves special mention, as total damage caused by that event amounted to about $0.5 billion (in 2022 prices), while total deaths and total affected persons stood at 29 and about 8,080, respectively.

Based on the foregoing, we come to the conclusion that **earthquakes and floods** are the main types of natural hazard events capable of producing a significant impact on the economy and debt sustainability of Tajikistan.

3. Assessment of Potential Economic Damage from Natural Hazard Events

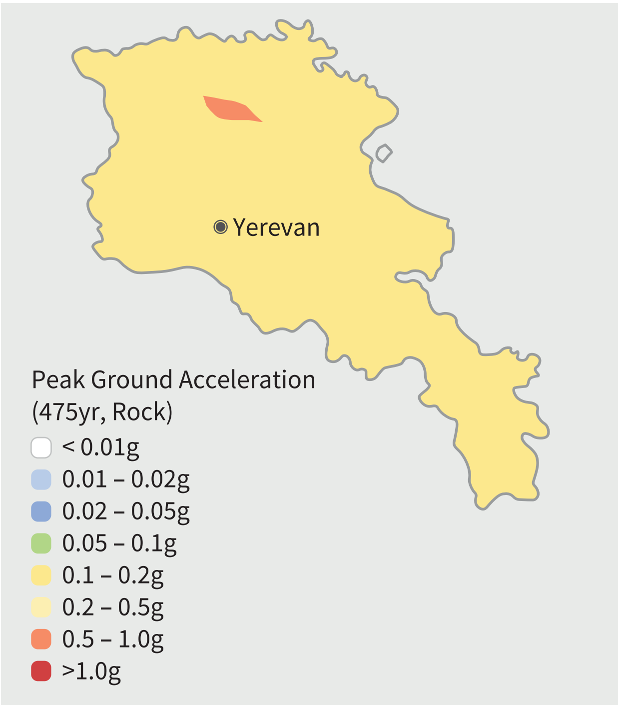
3.1. Earthquakes

In this Working Paper, the scale and geographic footprint of earthquakes in the countries under review were determined by using stochastic modelling methods (GEM (2023a), JBA Risk Management (2023)). Such modelling illustrates the ways in which natural phenomena interact with areas characterised by high population and asset density, thereby giving rise to economic losses.

3.1.1. Armenia

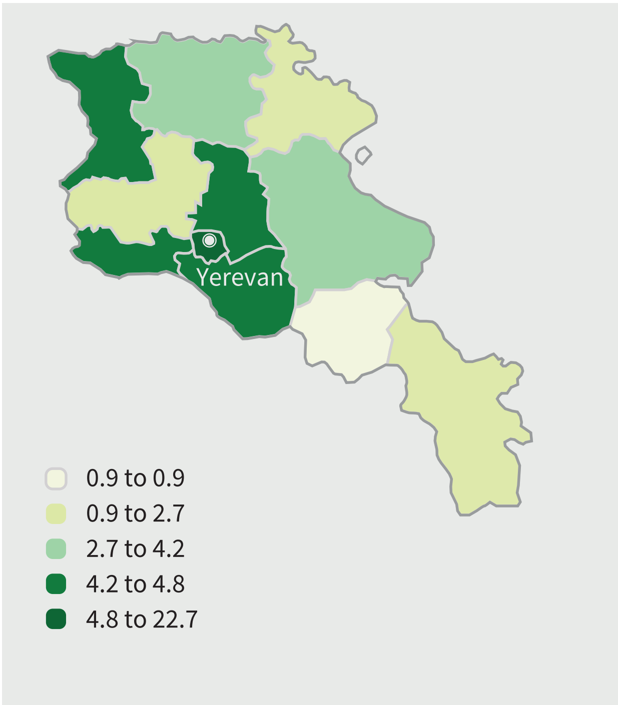
According to the Peak Ground Acceleration (PGA) indicator used to measure seismic hazard, most of the territory of Armenia is exposed to earthquakes, with the south of Lori being the most vulnerable area (Figure 3.1).

Figure 3.1. Seismic Hazard, Peak Ground Acceleration (PGA) as a Fraction of g=9.81 m/s² (Return Period:[12] 475 Years)



Source: GEM (2023b).

Figure 3.2. Asset Value,[13] $ billions



Source: GEM (2023b).

[12] Return period is an estimated interval between natural hazard events (such as earthquakes, floods, or changes in river discharge flow) of comparable intensity or strength. It is a statistical value indicating the average repeat interval over a long period of time. As a rule, repeat periods need to be measured to analyse risks (including for the purposes of project assessment in risk-prone areas) or the seismic stability of structures in the event of repeat earthquakes (of comparable intensity).

[13] Here and below, asset value (capital) is defined as the replacement value of residential, commercial, and industrial buildings.

Taking into consideration the value of assets (buildings) in various regions of Armenia (Figure 3.2) and the possible intensity of earthquakes, we estimated the potential damage in the event of an earthquake (Table 3.1).

Table 3.1. Potential Asset Losses Subject to Earthquake Intensity, $ billions

Region	Assets		Intensity, points on the Richter scale (Structural Damage to Buildings,[14] %)			
	$ billions	% of Total Assets	10–12 (90–100%)	8–9 (40–80%)	6–7 (25–40%)	<5 (<25%)
Armenia	57.9	100	52.1–57.9	23.2–46.3	14.5–23.2	<14.5
City of Yerevan	22.7	39	20.4–22.7	9.1–18.2	5.7–9.1	<5.7
Ararat	4.8	8	4.3–4.8	1.9–3.8	1.2–1.9	<1.2
Kotayk	4.8	8	4.3–4.8	1.9–3.8	1.2–1.9	<1.2
Armavir	4.8	8	4.3–4.8	1.9–3.8	1.2–1.9	<1.2
Shirak	4.8	8	4.3–4.8	1.9–3.8	1.2–1.9	<1.2
Lori	4.2	7	3.8–4.2	1.7–3.4	1.1–1.7	<1.1
Gegharkunik	4.2	7	3.8–4.2	1.7–3.4	1.1–1.7	<1.1
Syunik	2.7	5	2.4–2.7	1.1–2.2	0.7–1.1	<0.7
Aragatsotn	2.2	4	2.0–2.2	0.9–1.8	0.6–0.9	<0.6
Tavush	1.8	3	1.6–1.8	0.7–1.4	0.5–0.7	<0.5
Vayots Dzor	0.9	2	0.8–0.9	0.4–0.7	0.2–0.4	<0.2

Source: authors' calculations based on GEM data (2023b).

Note: according to GEM (2023b), of all the assets listed in the table, the shares of those that are used for commercial and industrial purposes are 26.7% and 4%, respectively.

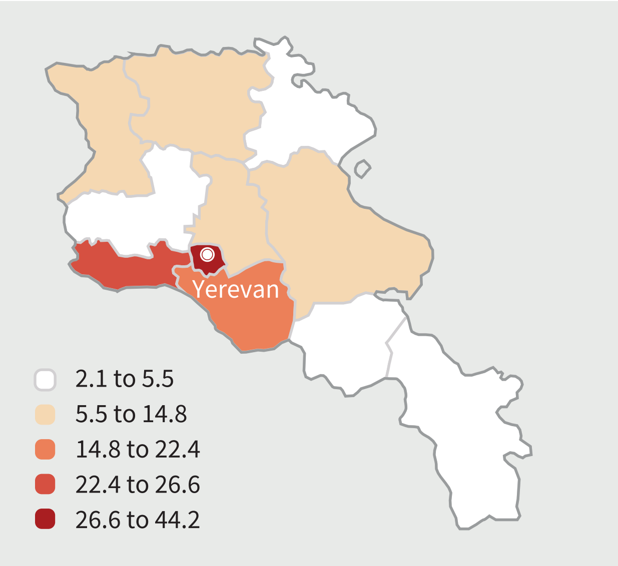
Table 3.1 demonstrates potential earthquake-related capital losses depending on the area where the natural hazard event occurred, and on its intensity. For example, if a 6–7-point earthquake occurs in the vicinity of the City of Yerevan, potential capital losses may be as high as $5.7–9.1 billion, or up to 9.8–15.7% of the value of all assets in the country.

According to GEM (2023b), average annual damage from earthquakes in Armenia is $166.8 million (Figure 3.3), including $44.2 million in the City of Yerevan (the highest in the country).

An analysis of ratios of average annual earthquake-related losses to asset values (Figure 3.4) (which enables a comparison of relative risk exposures across regions) revealed that the highest ratios were observed in Armavir and Ararat, and the lowest ratios in Syunik and Tavush.

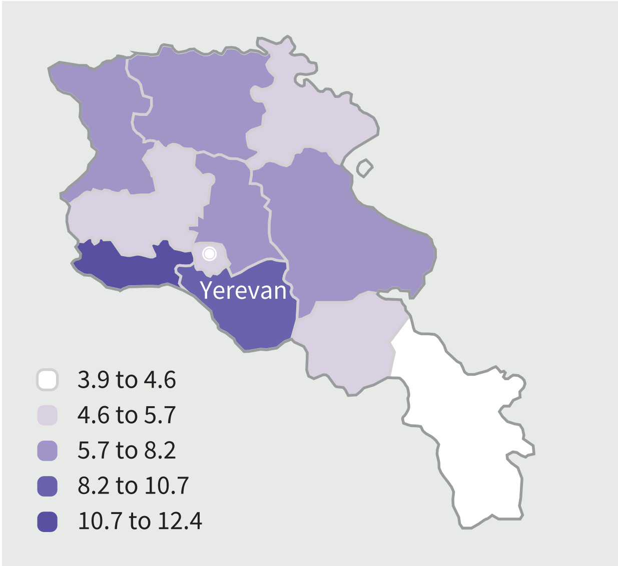
[14] Authors' estimate.

Figure 3.3. Average Annual Earthquake-Related Losses, $ millions



Source: GEM (2023b).

Figure 3.4. Ratio of Average Annual Earthquake-Related Losses to Asset Values by Region, ‰

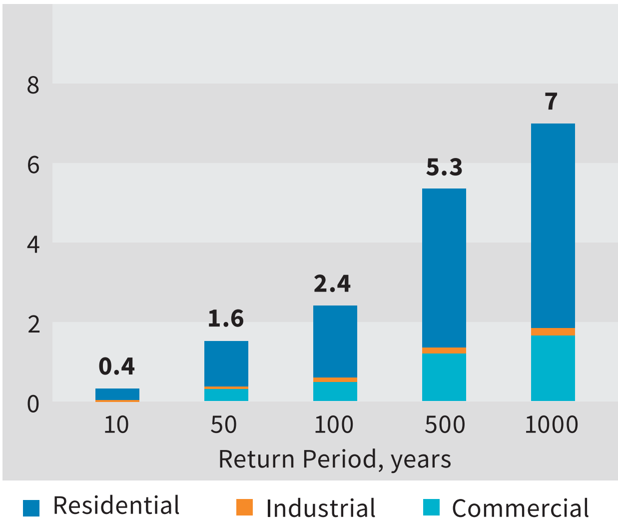


Source: GEM (2023b).

The results of modelling of the average long-term direct earthquake-related losses in Armenia (GEM, 2023b) for the displayed return periods are presented in Figure 3.5.

Direct losses for 50-year and 100-year return periods amount to $1.6 billion and $2.4 billion, respectively, or 8.2% and 12.3% of the 2022 GDP, respectively.

Figure 3.5. Potential Direct Earthquake-Related Damage, $ billions



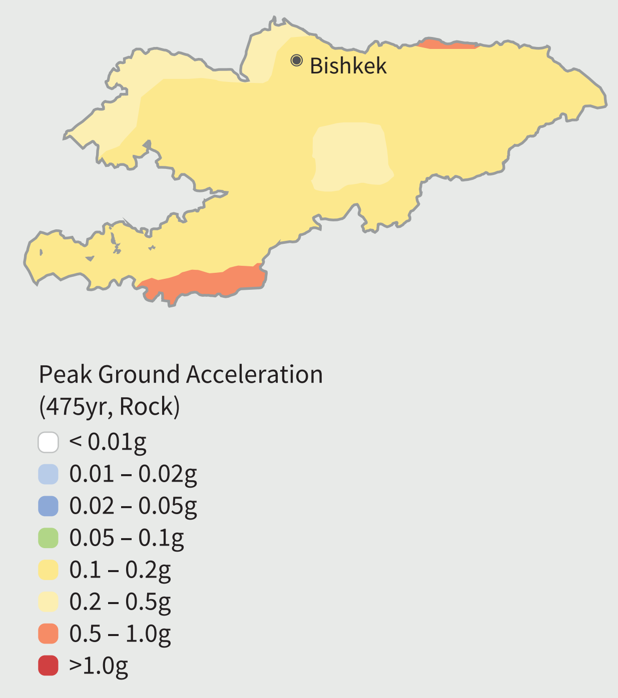
Source: GEM (2023b).

3.1.2. Kyrgyzstan

According to the Peak Ground Acceleration (PGA) indicator, the most vulnerable regions in Kyrgyzstan are in the south-west and north-east of the country (Figure 3.6).

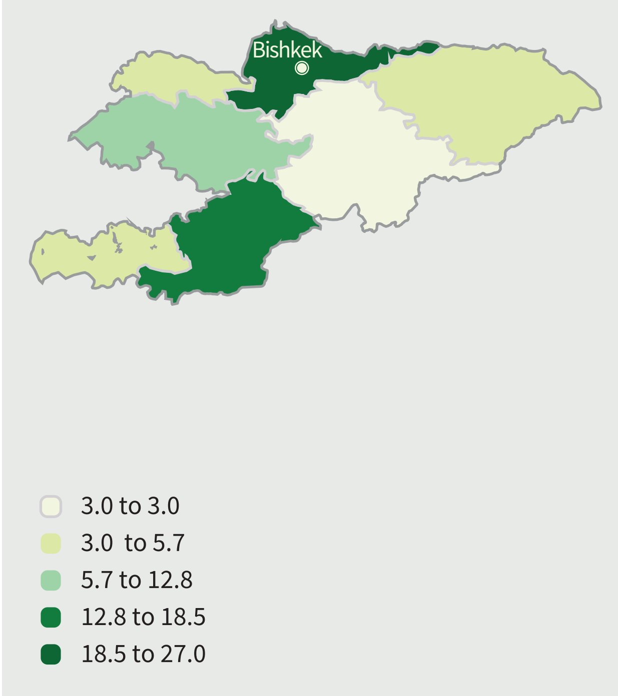
Taking into consideration the value of assets (buildings) in various regions of Kyrgyzstan (Figure 3.7) and the possible intensity of earthquakes, we estimated potential asset losses in the event of an earthquake (Table 3.2).

Figure 3.6. Seismic Hazard, Peak Ground Acceleration (PGA) as a Fraction of g=9.81 m/s^2 (Return Period: 475 Years)



Source: GEM (2023c).

Figure 3.7. Asset Value, $ billions



Source: GEM (2023c).

Table 3.2. Potential Asset Losses Subject to Earthquake Intensity, $ billions

Region	Assets		Intensity, points on the Richter scale (Structural Damage to Buildings, %)			
	$ billions	% of Total Assets	10–12 (90–100%)	8–9 (40–80%)	6–7 (25–40%)	<5 (<25%)
Kyrgyzstan	75.7	100	68.1–75.7	30.3–60.6	18.9–30.3	<18.9
City of Bishkek and Chüy Region	27	36	24.3–27.0	10.8–21.6	6.8–10.8	<6.8
City of Osh and Osh Region	18.5	24	16.7–18.5	7.4–14.8	4.6–7.4	<4.6
Jalal-Abad Region	12.8	17	11.5–12.8	5.1–10.2	3.2–5.1	<3.2
Batken Region	5.7	8	5.1–5.7	2.3–4.6	1.4–2.3	<1.4
Issyk-Kul Region	4.5	6	4.1–4.5	1.8–3.6	1.1–1.8	<1.1
Talas Region	4.2	6	3.8–4.2	1.7–3.4	1.1–1.7	<1.1
Naryn Region	3	4	2.7–3.0	1.2–2.4	0.8–1.2	<0.8

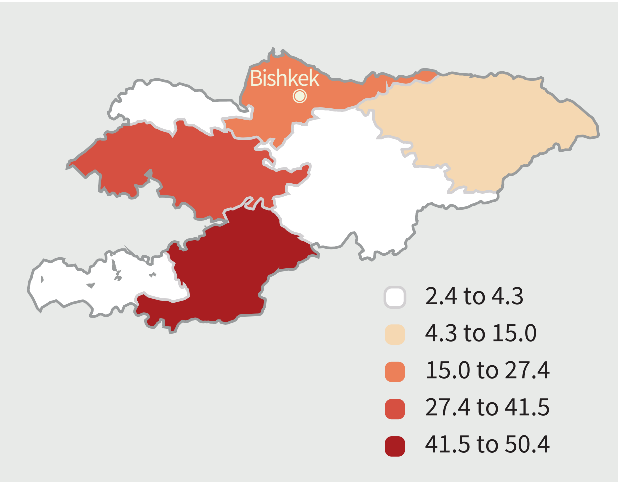
Source: authors' calculations based on GEM data (2023c).

Note: according to GEM (2023c), of all assets listed in the table above, the shares of those that are used for commercial and industrial purposes are 11% and 6.6%, respectively.

According to GEM (2023c), average annual damage from earthquakes in Kyrgyzstan is $143.8 million (Figure 3.8), including $50.4 million in Osh Region (the highest in the country), and $41.5 million in Jalal-Abad Region.

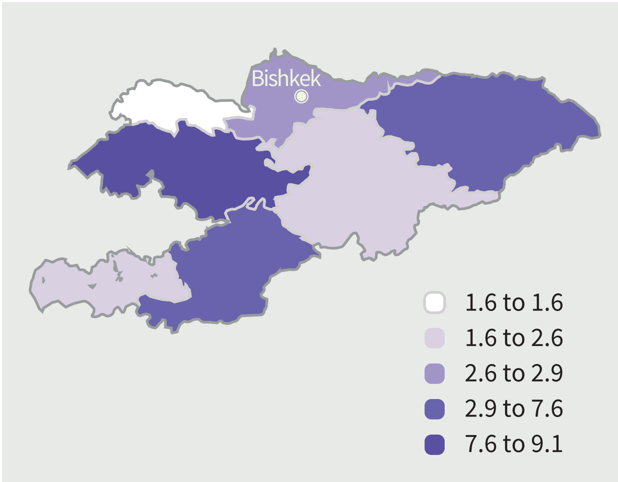
The highest ratios of average annual earthquake-related losses to asset values (Figure 3.9) were observed in Jalal-Abad Region, Osh Region, and Issyk-Kul Region, and the lowest ratio in Talas Region.

Figure 3.8. Average Annual Earthquake-Related Losses, $ millions



Source: GEM (2023c).

Figure 3.9. Ratio of Average Annual Earthquake-Related Losses to Asset Values by Region, ‰

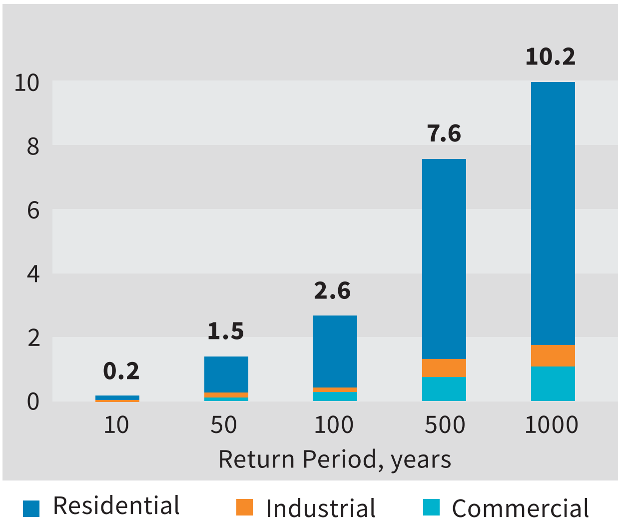


Source: GEM (2023c).

The results of modelling of the average long-term direct earthquake-related losses in Kyrgyzstan (GEM, 2023c) for various return periods are presented in Figure 3.10.

Direct losses for 50-year and 100-year return periods amount to $1.5 billion and $2.6 billion, respectively, or 13.8% and 23.9% of the 2022 GDP, respectively.

Figure 3.10. Potential Direct Earthquake-Related Damage, $ billions

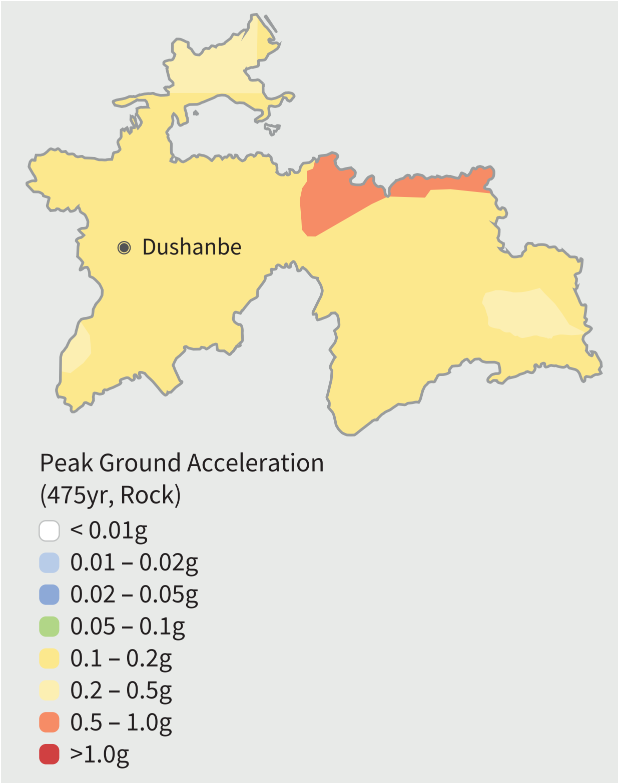


Source: GEM (2023c).

3.1.3. Tajikistan

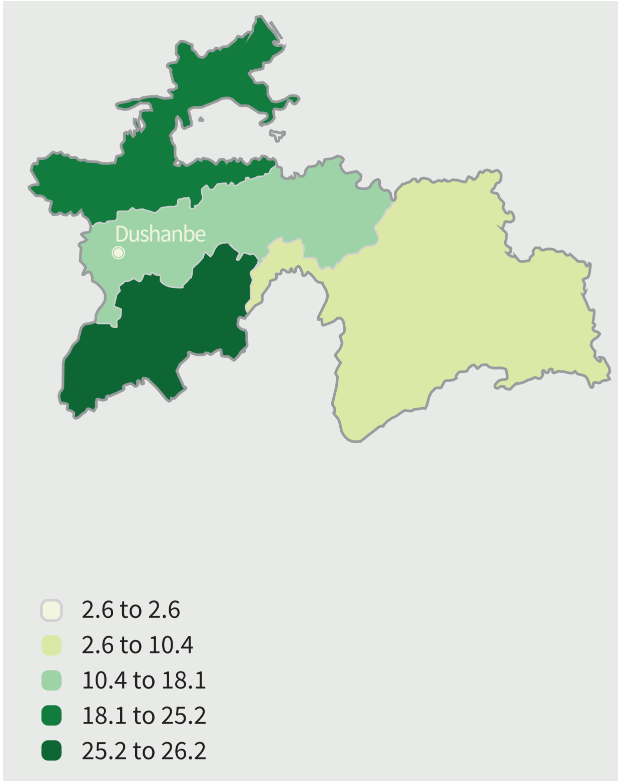
According to the Peak Ground Acceleration (PGA) indicator, the most vulnerable areas in Tajikistan are in the north of the regions of republican subordination and Gorno-Badakhshan Autonomous Province (Figure 3.11).

Figure 3.11. Seismic Hazard, Peak Ground Acceleration (PGA) as a Fraction of g=9.81 m/s² (Return Period: 475 Years)



Source: GEM (2023d).

Figure 3.12. Asset Value, $ billions



Source: GEM (2023d).

Taking into consideration the value of assets (buildings) in various regions of Tajikistan (Figure 3.12) and the possible intensity of earthquakes, we estimated potential asset losses in the event of an earthquake (Table 3.3).

Table 3.3. Potential Asset Losses Subject to Earthquake Intensity, $ billions

Region	Assets		Intensity, points on the Richter scale (Structural Damage to Buildings, %)			
	$ billions	% of Total Assets	10–12 (90–100%)	8–9 (40–80%)	6–7 (25–40%)	<5 (<25%)
Tajikistan	82.5	100	74.3–82.5	33.0–66.0	20.6–33.0	<20.6
Khatlon Region	26.2	32	23.6–26.2	10.5–21.0	6.6–10.5	<6.6
Sughd Region	25.2	31	22.7–25.2	10.1–20.2	6.3–10.1	<6.3
Districts of Republican Subordination	18.1	22	16.3–18.1	7.2–14.5	4.5–7.2	<4.5
City of Dushanbe	10.4	13	9.4–10.4	4.2–8.3	2.6–4.2	<2.6
Gorno-Badakhshan Autonomous Province	2.6	3	2.3–2.6	1.0–2.1	0.7–1.0	<0.7

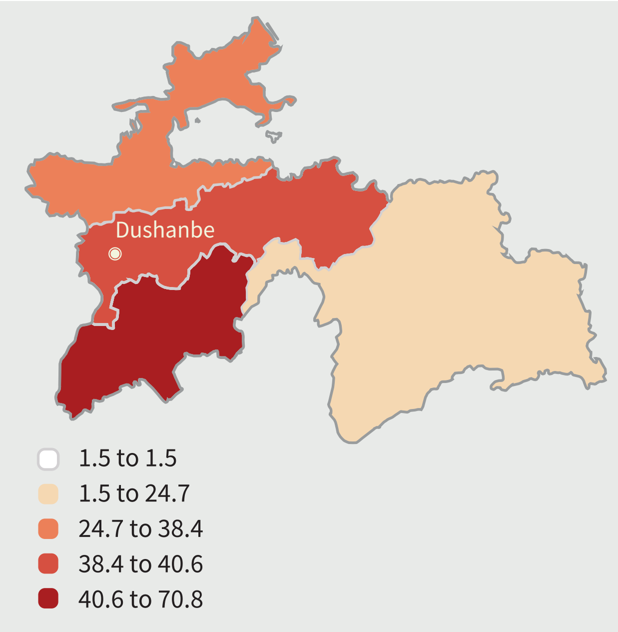
Source: authors' calculations based on GEM data (2023d).

Note: according to GEM (2023d), of all assets listed in the table above, the shares of those that are used for commercial and industrial purposes are 3.9% and 1.8%, respectively.

Average annual damage from earthquakes in Tajikistan is $176 million (Figure 3.13), including $70.8 million in Khatlon Region (the highest in the country), $40.6 million in the districts of republican subordination, and about $38.4 million in the City of Dushanbe.

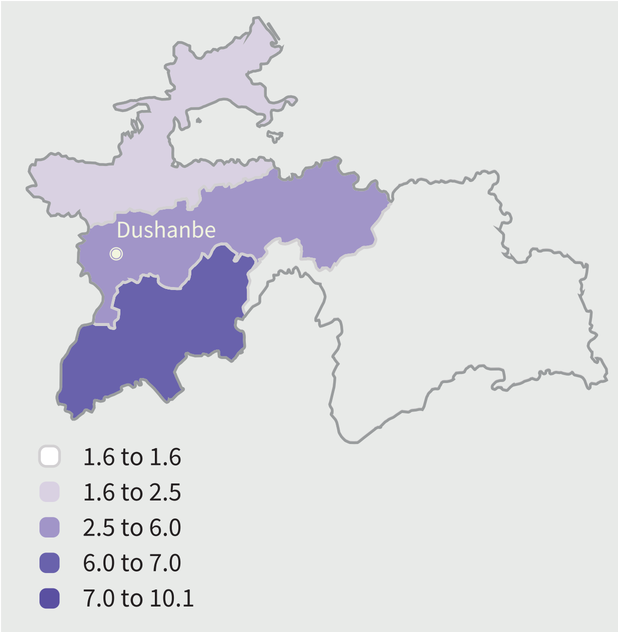
The highest ratios of average annual earthquake-related losses to asset values (Figure 3.14) were observed in the City of Dushanbe, Khatlon Region, and the districts of republican subordination, and the lowest ratio in the Gorno-Badakhshan Autonomous Province.

Figure 3.13. Average Annual Earthquake-Related Losses, $ millions



Source: GEM (2023d).

Figure 3.14. Ratio of Average Annual Earthquake-Related Losses to Asset Values by Region, ‰

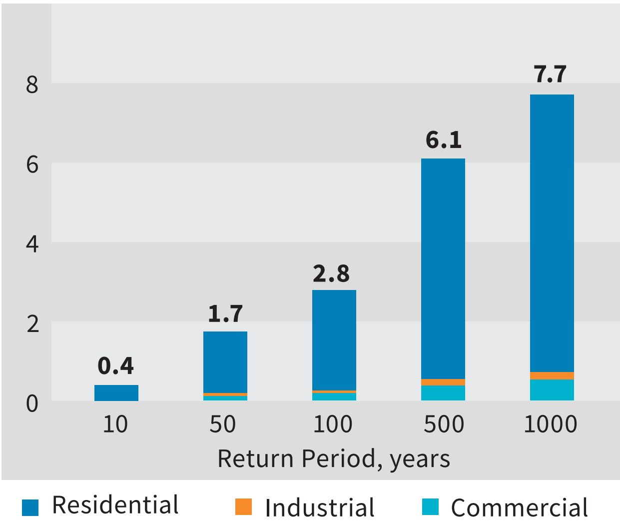


Source: GEM (2023d).

The results of modelling of the average long-term direct earthquake-related losses in Tajikistan (GEM, 2023d) for the displayed return periods are presented in Figure 3.15.

Direct losses for 50-year and 100-year return periods amount to $1.7 billion and $2.8 billion, respectively, or 16.2% and 26.7% of the 2022 GDP, respectively.

Figure 3.15. Potential Direct Earthquake-Related Damage, $ billions



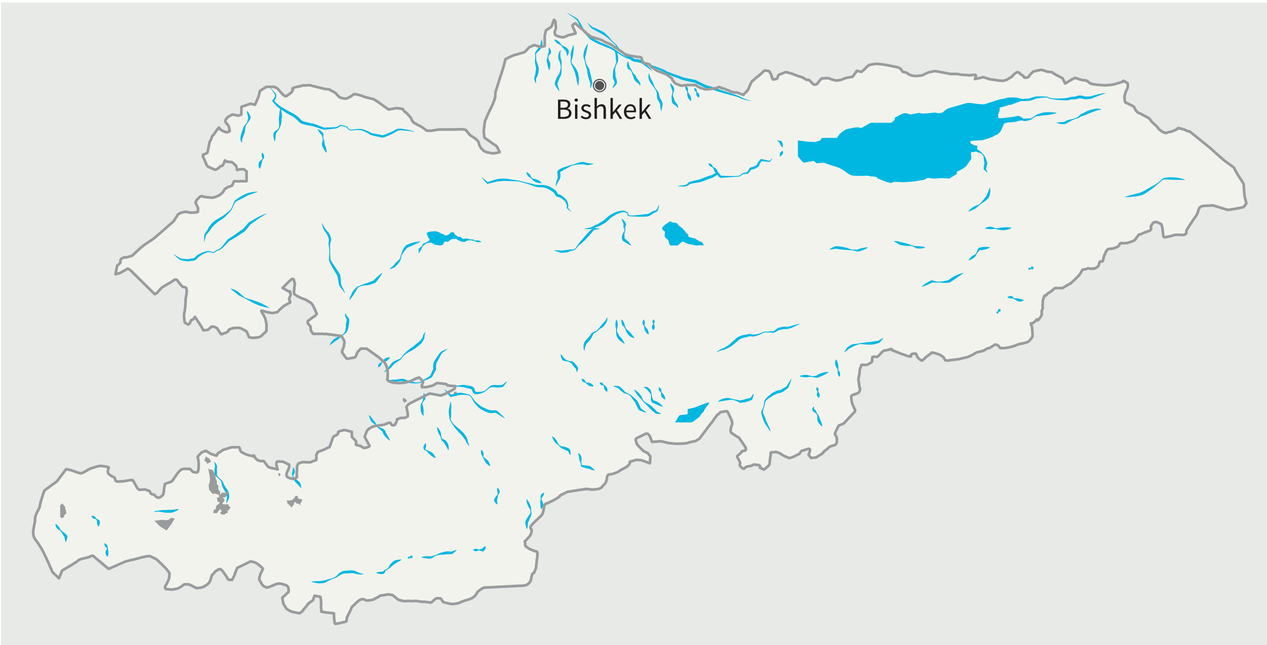
Source: GEM (2023d).

3.2. Floods

3.2.1. Kyrgyzstan

Freshet maps for riverine (fluvial) and surface (pluvial) floods for various return periods are used globally to model floods and estimate potential flood-related losses. Figure 3.16 shows riverine floods in Kyrgyzstan with a return period of 200 years. That particular return period is frequently used for planning purposes, and assumes actual occurrence of an extreme event.

Figure 3.16. Riverine (Fluvial) Floods (Highlighted in Blue) for 200-Year Return Period



Source: JBA Risk Management.

There are about 2,000 lakes in Kyrgyzstan, the largest three being Issyk-Kul, Son-Kul, and Sary-Chelek. Their total surface area is 6,800 km^2. Most lakes are in the mountains at heights ranging from 2,500 to 4,000 metres above sea level. In most cases, they were formed by glacier melting.

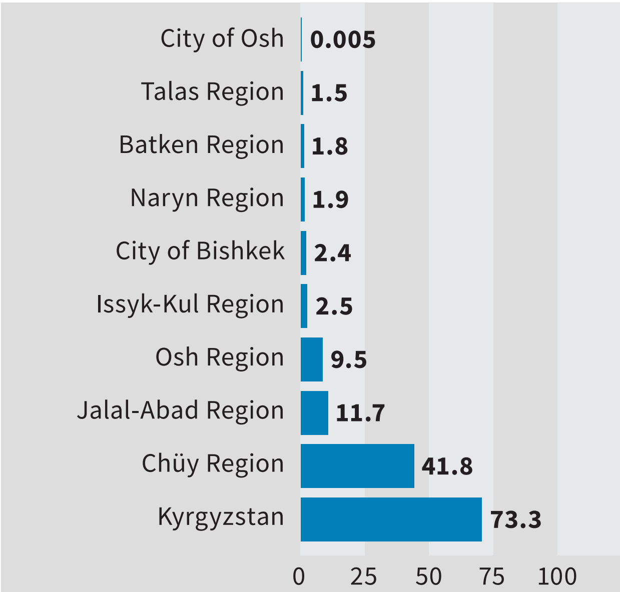
Kyrgyzstan has more than 40,000 rivers with a total length of about 150,000 km. The main source of water in the rivers is melt-water from alpine glaciers, with rainfall accounting for less than 1/5 of total runoff. Kyrgyzstan's rivers belong to three main drainless basins (the Aral Sea, Lake Issyk-Kul, and Lake Lop Nur), and the Lake Balkhash basin.

The Naryn is the longest river in Kyrgyzstan with a length of 807 km, and a basin area of 59,000 km^2. It flows through narrow gorges and plains, starting in Naryn State National Park and crossing the cities of Naryn, Tash-Kömür, and Uchqo'rg'on. The river is widely used for irrigation, and its water forms several canals and Kyrgyzstan's largest reservoir, the Toktogul. There are several large hydro power plants along the river (Toktogul HPP, Tash-Kömür HPP, Üch-Korgon, and others).

According to JBA Risk Management, average annual flood-related damage in Kyrgyzstan amounts to $73.3 million (Figure 3.17). Most damage is reported in Chüy Region, Jalal-Abad Region, and Osh Region.

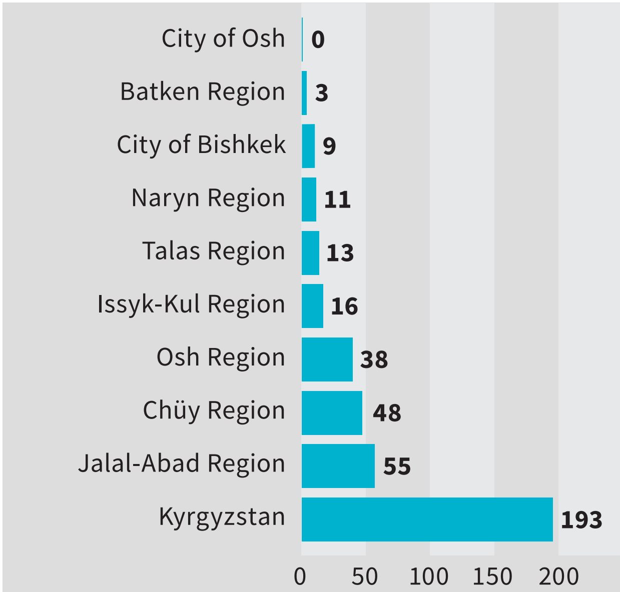
The average annual number of flood-related deaths in Kyrgyzstan is 193 people (Figure 3.18), with Jalal-Abad Region, Chüy Region, and Osh Region reporting the highest death tolls.

Figure 3.17. Average Annual Flood-Related Losses, $ millions



Source: JBA Risk Management.

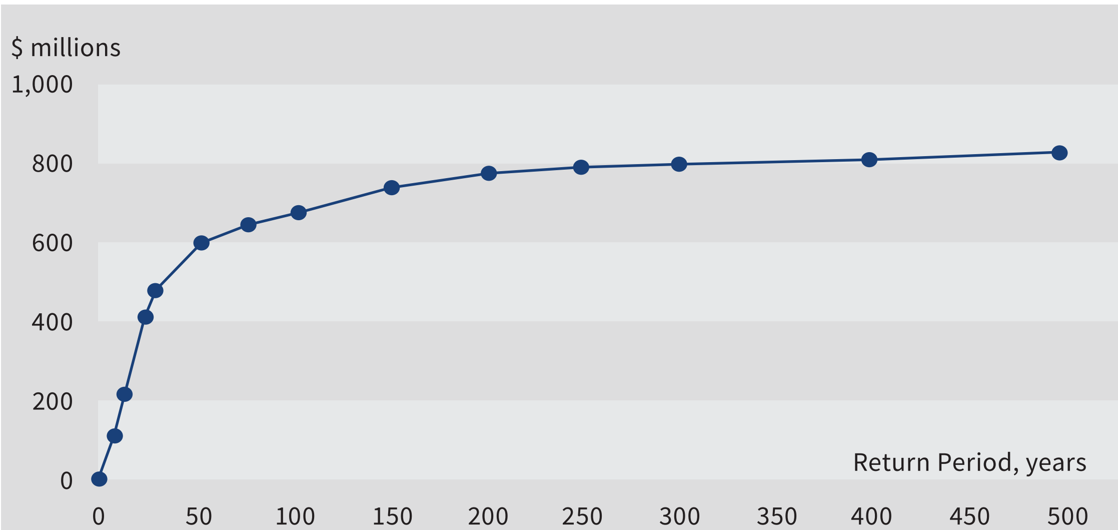
Figure 3.18. Average Annual Flood-Related Deaths



Source: JBA Risk Management.

The results of modelling of the average long-term direct flood-related losses in Kyrgyzstan for various return periods are presented in Figure 3.15. According to our calculations, potential losses significantly increase in the interval between return periods from 2 years to 25 years, which points to higher susceptibility to floods during those return periods. Direct losses for 100-year and 200-year flood return periods are estimated at about $700 million and $800 million, respectively, or 6.4% and 7.3% of the 2022 GDP, respectively.

Figure 3.19. Potential Direct Flood-Related Damage by Return Periods



Source: JBA Risk Management.

3.2.2. Tajikistan

The evolution of Tajikistan's river network is largely determined by the copious glacial water sources. The country's hydrographic network comprises more than 25,000 rivers with a total length of 69,200 km. There are 947 rivers with lengths ranging from 10 km to 100 km, 16 rivers with lengths ranging from 100 km to 500 km, and four rivers with lengths of more than 500 km. The lakes cover 2% of the country.

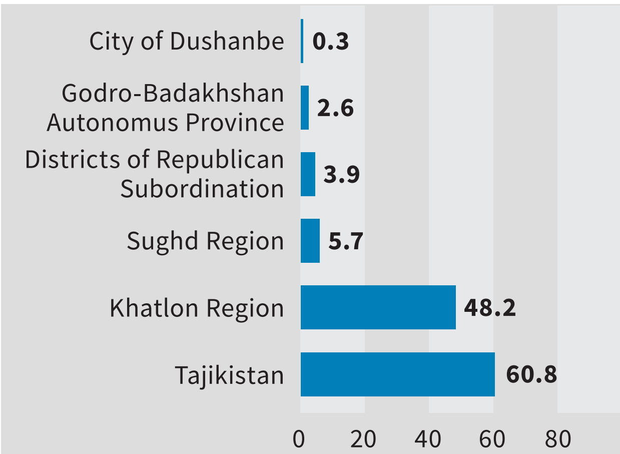
Riverine floods usually occur either in spring after torrential rains, or in summer during the snow-melting period. Torrential rains during the snow-melting period can lead to strong freshets. Extreme high-intensity downpours can cause flash floods on steep slopes and in narrow valleys.

In the east of the country with its mountainous terrain, there are numerous steep-walled river valleys; in some of these valleys, rivers flow only during the rainy season or the snow-melting period. This part of the country is sparsely populated, and flood risks are related mostly to flash floods and subsequent landslides and mudslides.

According to JBA Risk Management, average annual flood-related damage in Tajikistan amounts to $60.8 million (Figure 3.20). Most damage is recorded in Khatlon Region.

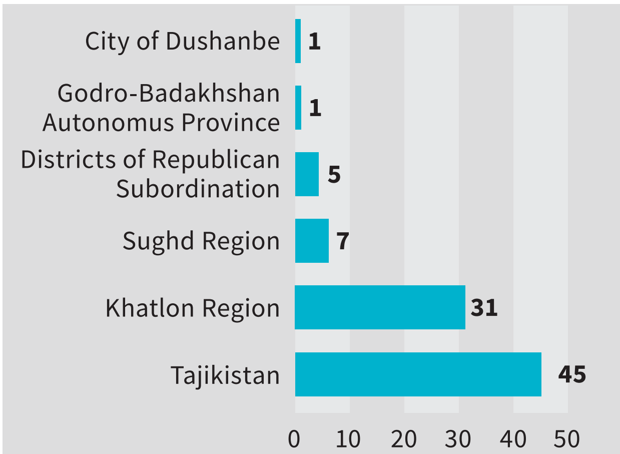
The average annual number of flood-related deaths in Tajikistan is 45 (Figure 3.21), with Khatlon Region reporting the highest death toll. The region is home to about 36% of the country's population, and has several densely populated cities, including Bokhtar on the River Vakhsh, and Kulob on the River Yakhsu.

Figure 3.20. Average Annual Flood-Related Losses, $ millions



Source: JBA Risk Management.

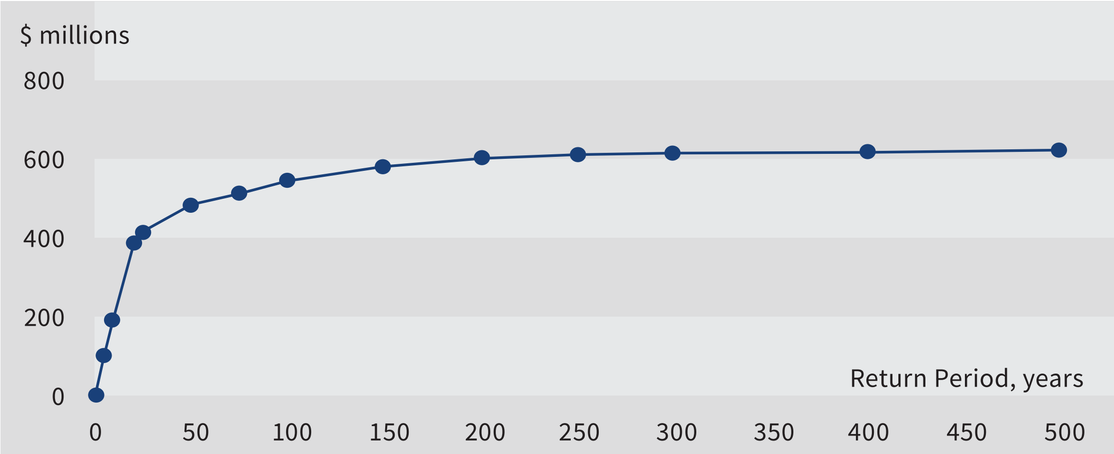
Figure 3.21. Average Annual Flood-Related Deaths



Source: JBA Risk Management.

The results of modelling of the average long-term direct flood-related losses in Tajikistan for various return periods are presented in Figure 3.22. According to our calculations, potential losses significantly increase during the interval between return periods from 2 years to 25 years, which points to higher susceptibility to floods during those return periods. Direct losses for 100-year and 200-year flood return periods are estimated at about $550 million and $600 million, respectively, or 5.2% and 5.7% of the 2022 GDP, respectively.

Figure 3.22. Potential Direct Flood-Related Damage by Return Periods



Source: JBA Risk Management.

3.3. Potential Drought Impact in Armenia

Armenia may be exposed to two main types of drought: meteorological drought (caused mostly by insufficient precipitation) and hydrological drought (caused by insufficient superficial and subterranean water runoff). According to the Standardised Precipitation Evapotranspiration Index (SPEI) (which is less than –2), every year there is a substantial probability that Armenia will suffer from a strong meteorological drought.

Such a drought may cause degradation of land and reduction of crop yields, up to and including their total loss, which will inflict heavy losses on the agricultural sector.

Taking into consideration the data on maximum temperatures (Figure 2.3) and average annual precipitation (Figure 2.5), we conclude that Ararat, Armavir, and Aragatsotn are the most drought-prone regions of Armenia.

Subject to gross agricultural and horticultural output data with the breakdown by Armenian regions presented in Table 3.4 and Table 3.5, we conclude that in the event of total loss of crops in the most vulnerable regions (which may also decrease output of livestock products), economic losses may amount to 4–5% of GDP.

Table 3.4. Gross Agricultural Output in Armenia by Regions

	2017	2018	2019	2020	2021	2022
AMD billions						
Total	908.6	892.9	853.3	833.3	934.4	1,021.4
City of Yerevan	10.6	12.1	10.5	8.9	9.3	11.7
Aragatsotn	88.4	91.3	79.7	82.5	87.2	101.2

	2017	2018	2019	2020	2021	2022
Ararat	125	124.8	127.2	125	141.1	149.7
Armavir	184.2	177.5	178.7	181	211.1	224.9
Gegharkunik	122.6	118.2	112.4	99.4	113.8	119.1
Lori	79	73.2	68.5	67.2	78.6	88.5
Kotayk	73.4	72.9	70.6	73.7	78.6	86.3
Shirak	99.4	97.9	88.7	83.5	87.4	105
Syunik	62.1	63.4	58.9	54.4	59.5	65.1
Vayots Dzor	24	22.3	21.1	21.8	22.2	23.9
Tavush	39.9	39.3	37	35.9	45.6	46
% of GDP						
Total	16.3	14.8	13.0	13.5	13.4	12.0
City of Yerevan	0.2	0.2	0.2	0.1	0.1	0.1
Aragatsotn	1.6	1.5	1.2	1.3	1.2	1.2
Ararat	2.2	2.1	1.9	2.0	2.0	1.8
Armavir	3.3	2.9	2.7	2.9	3.0	2.6
Gegharkunik	2.2	2.0	1.7	1.6	1.6	1.4
Lori	1.4	1.2	1.0	1.1	1.1	1.0
Kotayk	1.3	1.2	1.1	1.2	1.1	1.0
Shirak	1.8	1.6	1.4	1.4	1.3	1.2
Syunik	1.1	1.1	0.9	0.9	0.9	0.8
Vayots Dzor	0.4	0.4	0.3	0.4	0.3	0.3
Tavush	0.7	0.7	0.6	0.6	0.7	0.5

Source: SC RA.

Table 3.5. Gross Horticultural Output in Armenia by Regions

	2017	2018	2019	2020	2021	2022
AMD billions						
Total	469.3	415.8	410.9	399.5	469.1	518.8
City of Yerevan	3.4	2.8	3.7	2	1.8	2.0
Aragatsotn	41.2	40.3	31.1	35.2	37.9	41.9
Ararat	93	91.1	95.1	94	108.1	119.6
Armavir	139.7	126.8	128.4	133.3	162.2	179.4

	2017	2018	2019	2020	2021	2022
Gegharkunik	52.9	44.2	47.5	38	45.9	50.8
Lori	29	21.6	21.6	20.4	25	27.6
Kotayk	27.6	21.3	20.2	20.5	25.2	27.9
Shirak	41.4	35.5	32.3	29.2	28.7	31.7
Syunik	20.5	15.4	16.1	12.7	16.4	18.1
Vayots Dzor	7.3	5.7	4.9	5	5.9	6.5
Tavush	13.3	11.1	10	9.2	12	13.3
% of GDP						
Total	8.4	6.9	6.3	6.5	6.7	6.1
City of Yerevan	0.1	0.0	0.1	0.0	0.0	0.0
Aragatsotn	0.7	0.7	0.5	0.6	0.5	0.5
Ararat	1.7	1.5	1.5	1.5	1.5	1.4
Armavir	2.5	2.1	2.0	2.2	2.3	2.1
Gegharkunik	1.0	0.7	0.7	0.6	0.7	0.6
Lori	0.5	0.4	0.3	0.3	0.4	0.3
Kotayk	0.5	0.4	0.3	0.3	0.4	0.3
Shirak	0.7	0.6	0.5	0.5	0.4	0.4
Syunik	0.4	0.3	0.2	0.2	0.2	0.2
Vayots Dzor	0.1	0.1	0.1	0.1	0.1	0.1
Tavush	0.2	0.2	0.2	0.1	0.2	0.2

Source: SC RA. 2022 regional data breakdown — EFSD estimates.

4. Assessment of the Impact of Natural Hazard Events on Debt Sustainability

In this paper, the impact of natural hazards on the debt sustainability of countries is assessed through stress testing within the framework of the Debt Sustainability Analysis (DSA), the methodology of which was developed by the IMF and the World Bank.[15]

According to that methodology, stress testing to assess the impact of natural hazards assumes a substantial decrease of the real GDP with a subsequent increase of the ratio of public debt and gross financing needs to GDP.[16] The methodology, however, does not consider the impact of natural hazards on various macroeconomic indicators.

We present an approach to constructing a shock scenario which considers the impact of natural hazards on the following macroeconomic indicators:

- real and potential GDP,
- inflation,
- exchange rate of the national currency against the US dollar,
- key rate of the central bank (refinancing rate).

Under our approach, the shock scenario is created in several stages (Figure 4.1).

At **Stage 1**, it is necessary to select the type of natural hazard under review.

In line with the country climate profiles described above, we suggest examining the following natural hazard types:

- earthquakes — for Armenia, Kyrgyzstan, and Tajikistan;
- floods — for Kyrgyzstan and Tajikistan;
- droughts — for Armenia.

At **Stage 2**, we assess the supply shock triggered by the natural hazard which, in turn, impacts economic activity (GDP).

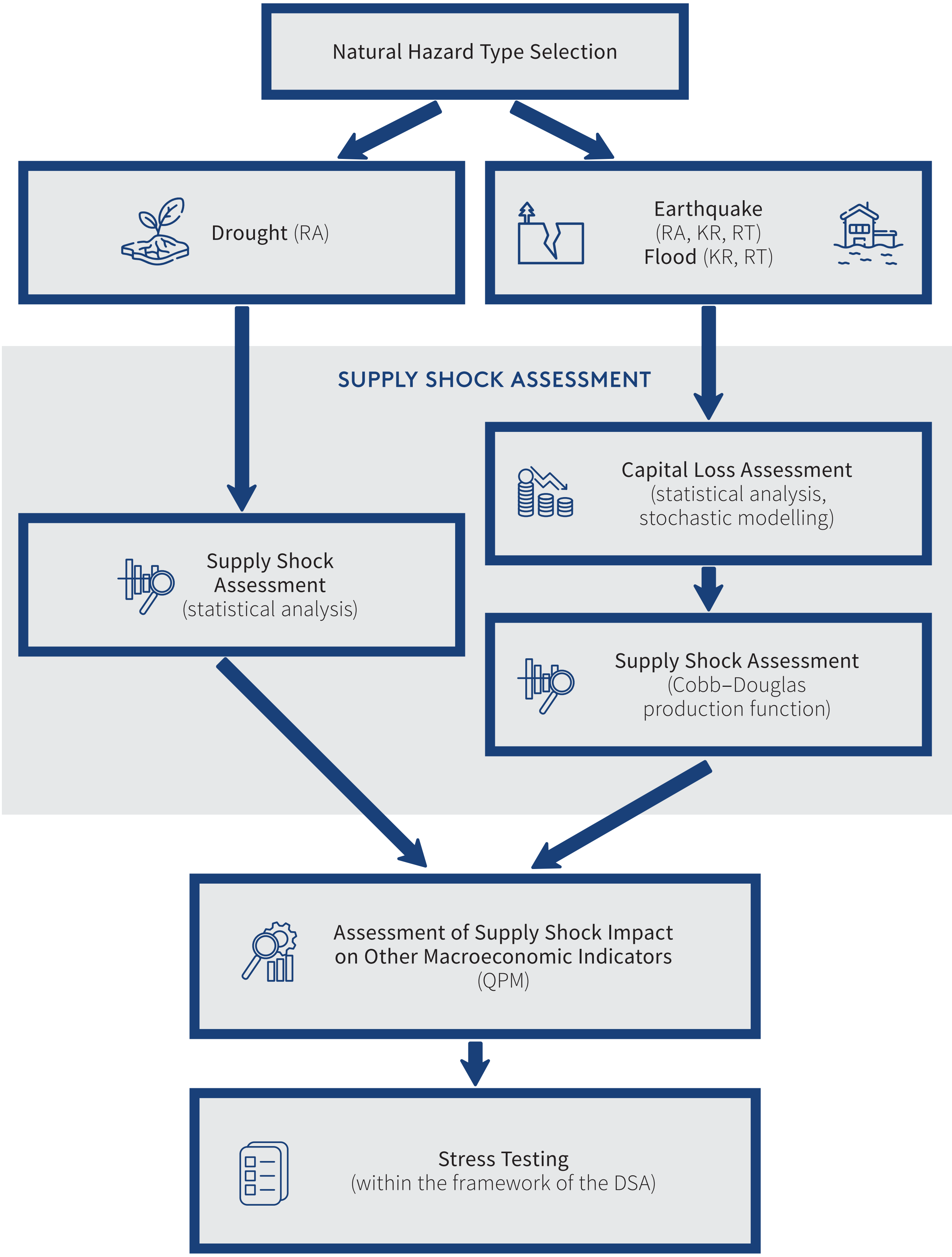
We suggest the use of different supply shock assessment methods subject to the type of the natural hazard under review.

In the case of *drought* in Armenia, supply shock assessment is performed in one stage using the statistical analysis method. Potential economic losses can be measured on the basis of the data presented in Table 3.4 and Table 3.5.

[15] The DSA methodology is described in the 2018 IMF Policy Paper (IMF, 2018) for low-income countries with emerging markets, and in the 2021 IMF Policy Paper (IMF, 2021) for countries with access to international capital markets.

[16] An example of such stress testing is described in Vinokurov et al., 2020.

Figure 4.1. Stages of Construction of the Shock Scenario for DSA Stress Testing



Source: developed by the authors.

In the case of an *earthquake* or a *flood*, supply shock assessment is performed in two stages:

1. Assessment of the potential loss of capital[17] which can be performed by using:

- statistical analysis:
  - for earthquakes, potential loss of capital can be measured using the data presented in Tables 3.1, 3.2, and 3.3 for Armenia, Kyrgyzstan, and Tajikistan, respectively,
  - for floods, potential loss of capital can be measured using the data in Figures 3.17 and 3.20 for Kyrgyzstan and Tajikistan, respectively;
- stochastic modelling (according to the results of the loss of capital assessment subject to the selected natural hazard return period):
  - for earthquakes, potential loss of capital can be measured using the data presented in Figures 3.5, 3.10, and 3.15 for Armenia, Kyrgyzstan, and Tajikistan, respectively,
  - for floods, potential loss of capital can be measured using the data in Figures 3.19 and 3.22 for Kyrgyzstan and Tajikistan, respectively;

2. Assessment of the supply shock (impact of the loss of capital on GDP) which can be performed using the Cobb-Douglas production function (Cobb et al., 1928; Hallegatte et al., 2016; Hallegatte et al., 2022).

World Bank data for 1994–2022 were used to construct production functions for the countries under review. The following results were obtained:

- Production function for Armenia:

$$Y_t = e^{5,53 + 0,04 \cdot trend} \cdot K_t^{0,35} \cdot L_t^{0,65}, \qquad (4.1)$$

where Y_t is GDP (in 2015 constant prices) during time period t, US dollars,

K_t is gross capital formation (in 2015 constant prices) during time period t, US dollars,

L_t is workforce during time period t, people.

- Production function for Kyrgyzstan:

$$Y_t = e^{5,16} \cdot K_t^{0,40} \cdot L_t^{0,60}. \qquad (4.2)$$

Equations (4.1) and (4.2) were estimated using the LSM (Annexes 2 and 3). To validate the resultant estimates, we analysed the overall quality of the proposed equations, and tested the residuals for the feasibility of the main LSM assumptions. Based on the outcomes, we drew conclusions as to the adequacy of the estimated models.

[17] Here and below, the reference is to the capital used for commercial and industrial purposes. In this Working Paper, the emphasis is on assessing the impact that loss of capital (as a key factor) may have on the scope of the supply shock. This research may be expanded by incorporating the impact produced by loss of workforce.

It should be noted that the production function for Tajikistan was not constructed because of the inferior quality of available statistical data. Inasmuch as Tajikistan and Kyrgyzstan have similar economic environments, it was decided to perform subsequent analyses of macroeconomic interrelationships in Tajikistan using the modelling outcomes obtained with data from Kyrgyzstan.[18]

We come to the following conclusions:

- in Armenia, reduction of capital by 1% leads to a 0.35% (potential) GDP decrease;
- in Kyrgyzstan and Tajikistan, reduction of capital by 1% leads to a 0.4% (potential) GDP decrease.

At **Stage 3**, we assess the impact of the supply shock on other macroeconomic indicators.

To perform a comprehensive analysis of the impact of economic shocks caused by natural hazards on macroeconomic indicators of Armenia, Kyrgyzstan, and Tajikistan, we adapted the Quarterly Projection Models (QPMs) described in EDB (2016). To analyse macroeconomic interrelationships in Tajikistan, we used the modelling outcomes obtained with data from Kyrgyzstan.

Assessment of the Impact of Earthquakes and Floods on Macroeconomic Indicators of Armenia, Kyrgyzstan, and Tajikistan

When adapting the QPMs to earthquake- and flood-related shocks, we supplemented the models by integrating an additional variable which reflects capital loss percentages resulting from the impact generated by the natural hazards under review.

The interrelationships between the capital loss variable and the other macroeconomic indicators were constructed subject to the economic effects described below. Earthquakes and floods are accompanied by massive loss of capital, leading to an immediate potential GDP decrease. Economic resources of the country are subsequently mobilised to restore affected infrastructure and assets, which increases the marginal product from capital investments and, consequently, accelerates potential GDP growth during the post-disaster periods.

Concurrently, the natural hazard under review produces a direct adverse impact on the current GDP, and on the level of supply in the economy. However, despite the substantial potential GDP response to such shocks, the existing economic mechanisms demonstrate the ability to mitigate and delay the actual GDP response. This can be explained by the fact that the economic system has certain stabilising factors and resource management and redistribution tools which partially offset direct economic losses, and ensure a smoother transition from crisis to recovery.

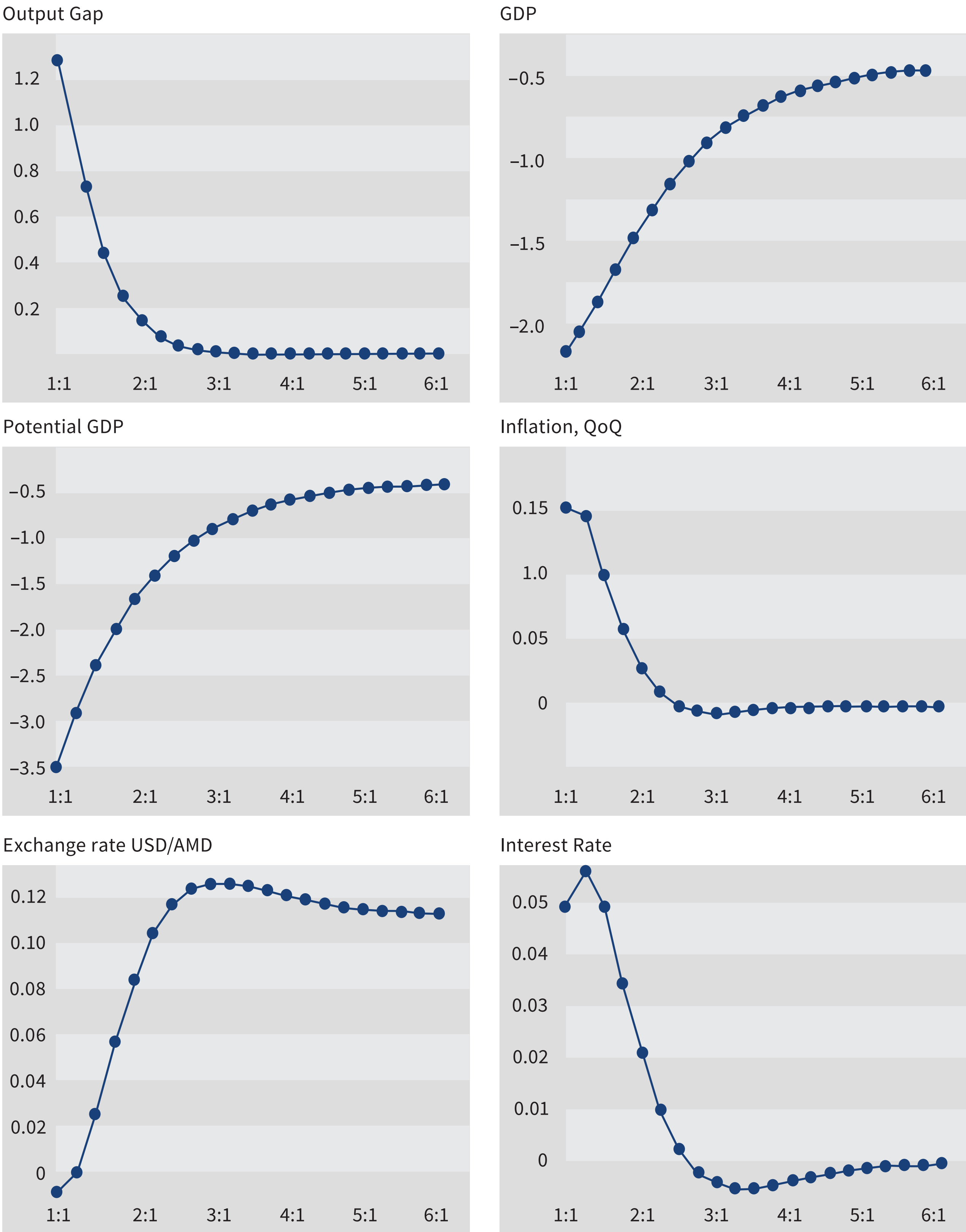
Armenia

Figure 4.2 demonstrates the impact of an earthquake or a flood on Armenia’s economy using, by way of example, a shock resulting in a 10% capital reduction. An assessment of the capital elasticity of Armenia’s production function shows that such a shock will decrease the potential GDP by 3.5%. The actual GDP will drop by 2.3%, creating a 1.2% positive output gap.[19]

[18] Yormirzoev (2022) also assumes that the capital elasticity coefficient in the production function is the same for all Central Asia countries, and equals 1/3.

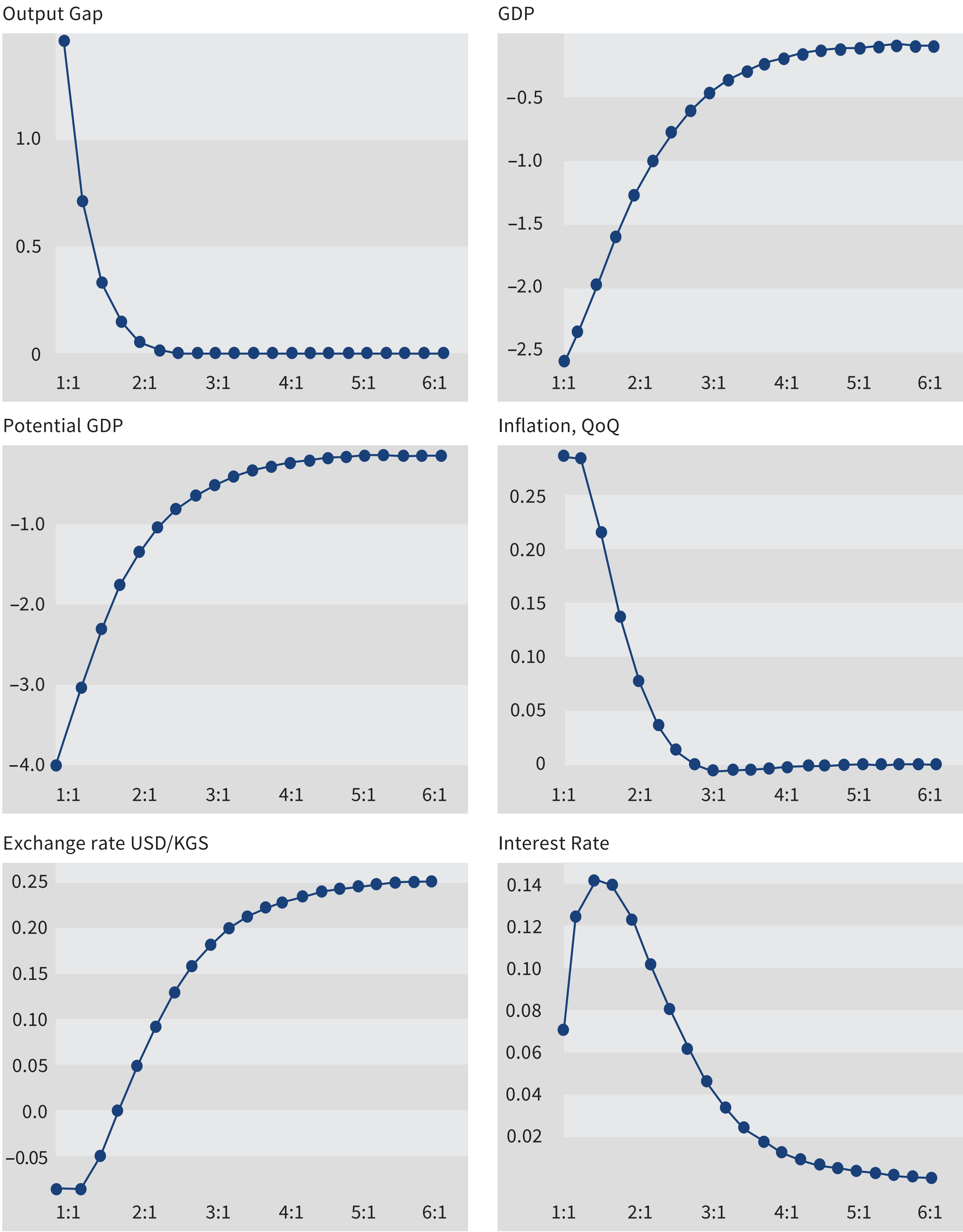
[19] Parameters were calibrated in line with World Bank research (Hallegatte et al., 2022).

Figure 4.2. Impact of a 10% Capital Reduction Shock Triggered by an Earthquake or a Flood on the Economy of Armenia



Source: authors' calculations.

Figure 4.3. Impact of a 10% Capital Reduction Shock Triggered by an Earthquake or a Flood on the Economy of Kyrgyzstan (Tajikistan)



Source: authors' calculations.

The positive output gap points to the emergence of excessive demand which cannot be met due to a substantial decline in supply, particularly in the durable products segment. The same dynamics are displayed by the model described by Coletti et al. (1996), who also examined economic impacts of natural hazard shocks.

The newly emerged supply shortage gives rise to some inflationary pressure which, in turn, accelerates price growth. In the context of a 10% capital reduction shock, inflation increases by 0.15% quarter-on-quarter (0.6% year-on-year). Notably, the inflationary pressure is directly generated by the supply shock and, consequently, does not elicit any significant monetary policy response. It does, however, exert pressure on the currency market, with the Armenian dram having depreciated by 0.12% over the last two years.

Kyrgyzstan / Tajikistan

Figure 4.3 illustrates the economic impact of a 10% capital loss on Kyrgyzstan's economy. That scenario assumes a 4% potential GDP decrease, as follows from the analysis of the country's production function. Concurrently, the actual GDP goes down by 2.6%, creating a 1.4% positive output gap.

Due to the structure of Kyrgyzstan's economy and the significant shortage, inflation increases by 0.3% quarter-on-quarter (1.2% year-on-year). Such a powerful inflation hike is an incentive for the country's monetary authorities to temporarily increase the key rate by 0.14 p.p. Additionally, inflation growth entails depreciation of the national currency by 0.25% over the next four years.

Drought in Armenia

Drought is a natural phenomenon which differs drastically from the other types of natural hazards due to its unique impact on the economy. In particular, drought does not affect the potential GDP, and its impact is, as a rule, short-lived. The effect produced by drought becomes insignificant as a new crop comes along, usually within one year. In addition, food shortages may be rather quickly offset by boosting imports.

To analyse the impact of droughts, we selected a scenario that involves total loss of crops in several Armenian regions (Ararat, Armavir, and Aragatsotn) which, combined with an additional decrease in output of livestock products, reduces the current GDP by 4–5%.

To assess the impact of drought on inflation, we examined the minimum food basket in Armenia in 1Q 2023 (Statistical Committee of the Republic of Armenia, 2023). Our findings (Table 4.1) indicate that drought, accompanied by a decrease in agricultural production, may result in an additional price increase of 3%.

To analyse the impact of the drought shock on the other macroeconomic variables, we used a quarterly projection model to simulate supply shocks in the form of simultaneous GDP reduction and inflation growth.

Figure 4.4 shows how economic indicators respond to a drought shock resulting in a 4% decrease in the GDP and the output gap. The charts indicate that Armenia's GDP will fully recover within 1–1.5 years.

Table 4.1. Minimum Food Basket in Armenia

	Cost of Annual Consumption per Capita, AMD	Share Covered by Domestic Production	Drought-Related Price Rise	Cost of Annual Consumption per Capita during Drought, AMD
Grain Products	102,662	0.24	1.024	105,126
Meat Products	135,601	0.39	1.065	144,415
Potatoes	32,439	1.00	1.100	35,683
Fruit	47,019	1.00	1.100	51,721
Vegetables	25,327	1.00	1.100	27,860
Sugar	7,761	0.02	1.002	7,777
Dairy Products	111,428	—	1.065	118,671
Eggs	13,815	1.00	1.065	14,713
Vegetable Oil	7,123	0.00	1.000	7,123
Fish	34,700	1.00	1.000	34,700
Margarine	5,650	0.01	1.001	5,654
Food Basket	**523,526**			**553,442**
Minimum Subsistence Basket	**968,523**			**998,440**

Source: SC RA.

Note: the price rise was measured based on an assumption that deficit products will be replaced with imported goods whose prices are, on the average, 10% higher due to shipping costs. Under this scenario, output of livestock products will decrease by 10–15%. Milk and eggs are animal products, margarine is a plant product. Fish prices are not affected by drought.

The ensuing market shortage of agricultural products produces an additional price rise of 3% over the next two quarters. Additional demand for imported products leads to a 0.7–0.8% depreciation of the national currency over the next year.

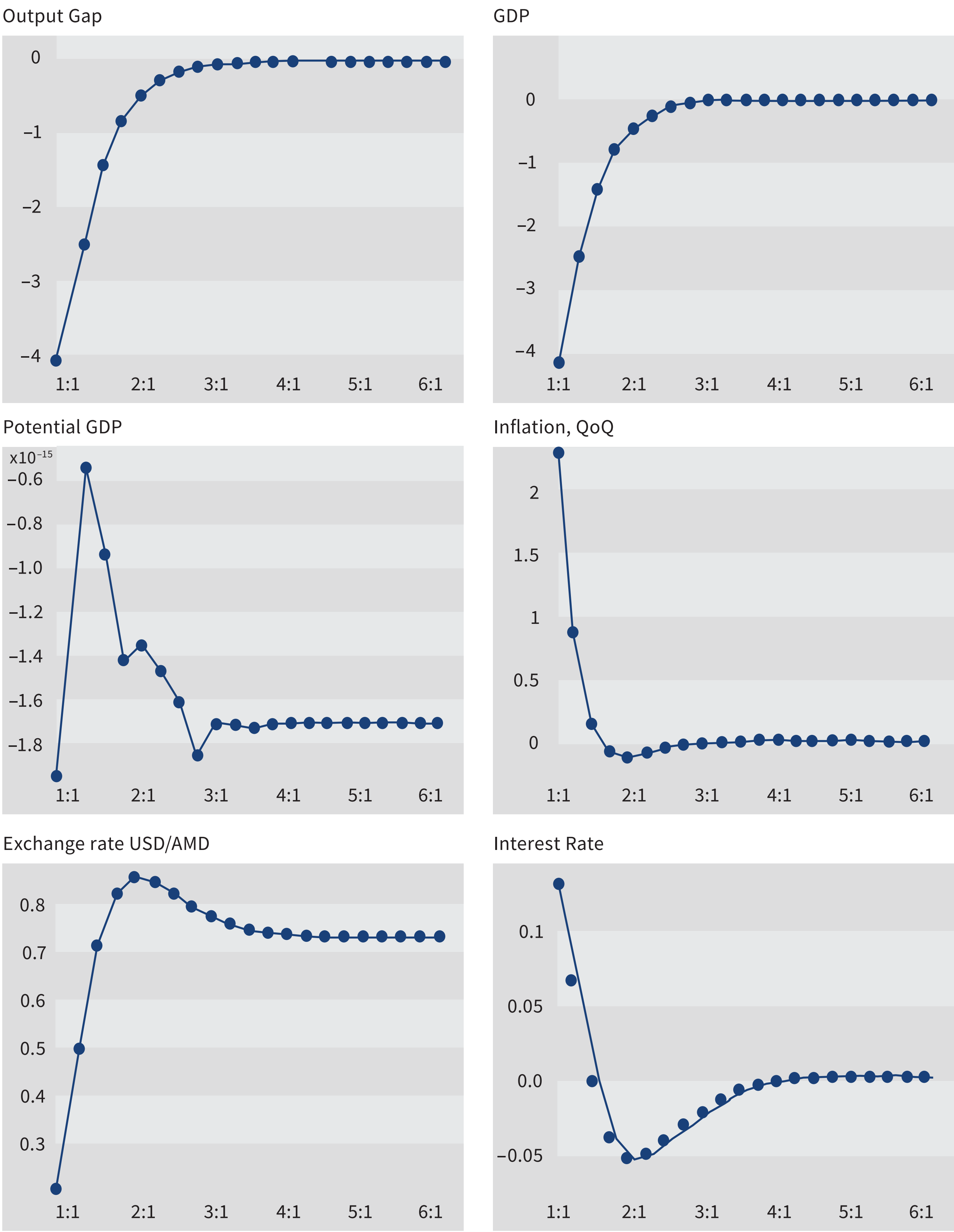
In response to the accelerating inflation, monetary authorities additionally increase the key rate by 0.15 p.p. In this case, the relatively low-key reaction of the monetary authorities can be attributed to their focus on the decline of aggregate demand caused by shrinking household incomes, especially in the agricultural sector, which, according to the estimates of the Eurasian Food Security Centre (2023), employs 22% of the population.

Stress testing is performed at the **last stage**. In this case, we suggest that the shock scenario be constructed on the basis of:

- the baseline scenario used for DSA purposes, and
- the estimated impact of natural hazard events on the key macroeconomic indicators.

Subject to the estimated impact of natural hazard events on the key macroeconomic indicators (as described above), and the use of annual data for DSA purposes, we examined the following shock scenario construction variants:

Figure 4.4. Drought Shock Impact on the Economy of Armenia



Source: authors' calculations.

Armenia:

Shock 1 — a 10% capital reduction triggered by an earthquake or a flood. The estimated deviation of the shock scenario from the baseline scenario is presented in Table 4.2.

Table 4.2. Deviation of Projected Macroeconomic Indicator Values from the Baseline Scenario (*shock: a 10% capital reduction triggered by an earthquake or a flood in Armenia*)

Indicator	Forecast Period				
	t+1	t+2	t+3	t+4	t+5
GDP (in constant prices), %	-1.9	-1.1	-0.5	-0.3	-0.2
Consumer prices increase, year-on-year, p.p.	0.5	0.0	0.0	0.0	0.0
Consumer prices increase, annual average, p.p.	0.3	0.2	0.0	0.0	0.0
Ratio of primary government expenditures to GDP, p.p.	7.4	0.2	0.0	0.0	0.0
Exchange rate of the national currency against the US dollar, end of period, %	0.06	0.12	0.12	0.11	0.11
Exchange rate of the national currency against the US dollar, annual average, %	0.02	0.11	0.12	0.12	0.11
Key rate, end of period, p.p.	0.0	0.0	0.0	0.0	0.0
Key rate, annual average, p.p.	0.0	0.0	0.0	0.0	0.0

Source: authors' calculations.

Note: 1. Under this scenario, the increase in primary government expenditures is related to the need to maintain domestic demand and finance restoration of affected buildings used for commercial and industrial purposes.

2. Restoration of residential buildings at government expense is not envisaged. Otherwise, restoration of 1% of all residential buildings will require an increase of primary government expenditures by 1.5% of GDP.

Shock 2 — total loss of crops in several Armenian regions (Ararat, Armavir, and Aragatsotn). The estimated deviation of the shock scenario from the baseline scenario is presented in Table 4.3.

Table 4.3. Deviation of Projected Macroeconomic Indicator Values from the Baseline Scenario (*shock: total loss of crops in several Armenian regions (Ararat, Armavir, and Aragatsotn)*).

Indicator	Forecast Period				
	t+1	t+2	t+3	t+4	t+5
GDP (in constant prices), %	-1.6	-0.8	0.0	0.0	0.0
Consumer prices increase, year-on-year, p.p.	3.0	-0.2	0.0	0.0	0.0
Consumer prices increase, annual average, p.p.	1.3	1.6	-0.2	0.0	0.0
Exchange rate of the national currency against the US dollar, end of period, %	0.5	0.82	0.78	0.74	0.74
Exchange rate of the national currency against the US dollar, annual average, %	0.18	0.79	0.80	0.75	0.74
Key rate, end of period, p.p.	0.15	0.0	0.0	0.0	0.0
Key rate, annual average, p.p.	0.08	0.0	0.0	0.0	0.0

Source: authors' calculations.

Note: under this scenario, the shock occurs in the beginning of the second half of the first forecast year, and primary government expenditures are not expected to increase throughout the entire forecast period.

Kyrgyzstan / Tajikistan:

Shock — a 10% capital reduction as a result of an earthquake or a flood. The estimated deviation of the shock scenario from the baseline scenario is presented in Table 4.4.

Table 4.4. Deviation of Projected Macroeconomic Indicator Values from the Baseline Scenario (*shock: a 10% capital reduction triggered by an earthquake or a flood in Kyrgyzstan or Tajikistan*)

Indicator	Forecast Period				
	t+1	t+2	t+3	t+4	t+5
GDP (in constant prices), %	-2.1	-0.9	-0.4	-0.2	-0.1
Consumer prices increase, year-on-year, p.p.	0.9	0.1	0.0	0.0	0.0
Consumer prices increase, annual average, p.p.	0.6	0.4	0.0	0.0	0.0
Ratio of primary government expenditures to GDP, p.p.					
Kyrgyzstan	11.0	0.0	0.0	0.0	0.0
Tajikistan	4.8	0.0	0.0	0.0	0.0
Exchange rate of the national currency against the US dollar, end of period, %	0.00	0.16	0.22	0.24	0.25
Exchange rate of the national currency against the US dollar, annual average, %	-0.06	0.10	0.20	0.24	0.25
Key rate, end of period, p.p.	0.15	0.0	0.0	0.0	0.0
Key rate, annual average, p.p.	0.08	0.11	0.0	0.0	0.0

Source: authors' calculations.

Note: 1. Under this scenario, the increase in primary government expenditures is related to the need to maintain domestic demand and finance restoration of affected buildings used for commercial and industrial purposes.

2. Restoration of residential buildings at government expense is not envisaged. Otherwise, restoration of 1% of all residential buildings will require an increase of primary government expenditures by 4.8% and 6.8% of GDP for Kyrgyzstan and Tajikistan, respectively.

It should be noted that the assumed severity of the shock (capital reduction, drought-related losses) can be modified on the basis of a different expert judgment, which will necessitate an appropriate adjustment of the macroeconomic projections.

Let us consider the outcome of the proposed approach to DSA stress testing for the three countries under review (Figures 4.5–4.7).

The baseline scenarios for the three countries under review are consistent with their socio-economic development forecasts prepared by EFSD experts, and with the national public debt management strategies (Ministry of Finance of the Republic of Armenia, 2023; Ministry of Finance of the Kyrgyz Republic, 2023; Ministry of Finance of the Republic of Tajikistan, 2023).

The following shock scenarios were examined for stress testing purposes:

Armenia:

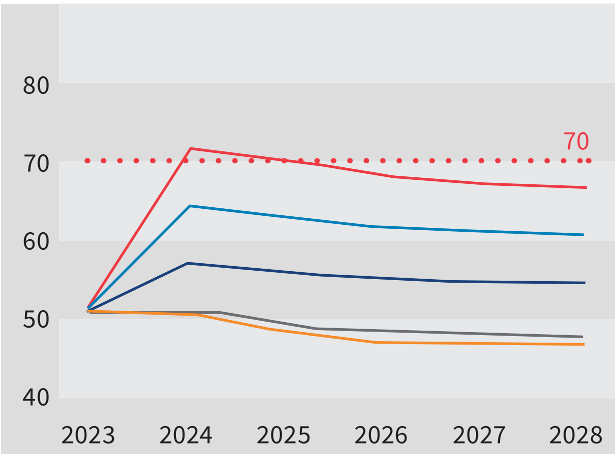
- **drought:** total loss of crops in several Armenian regions (Ararat, Armavir, and Aragatsotn) in 2024, which corresponds to economic losses of 4% of GDP.

All countries under review:

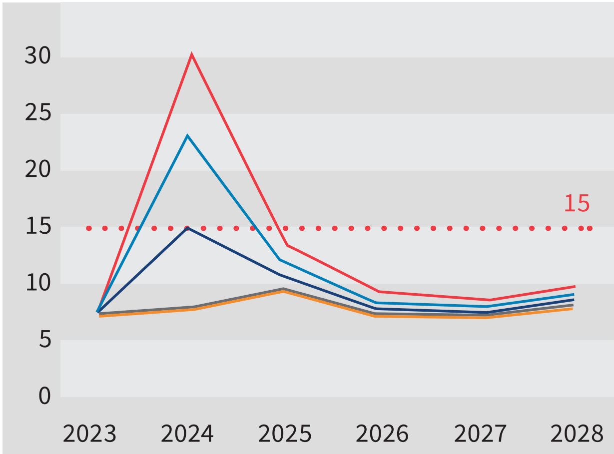
- **scenario (100%–0%):** loss of 10% of assets triggered by an earthquake/flood in 2024; the government finances restoration of 100% of affected commercial and industrial buildings;
- **scenario (100%–50%):** loss of 10% of assets triggered by an earthquake/flood in 2024; the government finances restoration of 100% of affected commercial and industrial buildings, and 50% of affected residential buildings;
- **scenario (100%–100%):** loss of 10% of assets triggered by an earthquake/flood in 2024; the government finances restoration of 100% of affected commercial, industrial, and residential buildings.

Figure 4.5. Results of Stress Testing of Armenia's Debt Sustainability

Public Debt, % GDP



Gross Financing Needs, % of GDP

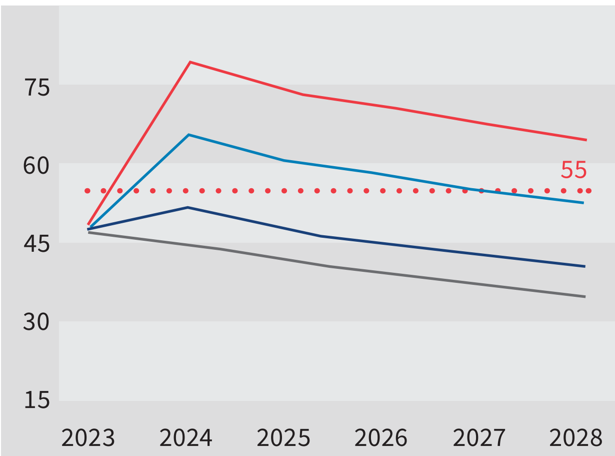


Critical Level | Baseline Scenario | Drought
Scenario (100–0%) | Scenario (100–50%) | Scenario (100–100%)

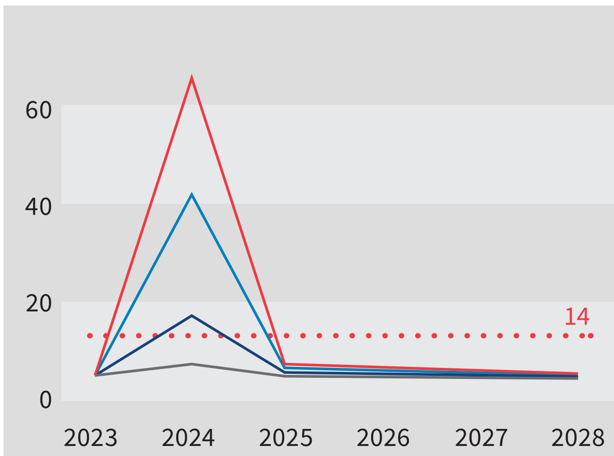
Source: authors' calculations.

Figure 4.6. Results of Stress Testing of Kyrgyzstan's Debt Sustainability

Discounted Public Debt Value, % GDP



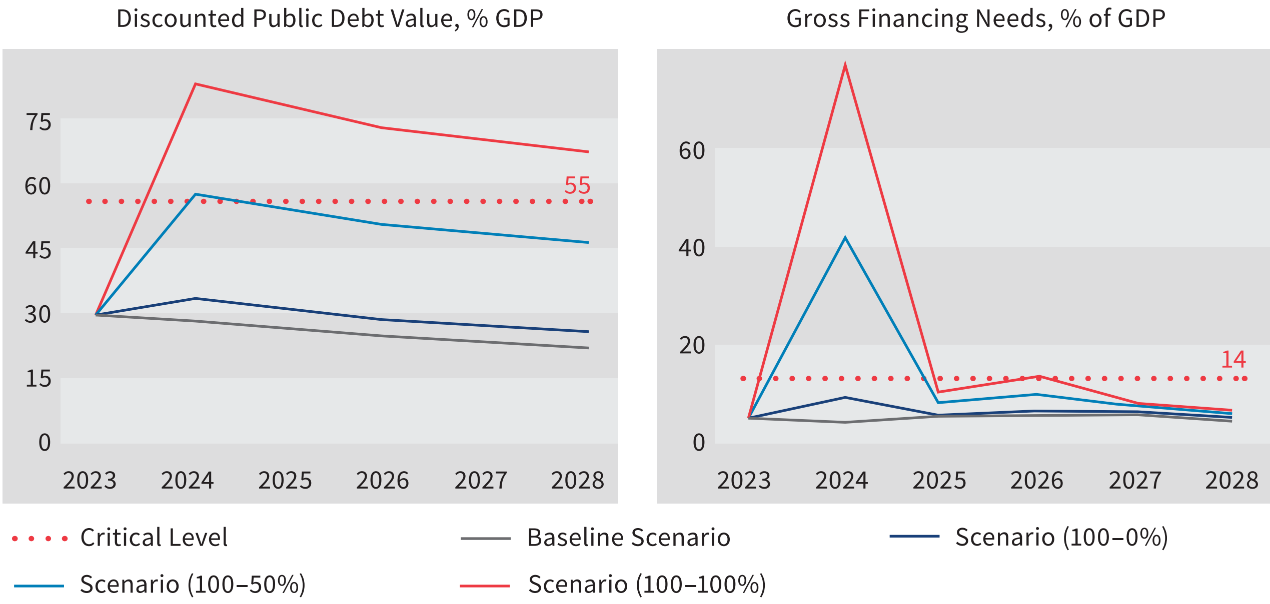
Gross Financing Needs, % of GDP



Critical Level | Baseline Scenario | Scenario (100–0%)
Scenario (100–50%) | Scenario (100–100%)

Source: authors' calculations.

Figure 4.7. Results of Stress Testing of Tajikistan's Debt Sustainability



Source: authors' calculations.

The following conclusions can be drawn on the basis of the stress testing results (Table 4.5):

Table 4.5. Analysis of Solvency and Liquidity Risks in the Event of Realisation of Stress Scenarios

Scenario	Solvency Risk			Liquidity Risk		
	Armenia	Kyrgyzstan	Tajikistan	Armenia	Kyrgyzstan	Tajikistan
Drought	–	N/A		–	N/A	
Scenario (100%–0%)	–	–	–	+	+	–
Scenario (100%–50%)	–	+	+	+	+	+
Scenario (100%–100%)	+	+	+	+	+	+

Source: authors' calculations.

Armenia:

- Solvency[20] risk increases substantially in the event of realisation of Scenario (100%–100%): projected public debt/GDP ratio exceeds the critical level (70%) in 2024;

[20] "Solvency" is defined as the ability of the government to generate sufficient primary budget surpluses in the future to repay its outstanding debt (Bouabdallah et al., 2017).

- Liquidity[21] risk increases substantially in the event of realisation of all proposed scenarios which assume loss of assets due to an earthquake: projected financing needs/GDP ratio reaches or exceeds the critical level (15%) in 2024;
- No substantial deterioration of Armenia's debt sustainability is expected if drought-related economic losses reach 4% of GDP.

Kyrgyzstan:

- Solvency risk increases substantially in the event of realisation of Scenario (100%–50%) and Scenario (100%–100%);
- Liquidity risk increases substantially in the event of realisation of all proposed scenarios which assume loss of assets due to an earthquake.

Tajikistan:

- Solvency and liquidity risks increase substantially in the event of realisation of Scenario (100%–50%) and Scenario (100%–100%).

It should be borne in mind that the proposed scenarios do not cover all possible contingencies. In practice, other variants are possible, for example:

- the government may pursue a different policy to finance recovery of capital losses, paying more attention to restoration of residential buildings rather than industrial and commercial buildings;
- rebuilding of infrastructure and assets may proceed slower than projected, with more time required to restore the potential GDP during the post-disaster period;
- upon occurrence of natural hazard events, the government may employ its own support facilities, which will result in a less significant public debt increase due to a reduced need for new external and internal borrowing.

The proposed stress testing approach may be used by the governments of the countries under review to develop national debt sustainability improvement strategies to deal with the aftermath of natural hazard events. In addition, the proposed algorithm makes it possible to determine the required level of financing support by international financial institutions. That, in turn, improves the quality of financial risk management, and generally ensures steady economic growth.

21 "Liquidity" is defined as the ability of the government to maintain access to financial markets (whenever it does not have sufficient cash or other liquid assets), ensuring its ability to service all upcoming obligations in the short term (Bouabdallah et al., 2017).

Conclusion

This Working Paper presents an approach to assessing the potential impact of natural hazards on the debt sustainability of Armenia, Kyrgyzstan, and Tajikistan. In the course of its development, the authors accomplished several tasks:

First, they compiled country profiles and analysed economic risks associated with the possible occurrence of natural hazard events. It was established that, although Armenia, Kyrgyzstan, and Tajikistan are relatively less exposed than other countries, losses resulting from certain natural hazard events may be significant. For example, in Armenia direct losses from earthquakes may reach $2.4 billion (12.3% of the 2022 GDP), in Kyrgyzstan $2.6 billion (23.9 of the 2022 GDP), and in Tajikistan $2.8 billion (26.7% of the 2022 GDP). Having analysed historical country data, the authors came to the conclusion that earthquakes and droughts are the main natural hazard events capable of producing a significant impact on the economic resilience of Armenia. Earthquakes and floods may have a similar effect on Kyrgyzstan and Tajikistan.

Second, the authors developed an algorithm that can be used to assess the impact of natural hazards on macroeconomic indicators and debt sustainability of various countries. The algorithm has several steps: (1) selection of the natural hazard type for analysis, (2) assessment of the supply shock affecting economic activity, (3) application of general equilibrium models to assess the impact that such supply shock may have on various macroeconomic indicators, and (4) stress testing within the framework of the debt sustainability analysis system.

The authors used the proposed approach to perform a comprehensive analysis of the impact of economic shocks triggered by natural hazard events on macroeconomic indicators of Armenia, Kyrgyzstan, and Tajikistan, and presented forecasts of possible changes in public debt and financing needs of those countries subject to certain shock scenarios. It was demonstrated that if Armenia, Kyrgyzstan, and Tajikistan lose 10% of their vulnerable capital due to earthquakes/floods, they will not be able to fully recover those losses due to their inability to generate sufficient primary budget surpluses in the future to repay their outstanding debt. That will force the governments to prioritise their decisions about recovery of industrial, commercial, and residential buildings.

The research findings can be used to engage in a dialogue with government agencies aimed at designing fiscal strategies and natural hazard mitigation strategies to reduce the vulnerability of the countries under review to potential adverse events. That, in turn, will improve the quality of financial risk management, and generally ensure steady economic growth.

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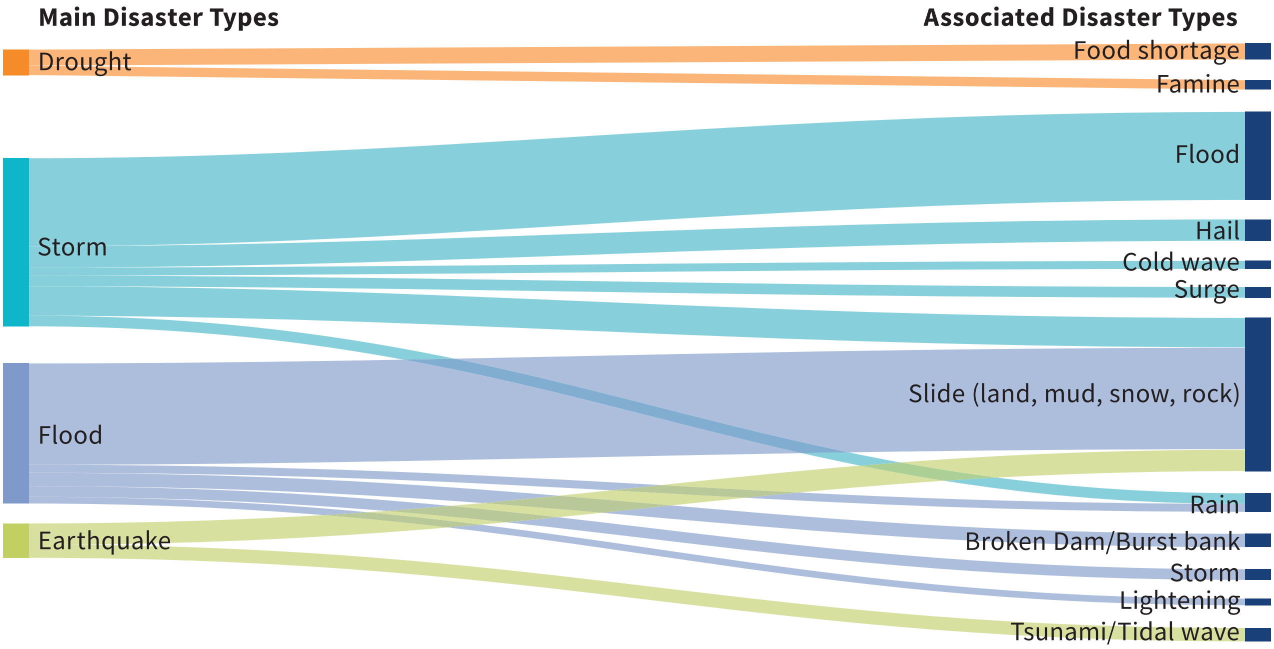
Annex 1

Interrelationships Among Key Natural Hazard Types



Source: EM-DAT Documentation (2023).

Annex 2

Results of Cobb-Douglas Production Function Estimation for RA

Dependent Variable: LOG(Y)

Method: Least Squares (Gauss-Newton / Marquardt steps)

Sample: 1994 2022

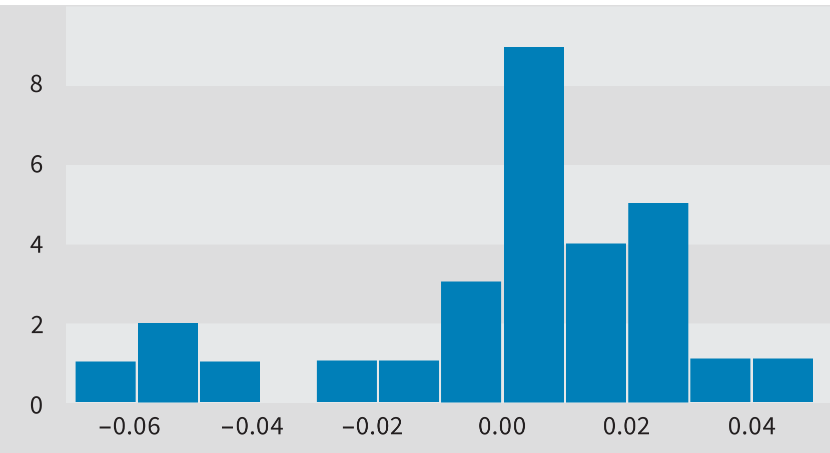
Included observations: 29

LOG(Y)=C(1)+C(2)*LOG(K)+(1-C(2))*LOG(L)+C(3)*@TREND+C(4)

*D2009+C(5)*D2010

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	5.531663	0.098737	56.02431	0.0000
C(2)	0.349189	0.015992	21.83529	0.0000
C(3)	0.038386	0.001158	33.13637	0.0000
C(4)	-0.091440	0.031474	-2.905243	0.0078
C(5)	-0.098146	0.031153	-3.150409	0.0043
R-squared	0.997027	Mean dependent var		22.68359
Adjusted R-squared	0.996532	S.D. dependent var		0.506399
S.E. of regression	0.029822	Akaike info criterion		-4.031573
Sum squared resid	0.021344	Schwarz criterion		-3.795833
Log likelihood	63.45781	Hannan-Quinn criter.		-3.957742
F-statistic	2012.453	Durbin-Watson stat		1.418097
Prob(F-statistic)	0.000000			

Distribution of model residuals



Series: Residuals
Sample 1994 2022
Observations 29

Mean	−2.70e−15
Median	0.005441
Maximum	0.042017
Minimum	−0.067998
Std. Dev.	0.027610
Skewness	−1.046597
Kurtosis	3.427535
Jarque-Bera	5.515135
Probability	0.063446

Testing the hypothesis of no autocorrelation of model residuals based on the Breusch-Godfrey test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.748803	Prob. F(2,22)		0.4846
Obs*R-squared	1.848299	Prob. Chi-Square(2)		0.3969

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Sample: 1994 2022

Included observations: 29

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.012543	0.100583	0.124707	0.9019
C(2)	-0.002189	0.016318	-0.134172	0.8945
C(3)	0.000217	0.001197	0.181057	0.8580
C(4)	0.002867	0.032141	0.089215	0.9297
C(5)	0.001711	0.031537	0.054269	0.9572
RESID(-1)	0.211571	0.210009	1.007436	0.3247
RESID(-2)	-0.202527	0.237383	-0.853167	0.4028

R-squared	0.063734	Mean dependent var		-2.70E-15
Adjusted R-squared	-0.191611	S.D. dependent var		0.027610
S.E. of regression	0.030139	Akaike info criterion		-3.959498
Sum squared resid	0.019984	Schwarz criterion		-3.629461
Log likelihood	64.41272	Hannan-Quinn criter.		-3.856135
F-statistic	0.249601	Durbin-Watson stat		1.819822
Prob(F-statistic)	0.954276			

Testing the hypothesis of homoscedasticity of model residuals based on the White test

Heteroskedasticity Test: White

F-statistic	1.469997	Prob. F(4,24)		0.2424
Obs*R-squared	5.706818	Prob. Chi-Square(4)		0.2221
Scaled explained SS	4.744123	Prob. Chi-Square(4)		0.3146

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Sample: 1994 2022

Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002873	0.001532	1.874578	0.0731
(LOG(K)-LOG(L))^2	-5.72E-05	3.52E-05	-1.624967	0.1172
(@TREND())^2	2.65E-06	1.19E-06	2.225156	0.0357
(D2009)^2	-0.000218	0.001194	-0.182176	0.8570
(D2010)^2	-0.000326	0.001183	-0.275184	0.7855

R-squared	0.196787	Mean dependent var		0.000736
Adjusted R-squared	0.062918	S.D. dependent var		0.001167
S.E. of regression	0.001130	Akaike info criterion		-10.57811
Sum squared resid	3.06E-05	Schwarz criterion		-10.34237
Log likelihood	158.3826	Hannan-Quinn criter.		-10.50428
F-statistic	1.469997	Durbin-Watson stat		1.264573
Prob(F-statistic)	0.242379			

Annex 3

Results of Cobb-Douglas Production Function Estimation for KR

Dependent Variable: LOG(Y)

Method: Least Squares (Gauss-Newton / Marquardt steps)

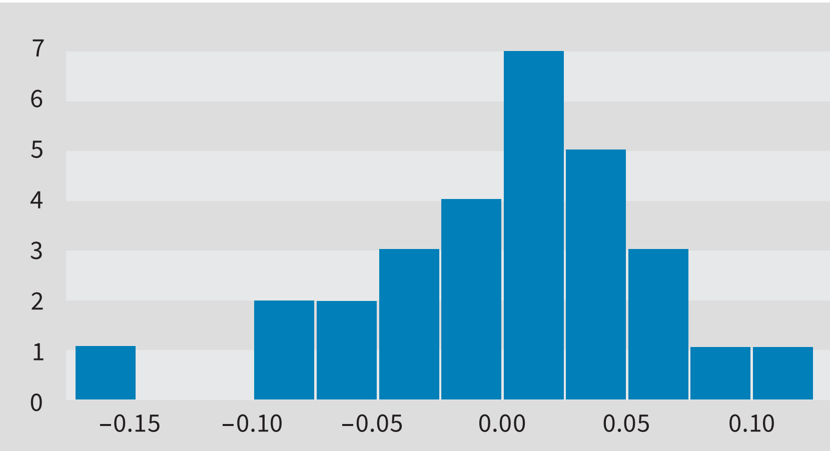
Sample: 1994 2022

Included observations: 29

LOG(Y)=C(1)+C(2)*LOG(K)+(1-C(2))*LOG(L)+C(3)*D1995+C(4)*D2022

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	5.163012	0.144043	35.84347	0.0000
C(2)	0.402322	0.023029	17.47026	0.0000
C(3)	-0.292856	0.065342	-4.481895	0.0001
C(4)	0.195130	0.065819	2.964633	0.0066
R-squared	0.970342	Mean dependent var		22.30653
Adjusted R-squared	0.966783	S.D. dependent var		0.350428
S.E. of regression	0.063867	Akaike info criterion		-2.536589
Sum squared resid	0.101975	Schwarz criterion		-2.347997
Log likelihood	40.78054	Hannan-Quinn criter.		-2.477524
F-statistic	272.6508	Durbin-Watson stat		1.661636
Prob(F-statistic)	0.000000			

Distribution of model residuals



Series: Residuals
Sample 1994 2022
Observations 29

Mean	3.72e−16
Median	0.001680
Maximum	0.118275
Minimum	−0.174810
Std. Dev.	0.060349
Skewness	−0.683802
Kurtosis	3.977671
Jarque-Bera	3.414972
Probability	0.181321

Testing the hypothesis of no autocorrelation of model residuals based on the Breusch-Godfrey test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.448428	Prob. F(2,23)	0.6441
Obs*R-squared	1.088377	Prob. Chi-Square(2)	0.5803

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Sample: 1994 2022

Included observations: 29

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.001618	0.148809	-0.010873	0.9914
C(2)	0.000230	0.023782	0.009663	0.9924
C(3)	0.006464	0.067193	0.096194	0.9242
C(4)	-0.005498	0.067885	-0.080985	0.9362
RESID(-1)	0.184660	0.210441	0.877492	0.3893
RESID(-2)	-0.102535	0.211374	-0.485091	0.6322

R-squared	0.037530	Mean dependent var	3.72E-16
Adjusted R-squared	-0.171702	S.D. dependent var	0.060349
S.E. of regression	0.065324	Akaike info criterion	-2.436911
Sum squared resid	0.098147	Schwarz criterion	-2.154022
Log likelihood	41.33520	Hannan-Quinn criter.	-2.348313
F-statistic	0.179371	Durbin-Watson stat	2.000238
Prob(F-statistic)	0.967588		

Testing the hypothesis of homoscedasticity of model residuals based on the White test

Heteroskedasticity Test: White

F-statistic	1.144399	Prob. F(3,25)	0.3505
Obs*R-squared	3.501637	Prob. Chi-Square(3)	0.3205
Scaled explained SS	3.874377	Prob. Chi-Square(3)	0.2754

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Sample: 1994 2022

Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.015205	0.007022	2.165441	0.0401
(LOG(K)-LOG(L))^2	-0.000292	0.000177	-1.651024	0.1112
(D1995)^2	-0.004832	0.006273	-0.770305	0.4483
(D2022)^2	-0.002206	0.006313	-0.349491	0.7296

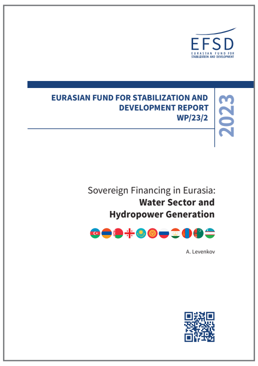
R-squared	0.120746	Mean dependent var	0.003516
Adjusted R-squared	0.015236	S.D. dependent var	0.006175
S.E. of regression	0.006128	Akaike info criterion	-7.224457
Sum squared resid	0.000939	Schwarz criterion	-7.035865
Log likelihood	108.7546	Hannan-Quinn criter.	-7.165392
F-statistic	1.144399	Durbin-Watson stat	2.080830
Prob(F-statistic)	0.350487		

Working paper WP/23/3

(RU/EN)

International Reserves as the core element of the GFSN for developing economies

The paper assesses factors affecting the decision of developing economies on the source of anti-crisis support. The study showed that international reserves are the most sought-after instrument among all the elements of the GFSN.

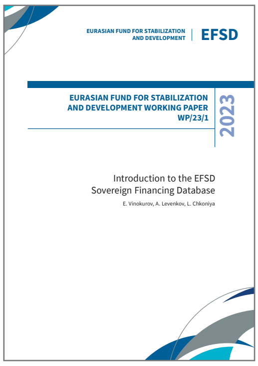


Working paper WP/23/2

(RU/EN)

Sovereign Financing in Eurasia: Water Sector and Hydropower Generation

The purpose of this Working Paper is to analyse operations of IFIs, climate funds, and development agencies in the water and HPP sector between 2008 and H1 2023 in 11 countries of the Eurasian region.

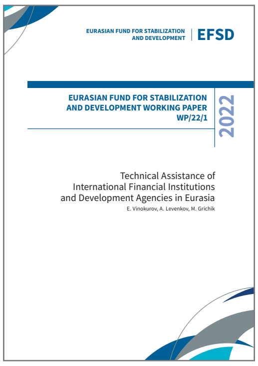


Working Paper WP/23/1

(RU/EN)

Introduction to the EFSD Sovereign Financing Database.

In this Working Paper the Sovereign Financing Database (SFD) Methodology is presented and also quantitative and qualitative analysis of sovereign financing operations in 11 countries of the region from 2008 to 2022 is carried out.

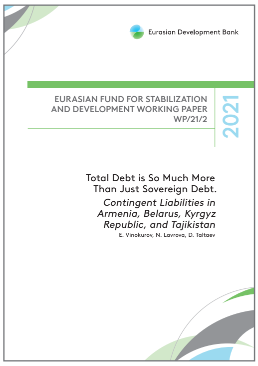


Working Paper WP/22/1

(RU/EN)

Technical Assistance of International Financial Institutions and Development Agencies in Eurasia.

The purpose of this analytical document is to review technical assistance projects implemented by international financial institutions and development agencies in 2009–2021 in 11 Eurasian countries with a detailed thematic and institutional breakdown.

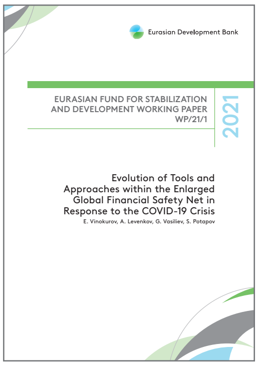


Working Paper WP/21/2

(RU/EN)

Total Debt Is So Much More Than Just Sovereign Debt. Contingent Liabilities in Armenia, Belarus, Kyrgyz Republic and Tajikistan

The study aims to contribute to understanding the potential risks and impacts of both explicit and implicit contingent liability shocks on government fiscal and debt positions in the EFSD recipient countries. Special attention is paid to the significance of state-owned enterprises and their role in countries' debt positions.



Working Paper WP/21/1

(RU/EN)

Evolution of Tools and Approaches within the Enlarged Global Financial Safety Net in Response to the COVID-19 Crisis

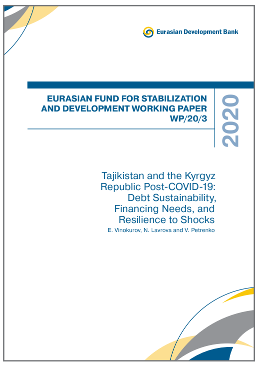
This working paper provides the analysis how the GFSN responded to pandemic on global level and on regional level (in the EFSD countries).

Working Paper WP/20/4

(RU/EN)

Optimal Debt and the Quality of Institutions

Amid the COVID-19 pandemic policymakers now face the dilemma of whether to stimulate infrastructure development by raising debt, which may reduce future flexibility, or to strengthen their fiscal positions.

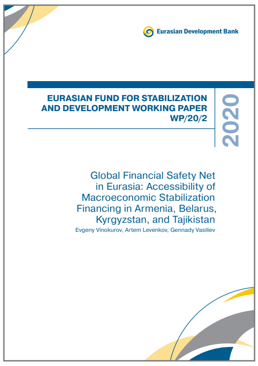


Working Paper WP/20/3

(RU/EN)

Tajikistan and the Kyrgyz Republic Post-COVID-19: Debt Sustainability, Financing Needs, and Resilience to Shocks

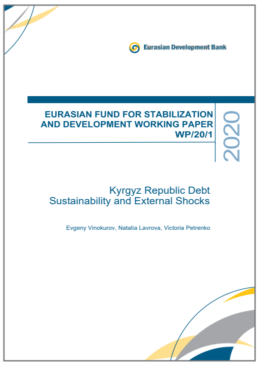
The COVID-19 outbreak has revealed the sensitivity of economies and their debt positions to a wide range of disruptions.



Working Paper WP/20/2
(RU/EN)

Global Financial Safety Net in Eurasia: Accessibility of Macroeconomic Stabilization Financing in Armenia, Belarus, Kyrgyzstan, and Tajikistan

The document estimates the availability of stabilization financing for Armenia, Belarus, the Kyrgyz Republic, and Tajikistan based on three approaches.



Working Paper WP/20/1
(RU/EN)

Kyrgyz Republic Debt Sustainability and External Shocks

The document examines the resilience of the Kyrgyz debt under three stress-scenarios: (1) a global recession, (2) a financial crisis, and (3) the combination of a global recession and a financial crisis.

Working Paper WP/19/2
(RU/EN)

Achieving Stabilization and Development Objectives in a Single Agenda: The Experience of the Eurasian Fund for Stabilization and Development

This working paper analyses the experience of the EFSD, which suggests that in the context of low-income countries, the RFA's stabilisation mandate may benefit from complementing it with developmental agenda.

Working Paper WP/19/1
(RU/EN)

The Eurasian Fund for Stabilization and Development: A Regional Financing Arrangement and Its Place in the Global Financial Safety Net

The objective of the first working paper is to bridge the gap in understanding the dynamics of EFSD development and its place in the Global Financial Safety Net (GFSN) and the region's financial architecture.

S. Ulatov, T. Tsukarev, K. Lemba, O. Korotkikh

Assessment of the Potential Impact of Natural Hazard Events
on Debt Sustainability of Armenia, Kyrgyzstan, and Tajikistan

The **Eurasian Fund for Stabilization and Development (EFSD)** amounting to US$8.513 billion was established on June 9th, 2009 by the governments of the Republic of Armenia, the Republic of Belarus, the Republic of Kazakhstan, the Kyrgyz Republic, the Russian Federation, and the Republic of Tajikistan. The objectives of the EFSD are to assist its member countries in overcoming the consequences of the global financial crisis, ensure their economic and financial stability, and foster integration in the region. More information about the EFSD is available at: efsd.org/en/.

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