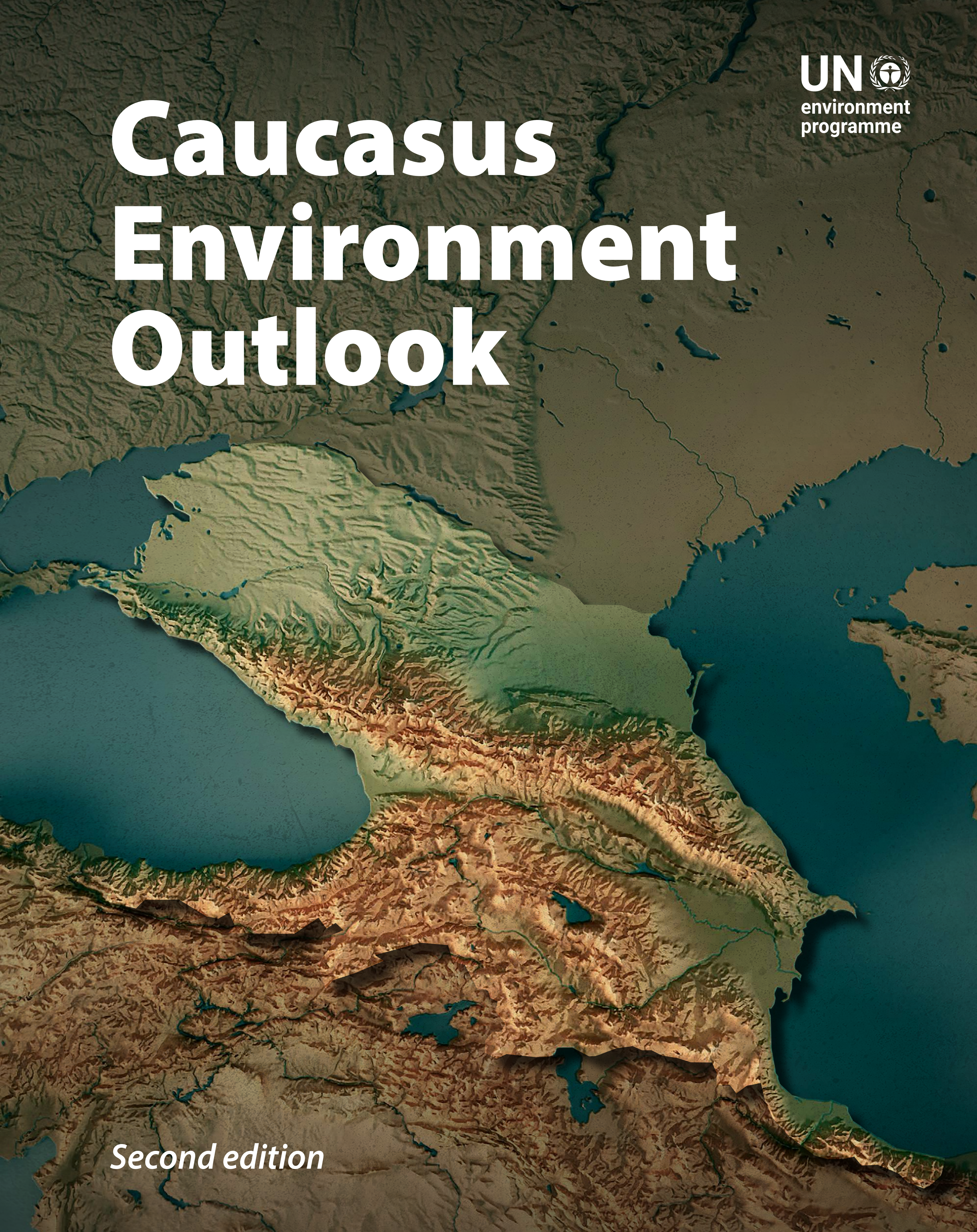
Caucasus Environment Outlook

UN environment programme



Second edition

Caucasus Environment Outlook

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Acronyms

AFF	Agriculture, Forestry, and Fishing Sector
BL	Bridging Landscape
CL	Conservation Landscapes
EMEP	European Monitoring and Evaluation Programme
ESD	Education for sustainable development
FAO	The Food and Agriculture Organization of the United Nations
FAOSTAT	FAO statistics on-line databases
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GHG	Greenhouse gasses
GRID	Global Resource Information Database
HDI	Human Development Index
HFCs	Hydrofluorocarbons
IEA	International Energy Agency
INDCs	Intended Nationally Determined Contributions
IPCC	The Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
KBA	Key biodiversity areas
LCCs	Land-cover classes
LULUCF	Land use, land-use change and forestry
NDC	Nationally Determined Contributions
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PM	Particulate matter
SDG	Sustainable Development Goal
SNC-MT	Scientific Network for the Caucasus Mountain Region
TJ	Terajoule
TPES	Total Primary Energy Supply
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WMO	World Meteorological Organization

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Sighnaghi, a town in Kakheti, Georgia. ©iStock/Parshina Olga

Foreword

The Caucasus Ecoregion is a remarkable example of a transboundary mountain ecosystem that provides rich biodiversity and numerous ecosystem services to six countries: Armenia, Azerbaijan, Georgia, the Islamic Republic of Iran, the Russian Federation and Türkiye. Like other international mountain ecosystems, the Caucasus Ecoregion is extremely vulnerable to the pressure of our societies and economies, and to the impacts of the triple planetary crisis: biodiversity loss, climate change and pollution.

Addressing these complex challenges requires collaboration to produce science that is not sterile, but that can be transformed into action – not only across national borders, but also between governmental and scientific institutions. This is why the United Nations Environment Programme (UNEP) has been working closely with the University of Geneva, GRID-Geneva and GRID-Arendal to support the Scientific Network for the Caucasus Mountain Regions (SNC-mt) in its efforts to strengthen exchange and collaboration, and to build capacity among the researchers and scientific institutions in the six Caucasus countries. This second edition of the Caucasus Environment Outlook (CEO-2) shows the results of this collaboration.

Co-authored by national and regional experts, the Caucasus Environment Outlook is based on state-of-the-art data from all six Caucasus countries, providing analyses of the environmental and socioecological state of the region and outlining key policy recommendations for the governments of the Caucasus countries to ensure protection of this unique ecosystem and its sustainable development.

The perspectives and visions of young and early-career scientists from the six Caucasus countries are shared here, discussing this unique ecoregion and its challenges, as well as the relevance of the CEO for enabling further efforts towards the sustainable development of the ecoregion. Their connection to and their interest in studying their ecoregion and their determination to contribute to its prosperous future through their research are key to understanding and tackling regional sustainable-development challenges. We hope and expect that the second edition of the CEO shall contribute to this end.

Arnold Kreilhuber
Regional Director
United Nations Environment Programme
Regional Office for Europe

Quotes from young scientists of the Caucasus region

The Caucasus Ecoregion is one of the world's most biologically rich and culturally diverse regions.

Nuray Çaltı, independent researcher and youth trainer, Türkiye

Traditional ecological knowledge, cultural practices and spiritual values associated with the region's biodiversity and landscapes are essential for understanding and preserving the region's cultural heritage.

Emil Jabrayilov, researcher, Institute of Geography, Baku, Azerbaijan

The authenticity of mountainous territories is important, as are the preservation of natural landscapes and pollution control.

Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

Why is the environment of the Caucasus important to me? I think the most obvious reason is that it is where I live; my own mental and physical health, and that of my loved ones, depends on the protection of the environment.

Zahra Veisi, Ph.D. Student, Malayer University, the Islamic Republic of Iran

The socioeconomic dynamics of the Caucasus region are intricately linked to its natural and environmental conditions. Our region is facing ongoing socioeconomic and political challenges, highlighting the importance of dedicated research in these areas. Understanding these complexities is crucial for predicting and shaping the region's future trajectory.

Natia Kekenadze, researcher, Ivane Javakhishvili Tbilisi State University, Georgia

I hope that in the coming years, we will witness some changes in the Caucasus region such as the protection of species, the revival of natural areas that are at risk of destruction, and the preservation of the unity of the Caucasus region.

Mobina Mohammad Alizadeh, MSc student, the Islamic Republic of Iran

To ensure that decisions are inclusive and relevant to the local context, it is crucial to involve and integrate the perspectives of local communities. We need more research and action regarding governance issues like decentralization, management of protected areas, and so on.

Temur Gugushvili, Assistant Professor, International Black Sea University, Georgia

By fostering cross-border scientific cooperation, Caucasus scientists can play a vital role in promoting peace, sustainable development and environmental cooperation in the region.

Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

How can the Caucasus Environment Outlook second edition contribute to the knowledge about the Caucasus and to the role of scientists in the protection and sustainable development of the ecoregion?

It is extremely important for young researchers to have a general collection of information about land use, population, economy, soil, vegetation cover, hydrological regime and, most importantly, the ecological problems of the Caucasus region.

Samira Abushova, Ph.D in geography, researcher, Ministry of Science and Education Republic of Azerbaijan, Institute of Geography, Baku, Azerbaijan

The CEO is useful for understanding nature-economy-population systems in different regions of the Caucasus and their possible adaptation for sustainable mountain development.

Linar Imangulov, postgraduate student, the Russian Federation

The CEO can help to increase the awareness of researchers by providing reports on the state of the region and also by predicting future socioeconomic scenarios for sustainable development.

Elahe Khangholi, PhD student, Malayer University, the Islamic Republic of Iran

The CEO can support my contribution to the future of the Caucasus region by providing valuable insights, research and policy recommendations specific to the region's environmental and socioeconomic challenges.

Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

Environmental and socioeconomic processes in the Caucasus countries are highly similar, especially in mountainous territories. However, each country independently seeks solutions to problems, whereas joint efforts would yield better results. Exchange of research and practical experiences would help expedite problem-solving.

Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

The CEO will be a valuable resource for studying ongoing challenges and planning research related to the Caucasus region, providing insights into real-time issues and guiding future career paths in environmental sustainability and policymaking. It can support decision-making processes by providing valuable insights and recommendations for promoting sustainability in the region.

Gvantsa Salukvadze, senior scientist, Tbilisi State University, Georgia

The CEO will be an important resource not only for my academic development, but also for filling the gap in the literature.

Nuray Çaltı, independent researcher and youth trainer, Türkiye

Executive summary

The Caucasus Ecoregion extends over 570,000 km^2 throughout six countries: Armenia (5.2 per cent of the total area of the Ecoregion), Azerbaijan (15.2 per cent), Georgia (12.3 per cent), the north-west part of the Islamic Republic of Iran (10.5 per cent), the southern part of the Russian Federation (44.6 per cent) and north-east Türkiye (12.2 per cent). The Caucasus Ecoregion covers the entire national territories of Armenia, Azerbaijan and Georgia, but lesser percentages of the Islamic Republic of Iran (3.5 per cent), the Russian Federation (1.5 per cent) and Türkiye (9 per cent).[1]

[1] The area of the Caucasus Ecoregion used here (570,000 km^2) is slightly different from the 580,000 of Zazanashvili, Garforth, and Bitsadze (2020) and Zazanashvili *et al*. (2020b) cited in the Introduction. The Ecoregion boundaries have been adapted here to follow the subnational borders of the Islamic Republic of Iran, the Russian Federation and Türkiye in order to allow for socioeconomic data collection at NUTS equivalent level (see annex). All values in this paragraph were calculated by Yaniss Guigoz (UNEP/GRID-Geneva) based on United Nations Cartographic section official boundaries.

Map 1. *Caucasus Ecoregion topography*

Home to an estimated 42 million people, the Caucasus Ecoregion has seen a clear trend of rural outmigration in recent years due to the attractiveness of urban areas that offer more services, income opportunities, and connectivity. Urban centres are becoming a melting pot of innovation and culture, with a diverse population as a great economic driver. However, urban centres are also major contributors to climate change, responsible for about 75 per cent of global CO_2 emissions, with transport and buildings among the largest contributors. Larger cities increase the risk of certain hazards, especially within improperly planned and managed areas where informal housing for residents with lower incomes are often found. Income inequalities also continue to rise in cities throughout the world.

The effects of climate change are also exacerbated in urban areas due to interactions between residents, urban infrastructure systems and economic activities. Increasing average temperatures have been consistently observed in the last decade, and forward-looking climate scenarios unanimously predict continued temperature increases. Urban planning should thus be organized taking these changes into account, to preserve and improve the health and comfort of all people, including vulnerable groups, such as displaced people, migrants, religious and ethnic minorities, the elderly, women, children and people with lower incomes. Mountain areas are warming at faster rates than lowlands.

Environmental and biodiversity conservation in the Caucasus Ecoregion, internationally recognized as a biodiversity hotspot, should be a priority. Mountains make up more than half of this territory. Highlands provide essential ecosystems services. Glacial meltwater, pastureland and forests benefit people living in lowlands and cities. The negative impacts of land use, pollutant emissions in the atmosphere or availability and quality of freshwater and other cross-cutting issues in the Caucasus Ecoregion can be mitigated. Enhanced monitoring and evaluation of various measures undertaken would serve to strengthen climate change and adaptation. Ecosystem-based adaptation solutions need to be developed to reduce the impacts of climate change.

At the time of writing this publication, all countries in the Caucasus Ecoregion are among the 196 total countries to have signed the Paris Agreement adopted at the United Nations Framework Convention on Climate Change Conference of Parties 21 (UNFCCC-COP 21) in 2015. All countries, except the Islamic Republic of Iran, have also ratified it and published their Nationally Determined Contributions (NDC). The NDCs communicate plans to reduce greenhouse gas emissions to reach the Paris agreement goal to keep global warming to well below 2°C. Ratifying and implementing several other international conventions is critical, including the Convention on Biological Diversity (CBD) with the Kunming-Montreal Global Biodiversity Framework, the Ramsar Convention on Wetlands of International Importance and other treaties that provide guidelines to improve relevant environmental, social, and health aspects for the Caucasus Ecoregion. The Caucasus Environment Outlook focuses on efforts to fill gaps and better enable the mitigation of environmental change in its overview of the state of the environment in each country and on each theme.

Promoting the sustainable development of the Caucasus Ecoregion necessitates robust collaboration and communication among diverse stakeholders. However, the prevailing economic and sociopolitical context in the region erodes the unity of the Caucasus space. Conflicts within and between certain countries also present challenges for regional cooperation.

Establishing national regulations to follow this path requires a long-term perspective that can allow for decisions offering greater certainty and clarity to industries and companies that need to apply changes, which sometimes involve large investments. Ultimately, reducing emissions should be at the heart of every decision in order to reach the goal of net-zero emissions by 2050. Policies that do not protect the environment should be updated. Individual actions are important and should be supported, but large collective efforts toward reducing greenhouse gas emissions are to be implemented at the national level to increase the rate of climate change mitigation. Involving the scientific community in guiding decisionmakers to the most environmentally friendly options is necessary. The Scientific Network for the Caucasus Mountain Region (SNC-mt) provides an excellent example of international cooperation on environmental research. Other scientific bodies exist at the local and regional levels to determine and reach long-term goals and targets.

Policy recommendations

Information and awareness

- Raise awareness among governmental bodies, including political leaders and other stakeholders within and beyond the environmental sector, about the effects of climate change on air quality and natural resources and ecosystems, particularly in mountainous regions.

- Develop strategies and action plans that incorporate measurable indicators to provide clearer guidance for the implementation, monitoring, reporting, and verification (MRV) of associated initiatives, with a specific emphasis on the local level.

Research and assessments

- Increase support to research in all countries of the Caucasus Ecoregion to enhance knowledge and enable implementation of better and more effective actions and solutions. Such documents as the Caucasus Research Agenda 2020–2030 were written in collaboration with a representative panel of scholars from the Ecoregion to guide policymakers on environmental research.

- Enhance scientific knowledge on the structure and function of the main ecosystems in the Caucasus, aiming for the future sustainability of natural ecosystems and biological communities.

Policy and law

- Focus on developing an overall governance framework with a strategic vision for sustainable and resilient development. Climate change and adaptation measures should be integrated into policies and legislation, requiring strong political support.

- Climate change adaptation policies and legislation should always consider the perspective of the Caucasus as an ecoregion. Data and information, research methodologies, climate change monitoring and coordination of actions in the field among the countries of the Caucasus Ecoregion should be approached from a regional perspective.

- Promote gender equality, social inclusion, and environmental justice in policies and laws to ensure equal access to resources and opportunities for women and vulnerable groups. This approach fosters a more inclusive society and mitigates environmental risks.

- Adopt integrated urban planning frameworks that include environmental considerations by incorporating environmental impact assessments into urban development plans. Promote compact, mixed-use development patterns and green infrastructure initiatives to mitigate environmental impacts.

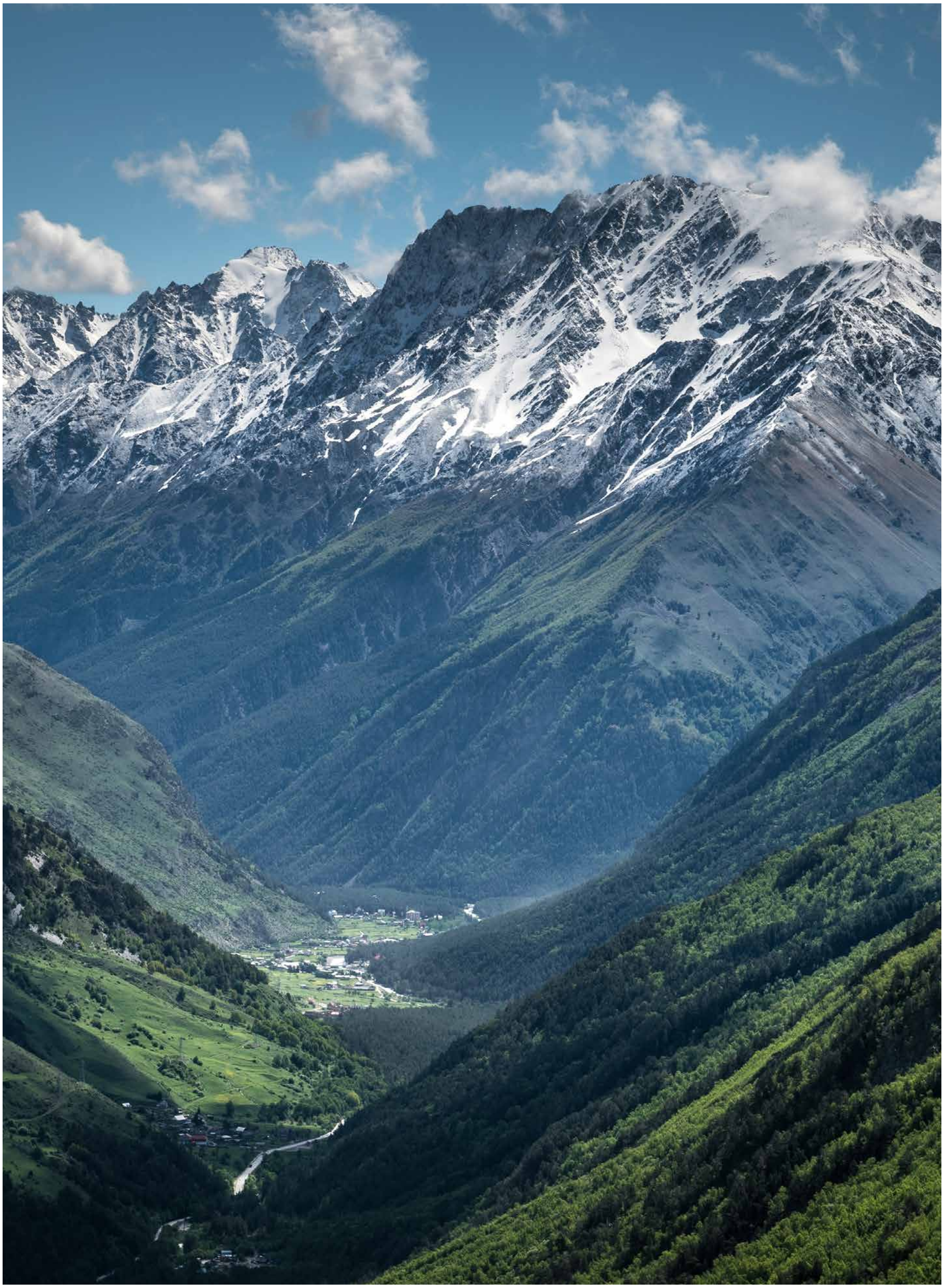
- Implement a multi-faceted policy approach that establishes cross-sectoral links between governmental bodies and agencies to address the current and future impacts of air pollution and climate change on public health.

Financial mechanisms

- Mobilize resources and allocate of sufficient governmental funds to support the implementation of climate change adaptation programmes and initiatives.
- Develop innovative funding mechanisms to promote climate change adaptation, with a specific focus on mountain regions.
- Foster cross-country cooperation to create shared sustainable infrastructure that allows countries of the Caucasus Ecoregion to develop trade routes and industry, while limiting environmental impact and enhancing climate resilience.
- Promote cross-country cooperation in the energy sector to harness the clean and renewable energy potential of the Caucasus Ecoregion, while reducing overall emissions.
- Increase financial support and investment in scientific research to facilitate evidence-based decision-making, which is crucial given the anticipated impacts of climate change.

Cooperation and coordination

- Establish pertinent coordination mechanisms, such as intersectoral working groups and councils, to reaffirm and tackle country and (sub)regional needs and priorities, fostering a more cohesive approach to action. Improved communication among diverse stakeholders engaged in climate change activities would facilitate synergies among various initiatives.
- Promote knowledge exchange in the region by adopting comparable frameworks and methodologies for data collection, as well as developing open-source datasets to improve decision-making processes at national and regional levels.
- Design programmes and projects to be user-driven, prioritizing civilians, vulnerable groups, and civil society, and avoiding top-down approaches.
- Strengthen collaborative and sustainable resource management and conflict resolution by establishing frameworks for dialogue and joint decision-making among diverse stakeholder groups.
- Develop and implement transboundary water basin management plans, considering climate change scenarios, improving water efficiency, and addressing priority water needs across the Ecoregion.
- Allocate additional resources for waste management, infrastructure upgrades, the deployment of advanced technologies, and service enhancements to support waste and wastewater infrastructure development and management.



Snowy peaks in the Caucasus Mountains. ©iStock/katerinasergeevna

Introduction

Following the United Nations Conference on the Human Environment held in Sweden in 1972, the United Nations Environment Programme (UNEP) was established to evaluate and report on the state of the environment, develop scientific arguments to inform policy, and help address the world's environmental challenges.

The first edition of the Global Environment Outlook (GEO) was released in 1997, (United Nations Environment Programme [UNEP] 1997), marking a significant step towards fulfilling UNEP's mandate to continuously monitor the global environment. At the time of writing, the seventh edition is being prepared to guide today's policymakers.

The first edition of the Caucasus Environment Outlook was released in 2002 (UNEP 2002), providing an overview of the state of the environment just over a decade after the collapse of the Soviet Union. This edition focused on four countries, Armenia, Azerbaijan, Georgia and the Russian Federation, thus covering only part of the Caucasus Ecoregion as defined above.

This second edition of the Caucasus Environment Outlook (CEO-2) focuses on the environmental monitoring process at the regional level through a participatory and consultative approach. CEO-2 examines the relationship between policy and the environment, showing how policy can impact the environment and how environmental change can influence policy. The analysis of environmental trends considers a wide range of social, cultural, economic, environmental and political drivers, providing a cross-sectoral overview based on the Driver-Pressure-State-Impact-Response (DPSIR) framework.

The DPSIR Framework is used to describe interactions between societies and environments, enabling a feedback loop between policymakers and environmental quality, especially related to past or future political choices. This framework has been applied in multiple regional and global reports on the environment (Smeets and Weterings 1999; UNEP 2006; UNEP 2019). The ability to integrate knowledge across different disciplines and to formulate various scenarios to support decision-making is essential in linking science to management and policy (Svarstad et al. 2008). Understanding the nature and motivations behind human activities that lead to environmental decline is an important step in enabling the most suitable response.

In the DPSIR Framework, drivers are defined as human needs such as food, shelter and water. The resulting industrial and technological systems in human societies, which aim to satisfy human lifestyle and consumption desires, create secondary drivers, each with its own internal logic and rules. GEO-6 considers climate change an additional driver, and it will be considered one here as well. Global warming, as described in the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC-AR5 2014) and the Sixth Assessment Report (IPCC-AR6 2023), is seen as unequivocal, with its "associated impacts will continue even if anthropogenic emissions of greenhouse gases are stopped" (IPCC-AR5 2014, p.16).

According to the DPSIR Framework, pressures are the consequences of the drivers that ultimately influence the state of the environment. Pressures can have an effect over the short or long term and are usually depicted as negative and unwanted, based on the concept that any change induced by human activity is damaging and degrading. States are the current chemical, physical and biological conditions of the environment or the observable temporal changes in the system. This concept applies not only to natural systems but also to socioeconomic systems or a combination of both. Impacts are changes in the quality and functioning of the system that affect human well-being through ecosystem services.

Finally, responses are formulated after understanding the drivers, pressures and resulting unwanted impacts on the state of the environment. These responses aim to modify drivers, reduce pressures, and restore a system back to its original state, thereby mitigating negative impacts. While responses are usually associated with government actions, they can also include societal movements by individuals and/or groups across private or non-governmental sectors.

CEO-2 aims to answer the following questions based on this DPSIR analysis:

- What are the drivers and pressures changing the state of the environment in the Caucasus?
- What is the current state of the environment in the Caucasus?
- What are the impacts on the environment, and which drivers and pressures are causing them?
- What responses, such as policy measures, have been implemented to improve environmental protection and governance?
- What other potential responses could be undertaken to transform the human-environment system towards sustainability?

The foreword features quotes from young scientists and students from the Caucasus Ecoregion, expressing their hopes and expectations for CEO-2. Part One explores the main drivers of environmental change in the Caucasus, including population (Chapter 1), urbanization (Chapter 2), economic development (Chapter 3) and climate change (Chapter 4). Part Two covers the insights, key data, main gaps and a brief evaluation of responses or policies related to the following elements of the state of the Caucasus Ecoregion: land cover (Chapter 5), biodiversity (Chapter 6), air quality (Chapter 7), freshwater (Chapter 8), and cross-cutting issues (Chapter 9). Throughout all chapters, links are made to the responses to these drivers, pressures and impacts such as regional and global processes and frameworks like Agenda 2030 and the Sustainable Development Goals, the United Nations Framework Convention on Climate Change, and the Kunming-Montreal Global Biodiversity Framework. Issues and gaps related to gender, including the effects of socioecological change on women and their roles in regional processes, are also addressed. The conclusion briefly summarizes policy needs and recommendations at the Caucasus Ecoregion level and outlines key messages.

With a better understanding of the linkages between socioeconomic drivers and pressures on the environment at the regional level, grounded in scientific research, integrating national and regional information, and considering global environmental change, this publication will support decision makers in contributing to a healthier environment and more sustainable and equitable development pathways in the Caucasus Ecoregion.

The Caucasus and the Caucasus Ecoregion

The Caucasus is a region located between the Black Sea and the Caspian Sea, at the intersection of Europe and Asia. The name "Caucasus" is thought to have been derived from *croucasis* which means "shimmering with snow" in the Scythian language (Secundus 1634). The Caucasus region spans six countries: Armenia, Azerbaijan, Georgia, the Islamic Republic of Iran, the Russian Federation, and Türkiye. The region features a variety of natural landscapes characterized by vast plains, plateaus and mountain ranges. The highest peak in the region, Mount Elbrus, reaches 5,642 metres above sea level, and is in the Greater Caucasus Mountain range. The Lesser Caucasus Mountain range is located in the southern part of the region, with Mount Ararat being the highest point at 5,137 metres above sea level. The lowest point in the Caucasus is 28 metres below sea level near the Caspian Sea in the east. The main rivers are the Kura and Aras, both having transboundary water basins covering over 200,000 km^2 (see Map 1).

The Greater Caucasus Mountains form a barrier between the temperate mid-latitude climate in the north and the warm sub-tropical climatic zones in the south. The western region is cooler with a maritime-dominated climate, whereas some semi-arid and even desert-like areas exist close to the Caspian Sea. The variety of climates is reflected in diverse types of vegetation from dense sub-tropical forests to steppes, arid and semi-arid deserts, and alpine meadows nourished by glacial runoff.

The Caucasus Ecoregion was first identified by an international consortium as one of 25 terrestrial biodiversity hotspots in the world based on the presence of a significant number of endemic vascular plant and non-fish vertebrate species (Mittermeier *et al*. 1999, chapter 3). The term "ecoregion" has been used extensively to recognize cross-border areas necessary for strengthening biodiversity conservation at a global level (Olson *et al*. 2001; Norman 2003; Zachos and Habel 2011). The term "the Caucasus Ecoregion" has been adopted by the scientific community and environmental organizations and has become a common reference area (Krever *et al*. 2001; Bohn *et al*. 2007; Zazanashvili and Mallon 2009; Zazanashvili, Garforth, and Bitsadze (2020); Zazanashvili *et al*. (2020); Dering *et al*. 2021). Now recognized as one of 35 "priority places" and one of 36 "biodiversity hotspots" by Conservation International, the geographic area of the Caucasus Ecoregion is 580,000 km^2 as calculated by Zazanashvili, Garforth, and Bitsadze (2020) and Zazanashvili *et al*. (2020).[2]

Scientific Network for the Caucasus Mountain Region

Ongoing development efforts in the Caucasus region are undermined by divergent economic and sociopolitical trends. Frequent geopolitical tensions, rooted in complex historical processes spanning the region, hamper economic and social progress. In this context, expected climate warming threatens to further exacerbate transboundary environmental issues, especially those related to water management and ecosystem protection (Shatberashvili *et al*. 2015).

Lasting regional cooperation is essential to address many of these challenges. With the aim of supporting such cooperation, the Scientific Network for the Caucasus Mountain Region (SNC-mt) was established in 2014 alongside the Caucasus Network for Sustainable Development of Mountain Regions (Sustainable Caucasus), which serves as a coordination unit. The SNC-mt aims to: (1) promote collaboration in research to increase the availability of data and research about mountains to contribute to sustainable development; (2) develop an overarching research strategy; (3) enhance research capacities and increase the profile of the Caucasus in the European and global context; (4) exchange knowledge, data and best practices within the Caucasus and with other mountain regions; and (5) strengthen connections across scientific domains between researchers, practitioners and decision makers (Shatberashvili *et al*. 2023).

[2] This area is slightly different from the number used in the CEO-2 (see footnote 1 and the annex).

These two organizations, the SNC-mt and Sustainable Caucasus, have developed a platform and tools to facilitate the co-creation of knowledge and address some of the challenges of scientific research and regional academic exchange, thereby facilitating sustainable development. The Caucasus Regional Research Agenda 2020–2023 (SNC-mt Scientific Steering Group 2019), the guiding document of the SNC-mt, outlines the current state of knowledge in core areas of sustainable mountain development in the Caucasus region.[3] Formulating the Agenda was made possible through the facilitation of transboundary cooperation and collaboration across different government levels and with stakeholders from multiple sectors.

Place names

Throughout CEO-2, we use the following terms to refer to different parts of the Caucasus region:

The Caucasus, the Caucasus region, the Caucasus Ecoregion, the Ecoregion: These terms are used interchangeably throughout this reference work and refer to the entire national territories of Armenia, Azerbaijan and Georgia, as well as those parts of the Russian Federation, the Islamic Republic of Iran, and Türkiye that fall within the Caucasus region (see Map 1). The Caucasus Ecoregion was specifically defined as such in 2006 in the Ecoregional Conservation Plan for the Caucasus by more than 200 experts and multiple governmental and non-governmental organizations.

Caucasus countries: This term encompasses Armenia, Azerbaijan and Georgia, the Russian Federation, the Islamic Republic of Iran, and Türkiye

South Caucasus: Refers to the entire national territories of Armenia, Azerbaijan, and Georgia.

Caucasus part of the Russian Federation, the North Caucasus: Indicates the southern part of the Russian Federation (located within the borders of the Caucasus Ecoregion).

Caucasus part of Türkiye: Refers to the northeastern part of Türkiye, located within the Caucasus Ecoregion.

Caucasus part of the Islamic Republic of Iran: Refers to the northwestern part of the Islamic Republic of Iran, located within the Caucasus Ecoregion.

Data overview

In this publication, comparable subnational unit sizes throughout the Caucasus Ecoregion were needed to meet the requirements of homogeneous spatial analysis at a consistent territorial scale. The Nomenclature of Territorial Units for Statistics (NUTS), a geographical standard used by EU member states, was considered an appropriate method for defining comparable sub-national units. However, out of the six Caucasus countries, only Türkiye formally recognizes the EU NUTS system (Eurostat, n.d.). As a result, the regional statistical units of the six countries in the Ecoregion vary according to country size. Therefore, the authors defined the data collection levels in each country correspond to NUTS 2 or NUTS 3 levels. A detailed description of each country's administrative units and their correspondence to sub-national administrative divisions is provided in the annex.

[3] Available here: https://www.caucasus-mt.net/regional-research-agenda.

Most of the maps available in this publication, and additional ones, can also be accessed as GIS layers in the geoportal developed through this project: https://sustainable-caucasus.unepgrid.ch/ and a general introduction to the Caucasus SDI can be found at https://www.caucasus-mt.net/Caucasus-SDI.

Armenia: Regions (marzes) are defined as subnational units for data collection, serving both as NUTS 2 and NUTS 3 equivalent (Government of the Republic of Armenia n.d.).

Azerbaijan: Districts (rayon) and cities (şəhər) are defined as subnational units, equivalent toboth NUTS 2 and NUTS 3 for data collection.

Georgia: Regions (mkhare) are designated as subnational units of NUTS 2 equivalent, while municipalities (munitsip'alit'et'i) serve as NUTS 3 equivalent.

Iran (Islamic Republic of): Provinces (ostānhā) are defined as subnational units of NUTS 2 equivalent, with districts (shahrestan) as NUTS 3 equivalent

Russian Federation: "Constituent entities" comprising republics, krays, oblasts, cities of federal significance, an autonomous oblast and autonomous okrugs serve as the NUTS 2 equivalents, while districts (rayons) and cities (gorod)are designated as the NUTS 3 equivalent.

Türkiye: Provinces (İlleri) are defined as subnational units of NUTS2 equivalent, and districts (ilçeler) as NUTS 3 equivalents. However, this does not align with official NUTS classifications, where NUTS 2 and NUTS 3 in Türkiye correspond to Alt bölgeler and İlleri, respectively.

To assign a unique identifier to each sub-national unit for data collection and mapping, a specific coding scheme was developed based on the United Nations Second Administrative Level Boundaries project (UN SALB) coding scheme (United Nations Geospatial 2021). The lists of NUTS 2 and NUTS 3 equivalent units used for the Caucasus Ecoregion, along with their respective unique codes, are available in the annex.

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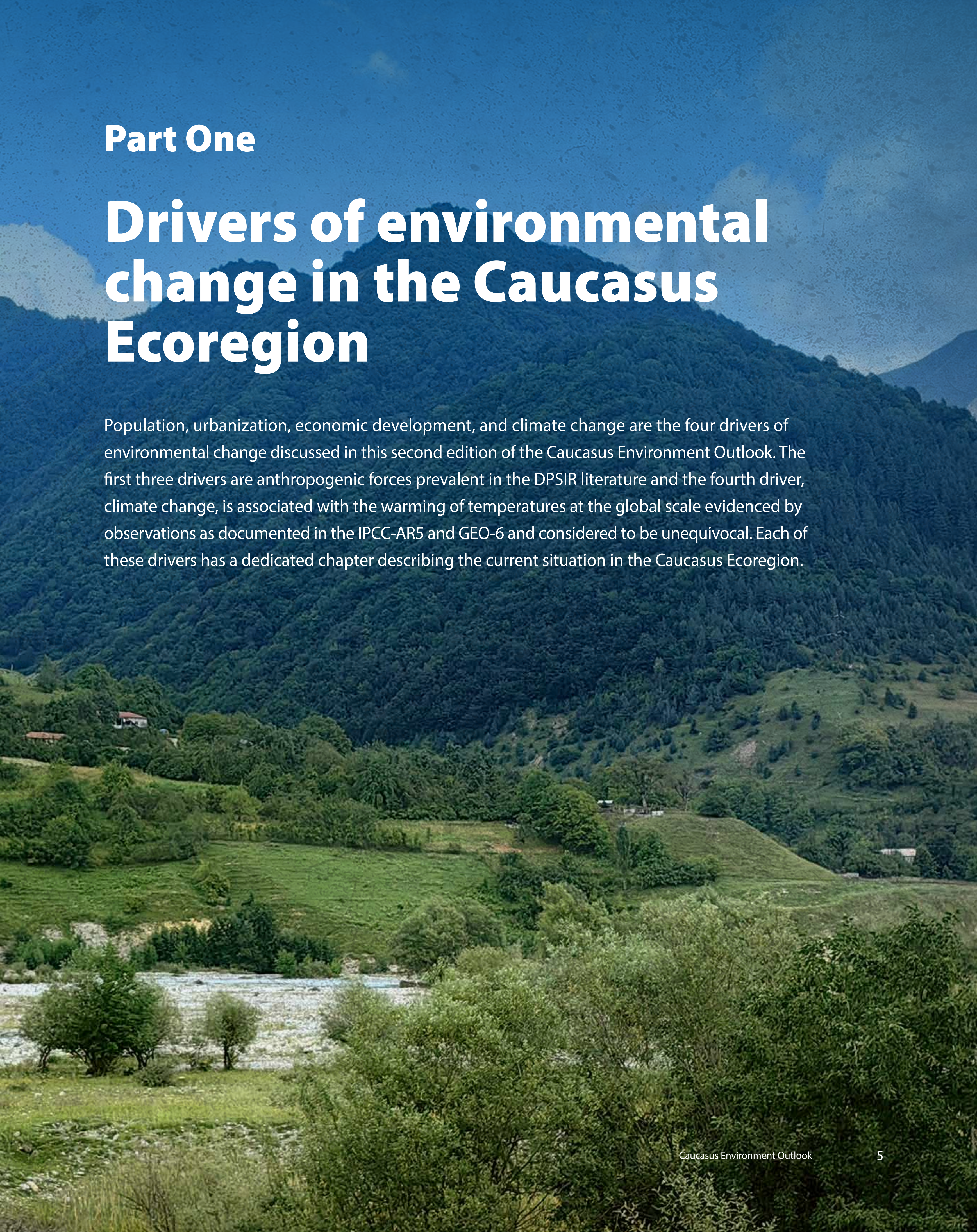


Part One

Drivers of environmental change in the Caucasus Ecoregion

Population, urbanization, economic development, and climate change are the four drivers of environmental change discussed in this second edition of the Caucasus Environment Outlook. The first three drivers are anthropogenic forces prevalent in the DPSIR literature and the fourth driver, climate change, is associated with the warming of temperatures at the global scale evidenced by observations as documented in the IPCC-AR5 and GEO-6 and considered to be unequivocal. Each of these drivers has a dedicated chapter describing the current situation in the Caucasus Ecoregion.

Chapter 1. Population

1.1. Population size

The Caucasus Ecoregion is home to almost 42 million people. Over the last 20 years, population increased by more than 3 million residents for an average annual growth rate of 0.4 per cent. The Caucasus part of the Russian Federation is the most populous area in the Caucasus Ecoregion, followed by Azerbaijan. These two countries also have the fastest population growth rates of the Ecoregion (see Table 1).

Population size is closely correlated with resource use: a greater number of residents means higher consumption and, as a result, population growth places increased strain on natural resources in the long run (UNEP 2019, p. 25).

> *Population growth can affect the environment not only through consumption and use of natural resources, but also through its impact on other factors. This includes the strain it can create on governance, its effects on the probability of conflict over limited resources, and its impact on rapid and unplanned urbanization.*
>
> – Organisation for Economic Co-operation and Development [OECD] 2016, as cited in UNEP 2019, p. 26.

1.2. Population growth and density

Changes in population size are determined by natural increase combined with the effects of migration. Natural increase is the difference between the birth rate (births per 1,000 people) and the death rate (deaths per 1,000 people) and thus shows population change per annum. Azerbaijan as well as the Caucasus parts of the Islamic Republic of Iran and Türkiye have higher natural increases (8 per cent or more) compared with Armenia, Georgia and the Caucasus part of the Russian Federation (less than 5 per cent). The population of the Caucasus part of the Russian Federation is growing faster than other parts of the Caucasus Ecoregion since it is increasing through both migration and natural increase: "the population growth of Russian-speaking subjects is mainly due to the migration influx of the population, while several national subjects are characterized by high natural growth" (Kazalieva *et al*. 2018, p. 89). In Armenia, Georgia and the Caucasus part of Türkiye, outward migration is the main cause of population reduction over the past 20 years.

Diverse trends in population size in the Caucasus Ecoregion are thus evident; some areas are increasing in population and others are decreasing (see Map 2). The mountainous regions of Georgia, Armenia and Türkiye are among those experiencing the greatest depopulation. In contrast, the population of the eastern half of the Ecoregion is primarily increasing, including Azerbaijan, the Islamic Republic of Iran and the autonomous republics of the Russian Federation such as Chechnya, Ingushetia and Dagestan.

Rapid population growth usually produces high population densities, including overpopulation, which continues to be a major underlying force of environmental degradation and a threat to sustainable use of natural resources. High population densities can cause over-exploitation, which reduces the quality and quantity of natural resources through mass construction, intensive farming and land fragmentation (Maja and Ayano 2021).

Table 1. Population by Caucasus countries or parts of countries, 2020

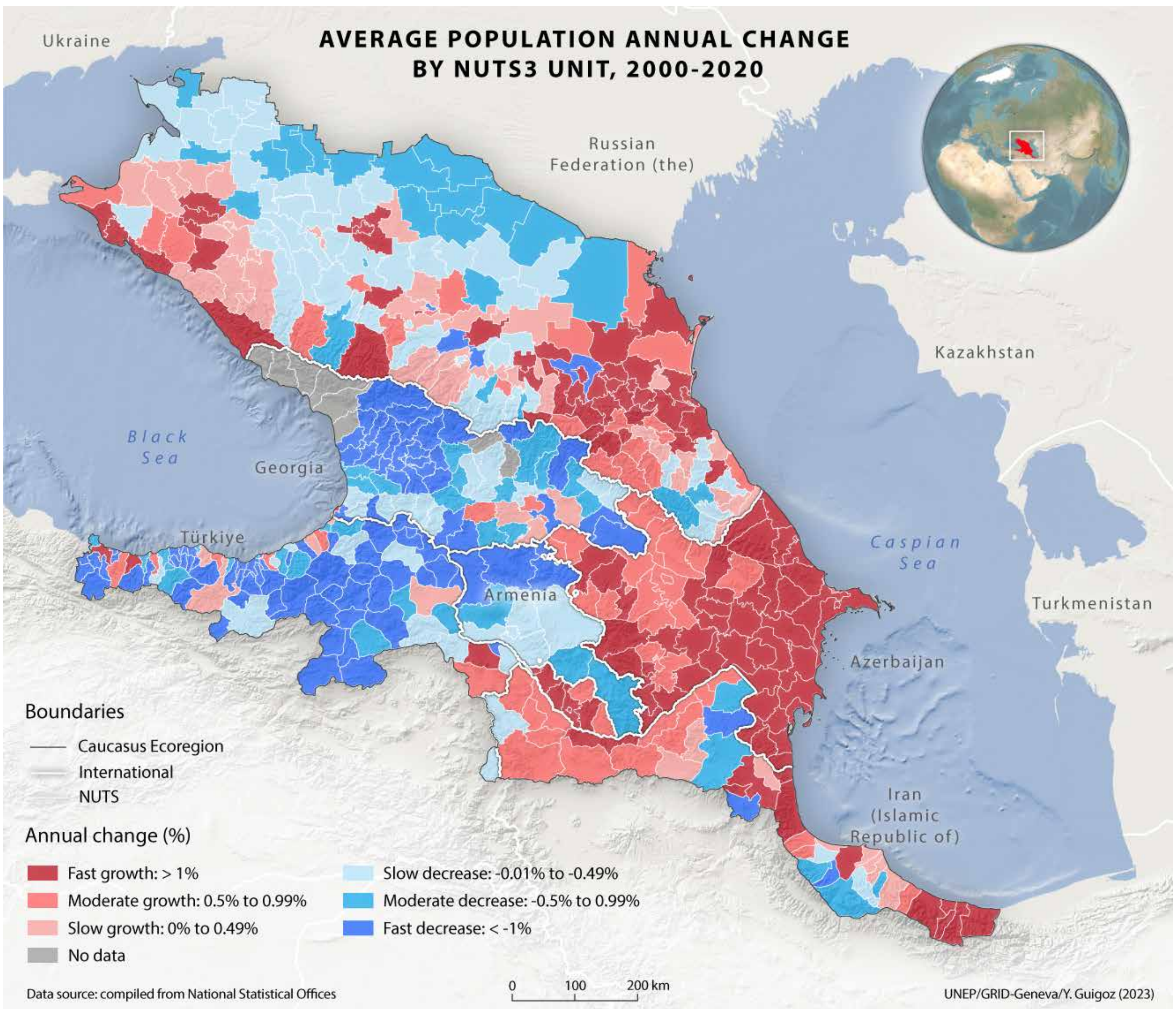
Country/subregion	Population in 2020		Average annual change between 2000–2020 (percentage)
	Population (millions)	Share of the Caucasus Ecoregion (percentage)	
Armenia	3.0	7	–0.44
Azerbaijan	10.1	24	1.00
Georgia	3.7	9	–0.34
Islamic Republic of Iran	5.5	13	0.59
Russian Federation	16.1	39	2.00
Türkiye	3.2	8	–0.63
Total	41.6	100	0.43

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).
Note: The data for the Islamic Republic of Iran, the Russian Federation and Türkiye are for the national level.

The Caucasus Ecoregion is unevenly populated. A few areas with higher population densities are: (i) the territories of large cities and urban agglomerations; (ii) the coastlines of the Black Sea and the Caspian Sea; and (iii) fertile valleys and lowlands of the intermountain depression between the Greater and Lesser Caucasus in Georgia, the Kura-Aras Lowland in Azerbaijan and the Ararat Valley in Armenia (see Map 3). Low-population density, on the other hand, is found in mountainous territories as well as climatically inconvenient deserted lands with low-fertility soils, densely forested landscapes and marshland. Density in such areas might be as low as 10 people per square kilometre.

1.3. Age and sex structure

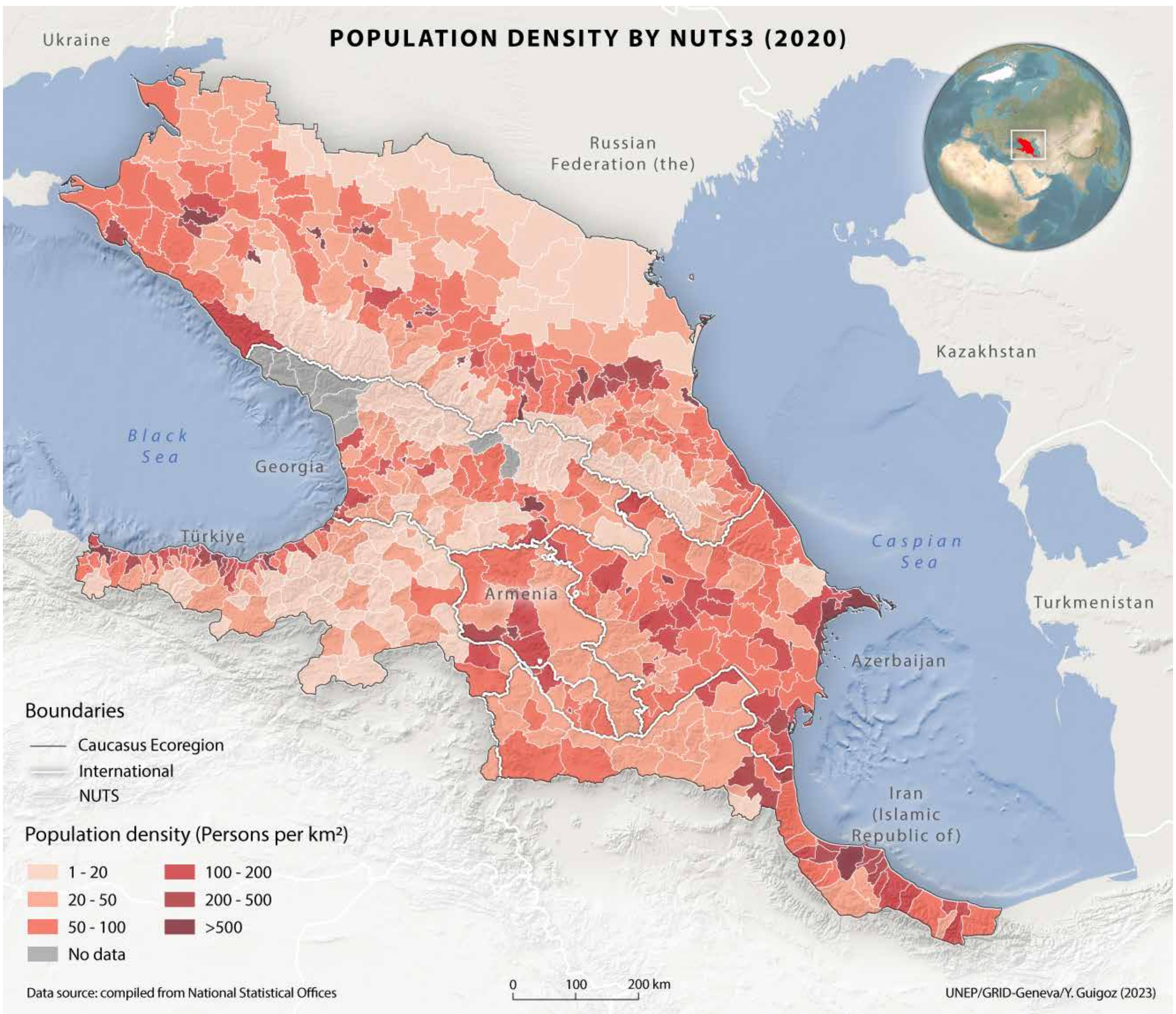
Changes in demographics and population reproduction, particularly lower birth rates, have significantly influenced the age structure of Caucasus countries' populations. During



Map 2. *Population density by NUTS 3, 2020.*

the last two decades, the percentage of children under the age of 15 years has decreased on a national basis in Armenia, Azerbaijan and Georgia, as well as in the Caucasus parts of the Islamic Republic of Iran and Türkiye. The only exception is the Russian Federation. In contrast, the proportion of older persons (over 65 years of age) has increased in all nations (see Table 2).

These structural changes impacted the population dependency ratio, a demographic indicator comparing the number of those who are of working age to those who are not of working age. Over the past 20 years, the dependency ratio increased in Georgia and the Russian Federation (including its Caucasus part), surpassing 50 per cent in both. Furthermore, within the Caucasus part of the Russian Federation in 2020, the share of people who are of working age was substantially less (59.7 per cent) than in the entire country, while the shares of young people and older persons (20.5 per cent and 19.8 per cent respectively) exceeded the national averages. This means that the population dependency ratio in the Caucasus part of the Russian Federation is above 60, the highest in the region. Meanwhile, in the other four countries (Armenia, Azerbaijan, the Islamic Republic of Iran and Türkiye), the dependency ratio decreased to less than 50 by 2020, owing to a substantial reduction of young age groups in their demographic structures. Consequently, Georgia and the Caucasus part of the Russian Federation have a considerably greater economic load on their workforce than other countries, and this burden is growing.



Map 3. *Annual change in average population by NUTS 3, 2000–2020.*

Table 2. Population age groups, dependency ratio, median age, life expectancy and gender balance, 2020

Country	Age groups in 2020 (percentage) (difference between 2000 and 2020)			Dependency ratio 2020	Median age (years) 2020	Life expectancy (years) 2020	Gender balance (female per 100 male) 2020	
	0–14	15–64	65+				Total population	65+ age group
Armenia	20.8 (-5.0)	67.4 (+3.2)	11.8 (+1.8)	48.4	35.4	74.9	112	157
Azerbaijan	23.5 (-7.6)	69.8 (+6.8)	6.7 (+0.8)	43.4	32.3	72.8	101	138
Georgia	20.2 (-0.6)	64.5 (-1.8)	15.3 (+2.4)	55.0	38.3	73.5	108	170
Islamic Republic of Iran	24.7 (-9.3)	68.7 (+7.1)	6.6 (+2.2)	45.6	32.0	76.4	98	96
Russian Federation	18.4 (+.2)	66.1 (-3.4)	15.5 (+3.1)	51.2	39.6	72.3	115	203
Türkiye	23.9 (-6.7)	67.1 (+3.8)	9.0 (+2.9)	49.1	31.6	77.3	102	129

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); World Bank 2021; World Bank 2022.
Note: The data for the Islamic Republic of Iran, the Russian Federation and Türkiye are for the national level.

The last two decades have witnessed an increase of the population's median age in all countries of the Ecoregion. In the Islamic Republic of Iran, median age increased by more than 10 years, which is the highest increase. The median age of the population in all six nations is now above 30 years. Additionally, the Russian Federation and Georgia are closer to the 40-year threshold. Life expectancy in all six countries exceeds 70 years.

The overall gender balance is slightly distorted in favour of the female population in two countries of the Ecoregion (Azerbaijan and Türkiye) and significantly distorted in three others (Armenia, Georgia and the Russian Federation), but not at all distorted for the Islamic Republic of Iran. Furthermore, Armenia, Georgia and the Russian Federation are in the top 20 countries worldwide where women substantially outnumber men (Byrnes 2019). The female population is the most dominant among older persons (over 65 years of age) and the Russian Federation has the most significant imbalance, with 203 females per 100 males in this age group (see Table 2). Armenia and Azerbaijan are among the countries of the world with the highest rates of selective abortion where, respectively, 112 and 109 male infants are born per 100 female infants (United States of America, Central Intelligence Agency [CIA] 2023).

1.4. Social aspects: Inequality and vulnerability

Population growth leads to an unsustainable environmental path because of resulting production and consumption patterns (UNEP 2019). Population expansion combined with limited resource availability frequently results in unequal access to basic goods and amenities for different population groups, which might be seen as a failure of governance, resource control, and sporadic and unplanned urbanization (OECD 2016). Inequality remains one of the most severe threats to long-term environmental development (Chancel and Piketty 2015; Oxfam 2015; UNEP 2019), as unequal distribution of resources necessitates far more extensive efforts to lift people out of poverty than would be required in a more egalitarian distribution (Ravallion 2001; Bourguignon 2003; Bourguignon 2004).

The gendered impact on reproductive health due to rapid urbanization can lead to increased vulnerabilities for women. At the same time, urbanization can benefit women by providing greater economic and social opportunities as well as access to better services (WomenWatch n.d.). As Ravallion (2001) states, based on an analysis of empirical data obtained by different studies in the 1980s–2000s:

> *In the countries where [economic] growth occurred, it tended to be poverty reducing, though more so in low inequality countries and countries that avoided rising inequality with growth. Differences in how much impact a given rate of growth has on poverty reflect initial inequalities in incomes, education attainments and other dimensions, including geographic differences within countries (Ravallion 2001, p. 22).*

Excessive inequality in a society tends to correlate with overconsumption of private and positional goods and fewer public and merit goods (López and Palacios 2014). Furthermore, public and merit goods, founded on economies of scale, involve collective consumption and lower marginal costs per unit consumed and are therefore considerably more efficient than private and positional goods in terms of the environmental footprint of production and consumption (United Nations Economic Commission for Latin America and the Caribbean 2014; UNEP 2019, p. 27). Jorgenson *et al*. (2015) suggest that collective catering, public transport and public parks have the potential to satisfy needs in food, mobility and leisure with a significantly lower environmental footprint than individual food preparation, private cars or an enclosed shopping mall. Yet, high inequality leads precisely to a preference for private goods and services because of fear, fragmentation, status competition and segregation (UNEP 2019, p. 27).

The countries of the Caucasus Ecoregion do not stand out for extreme inequalities. However, they are not the most egalitarian societies either. The Gini coefficient, also called the Gini index or Gini ratio, is a measure of statistical distribution of income or wealth. The Gini coefficient ranges from 0 (0 per cent) to 1 (100 per cent), with 0 representing perfect equality and 1 representing perfect inequality. A higher Gini coefficient thus means greater inequality. For the Caucasus Ecoregion, the Gini indexes vary from 33.7 in Azerbaijan to 34.4 in Armenia, 36.4 in Georgia, 37.5 in the Russian Federation, 40.8 in the Islamic Republic of Iran and 41.9 in Türkiye (World Population Review 2021). Nonetheless, several vulnerable social groups face unequal rights and lack access to essential resources and basic public services in each country.

Refugees and internally displaced people residing in the countries of the Ecoregion (e.g., Armenia, Azerbaijan, Georgia) are characterized by a high degree of vulnerability. They often tend to experience poorer integration into mainstream societies, with unequal access to basic resources and amenities such as housing, communal and social services, employment, etc. People are typically displaced because of ethnopolitical conflicts as well as natural/environmental hazards and catastrophes. In the last 30 years, we estimate that at least 1 million people have been displaced in the Ecoregion due to political and natural factors (Burman 2014; United States of America CIA 2024; United States of America, State Department 2024). Unfortunately, official policies towards displaced people do not suffice to ensure that basic needs are met. Displaced people within compact settlements may be required to engage in practices that are potentially harmful to the environment, aggravating a negative footprint, such as illegal forest-cutting for heating, informal construction for dwellings, and unregulated waste disposal.

Although the constitutions of all Caucasus countries ensure equal rights for both genders, it is unusual throughout the Ecoregion for women, particularly those living in rural areas, to benefit from total inclusivity, equal opportunities and human rights protections. Indeed, quite often, women have restricted access to land and property ownership rights. They continue to confront severe hurdles to achieving education, socialization and access to sexual and reproductive health care (United Nations Population Fund 2018). The example of property rights is well documented. A report of the National Agency of Public Registry of Georgia states that during 2010–2014, more than 1.3 million persons registered their properties (land, flats and buildings). Almost 60 per cent of the total were men and only 40 per cent were women (Georgia National Agency of Public Registry 2022). Women lagged men in all municipalities, especially in rural and mountainous regions, where their share in property registration is less than 20 per cent. Despite the lack of availability of similar data for other Caucasus countries, presumably the situation would not be very different there.

> ***Preserving diversity, including ethnic, religious and linguistic diversity, is important.***
>
> Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

Inequalities between rural and urban regions are considerable, particularly in rapid and uncontrolled urban expansion as discussed in the chapter on urbanization and its environmental consequences (see chapter 2).

1.5. Cultural diversity

Historically, the Caucasus Ecoregion served as a crossroads for various ethnic and cultural groups to meet and interact. Currently, it is home to several dozen ethnic groups, the majority represent the titular nations of the six Caucasus countries, which are members of three different linguistic families. Armenians, Iranians and Russians belong to the Indo-European language family; Azerbaijanis and Turkish to the Altaic language family, and Georgians to the Caucasian language family. This is a complicated mosaic of main ethnic groups and ethnic minorities, particularly on the North Caucasus borders of the Russian Federation and Georgia (see Map 4). In contrast, Armenia is the most ethnically homogeneous country in the area.

Cultural diversity in the Ecoregion extends to the religious composition of the population in addition to the considerable ethnic mosaic. During the Soviet era, the populations of the Soviet republics were primarily non-religious and atheist, in keeping with the beliefs of that era. Almost immediately following the disintegration of the Soviet Union, these same peoples resumed practicing their traditional faiths.

Competing interests in the same natural resources and territorial assets from various communities have always been a concern in places populated by mixed cultural groups. Often, such problems have been resolved peacefully, but when consensus over resource appropriation and management could not be reached, local or even regional conflicts over contested areas would develop. This can create long-term unrest and conflicts that severely impact the environment of conflict regions, resulting in significant deterioration of nature, settlements and the general humanitarian situation in the Ecoregion, especially if they reach a high political level. Such unfortunate circumstances have been observed in several parts of the Caucasus. Obviously, the ethnopolitical conflicts of the Ecoregion, along with geopolitical, strategic and nationalistic disputes, also involve an interest for full control of natural resources in the contested territories.

Map 4. *Distribution of major ethnic groups in the Caucasus Ecoregion.*

Chapter 2. Urbanization

Today, the socioeconomic progress of humankind is closely linked to global urbanization, which means increased urban influence and the spread of urban lifestyles. Densely populated, built-up and infrastructure-abundant urban spaces systematically grow and attract a rising number of individuals seeking better incomes, broader consumption options and improved quality of life. According to the United Nations, urbanization "is closely related to the three dimensions of sustainable development: economic, social, and environmental" (United Nations Department of Economic and Social Affairs [UNDESA] 2019, p. 4). Urbanization has contributed to economic growth, poverty alleviation and human development when properly managed. The fact that all economically prosperous countries are extensively urbanized demonstrates this. At the same time, urbanization has a considerable influence on the environment and natural resources. All countries and regions must plan and regulate urban expansion to ensure sustainable development.

The purpose of this subchapter is twofold: (i) to present the main characteristics of the Caucasus region's urbanization, such as degree of urbanization, hierarchy of cities and territorial growth of urban settlements; and (ii) to reveal how urbanization affects/drives environmental change.

2.1. Degree of urbanization

The degree or level of urbanization is typically expressed as the percentage of the population residing in urban areas (UNDESA 2019, p. iii). The Caucasus Ecoregion has an urbanization rate of around 55 per cent, which broadly equals the average world index. The countries of the Ecoregion fall behind the world's most urbanized and industrialized nations, however. Comparatively, the world's wealthiest countries have an urbanization rate of more than 80 per cent (World Bank n.d.).

On the national level, South Caucasus countries (Armenia, Azerbaijan and Georgia) are less urbanized than the other three Caucasus countries. This disparity is expected to persist in the coming decades (see Table 3). At the same time, the Caucasus parts of the Russian Federation and the Islamic Republic of Iran have lower urbanization rates (52 per cent and 63 per cent in 2020, respectively) than the nations in which they are located.

The Caucasus Ecoregion has highly urbanized territories confined to a few geographical locations and clusters (see Map 5). They are found along the coastlines of the Black

Armenia. *©Hakob Sargsyan*

Table 3. Degree of urbanization and average annual rates of urban population change in Caucasus countries

Country	1990	2018	2030 (projection)	2050 (projection)	Average annual rate (percentage)
Armenia	67	63	66	74	0.2
Azerbaijan	54	56	61	71	1.6
Georgia	55	59	64	73	0.4
Islamic Republic of Iran	56	75	80	86	1.7
Russian Federation	73	74	77	83	0.2
Türkiye	59	75	80	86	2.0

Source: United Nations Department of Economic and Social Affairs Population Division (2019, pp. 23–24.).
Note: National level data for all countries.

Map 5. *Level of urbanization by NUTS 3, 2020.*

Sea and Caspian Sea, inside national capital metropolises and agglomerations, as well as regional administrative and industrial centres. Simultaneously, vast portions of the Ecoregion are still urbanizing, with fewer than half of the population residing in cities and towns.

2.2. Urban hierarchy

Cities with 1 million or more residents are often political and economic powerhouses. They have higher incomes, consumption and economic growth but deplete natural resources. Small cities emit less pollution but are more prone to natural hazards (Birkmann *et al*. 2016).

The Caucasus is predominantly a region of small urban settlements. Only 7 of more than 400 urban settlements have 500,000 or more residents (see Figure 1). The three capital cities of the South Caucasus countries – Baku (2.3 million), Tbilisi (1.2 million) and Yerevan (1.1 million) – are the largest in the Ecoregion. They dominate the Ecoregion's urban hierarchy (see Figure 1). The most populated and fastest-growing city of Baku grew by an average annual rate of 1.14 per cent during the 2010s. Notably, each of these three cities has a population that is larger than the second city in its country by a factor of seven or more. Baku accounts for 43 per cent of the total urban population of Azerbaijan and Yerevan accounts for 57 per cent of the total urban population of Armenia. The three capital cities account for one fifth of the Caucasus' urban population on a regional scale.

Four other significant cities with populations between 500,000 and 1 million are designated as provincial/district centres outside the South Caucasus – in the Russian Federation (Krasnodar and Makhachkala) and the Islamic Republic of Iran (Rasht and Ardabil). Trabzon, the largest Turkish city in the Ecoregion, has fewer than 500,000 inhabitants. Cities with fewer than 500,000 people account for two thirds of the Ecoregion's urban population (see Table 4).

Urban communities of varying sizes exhibit varying population change trends. However, a general pattern can be identified: big cities (500,000 and more) undergo population expansion due to the migration of people from smaller towns and rural areas. Small communities have a weaker economic foundation, fewer job prospects and lower living standards, which are the main reasons for a negative migratory trend. When natural growth does not entirely compensate for outmigration from small towns, population declines occur, like in Armenia and Georgia, and to a lesser extent, the Russian Federation. As a result, big cities continue

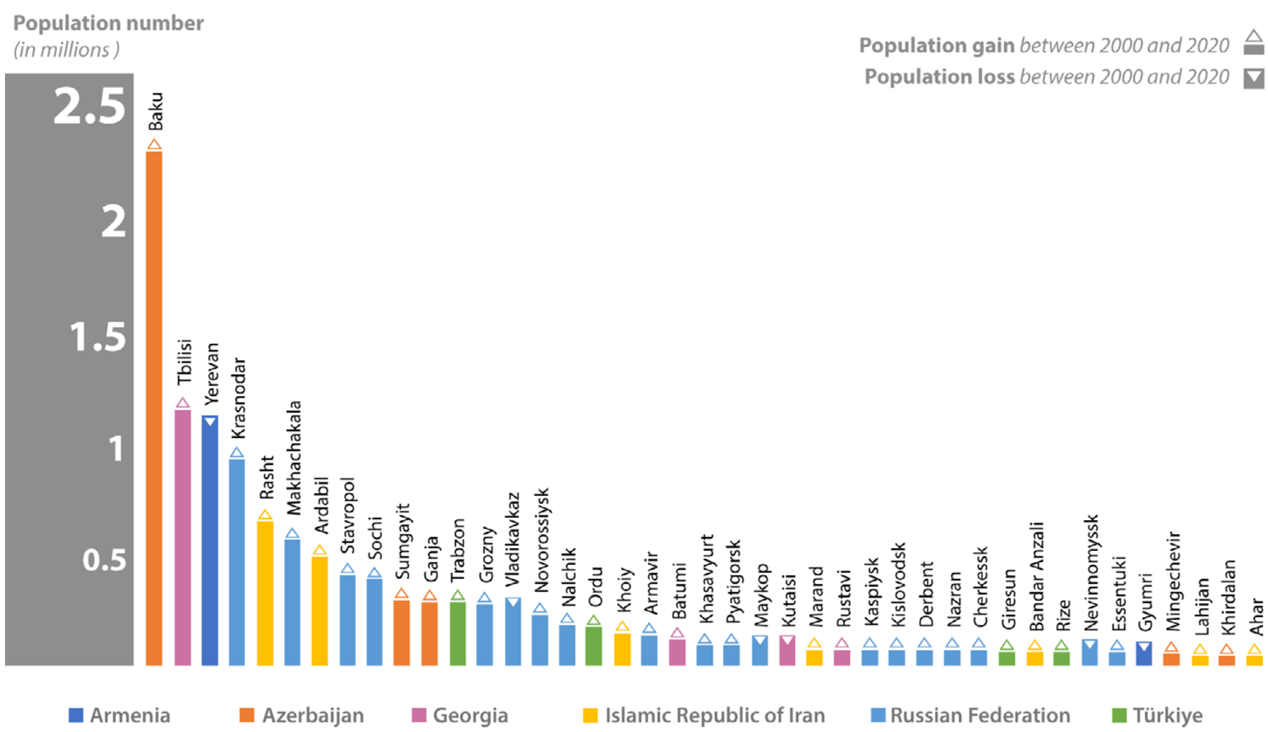


Figure 1. *Hierarchy (size-rank) of large and medium cities of the Caucasus Ecoregion.*

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).

Table 4. Population by city size, 2020

City size	Population (thousands)	Urban population by city size (percentage)
1 million and more	4,549	21
500,000–999,999	2,762	12
100,000–499,999	6,514	29
Less than 100,000	8,407	38
Total	22,232	100

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).
Note: National-level data for all countries.

to grow while many smaller ones shrink. Consequently, in the future, the share of the urban population in the Ecoregion is quite likely to shift in favour of big cities (United Nations Human Settlements Programme [UN-Habitat] 2013; Salukvadze 2019). This means that environmental pressure caused by urbanization is significantly increasing in the areas of the Ecoregion's large cities.

2.3. Territorial growth of cities

In the Caucasus Ecoregion, urbanized areas account for 3 per cent of the total land area (UN-Habitat 2013) and host about 22 million people. The percentage of urbanized areas is in accord with recent global projections (National Aeronautics and Space Administration n.d.). To accommodate population growth, several big cities of the Ecoregion have been expanding their territories as well as the hinterlands of their influence.

Extended urbanized areas accommodate large populations within a contiguous territory inhabited at high-density levels, regardless of administrative borders. Such urbanized territories are called urban agglomerations (UNDESA Population Division 2019) and are regarded as beneficial in terms of economic gains. Mainly, "agglomeration economies reflect the advantage of people clustering to reduce transport costs for goods, people, and ideas. Higher productivity attracts inflows of people, who in turn further increase productivity" (UNEP 2019, p. 32). Agglomeration economies magnify the influence of external productivity variables, boosting urban population and wages (Glaeser and Gottlieb 2009; Zenghelis 2017). However, improperly managed urbanization and agglomeration increase environmental degradation and other potential negative consequences of an expanding number of city inhabitants and enlarged built-up spaces.

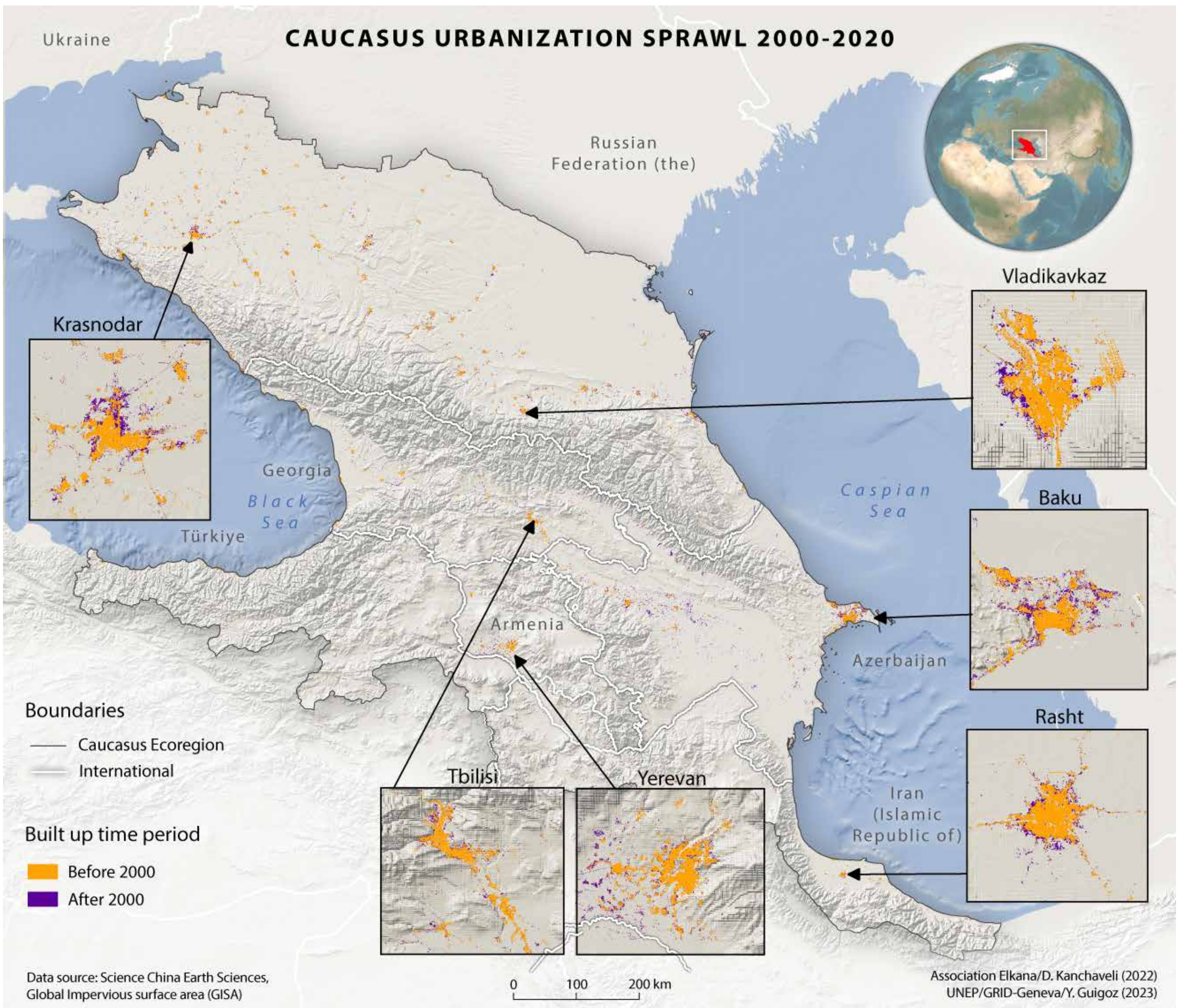
In the last 20 years, we have witnessed the expansion of urbanized territories in the Ecoregion (see Map 6), which has primarily occurred in the metropolitan areas of the Ecoregion's national capitals and big city agglomerations. For example, the jurisdictional area of Tbilisi has increased from 365 to 504 square kilometres since 2007, while the Baku agglomeration has expanded to 7 per cent of the total area of Azerbaijan, primarily on the Absheron Peninsula (now containing about 3 million people and numerous settlements, including Azerbaijan's second-largest city, Sumgait, along with six other satellite urban settlements). The Baku agglomeration comprises 53 per cent of the total urban population of Azerbaijan (Badalov 2020, p. 107).

Urbanization in the Caucasus Ecoregion has been regulated, monitored and institutionalized in recent decades, but not fully incorporated into planned development frameworks. Uncontrolled urban territorial growth usually manifests as sprawling development (Seto *et al*. 2016). Pollution, congestion, urban heat effects, poor health and other costs of economic success are borne through urban sprawl (UNEP 2019, p. 33). In addition to constructing on agricultural land and public open spaces, urban sprawl also produces a significant alteration of land uses, complicates waste management, causes water pollution and soil contamination, and puts a strain on nature and landscapes. As a result, it poses substantial environmental and ecological difficulties.

The emergence of informal settlements typically accompanies urban sprawl. Baku is an illustrative case. People from rural areas have been increasingly moving to Baku in search of employment opportunities for over three decades. They began building houses and installing utilities in Baku's suburbs without official permission. A total of 600,000 individual houses do not have registration: these are homes to more than 2 million people who do not have a residence permit. More than 500,000 of these residents are refugees who live here temporarily (Badalov 2019, p. 31). Informal settlements lack permanent postal addresses and essential facilities such as running water and sewerage, which become difficulties for their residents, requiring urgent reaction and resolution from city authorities (Valiyev 2013). In the meantime, the high-income population groups also started building residences in suburban areas. Due to such suburbanization dynamics, the Baku metropolitan region has grown significantly (Allahveranov, Aliyeva and Sadigov 2012).

The shorelines of the Caspian Sea and the Black Sea have become increasingly urbanized as well, putting pressure on land and marine environments. Population concentration and density increased in the cities of the Russian Federation, the Islamic Republic of Iran and Türkiye, where unplanned urban sprawl occurred along the coasts, which have become scenes of intense settlements. Numerous settlements (e.g., Rize in Türkiye and Makhachkala in the Russian Federation) have expanded their territory along the narrow land strip of the coastline. Rapid unplanned urban sprawl on the Iranian coastlines, with limited and poorly managed basic urban services available, have contributed to the pollution of the coast of the Caspian Sea, extending a threat to both the environment and humans alike (Adaptation Fund 2021, p. 5).

The negative traits of unplanned urbanization, such as urban sprawl and informal settlements, cause serious problems for the population. Often this is expressed as urban poverty, which has the most severe impact on women and girls who suffer the most from poor sanitation, inadequate access to clean water, crime, unemployment, threats of eviction, overcrowding and poor-quality housing (WomenWatch n.d.). Urban women in slums and informal settlements often suffer disproportionately, not only because they are, on average,



Map 6. *Level of urbanization by NUTS 3, 2020.*

more economically challenged than men, but often because they also experience greater difficulty in accessing decision-making opportunities and resources and services tailored to their needs (WomenWatch n.d.).

This is why the major international strategic document for urban development and housing, The New Urban Agenda, aims to "achieve gender equality and the empowerment of all women and girls in order to fully harness their vital contribution to sustainable development" (United Nations Habitat III Secretariat 2017, p. 3). In particular, it calls for developing "sustainable, people-centred, age- and gender-responsive and integrated approaches to urban and territorial development by implementing policies, strategies, capacity development and actions at all levels, based on fundamental drivers of change", such as (i) adoption of inclusive urban policies; (ii) strengthening urban governance; (iii) reinvigorating long-term and integrated urban and territorial planning and design; and (iv) supporting effective, innovative and sustainable financing frameworks and instruments (United Nations Habitat III Secretariat 2017, p. 8).

Increased needs for comfort, housing, and infrastructural and economic facilities induce urban territorial development even when city populations stay stable or decline (Wolf, Haase, and Haase 2018). Thus, the region must plan, monitor and control current urbanization and adopt effective governance techniques to prevent urban sprawl and degradation of the environment and resources.

2.4. Urban environmental challenges

During growing urbanization in the Caucasus Ecoregion, urban centres act as leading edges of increasing consumption per capita, putting pressure on the environment and resources. This makes environmental sustainability one of the Ecoregion's most pressing challenges.

Rapid urbanization, driven by population and economic growth, changes consumption and production. It becomes a driver of several threatening processes in the Ecoregion to be urgently tackled. Consumption of food, water, energy and other goods leads to an increase in per capita consumption. Domestic consumption per capita in Azerbaijan, for example, more than doubled between 2000 and 2015, expanding the material footprint from 5 tons in 2010 to 6.3 tons per capita in 2017 (Azerbaijan, State Statistical Committee of the Republic of Azerbaijan 2021).

Waste management is one of the Ecoregion's most severe environmental challenges, particularly in urban areas, both in large urban agglomerations and in nearby territories. Presumably, the quantity of waste produced per inhabitant per day in the Ecoregion is between 0.5 and 1.5 kg (Kaza *et al*. 2018, p. 19). Waste generation is also increasing because of

> ***Governments should prioritize sustainable urban development, including improving public transportation, promoting green spaces and enhancing energy efficiency in buildings.***
>
> Emil Jabrayilov, researcher, Institute of Geography, Baku, Azerbaijan

urbanization. Except for Baku, the cities in the South Caucasus lack modern waste treatment and recycling facilities. As a result, waste is dumped in landfills, which, on average, do not fulfil minimal sanitary standards. Furthermore, landfills near bodies of water, such as Neftchala in Azerbaijan, leach toxic components into the water, causing severe environmental damage (UN-Habitat 2013, pp. 227–228). Some areas of the metropolitan coastline of the Caspian Sea in Azerbaijan, the Islamic Republic of Iran and the Russian Federation have devolved into de facto garbage dumps.

The region's industrial sector often endangers the environment and sustainability. Oil spills into water sources continue to damage wildlife and fish in the densely populated, oil-rich and economically thriving Absheron Peninsula of Azerbaijan, which accounts for more than 95 per cent of the gross industrial output and 20–30 per cent of the country's agricultural output. All oil production and processing as well as natural gas production, 100 per cent of each, more than 90 per cent of electricity production, 97 per cent of the chemical industry and 95 per cent of various types of engineering products are in this Ecoregion due to great demand. Light and food industries are highly developed here. In general, almost 90 per cent of the economic potential of the country is concentrated in this Ecoregion, especially in the cities of Baku and Sumgayit (Eminov 2010). As a result, thousands of hectares of soil are contaminated and unusable for agriculture (UN-Habitat 2013, p. 228).

The situation is not very different in the Caspian coastline oilfields of the Islamic Republic of Iran and the Russian Federation. The most significant impacts of rapid and sometimes unplanned urbanization along the Caspian Sea coastlines, driven by amplified economic development and higher levels of consumption, are resulting in urban heat islands. Further critical impacts are the loss or degradation of cropland, the reduction of biodiversity, and desertification as well as rapid land resource consumption related to agricultural land loss due to urban sprawl (Adaptation Fund 2021, p. 6).

Thermal plants, petrochemical plants, oil refineries, aluminium smelters and cement factories in Baku and Sumgayit, Azerbaijan; metallurgical plants in Rustavi and Zestafoni, Georgia; and the Alaverdi copper smelting plant in Armenia, all contribute significantly to nitrogen dioxide, sulphur dioxide and unburned carbon pollution. Elevated levels of a wide range of hazardous air pollutants endanger human health in the respective cities (UN-Habitat 2013).

Vasil Barnovi street in Tbilisi, Georgia. *©iStock/VvoeVale*

The mining quarries of Chiatura, Tkibuli and Kazreti in Georgia, Alaverdi and Syunik in Armenia, Murgul in Türkiye (now closed), and others, damage groundwater and rivers significantly. River pollution is commonly transboundary since major rivers like the Kura in Türkiye and Georgia as well as the Aras in Armenia transport polluted waters to neighbouring Azerbaijan (Shirinov 2017).

Commercial agriculture, such as tea and citrus cultivation as well as domestic, sometimes informal, economic activities pollute Turkish water bodies heavily. Pollution of rivers flowing into the Black Sea is caused by urban and rural communities and scattered industrial plants. Due to livelihood practices and agricultural activities, intense soil erosion is observed in those areas.

Larger cities and more inhabitants imply more vehicles, which are a major cause of pollution. Transport is the leading source of outdoor air pollution in Armenia, contributing 51.5 per cent of total pollution (Asian Development Bank 2019, p. 26). The same factor causes up to 80 per cent of air pollution in Tbilisi, Georgia (UN-Habitat 2013). Similarly, the Black Sea Coast highway of Türkiye is responsible for most of the air pollution in that area.

Urban governance, which is focused on modernization through constructing new infrastructure and buildings, attracting more capital and improving the image and reputation of the Ecoregion's cities via branding, is often ignorant of environmental issues. For instance, in the last decade, notable mega events including the 2014 Winter Olympics in Sochi, the 2015 European Games and the Formula 1 Azerbaijan Grand Prix (since 2017) in Baku, and the 2015 European Youth Summer Olympic Festival in Tbilisi have contributed to urban territorial expansion. The hosting cities became foregrounds of large-scale infrastructural building and redevelopment activities, placing hundreds of hectares of new land under construction. New developments often took place along with the suspension of the conventional regulatory framework of governance. As in the case of Sochi, restrictions were ignored throughout building and development, putting natural ecosystems, valuable landscapes and other environmental components at risk (Golubchikov 2017).

We acknowledge that the current state of urbanization and city governance in the Caucasus Ecoregion is not fully in line with the directives of the United Nations regarding securing a greener urban future. The recent World Cities Report by the United Nations (UN-Habitat 2022) clearly states that "inclusive spaces to deliver green urban futures are necessary for sustainability transitions" (UN-Habitat 2022, p. xxii). Consequently, the Ecoregion's urbanization with significant infrastructure and transport projects should not be accomplished at the expense of various social groups in urban areas to avoid entrenching existing inequalities and vulnerabilities.

> ***Development of engineering, transportation and sanitation infrastructure is necessary to maintain the quality of life for the population.***
>
> Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

Chapter 3. Economic development

3.1. Development level, poverty and economic structure

The economies of the Caucasus countries have seen many developments in socioeconomic and environmental conditions over the past 24 years since the production of the first edition of the Caucasus Environment Outlook (UNEP 2002). The United Nations classifies countries of the Caucasus as developing countries and countries in transition (United Nations Trade and Development 2020). World Bank classification places Armenia, Azerbaijan, Georgia, the Russian Federation and Türkiye as upper-middle income and the Islamic Republic of Iran as lower-middle income (World Bank n.d.). However, all upper-middle income countries and regions of the Caucasus, which have from US$4,096 to US$12,695 gross domestic product (GDP) per capita are in the lower quartile of this category. The GDP per capita figures for the respective countries of the Caucasus or the value composite for the regions show that since 2004, the economic situation in each country has improved (see Figure 2). There were certain declines related to the 2008 world financial crises and the regional depreciation of national currencies against the United States dollar since 2014 in relation to the decrease in international oil prices. Despite the decrease of GDP per capita since 2014 in dollar terms, most of the countries in the region (except the Islamic Republic of Iran and the Russian Federation) still had mild economic growth in their respective national currencies. The next economic shock was the 2020 COVID-19 pandemic, which limited economic activity in all countries and caused a substantial increase in inflation. However, all countries managed to rebound shortly after the end of the pandemic. Another important impact on the economies of the Caucasus countries was from the Russian invasion of Ukraine in February 2022, which created substantial migrant, investment and foreign currency inflows to Armenia, Azerbaijan and Georgia, substantially influencing economic growth.

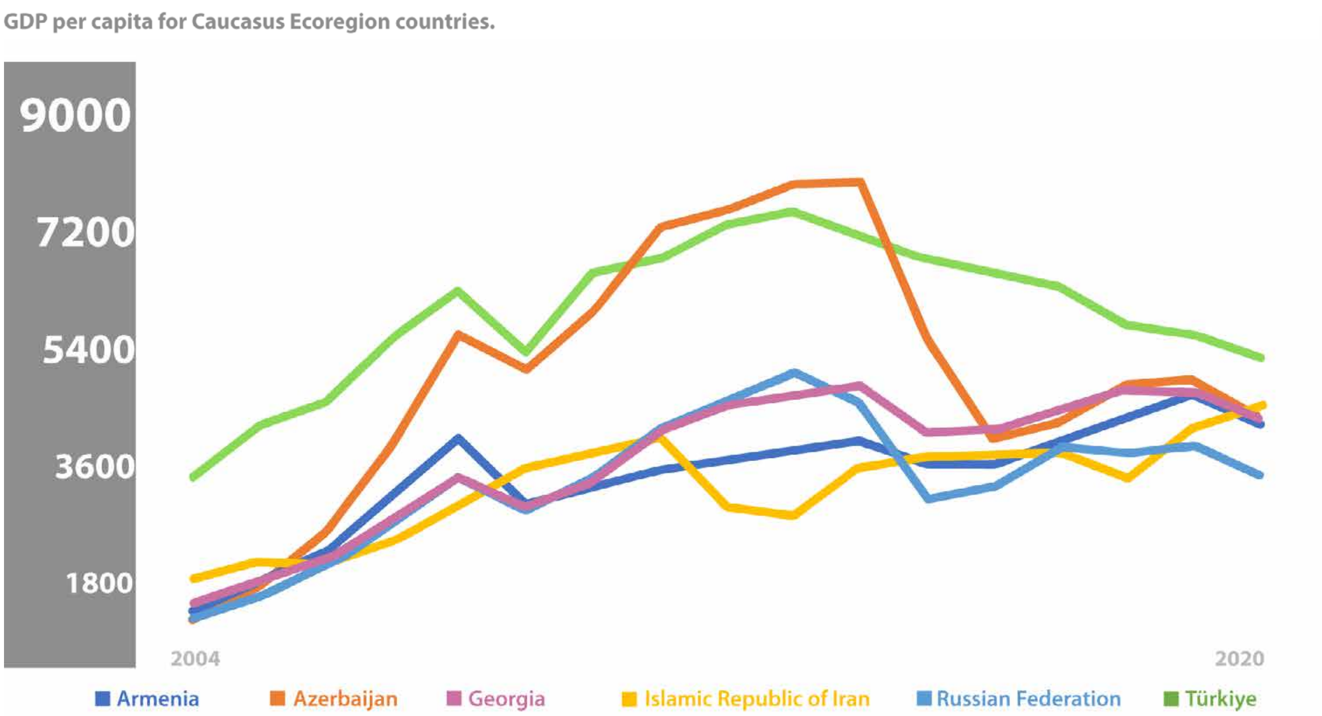


Figure 2. *GDP per capita for Caucasus countries (in United States dollars).*

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).
Note: For the Islamic Republic of Iran, the Russian Federation and Türkiye, the average GDP per capita across the region is used in the figure. Furthermore, in the Islamic Republic of Iran, the GDP per capita value for 2018–2020 was estimated using the average GDP per capita growth rate from the IMF World Economic Outlook, since otherwise the last available value of regional GDP per capita was for 2017. In addition, GDP per capita values for the Islamic Republic of Iran represent the Iranian year, which starts on 21 March and ends on 20 March of the Gregorian calendar. For the Russian Federation, GDP per capita values are not available, rather there is gross regional product per capita, which is a similar indicator.

3.2. Employment

The relatively low levels of GDP per capita are also reflected in unemployment levels during the past 10 years (see Figure 3). Based on 2019 data, the highest unemployment levels are in Armenia and Georgia (18 per cent in both countries). The unemployment level in 2019 was relatively low in Azerbaijan at 5 per cent, while 2019 unemployment levels in Türkiye, the Russian Federation and the Islamic Republic of Iran were 13 per cent, 9 per cent and 10 per cent respectively. However, these figures should be interpreted with caution, as the methodology for calculating unemployment rates can differ across countries. Interestingly, over the past 10 years, the unemployment rate has decreased the most in Georgia. This could be explained by relatively high economic growth compared with other countries in the region. Another reason for the decrease in unemployment in Georgia could also be related to the growth in tourism, which is a labour-intensive sector.

3.3. Poverty

Along with unemployment, relatively high poverty levels are an important challenge in the Caucasus region. After the 1990s, accompanied with local conflicts across the Caucasus region, a large proportion of the populations of Armenia and Georgia were living below nationally defined poverty levels (54 per cent and 36 per cent respectively). Over the past two decades, absolute poverty levels have substantially decreased in both countries to 26 per cent and 20 per cent respectively (see Figure 4). However, poverty levels are still significant and will remain a major economic challenge for both countries.

Addressing Sustainable Development Goal (SDG) 1 to "end poverty in all its forms everywhere", Armenia is using various targeted social assistance programmes, including a gradual increase in childbirth benefits, supporting non-competitive people on the labour market (especially in the agriculture sector) and setting the value of the minimum pension equivalent to the extreme poverty line (Government of Armenia 2020). Similarly, Georgia uses a targeted social assistance programme to address poverty, and as of 2020, approximately 12 per cent of the population were beneficiaries of the programme. Furthermore, agricultural subsidies targeting low productivity in the regions of the country with the highest poverty levels are also contributing to meeting the targets underlined under SDG 1 (Government of Georgia 2020). Looking at past data, absolute poverty was very high in Azerbaijan as well. However, after an increase

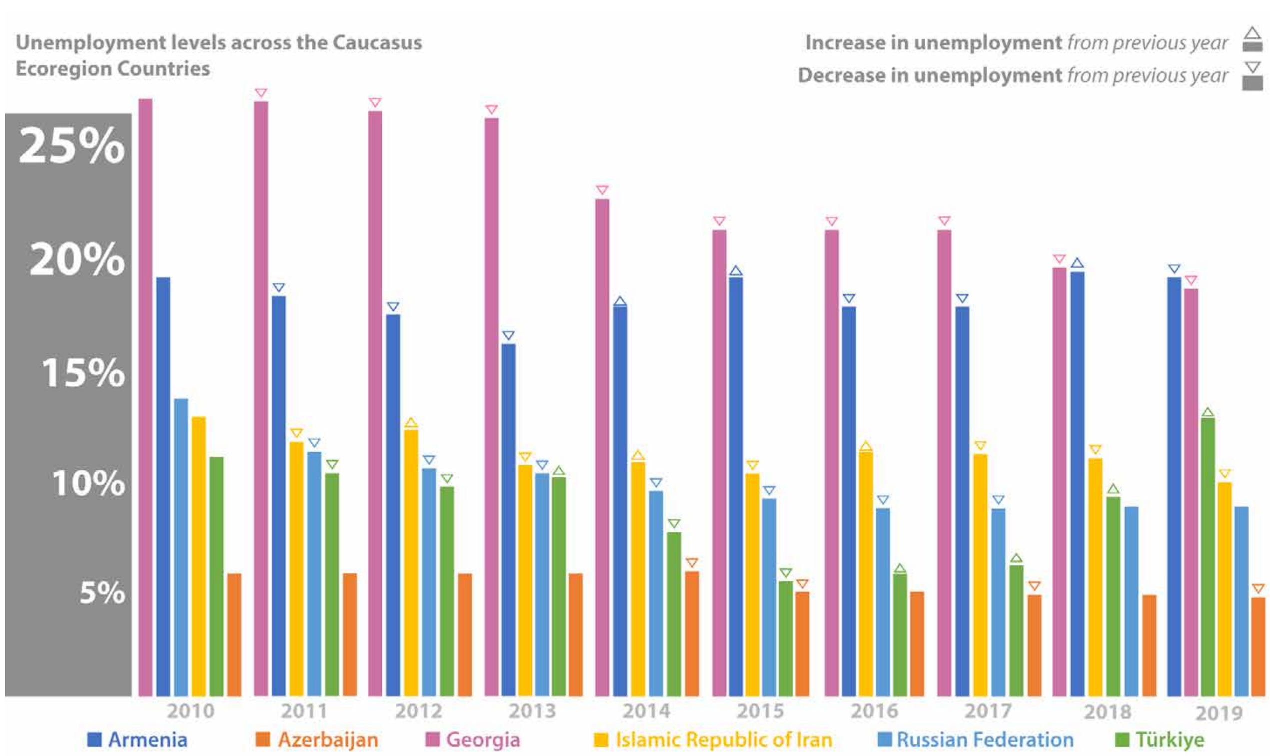


Figure 3. *Unemployment levels across the Caucasus region.*

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).
Note: Aggregating unemployment levels in the Caucasus parts of the Islamic Republic of Iran and the Russian Federation and Türkiye was done by calculating the weighted average of unemployment levels in the respective regions. The population of each region was used as the weight for each country. Furthermore, in Azerbaijan, unemployment data are only continuously available from 2015, while the statistics office also presented data for 2005 and 2010.

Population below the poverty level in the South Caucasus

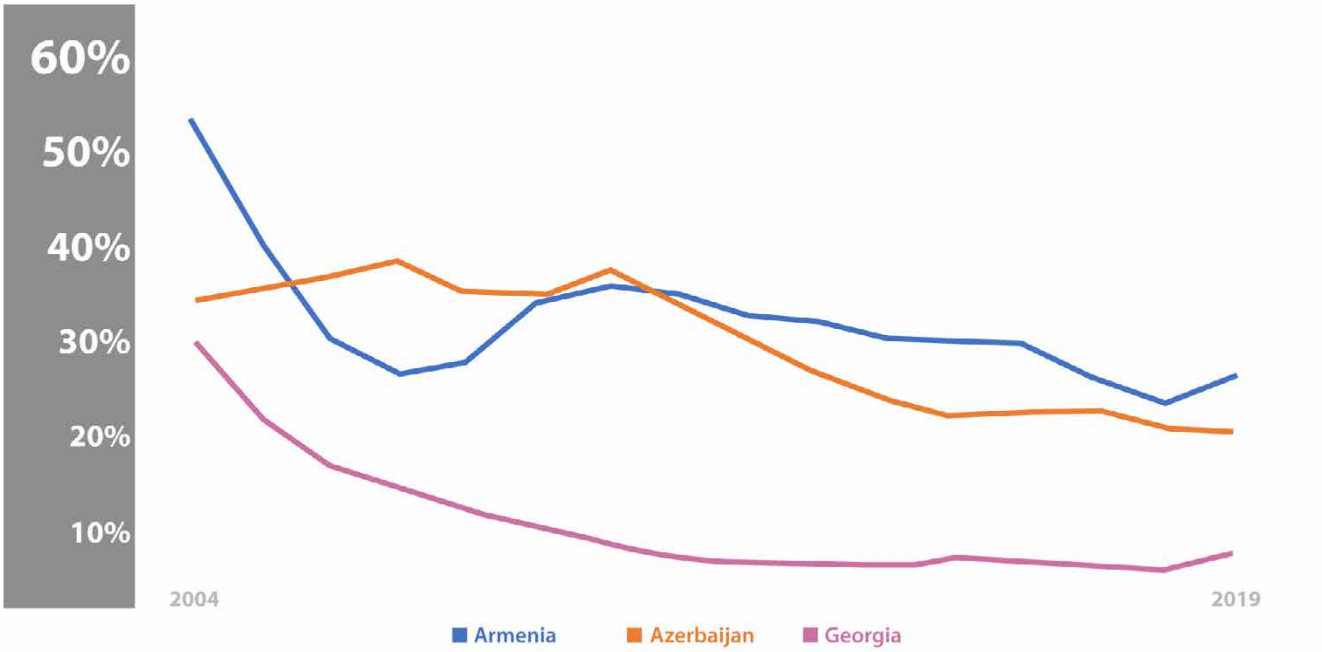


Figure 4. *Population below the poverty level in the South Caucasus.*

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).

Note: Data on the population living below the absolute poverty level is not available for the Russian Federation and the Islamic Republic of Iran.

in oil and gas incomes since the opening of the Baku-Tbilisi-Ceyhan and South Caucasus pipelines, the country managed to substantially decrease its poverty levels from 29 per cent to 6 per cent of the population in 2019. Azerbaijan also implemented "the state program for poverty reduction and sustainable development in the Republic of Azerbaijan in 2008–2015", which contributed to a drastic reduction in poverty (Government of Azerbaijan 2019). Poverty levels in the Caucasus provinces of Türkiye are also relatively low, with around 6 per cent of the population living below the national absolute poverty level. Between 2000 and 2018, Türkiye restructured its social protection systems and plans to further improve targeting of social assistance (Government of Türkiye 2019). Lastly, to address poverty challenges, the Russian Federation is providing targeted support of lower-income families with children, expanding support based on needs assessments, and registering low-income families in need of state assistance (Government of the Russian Federation 2020). A decade of low economic growth along with high inflation caused Iranian households to face a decrease in welfare in the 2010s. The main reasons for the increase in poverty in the economy of the Islamic Republic of Iran are low economic growth, high inflation and the lack of employment in accordance with the needs of the economy. In this regard, different governments in the Islamic Republic of Iran have implemented programmes to deal with poverty in the field of universal insurance coverage, providing housing for all people and even cash payments to economically weak groups.

3.4. Structures of economies

The Caucasus region economies have diverse levels of resource availability and development. The pre-pandemic shares of different economic sectors in the GDP of Caucasus countries and regions in 2019 shows that the largest sector in most of the economies is the service sector, which includes both private and public services (see Figure 6). The service sector of Georgia contributes around 61 per cent of its GDP, which includes development of trade routes, related transportation, and storage and repair services. Furthermore, the North Caucasus parts of the Russian Federation have a similarly large service sector making up to 67 per cent of the economy.

The service sector is not the largest sector of the economy in Azerbaijan. This is due to a greater presence of industry, including oil and gas extraction activities, which accounted for 37 per cent of the economy in 2019. Industry is the second largest sector in Armenia and Georgia including relatively larger shares of manufacturing and a smaller mining sector. This is similar to the Caucasus parts of the Russian Federation and the Islamic Republic of Iran.

In the Caucasus parts of Türkiye, agriculture- and forestry-related activities are the second largest sectors of the economy, with approximately 17 per cent of GDP from agriculture. Agriculture and forestry comprise relatively large shares of the Armenian economy, and the same is true for the Russian Federation and the Islamic Republic of Iran, in which it is estimated to account for 17 per cent of the economy (see section 5.4.1). Such a large share for agriculture is indicative of low levels of industrialization in the Caucasus parts of Türkiye and the Islamic Republic of Iran. Furthermore, this sector is highly exposed to environmental changes and to decreases in freshwater levels. Climate change could thus directly influence these economies. On the other hand, a substitution of agriculture by industry may decrease the supply of food and agricultural input to other sectors and increase the risk of negative externalities induced by production of goods, impacting the livelihoods of women farmers and people in vulnerable situations as they predominantly depend on agriculture (UNEP 2010; UNEP 2021).

Lastly, the construction sector is an important part of the economy in Armenia, Azerbaijan and Georgia, as well as the Caucasus part of the Russian Federation. The sector represents roughly 7 per cent of the economy in all three countries and 8 per cent in gross regional product (GRP) in the Caucasus part of the Russian Federation. The construction sector is particularly large in the Dagestan, Ingush, Chechen and Kabardino-Balkarian Republics, representing between 11 and 16 per cent of the GRP. The analysis of data from 2005 for each country in the Caucasus Ecoregion shows that the relative sizes of the sectors compared with the total economy have not changed substantially. Thus, analysis of 2019 data is relevant for understanding the structure of economies of the past two decades.

Current levels of GDP per capita, unemployment and poverty show that countries in the Caucasus Ecoregion have substantially developed over the past two decades. However, income levels in the Caucasus Ecoregion are still such that environmental pollution from economic development is expected to further increase before decreasing. This trend is likely to follow the Environmental Kuznets Curve, an inverted U-shaped relationship underlining that before reaching a certain threshold, low-income countries are expected to increase pollution, after which a decrease in environmental footprint takes place.

The COVID-19 pandemic, which began in early 2020, had a substantial negative impact on economic development throughout the Caucasus. However, a relatively fast recovery was expected from 2022 onwards. The International Monetary Fund (IMF) estimates GDP growth rates of 5–6 per cent in Armenia and Georgia and around 2 per cent in Azerbaijan

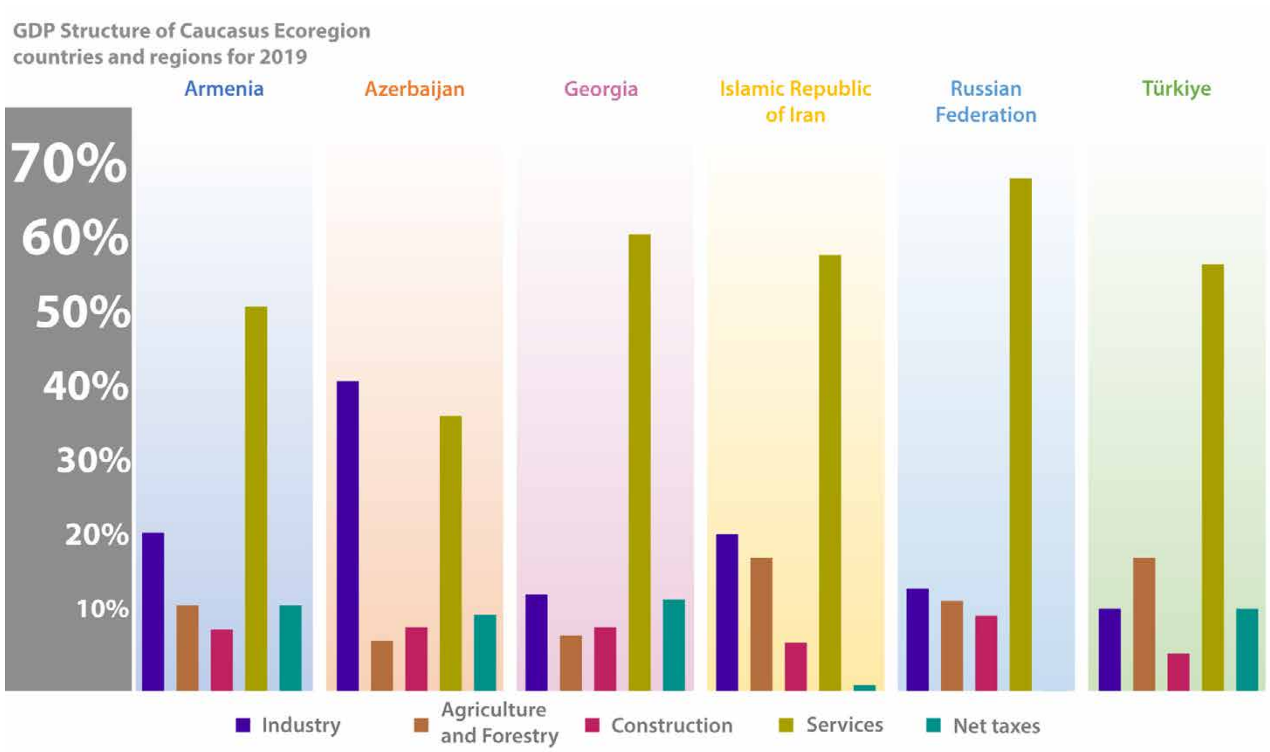


Figure 5. *GDP structure of Caucasus countries and regions, 2019.*

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); The Statistical Centre of Iran (n.d.); Federal State Statistics Service of the Russian Federation (n.d.) and the Turkish Statistical Institute (n.d.).
Note: National level data.

between 2022 and 2026 (IMF n.d.). The economy is also expected to grow up to 4 per cent in Türkiye. As for the Islamic Republic of Iran and the Russian Federation, economic growth will be relatively low with around 2 per cent per annum over the same period.

Mild economic development forecasts and past trends create an expectation that overall, the structure of the economies in the Caucasus region will not change substantially. However, it can be expected that environmental pollution from economic activities will grow if no appropriate countermeasures are taken (e.g. regulatory frameworks, support for technological leapfrogging). With varied success, there have been several initiatives implemented to leapfrog production modes and technologies. In particular, the European Neighbourhood Programme for Agriculture and Rural Development (ENPARD) established exchanges between Georgian local action groups (working on the European Union LEADER principles)[4] and European groups, safeguarding innovation transfer in production techniques (e.g. food processing and other productions along the value-added chain of agricultural produce as related to the circular economy) and service provision such as sustainable tourism (European Union Common Agricultural Policy Network n.d.). Similar initiatives have been implemented in Armenia with funding from the Austrian Development Agency (ADA), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Swiss Agency for Development and Cooperation (SDC).

> ***My hopes for the Caucasus Ecoregion in 2030–2050 focus on the economy, including the creative industries, sustainable tourism and agriculture. The importance of sustainable tourism and agriculture will increase. Sustainable tourism and agriculture will have an important part in economic development. Technological transfer studies will be supported more than ever. Adaptation measures for the protection of ecological tourism areas will be even more necessary if they remain insufficient for much longer.***
>
> Nuray Çaltı, independent researcher and youth trainer, Türkiye

[4] The European Union "LEADER" approach dates to the early 1990s when it was created to improve the effectiveness of previously unidirectional, top-down, development policies in rural areas, it is the acronym for the French title: Liaison Entre Actions de Développement de l'Économie Rurale" which can be translated as: "Links among development activities of the rural economy".

Wheat fields in Türkiye. ©iStock/okeyphotos

3.5. Energy

The energy sector has one of the largest environmental footprints in the Caucasus region, especially considering the large size of the service sector in most of the economies. The Caucasus region has diverse energy sources, and several countries have a large endowment of oil resources, such as Azerbaijan, the Russian Federation (with oil resources of the Republic of Chechnya) and the Islamic Republic of Iran. Armenia, Georgia and the Caucasus parts of Türkiye are primarily dependent on imports of fossil fuels. However, they are well endowed with renewable resources, in particular solar energy potential in Armenia and hydropower potential in Georgia and the Caucasus parts of Türkiye.

In the following paragraphs, the national energy balances of Armenia, Azerbaijan and Georgia based on International Energy Agency statistics (IEA 2019) are analysed and predictions for future developments are made (see Figure 6). None of the Caucasus countries provide an energy balance on the regional level: most countries have one energy system, and it is very hard to track energy flows across regions (unlike energy trade flows among countries). Consequently, the Caucasus parts of the Russian Federation, Türkiye and the Islamic Republic of Iran are excluded from the analysis of energy balances since these are sub-national areas.

The total primary energy supply (TPES) of the three South Caucasus countries shows the share of different energy source. The TPES of Armenia is 142,370 terajoules (TJ), where 63 per cent comes from natural gas and 9 per cent comes from renewable energy consisting of hydropower, biofuels and waste. Other fuels constitute 17 per cent of the TPES including nuclear power generation in Armenia, which is an important part of their TPES. The Georgian TPES is larger than that of Armenia at 213,570 TJ in 2019. The Georgian TPES also has a large share of natural gas at roughly 45 per cent. Due to substantial hydropower generation, the renewable energy share of the TPES is 20 per cent in Georgia. However, the share of renewable energy is a bit inflated, since up to 5 per cent of the TPES consists of biofuels and biomass from using firewood for heating purposes in different regions of the country. Considering that this firewood is not produced with sustainable forestry practices, counting it as a renewable energy resource could be misleading (Government of Georgia 2020).

The TPES of Azerbaijan is substantially larger compared with both of its neighbouring countries with a total of 667,213 TJ in 2019. This consists of a large share of crude oil and natural gas supply accounting for 33 per cent and 65 per cent respectively. Renewable energy is thus negligible at below 2 per cent of the TPES for Azerbaijan, therefore not moving towards meeting Sustainable Development Goal 7 for affordable and clean

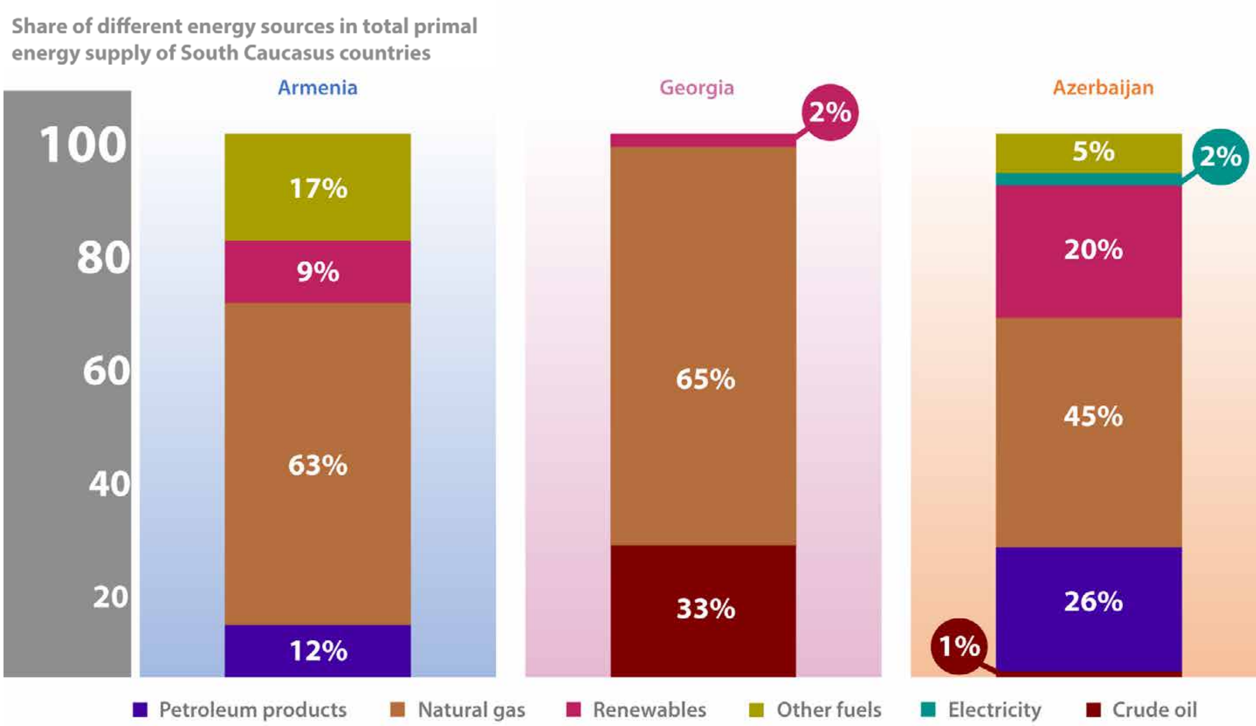


Figure 6. *Energy sources in total primary energy supply of Caucasus countries.*

Sources: International Energy Agency (2019).

Note: The 0 per cent for electricity in the TPES for Armenia and Azerbaijan represents the fact that the countries are not net importers, thus electricity trade does not represent a part of primary energy supply.

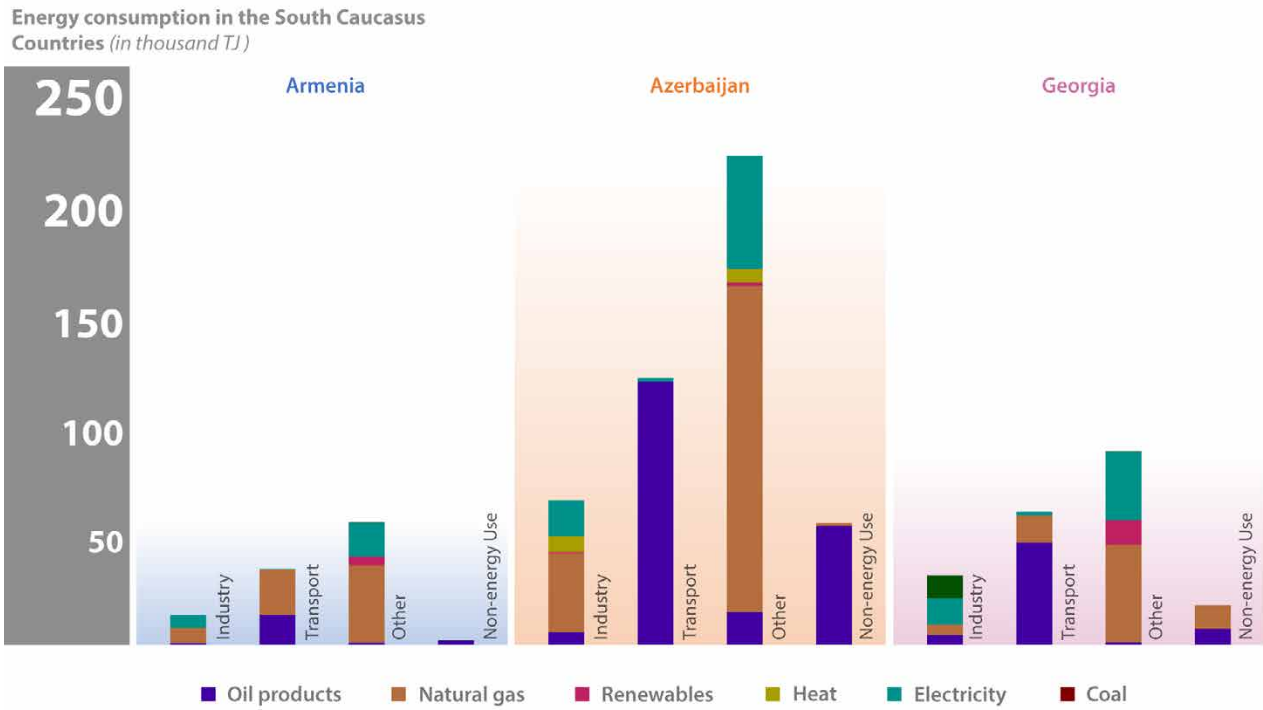


Figure 7. *Consumption of energy resources by economic sectors.*

Sources: International Energy Agency (2019)

energy. Azerbaijan has a large consumption of petroleum products, but net exports are also removed from the TPES total share of crude oil to avoid double counting. The primary use of renewable energy in Azerbaijan is in electricity generation, which is around 8 per cent in the TPES, consisting of hydropower, solar power, wind power and waste incineration. Most Caucasus countries started producing an energy balance as of 2014 (except for Azerbaijan, where the time series from 2007 are available). Over these years, the composition of the TPES has not changed considerably.

Information about the consumption patterns of different energy resources is important to better understand the environmental impacts from different sectors of the economy (see Figure 7). Total energy consumption in Armenia amounted to 102,837 TJ, and the largest energy users in the country are households as well as commercial and public services, consuming nearly 52 per cent of total energy use. The transportation sector is another important user of energy with 33 per cent of total consumption. The residential, commercial and public service sector primarily consumes natural gas (63 per cent of total consumption of the sector) and electricity (28 per cent of total consumption of the sector).

In Georgia, the total energy consumption accounted for 192,246 TJ in 2019. Most of this energy was consumed by households and the service sector of the economy. For heating, 51 per cent of the energy stems from natural gas and 35 per cent from electricity. Furthermore, as explained earlier, firewood, a renewable, is primarily consumed in the household sector, which is an important challenge for Georgia's forestry sector. The transportation sector uses a substantial amount of natural gas with around 17 per cent of consumption. This is due to a substantial car fleet operating on compressed or liquified natural gas. Due to the lack of railroad development, Georgia has a relatively small consumption of electricity in the transportation sector at only 3 per cent of the total consumption. Lastly, it is noteworthy that 33 per cent of energy consumed in industry originates from other fuel products, primarily coal in the case of Georgia, which is used in iron and steel production as well as the non-metallic minerals industry.

Energy consumption in Azerbaijan is substantially higher at 452,022 TJ. Industry, along with the household and service sector, are primarily dependent on natural gas (55 per cent and 67 per cent respectively). Transportation and non-energy applications (such as use of oil as a lubricant for mechanical processes) use petroleum products for most of their needs with roughly 99 per cent for each of these sectors. Azerbaijan also relies on heat plants operating on natural gas, primarily in the petrochemical industry but in households as well.

The relative environmental footprint of the energy sectors of Armenia, Azerbaijan and Georgia is evident in the data on tons of carbon dioxide (CO_2) emissions per TJ of energy

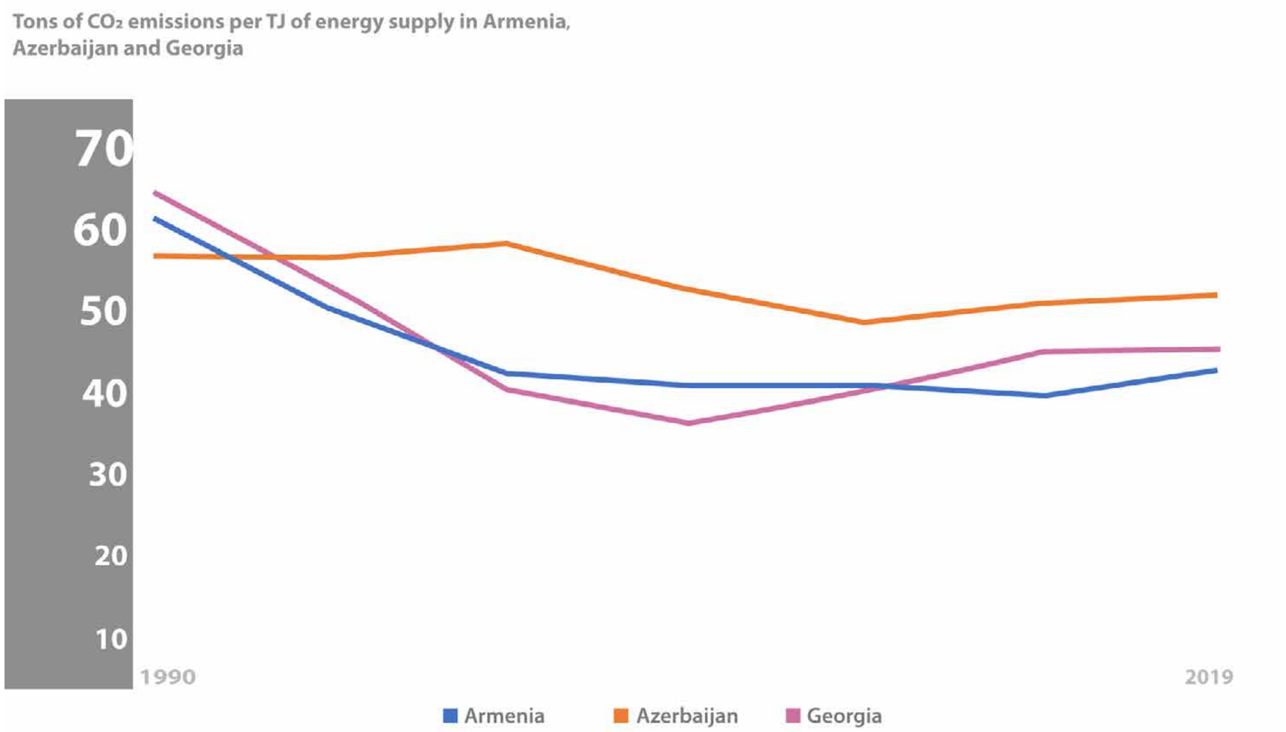


***Figure 8.** CO_2 emissions from the energy supply in Armenia, Azerbaijan and Georgia (1990 base year).*

Sources: International Energy Agency (1990, 1995, 2000, 2005, 2010, 2015, 2019).

Note: The 0 per cent for electricity in the TPES for Armenia and Azerbaijan represents the fact that the countries are not net importers, thus electricity trade does not represent a part of primary energy supply.

supply in each country (see Figure 8). Azerbaijan emits a substantially larger amount of CO2 per TJ of energy supply compared with Georgia and Armenia. Although the renewable energy share in Georgia is larger than its neighbours, tons of CO2 emissions per TJ is greater than Armenia. The major reason for this is the large share of nuclear power generation in Armenia, which does not emit CO2 during power generation processes.

The energy sectors of the Caucasus countries have diverse profiles, as we have seen, including in their emissions. All countries are highly reliant on natural gas for their primary energy supplies. While Georgia and Armenia are importers, with the Russian Federation supplying Armenia with this resource, Azerbaijan is one of the major producers of natural gas in the region. The major differences between the countries are in relation to the use of renewables in the energy balance. Georgia has the highest share of renewables in the energy balance, while Armenia uses nuclear power for its electricity supplies. Despite production and input differences, consumption patterns are similar, with relatively small consumption in the industrial sector and large consumption for the transportation, household and non-industrial business sectors in all three countries. Despite relatively stable levels of emissions over the past three decades, development of industrial sectors might push emissions levels higher. However, development of cost-efficient renewable energy sources can potentially serve as substitutes for existing polluting energy sources in the region over the next decade (see chapters 4 and 7 for additional information about international commitments of the Caucasus countries.)

To fuel the development of renewable energy sources and support cooperation, countries in the Caucasus Ecoregion might try implementing set-off actions through emissions trading (European Commission n.d.). Such initiatives could create additional resources for development of renewables and support countries in the region to meet their international targets. Discussions on utilizing private-public partnerships for carbon trading have started in Georgia with the support of the United Nations Development Programme (United Nations Development Programme [UNDP] 2023). In Armenia, the Multilateral Carbon Credit Fund with the European Bank for Reconstruction and Development and the European Investment Bank bought carbon credits from small Armenian hydropower plants in 2010. Furthermore, the Multilateral Carbon Credit Fund has also been involved in the development of energy-efficient power generation in Azerbaijan (European Bank for Reconstruction and Development Press Office 2019).

Chapter 4. Climate Change

An ongoing and increasingly important driver for environmental change is climate change, the nature and effects of which are defined by the United Nations Framework Convention on Climate Change (UNFCCC) as follows:

> *A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (United Nations 1992, Article 1, paragraph 2).*

In the same text, the "adverse effects of climate change" are defined as:

> *Changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socioeconomic systems or on human health and welfare (United Nations 1992, Article 1, paragraph 1).*

The impacts of climate change have caused widespread losses and damages to nature and people, beyond natural climate variability, and should hence be included as an independent driver for environmental change (UNEP 2019). Even when anthropogenic emissions are reduced, the effect of increasing global temperatures, widespread melting of snow and ice, and rising sea levels will last for millennia. Climate change affects vital ecosystems, agriculture, health, local economic activities and biodiversity, exacerbating challenges such as poverty, poor healthcare, inequity and energy security. There is well-established evidence that climate change poses a serious challenge to future economic development, as well as risks to human societies through impacts on food and water security (Pörtner *et al*. 2022). According to the Annual Greenhouse Gas Index (AGGI), the warming influence from greenhouse gases (GHG) increased by 49 per cent between 1990 and 2021. By comparison, it took 240 years for the AGGI to grow from 0 to 1 to reach 100 per cent. In terms of carbon dioxide (CO2) equivalents, the atmosphere in 2022 contained 523 ppm, of which 417 was CO2 and the rest were other gases (United States of America, National Oceanic and Atmospheric Administration [NOAA] Global Monitoring Laboratory 2023). The Intergovernmental Panel on Climate Change (IPCC) suggests that a constant concentration of CO2 alone at 550 ppm would lead to an average increase in Earth's temperature of circa 3°C (IPCC 2014). Despite the COVID-19 pandemic, the warming effect on the planet continued to increase at a rate similar to that of previous years (see Figure 9).

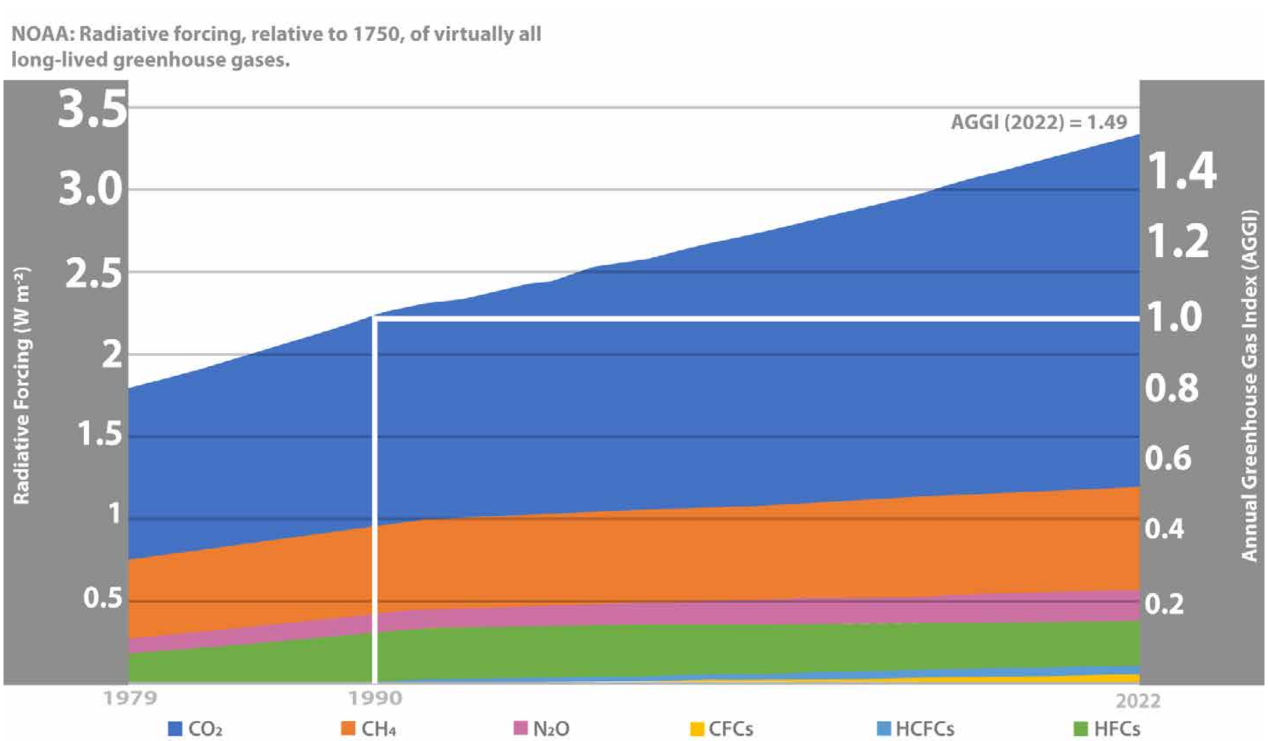


Figure 9. *Radiative forcing of virtually all long-lived greenhouse gases relative to 1750.*
Sources: National Oceanic and Atmospheric Association (2023).

Moreover, the United Nations Environment Programme (2022) Emissions Gap Report suggests that the emissions gap remains large. Unconditional and conditional nationally determined contributions (NDCs) are estimated to reduce global emissions in 2030 by 5 and 10 per cent respectively compared with emissions based on policies currently in place. To get on a least-cost pathway to limiting global warming to 2°C and 1.5°C, these percentages must reach 30 per cent and 45 per cent respectively.

4.1. Greenhouse gas emissions and nationally determined contribution targets

Even though reports showcase an urgent need to cut GHG emissions (Pörtner *et al*. 2022), the trend of growing GHG emissions continues across many countries (UNFCCC 2021). The GHG emission-reduction commitments on a global scale for all countries were first pledged in the framework of the Paris Agreement (United Nations 2015), which has been ratified by most of the Caucasus Ecoregion countries. Türkiye ratified the Paris Agreement in 2021, however, the Islamic Republic of Iran remains one of the three countries in the world that have not yet ratified it (United Nations n.d.).

The emissions per capita from the six countries of the Caucasus Ecoregion show divergent trends (see Figure 10). After the collapse of the Soviet Union in 1991 emission levels drastically decreased in Azerbaijan, Armenia, Georgia and the Russian Federation from their previous peaks due to industrialization processes. The per capita emissions of Armenia and Georgia are very low compared to the other Caucasus countries (see Figure 11). The Islamic Republic of Iran was one of the top ten GHG emitters according to 2019 data (Li *et al*. 2020; Freidrich *et al*. 2023), while energy-related CO2 emissions for Türkiye were 141.6 per cent higher in 2018 than in 1990, owing to emissions from coal, oil and gas industries (International Energy Agency 2021). The Russian Federation per capita emissions remain the highest.

The global cumulative share of the Caucasus Ecoregion countries on a global scale shows some marked changes (see Figure 11).

The two largest emissions sectors in Armenia, Azerbaijan and Georgia are the energy and agricultural sectors (EU4Climate 2021). The largest share of GHG emissions in the Russian Federation also comes from the energy sector, followed by industrial processes and agriculture (Russian Federation, Ministry of Natural Resources and Ecology 2020). In Türkiye, emissions from the energy sector are also the major contributor to GHG emissions (Turkish Statistical Institute 2021). The Islamic Republic of Iran has not provided its biennial update reports to the UNFCCC; however, its national communication states that based on 2010 data, the energy sector contributed 88 per cent of total emissions, with industrial processes and forestry contributing about 9 per cent and 3 per cent respectively (Islamic Republic of Iran, National Climate Change Office 2017).

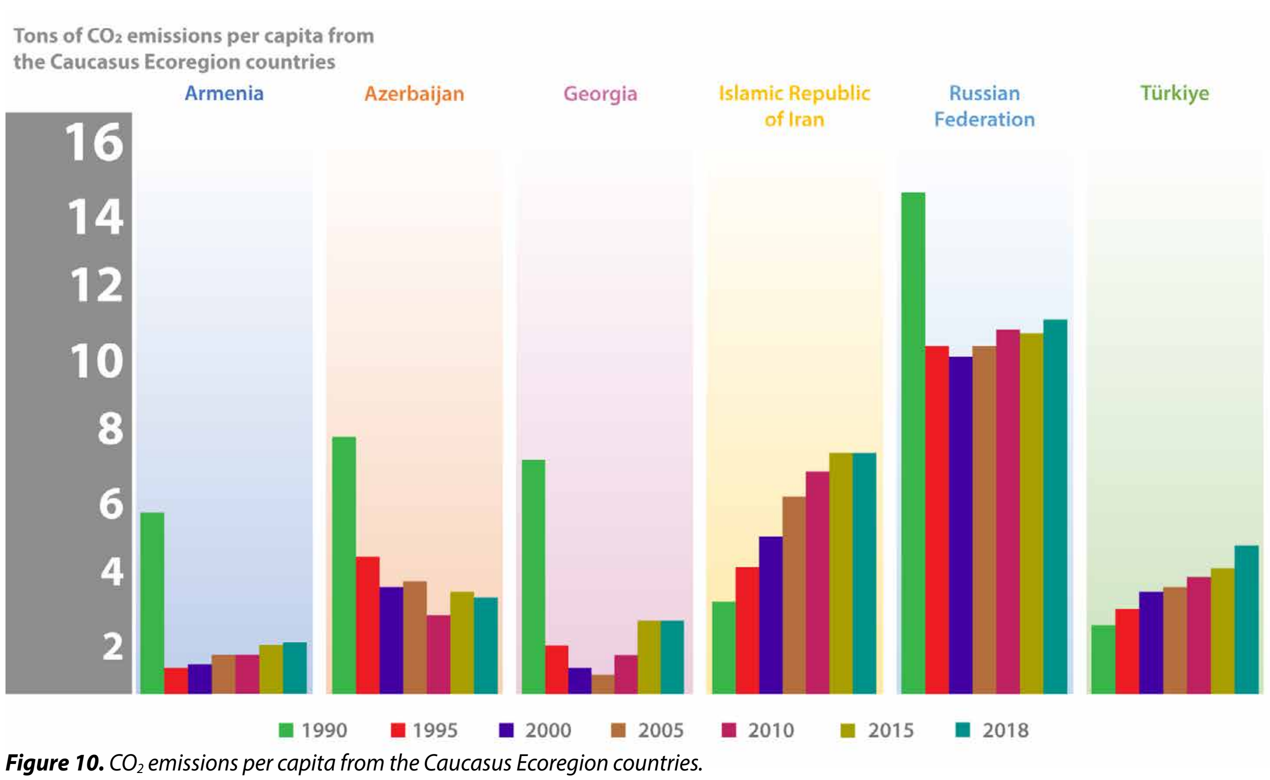


Figure 10. *CO_2 emissions per capita from the Caucasus Ecoregion countries.*

Sources: International Energy Agency (n.d.)

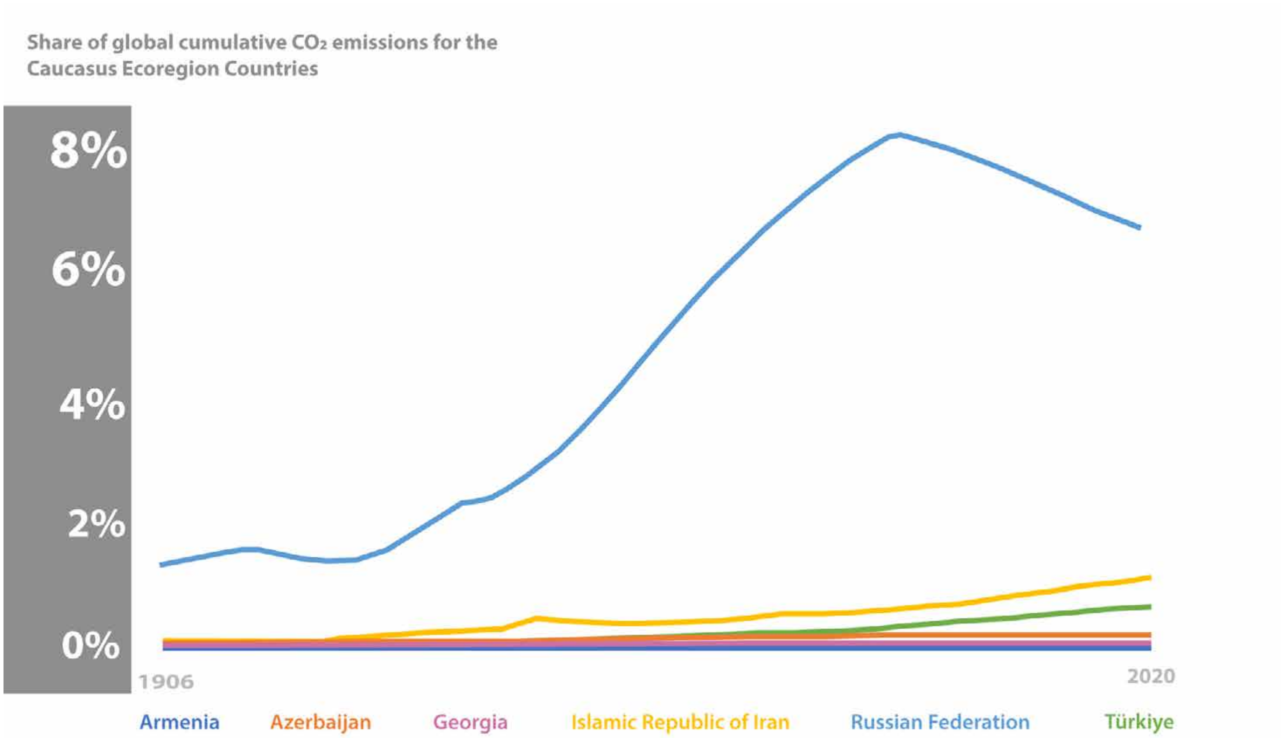


Figure 11. *Share of global cumulative CO_2 emissions for the Caucasus Ecoregion countries.*
Sources: Our World in Data (2023).

4.2. Climate change impacts

The Caucasus Ecoregion is a mountainous biodiversity hotspot with significant coastal areas, accommodating nine climate zones, including arid and semi-arid territories, alpine meadows, and deep forests. The Caucasus Ecoregion encompasses a diverse range of landscapes and ecosystems including mountains, forests, grasslands and wetlands (Zazanashvili *et al*. 2020). The Ecoregion also hosts a rich assembly of plant and animal species, some of which are endemic and highly sensitive to changes in temperature and habitat. These characteristics make the Ecoregion prone to the impacts of climate change (Caucasus Nature Fund 2021). Two types of systems are impacted due to climate change: natural systems and human systems. The impacts on these systems have already resulted in increased risks through the interaction of hazards, vulnerability and exposure (Pörtner *et al*. 2022), and they disproportionately affect women due to their roles in water management, agriculture and household responsibilities.

This Ecoregion is vulnerable to various climate change impacts that can have significant environmental, social and economic consequences, including glacier retreat that leads to water scarcity, affecting agriculture, hydroelectric power generation and ecosystems dependent on water availability. Changing precipitation patterns are another factor causing increased water stress in the Ecoregion. Rising temperatures, altered precipitation patterns and habitat degradation pose a threat to

> *In recent years, the effects of climate change on ecosystems have become more apparent.*
> Siavash Rezazadeh, Ph.D. Student of Environmental Science, Malayer University, Islamic Republic of Iran

biodiversity, leading to shifts in species distribution, increased risk of extinction and disruption of ecological processes. Forests are another vulnerable ecosystem that is affected and subject to degradation, decreased productivity and susceptibility to wildfires (Elizbarashvili *et al*. 2017; Türkiye Ministry of Environment and Urbanization 2018; Chapman, Davies and Downey 2021a; Chapman, Davies and Downey 2021b).

Several tested and successful adaptation solutions and approaches to serve as potential responses in the South Caucasus to adverse climate change impacts have been identified and disseminated among policymakers and practitioners. The analysis shows that local community support, economic co-benefits, empowerment of women and incorporating traditional knowledge and socioeconomic practices are key factors in successful efforts to strengthen local climate resilience (UNEP and GRID-Arendal 2022).

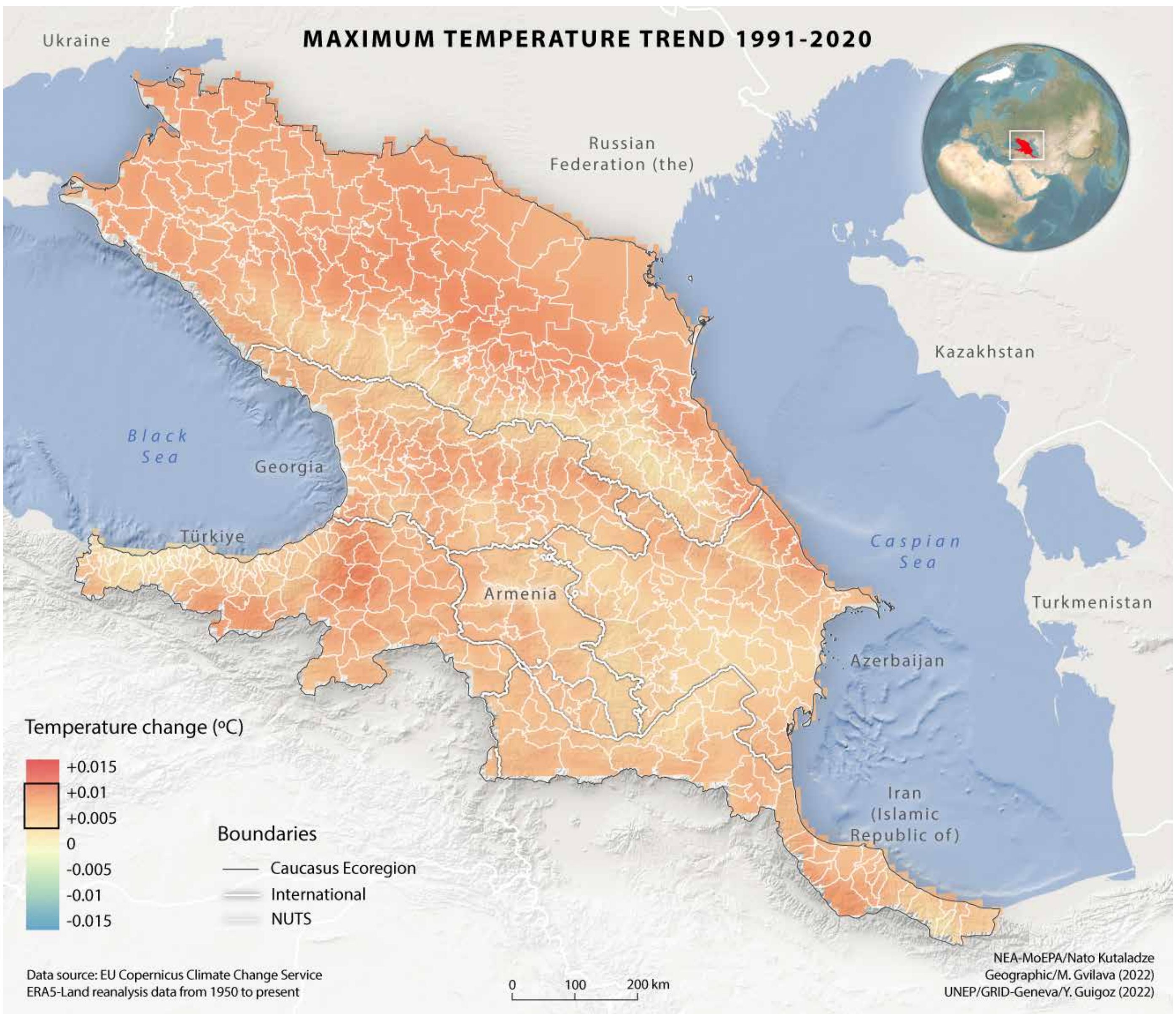
4.2.1. Observed temperatures

All Caucasus Ecoregion countries report an increase of observed temperature across their territories (see Map 7). For decades, a significant increase in the annual temperature in Armenia has been observed compared to the 1961–1990 annual average.

From 1929 to 1996, the average annual temperature increased by 0.4°C, from 1929 to 2007 by 0.85°C, from 1929 to 2012 by 1.03°C, and from 1929 to 2016 by 1.23°C (Armenia, Ministry of Environment 2020). In Azerbaijan, from 2000 to 2020, compared to the 1971–2000 period, temperatures increased 0.7–1.5°C depending on the region, and the last 10 years were the hottest decade recorded (Azerbaijan, Ministry of Ecology and Natural Resources 2021).

In Georgia, comparing the two 30-year periods 1956–1985 and 1986–2015, the average annual surface air temperature increased by 0.25–0.58°C, with an average increase of 0.47°C (Georgia, Ministry of Environmental Protection and Agriculture 2021).

Türkiye has reported an increase in temperature and decrease in precipitation in the Mediterranean region and increase in precipitation along the Black Sea coast (Türkiye, Ministry of Environment and Urbanization 2011). Spring average air temperatures have moved upwards in most parts of the country. Warming trends have been observed, especially in the Aegean, Central Anatolia, Marmara, Mediterranean and South-eastern Anatolia regions. Strong warming trends seen in the summer season are statistically significant at a 1 per cent level in most stations, accelerating from the 1980s, and weak warming and cooling trends are seen throughout the Black Sea and northern parts of Central and Eastern Anatolia regions (Blunden and Boyer 2020).



Map 7. *Maximum temperature trends in the Caucasus Ecoregion, 1991–2020.*

In the Islamic Republic of Iran, warm nights (over 90 per cent of the stations) and warm days in the period 1975–2010 have been increasing. Cold days and nights have experienced a downward trend in most stations of the country in the same period (Islamic Republic of Iran, National Climate Change Office 2017).

4.2.2. Observed precipitation

Armenia reports that estimated changes in the amount of precipitation compared over different periods since 1935 shows that a decreasing trend in precipitation has been maintained. Over the period 1935–1996, the average annual precipitation decreased by 6 per cent, and during the period 1935–2016 by about 9 per cent (Armenia, Ministry of Environment 2020).

The rainfall indicators analysed for 2010–2020 in Azerbaijan also showed that the amount of precipitation was lower in most parts of the country compared with the precipitation norms of 1971–2000 and that they had decreased by about 3.4 per cent over the 2011–2021 period (Azerbaijan, Ministry of Ecology and Natural Resources 2021).

The mean real precipitation of Türkiye in 2020 was 500 mm, 13 per cent below the mean for 1981–2010 (574 mm). Geographically, Adıyaman, Batman Kırklareli Diyarbakır, Giresun, Hakkari, the Lakes regions, Mersin, Şırnak and Trabzon had below-normal precipitation in 2020 (Blunden and Boyer 2020).

In Georgia, annual precipitation has increased in the west of the country and decreased in some eastern regions, although changes in annual precipitation were mainly unstable with no clear trends (Georgia, Ministry of Environmental Protection and Agriculture 2021). The Black Sea coast, the Colchis Lowland accommodating wetlands and the lowland regions of Eastern Georgia representing semi-arid areas of the country, are most sensitive to changes in climatic conditions of humidification, even compared to the mountainous areas and the coastal zone of the Black Sea. The changes in the number of days with precipitation of at least 10 mm and 20 mm, the duration of rainless and rainy periods, and the annual amount and intensity of precipitation, are statistically significant. The change in these indices, except for the duration of the rainless period in the coastal lowland areas and on the plains, is characterized by a positive trend, and in the mountains by a negative trend. The duration of the rainless period decreased in low-lying areas and increased in the mountains. The identified climatic changes may contribute to the humification of the climate of the Black Sea coast and the Colchis Lowland, and to some mitigation of the arid climate of Eastern Georgia and an increase in the aridity of the Greater Caucasus climate (Elizbarashvili *et al*. 2017).

4.2.3. Status of glaciers

The Caucasus Ecoregion follows the global trend proved by observations of glaciers in the Greater Caucasus (Rucevska *et al*. 2017). On the north slopes of the Greater Caucasus Mountain range, from 1895 to 2011, all glaciers were in retreat. The average retreat of glaciers in the Ecoregion over the past 100 years is 600 m. Analysis of mountain glaciation using space images from 2015 and 2016 showed that some glaciers (Bolshoi Azau, Midagrabin, Marukh) are shrinking at an accelerated rate, while others, due to the impact of avalanche processes, had dramatically slowed their retreat (Russian Federation, Ministry of Natural Resources and Ecology 2017).

Results from the latest study of Greater Caucasus glaciers, including in Azerbaijan, Georgia and the Russian Federation, compared inventories in two periods between 2000 and 2020. The total retreat amounts to 320.6 ± 45.9 km^2 or 23.2 ± 3.8 per cent (-1.16 per cent per year), with the east part experiencing the highest absolute decrease and Elbrus Massif the lowest, although its mean area changed from 6.07 km^2 in 2000 to 3.98 km^2 in 2020. The study also revealed that the decline in glacier extent between 2000 and 2020 was four times higher than between 1911 and 1960, three times higher than 1960–1986, and twice as high as 1986–2000; the highest decline was recorded in the preceding six years (Tielidze *et al*. 2022). Compared to the glacier inventory released in 1970 of the Enguri glacier basin, the 2018 report revealed that the number of glaciers was reduced by 21 per cent, and their area by 23 per cent (Georgia, Ministry of Environmental Protection and Agriculture 2021).

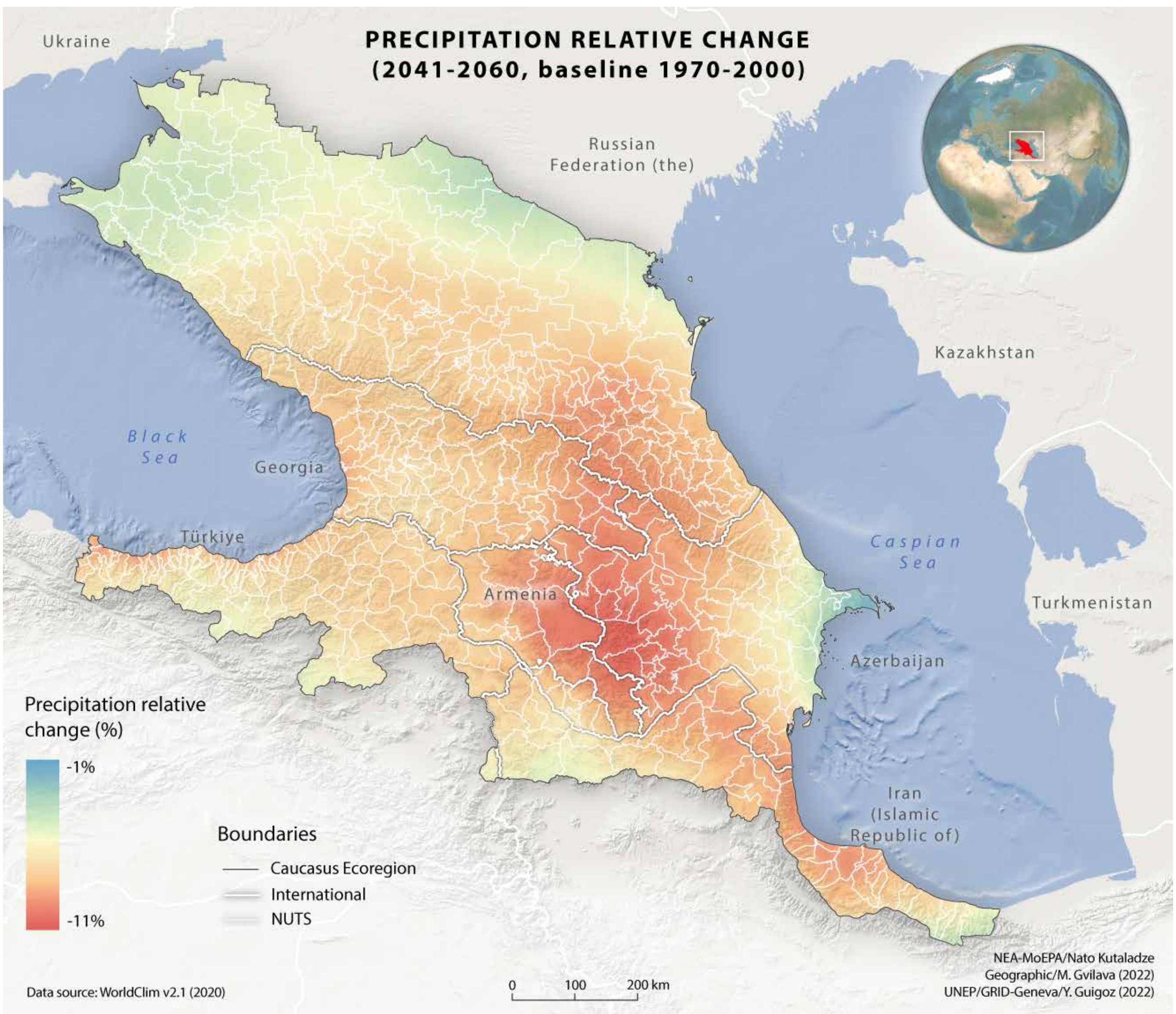
Climate change causes severe hazards originating from the glacier and periglacial zones. Rising temperatures intensify melting processes and impact permafrost and glaciers. Permafrost thaw plays a significant role in how climate influences the stability of slopes, the evolution of landscapes, and potential natural hazards in mountainous regions. Glacier melting and retreating causes excess water to accumulate in the debris, moraines (proglacial lakes), under the glacier (subglacial lakes) or above the glacier (supraglacial lakes). This, in turn, creates a high probability of glacial lake outburst floods. During the last decade, multiple glacier-related hazards have already occurred in Georgia and other countries of the Greater Caucasus (e.g. in the areas of the Devdoraki-Amali, Hokrila-Nenskra, Mestiachala, Seri-Tviberi, and Tbilisa-Buba glaciers). Observations show that the risk of such hazards will increase. Satellite imagery reveals a growing number of glacier lakes and increasing exposed areas of permafrost zones in steep terrains. This raises the absolute need for constant monitoring of this dynamic process and frequent hazard and risk assessment updates.

Warming in the winter season has also led to a significant change in the sea ice cover. Observations of the Azov-Black Sea basin comparing the periods 1977–2015 to 1924–1976, reveal that mild winters have become more common, increasing from 39 to 54 per cent in the northern Black Sea, and from 29 to 48 per cent in the Sea of Azov, while severe winters have become 6 per cent less common. In the Sea of Azov, the average monthly ice coverage in February and March has decreased over the last 35 years. Both seas demonstrate a significant negative linear trend in the number of days with ice, and the duration of the ice period for the entire observation (Russian Federation, Ministry of Natural Resources and Ecology 2017) (see Map 20).

4.3. Predicted climate by 2041–2060

Future climate changes for the Caucasus Ecoregion were assessed based on an ensemble of Intercomparison Project Phase 6 (CMIP6) Global Climate Models (GCM) models, statistically downscaled to 1-km resolution (R Package Documentation [n.d.]). In this model, emissions and temperatures rise steadily, and CO_2 emissions roughly double from current levels by 2100. Countries become more competitive with one another, shifting toward national security and ensuring their own food supplies. By the end of the century, average temperatures will have risen by 3.6°C. This is one of the new IPCC scenarios, considered as an upper-medium scenario.

Precipitation (see Map 8) and maximum temperature (see Map 9) for the 2041–2060 summer period show predicted evolutions. The changes in the seasonal sum of precipitation are relative to the base period 1970–2000 and are in the range of -1 to -11 per cent. The lowest decrease in precipitation is expected in the territories surrounding the Caspian Sea and in the northern part of the Ecoregion. The highest reduction



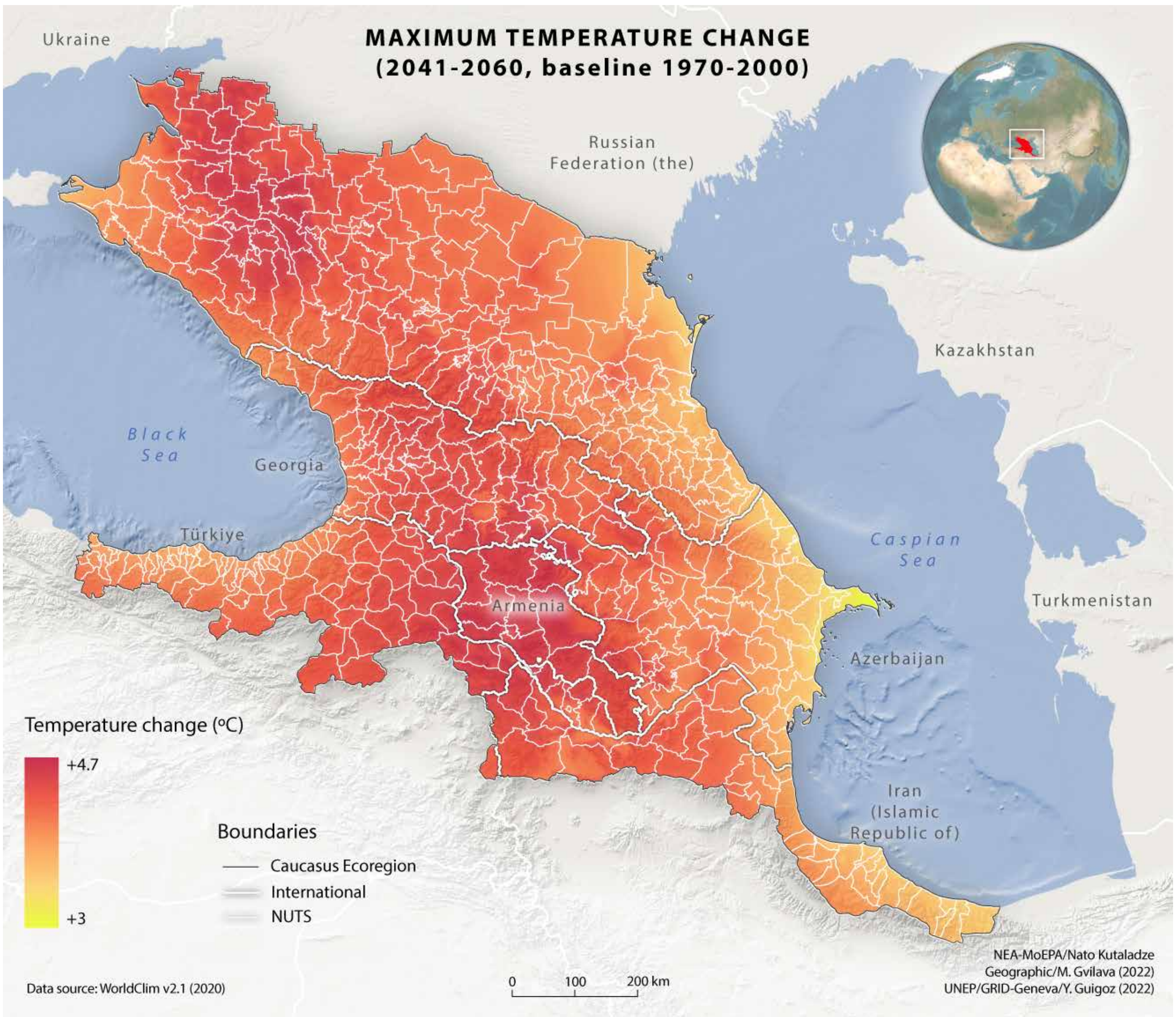
Map 8. *Forecast relative change in precipitation for the period 2041–2060 (baseline 1970–2000).*

of summer precipitation will happen along the border between Armenia and Azerbaijan. The summer maximum temperatures show an increase in the range of 3°C to 4.7°C, with approximately 4°C observed across the Ecoregion.

4.4. Increased risk of natural hazards and extreme weather events

The countries of the Caucasus Ecoregion report on the increase in frequency and intensity of natural hazards, and the total number of observed hazardous phenomena throughout 1975–2016 increased by 40 cases (Armenia, Ministry of Environment 2020). The Russian Federation scores highest among industrialized and emerging economies on the climate risk index of weather-related fatalities per 100,000 inhabitants (Climate Transparency 2021, p.9).

Armenia reports an increase in the number of droughts, from 2000 to 2017, reaching 33 days compared to the 1961–1990 average. The boundary of the drought zone has moved upwards in altitude and includes mountainous areas, with an earlier start of drought (Armenia, Ministry of Environment 2020). In Azerbaijan, the number and duration of extremely hot days and heatwaves in the summer months have been significant. For example, the maximum number of days with a maximum air temperature of 35°C and higher in Baku during the entire baseline period of 1960–1990 (30 years) was 86 and a total of 365 days at 35°C and higher in the period of 1991–2020



Map 9. *Maximum temperature change for the period 2041–2060 (baseline 1970–2000).*

(29 years). The maximum number of consecutive days with such temperatures in Baku was 5 days in the baseline period (1960–1990), and 25 days in recent decades (1991–2020) (Azerbaijan, Ministry of Ecology and Natural Resources 2021).

The floods in the North Caucasus have increased in frequency due to the dynamics of the autumn precipitation patterns (Russian Federation, Ministry of Natural Resources and Ecology 2017). However, wildfire frequency change is not sufficiently assessed in the Caucasus. For example, in Georgia, the impact of climate change on wildfires in forests will increase, particularly in Central and Eastern Georgia (Gaprindashvili *et al*. 2016). Reports from the IPCC (Pörtner *et al*. 2022) indicate with high confidence that climate change is attributable to human activity. However, the attribution of natural hazards to climate change in the specific context of the Caucasus Ecoregion has not yet been scientifically researched. According to the IPCC, many of these risks are unavoidable; however, their impact might be mitigated through adaptation planning. Adaptation action is not only a commitment under the UNFCCC to increase adaptive capacity, but also leads towards the achievement of the Sustainable Development Goals.

The Notre Dame-Global Adaptation Initiative (ND-GAIN) Country Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. Caucasus Ecoregion countries are vulnerable to the impacts of climate change (see Figure 12); however, they do have the readiness to increase their resilience (University of Notre Dame 2021). Hence, efforts on adaptation actions are of critical importance.

Armenia is a pioneer country for the Ecoregion in terms of adaptation action in submitting its national adaptation plan (NAP) in September 2021 to improve its impact assessment and increase the country's resilience towards the adverse impacts of climate change (Armenia Ministry of Environment 2021). Georgia has been working on its NAP for several years, which will assess the impact on the coastal zone, mountain ecosystems and ecosystem services, and affected livelihoods and local population (Government of Georgia 2021). A plan to support the development of a NAP in Azerbaijan was submitted to the Government for approval. The project aims to identify the adaptation priorities for agriculture, water resources and coastal areas, and assess the economic prospects for the adaptation process (Azerbaijan, Ministry of Ecology and Natural Resources 2021).

Türkiye adopted the National Adaptation Strategy and Action Plan until 2023, which describes actions on five vulnerability areas: water resources management; the agricultural sector and food security; ecosystem services, biodiversity and forestry; natural disaster risk management; and public health (Türkiye Ministry of Environment and Urbanization 2011, p. 53).

In late December 2019, the Russian Government approved a national plan of 29 broad measures that encompass

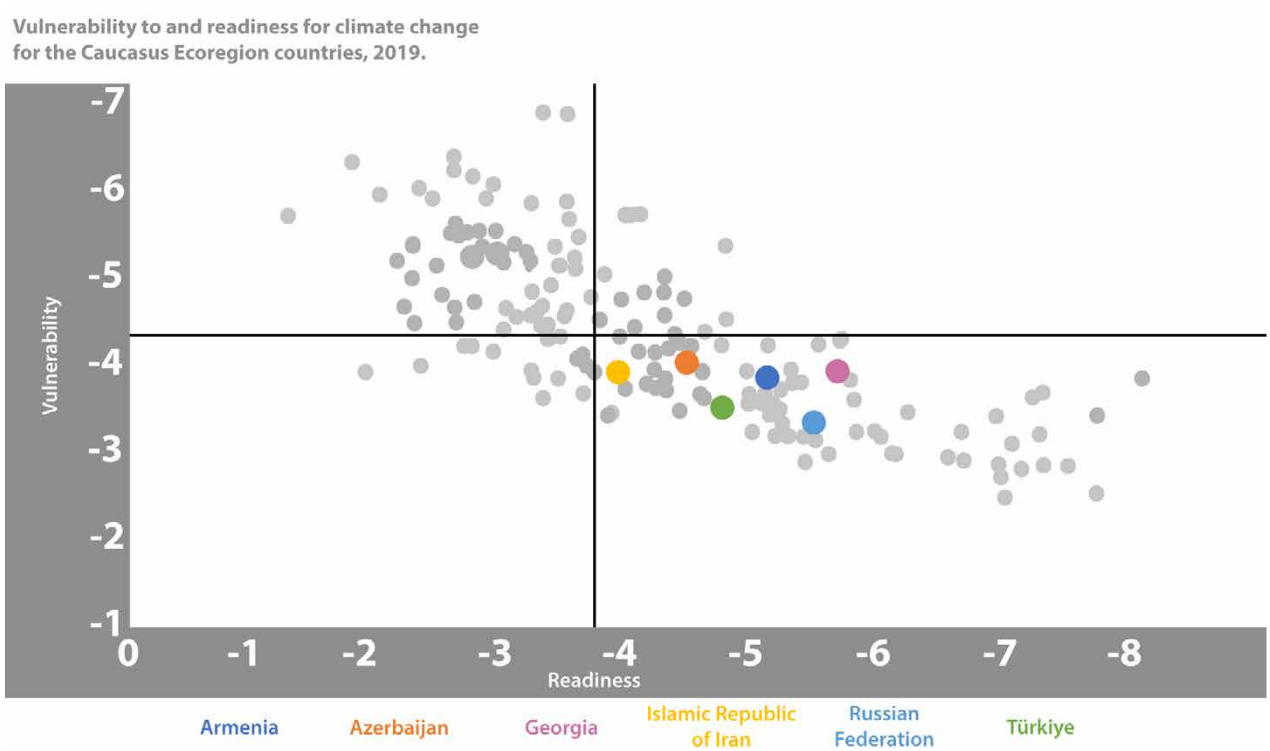


Figure 12. *Vulnerability to and readiness for climate change of the Caucasus countries.*
Sources: University of Notre Dame (n.d.).

> *The protection of our genetic resources is of great importance in the fight against climate change.*
> Nuray Çaltı, independent researcher and youth trainer, Türkiye

institutional, organizational and methodological measures aimed at shaping government approaches to adaptation (Climate Transparency 2021). Following these measures, in March 2023 the Russian government adopted the second stage of the National Action Plan of adaptation to climate change for the period up to 2025 with the aim to put in place a framework orienting resources toward priority issues.

4.5. Impacts on human systems

4.5.1. Economic sectors

As seen in the IPCC reports, the impacts of climate change are expected to exacerbate poverty in most developing countries and create new poverty pockets in countries with increasing inequality (Pörtner *et al*. 2022). The impacts on the natural system explained above lead to major losses in economic sectors, especially agriculture. Declines in precipitation increase dependency on irrigation systems and demand for water for irrigation (Shatberashvili *et al*. 2016). Under all climatic scenarios, irrigation water shortages can be expected in six water basins by 2040 in Ganykh, Eastern Lower Kura, Lenkeran/Vilesh and Samur (Azerbaijan), Alazani (Georgia) and Upper Ara(k)s (Armenia) (Rucevska *et al*. 2017). In rural areas, poorer farmers and communities are least able to afford local water storage, irrigation infrastructure and technologies for adaptation, reducing productivity and damaging crop yields (Chapman, Davies and Downey 2021b). Population vulnerability is also high in the North Caucasus, characterized by low living standards and ineffective action and response of the local authorities to the impacts of severe natural hazards, such as floods, winds, and forest fires (Russian Federation, Ministry of Natural Resources and Ecology 2017). The fishing communities along the Caspian Sea will be also negatively affected due to the impacts on species balance and sea level fluctuations (Islamic Republic of Iran, National Climate Change Office 2017; Rucevska *et al*. 2017).

Impacts on glaciers increase risks related to freshwater availability, their role as suppliers of hydroelectric power, and the economic benefits of being a major tourist attraction with thousands of visitors each year (Tielidze *et al*. 2022). In terms of energy demand, climate change is projected to reduce heating pressure and increase energy demand for cooling in the residential and commercial sectors, though it will affect energy sources differently depending on resources, technological processes and locations (IPCC 2014). Urban heat islands could lead to a median of 19 per cent increase in cooling energy consumption for buildings, and to a median of 18.7 per cent decrease in heating energy consumption for buildings (Li *et al*. 2020).

Tourism is a crosscutting economic sector dependent on favourable weather conditions, the safety of destination areas, and energy, water, and agricultural product supplies, and as such, it is also highly affected by climate change. Winter tourism is particularly vulnerable (Gaprindashvili *et al*. 2016). The Georgian tourism sector brings in 7.6 per cent of GDP (Georgia, Ministry of Internal Affairs 2022) (Georgia, Georgian National Tourism Agency 2022) and can be assumed to be highly vulnerable to climate change as well.

Temperature rise and extreme weather events also negatively affect power transmission lines and other infrastructure such as roads and railroads. Increased geological and weather-related risks can damage critical energy infrastructure (Gaprindashvili *et al*. 2016; Russian Federation, Ministry of Natural Resources and Ecology 2017; Georgia, Ministry of Environmental Protection and Agriculture 2021).

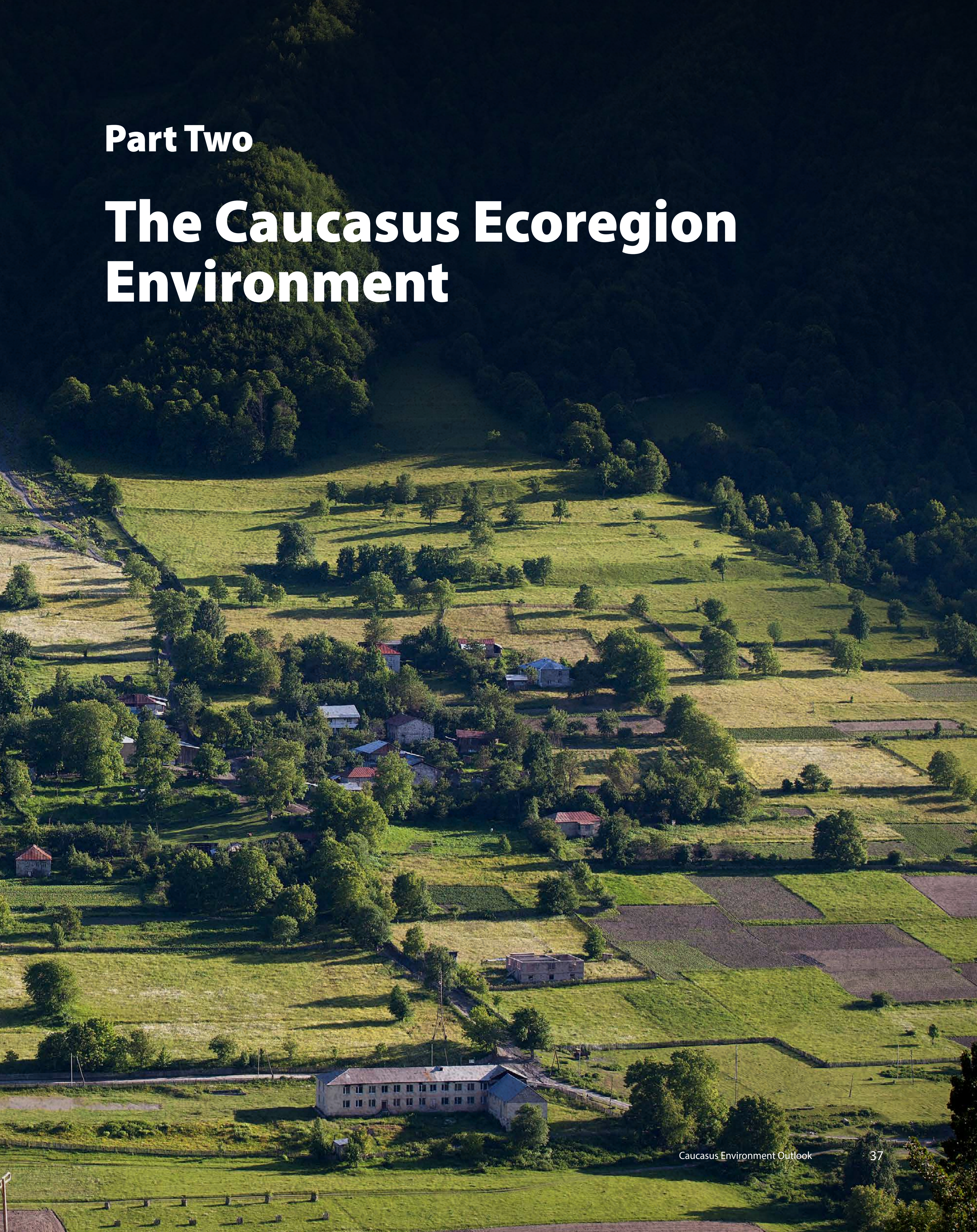
4.5.2. Human health

The countries of the Caucasus Ecoregion are prone to heatwaves and heat-related illnesses, especially in urban settlements where air pollution exacerbates the impacts of climate change on health. Dust storms, desertification and increased droughts lead to respiratory illnesses, allergies, vector-borne illnesses, heart strokes and other cardiovascular illnesses (Gaprindashvili *et al*. 2016; Islamic Republic of Iran, National Climate Change Office 2017; Türkiye, Ministry of Environment and Urbanization 2018; Azerbaijan, Ministry of Ecology and Natural Resources 2021). Poor people, pregnant women and elderly people may be disproportionately vulnerable to the effects of extreme heat and thus to the impacts of climate change due to their high dependency on natural resources and limited capacity to cope with climate extremes and variability (Gaprindashvili *et al*. 2016).

When heat-related emergency calls and sunstrokes were analysed, it was concluded that there is an increase in the number of cardiovascular diseases and deaths in summer periods; however, meteorological warnings and better preparedness have helped reduce more severe outcomes in recent years (Azerbaijan, Ministry of Ecology and Natural Resources 2021). Extensive heat can trigger malaria outbreaks, which have been under control in the last few years (Chapman, Davies and Downey 2021a; Chapman, Davies and Downey 2021c).

4.5.3. Gender mainstreaming into climate policies

Gender mainstreaming into climate policies needs to be improved across all countries in the Caucasus Ecoregion. While information and documents on gender related to climate are available in most countries of the Ecoregion, not all of them can be considered gender sensitive. Türkiye and Azerbaijan have more policies in place than other countries (McLaughlin 2019; Mammadov 2022; Sohrabizadeh, Bahramzadeh and Hanafi-Bojd 2022). Proper gender needs assessments related to climate change must therefore be carried out in all Caucasus countries.



Part Two

The Caucasus Ecoregion Environment

Chapter 5: Land cover

This chapter aims to describe the state of the land-cover classes (LCCs) in the Caucasus Ecoregion, their importance in terms of economic development and food security, different pressures they are enduring, and their development trends between the years 2000 and 2020. This chapter also analyses the potential impact of the predicted change in the future of these LCCs on the implementation of the 2030 Agenda for Sustainable Development and provides recommendations for policy responses.

"Land cover" is generally defined as the observed physical cover of the Earth's surface by vegetation (natural systems) and man-made features (artificial or artificially maintained systems) (van Westen *et al*. 2018, p. 25). However, for the purpose of this publication, we use a broader definition that encompasses all types of land surface (e.g., rocks and bare land), including soil cover.

Box 1. Land cover spatial data calculations

A total of 11 main land cover classes are defined and used in this chapter. The surface area data in hectares (ha) was acquired from global geospatial data sources, such as the Copernicus Global Land Cover Service. To ensure homogeneous and comparable analysis of landcover of the Caucasus Ecoregion, the geospatial data was produced by visual interpretation of high-resolution satellite imagery. For example, Land Cover Data for 2020 was calculated using the European Space Agency WorldCover 2020 V100 satellite images to create a 10-metre resolution map. For analytical purposes, the acquired data was converted into hectares. There was no more detailed geospatial information available for 2000 than 300-metre resolution information. This data for the 11 land cover classes in 477 Nomenclature of Territorial Units for Statistics – level 3 (NUTS 3) covering the whole Caucasus Ecoregion was thus calculated in hectares with 350 m resolution for both 2000 and 2020 (see the annex). Due to this limitation, which does not provide fully accurate information in absolute numbers, percentages were often used rather than hectares when describing the changes.

Alpine meadow in Kabardino-Balkaria, Russian Federation. ©iStock/Inna Polekhina

5.1. Main ecological sub-regions and landscapes

The location of the Caucasus Ecoregion on the frontier of temperate and subtropical climatic zones, and its topography as an isthmus between the Black and Caspian Seas around the Greater and Lesser Caucasus Mountain ranges descending into plains and depressions, result in an extraordinary diversity of soils, microclimates and landscapes. These diverse landscapes form one of the most biologically and culturally diverse and rich regions on Earth, further enhanced by its geographic location as a biological crossroads between Europe and Asia and between the north and south of the Eurasian continent (see Map 10).

Altitudes in the Caucasus Ecoregion stretch from 28 metres below sea level, to 5,642 metres above sea level. Approximately 65 per cent of the Ecoregion is mountainous,

***Map 10.** Caucasus land cover, 2020.*

Note: Classification based on the FAO Land Cover Classification System (LCCS) (di Grigorio and Jansen 2002).

Table 5. Distribution of land cover classes in the Ecoregion, 2020 (percentage)

Country	Grass-land	Tree cover	Crop-land	Bare/ sparse vegetation	Built-up	Wet-land	Shrub-land	Permanent water bodies	Moss and lichen	Snow and ice	Total land cover
Armenia	64.58	12.38	10.42	5.37	1.99	0.01	0.12	4.65	0.47	0.00	100
Azerbaijan	38.08	14.24	23.13	11.73	2.61	1.12	7.28	1.49	0.30	0.00	100
Georgia	30.69	52.08	8.32	3.07	1.06	0.26	1.51	0.62	1.76	0.63	100
Islamic Republic of Iran	48.88	17.49	18.93	10.90	1.68	0.45	0.68	0.37	0.62	0.01	100
Russian Federation	28.58	24.55	36.46	3.38	1.49	2.69	0.07	1.26	1.17	0.35	100
Türkiye	57.01	25.61	9.50	5.53	0.69	0.02	0.00	0.54	1.09	0.00	100
Total	37.77	25.10	24.50	5.77	1.55	1.46	1.40	1.21	1.01	0.23	100

Source: Fick and Hijmans (2017).
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

and 35 per cent is lowlands (Williams *et al*. 2006, p. 8). The primary land cover classes across the Ecoregion and the countries based on the 10-metre spatial resolution data (see Map 10) are summarized here (see Table 5).

The Caucasus Ecoregion is a composite ecoregion encompassing 10 different terrestrial ecoregions (Olson and Dinerstein 2002). The Ecoregion includes the whole of the Caucasus mixed forest and Azerbaijani shrub desert and steppe ecoregions, as well as the Colchic part of the Euxine-Colchic deciduous forests, and it partly covers seven other ecoregions (Olson *et al*. 2001). Topographically, the Caucasus can be divided into seven subregions (listed below), within which Zazanashvili *et al*. (2020) identify 13 main conservation landscapes (CLs), 7 bridging landscapes (BLs) and 231 key biodiversity areas (KBAs).

The main topographic subregions of the Caucasus Ecoregion are:

1. North Caucasus plains: These plains extend from the Kuma-Manych River Depression to the north to the northern highlands of the Greater Caucasus Mountain Range. Both the east (Caspian Lowland, which descends as low as 28 metres below sea level) and west (Kuban-Azov Lowland) parts of the plains have large areas covered with herbaceous wetlands. The subregion is rich in permanent water bodies. In the central part of the lowland, the Stavropol Plateau rises above the plains. The west and central parts of the plains are mostly covered by croplands, which were once grassland steppe, while the east includes semi-desert areas used as winter pastures. The North Caucasus Plains are quite densely populated (especially Krasnodar and Stavropol). The subregion includes Kuma-Manych and the Caspian CLs of the Ecoregion, around 25 KBAs, several candidate sites of the Emerald Network (linked Areas of Special Conservation Interest whose establishment meets Bern Convention obligations), Ramsar sites, and national protected areas of different International Union for the Conservation of Nature (IUCN) categories.

2. Greater Caucasus Mountain range: This mountain range is in the centre of the Ecoregion and divides it into two parts, the North and South Caucasus. The range is mostly covered by broadleaf and coniferous forests at lower altitudes, changing to subalpine and alpine meadows and glaciers as the elevation increases. The last intact forest zone of the Caucasus Ecoregion is located along the west and the central parts of the range on both the north and south slopes (in the Russian Federation and Georgia). In the west Greater Caucasus, forest cover prevails in the ecosystem, while the central and east Greater Caucasus have more areas covered with subalpine and alpine meadows. The subregion is poorly populated and has a marginal share of croplands. The subregion includes the west, central and east Greater Caucasus CLs of the Ecoregion, about 28 KBAs in the Russian Federation, 19 KBAs in Georgia and 6 KBAs in Azerbaijan, as well as several already adapted and candidate sites for the Emerald Network, and national protected areas of different IUCN categories.

3. South Caucasus Depression: This lies between the Greater and Lesser Caucasus Mountain Ranges and extends across Azerbaijan and Georgia. The area is divided in two by the bridging landscape of the Likhi Gorge, connecting the Greater Caucasus and the Lesser Caucasus Mountains. The west part of the subregion (Kolkheti Lowland) is humid, covered with relict endemic alder forests and temperate rainforests and wetlands, while the east part (Kura-Aras Lowlands and the Iori-Ajinour Plateau) is dry, covered with steppes, semi-desert, desert, floodplains, forests and woodlands. The topographic subregion includes the Kolkheti, Caspian and Iori-Mingachevir

CLs of the Ecoregion, about 28 KBAs in Azerbaijan and 24 KBAs in Georgia and hosts several national protected areas of different IUCN categories, several adopted Emerald Network sites, Ramsar sites and a biosphere reserve.

4. Lesser Caucasus Mountains: This mountain chain in the South Caucasus connects with the Greater Caucasus Mountain Range through Likhi Gorge. The mountain chain borders the South Caucasus Uplands to the north, east and west sides. It includes west and east Lesser Caucasus CLs and Likhi and Trialeti-Gombori BLs of the Ecoregion, about 13 KBAs in Georgia, 10 KBAs in Türkiye, 5 KBAs in Armenia, 4 KBAs in Azerbaijan and 4 KBAs in the Islamic Republic of Iran. The Lesser Caucasus hosts several candidate and adapted sites of the Emerald Network, and several national protected areas of different IUCN categories.

5. South Caucasus Uplands: These cover inter-mountain canyons, volcanic plateaus and folded mountains surrounded by the Lesser Caucasus Mountains, with an average elevation of 1,700–1,900 m above sea level, rising to over 5,000 m. The subregion includes the South Caucasus Uplands and Sarikamish-Maku CLs, Sarikamish-Posof, Aras,Bazum and Argats BLs of the Ecoregion, hosts about 18 KBAs in Türkiye, 14 KBAs in Armenia, 6 KBAs in Georgia, 3 KBAs in Azerbaijan and 3 KBAs in the Islamic Republic of Iran, and covers a number of national protected areas of different IUCN categories, several Emerald Network adopted and candidate sites, and several Ramsar sites.

6. Talysh-Western Alborz Mountains: These extend along the Caspian Sea across the border between Azerbaijan and the Islamic Republic of Iran, covered mostly with relict Hyrcanian broadleaf forests. The subregion includes Hyrcan and Arasbaran CLs of the Ecoregion, hosts 6 KBAs in the Islamic Republic of Iran and 2 KBAs in Azerbaijan, and several national protected areas of different IUCN categories and Emerald Network candidate sites.

7. Sabalan (Savalan): This is a mountain range located in the Islamic Republic of Iran that serves as a natural bridge between the Lesser Caucasus and the Talysh-Alborz Mountains. The range consists of high mountain steppes and mountain grasslands, and includes the Arasbaran CL of the Ecoregion, 6 KBAs, several national protected areas of different IUCN categories and a biosphere reserve.

If we look at the land-cover data of the Ecoregion in the last 20 years, the major LCCs that changed the most are shrublands (decreased) and built-up and bare spaces (increased) (see Table 6).

The most serious change among all LCCs in the Ecoregion is in addition of built-up areas, which increased almost everywhere in the Ecoregion. A total of 91 per cent of the administrative units show an over 3 per cent increase in built-up areas, and 18 per cent of administrative units showed a more than 15 per cent increase. At country level, "urban sprawl" is most common in the Turkish part of the Black Sea coast, where built-up areas in some municipalities increased by more than 80 per cent. This can be explained by the rapid industrialization of Türkiye and tourism development along the Black Sea coast in the last decades. Only 8 administrative units out of a total of 477 in the whole Ecoregion show a decline in built-up areas, of which three belong to occupied areas in Georgia. If we look at the three capital cities of the South Caucasus countries, Baku, Azerbaijan and Tbilisi, Georgia both increased their surface by 23 per cent each. Yerevan, Armenia increased slightly less, by 16 per cent (see chapter 3).

Shrublands seem to be the most "convertible" LCC as they have become built-up areas, croplands or grasslands all over the Ecoregion. A total of 65 per cent of the administrative units show a more than 3 per cent decrease in shrubland area, and 33 per cent show a more than 15 per cent decrease. Ten administrative units saw an 80–100 per cent reduction in shrublands but 13 per cent of administrative units saw an increase in shrublands.

Table 6. Land-cover change according to 300-m spatial resolution data, 2000–2020

Land-cover class	Change (ha)	Change (percentage)
Tree cover	-277,318.50	-2.05
Shrubland	-26,992.42	-8.53
Cropland	-9,907.82	-0.05
Snow and ice	-4,700.79	-2.84
Permanent water bodies	-4,551.18	-0.80
Moss and lichen	267.75	-0.22
Bare/sparse vegetation	25,173.38	3.28
Built-up	94,153.83	7.78
Grassland	204,411.26	0.94

Source: Author calculations based on 2019 data from European Union (n.d.).
Notes: Grassland includes wetlands since there was no separate spatial data available for this LCC in 2000. Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

As can be seen, overall change of land cover is not very high in percentage terms, and the most "changeable" LCCs are shrublands and artificial land cover or built-up land. Similar results were obtained by Buchner *et al*. (2020), who measured croplands and forests in the three South Caucasus countries and the North Caucasus between 1987 and 2020.

Regarding the qualitative changes in natural land cover (vegetation), the situation in the Caucasus Ecoregion is rather positive according to the Global 300-m spatial resolution data on land degradation based on European Space Agency (ESA) Land Cover Climate Change Initiative (CCI) Products, which were analysed for the purposes of this publication. About 96 per cent of land cover stayed stable in the last 20 years, 3 per cent of the land cover has been improved, and only about 1 per cent has degraded (UCLouvain 2017). However, while looking at the concentration of degradation, the most serious issues occurred on the Black Sea coast in the Turkish part of the Ecoregion, near urban areas and along the boundaries of forest areas. The central North Caucasus Plains showed some significant improvements in vegetation cover, which can be explained by the conversion of degraded pasturelands into better-managed croplands.

On the other hand:

1. Some studies (e.g. from the Russian Federation) suggest that tools such as Trends.Earth from Conservation International are not precise enough due to relatively low resolutions (250–300 m) and differ to various extents from local or national data. These studies consider cross-country comparison based on global databases to be problematic due to the possible mismatch of boundaries and erroneous interpretation of satellite imagery (Russian Federation 2019; Kust *et al*. 2023; Slavko, Andreeva and Kust 2023).

2. The low level of land degradation between 2000–2020, should not be confused with the general condition of the soil cover, as land erosion (both wind and water), pollution, salinization, acidification, and other types of erosion/degradation due to natural disasters and/or human activities, represent a serious problem for the Ecoregion (Yigini *et al*. 2013). For example, according to scientific data:

- In Armenia, about 44 per cent of the lands are exposed to erosion to varying extents, and 80 per cent of the area is prone to erosion (Suvaryan and Sargsyan 2008).
- In Azerbaijan, 43.29 per cent of the total area is subject to various degrees of erosion, and 66.6 per cent of the total area of the southern slope of the Greater Caucasus is eroded (Aliev 2020).
- Eroded arable soils in Georgia occupy 205,700 ha, or 30.5 per cent of the total arable land area, including 20,800 ha of strongly eroded soils (Gogichaishvili 2016).
- In the Russian Federation, the North Caucasus is considered one of the territories most threatened by water erosion, especially the Stavropol Uplands (Gusarov *et al*. 2021), the Kuma-Manych Depression and the northern slopes of the Greater Caucasus Mountains (Russian Federation 2019).
- In Türkiye, 59 per cent of rangelands, 54 per cent of forest lands, and 71 per cent of agricultural lands are under active erosion threat (Oğuz *et al*. 2016).

Finally, as the percentage of the rural population is still high (see Table 4 and map 5) and the level of industrialization is still relatively low, with variations between countries, one can assume that there is room for continued economic growth (see Figure 2). Therefore, the trends of urbanization and industrialization will persist and artificial surfaces like built-up areas and bare spaces will further increase (see Map 6). Also, climate change is expected to have a continuous impact in the Ecoregion resulting in increased arid and semi-arid areas. These tendencies will have other negative effects such as a mild but continued downward trend in tree cover and shrubland, as well as snow and ice. Nevertheless, if the rate of change stays relatively constant, the overall change in LCCs should be moderate within the coming years.

Even small changes in KBAs can have a devastating effect on ecosystem functioning and biodiversity in the Ecoregion. A good example is the Turkish part of the Ecoregion along the Black Sea. The area is not large enough to have a high impact on the overall land-cover change in the Ecoregion; however, together with Kolkheti Lowlands, it is the only homeland of the Colchic part of the Euxine-Colchic deciduous forests. Therefore, a high decline in tree cover, and increase in built-up areas and croplands in this area can lead to very significant degradation of land-cover quality, and seriously affect the Ecoregion's biodiversity.

Therefore, it is recommended in the future to conduct land cover change observation based on remote sensing and spatial analysis, not only at the NUTS 3 level, but also on the level of terrestrial ecoregions of the world, CLs, BLs and KBAs. This coupled with in situ monitoring will give the possibility to better assess not only the extent, but also the quality of land cover change in the Ecoregion.

5.2. Agricultural land: Cropland and grassland

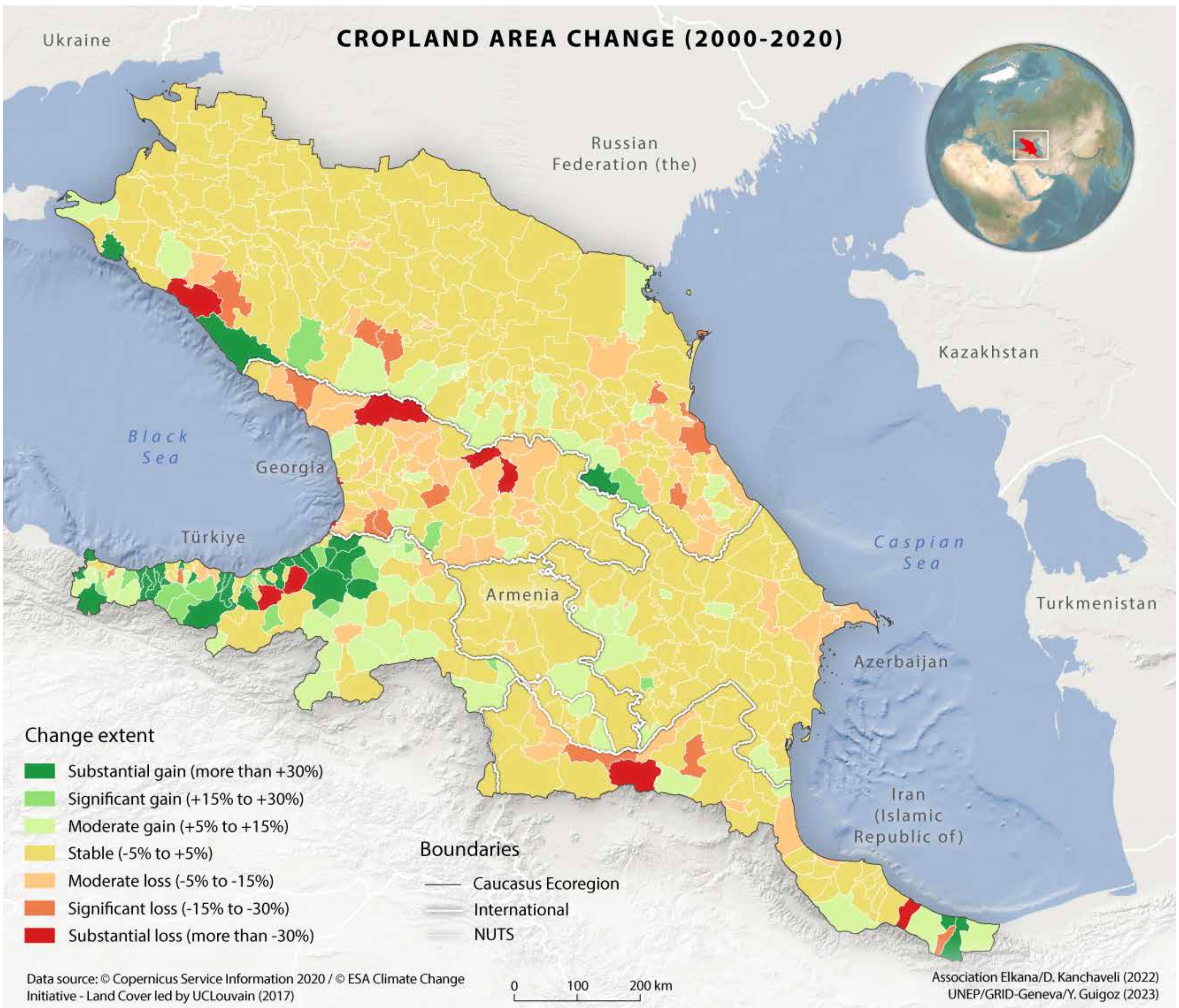
Based on spatial analysis, croplands and grasslands occupy approximately 35.8 million ha or 62.3 per cent of the territory of the Caucasus Ecoregion. Croplands make up 24.5 per cent of the total land cover, and grasslands cover 37.8 per cent.

Croplands are concentrated in the west and central parts of the North Caucasus Plains in the Russian Federation (66.4 per cent), followed by Azerbaijan (14.4 per cent) and the Islamic Republic of Iran, specifically, the territories containing the Kura-Aras Lowlands (8.1 per cent), Türkiye (4.8 per cent), Georgia (4.1 per cent) and Armenia (2.2 per cent).

As for grasslands, they are mainly concentrated in the south of the Ecoregion, in the territories of the South Caucasus Uplands, as well as on the Iori-Ajinour Plateau and Sabalan in Türkiye (18.4 per cent), Azerbaijan (15.3 per cent), the Islamic Republic of Iran (13.7 per cent), Georgia (9.9 per cent) and Armenia (8.9 per cent). In the north, grasslands dominate in the eastern North Caucasus Plains, as well as alpine zones of the Greater Caucasus Mountain Range, mostly within the Russian Federation (33.8 per cent).

A comparison of the data shows that both cropland and grassland area remained stable between 2000 and 2020 on both the Ecoregion and country levels (see Table 7). The highest increase in grasslands occurred in Georgia and the Russian Federation, a rise of 1.8 per cent in each country. Cropland area increased in Türkiye and Armenia by 5 per cent and 3.2 per cent respectively. Excessive or massive changes observed on NUTS 3 levels occurred mostly in areas with marginal shares of cropland and/or grassland (see Map 11). The data also clearly shows that the decrease in croplands was especially high in "urban" administrative units (areas with large cities) and occupied territories in Georgia (except Gali district, which had a 10 per cent increase in croplands in this period). Out of 47 NUTS 3 with above a 15 per cent increase in cropland area, 40 are in Türkiye, which, again, is a result of urban and industrial area expansion along the Black Sea coast.

The geospatial data, it should be noted, are not the same as official data published by the Food and Agriculture Organization of the United Nations (FAO) on "land under



Map 11. *Cropland area change by NUTS 3, 2000–2020.*

Table 7. Change in grasslands and croplands according to 300-m spatial resolution data, 2000–2020

Country	Grassland		Cropland	
	Difference (hectares)	Difference (percentages)	Difference (hectares)	Difference (percentages)
Armenia	-8,781.07	-0.51	14,419.26	3.18
Azerbaijan	-31,596.60	-1.14	46,908.54	1.41
Georgia	35,416.31	1.82	-14,312.71	-1.29
Islamic Republic of Iran	37,535.66	1.43	-22,651.02	-1.23
Russian Federation	156,902.63	1.82	-59,563.96	-0.44
Türkiye	14,934.33	0.38	25,292.08	4.98
Caucasus Ecoregion	204,411.26	0.94	-9,907.82	-0.05

Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

agricultural use" (FAO 2021a). This can be explained by methodological differences. Official country statistics and FAO data (see Table 8) are based on the total available land area defined as "agricultural" or "forest land", while sometimes these figures are outdated. For example, Georgia uses the numbers defined yearly as they were during the Soviet period. On the other hand, Georgia also publishes information on utilized arable and perennial cropland areas for a particular year and/or for the year of the last statistical survey (census). Therefore, for the calculation of the long-term change, the data comparison using FAO information is less reliable. Nevertheless, the data comparison below clearly shows that a significant share of croplands is not cultivated in the three South Caucasus countries.

Buchner *et al*. (2020) confirm poor utilization of croplands by the South Caucasus countries. Their study found that the decline in cropland from 1987 to 2000 in the North Caucasus was much lower than in the three South Caucasus countries. The possible explanations for this difference are less land

Table 8. Difference between official country statistics, FAO (2019) and 10-m geospatial resolution data (2019)

Country	Land-cover class	Country statistics office (2020)	FAO (2019)	10-m resolution geospatial data (2020)	Difference between country official statistics and 10-m resolution geospatial data (ha, percentage)	
Armenia	Forest area	334,020.00	328,700.000	367,259.971	33,239.97	9.95
	Grassland	1,562,170.00	1,172,000.000	1,916,680.923	354,510.92	22.69
	Cropland	481,340.00	505,000.000	309,328.273	-172,011.73	-35.74
	Agriculture	2,043,510.00	1,677,000.00	2,226,009.20	182,499.20	8.93
Azerbaijan	Forest area	1,040,200.00	1,120,200.000	1,233,511.474	193,311.47	18.58
	Grassland	2,426,600.00	2,423,400.000	3,299,904.638	873,304.64	35.99
	Cropland	2,352,900.00	2,356,400.000	2,004,398.719	-348,501.28	-14.81
	Agriculture	4,779,500.00	4,779,800.00	5,304,303.36	524,803.36	10.98
Georgia	Forest area	3,063,600.00	2,822,400.000	3,626,867.640	563,267.64	18.39
	Grassland	1,940,400.00	1,940,000.000	2,137,247.205	196,847.21	10.14
	Cropland	1,065,600.00	427,800.000	579,324.673	-486,275.33	-45.63
	Agriculture	3,006,000.00	2,367,800.00	2,716,571.88	-289,428.12	-9.63

Sources: Calculations based on Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); FAO (2019).
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

fragmentation and bigger parcels, uninterrupted market demand in the 1990s, more fertile chernozem soils (black soils), and more favourable climatic conditions compared to the complex mountainous terrain of the South Caucasus.

5.3. Biodiversity value of agricultural land

5.3.1. Crops, domesticated animals and farming systems

Agriculture in the Caucasus Ecoregion has ancient roots. Not only is there an extreme diversity of local crops and domesticated animals, but also of indigenous mixed farming systems adapted to the Ecoregion's climate conditions and vast variety of traditional products (see section 6.1.6.)

The territory of the South Caucasus borders the Fertile Crescent and is part of the extended Western Asian (or Near East) centre of the domestication of plants and animals. This area is home to 83 endemic plant species, including apricots, barley, grapes, lettuce, oats, peas, pomegranates, radish, rye, wheat, and many others (Yakar, Gerard and Thissen 2003; Akhalkatsi *et al*. 2012; Barker 2020). Plant remains discovered on the sites of ancient settlements in the Caucasus Ecoregion suppose the existence of developed farming in the sixth millennium BCE, inferring that farming practices had begun even before this era (Elkana 2019). Many species of non-native cultivated plants were also introduced and cultivated here over hundreds of years. The resulting abundance of these cultivated plants has led to landraces that are integral to the Ecoregion's landscape and culture. They play a crucial role in ensuring local food security (FAO 2021b) (see chapter 6).

Animal husbandry has a very long history in the Ecoregion due to a variety of natural, climatic and relief conditions with the coexistence of alpine, subalpine, valley and winter pastures. Because of the diversity of interconnected ecosystems, a semi-mobile form of pastoralism, transhumance, adapted to varying climate conditions became particularly common. Animals such as cattle, pigs, goats and sheep are believed to have been domesticated in the territory of the Ecoregion on the Anatolian plateau. Later, the horse, dog and different types of poultry were introduced and became an integral part of local farming and agricultural biodiversity. Semi-nomadic pastoralism with an annual transhumance between summer and winter pastures with sheep and cattle, also including local breeds of horses and dogs, is part of the regional past that shaped the landscapes. Ancient types of beekeeping and pastoral pig farming in the forests have been preserved in the Ecoregion (e.g., Jara honey and Kakhetian pig breeding in Georgia). All this contributes to the unique biodiversity reservoir that is not only of regional but also of global significance. Traditional crops and animal products have also been the source of an immense variety of long-established local commodities and unique cuisines, which have been instrumental in the development of organic agriculture and cultural and agrotourism sectors (FAO 2021b).

5.3.2. Grasslands

Subalpine and alpine ecosystems as well as semi-arid areas form the main grassland areas (Lewińska *et al*. 2021). Grassland in the Ecoregion includes grass phytocoenoses that vary significantly due to elevation, humidity, and other biophysical factors.

The biodiversity value of natural grassland and pasture ecosystems is evident due to increased species richness that often enhances biomass productivity and ecosystem functioning. Subalpine, alpine, and subnival mountain areas in the southern part of the Greater Caucasus Mountain range are largely covered with grasslands. Many former grassland steppes in the north and valleys in the south of the Ecoregion are today used for agriculture. Semi-deserts in the east, on the other hand, are used as winter pastures (see section 5.1). The Black and Caspian Sea coasts that stretch along the edges of the North Caucasus Plains contain large areas of herbaceous wetlands.

The Caucasus Ecoregion contains different meadow types noted here according to their phytosociological classification (REC-Caucasus 2019):

- Alpine meadows: Subalpine tall grasslands, alpine patches, and alpine meadows have distinct dominant species. The degree of grass vegetation and plant height, life forms, and biomass vary.
- Low mountain and plain meadows: Human activity and deforestation have led to the creation of these areas that typically include various forms of dale meadows.
- Steppes: Unique to semi-arid regions, needle grass (*stipa capillata, stipa lessigiana*), steppe needle grass (*stipa zalesskii*), yellow bluestem (*bothriochloa ischaemum*) and Volga fescue (*festuca valesiaca*) are the prevalent flora in steppe ecosystems.
- Semi-deserts: Artemisia and dale saltwort (*salsola dendroides, salsola ericoides*) dominate semi-deserts. These plants are primarily found in the most arid of the valleys and plains of the Ecoregion, usually up to 800 meters above sea level. Precipitation levels extend from less than 400 mm to 250 mm.

Habitats found in the Caucasus Ecoregion are classified as part of "Group E: Grasslands and land dominated by forbs, mosses or lichens" as defined by the European Union Nature Information System (EUNIS) (Davies, Moss and Hill 2004):

- E1. Dry grasslands
- E2. Mesic grasslands
- E3. Seasonally wet and wet grasslands
- E4. Alpine and subalpine grasslands
- E5. Woodland fringes, clearings and tall forb stands
- E6. Inland salt steppes
- E7. Sparsely wooded grasslands

Table 9. Share of total GDP for the agriculture, forestry and fishing sector, 2019

Country	Percentage of total GDP	Percentage of total employment	Percentage of total central government expenditures
Armenia	12	12	58
Azerbaijan	7	7	57
Georgia	6.6	6.6	50
Islamic Republic of Iran	12	12	21
Russian Federation	4	4	33
Türkiye	6	6	43
World	4	4	37

Source: FAO (2021a).
Note: National-level data for all countries.

Hay meadows and pastures of the Caucasus Ecoregion consist of natural and semi-natural habitats that are essential to biodiversity (Nakhutsrishvili 2013). Endemic species require support from these landscapes and indeed the economies and livelihoods of the Ecoregion that depend on livestock production also need these grasslands. Meadows and pastures will benefit from management through sustainable practices to mitigate environmental degradation (REC Caucasus 2019).

5.4. Socioeconomic and food security value of the agriculture, forestry and fishing sector

5.4.1. General socioeconomic profile of the sector

The agriculture, forestry and fishing sector is among the most important socioeconomic sectors in the Caucasus Ecoregion (see Table 9). Relatively low urbanization rates, especially of the three South Caucasus countries, lead to high social dependency factors. The socioeconomic importance of these activities is reflected in high central government expenditure rates for agriculture, forestry and fishing.

The agriculture, forestry and fishing sector (AFF) employs over 16.3 million people across the Caucasus countries. This includes numbers from the whole populations of Islamic Republic of Iran, the Russian Federation and Türkiye and not only those areas of these countries that are in the Caucasus Ecoregion. A total of 2.7 million people from the three South Caucasus countries are employed in AFF and over half of them are women (55 per cent). This is a much higher female participation rate than the world average. In fact, Armenia and Azerbaijan have one of the highest percentages of female employment in agriculture in the world (see Table 10).

Women participate at a level of 43 per cent in the agricultural labour force worldwide (FAO 2011, p.2). Agriculture is essential to food security and global food production, but also clearly contributes to the socioeconomic wellbeing of women through their employment in this sector. Women contribute to sustainable agricultural practices and economic development in the mountain communities of the Ecoregion and, since they are often stewards of the land, they are thus at the forefront of sustainable development efforts. Women are also, however, potentially more vulnerable to climate change than men, due to their limited accessibility to land and livestock ownership, their risk of natural hazards and a lack of inclusion in decision-making. Difficulties accessing financial services along with other economic barriers also have a negative impact on women (FAO 2022).

Considering the added value from production and employment, there was a clear global trend between 2000 and 2019 of increased added value in the AFF sector, with a reduction in added value as a percentage of total GDP and employment (see Table 11). The Ecoregion has followed the global pattern that results from other sectors developing faster than AFF. The opposite is true in the Islamic Republic of Iran, where added value in the total GDP and employment in the sector increased; this may demonstrate the impact of Western sanctions on the Iranian economy, which slowed the development of other sectors. Armenia and Azerbaijan, followed by the Islamic Republic of Iran, show an especially high increase in added value production, while Georgia increased value added by only 11 per cent, taking into consideration that the country increased the percentage contribution to GDP of government expenditures by 525 per cent between 2010 and 2019 (from 0.04 per cent to 2.3 per cent). In general, Armenia seems to have the most efficient development with a high increase of added value, in light of decreased central government expenditure and employment.

Table 10. Female employment in agriculture, forestry and fishing sector, 2019

Country	Female participation (thousands)	Female participation (percentage)
Armenia	216.21	58
Azerbaijan	949.44	57
Georgia	319.07	50
Islamic Republic of Iran	898.53	21
Russian Federation	1,380.93	33
Türkiye	2,280.95	43
Total	6,045.13	37

Source: Author calculations based on FAO (n.d.)
Note: National-level data for all countries.

5.4.2. Main agricultural production areas and structures

Agriculture of the Ecoregion countries is dominated by privately owned and managed traditional smallholder family farms, characterized by a diversity of traditional production systems and crops.

- According to the 2014 agricultural census in Armenia, 96 per cent of the agricultural land under private ownership is held in 346,000 small family farms, with an average size of 1.48 ha. These are usually fragmented into several parcels (Statistical Committee of Armenia 2014). Such farms produce over 95 per cent of the country's total agricultural output (Statistical Committee of Armenia 2019; FAO 2020). Commercial farms account for only 4 per cent of the total number of agricultural holdings and have an average size of 62 ha.
- The agricultural sector of Azerbaijan includes 1,351,000 family farms (99 per cent of the total number of agricultural holdings) with an average size of 1.5 ha (FAO 2015). These small farms are usually fragmented in several parcels and produce 91 per cent of the agricultural output of the country (International Fund for Agricultural Development 2018; State Statistical Committee of Azerbaijan 2019).
- Georgian agriculture is also dominated by smallholder production. According to the 2014 census, 1.52 million people live in rural areas, and 574,100 holdings operate

Table 11. Change of economic share of the agriculture, forestry and fishing sector, 2000–2019

Country	Added value 2000-2019 (percentage change)	Added value (percentage of total GDP)	Employment in the sector (percentage of total employment)	In total employment (percentage of total employment)	In central government expenditure 2010–2020 (percentage of total government expenditure)
Armenia	106	-7	-48	-19	-53.5
Azerbaijan	134	-7	12	-5	20.0
Georgia	11	-10	-33	-14	525.0
Islamic Republic of Iran	95	2	5	-7	N/A
Russian Federation	42	-1	-57	-9	350.0
Türkiye	57	-4	-5	-9	-14.6
Caucasus Ecoregion	62	-4	-26	-10	N/A
World	73	N/A	-17	-13	N/A

Source: FAO (2021a).
Note: National-level data for all countries.

on agricultural land, with two or more parcels and 1.31 ha average size (National Statistics Office of Georgia 2014).

- According to the 2014 census, arable lands in the Islamic Republic of Iran under temporary and permanent crops came to about 16,477,000 ha distributed among 3,359,000 agricultural holdings with an average size of 4.9 ha (Statistical Centre of Iran 2022).
- Unlike the South Caucasus countries where agricultural land was primarily redistributed among the rural population after the collapse of the Soviet Union, in the Russian Federation most of the kolkhozes and sovkhozes were transferred into agricultural enterprises or corporate farms of different legal forms in the early 1990s (Russian Federation, Federal State Statistics Service 2021). At present, there are three main holding types in the Russian Federation: 457,000 rural household plots (an average size of 28 ha), 175,000 peasant farm holdings (an average size of 226 ha) and 36,000 corporate farms (an average size of 2,500 ha) (Russian Federation, Federal State Statistics Service 2016).
- Subsistence and semi-subsistence farming are important characteristics of Turkish agriculture as well, with an average farm size of 12.9 ha and up to six parcels of land per holding (Turkish Statistical Institute 2016).

The range of crops produced in the Ecoregion is very broad and includes almost all major products. A variety of cereals, tea, spices, wine, nuts, continental and subtropical fruits, greens and vegetables, oil and root crops are produced in the Ecoregion. The Islamic Republic of Iran, the Russian Federation, and Türkiye are among the world's top producers of many crops, including wheat, barley, rye, oats, sunflower seed, potatoes, sugar beet, pumpkin, meat and dairy products (the Russian Federation); tomatoes, hazelnuts, walnuts, figs, apricots, cherries, melons, leeks, lentils, beans, watermelons and fresh grapes (Türkiye); and raisins, barberries and pistachios (the Islamic Republic of Iran).

The Ecoregion harvested area of agricultural crops accounts for about 6.8 per cent of the global harvested area of primary crops, including 9.1 per cent of the globally harvested area of cereals, 5.2 per cent of the globally harvested area of oil crops and 5.3 per cent of globally harvested area of fruits (FAO 2019). The Ecoregion produces 6 per cent of the world's cereals and 5 per cent of the world's fruits and vegetables. A total of 67 per cent of the total harvested area of the Ecoregion is sown with cereals and 17 per cent with oil crops, while only 4 per cent is used for vegetable and fruit production.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The Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye are very important for the AFF sectors of these countries. For instance, Kransodar and Stavropol are one of the main agricultural regions in the Russian Federation; the Turkish Black Sea area is the main production area of subtropical fruits, tea, hazelnuts and more; and the Iranian part of the Ecoregion produces wheat, barley, citruses, tea and other crops.

In Armenia, production of fruits (e.g. table grapes, apricots, pomegranates, figs) and berries makes up an important part of agricultural production and significantly contributes to exports; the country also produces meat, dairy and cereal products, mainly for its own food supply, ensuring food security. Azerbaijan produces several industrial crops like cotton and tobacco, as well as fruits, nuts, tea and berries. Georgian agriculture is very diverse; however, wine grapes, nuts, fruits, citruses, tea and greens are produced more as export commodities, while grains, vegetables and livestock products are produced mainly for local consumption.

5.4.3. Food security: Importance of agriculture, forestry and farming

Food security is ensured, according to the FAO (2008, p.1), "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". Food security is a complex term, measured using different indicators. For example, the Global Food Security Index is based on 59 unique indicators, and measures the state of food affordability, availability, quality, safety and resilience (Economist Impact 2022). Unfortunately, the 2022 iteration did not include information on Armenia, Georgia and the Islamic Republic of Iran.

The term "food self-sufficiency" is closely related to food security. However, recent publications (FAO *et al*. 2021a) place less emphasis on national self-sufficiency than on cereal import dependency, as food trade is an alternative to self-sufficiency. Therefore, it is difficult to obtain comparable data in terms of dependency on food imports for major commodities essential to food security. Porkka *et al*. (2013) manage nonetheless to show that while the global food supply increased between 1965 and 2005, food self-sufficiency (domestic production > 2500 kcal per capita per day) has not followed that trend. While in the 1960s, the insufficiency of domestic production was directly linked to the insufficient food supply at the national level, food imports have increasingly compensated for deficits and thus have become more important to food security (Porkka *et al*. 2013). Trade, however, has its limitations in times of global crises, such as wars and geopolitical turbulence, pandemics, or climate change and climatic disasters. Long-distance food trade can also have high environmental costs, including an increased carbon footprint. In low-income countries, there can be impacts on the quality of available food and on rural economies. Maintaining a healthy balance between local production and trade is therefore vital. At present, the only country in the Ecoregion in which the total value of agricultural exports exceeds the value of agricultural imports is Türkiye (see Table 12).

The world's top exporter, the Russian Federation, is the ultimate leader in the region considering cereal-import dependency with a self-sufficiency ratio of 164 per cent, followed by Türkiye, which is also close to cereal self-sufficiency. Other Caucasus countries, especially Armenia and Georgia, heavily depend on cereal imports (see Table 13) due to scarcity and fragmentation of arable lands suitable for production of cereals, especially wheat and, in case of Georgia, relatively low per/ha production (see Table 14). At the same time, Türkiye was the third-largest importer of wheat in the world (FAO 2021a).

Outside of Armenia and Azerbaijan, other countries in the Ecoregion are clearly behind in per hectare production of cereals and oil crops, while relatively well-performing in other areas (see Table 14).

Table 12. Food exports versus food imports, USD millions, 2019

Country	Exports (millions of US dollars)	Imports (millions of US dollars)	Difference (millions of US dollars)	Difference (percentage)
Armenia	473	630	-157	-33
Azerbaijan	740	1,701	-961	-130
Georgia	788	1,071	-283	-36
Islamic Republic of Iran	4,117	9,690	-5,573	-135
Russian Federation	23,329	26,836	-3,507	-15
Türkiye	17,902	11,720	6,182	35

Source: Author calculations based on FAO (2021a).
Note: National-level data for all countries.

Table 13. Cereal import dependency ratio

Country	2000–2002 (percentage)	2016–2018 (percentage)
Armenia	61.6	53.3
Azerbaijan	29.0	30.6
Georgia	59.3	62.9
Islamic Republic of Iran	37.4	36.1
Russian Federation	-3.5	-63.6
Türkiye	1.1	0.8
World	-0.5	-0.2
Europe	-18.5	-28.4

Source: FAO (2021a).
Note: National-level data for all countries.

5.5. Environmental pressure from the agriculture sector on land cover

5.5.1. Agricultural biodiversity loss and land degradation

Modern agriculture causes a drastic reduction in local plant and animal diversity, which may impact long term food and agriculture, and the Caucasus Ecoregion has been no exception (Soysal Al 2019).

Characterized by increased use of chemical pesticides and fertilizers, monoculture production and a shift to a few modern high-yield crop varieties and animal breeds, the rapid industrialization of agriculture has had significant effects on soil biodiversity and health, agricultural ecosystem balance (including spread of pollinator and other beneficial species), water use by the agricultural sector, and diversity of traditional crop and animal varieties/breeds in the last hundred years.

Different types of economies – communist/socialist economies in the Soviet Union in the Russian Federation and South Caucasus until the early 1990s, and capitalist economies elsewhere since the 1990s – have pushed the sector in the same direction of modernization, farm enlargement and standardized production. With its drive towards collectivization, the Soviet planned economy was even more intensive and severe, and therefore had faster and deeper impacts on the ground from the 1930s to the 1950s, while these processes started to accelerate in Türkiye and the Islamic Republic of Iran by the 1980s.

Serious problems affecting both agriculture and livestock breeding of the Ecoregion include different types of land degradation such as wind erosion in arid and semi-arid areas and farmlands with damaged windbreak systems, water erosion in unsustainably irrigated or drained farmlands and steep mountain slopes (especially with degraded vegetation due to overgrazing in high mountain areas) as well as salinization, acidification, and chemical pollution of agricultural land.

Table 14. Average tons/hectare production of agricultural products, 2019

Country	Cereals	Vegetables	Oil crops	Fruit	Roots and tubers
Armenia	13.00	27.35	N/A	11.32	20.20
Azerbaijan	3.23	24.87	2.69	12.26	17.61
Georgia	2.55	11.50	1.67	4.11	12.19
Islamic Republic of Iran	2.19	30.88	1.82	15.66	33.49
Russian Federation	2.72	24.62	1.64	8.87	17.82
Türkiye	3.20	33.92	2.74	16.83	35.33
Region	2.72	29.73	1.80	14.19	20.38
World	4.11	18.90	3.39	13.53	13.38

Source: Author calculations based on FAO (2021a).
Note: National-level data for all countries.

Table 15. Application of pesticides and chemical fertilizers per hectare of cropland area

Country	Pesticide use per cropland area (kg/ha)			Inorganic fertilizer use per cropland area by nutrient (kg/ha)		
	2000	2019	Difference (percentage)	2000	2019	Difference (percentage)
Armenia	0.14	1.04	7.4	N/A	178.90	N/A
Azerbaijan	0.07	0.23	3.3	N/A	67.20	N/A
Georgia	2.90	6.00	2.1	N/A	49.20	N/A
Islamic Republic of Iran	0.58	0.39	0.7	53.00	39.80	0.8
Russian Federation	0.24	0.63	2.6	7.60	22.30	2.9
Türkiye	1.27	2.22	1.7	52.30	106.80	2.0
World	2.06	2.69	1.3	91.30	122.00	1.3

Source: Author calculations based on FAO (2021a).
Note: National-level data for all countries.

Use of chemical fertilizers and pesticides is neither the primary nor the most important cause of land degradation in the Ecoregion. According to official statistical data, countries of the Ecoregion have significantly lower than world average pesticide use (except for Georgia) and fertilizer use (except for Armenia) (see Table 15). Industrial, urban and mining contamination are believed to be the most significant contributors to land pollution and degradation in all countries of the Ecoregion. In Azerbaijan, 33,300 ha of soils are contaminated, one third or 11,143 ha are polluted by petrochemistry products, another third or about 11,000 ha with mining products and another 5,000 ha with construction waste (FAO 2018, p. 18). Scientific studies conducted in Georgia, the Russian Federation and Türkiye show similar results.

Mining, smelting, fertilizer application and high use of plastics and micro-plastics lead to the contamination of farmland soils with heavy metals in the Islamic Republic of Iran. In addition, the shortage of irrigation water leads to a substitution by sewage irrigation and sludge reuse. Indeed, the scarcity of good quality water makes it difficult to implement policies that would prevent soil contamination (FAO 2018, p. 387).

On the other hand, these data might be misleading, especially in the South Caucasus countries. Application of pesticides and fertilizers by peasant farm holdings is sporadic. In some areas, there is very low application, but in other areas with more intense farming, there can be high and unprofessional application of pesticides causing contamination of water and soil. In this regard, awareness-raising activities carried out by public extension systems is critical, since the application of synthetic pesticides affects pollinator species.

Climate change-related extreme weather events such as drought, heavy rains (followed by floods and landslides), mudflows, strong winds, and dust aerosol are among the main contributors of land degradation, including wind and water erosion. Underdeveloped windbreak systems or their elimination, damage or lack of drainage and sustainable irrigation systems and excessive watering of crops further accelerate this process.

A significant factor for environmental and soil degradation is water stress, or the ratio between total fresh water withdrawn by all major sectors and total renewable freshwater resources, after considering environmental water requirements. As a result, non-renewable water resources are used excessively and are diminishing rapidly. Water stress is an important problem in all the countries of the Ecoregion except Georgia and the Russian Federation, with the Islamic Republic of Iran having the highest water stress level of 81 per cent, followed by Armenia at 55 per cent, Azerbaijan at 54 per cent and Türkiye at 45 per cent. The increase of this indicator between 2000 and 2020 was especially high in Armenia (17 per cent) and Türkiye (14 per cent). The withdrawal of water by the agricultural sector is one of the main factors of water stress. Often in these countries the water withdrawal of the agricultural sector is a high proportion of the total water withdrawal (see Table 16). In these countries, investment in sustainable irrigation is especially important.

Ecological and agroecological movements in the 1990s (such as organic and regenerative agriculture, agroecology, and permaculture) led to increased popularity of soil and agricultural biodiversity conservation techniques among farmers and the broader public. Organic production is thus slowly increasing in the Ecoregion, which is a positive

Table 16. Share of water withdrawal by agriculture in total withdrawal (percentage)

Country	2000	2019	Difference
Armenia	4.0	4.0	3
Azerbaijan	8.7	8.7	34
Georgia	21.7	21.7	-37
Islamic Republic of Iran	3.1	3.1	-2
Russian Federation	3.4	3.4	9
Türkiye	0.8	0.8	7

Source: Author calculations based on FAO (2021a).
Note: National-level data for all countries.

For me, sustainable land management is the most important issue in the Caucasus Ecoregion. Sustainable land practices ensure the preservation of natural ecosystems, protect biodiversity, promote resilient agriculture and support the well-being of local communities. By prioritizing sustainable land management, we can strive for a harmonious balance between human activities and the conservation of nature, fostering long-term environmental sustainability and socioeconomic development in the Caucasus.

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development. If done properly, these techniques prevent soil degradation and enhance agricultural biodiversity conservation. Local landrace seeds and breed conservation initiatives were begun by producer and consumer cooperatives and associations. In parallel, demand for agroecological and traditional products started to increase among consumers. International treaties such as the International Treaty on Plant Genetic Resources for Food and Agriculture, the Convention on Biological Diversity and FAO-led initiatives in biodiversity conservation further pushed the countries to accelerate agricultural biodiversity conservation efforts (FAO 2021b). However, progress remains at an early stage, and policies to accelerate the application of agroecological and organic practices by the farmers of the Ecoregion are still needed. Türkiye and the Russian Federation are among the top 20 organic producer countries. Nevertheless, the share of organic-certified agricultural land in the total agricultural land is marginal in the Ecoregion, with the highest share being in Türkiye (1.7 per cent in 2020); other countries have lower shares (Willer *et al*. 2020).

5.5.2. Grassland degradation

Global temperature increases are likely to have a significant impact on high mountain species which are adapted to lower temperatures. Present assumptions determining the influence of climate change stress factors on the biodiversity of the high mountain and semi-arid ecosystems of the Ecoregion are not based on credible assessments (Turner *et al*. 2020). The high mountain and semi-arid ecosystem species may become replaced by thermophilous species, which are presently limited by the low temperatures of high altitudes leading to major shifts in the plant communities of the alpine and subnival zones.

Grazing practices can contribute to the sustainability of grassland management, which directly affects vegetation diversity and composition as well as associated biodiversity (Olff *et al*. 1998). Uncontrolled intensive grazing results in degradation of the vegetation. Soil erosion follows, which further influences biodiversity and livestock breeding. Natural meadows, used traditionally for grazing, have rates of pasture degradation that often exceed that of restoration, impeding the self-regeneration of natural vegetation. Winter pastures are particularly vulnerable, and overgrazing can also trigger desertification processes. Moderate to severe soil erosion is evident in areas heavily grazed by sheep (see section 6.2.2.).

On the other hand, the rate of natural afforestation in former Soviet republics increased considerably after the disintegration of the Soviet Union, spurred on by major economic and local demographic changes. After the end of the Soviet livestock farming system, large portions of grasslands in the Greater Caucasus were abandoned, giving way to natural succession and afforestation. Grazing is believed to be a crucial factor in maintaining these meadows; without constant grazing, forest may soon completely replace natural grassland ecosystems. Studies conducted in the Ecoregion highlight the issue of the afforestation processes evident in many grassland areas and meadows; open areas are being invaded by woody plants, apparently due to reduced grazing pressure (NACRES 2019).

FAO data suggest that there was only a 2 per cent general increase in livestock head in the Ecoregion countries between 2000 and 2020 (see Table 17) with an 11 per cent reduction in cattle and buffalo breeding, a 24 per cent reduction in breeding of asses, horses and camels, and a 7 per cent increase in sheep and goat farming (FAO n.d.).

As the data from the Islamic Republic of Iran, the Russian Federation and Türkiye cannot be extrapolated on the Ecoregion level, we will only consider the pressure from livestock in Armenia, Azerbaijan and Georgia more closely. A total of 13,911,000 head of livestock were reported in 2020 in these three countries of the South Caucasus. Only Azerbaijan had a high average density in livestock per hectare (see Table 18). The average density for the South Caucasus is 2.5 heads per hectare of officially reported grassland area, which already

Table 17. Livestock head, Change between 2000 and 2020 (percentage)

Country	Cattle and buffaloes (percentage)	Sheep and goats (percentage)	Other (donkeys, horses, camels) (percentage)
Armenia	21	21	-30
Azerbaijan	35	40	40
Georgia	-24	41	9
Islamic Republic of Iran	-37	-21	-3
Russian Federation	-35	53	-23
Türkiye	62	42	-77
Ecoregion	-13	7	-24

Source: Author calculations based on FAO (n.d.).
Note: National-level data for all countries.

shows a serious threat of overgrazing and pasture degradation in the case of a high level of open grazing. However, it is necessary to analyse data on the NUTS 3 level for the winter and summer periods separately.

Pasture restoration and afforestation can be encouraged through better management of grazing, pastures and choice of livestock breeds. Knowledge of relief, soil and climate conditions should be mastered to arrive at realistic conservation goals. Furthermore, sustainable practices in grazing along with soil and biodiversity efforts can lead to improved economic output thanks to better quality animal feed and thus greater productivity for herders whose livelihoods depend on their livestock.

5.5.3. Climate change and agriculture, forestry, and fishing sector

Climate change is leading to an increase in average annual temperatures all over the world, accompanied by extreme meteorological events such as severe heat waves, droughts, storms, heavy rain and hail, glacial melt, shrinking of water resources, increased forest fires, desertification, floods, snow avalanches and more. All these factors seriously affect the environment, including the AFF sector. In addition, scientists point to the specific impacts of a changing climate on the AFF:

- Increased carbon effects: Higher rates of photosynthesis can result in increased growth, decreased water use, and lower protein production in plants (Taub 2010).
- Daylight effect: Due to higher temperatures, plants will expand to the north, but this change may lead to lower yield due to reduced sun exposure.
- Pest, pathogen and disease effect: Warmer climates and/or increased humidity will lead to an expansion of pests and diseases into new areas and thus reduce yield, possibly contributing to increased use of pesticides and fertilizers. Dryer summers could also contribute to a reduction of fungal diseases, however.

The correlation between all these factors will determine the change in agricultural productivity and composition of natural habitats in the future.

The year 2020 was the warmest globally, with a 1.7°C temperature change compared to the 1951–1980 average. The largest mean annual temperature change in the world was 3.7°C, recorded in the Russian Federation. A 1.93°C average change was recorded in the three South Caucasus countries (FAO 2021a.).

Table 18. Average head of livestock per hectare of grassland in the South Caucasus countries, 2020

Country	Cattle and buffaloes	Sheep and goats	Other (asses, horses, camels)	Total livestock
Armenia	0.49	0.57	0.01	1.07
Azerbaijan	1.09	3.33	0.03	4.46
Georgia	0.46	0.46	0.03	0.94
Total South Caucasus	0.74	1.74	0.03	2.51

Source: Author calculations based on FAO (n.d.).

There are many methods to adapt to these changes, from general disaster risk prevention measures to specific measures in agriculture: choosing breeds and varieties adapted to pests, diseases and weather extremes; shifting from monoculture to diversified production; applying sustainable methods of irrigation; using land cultivation measures such as intercropping and crop rotation, conservation tillage, and contour or terrace farming; rotational or centripetal grazing; and building windbreaks or buffer strips. Overcoming the gaps between scientific and local/traditional knowledge through a greater integration and dialogue between them should contribute to determining best agricultural management practices.

Agricultural emissions are one of the main contributors to climate change. Agriculture, forestry and land use directly account for 18.4 per cent of global greenhouse gas emissions. The food system, including refrigeration, food processing, packaging and transportation, accounts for around 26 per cent of global greenhouse gas emissions. The three South Caucasus countries contribute 0.5 per cent of these emissions. If the Islamic Republic of Iran, Russian Federation and Türkiye are counted as a whole, the Ecoregion countries make up 4 per cent of global agriculture, forestry and fishery emissions. The most important contributors of these emissions are livestock farming, including enteric fermentation and manure left on pastures – accounting for 43 per cent of the total emissions of the six countries of the Ecoregion, followed by synthetic fertilizers (8 per cent) and "other", including field crop burning, deforestation and emissions from soil cultivation (47 per cent). Action by the countries of the Ecoregion to reduce emissions should focus on:

- improving livestock feeding systems and manure management practices (e.g. aerobic decomposition),
- using fertilizers efficiently,
- stopping the burning of crop residues in agricultural fields,
- improving grazing practices, and
- using effective strategies for forest fire management.

5.5.4. Progress towards relevant Sustainable Development Goals for agriculture, forestry and farming

Progress towards more sustainable land-cover management could be assessed with the use of data from the following Sustainable Development Goal indicators, disaggregated by sex and rural/urban areas:

- SDG 1: End poverty in all its forms (targets 1.1, 1.2, 1.4);
- SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture (targets 2.1, 2.2, 2.3, 2.4, 2.5, 2.a);
- SDG 5: Achieve gender equality and empower all women and girls (target 5.a);
- SDG 12: Ensure sustainable consumption and production patterns (target 12.2);
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (targets 15.1, 15.2, 15.3, 15.4).

Available statistical data in the United Nations databases for some relevant SDG indicators (1.4, 2.3, 2.4, 5.a, 12.2) do not allow for systematic analysis on the regional level. More information is available on certain indicators

Table 19. Prevalence of undernourishment, food insecurity and obesity in the Caucasus Ecoregion countries (percentage)

	Undernourishment		Severe food insecurity	Moderate or severe food insecurity	Obesity
Country	2000–2002 (percentage)	2018–2020 (percentage)	2018–2020 (percentage)	2018–2020 (percentage)	2016 (percentage)
Armenia	26.1	3.4	1.1	12.7	20.2
Azerbaijan	17.0	<2.5	<0.5	8.9	19.9
Georgia	7.7	8.7	9.5	39.7	21.7
Islamic Republic of Iran	4.8	5.5	8.7	42.5	25.8
Russian Federation	4.0	<2.5	<0.5	6.0	23.1
Türkiye	<2.5	<2.5	N/A	N/A	32.1
World	13.2	8.9	10.5	27.6	13.1
Europe	<2.5	<2.5	1.1	8.0	N/A

Source: FAO (2021a).
Note: National-level data for all countries.

(1.1, 1.2, 2.1, 2.2, 2.5, 2.a and 15.1 through 15.4) (United Nations Department of Economic and Social Affairs [UNDESA] n.d.). Poverty levels have been falling in all countries of the Ecoregion; however, the eradication of extreme poverty and the halving of national poverty rates are still milestones to reach for the Caucasus countries (the Russian Federation and Türkiye report zero poverty for indicator 1.1 of SDG 1).

Global food security data (see Table 19) suggest that the global commitment to Zero Hunger (SDG 2) was already under threat even before the COVID-19 pandemic. Making progress in this regard was even more difficult after the pandemic (FAO *et al*. 2021). Recent developments clearly show that the sustainability of food, agriculture and natural resource management systems can only be sustained through inclusive polices. Vulnerable and disadvantaged populations in rural communities must be targeted with effective policies to tackle the root causes of malnutrition and poverty to achieve zero hunger (FAO 2020). Statistical data suggest that Georgia and the Islamic Republic of Iran still experience undernourishment and severe food insecurity. The prevalence of moderate or severe food insecurity and obesity are problematic for the entire region (all Caucasus countries are above the world average and Türkiye is among the top 15 in the world).

Detailed data is available on all relevant indicators for SDG 15: Life on land (see Table 20). The average proportion of terrestrial (and mountain) key biodiversity areas (KBAs) covered by protected areas in the Ecoregion is high, except for in Türkiye.

5.6. Forestry

5.6.1. Tree cover profile and its biodiversity value

Based on spatial analysis, tree cover in the Caucasus Ecoregion amounts to approximately 14.3 million ha or 25.1 per cent of the territory. Forests of the Caucasus Ecoregion have a high level of endemism and unique biodiversity. Tree cover has important ecological functions that provide ecosystem services such as climate formation (i.e., oxygen production and carbon sequestration), soil protection (i.e., control of erosion and floods), and water regulation. These indirect benefits of forest ecosystems help mitigate the impacts of climate change and natural disasters.

Tree cover is mainly concentrated on the south-west and north-west slopes of the Greater Caucasus Mountain Range in the Russian Federation (43.6 per cent), followed by Georgia (25.4 per cent), the Black Sea coast of Türkiye (12.4 per cent), Azerbaijan (8.6 per cent), the Talysh-Western Alborz Mountains in the Islamic Republic of Iran (7.3 per cent) and Armenia (2.6 per cent).

Data show that forest area remained stable between 2000 and 2020 on Ecoregion, country and NUTS 3 levels in 333 NUTS 3 out of 477 (see Map 12). Moderate and significant loss of tree cover was observed in 98 NUTS 3 and substantial loss was seen in 36 NUTS 3. Reductions mainly occurred in the North Caucasus Plains, Kura-Aras Lowlands, Iori-Ajinour Plateau and South Caucasus Uplands of Armenia and Türkiye. The spatial analysis suggests that most of this reduction in the

Table 20. Selected SDG 15 indicator data

	Indicator 15.1.2(b) Average proportion of Terrestrial KBAs covered by protected areas, percentage		Indicator 15.2.1(a) Above-ground biomass in forest, tons per hectare		Indicator 15.2.1(c) Proportion of forest area with a long-term management plan, percentage		Indicator 15.2.1(d) Proportion of forest area within legally established protected areas, percentage		Indicator 15.3.1 Proportion of land that is degraded over total land area, percentage		Indicator 15.4.1 Average proportion of Mountain KBAs covered by protected areas, percentage	Indicator 15.4.2 Mountain green cover index
Country	2020	Change since 2010	2020	Change since 2010	2020	Change since 2010	2020	Change since 2010	2020	Change since 2015	2020	2015
Armenia	22.57	1.02	80.70	0.60	N/A	N/A	N/A	N/A	19.40	0.10	23.40	95.90
Azerbaijan	36.61	0.52	N/A	N/A	N/A	N/A	34.42	N/A	12.80	1.20	55.51	89.95
Georgia	40.35	5.93	119.30	N/A	16.09	10.39	11.19	3.34	6.60	1.80	40.91	95.41
Islamic Republic of Iran	43.49	N/A	N/A	N/A	28.99	0.18	14.12	4.12	N/A	N/A	43.22	34.28
Russian Federation	25.48	2.73	77.30	3.40	100	N/A	2.28	0.12	N/A	N/A	38.65	85.39
Türkiye	2.33	0.06	48.10	6.50	100	2.53	34.33	2.61	13.40	(0.90)	0.79	92.05

Source: Author calculations based on data from UNDESA (n.d.)
Note: National-level data for all countries.

South Caucasus occurred in arid or semi-arid areas vulnerable to climate change, with a marginal share of forestlands and intensive livestock breeding or grain production; while in the North Caucasus Plateau, 28 NUTS 3 with high rates of tree cover suffered moderate or high reductions, which can be explained by intensive legal or illegal forest cutting. Shamakhy was the only NUTS 3 in Azerbaijan with a substantial gain of tree cover. Georgian tree cover decreased the least in the Ecoregion by just 0.8 per cent (see Table 21).

This overview, based on the 300-m resolution map, might not fully reflect the afforestation process in some high mountainous areas of Armenia, Georgia and the North Caucasus, due to high migration and abandonment of croplands and rangelands (e.g. Tusheti), as well as the loss of high-value intact forest areas spread across the western slopes of the Greater Caucasus Mountain range. The loss of intact forest is quite significant at 5 per cent (see Table 22). In the territory of the Russian Federation, the loss was two times higher than in Georgia.

Buchner *et al*. (2020) show a slight increase in forest cover for the North Caucasus, Georgia and Armenia and a decrease until 2005 for Azerbaijan. The increased forest cover was smaller than in Central and Eastern Europe and the former Soviet Union during the same period. Large areas of forest loss in the North Caucasus were noted in 2014, which can be attributed to the Olympic Games in Sochi (Buchner *et al*. 2020) (see chapter 6).

Map 12. *Tree cover area change by NUTS 3, 2000–2020.*

Table 21. Change in tree cover according to 300-m spatial resolution data, 2000–2020

Country	Difference (hectares)	Difference (percentage)
Armenia	-10,065.16	-2.46
Azerbaijan	-35,514.57	-2.49
Georgia	-28,688.35	-0.81
Islamic Republic of Iran	-20,164.54	-2.09
Russian Federation	-138,610.67	-2.54
Türkiye	-44,275.21	-2.57
Ecoregion	-277,318.50	-2.05

Source: ECMWF(n.d.); UCLouvain (2017).
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

Forests in the Ecoregion contain diverse plant communities and over 200 habitats. These forests are home to more than 2,870 plant species, of which 120 are trees and 250 are shrubs. Oriental beech, chestnut, hornbeam, and oak forests (temperate broadleaf forests) are the most prevalent. The altitudes of subalpine forests (1,800–2,500 m) vary in the east and west of the Ecoregion; the forest line is much lower in the west (150–200 m) than in the east (450–600 m). Forests in very wet areas (Colchic and Hyrcanian) descend to sea level, others are in dry areas (Aras River basin) (Zazanashvili *et al*. 2020). The western Lesser and Greater Caucasus Ranges are home to dark coniferous forests made up of Oriental spruce and Caucasian fir trees that flourish on acidic mountain-forest soils. They are generally found between 1,400 m to 1,750 m (Zazanashvili *et al*. 2020).

The central Greater Caucasus Range also contains dark coniferous forests and spruce and fir forests, which are found in the western Lesser Caucasus at the same altitudes and on the same acidic soils. Pine forests (P. kochiana) are distributed throughout the upper Kura River basin. Floodplains and terraces contain plain forests that grow on humid soils. These lowland forests are to be found throughout low river terraces and floodplains. Tugai forests are riparian forests located along rivers in continental arid regions. Alnus, Betula, Populus, Salix, and Tamarix are the principal shrub communities and grassland vegetation making up these forests. Hydroelectricity and irrigation are chief among human activities that have made these forests the most endangered in the Ecoregion. These crucial habitats are home to diverse plant and animal life including many species on national red lists. Their vulnerability thus underscores an urgent need for conservation. Rocky slopes of the eastern and southern Caucasus have woodlands made up of pistachio and juniper trees and a mix of mountain-xerophytic and mountain-steppe species of grass and shrubs adapted to dry conditions. The Caucasus Ecoregion also has maple-elm, maple, lime tree, and alder forests on rocky slopes and in mountain ravines (Zazanashvili *et al*. 2020).

The Colchic Forest in the Black Sea catchment basin and the Hyrcanian Forest at the southeastern tip of the Caucasus are refugia of Tertiary flora that contain many endemic species. These forests are considered "the most unique features of the Caucasus Ecoregion" (Nakhutsrishvili *et al*. 2015, p. 185) and are at the origin of the evolutionary histories of western Eurasian forests. These important forests have a high diversity of relict and endemic woody species and tree species (Nakhutsrishvili *et al*. 2015).

Table 22. Change in intact forest area according to 300-m spatial data, 2000–2020

Country	2000 (hectares)	2020 (hectares)	Difference (hectares)	Difference (percentage)
Georgia	907,813.51	882,337.64	-25,475.87)	-2.81
Russian Federation	1,254,835.95	1,179,714.35	-75,121.61)	-5.99
Total	2,162,649.46	2,062,051.99	-100,597.48)	-4.65

Note: Data calculated based on the Caucasus Intact Forests Difference 2000–2013 by excluding all adjacent areas that in high satellite imagery (Sentinel 210-m resolution) did not appear to be forested areas.

Waterfall in the North Caucasus mountains, Karachay-Cherkessia, Russian Federation. ©iStock/Iuliia Leonteva

5.6.2. Main pressures on forest cover

The extent of forest cover is impacted by anthropogenic pressures, especially illegal commercial logging, firewood demand for local communities, overgrazing and hydroelectric schemes along the rivers, which all result in a loss of forest cover throughout the Ecoregion (FAO and United Nations Economic Commission for Europe [UNECE] 2019) (see chapter 6). Rural poverty and a lack of alternative energy sources mean that local populations still turn to the forest for their energy needs. In the South Caucasus, the real levels of forest use are unknown and little monitoring takes place (Government of Georgia 2014). With economic growth, and without effective monitoring, deforestation or degradation will likely continue.

Overgrazing due to excessive numbers of livestock on summer and winter pastures, especially around human settlements, is connected to ineffective pasture management policies, lack of law enforcement, rural poverty and limited awareness among shepherds and livestock owners. Overgrazing can make soil more compact, causing soil erosion and a decline in the capacity of the forest to naturally regenerate.

> ***"** Mountain agriculture should prioritize ecological practices, promoting biodiversity and preserving traditional farming methods, providing sustainable livelihood opportunities, ensuring the preservation of unique landscapes and the well-being of local communities.*
>
> Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

Certain alien tree species such as Paulownia tomentosa and Ailanthus altissima also pose a threat to the Caucasian endemic forests and grasslands. Detailed studies are needed to assess the potential threats from certain invasive tree species in the Ecoregion.

Among various risks of climate change is the spread of forest diseases (Bowman *et al*. 2020). Climate change allows existing pests to proliferate and new harmful insects and diseases to spread around the world (Schneider *et al*. 2022). Warming winter temperatures may facilitate the process of overwintering and promote the growth of pest populations harmful to forests. Pests and diseases, such as chestnut cancer Cryphonectria parasitica (formerly Endothia parasitica), Calonectria pseudonaviculata and Cydalima perspectalis pose a significant threat to the Ecoregion's forests (see section 5.5.3).

Higher temperatures and decreased levels of precipitation predicted for the Ecoregion are likely to severely affect forest ecosystems. Changes in species composition because of climate change is yet another problem that is connected to the migration of heat-tolerant species facilitated by rising temperatures.

Forest fires are not a frequent natural phenomenon in the Ecoregion's forests, and Ecoregion plant species are not adapted to them. But more frequent and prolonged droughts have led to an increase in forest fires. For example, according to the Georgian National Forest Agency (2022), the average number of forest fires each year between 2007 to 2011 was 14, while between 2012 and 2016 there were 45 and between 2017 and 2021 there were 64 per year. In addition, the mountainous terrain landscapes of the Ecoregion, steep slopes and a lack of access roads complicate firefighting efforts (Zazanashvili *et al*. 2011).

5.7. Legislative framework of land-cover management, key policy responses and outlook

All countries of the Ecoregion have detailed regulations concerning ownership, registration and management of different categories of land use (including agricultural land, pastureland, forests, land used for mining, industry and infrastructure as well as housing). The establishment of protected areas for important natural and cultural sites, soil protection and preservation are also well established in the legal framework. The Governments of Azerbaijan (2000a), Georgia (2018), the Islamic Republic of Iran (2004) and the Russian Federation (2001) also have approved special laws on spatial planning, and the Government of Türkiye (2017) has a law on agricultural land planning. In Armenia, spatial planning is regulated by the Urban Development Law of 1998. In addition, Armenia, Azerbaijan, Georgia and Türkiye are part of the Council of Europe Landscape Convention. Türkiye has perhaps the most developed legislative mechanisms for controlling soil pollution (FAO 2018). However, none of the countries has special legislation or a comprehensive state strategy to address pressing issues related to the management of natural and cultural landscapes. Low awareness of the importance of landscape preservation, high levels of poverty and corruption, and limited public participation further contribute to a manipulative application of law. Changing the legal status of land categories for commercialization or personal short-term economic gains, and infrastructure and mining projects occurs (Demytrie 2014). As for soil protection legislation, the Caucasus countries often lack practical control and monitoring mechanisms or a holistic vision on restoration strategies for privately owned and public land of different categories.

5.7.1. Crop and grassland management framework in the Caucasus Ecoregion

Four out of six countries of the Ecoregion were once part of the Soviet Union and have undergone important changes in agricultural land ownership and management forms since the early 1990s. The Soviet system was based on small household plots privately owned by rural families (sovkhozes), and large state-owned communal farms with centralized and specialized production employing citizens in rural areas (kolkhozes).

After 1991, the countries that had formerly belonged to the Soviet Union transitioned to a market system, with the first land reforms starting in the early 1990s followed by another stage in the 2000s. There were, however, differences between the approaches of these countries. Those with a scarcity of agricultural land in the South Caucasus mainly redistributed the crop and perennial lands of former sovkhozes and kolkhozes to several million rural families (see section 5.4.2). In the Russian Federation, state farms were instead transferred to large corporations or cooperatives co-owned by workers. Armenia took a mixed approach in the 1990s. The agriculture of the Islamic Republic of Iran and Türkiye remains based on small to medium-sized family farms.

Today, the existence of millions of peasant farms, each with less than 2 hectares of land, with high farmland parcelization, are considered obstacles to agricultural development in the South Caucasus. However, these farms also played a crucial role in the avoidance of famine during the market and economic collapse in the 1990s by ensuring the basic food supply for rural families and their extended family members in urban areas, as well as access to startup capital in the form of property ownership. The redistribution of large plantations, on the other hand, resulted in the collapse of some industries (e.g., tea production in Georgia). Another problem is related to the registration of private ownership in official cadastres, which remains a serious issue today despite efforts to address it. In Azerbaijan and Georgia, there are restrictions on foreigners buying agricultural land, while in Armenia, the Islamic Republic of Iran and the Russian Federation, a local legal entity established by a foreign citizen can own agricultural land.

In Georgia, the land market is further hampered by government social policies, which exempt small rural landowners from land tax. Some citizens who have not cultivated their land for years can thus own an asset without any obligations to the state, indirectly limiting access to land for those who live in villages and want to farm professionally. Subsequently, this contributes to further land degradation and prevents the consolidation of fragmented land.

Pasturelands are mainly held in state/communal ownership with limited leasing opportunities. Some parts of pasturelands are privatized for larger livestock farms. The main issue is related to the fair redistribution and personalization of the responsibilities for pastures (including in protected areas) maintained by rural communities or private herders who lease them from private or state owners. Due to the informal use of large parts of pasturelands by rural smallholders/communities, and/or transhumance or nomadic livestock systems, identifying users and assigning responsibilities to them is especially challenging. Azerbaijani legislation provides more concrete instructions: if the productivity and fertility of pastures, hayfield and cattle ranges decrease for natural reasons, the relevant local authorities or municipalities shall conserve these areas by withdrawing them from use (Azerbaijan 2000b). Managing livestock migration roads (long-distance stock-migration tracks between summer and winter pastures), which often pass through different municipalities and privately owned land, are on many occasions not subject to spatial planning at the municipal level and thus cause conflicts and further land degradation (Robinson 2021).

Clear policies on registering legal rights to pastures, rules to be applied by responsible persons for maintaining the pastures, tailor-made pasture management (grazing and protection from degradation), guidelines adopted to local realities, as well as monitoring and enforcement systems are key to maintaining grassland cover in the Ecoregion (REC Caucasus 2019).

As mentioned above, it is also very important that countries consider reforms such as those encouraged under SDG target 5.a that would "give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources in accordance with national law" (UN DESA n.d.).

5.7.2. Forest management framework in the Caucasus Ecoregion

The forests of the Ecoregion are primarily owned and managed by state governments, with some parts leased on a long-term basis to timber or hunting businesses. Compiling proper national inventories of the forests, which would collect data on geographical area, biological diversity, structure, degradation status, timber stock, downed deadwood stock, regeneration, and topographic and other characteristics on which national forest policies would be based, is a challenge: the inventory data for most countries of the Ecoregion are outdated. Other problems are related to employing sufficient professional forest management and ranger staff and assuring their social and physical security. The separation of policy, management and supervision of the forest sector, with clear roles and functions of these three areas and effective coordination are crucial (FAO and UNECE 2019). Furthermore, for policies to work, local communities must be involved, and traditional forest-use practices integrated into the overarching policy framework.

Conclusion

Land-cover management is a very complex issue as it involves many different disciplines and practices, including ecology, disaster risk management (monitoring, prevention and adaptation), natural and cultural heritage management (specifically cultural landscapes), spatial and urban planning, agricultural and forestry engineering, and infrastructure standards, as well as different fields of industry and infrastructure. Therefore, land-cover management involves a very broad range of regulations and legislation, and public and private bodies that often have no coordination with each other. At the same time, land-cover management polices cannot be effective if they are not localized, involving both women and men from local communities, and taking into consider traditional knowledge and ecosystem specificities. At the same time, they need resources and decision-making power to achieve sustainable and resilient landscapes (UNEP 2004). In addition, it is more difficult to implement holistic and effective land-cover management in countries with high poverty rates, as their societies are oriented towards short-term economic gain.

Neglecting holistic approaches to land-cover management leads to increased risks of disasters, public health issues and lower productivity of the AFF sector, contributing to increased poverty and thus creating a vicious cycle. On the positive side, modern remote sensing and artificial intelligence technologies significantly simplify collection and analysis of the relevant land-cover data, making a holistic approach to the topic easier and thus providing additional tools for digitalization and public-awareness raising.

Therefore, the Caucasus Ecoregion countries should:

- Systematise land tenure and develop holistic and clear policy frameworks to land-cover management based on a landscape approach taking into consideration climate change and disaster risks, including from a gender perspective;
- Adopt or further refine spatial-planning laws, concepts, solutions and strategies at national and/or regional levels;
- Adopt or further refine master plans for key urban areas;
- Conduct inventories of forests and natural grasslands and improve forest and pasture management regulations and their enforcement;
- Stimulate agroecological approaches in agriculture;
- Regularly monitor the changes in land-cover categories, not only NUTS 3, but also on the level of Terrestrial Ecoregions of the World (TEOW), conservation landscapes, bridging landscapes and key biodiversity areas; and
- Strengthen public participation in decisions related to mining and infrastructure projects and improve their environmental assessment tools.

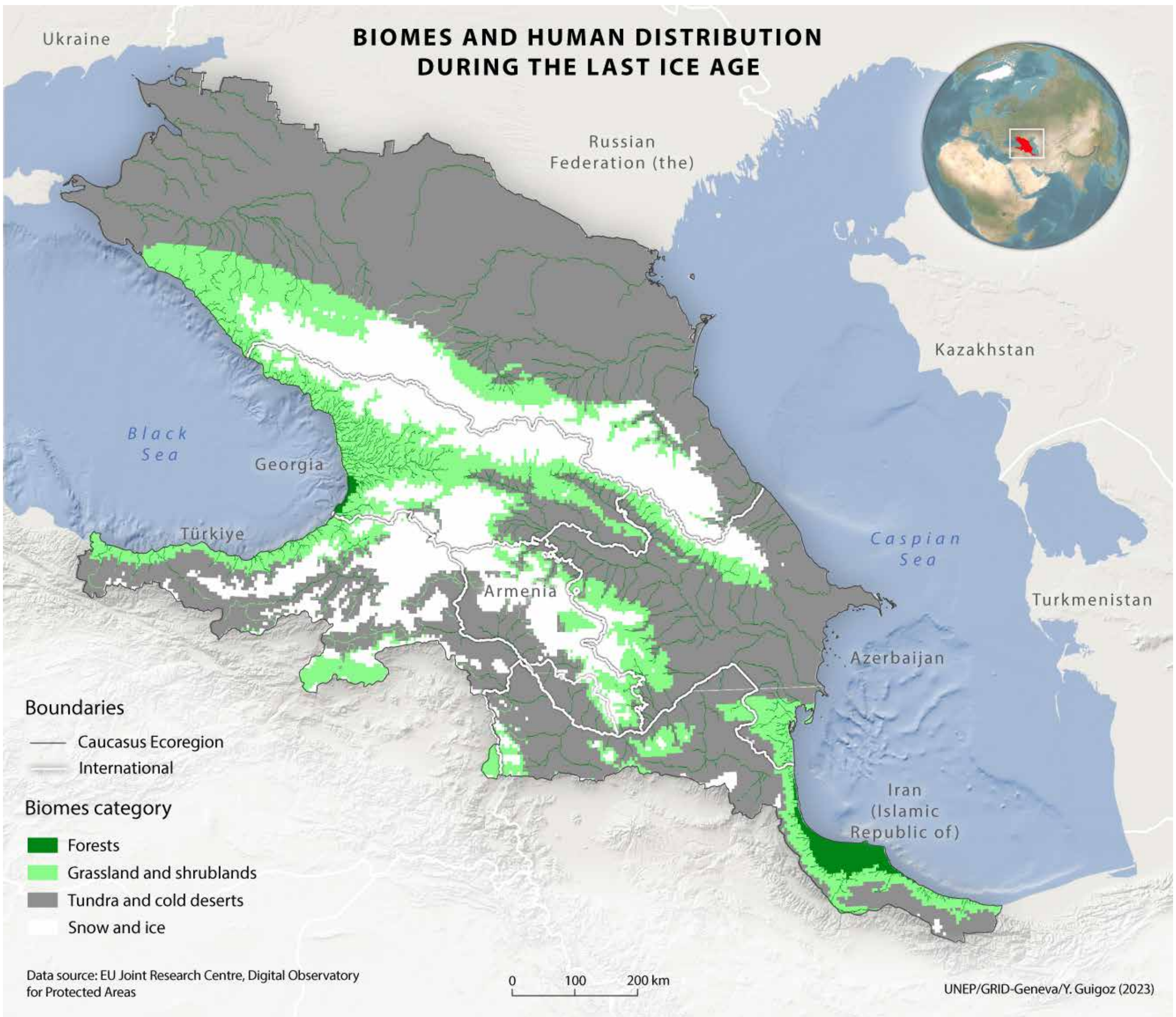
This, of course, will not be possible entirely within the assessments completed by governmental bodies that develop new policies or assess the effectiveness of existing policies. Development of effective policy will require the promotion of complex (multilayer/sectoral) and reliable spatial data infrastructure for land-cover planning and development, as well as collaborative scientific research by the scientists of the Ecoregion countries, especially on collecting and analysing quality spatial data and comparing them with statistics and the situation on the ground.

Chapter 6. Biodiversity

6.1. Biodiversity

6.1.1. Geographic location

The Caucasus Ecoregion covers the area between the Black and Caspian Seas. We follow the definition of the Caucasus Ecoregion by the Caucasus Office of the World Wide Fund for Nature (WWF) (Zazanashvili *et al*. 2004; Williams *et al*. 2006). The predominantly mountainous region includes the Greater Caucasus Mountain range that stretches from Taman Peninsula in the Black Sea to Apsheron Peninsula in the Caspian Sea and whose highest peaks exceed 5,000 metres above sea level. The Transcaucasian Depression in the valleys of the rivers Kura (Kura-Aras Valley) and Rioni (Colchis Plain) separate the Greater Caucasus from the Lesser Caucasus Mountain ranges, although they are linked with the smaller Likhi range separating the drainages of the Black and Caspian Seas. South of the Lesser Caucasus Mountains, the volcanic



Map 13. *Distribution of the main biomes in the Caucasus Ecoregion during the Last Glacial Maximum (ca. 21–25 kya).*

plateau is located at elevations of 1,500–2,000 m with peaks reaching over 4,000 metres above sea level. The total land area of the Ecoregion reaches roughly 580,000 km^2.

Rainfall measures up to 4,000 mm/year in the south-east Black Sea area (Vladimirov *et al*. 1991), decreasing to the east and the north. Another pole of high humidity is along the south-west coast of the Caspian Sea. In the lowlands of the West Caucasus, natural landscapes are largely replaced by cultivated lands. Dry semi-desert biomes dominate in the East Caucasus plains. In the mountains, vegetation and biome type change with elevation (Sokolov *et al*. 1989) (see chapter 5).

6.1.2. Natural history of the Ecoregion: Past and current landscape mosaics

The geological past of the Ecoregion has formed a refugial area hosting diverse organisms that have become extinct in most of the rest of Eurasia (Milne 2004; Tarkhnishvili, Gavashelishvili and Mumladze 2012; Gholamreza *et al*. 2014; Tarkhnishvili 2014; Ahmadi *et al*. 2018). The current landscape is shaped by a series of global climate changes, including glacial waves replaced by relatively short interglacial periods (Imbrie *et al*. 2003). Mountains of the Caucasus at an elevation of several hundred metres and above were covered with tundra landscape with snow and glaciers at higher elevations (Gavashelishvili and Tarkhnishvili 2016) (see Map 13). Forest remnants remain at the riverbanks, and two relatively large forest massifs survived the glacial waves, one at the south-west of the Caspian Sea, and the second south-east of the Black Sea. Tertiary relics survived within these forests along with cold-adapted species from the more recent glacial periods. The Ecoregion thus serves as a biodiversity reservoir throughout the geological timescale and is particularly interesting today as a natural laboratory of diversification and speciation in a continental, non-tropical area.

6.1.3. Landscapes and habitats

The Moderate Resolution Imaging Spectroradiometer (MODIS) Land Cover Type scheme (Strahler *et al*. 1999) identifies 12 schemes dominating the Caucasus Ecoregion, reduced here to nine biomes found throughout the Northern Hemisphere: (1) deciduous forest (including temperate cloud forests); (2) coniferous and mixed forest; (3) subalpine forest and shrubland; (4) alpine grassland; (5) lowland and foothill open areas; (6) lowland and foothill shrubland and light forest; (7) floodplain forest and wetlands; (8) freshwater habitats; and (9) sea and coast. The biome and landscape distribution in the Caucasus have been discussed previously (see chapter 5).

6.1.4. Species diversity by groups

The proportion of plants and animals of various groups relative to world flora and fauna is high for a region with a temperate climate and contains with a significant proportion of endemic species. The flora of Georgia includes 3,992–4,217 flowering plant species (Gagnidze 2005; Fischer, Gröger and Lobin 2018) comprising about 1.3 per cent of the world's flora, whereas the country's area is only 0.4 per cent of the world's land surface. There are almost 3,800 species of vascular plants in Armenia, 145 or 3.8 per cent of which are considered national endemics (Armenia, Ministry of Nature Protection 2014). In Azerbaijan, 4,846 plant species are recorded including more than 400 national endemics (Inashvili *et al*. 2020). A total of 1,255 regionally endemic plants are found in the North Caucasus; 338 of those are national endemics of the Russian Federation (Litvinskaya and Murtazaliev 2013). Between 25 and 40 per cent of the plant species of the Caucasus, and 21 genera, are regional endemics (Schatz *et al*. 2009; Fayvush and Aleksanyan 2020). These include 25 per cent of Rosaceae, 16 per cent of Asteraceae and 14 per cent of Fabaceae (Fischer, Gröger and Lobin 2018).

The Ecoregion has 15–17 amphibian species, 73 reptile species, 58 rodent species and 14 insectivore species (Tarkhnishvili 2014) of which 27 per cent are regional endemics. According to Georgia's biodiversity database (2013),[5] the country has 267 species of land snails (3.8 per cent of the world's fauna), 80 per cent of these species are endemics (Pokryszko *et al*. 2011). Georgia has 57 species of earthworms (*Lumbricidae*) (Kvavadze and Pataridze 2002) which comprise over 8 per cent of world earthworm fauna. The spider fauna of the Caucasus comprises 1,143 species (Otto 2020), which is about 2.3 per cent of the world's spider fauna.

Although most birds and large mammals are widespread species, the Caucasus has some endemics from these groups too, including the Caucasian black grouse (*Lyrurus mlokosiewiczi*), Caucasian snowcock (*Tetraogallus caucasicus*), warblers (*Phylloscopus lorenzii, P. nitidus* and East and West Caucasian turs (*Capra caucasica, C. cylindricornis*) (Gavashelishvili and Javakhishvili 2010; Javakhishvili *et al*. 2020) .

6.1.5. Agricultural diversity

The Caucasus is located north of the ancient Fertile Crescent, where agriculture first arose 8,000–10,000 years ago (Diamond 1997; Abbo *et al*. 2010), an area from which many Caucasus ethnic groups are culturally, linguistically and genetically descended (Rootsi *et al*. 2004; Tarkhnishvili *et al*. 2014; Balanovsky *et al*. 2017; Wang *et al*. 2018). The agricultural diversity in the Caucasus also largely reproduces that of this region. Georgia has the oldest fossil evidence of cultivated forms of grapes (McGovern 2013). European vine types are genetically related to the wild grape from the Caucasus (Pipia *et al*. 2012). The region is rich with local breeds of wheat (Mosulishvili *et al*. 2017). In the Greater Caucasus, a

[5] The Georgian biodiversity database (Tarkhnishvili and Chaladze 2013) was being rebuilt at the time of publication.

Armenia. *©Hakob Sargsyan*

large variety of local cereals adapted to high mountains are currently under threat due to changing land-use practices (Akhalkatsi *et al*. 2017). Wild relatives of cultivated plants (including wild species of wheat, fruit trees and others) have been identified in Armenia, which has been recognized as a rich origin of cultivated plants (Armenia, Ministry of Nature Protection 2014). Armenia holds 36 varieties of rye (Secale spp.) and eight species of wild barley (Hordeum spp.).

Hundreds of native species of plants are used in the Caucasus for culinary, medicinal, and other purposes (Bussmann 2017) (see chapter 5).

Conservation of biodiversity endemic to the Caucasus is essential to the conservation of non-tropical biodiversity heritage. The Caucasus has a particularly high species diversity, with several taxonomic groups and a particularly high diversity (20–30 per cent) of endemic species in most of the studied groups of vertebrates and up to 40 per cent of vascular plants are endemic species. An ongoing project called the Caucasus Barcode of Life (CaBOL) aims to categorize taxonomic and genetic diversity of the non-microbial biodiversity of the Caucasus. This is largely related to the multiple refugia, where mild climate and diverse biological communities are maintained during periods of unfavourable climates. These refugia serve as "biodiversity reservoirs" for adjacent regions. The lowland parts of the region have been heavily populated by humans since the early Holocene (starting roughly 11,000 BCE) and have an ancient agricultural past, due to favourable climates and closeness to the Fertile Crescent, which is reflected in the diversity of agricultural plants and domesticated animals. All this makes conservation of the biodiversity of the Caucasus particularly important in a broader Eurasian context.

6.2. Drivers and pressures

6.2.1. Direct transformation of landscapes and human-caused pollution

Among the most important drivers impacting biodiversity is land conversion for agriculture (Lambin and Meyfroidt 2011). Grasslands of the North Caucasus were effectively replaced by arable lands in the twentieth century (Litvinskaya 2021). Conversion of forests to cultivation lands, mining, and other changes are among important threats for biodiversity in the Caucasus part of Türkiye (Kurdoğlu and Çokçalışkan 2011). Transforming the natural landscape into agrolandscape, commonly monoculture, reduces resistance to invasive species and pathogens (see chapter 5).

Intensive agriculture commonly causes increasing use of fertilizers and pesticides, resulting in a decline of insect populations (Brühl and Zaller 2019). About 42 per cent of annual crop-planted areas are treated by mineral fertilizers, and 21 per cent by pesticides (Welton *et al*. 2013). Ukalska-

Jaruga *et al*. (2020) found high concentrations of DDT (dichlorodiphenyltrichloroethane) in soil in Azerbaijan. Tepanosyan *et al*. (2017) show that in all rural communities studied, carcinogenic risk caused by an excessive concentration of DDT exceeded the allowable level. Georgian rivers that belong to the Caspian Sea basin drainage area (see Map 19) are polluted with heavy metals, oil and pesticides caused by drainage from the agrolandscape and mining enterprises (Lomsadze *et al*. 2016). Pollution by heavy metals is reported for Baksan River (Dreyeva *et al*. 2019). Increased concentration of pesticides is reported even for groundwaters that provide a source of mineral waters in the North Caucasus (Karimova 2003). Another notable issue is the pollution of the Black Sea by chemical agents (Gileva 2005).

6.2.2. Forestry and logging

Commercial forestry was intensive in the nineteenth century, but later reduced due to timber imports from Siberia. In the 1990s, forest destruction was accelerated, driven by both local needs and trade. Since the 2000s, forest loss has declined; locally selective cuts were accelerated for various reasons, including the investments of timber-harvesting companies (see chapter 5).

Forests on mountain slopes have undergone less logging than lowland forests (Patarkalashvili 2016; Khardziani and Maisuradze 2020). As a result, most Caucasus forests today are in mountain areas. In fact, 78 per cent of Georgian forests are located on steep slopes (36° and more) (Patarkalashvili 2016); the same applies to the other countries of the South Caucasus.

6.2.3. Overgrazing

Overgrazing is causing erosion of grasslands in mountains and salinization of soils in the lowlands of the East and the North Caucasus (Zazanashvili *et al*. 2020). This may negatively affect wildlife, such as in Hyrcanian forests (Soofi *et al*. 2018). Grazing has a major impact on vegetation and insects (Bontjer and Plachter 2002). Erosion of soils by overgrazing declines agricultural productivity (Adinyayev 2016). The Fifth National Report to the Convention on Biological Diversity (CBD) of Armenia (Armenia, Ministry of Nature Protection 2014) underlines the potential impact of over- and under-grazing. The latter results in the replacement of alpine carpets with alpine meadows, and penetration of subalpine weeds in alpine ecosystems. Welton *et al*. (2013) suggest that overgrazing is a particularly strong problem in community-owned pastures. Overgrazing can threaten dozens of endemic plants. The Azerbaijan Sixth National Report to the Convention on Biological Diversity (CBD) (Azerbaijan, Ministry of Ecology and Natural Resources 2019) suggests a 10- to 50-fold excess of pasture load related to the accepted grazing norm. The Sixth National Report to the CBD of Georgia (Inashvili *et al*. 2020) also underlines the destructive effect of overgrazing on biodiversity. In some areas of Georgia, grazing has been reduced over the last 20 years. Overgrazing is also an important driver for biodiversity loss in Türkiye (Kurdoğlu, Kurdoğlu and Eminağaoğlu. 2004; Kurdoğlu and Çokçalışkan 2011) (see chapter 5).

6.2.4. Infrastructural development and hydropower

The presence and development of roads cause habitat loss and increase habitat fragmentation. Increasing road density thus has a negative impact on wildlife (Bennett 2017). The road density in Georgia reaches 318 km per 1,000 km^2, in Armenia 279 km and in Azerbaijan 223 km (Asian Development Bank 2014). This is markedly less than in Central Europe and Türkiye and is comparable with the other post-Soviet countries. New highways are currently being built; however, their impact on the total density of the road network is modest.

Hydropower provides a very important supply of energy for the region (6.3–35 per cent of energy production for different countries (Gevorgyan and Sargsyan 2007; Capik, Yılmaz and Cavusoglu 2012). However, even small hydropower plants cause degradation of ecosystems and biodiversity loss (Kucukali 2014; Gevorgyan *et al*. 2017). The building of hydropower stations is associated with increased risk of erosion of the Black Sea coastline (Matchavariani *et al*. 2017) and may increase seismological threats. Building power plants destroys pathways of anadromous fish, including sturgeons and Black Sea salmon (Ninua *et al*. 2018). In addition, hydropower plant-building causes problems with local water supplies (see chapter 5).

6.2.5. Fishery, port construction and impact on sea ecosystems

In the past, fisheries were common in settlements close to waters (Ritchie *et al*. 2021). In historical times, they were a substantial source of food and income for coastal settlements. Overfishing in marine ecosystems has resulted in decreased commercial fish stock and total ichthyic fauna. The impact of the fishing industry, together with pollution or invasive alien species, have caused the decline of the Black Sea population of the European anchovy (Engraulis encrasicolus) as of some 25 years ago (Kideys 1994). Fishing causes the decline of some fish populations (Demirel, Zengin and Ulman 2020) and of cetaceans through bycatch in nylon nets (Birkun 2002).

6.2.6. Invasive and introduced species

Some species that are endemic to the Caucasus are invasive elsewhere (Jahodová *et al*. 2007; Simberloff 2013; Moulin 2020), and multiple invasive species from elsewhere destroy wild and agricultural plants and spread disease in the

Caucasus. Two of the most well-known invasive pests are the fungus *Cryphonectria parasitica*, which arrived in the region in the 1930s and is destroying the population of sweet chestnut (Beridze and Dering 2021); and the mollusc *Rapana venosa*, predating the local bivalve molluscs (Janssen *et al*. 2014). Recently, the dramatic loss of box tree stands in the West Caucasus was caused by the invasion of the box tree moth (*Cydalima perspectalis*) from East Asia (Vétek *et al*. 2019). Boxwood blight *Cylindrocladium pseudonaviculatum* and moth *Cydalima perspectalis* caused the decline of boxwood in Türkiye (Akıncı and Kurdoğlu 2019; Özkaya 2020). Brown marmorated stink bug (*Hallymorpha halys*) had a negative impact on agriculture in 2016–2018 (Murvanidze *et al*. 2018; Uysal and Boz 2018; Burjanadze *et al*. 2020).

There are likely hundreds of other alien species that have not had such a dramatic impact on the local ecosystems, such as the freshwater jellyfish *Craspedacusta sowerbii*. The real number of alien species in the regional fauna and flora cannot be estimated without wide-scale projects covering a large part of the region's biodiversity; CaBOL makes some steps in this direction. But there are dozens of introduced species in the Caucasus fauna and flora. Some of them, including Coregonid fish (*Coregonus* spp.) or racoon (*Procyon lotor*) appear to have a substantial impact on regional ecosystems. Others, including the red squirrel (*Sciurus vulgaris*), coypu (*Myocastor coypus*) and muskrat (*Ondatra zibethicus*) do not appear to have substantially impacted regional wildlife. Finally, some species that have long been extinct locally may potentially be reintroduced. One example is the European bison (*Bison bonasus*), which was reintroduced in the Caucasus Reserve as early as 1961. More recently, Shahdag National Park in north-east Azerbaijan was selected for the WWF European Bison reintroduction programme in 2012.

6.2.7. Climate change

Climate change is an important driver for ecosystem transformation (Arneth *et al*. 2020). In the Caucasus, global warming has accelerated glacial area loss (Tielidze *et al*. 2022). This may trigger a water deficit, especially in the Central Greater Caucasus. A warmer climate may drive up the timberline (Akhalkatsi *et al*. 2018). It is not clear how climate change will affect precipitation throughout the region. Elizbarashvili *et al*. (2017) have suggested that in the Caspian Sea drainage, climate warming is stronger than in the Black Sea drainage, which accelerates the risk of desertification in grasslands. Lewińska *et al*. (2020) underline that the negative effects of climate change in the Caucasus are accelerated by overgrazing.

Climate change may exacerbate the problem of invasive species (Mainka and Howard 2010), but most invasive species have reached the Caucasus from geographically distant parts of the world. The most important factor in these accelerating invasions appears, in fact, to be the continual increase in mobility of humans and cargo. Slodowicz *et al*. (2018) has shown that climate change will modify distribution patterns of invasive alien plants in the region, shifting them from West to East Caucasus. Shakarashvili *et al*. (2020) have showed recent expansion of the golden jackal into the mountains and expansion of the jackal from the Caucasus to north-east Europe (Rutkowski *et al*. 2015) due to climate change. Climate change also substantially impacts freshwater ecosystems by increasing runoff of sediments or changing salinity through saltwater intrusion (Reidmiller *et al*. 2017). Unfortunately, there is a lack of valid data for the analysis of climate change impact on the aquatic ecosystems specific to the Caucasus Ecoregion.

6.2.8. Prioritizing drivers and pressures

The next section shows that logging causes continuing change in the canopy closure, which in turn, substantially affects regional biodiversity. Because clear-cuts are rare in the region, forest loss does not cause a strong social impact, unlike hydropower plant construction. This makes forest degradation a particularly important threat for regional biodiversity. Other important threats are increased transportation links among and between the Caucasus countries, which accelerates the dispersal of invasive organisms and the development of intensive agricultural practices, specifically monoculture development, which leads to greater use of pesticides.

6.3. State and trends in biodiversity

6.3.1. Habitats and species loss: General trends

According to the International Union for the Conservation of Nature (IUCN), the Caucasus Ecoregion has 86 species of animals and 276 plants on their Red List, which indicates that they are globally threatened (IUCN 2013). A total of 3 species of mammals, 3 of birds, 6 of reptiles, 12 of fish and 98 species of plants are critically endangered (CR) (Zazanashvili *et al*. 2020). Three endemic Black Sea subspecies of cetaceans, *Delphinus delphis ponticus*, *Tursiops truncatus ponticus* and *Phocoena phocoena relicta*, are included on the IUCN Red List under vulnerable (VU), endangered (EN) and critically endangered (CR), respectively. There are many more threatened species at the regional level. The regional Red List of endemic plants of the Caucasus (Schatz *et al*. 2009) includes over 2,700 endemic taxa. The IUCN Red List is biased towards large-bodied species or decorative plants; it is almost impossible to estimate the true number of threatened invertebrates.

There are various reasons for species decline. Some are under direct human pressure from harvesting, hunting, poaching, and other actions. Directly and intensively exploited organisms include fish, birds and mammals, mushrooms, and flowering plants (for example bulbous plants and trees harvested for timber). Disturbances during construction has consequences on some species, including cetaceans. Disturbances in caves and other underground roosts is the main threat to vulnerable bat species (Kandaurov 2008).

The first Caucasus Environment Outlook report (UNEP 2002) outlined threats for natural habitats, chief among them being forest degradation and erosion of land caused by overgrazing. Juniper and pine forests are particularly vulnerable, as are the forests in river deltas. Almost two decades later, the Ecoregional Conservation Plan for the Caucasus (Zazanashvili *et al*. 2020) listed the same priority areas, highlighting forest and pastures as the most vulnerable ecosystems. The report also highlights the fragmentation of old-growth forests because of human activities, reduction in plant diversity in pastures, altering semi-desert ecosystems, and loss of floodplain forests.

Small mountain rivers and brooks concentrate a large portion of biodiversity and cover habitats of multiple endemic species. This habitat type is being degraded due to logging along banks and dragging felled trees along streambanks, destroying important microhabitats of endemic and relict amphibians, snails, rodents, insects and crustaceans.

Until the mid-twentieth century, habitat loss was largely associated with the transformation of natural grasslands and forests into agricultural lands. Agricultural lands cover close to 54 per cent of the region. Only around 12 per cent of the region's area is covered by pristine landscapes (Zazanashvili *et al*. 2020).

6.3.2. Decrease of biomes: Floodplain forests and wetlands

Around 2–3 per cent of the area covered historically by riparian forests has maintained this habitat type (Zazanashvili *et al*. 2020). Floodplains uninterruptedly covered the bank areas of the Kura and Aras Rivers in the past. Currently, these areas are severely fragmented and are no longer appropriate for populations of ungulates and large carnivores. Unfortunately, the loss of the floodplain forests, albeit less intensive, has continued until now, in particular the floodplain forests of the Alazani valley in west Georgia, in the middle currents of the Khobi River, and in the Mzymta valley in the Krasnodar region of the Russian Federation. Plain forests in Goryachi Kljuch, north-west Caucasus, were strongly damaged after 2010. Historically, the degradation of floodplain forests was most likely the reason for the extinction of the Caspian tiger (*Pantera tigris virgata*). Currently, further degradation of floodplains is causing the decline of hunted species, including francolin (F*rancolinus francolinus*) and the common pheasant (*Phasianus colchicus*) whose name means "pheasant from Colchis" (Zazanashvili *et al*. 2020).

6.3.3. Decrease of biomes: Mountain forest

The forest cover of the Caucasus Ecoregion has continually decreased since agriculture arose here in the Neolithic period (Murtskhvaladze *et al*. 2010). However, forest cover loss intensified in the twentieth century (see Table 23). For instance, in Armenia, forest cover decreased from around 35 per cent of the country in the last three millennia BCE to 8.1 per cent in the 1950s, rising again to 11.2 per cent in the 1980s and declining back to 7 to 8 per cent in the mid-2000s (Moreno-Sanchez and Sayadyan 2005). In recent decades, degradation of forest quality is a more important driver in the Caucasus than forest loss as a result of clear-cuts.

During the last five years, negative trends have been moderated in Armenia, Azerbaijan and Georgia, but have remained substantial in the Islamic Republic of Iran, the Russian Federation and Türkiye. At the south edge of the Borjomi-Kharagauli National Park in Georgia, fires in pine forest stands caused significant forest loss: Borjomi district in Georgia lost 2.3 per cent of its forest cover in 20 years (55 per cent of the district remains forested). Sochi district, of which 84 per cent is covered with forest, lost 0.57 per cent of its forest cover; Artvin

Table 23. Forest loss in the counties and regions of the Caucasus between 2001 and 2023

Country	Country/ region area (kha)	Forest area (kha, 2010)	Percentage of forest area	Forest loss 2001–2023 (Kha)	Forest loss (percentage)	Year	Forest loss peak	Status of forest change
Armenia	2964.28	2249	8.4	2.20	0.65	2003	0.396	Decline
Azerbaijan	8307.69	1080	13	8.16	0.64	2002	1.15	Decline
Georgia	6953.48	2990	43	11.90	0.38	2004	1.97	Decline
Islamic Republic of Iran	14058.2	1172.97	8.344	2.50	0.22	2012	0.466	Irregular
Russian Federation	25122.6	4879.00	19.42	33.19	0.68	2012	3.405	Irregular
Türkiye	1067034	1583.53	0.1484	16.66	0.80	2012	1.87255	Irregular

Source: Global Forest Watch (n.d.)
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

district (Türkiye) lost 1.66 per cent of forest cover; Dereli district (Türkiye), 1.9 per cent; Oguz (Azerbaijan), 1.1 per cent; Tlyarata (Dagestan, Russian Federation), 1.9 per cent. Nevertheless, this is incomparably less than forest loss in industrially logged areas; for instance, in Niurbinskyi district (Saha Republic, Russian Federation) during the same period, 32 per cent of forest cover was lost; forest loss in Kelantan (Malaysia) was 36 per cent; and in some areas of the Amazon Basin (Brazil), it has reached 77 per cent in the last 20 years. Forest loss related to clear-cuts in the Caucasus is relatively small (see chapter 5).

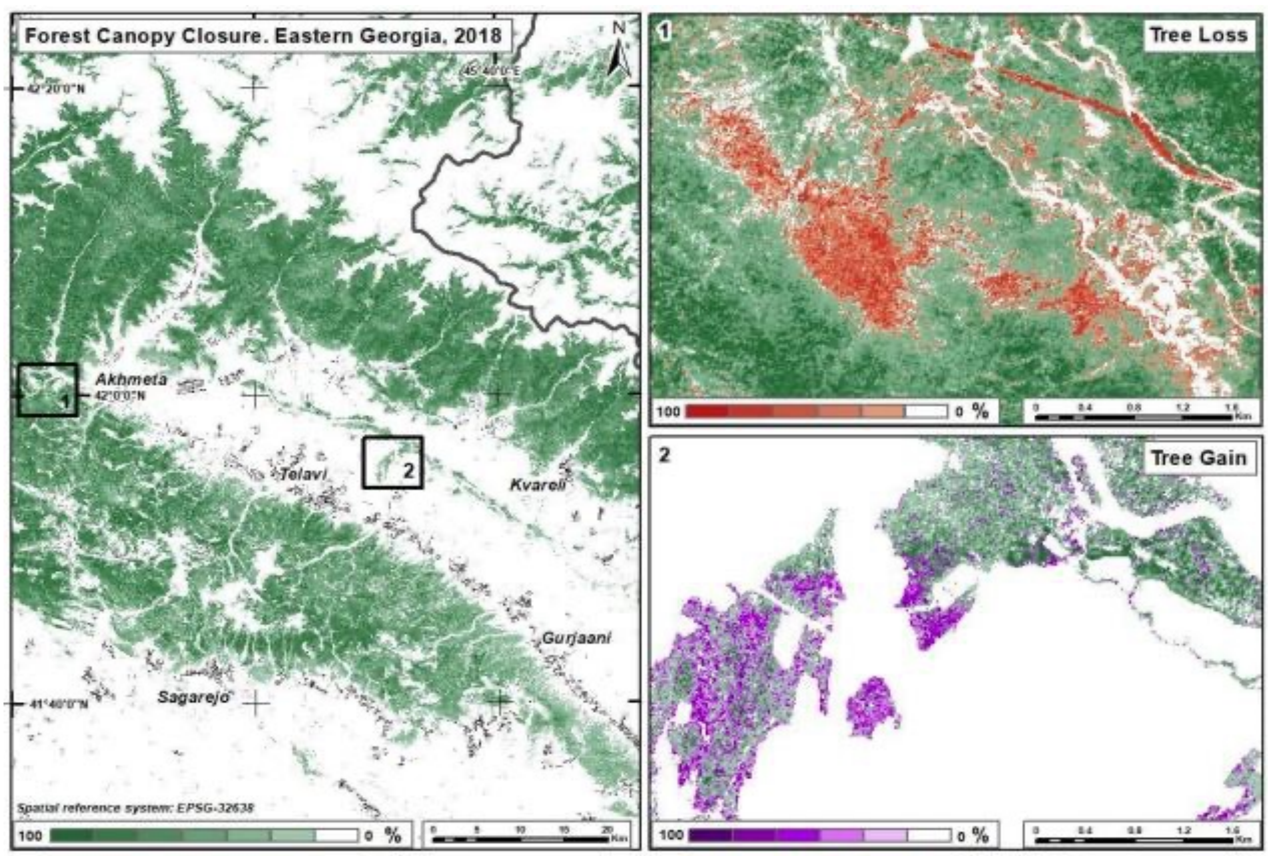
The existing data, based on the analysis of satellite images, suggests moderate forest loss in the countries and subregions of the Caucasus, varying between 0.33 and 0.93 per cent for different countries of the region (see Table 23). Interestingly, those provinces and subregions that have the smallest proportional forest cover underwent the highest forest loss rates.

Threats to the forest landscape include declining forest quality, which causes biodiversity loss and allows for fewer ecosystem services (Vardanyan 2016; Goginashvili *et al*. 2021). Recent remote sensing analysis (Mikeladze *et al*. 2020) (see Map 14) revealed statistically significant tree loss in sample areas of east Georgia, and even in Borjomi-Kharagauli National Park, between 2016 and 2018. Goginashvili *et al.* (2021) revealed substantial loss of plant diversity in the forests of south-west Georgia. Sweet chestnut (*Castanea sativa*) forests, covering the low mountain belt of the Caucasus, heavily suffer from the invasive fungus *Cryphonectria parasitica* (Beridze and Dering 2021).

6.3.4. Decrease of biomes: grasslands

Current overgrazing is a substantial driver of grassland loss (Zazanashvili *et al*. 2020) (see chapter 5). Intensive grazing decreases rates of nitrogen, phosphorus and potassium by 38 times compared to areas without grazing (Adinyayev 2016). However, the degradation and change of vegetation cover may also be a result of human influence that has had an impact on the grazing areas of the Caucasus since prehistoric times (Bock *et al*. 1995).

Grazing in grasslands surrounding Tbilisi city has caused a significant change in Orthoptera density and diversity (Bontjer and Plachter 2002). In North Ossetia, overgrazing has caused large-scale soil degradation. Overgrazing may act together with climate change, especially in the east of the Caucasus Ecoregion (Lewińska *et al*. 2020).



Map 14. *Forest cover change in two plots of east Georgia, 2016–2018, Mikeladze et al. (2020).*

Source: Mikeladze *et al*. (2020). https://creativecommons.org/licenses/by-nc/4.0/

Note: Global Forest Watch data did not record tree cover in these locations during the last 20 years.

6.3.5. Species loss: Large mammals

The decline of large mammals in the Caucasus has occurred since the Middle Ages. Vereshchagin (1959) suggests that European bison (*Bison bonasus*) and elk (*Alces alces*) were present in the West Caucasus in medieval times, and the beaver (*Castor fiber*) were present in the Colchis wetlands until the mid-nineteenth century. The Caspian tiger (*Panthera tigris virgata*) was found throughout the floodplains of East Caucasus until the 1950s (Vereshchagin 1959), and in the 1920s was even recorded near Tbilisi; the last tiger in Azerbaijan was killed in 1932. The last Caspian tiger in Iran was hunted in 1953 in the area that now belongs to Golestan National Park. There was a reported sighting of this species in the same area in 1959. All these species are regionally extinct. In the twentieth century, the goitered gazelle (*Gazella subgutturosa*) was extinct in the western edge of its range as a result of poaching. This species is currently recovering its natural range, thanks to a reintroduction programme implemented in the region (Askerov *et al*. 2021).

The Persian leopard (*Panthera pardus tulliana*) in the Caucasus Ecoregion has a fragmented distribution (Gavashelishvili and Lukarevskiy 2008). In this region, the leopard is considered critically endangered. Camera traps have shown evidence of leopards in Armenia (3–9 adult leopards) and in Azerbaijan (6–17 adult leopards). The Caucasus parts of Türkiye and the Russian Federation have even fewer leopards. The same is true of Georgia with only one confirmed observation. The Islamic Republic of Iran has the largest population of leopards in the region (Convention on the Conservation of Migratory Species of Wild Animals 2022).

According to Weinberg *et al*. (2020), the region currently has over 25,000 East Caucasian turs (*Capra cylindricornis*). The trends across the range are generally positive, although recent die-offs in Dagestan and Lagodekhi, potentially due to zoonoses, are a cause for alarm. Other threats persist, such as a loss of habitat and poaching. There are also a comparable number of roe deer (*Capreolus capreolus*); the populations of other ungulates are smaller. The West Caucasian tur (*C. c. caucasica*) is assessed by the IUCN as endangered, having suffered pronounced decline (over 50 per cent in the last three generations). The estimated population of the West Caucasian tur remains low at roughly 5,000 individuals, compared to an estimated 12,000 in the 1980s (TRAFFIC 2016). A recent analysis suggests that the geographic area of the East Caucasian tur habitat has not substantially changed for thousands of years (Gavashelishvili *et al*. 2018).

Tiger killed in northern Iran, early 1940s.
Wikimedia Commons (n.d.). Author unknown. https://creativecommons.org/licenses/by-nc/4.0

Verbal reports from different parts of Georgia suggest a substantial decline of wild boar in the Caucasus caused by swine flu. Hybridization with domestic pigs to change the genetic structure of this species remains an uncertain intervention. Red deer (*Cervus elaphus*) is rare and fragmentarily distributed (Gurielidze 2004). While poaching contributes to population decline, habitat degradation is equally important. For instance, grazing in forest landscapes has had a significant effect on populations of leopards (*Panthera pardus saxicolor*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*), while those of red deer have seen a significant negative effect from logging (Soofi *et al*. 2018).

Climate change may affect large mammal populations to some unknown extent. Shakarashvili *et al*. (2020) showed the expansion of golden jackal (*Canis aureus*) into mountain regions of Georgia, with climate change among potential reasons for this. The brown bear population, at least in some parts of the Caucasus, remains stable in spite of ongoing poaching and other anthropogenic impacts (Burton *et al*. 2018).

6.3.6. Species loss or decline: Economically important fish

Historically, the Caucasus had six species of Acipenserid fish, a genus of sturgeon: *Acipenser nudiventris, A. stellatus, A. ruthenus, A. gueldenstaedtii, A. persicus*, and *A. sturio* (Elanidze 1983; Vlasenko *et al*. 1989). Apart from *A. ruthenus*, listed under IUCN category vulnerable, all other acipenserids of the region are critically endangered. The combined annual catches of Acipenseridae in the Caspian decreased by over 50 times between 1988 and 2009. *A. sturio* is most likely extinct (Gessner *et al*. 2010). Sturgeon populations of the Caspian drainage currently consist of immature fish and can only be maintained by artificial stocking (Switzerland, State Secretariat for Economic Affairs 2009). A combination of overfishing and poaching has been decreasing stocks to the highly critical levels.

Another declining fish population is brown trout (*Salmo trutta complex*), which contains at least three anadromous and one purely riverine form (Turan, Kottelat and Engin 2009; Ninua *et al*. 2018). The decline of the density and body size of trout has been observed throughout Georgia (Tarkhnishvili and Ninua 2016). An endemic lake form, *Salmo ishkhan* is still reproducing in small rivers drawing into Sevan Lake, although it is critically endangered in Armenia (Asatryan *et al*. 2018).

Anchovy catches, one of the most important in the Black Sea, increased fivefold during the 1970s, but then declined fivefold in the 1980s (Prodanov *et al*. 1997). A similar trend occurred for the Black Sea population of spiny dogfish (*Squalus acanthias*). A total of 250,000–300,000 tons were caught annually by Turkish fishermen using purse-seine and mid-water trawl (Samsun 2015). A period of high catches of Black Sea sprat or anchovy sprat (*Clupeonella engrauliformis*) in the Caspian occurred in the 1990s (over 270,000 tons at peak). This caused overfishing and the virtual collapse of the stock in the early 2000s (historical minimum of 54,300 tons). Invasion of the ctenophore (*Mnemiopsis leidyi*) is thought to be another reason for this collapse (Daskalov and Mamedov 2007).

6.3.7. Species loss: Birds

The avifauna of the Caucasus includes over 450 bird species, including 15 from the vulnerable category of the IUCN Red List, 5 endangered and 3 critically endangered (Javakhishvili *et al*. 2020). Those include both nesting bird species and seasonal visitors. A number of species, including some birds of prey and most Galliformes found in the region, are prioritized in the Caucasus Biodiversity Action Plan (Zazanashvili *et al*. 2020). Populations of the Caucasian pheasant (*Phasianus colchicus colchicus*) and francolin (*Francolinus francolinus*) are thought to be in decline as a result of the degradation of their habitats in floodplain forests.

Some globally threatened bird species have large populations in the Caucasus Ecoregion. Over 7,000 white-fronted geese (*Anser erythropus*) are wintering around the Aras Dam. Two species were evaluated as critically endangered for Georgian avifauna: the sociable lapwing (*Vanellus gregarius*) and lesser kestrel (*Falco naumanni*). Altogether, 20 species of birds were evaluated as threatened in the country.

6.3.8. Species loss: Small terrestrial vertebrates

There are two species of amphibians and 21 reptiles of the Caucasus included in the IUCN Red List under different categories of threat. There is no documented decline of these species in nature, and their status reflects static variables such as rarity or small range. Tarkhnishvili *et al*. (2002) showed that the range of some reptiles dependent on arid habitats was reduced in the twentieth century; however, no range loss was recorded for species preferring humid forest and mountain areas.

Out of 89 species of rodents, insectivores, bats and mustelids of Georgia, only one, the European mink (*Mustela lutreola*), is included on the IUCN Red List under the critically endangered category as a declining species. The endemic narrow-ranged birch mouse (*Sicista kazbegica*) is placed in the endangered category, and five species (three bats, marbled polecat and endemic vole *Prometheomys schelkownikowi*) are in the vulnerable category. On the Red List in Georgia, two additional species are included in the endangered category (one bat and one vole), and six additional species (three bats, the pygmy mouse and two species of hamster) are included in the vulnerable category.

6.3.9. Species diversity trends: Invertebrates

In recent decades, the mass decline of insect populations, most likely associated with human impact, has been recognized as a huge threat to the global ecosystem (Shortall *et al*. 2009; van Klink *et al*. 2020; Schachat and Labandeira 2021). No quantitative data are available to judge the extent that this global trend applies to the Caucasus Ecoregion.

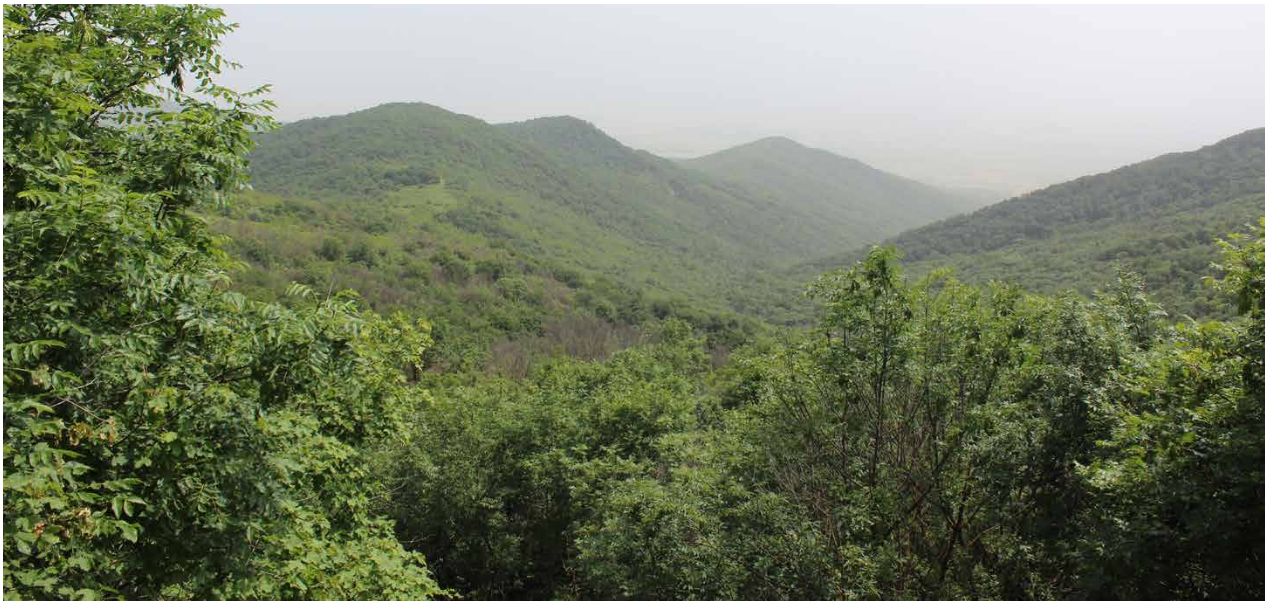
The decline of the European honeybee (*Apis mellifera*) may have different causes, including climate change (Foden *et al*. 2013) and parasite invasion (Pirk, Crewe and Moritz 2017). This applies to the Caucasus population of this insect, according to vernacular reports from different parts of the region.

There are multiple cave invertebrates whose distribution is limited and under threat, due to the intensive transformation of karst caves into tourist sights. No well-documented trend has been recorded for these species.

6.3.10. Invasive species and damage they cause

The stink bug (*Hallymorpha halys*) was first observed in the Caucasus in 2015 (Gapon 2016). Since then, it has caused substantial damage to Georgian agriculture, estimated at 200 million dollars, targeting mostly hazelnut production (Murvanidze *et al*. 2018; Burjanadze *et al*. 2020). Hazelnut damage is likely to be substantial in north-east Türkiye as well. In addition to hazelnut and tea plantations, endemic plants were damaged by Bur cucumber (*Sicyos angulatus*) in the east Black Sea region of Türkiye (Uysal and Boz 2018).

The recent invasion of two eastern Asian species, box tree moth (*Cydalima perspectalis*) and fungus (*Calonectria pseudonaviculata*), caused a rapid decline of box groves in West Caucasus and Hyrcanian Forests in Azerbaijan (Mitchell *et al*. 2018). Fungal diseases caused by *Cylindrocladium buxicola* and *Cylindrocladium pseudonaviculatum*, as well as caterpillars of the *Cydalima perspectalis* moth, are the biotic factors that have the most negative effects on boxwood in Türkiye (Lehtıjärvı, Doğmuş-Lehtıjärvı and Oskay 2014; Özkaya 2020). *C. pseudonaviculata* was detected in the Trabzon and Artvin boxwood areas in 2011 and spread over 90 per cent of the boxwood groves in a short time.



Sheki municipality, Azerbaijan. ©UNEP/Mariam Devidze

"Old" invaders also have an important damaging effect on the local ecosystems and biodiversity. The loss of chestnut forests from the invasive *Cryphonectria parasitica* is very high: in different regions of Georgia, 40–70 per cent of chestnut trees are heavily damaged or dying (Beridze and Dering 2021).

The sea mollusc *Rapana venosa* causes an important threat to the bivalve molluscs of the Black Sea; simultaneously, the mollusc is itself becoming an object of mariculture (Janssen *et al*. 2014). In the late 1980s and early 1990s, the invasion of a ctenophore, *Mnemiopsis* sp., in the Black Sea caused the decline of populations of small pelagic fish (Kideys 1994). This species is an important factor for the decrease in fish stocks of economic importance in the Black Sea (Uysal and Boz 2018).

Introduced alien species of mammals are an additional threat that local fauna have faced since the middle of the twentieth century. The raccoon (*Procyon lotor*) was introduced in Azerbaijan 80 years ago, and subsequently expanded into the rest of the Caucasus Ecoregion. After the Second World War, almost 1,200 animals were exported to the North Caucasus. The distribution pattern of the raccoon in the region is changing rapidly. From Azerbaijan, the raccoon is expanding into nearby regions (Saveljev *et al*. 2021). This is an omnivorous species with potentially significant impact on local fauna, in particular birds. In addition, from the 1930s to the 1970s, nine other species of mammals were introduced or reintroduced in Azerbaijan.

In the nineteenth century, the wild European rabbit (*Oryctolagus cuniculus*) was released on Azerbaijan islands near the capital where they reproduced rapidly (Hajiyev 2000). On Khara Zira Island, food and water resources are not abundant, causing competition between the rabbits and gazelles (Sarukhanova *et al*. 2021). The common squirrel (*Sciurus vulgaris*), a common urban species (Askerov and Aliyev 2001), was also aggressively competing with other squirrel species (*S. anomalus*) on slopes to the south of the Greater Caucasus range.

The introduction of fish from the Coregonid family (Kuljanishvili *et al*. 2021) changed the lake fauna of Georgia and Armenia. The fast expansion of crucian carp (*Carassius gibelio*) (Japoshvili *et al*. 2013) has caused threats to the fish communities of large lakes and endemic amphibian species in smaller lakes (Tarkhnishvili and Gokhelashvili 1999). More local cases of invasion include a grass, *Erigeron annuus*, in pastures of the North Caucasus (Pshegusov, Tembotova and Sablirova 2020). About 80 invasive and expanding plant species are registered in Armenia (Fayvush and Tamanyan 2011; Fayvush and Tamanyan 2014).

A special issue is the expansion of alien plants. Slodowicz *et al*. (2018) showed the highest concentration of these species in the east Black Sea area and around urban zones but predict their accelerated expansion, due to climate change, throughout the entire region.

6.3.11. Case study: Degradation of forest biodiversity in south-west Georgia due to selective logging

A recent study (Goginashvili *et al*. 2021) revealed important biodiversity loss in forest habitats of Ajara in south-west Georgia. The region is particularly important since it hosts the largest forest refugia in the west of the Ecoregion (van Zeist and Bottema 1991; Gavashelishvili and Tarkhnishvili 2016) with the highest relict biodiversity, declining away from this refugial area (Tarkhnishvili 2014). The authors conducted a detailed field study describing the structure of vegetation in 135 plots distributed at eight research areas. The research showed that the proximity to roads and protection status are among key factors that affect species richness through overexploitation of plant resources and, not least, facilitating expansion of invasive alien plants into natural forests, independently of climatic and other abiotic conditions. Tarkhnishvili (2014) shows clearly how human impact may drive unplanned degradation of forest biodiversity if the spatial distribution of climates and landscape types is not considered sufficiently when planning protected areas and other conservation-related activities.

6.4. Key policy responses and outlook

6.4.1. Protected area dynamics

The basic statistics on the protected areas of the region, according to Williams *et al*. (2006), Zazanashvili *et al*. (2012) and Zazanashvili *et al*. (2020) show that the most substantial absolute growth of the total protected area during the last 15 years was in the North Caucasus; the highest proportional growth was in Azerbaijan and Türkiye (see Table 24).

Currently, the highest proportion of the total area under protection is in Armenia (over 12 per cent), followed by Georgia and the Islamic Republic of Iran (over 10 per cent). Only 2.8 per cent of the Turkish Caucasus was under

Table 24. Dynamics of the number and area of protected lands in the Caucasus Ecoregion, 2006–2020

Country	2006	2012	2020	Growth (percentage)
Protected areas (number)				
Armenia	28	28		0.00
Azerbaijan	35	48		37.14
Georgia	34	43		26.47
Islamic Republic of Iran	16	17		6.25
Russian Federation	88	103		17.05
Türkiye	22	28		27.27
Total	223	267		19.73
Protected areas (hectares)				
Armenia	316,954		371,800	17.30
Azerbaijan	318,817		818,400	156.70
Georgia	382,746		661,600	72.86
Islamic Republic of Iran	300,250		439,000	46.21
Russian Federation	1,216,177		2,010,800	65.34
Türkiye	190,521		451,200	136.82
Total	2,725,465		4,752,700	74.38
Protected areas: coverage of national territories percentage				
Armenia	10.64		12.48	1.84
Azerbaijan	3.68		9.45	5.77
Georgia	6.30		10.89	4.59
Islamic Republic of Iran	7.44		10.88	3.44
Russian Federation	4.52		7.47	2.95
Türkiye	2.77		6.56	3.79
Total	4.19		7.31	3.12

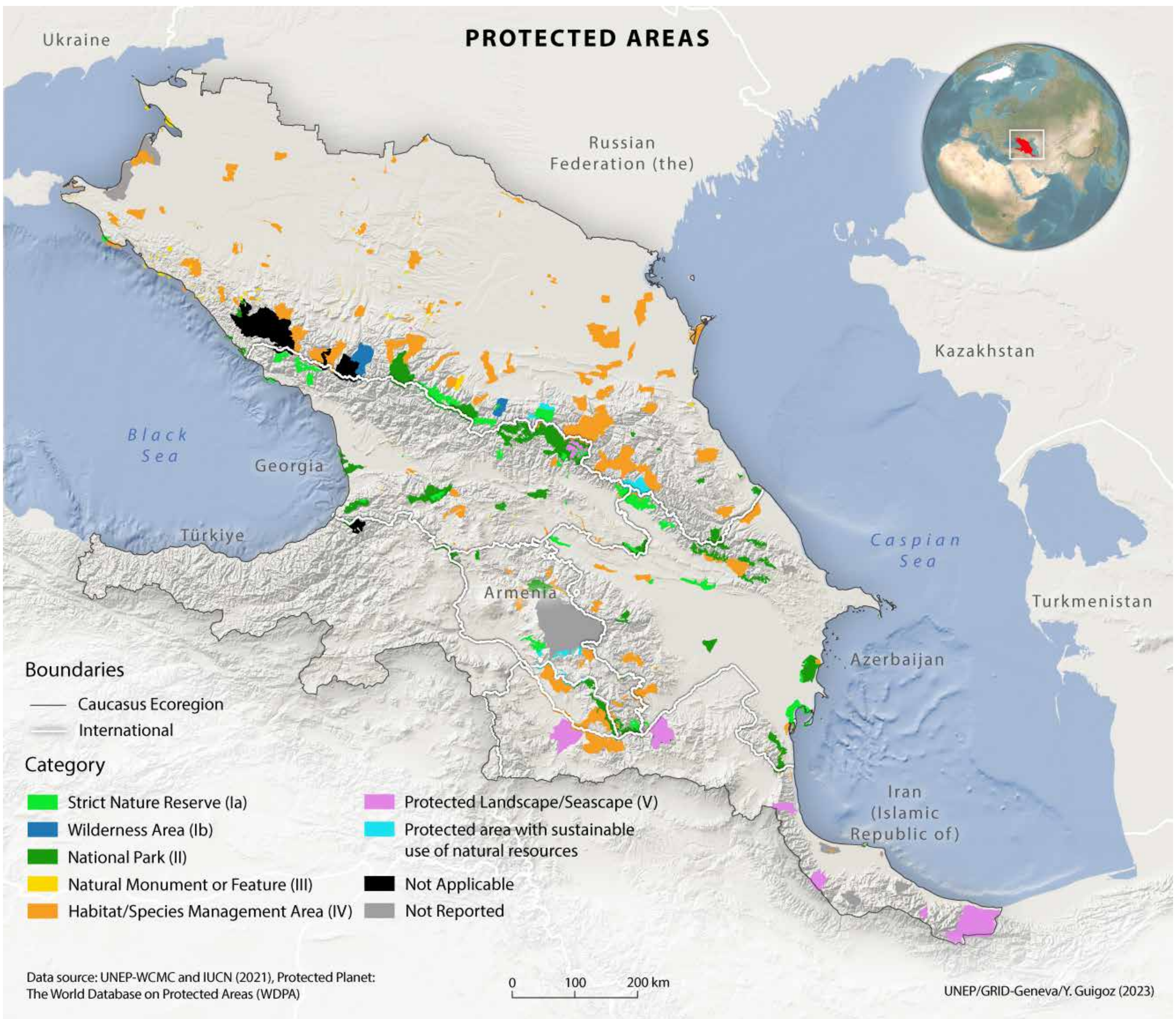
Sources: Williams *et al*. (2006), Zazanashvili *et al*. (2012), and Zazanashvili *et al*. (2020).

protection in 2020; Camili National Park (232 km²) remains the largest protected area here. In the Iranian Caucasus, there are 17 protected areas, the largest of which is Central Alborz National Park (4,107 km²).

The map of the protected areas of the Caucasus Ecoregion in 2017 shows that although Armenia, Georgia and the Islamic Republic of Iran have a higher coverage of their national territories than Azerbaijan, the Russian Federation and Türkiye, there are some important regions uncovered by the protected area system (see Map 15). There are large non-protected areas in the Caucasus part of Türkiye, the Georgian western Greater Caucasus, central Azerbaijan, and lowlands of east North Caucasus.

6.4.2. International treaties

All Caucasus countries have acceded to several international agreements related to the protection of biological diversity, including the Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Wetlands (Ramsar), the United Nations Convention to Combat Desertification (UNCCD), and a number of other treaties (see Table 25). Although most agreements were signed at least 11 years ago, it appears that their proper implementation is more important for the future in terms of policymaking and implementation, rather than involvement in new international agreements.



Map 15. *Protected areas of the Caucasus Ecoregion with IUCN categories.*

Table 25. International agreements on the environment signed or ratified by countries of the Caucasus Ecoregion.

International agreement (signature date)	Armenia	Azerbaijan	Georgia	Russian Federation	Türkiye	Islamic Republic of Iran
Convention on Biological Diversity (1992)	1993	2000	1994	1995	1997	1996
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)	2008	1998	1996	1992	1996	1976
Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971)	1993	2001	1997	1975	1994	1977
Convention on the Conservation of Migratory Species of Wild Animals; also known as the Convention on Migratory Species (CMS) (1979)	2011	N/A	2000	N/A	N/A	2008
United Nations Convention to Combat Desertification (1994)	1997	1998	1999	2003	1998	1997
UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)	1993	1993	1992	1988	1983	1975
United Nations Framework Convention on Climate Change (UNFCCC) (1992)	1993	1995	1994	1994	2004	1996
United Nations Economic Commission for Europe Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) (1998)	1993	1993	1993	1947	1947	N/A
Bern Convention on the Conservation of European Wildlife and Natural Habitats, (Bern Convention) (1979)	2008	2000	2009	N/A	1984	N/A
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention) (1989)	1999	2001	1999	1995	1994	1993
Cartagena Protocol on Biosafety to the Convention on Biological Diversity (Cartagena Protocol) (2000)	2004	2005	2009	N/A	2004	2004

6.4.3. Scientific research

There are many institutions conducting research on biodiversity in the Caucasus. The Scientific Network for the Caucasus Mountain Region has identified 4,280 titles of research papers published by 605 institutions devoted to the Ecoregion. According to SCImago journal and country rankings (SCImago n.d.), between 544 and 694,473 scientific papers in agrarian and biological sciences were published in the regional countries. The publication record for each of the regional countries, with Switzerland treated as a comparison is presented here (see Table 26).

The proportion of studies in the field of biological and agricultural sciences, in comparison to the scientific productivity of the Eastern European region, increased between 1996–2020 (see Figure 13).

Biodiversity studies are not a priority in national scientific programmes throughout the Ecoregion. In Armenia, Azerbaijan, and the Russian Federation, the proportion of citable publications in the field of biodiversity studies is below the world average.

Table 26. Citable papers published in the Caucasus Ecoregion in 2020 (in number and percentage of the total indexed scientific publications)

Country	Zoology	Entomology	Plant biology	Evolutionary biology	Agrarian science	Forestry	All
Country and number of articles by subject (number)							
Armenia	11	5	12	22	4	1	1175
Azerbaijan	9	9	28	22	14	2	1764
Georgia	33	10	38	54	9	10	1905
Islamic Republic of Iran	858	301	1128	754	1182	215	69754
Russian Federation	802	591	1339	2562	303	156	119195
Türkiye	683	237	874	663	707	242	53802
Switzerland	488	192	516	1362	236	183	47607
Country contribution to total number of publications (percentage)							
Armenia	0.94	0.43	1.02	1.87	0.34	0.09	100.00
Azerbaijan	0.51	0.51	1.59	1.25	0.79	0.11	100.00
Georgia	1.73	0.52	1.99	2.83	0.47	0.52	100.00
Islamic Republic of Iran	1.23	0.43	1.62	1.08	1.69	0.31	100.00
Russian Federation	0.67	0.50	1.12	2.15	0.25	0.13	100.00
Türkiye	1.27	0.44	1.62	1.23	1.31	0.45	100.00
Switzerland	1.03	0.40	1.08	2.86	0.50	0.38	100.00

Source: SCImago Journal and Country Rankings (n.d).

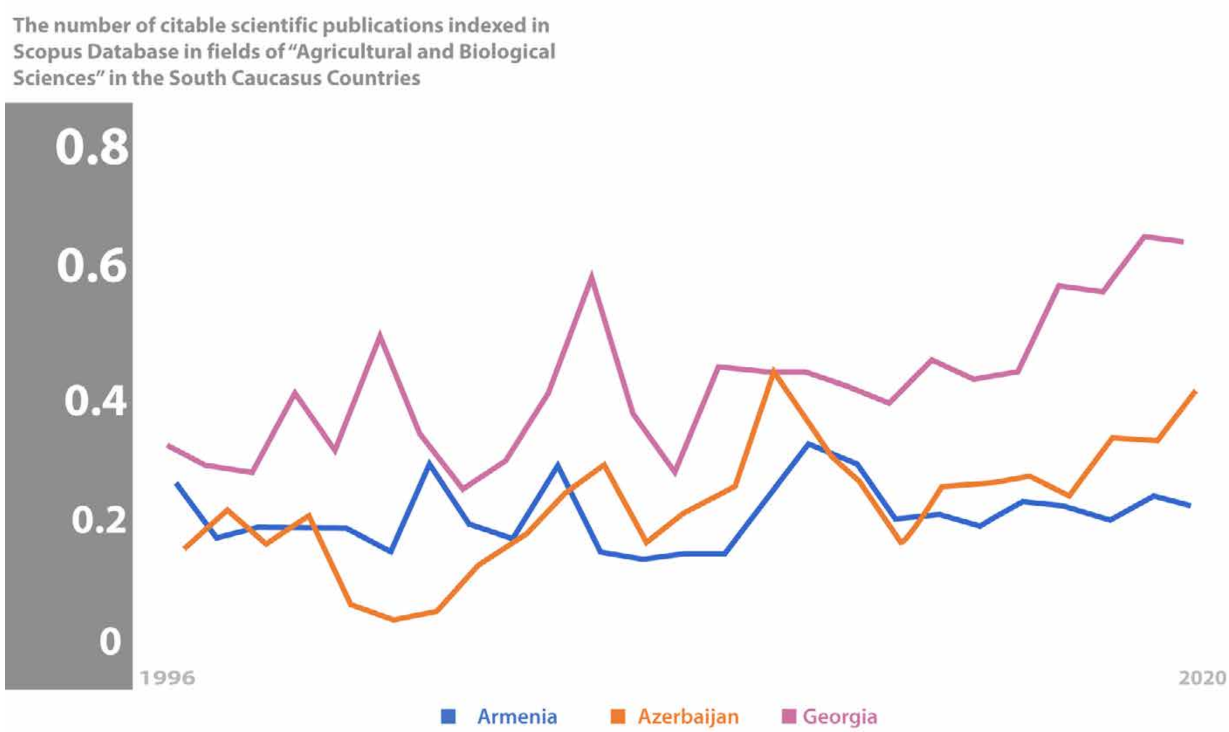


Figure 13. *Citable scientific publications indexed in Scopus Database in fields of "Agricultural and Biological Sciences" in Armenia, Azerbaijan and Georgia, 1996–2020.*

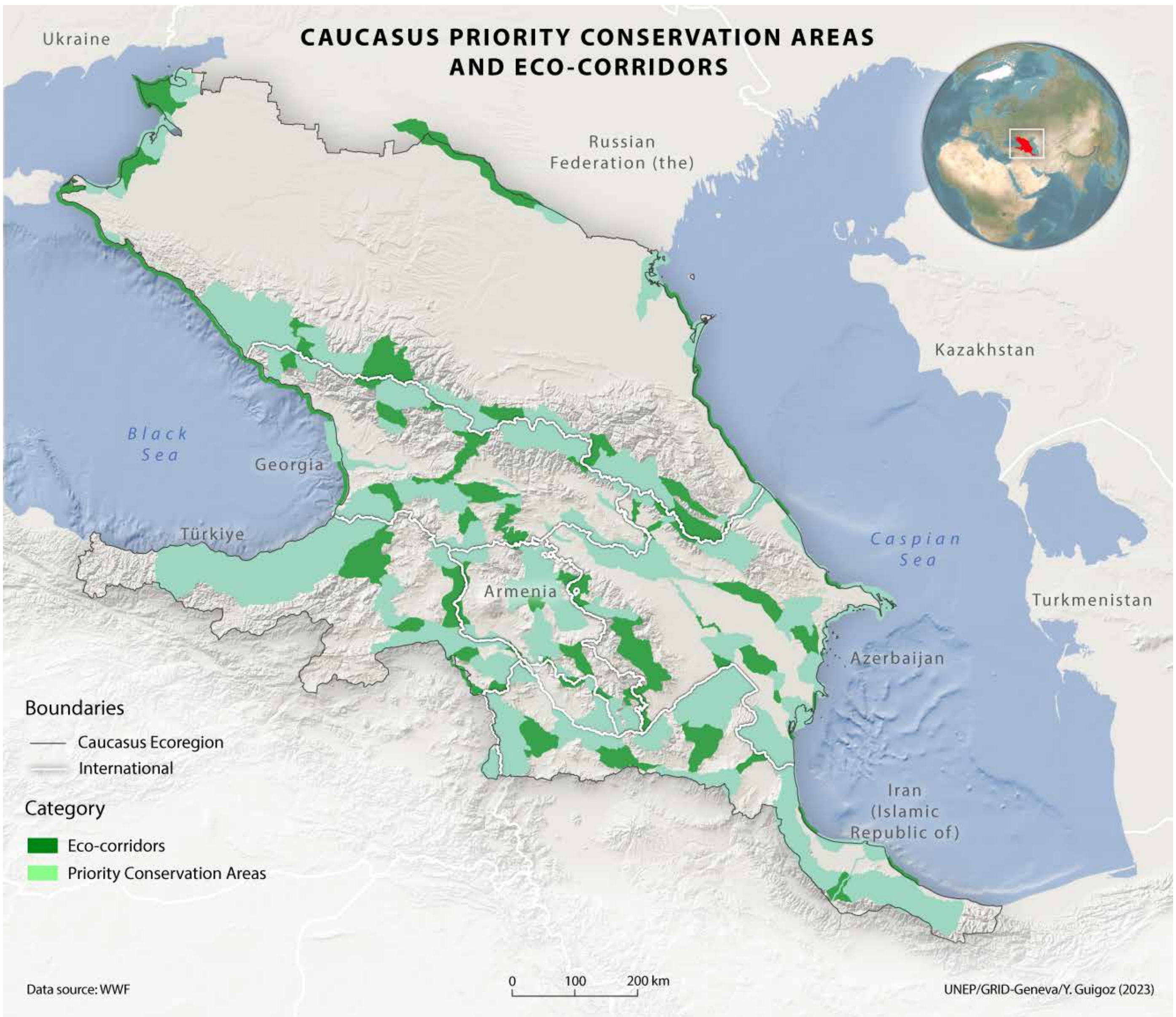
Sources: SCImago journal and country ratings (n.d.).

6.4.4. Key biodiversity areas and corridors, and the level of their protection

Zazanashvili *et al*. (2020) summarized data and developed maps of the Caucasus Ecoregion conservation landscapes (CL), key biodiversity areas (KBA) and bridging landscapes (BL) based on the consensus of more than 100 experts and governmental officials (see Map 16).[6] Currently, conservation landscapes almost cover the region, except for the mountain plateau in southern Georgia, Armenia and east Türkiye, and the valleys of the major rivers and the Kuma-Manych Depression. Key biodiversity areas are more fragmented and exclude agricultural landscapes. A bridging landscape connects the Greater and the Lesser Caucasus, the Western Lesser Caucasus to the Armenian part of the Lesser Caucasus, and the South Caucasus plains, KBAs of east and west Armenia at the Bazum Range, and KBAs of east Türkiye.

In 2020, the total area of conservation landscapes in the Caucasus covered 251,408 km^2, including 7,916 km^2 of marine aquatoria. This comprises about 43 per cent of the Ecoregion and covers 86 per cent of the KBAs (Zazanashvili *et al*. 2020). Just 20 per cent of the conservation landscapes and 39 per cent of the KBAs are covered by protected areas of different categories. The highest protected area coverage of the KBAs

[6] The Global Standard for the Identification of Key Biodiversity Areas (KBA Standard) (IUCN 2016) has the purpose "to locate and highlight sites that make significant contributions to the global persistence of biodiversity." These are then recognized as key biodiversity areas.

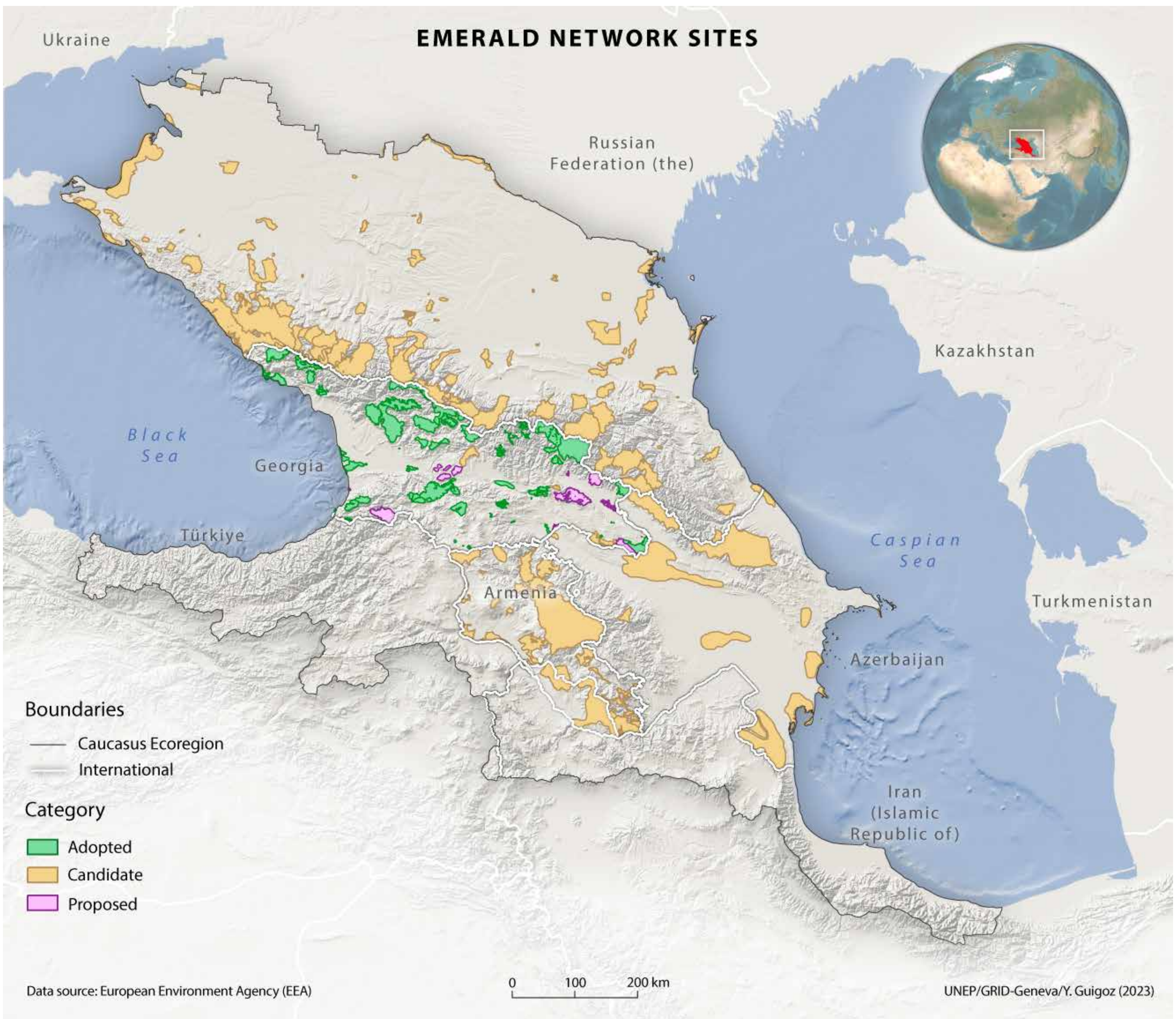


Map 16. *Key biodiversity areas and corridors in the Caucasus Ecoregion.*

is in the Eastern (82 per cent) and the Western (67 per cent) Greater Caucasus. The least protected areas are Kuma-Manych in the Russian Federation, Sarykamysh-Maku in the Islamic Republic of Iran and Türkiye, and the Western Lesser Caucasus (Zazanashvili *et al*. 2020).

The least protected large conservation areas covered by KBAs are the Georgian part of the Western Greater Caucasus, on the southern slopes with a high proportion of endemic plants and animals, and relatively well-preserved forest stand; and the Turkish part of the Western Lesser Caucasus/Doğu Karadeniz Mountains, especially in the west. Mancheno *et al*. (2017) suggest that the coverage of KBAs by protected areas has substantially increased since 2001; however, many areas remain unprotected. Although protected areas have varied levels of protection, their status ensures that they function as a corridor for wildlife and protects them from a substantial transformation of the natural landscape.

Armenia, Azerbaijan, Georgia and the Russian Federation are included in the European system called the Emerald Network, which is an ecological network made up of Areas of Special Conservation Interest that is organically related to the Bern Convention on the Conservation of European Wildlife and Natural Habitats. Georgia has adopted sites of the Emerald Network, whereas candidate sites have been identified in Armenia, Azerbaijan and the Russian Federation (see Map 17). The Islamic Republic of Iran and Türkiye are not included in the



Map 17. *Emerald Network sites in the Caucasus.*

network. The location of the Emerald Network partly overlaps with the location of KBAs, and many of them lay within the protected area network.

6.4.5 Case study: Restoring the natural range of goitered gazelle

The goitered gazelle (*Gazella subgutturosa*) is an ungulate originally found throughout a large swath of Eurasia, from Mongolia in the east to Türkiye and the South Caucasus in the west. The gazelle has traditionally been hunted, and today, once-abundant populations have declined to less than 50,000 individuals with a fragmented range.

In the 1950s, the Caucasus population of this species was reduced to around 200 individuals. However, until the late 1980s, the population was found throughout Azerbaijan and in south-east Georgia. In recent decades, poaching has caused local extinction of this ungulate from the central part of the South Caucasus. Thanks to the efforts in Azerbaijan, the population in the Shirvan area has increased to over 7,000 individuals in recent decades, accounting for more than 10 per cent of the global population.

Since the early 2010s, regular reintroduction actions of the gazelle have been implemented. The target release areas were located west and north of the Mingechaur Reservoir in Georgia and Azerbaijan. Three other reserves in west Azerbaijan were viewed as potential areas where the gazelles would expand after being established at the reintroduction locations. Every year, between 8 and 21 adult gazelles were translocated from Shirvan State Reserve to Ajinour reserve in Azerbaijan. Between 8 and 20 individuals were simultaneously translocated to the Vashlovani protected areas of Georgia, 71 gazelles altogether.

The translocated herds on both sides of the state border were monitored between 2010 and 2020. For a long period, while there was occasional reproduction of the gazelles, the herds increased mostly because of new translocations. In 2018, the Central Caucasus population of goitered gazelles started to grow rapidly due to the reproduction of the translocated animals. Although only 31 animals were translocated from Shirvan, the population increased by 141 gazelles between 2018 and 2019, bringing the population to 234, mostly by local reproduction. This effort is a good example demonstrating the successes and complications of reintroduction; a substantial lag between the first relocation of the target population and this population reaching self-sustainability is likely. Close monitoring is also essential for the success of reintroduction projects.

> ***Studies should be carried out to increase the number of protected areas in the Ecoregion, and solution-oriented scientific and social studies should be carried out in order to increase the awareness of conservation and use.***
>
> Nuray Çaltı, independent researcher and youth trainer, Türkiye

6.4.6. Impact of political responses on the actual situation

One of the most interesting but also controversial findings of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the highly variable progress towards different international biodiversity targets (IPBES 2019). Although important progress has been achieved in goals related to the policy responses and actions, the state of biodiversity continues to worsen worldwide (Tittensor *et al*. 2014). This is related to the different abilities and political will of the countries that are parties of the international agreements to implement measures related to biodiversity conservation (Robinson *et al*. 2009). This may depend on history, legacy effects and international relations (Raudsepp-Hearne *et al*. 2010). Policy actions often are unsuccessful in the establishment of institutions and governance responding to biodiversity loss (Geldmann *et al*. 2018).

Specifically in the Caucasus Ecoregion, the most important achievement is the growth in protected areas during the last 30 years that has had a simple and direct positive effect on biodiversity. There is a substantial increase in the number of signed international and national documents; however, it is not clear to what extent this progress has improved the situation on the ground. Economic growth in the countries of the South Caucasus has had a positive impact on corruption statistics, which did make the implementation of laws regulating logging, hunting, fisheries and construction more effective. Legislative discipline has a positive impact on illegal activities but nevertheless, this is hardly sufficient for their prevention or to oblige parties such as construction companies to develop objective and professional impact assessments and to implement mitigation measures.

6.4.7. Outlook: Identification of problems and pathways to their solution

Direct drivers that impact regional biodiversity include (1) loss, degradation or fragmentation of natural landscapes as a result of construction, infrastructure development, logging and grazing; (2) pollution of water and soil, especially by pesticides, herbicides and fertilizers; (3) expansion of invasive alien species; and (4) overexploitation of fish stock, hunted species and tree species of valuable timber, causing decline and extinction of rare species.

The economic state of the three South Caucasus countries remains poor. In 2020, the world ratings of the gross domestic product (GDP) per capita of Armenia, Azerbaijan and Georgia were between 119 and 130. After the decline of their economies from 1990 to 1995, all three countries enjoyed renewed economic growth, with rates similar to those in Central Europe (World Bank n.d.). However, the Islamic Republic of Iran, the Russian Federation and Türkiye, in spite of lower GDP growth rates, have higher GDP per capita than the three South Caucasus nations.

These facts suggest that economic growth, which is an essential precondition for achieving Sustainable Development Goals (SDGs) 1, 3, 4, 5, 8 and 9, which are all associated with human well-being, is particularly important for the South Caucasus to ensure sustainable development in the region. This is inevitably related to the rapid development of infrastructure, ensuring energetic independence, and the development of effective agriculture. However, such relative advancements may negatively impact regional biodiversity, ecosystem services, and the sustainability of natural habitats (SDG 12, 14, and 15; Aichi Biodiversity Targets B5-B8, C11-C13, D14).

Indirect and direct drivers on regional biodiversity can have a negative influence (see Figure 14). Some of the indirect drivers are linked with the economic development of the region and cannot be suspended or significantly limited. Rather, alternative ways need to be identified to minimize the impact on biodiversity. The other drivers, including unsustainable fisheries, pasturing, logging and hunting/poaching, do not have a substantial impact on macroeconomic development, while having the benefit of providing a source of living to many individuals in local populations.

> *Governments could prioritize conservation of biodiversity and the protection of endangered species in the region. This could involve implementing and enforcing regulations that prevent illegal hunting, overfishing, and the destruction of habitats. Governments could also support research and monitoring efforts to better understand the Ecoregion's biodiversity and promote conservation initiatives.*
> Emil Jabrayilov, Institute of Geography, Baku, Azerbaijan

In this case, long-term strategy should include gradual change from unsustainable to sustainable practices, even at the expense of the decline of summary income from fisheries, and wood production (applicable to SDGs 7, 11, 12 and Aichi Biodiversity Targets B5, B6, B7). Meat and fish production, simultaneously, may not be reduced if the dominating extensive practices would be at least partly replaced by intensive fish and livestock farming (SDGs 1, 2, 3).

Replacing fuel wood with alternatives such as natural gas, and replacing wood with other materials (for building, carpentry, etc.) will help to reduce logging (SDG 15, Aichi Biodiversity Targets B5, B7). Hunting, unlike fishing, logging and pasturing, is not an important source of food or income, instead it is a leisure activity, albeit a culturally important one

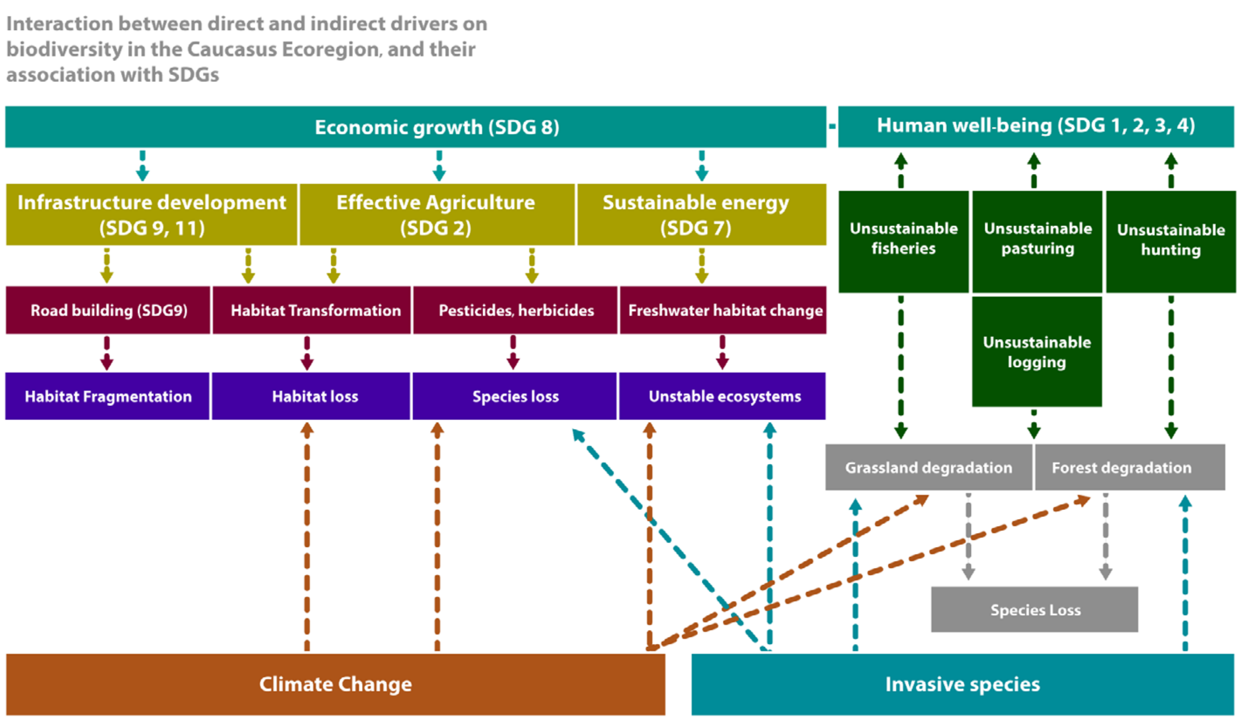


Figure 14. *Interaction between direct and indirect drivers on biodiversity in the Caucasus Ecoregion and their association (positive or negative) with SDGs.*

Note: Drivers are conventionally divided into those acting within the Ecoregion and hence largely depending on local policies and social and economic developments, and those (in the lower part of the diagram) that are the result of worldwide trends, with little dependence on regional policies.

in many parts of the Caucasus. Reducing hunting pressures on game populations could be done by increasing the extent of protected areas, imposing strict hunting regulations and, perhaps, developing game farms (SDGs 12, 15; Aichi Strategic Goal C).

The impact of the first group of indirect drivers – infrastructural development, intensive agriculture, and energy – cannot be readily decreased in the context of improved human well-being and continued economic development of the region in a competitive world (SDGs 1, 3, 4, 5, 8, 9). Slowing down each of these activities is not an approach to pursue, instead, technical solutions can be sought out to reduce harm to regional biodiversity.

Diminish fragmentation of natural habitats requires taking into account biodiversity issues in infrastructural design, including road-building, and encouraging a more even geographic distribution of socially important infrastructure. This means considering building pathways for animals, reducing the killing of animals on roads, and avoiding construction of broad highways wherever possible (SDG 15, Aichi Biodiversity Target B5).

Other types of construction activities should consider the value of a transformed landscape. Major construction activities in protected areas, including hydropower stations, recreation complexes, major roads, etc., must be completely prohibited, and personal sanctions should be issued against decision makers permitting such activities; on the other hand, the development of new protected areas should be considered, with decision makers participating in infrastructure planning to avoid potential complications in future.

Hydropower station maintenance and construction is a part of the strategy of regional development (Keogh and Bayramov 2021). For this reason, it is important to reduce building effects on biodiversity. Among other arrangements, ensuring uninterrupted pathways for anadromous fish is crucial (SDG 14, Aichi Biodiversity Targets B5, B6). In the absence of such pathways, construction companies should be sanctioned. Detailed ichthyological expertise and a plan of mitigation measures should be an essential part of the planning of all hydropower stations.

Another important problem is the development of intensive agriculture in the Caucasus, which still relies on imports of strategic food products from outside the region (Nazaretyan 2020) (relevant to SDGs 2, 3). The intensification of agriculture is related to the broad use of fertilizers, pesticides and herbicides that negatively affect insect populations (Brühl and Zaller 2019). Relying on extensive agricultural imports does not appear a plausible solution, because it will not help to solve regional food problems. Perhaps unpopular, but potentially prospective solutions such as the broader use of genetically modified crops could help to reduce the use of pesticides and fertilizers without a substantial decrease in the local food supply. High-tech approaches to food production will increase societal gender equality in regional communities, requiring less physical effort but more precision in technical work; moreover, the importance of agricultural land control, which is usually gender-biased, would decline. Other technologies, including indoor farming, where women play a significant role, can also be critical. Increasing the importance of the latter would also empower the societal roles of women. This would strengthen synergies among household food security, adaptation and mitigation (Arneth *et al*. 2019) (see chapter 5).

An important driver, however unmanageable at the regional level, is global climate change (Pittock 2017). In the face of global warming, the only effective actions that can be undertaken at the regional and national levels are adaptation measures. We refrain in this document from specific recommendations except those listed above; it is important to foster research activities at the regional level that help to improve and geographically adjust the existing climate change models, particularly changes of temperature and precipitation changes. It is also important to intensify research on the effect of invasive alien species. The evidence of the effective controlling of the invasive populations by humans is modest, and it remains unclear whether the efforts for controlling them reach targets (Epanchin-Niell and Hastings 2010). However, it appears that sustainable ecosystems have a high-enough potential to resist invasions and eventually integrate alien species into the local biological communities (Beaury *et al*. 2020). These processes are insufficiently understood and require intensive research in the future.

Chapter 7: Air quality

Clean air is a priority for all countries of the Caucasus Ecoregion: each undertakes purpose-driven air-pollution monitoring, emission limitation and record-keeping measures. Countries use different management approaches depending on their institutional development and economic capacities.

7.1. Air pollution

The World Health Organization (WHO) defines air as being polluted when its chemical composition can adversely affect the health of people, plants and animals, as well as other environmental elements (e.g., water and soil) (WHO 2021a). Air pollution is a key global environmental threat (see Box 1).

All the above-listed substances are observed in all the countries of the Ecoregion to some extent, since they are most often the direct consequences of human activity. The countries in the Ecoregion have adopted policies to control and account for emissions of harmful substances and to monitor air quality. All countries in the Ecoregion keep records of atmospheric emissions (see Table 27) and are developing measures to reduce them. Other than the Islamic Republic of

Box 2. Air pollution definitions and quality control

Air pollutants

World Health Organization Guidelines on air pollution focus on six "classical" pollutants: particulate matter (PM) with $PM_{2.5}$ defined as particles smaller than 2.5 microns and PM_{10}, which are particles smaller than 10 microns; ozone (O3), nitrogen oxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO) (WHO 2021c, p. xvii). Non-methane volatile organic compounds (NMVOCs) are another type of pollutant that is chemically reactive (methane is excluded as it is non-toxic).

Particulate matter is a broad category that includes pollutants of different chemical compositions, sizes and origins (i.e. dust, elemental carbon, organic or inorganic matter, dry solids, liquids, or aerosols) (California Air Resources Board [n.d.]; WHO 2021c, p.7). Their size influences the effects they may have on different elements of the environment. Particulate matter can contain chemical components such as ammonia, black carbon, mineral dust, nitrates, sodium chloride or sulphates (WHO 2022). Some pollutants arise naturally (dust, sand, forest fires [if of a natural origin], saltwater mist, etc.) while many are anthropogenic. Many result from combustion and are linked with the burning of fossil fuels for cooking, heating, transportation (land, air or water), power generation, industrial transformations or from human-sparked forest fires or the burning of agricultural waste. SO_2 is produced when sulphur-containing fuels are burnt. Ozone at the ground level (not the ozone layer in the upper atmosphere) is created when sunlight reacts with pollutants and volatile organic compounds from combustion. All pollutants become part of the air breathed by humans, animals and plants since they remain in the atmosphere (WHO 2021c, p. xvii).

Atmospheric air quality control

The quality of atmospheric air is the combination of its physical, chemical and biological properties that reflect the degree of its compatibility with atmospheric air quality standards. To assess atmospheric air quality, countries have determined air quality standards that indicate the maximum permissible concentration of pollutants. To evaluate the condition of the atmosphere, all countries need to compare data on the concentration of air pollutants with atmospheric air quality standards. Atmospheric air protection aims to prevent emissions from pollution sources, or to minimize them if complete prevention is not possible.

Atmospheric air pollution monitoring tends to observe, record and share data on the quantities of particulates in the air. Accounting of air pollutant emissions is carried out via aggregation of emissions from individual sources (bottom-up approach), often through specific monitoring stations established for this task, to control sources of air pollution and to regulate air quality.

The goal of the UNECE Convention on Long-range Transboundary Air Pollution (UNECE CLRTAP) is to limit and gradually abate and prevent air pollution. Parties to the Convention exchange emissions data for air pollutants and their effects, aspects likely to cause significant changes in long-range transboundary air pollution (particularly in national policies and industrial development), control technologies for reducing air pollution, estimated abatement costs, physicochemical and biological data, etc.

Sources: World Health Organization (2021a); World Health Organization (2021b); World Health Organization (2021c); World Health Organization (2022); UNECE (1979).

Iran, they are all Parties to the UNECE CLRTAP, and each year submit an annual emission inventory report to the Secretariat of the Convention.

Economic structures, as described earlier in this report (see section 3.4), will show some correspondence to emissions of harmful substances as officially submitted by the Ecoregion countries (see chapter 3). The key economic sectors of the countries are also the main emitters of harmful substances. In all countries of the Ecoregion, the key sources of emissions are energy production and consumption, industry, transport, agriculture and services. However, each country has its own specificities.

The main source of emissions in Armenia is copper production (European Monitoring and Evaluation Programme [EMEP] n.d.). In Azerbaijan, industrial emissions, particularly those resulting from oil extraction and production, road transportation, agriculture, construction and waste, account for a large share of air pollution. Main sources of emissions in Georgia include the development of trade routes, associated transportation, and storage and repair services, followed by emissions for manufacturing, construction, institutional, residential, agricultural and fishing industries. In the Islamic Republic of Iran, the transport sector is among the largest sources of emissions, including motor vehicles such as cars and motorcycles, as well as heavy vehicles such as trucks and buses over a certain weight, which are usually powered by diesel engines. The industrial sector, where factories run on coal-fired equipment, is also a large source of pollution. Finally, other sources of pollution, such as construction sites and poorly maintained roads, emit large amounts of fine gravel and quartz dust, as well as microplastics and toxic metals such as lead (Pb), mercury (Hg) and cadmium (Cd). Within the Caucasus part of the Russian Federation and the constituent entities of the North Caucasian Federal District, Stavropol Krai had the largest share of total emissions in 2019 (350,200 tons, including railway emissions) with its share of transport emissions making up 70.7 per cent. The Republic of Kabardino-Balkaria had the lowest share of emissions, amounting to 23,020 tons, 88.7 per cent of which were generated from mobile sources. In the Caucasus part of Türkiye, agriculture and forestry are the second largest sectors of the economy. The energy sector, which includes all forms of energy consumption, particularly transport and production, is the main source of CO, NOx and SO2 emissions. NMVOC emissions are mainly produced by agriculture.

Certain emission calculations were made for the entire Ecoregion based on official data submitted by the countries to the CLRTAP Secretariat in 2019 (see Figure 15). However, algorithms for emission estimations differ between countries due to their data submission peculiarities. For instance, for Armenia and Georgia, calculations were made solely based on data reported for 2019. For Azerbaijan, arithmetic averages of 2015–2017 emissions data were accepted, whereas in the cases of the Russian Federation and Türkiye, there was a need for per capita emission estimations for the Caucasus regions of the countries, given that the data submitted by each of these countries to the CLRTAP Secretariat are for entire national territories (see chapter 1).

Table 27. Emissions of key pollutants for entire national regions countries present in the Caucasus, 2019

Country	CO (Gg)	SO_X (Gg)	NO_X (Gg)	$PM_{2.5} + PM_{10}$ (Gg)
Armenia	147.409	0.6	22.735	6.069
Azerbaijan	128.403	14.466	80.043	18.194
Georgia	108.593	5.068	47.458	22.583
Islamic Republic of Iran	681.777	67.499	139.327	22.000
Russian Federation	531.23	97.812	204.643	69.09
Türkiye	63.096	96.995	34.264	17.002
Total	1660.508	282.44	528.47	154.938

Source: Author compilation from EMEP (n.d.).
Notes: Data for the Islamic Republic of Iran, the Russian Federation and Türkiye is from the national level. This means that the above data include the entire national territories of these countries and not only their Caucasus parts. A gigagram (Gg) is a decimal multiple of the base unit of mass in the International System of Units: 1 Gg = 10^6 kg = 10^9 g.

Calculations for the Islamic Republic of Iran were based on data presented by the Department of Electricity and Energy of the Ministry of Energy of Iran. Emissions data are reported for 2010–2017 either from all energy sources or from industrial sources. Since energy emissions also include motor vehicle emissions, the data provided can be used to reliably determine the contribution of the Islamic Republic of Iran to regional air pollution. Average emissions for 2015–2017 were calculated and extrapolated into the emissions estimations for 2019 as there were no spikes registered in the emission trends for the period. All countries submit data in gigagrams (Gg), apart from the Islamic Republic of Iran, which submits data in tons.

7.2. Global warming and greenhouse gas emissions

Climate change and air pollution are closely linked. Many measures addressing air pollution also directly reduce greenhouse gas (GHG) emissions. As such, reducing air pollution helps to combat climate change. All countries of the Ecoregion are Parties to the UNFCCC and to the Paris Agreement, although the Islamic Republic of Iran has signed but not yet ratified the Paris Agreement. GHG inventories are compiled by countries under the UNFCCC and submitted to the Convention Secretariat. In addition to inventory reports, countries develop national communications and

Box 3. Definition of greenhouse gases

Greenhouse gases (GHGs) are generally seen as the cause of global warming. They include carbon dioxide (CO_2), nitrous oxide (N2O), methane (CH4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). Anthropogenic activities that cause air pollution and global warming include emissions from industry (particularly from energy production); extraction and transportation of raw materials; chemical, processing and metallurgical industries; cement production; landfills for raw materials and waste; and transportation. The United Nations Framework Convention on Climate Change (UNFCCC) sets out the basic legal framework and principles for international climate change cooperation with the aim of stabilizing atmospheric concentrations of GHGs to avoid "dangerous anthropogenic interference with the climate system" (UNFCCC 1992 Article 2). In December 2015, the parties adopted the Paris Agreement, which requires all parties to determine, plan and regularly report on the nationally determined contribution (NDC) that it undertakes to mitigate climate change.

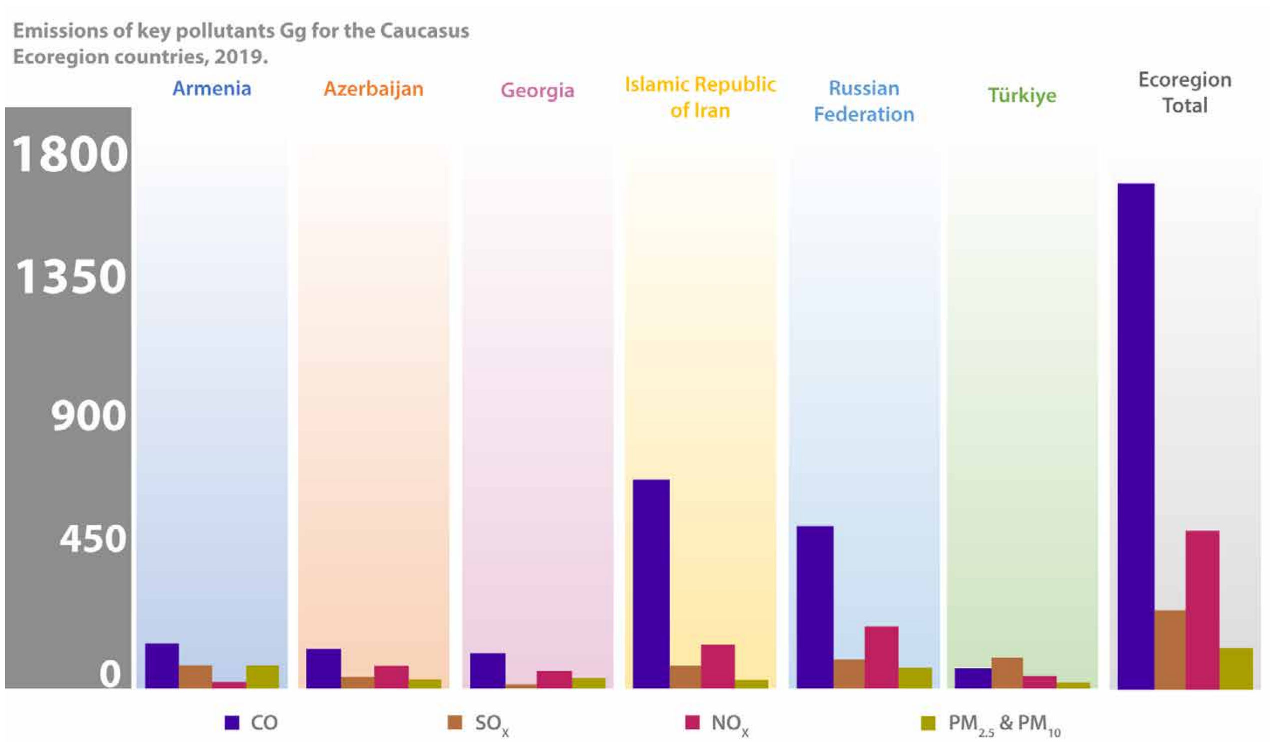


Figure 15. *Emissions of key pollutants for the Caucasus Ecoregion, 2019.*

Source: Author compilation from EMEP (n.d.).

Ore dressing treatment plant, Georgia. *©iStock/Vladimir Zapletin*

biannual reports on the performance of their commitments, including GHG reductions. They also submit future plans, formally called nationally determined contributions (NDCs) or intended nationally determined contributions (INDCs), to the UNFCCC Secretariat.

Below is the latest information from country reports of GHG emissions, noting that the land use, land-use change, and forestry sector (LULUCF) can compensate for and thus reduce emissions.

7.2.1. Greenhouse gas emissions by country

Total greenhouse gas emissions of Armenia in 2017 amounted to 10,624 Gg CO2e (excluding LULUCF). Emissions were 3 per cent higher than the previous year. CO2 represented 53 per cent of total emissions, the highest percentage, followed by CH4, at about 30.6 per cent. N2O represented 9.9 per cent of total emissions and HFCs accounted for roughly 6.5 per cent. The share of SF6 is negligible (Armenia, Ministry of Environment 2021).

The economy of Azerbaijan is one of the most energy-intensive in the Ecoregion due to oil and gas extraction, making the extraction industry the main contributor of greenhouse gas emissions in the country. In 2016, greenhouse gas emissions amounted to 61,257 Gg CO2e. The energy sector accounts for about 79 per cent of the total, excluding LULUCF. Agriculture is in second place, industrial processes and product use (IPPU) is third and waste is fourth, all excluding LULUCF. Increased electricity, heat, oil and gas production led to higher emissions in the energy sector after 2010 (Azerbaijan, Ministry of Ecology and Natural Resources 2021).

In 2017, greenhouse gas emissions amounted to 17,766 Gg CO2e in Georgia. The energy sector, excluding LULUCF, accounts for more than half of emissions, approximately 1,990.2 Gg CO2e, or 11 per cent of the total. Agriculture stands in second place. The IPPU and waste sectors are ranked third and fourth, excluding LULUCF (Georgia, Ministry of Environmental Protection and Agriculture 2021).

The Islamic Republic of Iran prepared its greenhouse gas emission inventory based on the available data for the year 2010 for the Third National Communication of the Islamic Republic of Iran to the UNFCCC. Based on the inventory, it was observed that there is uncertainty vis-à-vis the data gathered on the agriculture and forestry sector. The total CO2 emissions from different sectors in 2010 was about 668,575 Gg, with the energy sector contributing about 88 per cent of total emissions, industrial processes contributing about 9 per cent and forestry contributing about 3 per cent. The total CO2e emissions were estimated to be about 832,043 Gg in 2010. The energy sector contributed the largest share of overall greenhouse gas emissions (81 per cent) and the forestry and waste sector had the lowest share (3 per cent). The combustive emissions of other GHGs (CH4, N2O) are calculated considering the amount of fuel consumption and the gas emission factor. In addition, fugitive CH4 emissions are estimated from oil and gas activities (Islamic Republic of Iran, Department of Environment 2017).

In 2017, the total anthropogenic emissions of greenhouse gases in the Russian Federation, excluding LULUCF, amounted to 2,155.5 Mt CO2e. This value corresponds to 67.6 per cent of the cumulative emissions for the year 1990. With inclusion of the emissions and removals related to LULUCF, the total emissions in 2017 were calculated as 1,577.8 Mt CO2e (50.7 per cent of total 1990 emissions). The greatest contribution to greenhouse gas emissions in the Russian Federation is made by the extraction, transport, processing and use of various fossil fuels (except for feedstock and materials). CH4 emissions, accompanying the processes of extraction, processing, transportation, storage and use of fossil fuels, also play a significant role. Metallurgy, the largest source of emissions from IPPU, has the most important share in the overall GHG emissions from industry, making up 46.3 per cent in 2017. The chemical industry was the second largest source, with a share of 29.6 per cent. The share of emissions from mineral production made up 15.9 per cent (Russian Federation 2017).

Total GHG emissions in Türkiye in 2016 were 496.1 Mt CO2e, excluding the LULUCF sector and 428.0 Mt CO2e, with the LULUCF sector for an increase of 135.4 per cent above 1990 levels. The energy sector was responsible for 72.8 per cent of overall greenhouse gas emissions without LULUCF. Turkish greenhouse gas emissions from human activity arise above all from fuel combustion, which accounted for 97.7 per cent of energy sector emissions in 2016 or 361 Mt CO2e. The energy industry accounted for 41 per cent of energy sector greenhouse gas emissions (Turkish Statistical Institute 2021).

The greenhouse gas emissions of the Ecoregion countries in CO2e are calculated based on per capita emissions (see Table 28).

All countries consider the energy subsectors, including transport, industry and agriculture, as major sources of greenhouse gases.

7.3. State of atmospheric air quality

7.3.1. Air quality monitoring

All the countries of the Ecoregion monitor atmospheric air pollution by major air pollutants as well as some others. Activities under the CLRTAP are particularly important for monitoring the

Box 4. Air quality standards

Air quality standards (AQS) can neither be developed nor enforced without air quality monitoring to provide baseline and updated data on actions taken to improve air quality. Measurement stations are required elements of a monitoring system. Site location, financing and results interpretation are all political choices that will shape ambient air quality standards and monitoring schemes (UNEP 2021, p. 63). Air pollution legislation should establish requirements for monitoring that will develop transparency and meet international best practices in this regard (UNEP 2021, p. 77). The WHO (2021c) notes that measuring stations are often located in urban areas, while rural areas are neglected in many countries. Modelling and new approaches including satellite data could be a way to augment the capacity of air quality monitoring networks (WHO 2021c, p. 192.) The status of global air pollution that is available thanks to these monitoring methods is visible in the WHO Ambient Air Quality Database and OpenAQ (WHO 2021c, p. 5).

Table 28. Greenhouse gas emissions in tCO_2e by Ecoregion countries, 2019

Country/subregion	Per capita emissions (tCO_2e)	Population (number)	Emissions for the entire country/subregion (tCO_2e)
Armenia	2.09	3,000,000	6,270,000
Azerbaijan	5.4	10,000,000	54,100,000
Georgia	2.72	3,700,000	10,064,000
Islamic Republic of Iran	7.60	5,500,000	41,800,000
Russian Federation	11.80	16,100,000	189,980,000
Türkiye	4.76	3,200,000	15,232,000
Total	–	41,600,000	407,446,000

Source: World Bank (n.d.).
Note: Emissions for Armenia, Azerbaijan and Georgia apply to the whole countries. Emissions for the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye were estimated by multiplying the per capita emissions by the known population of these areas. Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

impact of air pollutants on ecosystems. While performing certain monitoring activities, Armenia and Georgia work in accordance with the special co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe (European Monitoring and Evaluation Programme [EMEP]). Some observation stations in the Caucasus Ecoregion operating as part of monitoring subsystems, such as background air pollution monitoring stations (in the Russian Federation) are included in the list of international observation systems. The rest of this section gives information on how monitoring is conducted in the countries of the Ecoregion (see Map 18).

7.3.2. Air quality monitoring by country

Armenia

Atmospheric air quality monitoring is performed at 18 stationary active sampling observation stations located in 11 settlements of Armenia. There are 7 observation stations in Yerevan, 1 each in the cities of Gyumri, Ararat, Tsaghkadzor and Hrazdan, 3 each in the cities of Vanadzor and Alaverdi, and 1 high mountainous station in Amberd. In Yerevan, the stations continuously conduct daily observations of nitrogen oxides, sulphur dioxides, ground-level ozone, dust and heavy metals contained in the atmospheric air. In Hrazdan, Vanadzor and Alaverdi, similar samplings are made of nitrogen oxides, sulphur dioxides and dust. In Gyumri and Ararat, samplings are made only of dust.

The Environmental Monitoring and Information Center high-mountain monitoring station in Amberd was founded and equipped within the framework of EMEP and is included in its network. The monitoring data from the station go to the Norwegian Institute for Air Research (NILU) European Monitoring and Evaluation Centre, where they are analysed and published.

No observations are made of $PM_{2.5}$ and PM_{10}, which are considered the main indicators of air pollution and the greatest threat to human health. The local air pollution assessment does not meet international standards according to which the level of air pollution is estimated based on the average hourly, daily and yearly concentrations of the main pollutants in the atmosphere (Armenia 2021b).

Azerbaijan

All activities related to air quality improvement and monitoring are carried out at the country level. The Meteorology and Standardization Center of the Ministry of Ecology and Natural Resources of Azerbaijan performs verification of measuring instruments used by monitoring stations in addition to carrying out intercalibration with reference instruments and providing maintenance when required.

The air quality monitoring network in Azerbaijan consists of 26 observation stations located in 8 industrialized cities (Baku, Sumgayit, Ganja, Mingachevir, Shirvan, Nakhichevan, Lankaran and Sheki).

Identified samples of air pollutants included PM (dust), SO_2, CO, nitrogen, hydrogen sulphide, soot, Hg, ammonia, chlorine gas, sulfuric acid and furfural.

In May 2016, as part of air quality improvement activities, an OPSIS monitoring station was installed in the country. The station measures O_3, SO_2, NO_2, C_6H_6, toluene, xylene and particulate dust (PM_{10}). In addition, three automatic stations were installed in Baku and one each in Sumgait and Ganja to measure the $PM_{2.5}$ yearly average of dispersed dust, concentration (in $\mu g/m^3$). In Baku, the average concentration of PM_{10} dispersed dust is also measured (in $\mu g/m^3$).

Air quality monitoring is predominantly carried out by observation stations with manual sampling. Data collection and data management are also largely manual operations. A Microsoft Access database and a comprehensive air quality data-collection system are currently under development. Data from manual sampling stations are analysed using the maximum allowable values established in Azerbaijan, whereas data from new automated stations are analysed using European Union air quality standards (European Commission n.d.).

Georgia

The Technical Regulation on the Approval of Atmospheric Air Quality Standards establishes standards in accordance with modern European directives (2008/50/EC and 2004/107/EC). The Technical Regulation on the List of Minimum Standard Number of Stations, their Locations and Operation Rules, and Standard Methods for Measuring Pollution Levels resets monitoring criteria based on the aforementioned European Union directives.

Currently, air quality is not assessed through modelling. However, with the support of the Swedish Government, work is under way to build an air quality modelling system as part of an ongoing project for strengthening data processing and modelling capacities to ensure better air quality monitoring countrywide. Quality control and quality assurance have been significantly improved under the same project. Notably, experience in the field of monitoring data validation was shared by Italian experts and relevant software was introduced.

According to the changes in the Georgian Law on Atmospheric Air Protection and Resolution No. 413 of the Government of Georgia of 31 December 2013 on the Approval of the Technical Regulation on Self-Monitoring and Reporting of Emissions from Stationary Pollution Sources, from 1 June 2021, large stationary sources of pollution are obliged to maintain continuous self-monitoring of main pollutants and continuously provide results to the Ministry of Environmental Protection and Agriculture. There is one EMEP station dedicated to observation of transboundary air pollution in Abastumani.

In Georgia, air quality monitoring is conducted by fixed automatic monitoring stations, a mobile automatic monitoring station, gravimetric monitoring equipment, a non-automatic monitoring station and indicative measurements. Currently, the country has 7 fixed automatic monitoring stations in Tbilisi, Batumi, Kutaisi and Rustavi; 1 mobile automatic station; 1 non-automatic fixed station in Zestaponi; 3 gravimetric monitoring machines; and quarterly passive samplings in 25 municipalities.

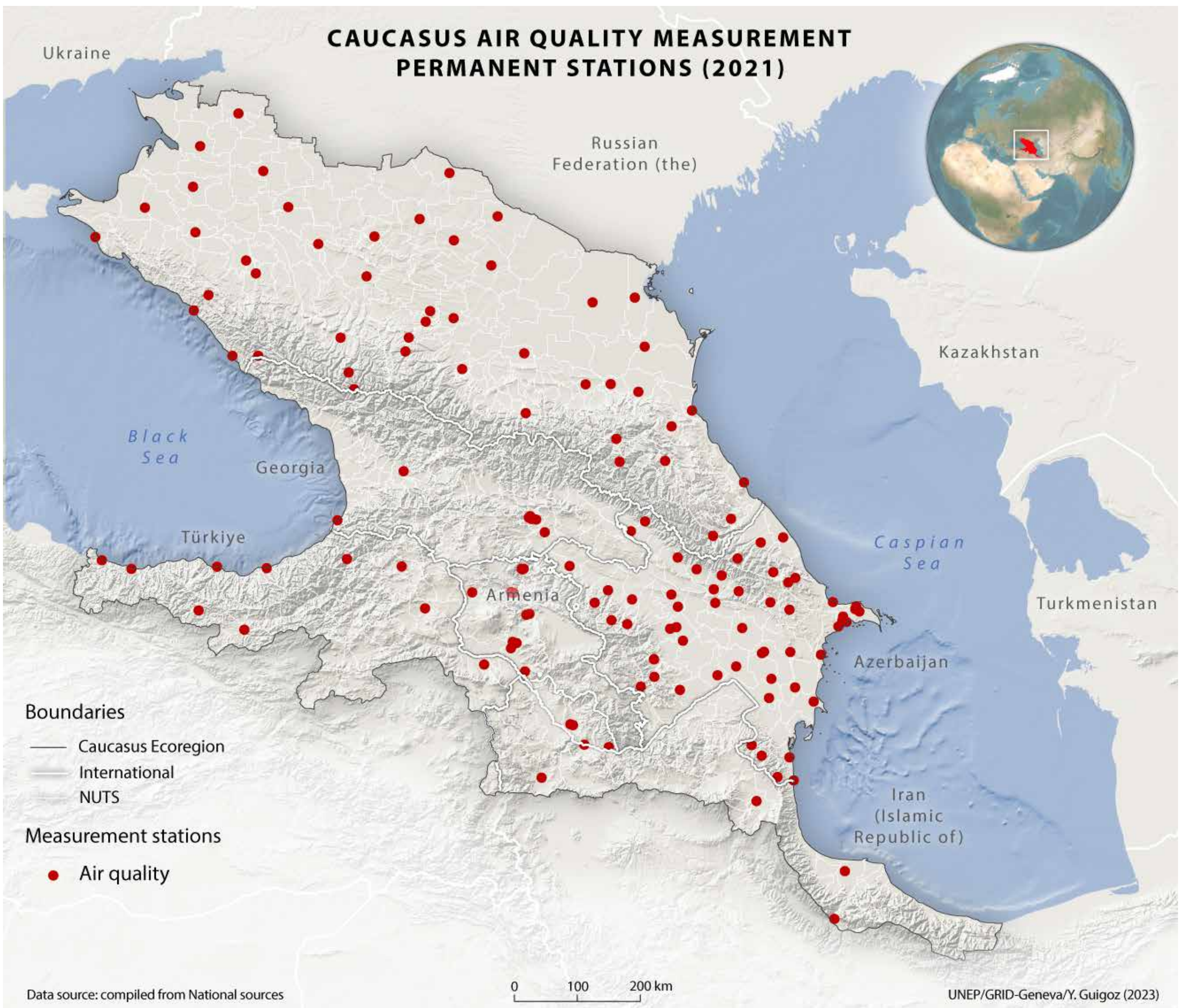
The monitoring network measures the concentrations of all pollutants for which air quality standards have been set. In addition to the key pollutants, the following chemicals are being observed: O_3, Pb, C_6H_6, CO, arsenic (As), Cd, nickel (Ni), polycyclic aromatic hydrocarbons and manganese dioxide (MnO_2).

Islamic Republic of Iran

An online platform shows daily air quality indexes in most major cities; it is operated by the Department of Environment, in charge of the environment in the Islamic Republic of Iran, headed by one of the country's vice presidents.

There are 186 air quality monitoring stations across the country that monitor CO, PM, SO_2, NO_x and O_3. To evaluate the air pollution level, the Islamic Republic of Iran uses the concentration of PM in the air as a proxy indicator.

In 2019, the Islamic Republic of Iran came in with a $PM_{2.5}$ reading of 24.27 µg/m^3, putting it in the 'moderate' pollution bracket (12.1 to 35.4 µg/m^3).



Map 18. *Permanent air quality measurement stations in the Caucasus Ecoregion, 2021.*

Box 5. Air Quality Data Platform and Air Quality Index (AQI)

In 2020, UNEP, UN-Habitat and IQAir launched an international air quality data platform that allows for participatory data collection and visualization. The platform brings together data on several key air pollutants, including real-time data, which can be provided by any interested actor: governments, NGOs, companies, local community groups or individuals. IQAir facilitates data accuracy and visualization via its global air quality map. The Air Quality Index (AQI) is calculated based on the air pollutant density which is then displayed on the map (UNEP 2022). The UNEP World Environment Situation Room (UNEP n.d.) displays these maps, as does the respective IQAir website, which also includes a comprehensive explanation of the Air Quality Index and how it is calculated. Historical AQI rankings for selected cities in the Caucasus countries are also available (IQAir n.d.).

The Islamic Republic of Iran operates 15 upper-air observation stations across the country. The Mashhad station is part of the Global Climate Observing System Upper-Air Network (GCOS) n.d.), which specifically serves the needs of global climate applications and has been established based on existing Global Climate Observing System networks, a minimum configuration required for global applications for upper air. The Global Atmospheric Watch station, which observes air pollution and meteorological parameters regularly in Firuzkuh, has sent data to the World Ozone and Ultraviolet Radiation Centre in Toronto, Canada since 1995.

Russian Federation

The Federal Service for Hydrometeorology and Environmental Monitoring and the relevant local environmental authorities are responsible for classifying the monitoring data and providing timely information on actual or projected levels of pollution, as well as warning the population against potential air pollution that may be caused by typical synoptic situations and changes in meteorological conditions.

In the Caucasus part of the Russian Federation, air quality monitoring is carried out by the North Caucasus Regional Administration for Hydrometeorology and Environmental Monitoring. According to the data provided by this body, there are 27 observation points for atmospheric air monitoring in the North Caucasus.

Concentrations of up to 57 pollutants are measured in the monitoring process including NO_2, SO_2, CO_2, $PM_{2.5}$ and PM_{10}, CH_4, sulphur hexafluoride, Pb, Cd, Hg, Ni, As, and dioxins. There are also 4 stations located in the European part of the Russian Federation (EMEP programme) which monitors the transboundary movement of air. Under the EMEP programme, sampling and analysis of atmospheric aerosols, gases (nitrogen and sulphur dioxides) and precipitation are performed.

Türkiye

Air quality monitoring networks have also been established in Türkiye. The Ministry of Environment and Urbanization, municipalities and organized industrial zones have established 220 air quality measuring stations. SO_2, PM_{10}, nitrous oxides (NO, NO_2, NO_x), carbon monoxide (CO) and ozone (O_3) are measured at these stations. The Data Operation Centre of the Environmental Reference Laboratory of the Ministry of Environment and Urbanization collects and analyses the data (Turkish Statistical Institute 2021).

Thus each of the Ecoregion countries, to varying degrees, monitors all key pollutants with the aim of determining whether the atmospheric air quality in a certain city or settlement meets the national standards adopted in the given country. Keeping in mind that sampling methods, time frames, density of station distribution, equipment in use, analysis methods and units of measurement differ between countries across the Ecoregion, and that the countries have different air quality standards (detailed below), air pollution data are largely utilised internally. Currently, it is thus not feasible to produce comparable air quality data for regional analyses. They are incomparable and therefore cannot be analysed together.

7.3.3. Air quality standards

Atmospheric air quality determines the degree of physical, chemical and biological impacts on people, flora and fauna, as well as on materials, constructions and the entire environment (WHO 2022). The WHO global air quality guidelines (AQGs) (see Table 29) provide global recommended limit values for the concentration of major air pollutants that pose a threat to human health. The recommendations are applicable for all countries of the world. They refer both to indoor and ambient air and are based on scientific evidence of the potential impact of pollutants on human health. The updated WHO global AQGs provide recommendations on air quality guideline levels as well as interim targets for six key air pollutants (WHO 2021b). The recent update of the guidelines lowered the recommended thresholds substantially, making them more difficult to adhere to in the short- to mid-term.

The European Union sets standards for the same pollutants as the WHO (European Commission 2022). On 26 October 2022, the European Commission proposed a tightening of rules on outdoor air pollutants (Telegraf 2022) and in February 2024, the European Union decided on new air quality guidelines, which include new limit thresholds for most air pollutants.

Table 29. World Health Organization Air Quality Guidelines (AQGs) 2005 and 2021

Pollutant	Averaging time	2005 AQGs	2021 AQG level
$PM_{2.5}$, µg/m^3	Annual 24-hour[a]	10 25	5 15
PM_{10}, µg/m^3	Annual 24-hour[a]	20 50	15 45
O_3, µg/m^3	Peak season[b] 8-hour[a]	– 100	60 100
NO_2, µg/m^3	Annual 24-hour[a]	40 –	10 25
SO_2, µg/m^3	24-hour[a]	20	40
CO, mg/m^3	24-hour[a]	–	4

Source: WHO (2021d).
Notes: (a) 99th percentile (i.e. 3–4 exceedance days per year); (b) Average of daily maximum 8-hour mean O3 concentration in the six consecutive months with the highest six-month running-average O3 concentration [µg = microgram].

> ***The Government should be asked to carry out strategic environmental assessments in large-scale civil and industrial projects, then consult with experts and advisors from neighbouring areas that are affected by the projects.***
> Zahra Veisi, Ph.D. Student, Malayer University, the Islamic Republic of Iran

Table 30. European Union limit values for air pollutants

Pollutant	Averaging time	Current EU limit values	EU limit values as of 2030
$PM_{2.5}$, µg/m^3	Annual 24-hour	25 –	10 25
PM_{10}, µg/m^3	Annual 24-hour	40 50	10 45
O_3, µg/m^3	8-hour 8-hour long-term	– –	120 100
NO_2, µg/m^3	Annual 24-hour 1-hour	40 – 200	20 50 200
SO_2, µg/m^3	Annual 24-hour 1-hour	– 125 350	20 50 350
CO, mg/m^3	24-hour 8-hour	– 10	4 10

Source: Council of the European Union (2024).
Note: The proposed revision of the air quality directives will set European Union interim air quality standards by 2030 that are more closely aligned with WHO recommendations and will also support European Union progress towards zero air pollution by 2050, in synergy with efforts to achieve climate neutrality.

7.3.4 Air quality standards by country

To assess atmospheric air quality, countries in the Ecoregion set their own air quality standards. While criteria and approaches in the development of these standards differ between countries, the content remains the same: for evaluation of the atmosphere's condition, actual data on the concentration of various air pollutants need to be compared with atmospheric air quality standards.

Armenia (2006) and Azerbaijan have standards inherited from the Soviet Union. Zone divisions and agglomerations are missing. There are no target values for $PM_{2.5}$. Both countries are working towards harmonization and convergence with European standards.

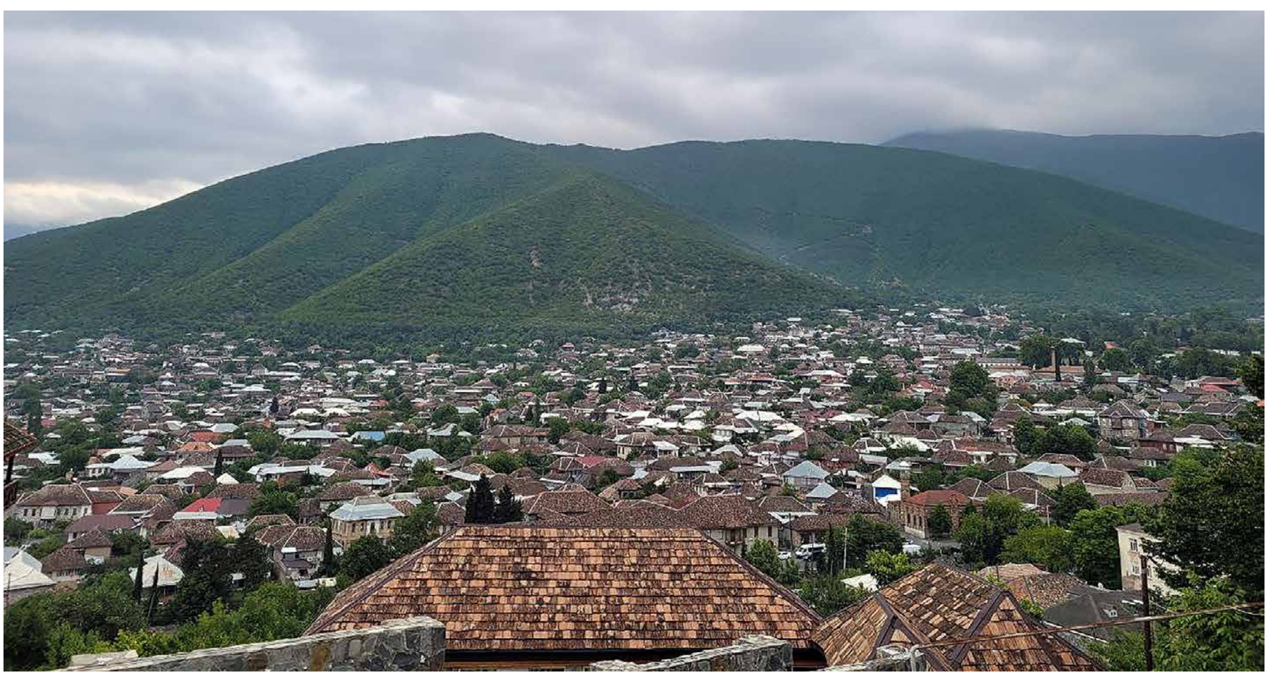
A Georgian Government Resolution (Georgia 2018) approved European ambient air quality standards. The regulation specifies permissible values of some pollutants (sulphur dioxide, nitrogen dioxide, particulate matter, lead, benzene and carbon monoxide). Assessment thresholds are outlined as well as target values and alert and notification thresholds. The regulation also covers protections for human health and plant and other ecosystems including target values and long-term goals.

Türkiye also applies European Union standards. Limit and target criteria for air pollution, information and warning thresholds, and upper and lower assessment thresholds have been established for the main pollutants, which are then used when assessing air quality. The legislation also defines regions and subregions in which air quality monitoring should be carried out.

> ***It is important and effective to implement preventive measures with the aim of reducing the damage caused by the destruction of the environment of the Caucasus Ecoregion and, if necessary, long-term strategies and policies, as well as allocating the necessary funds to support the measures taken.***
>
> Elahe Khangholi, PhD student, Malayer University, the Islamic Republic of Iran

In the Russian Federation, air quality is assessed based on compliance of the concentration of pollutants in the air with state sanitary standards for maximum permissible concentrations, as well as indicative safe exposure levels. For the atmospheric air of urban and rural settlements, maximum permissible concentration values were established for 657 pollutants and indicative safe exposure levels were established for 1,741 pollutants. There is also a list of 59 pollutants whose emissions are prohibited. However, the standards do not apply to the entire territory of the Russian Federation. For SO2 and nitrogen oxide, there are no limit values or separate standards aimed at protecting fauna and ecosystems. However, actions are being taken to bring all these standards closer to international standards, both in terms of parameters and quantity.

The Islamic Republic of Iran has its own approaches and developed standards. It has established primary and secondary air quality standards for all major pollutants. The country also applies emission standards for enterprises in certain industries.



Sheki municipality, Azerbaijan. ©UNEP/Mariam Devidze

7.4. Impacts of air pollution

7.4.1. Impacts on human health

Air pollution is estimated to cause 7 million premature deaths annually, reducing years of healthy living for millions more (WHO 2023). Children can have weaker lung function, respiratory diseases and asthma and adults can experience strokes or have increased risk of heart disease, which can result in premature death. The chance of having diabetes and neurodegenerative diseases may be increased by air pollution as well. Women can be more affected due to greater exposure to indoor air pollutants through combustion of cooking or heating fuels that releases harmful pollutants (WHO 2023). Air pollution impacts human health as much as other major health hazards such as tobacco smoking and poor diets. Along with climate change, such pollution is shaping the quality of human environments. Promoting human rights and gender equality and achieving the 2030 Agenda pledge to "leave no one behind" can have a significant positive impact on women's health and overall well-being (UNEP 2021). Additionally, improving air quality can enhance climate change mitigation efforts and reducing emissions will improve air quality (WHO 2021c).

7.4.2. Impacts on human health in the Ecoregion

In their national reports on the state of the environment or national communications on climate change, all countries in the Ecoregion place a priority on clean air as one of the fundamentals for ensuring human health and a prosperous environment. However, few official studies have confirmed the link between the increase in disease incidence in the Ecoregion and the deterioration of atmospheric air quality. In particular, the Russian Federation notes in its report that the population is also affected by factors such as chemical pollution of atmospheric air, water, soil and several physical factors (noise, vibration, electromagnetic fields, etc.) due to rapid urbanization. The Islamic Republic of Iran notes air pollution as a source of increasing health problems in the population. The country's relevant reports mention that outdoor air pollution can have direct and sometimes severe consequences for health.

The combination of climate change and air pollution worsens the risk of certain non-communicable diseases such as cardiovascular and respiratory illnesses and oncological diseases, due in part to $PM_{2.5}$, which has specific impacts on the poor and vulnerable, including women, the elderly and children, who are disproportionately affected (UNEP 2017).

The contribution of the Ecoregion to total air pollution is difficult to estimate, as the Caucasus countries are not obliged to submit data on the air pollution PM index, while the Islamic Republic of Iran, Türkiye and the Russian Federation provide data only for individual cities located far from the Ecoregion. Nevertheless, the countries of the Ecoregion pay close attention to the protection of atmospheric air and reduction of emissions of harmful substances. Over the past decades, the policies of the countries have undergone serious changes regarding environmental protection, including atmosphere protection.

7.4.3. Air pollution and ecosystems

Box 6. Air pollution impacts on ecosystems

Acidification, through sulphur and nitrogen emissions and "acid rain", along with ground-level ozone, are increasingly recognized as being detrimental to ecosystems. Ecosystem services and water are required for life on earth, but acidification, at times through the impact of air pollutants, adversely affects plants, animals and humans. High levels of ozone at the ground level also damage living beings, both plant and animal. Any plant loss resulting from these processes decreases the capacity of the environment to absorb pollutants. Plants can filter certain pollutants (NO_2, O_3 and PM) and remove them from the air. Carbon is also removed through photosynthesis, which could reduce the impact of climate change. Eutrophication describes another detrimental process that results from an overconcentration of minerals and nutrients, such as phosphorous and nitrogen (at times from fertilizers), that can lead to algae blooms and a reduction of oxygen leading to worsened conditions for some life forms (United Nations Economic Commission for Europe n.d.).

7.5. Key policy responses and outlook

7.5.1. Key policy responses to air pollution and greenhouse gas emissions

Box 7. International agreements on greenhouse gas emissions

The Paris Agreement, the 2030 Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction are three international efforts to reduce greenhouse gas emissions, reach sustainable development goals and decrease risk, all with the aim of improving human development possibilities. They promote a vision of low-carbon development that is sustainable in the long term, allowing countries to improve environmental conditions while still benefitting from better quality of life for their citizens (UNFCCC n.d.).

All the countries in the Ecoregion have declared their commitment to low-carbon development in their NDCs and INDCs. The production of energy and the use of new energy sources, such as wind and solar power, are considered priorities. In addition, tidal energy is seen by countries as an opportunity to partially phase out fossil fuels and thereby reduce emissions. The main GHG-reduction goals of the countries in the Ecoregion are defined in their NDCs/INDCs (see Table 31)

7.5.3. Integration of air quality and climate policy

Air pollution abatement strategies are closely linked to strategies for energy, climate, transport, trade, agriculture and biodiversity, and therefore cannot be viewed in isolation. An integrated approach allows for consideration of the added value of harmonizing climate policy with air quality policy (see Table 32), as well as the potential impact of measures taken in any given area.

Table 31. Greenhouse gas reduction goals of the countries in the Caucasus Ecoregion as defined in NDCs/INDCs

Country	Emissions (Gg CO_2e 1990)	Reduction percentage	Time frame	Targets (number)	GHGs	Sectors
Armenia (2021a)	25.9	40	2021–2030	Single, 2030	CO_2 CH_4 N_2O HFC SF_6	Agriculture Energy IPPU LULUCF Waste (solid)
Azerbaijan (2023)	79.0	40, taking account maximum absorption capacity	2023–2050	Single, 2050	CO_2 CH_4 N_2O HFC PFC	Agriculture Energy IPPU LULUCF Waste
Georgia (2021)	45.8	35	2021–2030	Single, 2030	CO_2 CH_4 N_2O HFC PFC SF_6, (nitrogen trifluoride [NF_3])	Agriculture Buildings Energy generation and transmission Forestry Industry Transport Waste
Islamic Republic of Iran	N/A	N/A	N/A	N/A	N/A	N/A
Russian Federation (2020)	3086.6	Up to 70%	2021–2030	Single, 2030	CO_2 CH_4 N_2O HFC PFC SF_6 NF_3	Agriculture Energy IPPU LULUCF Waste
Türkiye (2021)	270.7	21	2021–2030	Single, 2030	CO_2 CH_4 N_2O HFC PFC SF_6 NF_3	Agriculture Buildings Energy generation and transmission Forestry Industry Transport Waste

Sources: Armenia (2021a); Azerbaijan (2023); Georgia (2021); Russian Federation (2020); Türkiye (2021).

Table 32. International agreements on air protection and climate change ratified by countries of the Ecoregion

Country	The Convention on Long-range Transboundary Air Pollution (CLRTAP)	United Nations Framework Convention on Climate Change (UNFCCC)	Paris Agreement	Vienna Convention for the Protection of the Ozone Layer	Montreal Protocol on Substances that Deplete the Ozone Layer
Armenia	1997 Ac	14 May 1993 At	23 Mar 2017 R	1999-10-01 Ac	1999-10-01 Ac
Azerbaijan	2002 Ac	16 May 1995 R	9 Jan 2017 R	1996-06-12 Ac	1996-06-12 Ac
Georgia	1999 Ac	29 Jul 1994 Ac	8 May 2017 Ap	1996-03-21 Ac	1996-03-21 Ac
Islamic Republic of Iran		18 Jul 1996 R		1990-10-03 Ac	1990-10-03 Ac
Russian Federation	1980 R	28 Dec 1994 R	7 Oct 2019 Ap	1986-06-18 At	1988-11-10 At
Türkiye	1983 R	24 Feb 2004 Ac	11 Oct 2021 R	1991-09-20 Ac	1991-09-20 Ac

Sources: United Nations Treaty Collection website (n.d.); UNEP Ozone Secretariat Country Data (n.d.).
Notes: Accession (Ac); Acceptance (At); Approval (Ap); Succession (Sc); Ratification (R). Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

Pollutants are emitted from fossil fuels, as well as from biomass and agricultural waste burning. Additional improvements in fuel structure and energy-efficiency measures, as has already occurred in past decades, will reduce not only emissions of CO2, but also of SO2, nitrogen oxides, volatile organic compounds and fine particles such as $PM_{2.5}$. An additional benefit of cutting down primary emissions of fine $PM_{2.5}$ is reducing exposure to some heavy metals and persistent organic pollutants. Emissions of Hg and persistent organic pollutants will also decrease if coal use is reduced. Measures to address climate problems without considering air pollution policy objectives may lead to additional air pollution. For example, a focus on reducing CO2 emissions by encouraging use of wood-burning stoves, diesel-powered vehicles or biofuels could lead to a concomitant deterioration in air quality due to greater exposure to fine particles.

Air pollution can have a short-term regional impact on climate. Some pollutants act as coolers (e.g., sulphates), while others act as heaters (e.g., black carbon, O3 and its precursors). The use of biomass or measures to reduce CH4 emissions in agriculture are also examples of sectors where air pollution and climate impacts are closely interlinked, and where both aspects must be considered to limit harmful effects on health.

7.5.4. Sustainable Development Goals and air pollution

In September 2015, the world adopted the 2030 Agenda for Sustainable Development, a set of goals to overcome poverty, protect the planet and ensure the well-being of all people. The following Sustainable Development Goals (SDGs) relate to atmospheric air and have both direct and indirect effects on air pollution (United Nations 2015).

- SDG 3 focuses on ensuring good health and well-being for all, acting as a cornerstone enabling people to fulfil their potential at school, work and home. Every step people take to combat air pollution is a step towards achieving this goal. Target 3.9 focuses on environmental health: "By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination" (United Nations 2015, p. 16/35).
- SDG 7 envisions increasing the share of renewable energy in the energy mix and improving its efficiency to help reduce air pollution, of which the sector of energy production, consumption and transportation is a major source. Investments in clean energy technologies will contribute to air-pollution reductions, as will the improvement and modernization of many industrial facilities. Investment in research and innovation will improve industrial production, reduce waste and lower air pollution levels. Furthermore, improved compliance by enterprises with international and national regulations will contribute to further emissions reductions.
- SDG 11 establishes Target 11.6 for improving air quality: "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management" (United Nations 2015, p. 22/35). The reduction of air pollution in a country helps to improve urban air quality.
- SDG 13 addresses the challenges of climate change (United Nations n.d.). As GHGs and some of the key air pollutants have common sources, combating climate change will improve air quality. In turn, air pollution reduction will contribute to positive climate outcomes (WHO n.d.).

All countries of the region adopted Agenda 2030, and most are parties to international agreements on air protection and climate change that provide future guidelines and targets with respect to reducing air pollution and GHG emissions (see Table 32). Some countries with closer ties to the European Union will likely take their legislation into account. The Caucasus countries would benefit from closer regional exchanges, better coordination of and collaboration on air quality management and monitoring, as well as discussions on respective priorities for the Ecoregion.

Chapter 8: Freshwater

8.1. Freshwater bodies

Surface water is naturally open to the atmosphere and, in the Caucasus Ecoregion, includes rivers, lakes, reservoirs, streams, impoundments, seas and estuaries. The term also covers springs, wells and other collectors of water directly influenced by surface waters. Freshwater resources make up a large portion of available surface water. The hydrologic cycle describes the movement of water between the different stocks, for instance from groundwater to surface water. The freshwater resources of the Caucasus Ecoregion are defined by the basins of the Black, Caspian and Azov seas.

8.1.1. Water resources in the Caucasus Ecoregion

There are six main elements of the freshwater system in the Caucasus Ecoregion: rivers, lakes, reservoirs, glaciers, wetlands, and groundwater.

Rivers
There are about 67,500 rivers and streams in the Ecoregion, with a total length of approximately 196,000 km. The rivers of Armenia, Azerbaijan and the Islamic Republic of Iran flow into the Caspian Sea basin, while the rivers of Georgia, the Russian Federation and Türkiye flow into the Caspian, Azov and Black Sea basins (see Map 19). The rivers are fed by glaciers, snowmelt, rain and underground sources (see Table 32).

Lakes
There are about 3,770 lakes and natural ponds with a total area of 2,880 km^2 (containing mainly fresh water). The largest freshwater lake is Lake Sevan in Armenia, which is the second largest high-altitude freshwater lake on earth (1,900 metres above sea level) with a total volume of 38 km^3 and a maximum depth of 80 m. Most lakes originate from glacial, tectonic, volcanic or mass movement processes.

Reservoirs
Multifunctional reservoirs have been built to manage water resources in the Ecoregion. Stored water is used for drinking, irrigation, hydropower, fish farming, recreation and other purposes. The estimated volume of stored water resources is 35.5 km^3 in the Ecoregion, of which about 62 per cent (22 km^3) is in Azerbaijan. The largest reservoir in the Ecoregion is the Mingechevir reservoir in Azerbaijan, with an area of 605 km^2 and a volume of 15.7 km^3.

Glaciers
Most glaciers are in the Greater Caucasus Mountains of Azerbaijan, Georgia, and the Russian Federation (see Map 20). Approximately 20 years ago, there were 2,186 glaciers, totalling a surface area of 1,381.5 km^2. By 2020, the total glaciated surface had decreased by almost 24 per cent (Tielidze *et al*. 2022). The Bezingi Glacier is the largest single glacier in the Caucasus Ecoregion (Tielidze and Wheate 2018). A valley glacier, it routes from the peaks of Shkhara and Janga with an area of 36 km^2, length of 17.6 km, and tongue of about 9 km (Klok and Oerlemans 2018).

Wetlands
There are more than 1,500 wetlands in the Ecoregion with a total area of 12,000 km^2. They contribute to protection from floods and natural mitigation of potential pollution or act as carbon sinks with the surface turf layer estimated to

Table 33. River flow in the Caucasus Ecoregion, by country

Country	Catchment area (km^2)	River network density (average, km/km^2)	Local flow (km^3)	Inflow (km^3)	Total resource (km^3)	Outflow (km^3)
Armenia	59,200	0.89	4.77	2.08	8.32	7.71
Azerbaijan	86,600	0.36	10.3	20.6	30.9	7.45
Georgia	69,700	0.62	52.77	8.68	61.45	13.45
Islamic Republic of Iran	41,000	0.29	20.6	0	20.6	7.51
Russian Federation	108,400	0.50	23.05	11.7	34.75	8.0
Türkiye	60,200	0.026	25.8	2.9	28.7	27.2

Sources: Armmonitoring (n.d.); Food and Agriculture Organization of the United Nations (n.d.); Georgia, National Environment Agency (n.d.); Georgia, National Statistics Office (2020); Iran Statistical Yearbook 2018; Turkish Statistical Institute (n.d.).
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

absorb twice as much CO_2 as an equivalent forest area. The Ramsar Convention on Wetlands of International Importance Especially as Waterflow Habitat (Ramsar) was signed in the city of Ramsar, in the Islamic Republic of Iran in February 1971. All six countries of the Caucasus Ecoregion have ratified Ramsar and have national legal frameworks that protect wetlands. A total of 16 sites in the Ecoregion are identified as Wetlands of International Importance (also known as Ramsar Sites), with a surface area of about 9,400 km^2.

Groundwater

Due to the diversity of relief, climate and geology in the Caucasus Ecoregion, the hydrogeological conditions regulating groundwater flow are extremely complex (Mkheidze 2010). Groundwater and surface water arise primarily from precipitation and melt water in glacier zones (Israfilov and Israfilov 2011). Groundwater resources can also come to the surface through springs such as boreholes (fountaining or non-fountaining), some of which are underground ancient water supply systems used in southern Armenia and Azerbaijan, and the northern part of the Islamic Republic of Iran known as "qanat" or "kārīz" (Angelakis *et al*. 2016).

In the Caucasus Ecoregion, groundwater resources amount to about 41.7 km^3 (see Table 34). In recent years in Armenia, Azerbaijan and the Islamic Republic of Iran, reduction of surface water resources has led to overexploitation of groundwater resources. In the Islamic Republic of Iran, while the number of wells has increased, groundwater withdrawal has not risen in parallel since groundwater

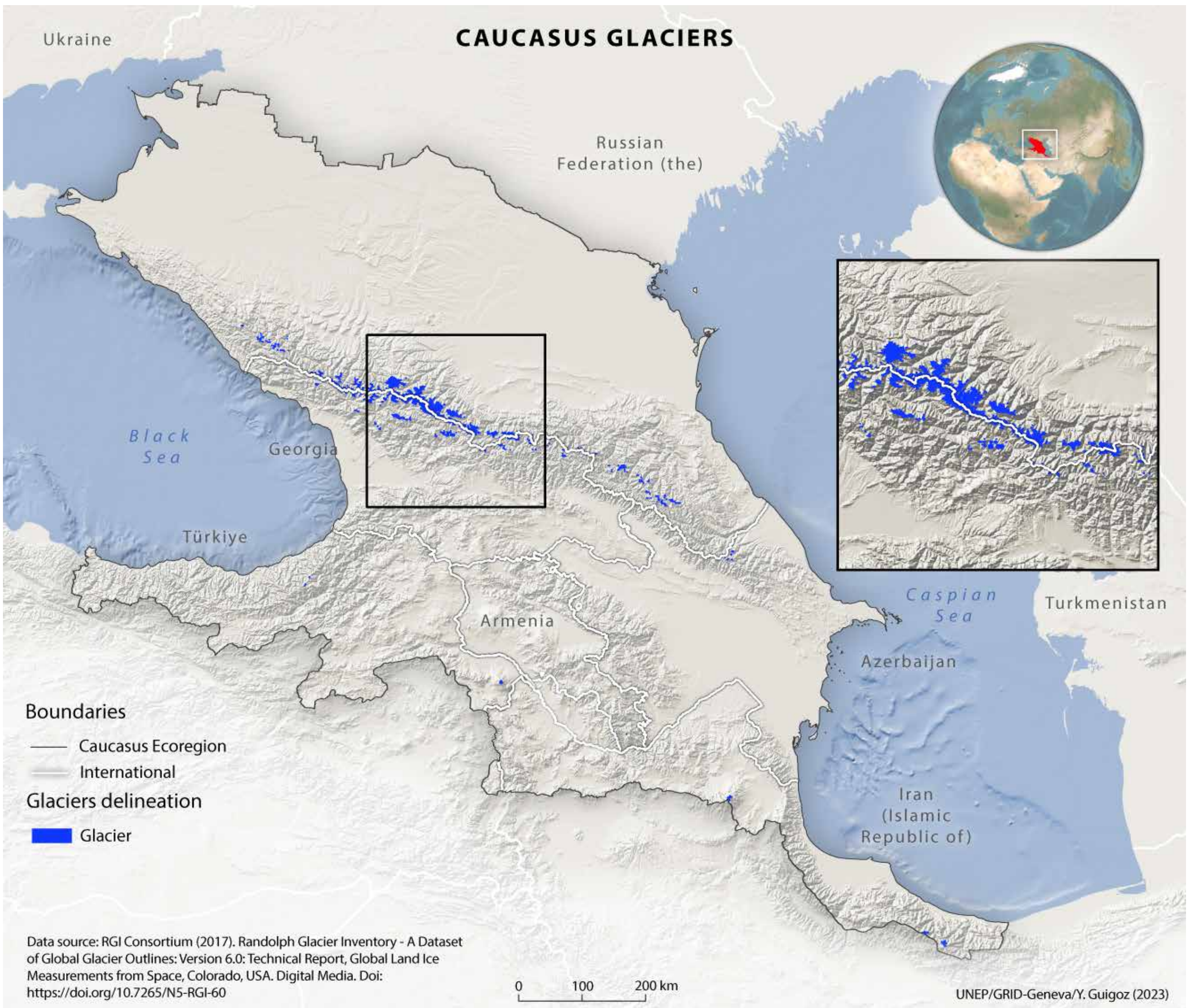
Map 19. *Main river basins of the Caucasus Ecoregion.*

tables have descended (Moridi 2017). In Azerbaijan, 7.5 m^3/s of water is pumped daily from different regions of the country to the Absheron Peninsula to provide the water supply of the cities of Baku and Sumgait (Imanov and Aliyeva 2020). Groundwater resources in Georgia flow at 573 m^3/sec. Georgia is famous for its health resorts with mineral and thermal waters. Armenia has high-quality groundwater resources that can be used for drinking purposes without additional treatment. Groundwater resources comprise 40 per cent of total water withdrawals, are of good quality and provide 96 per cent of potable water in the country (Yu, Cestti and Lee 2015). Türkiye has transboundary groundwater aquifers with Armenia that are separated by the Aras River (ORSAM Center for Middle Eastern Studies 2011).

Table 34. Groundwater resources of the Caucasus Ecoregion

Country	Total per year (km^3)
Armenia	4.0
Azerbaijan	8.7
Georgia	21.7
Islamic Republic of Iran	3.1
Russian Federation	3.4
Türkiye	0.8
Total	41.7

Source: FAO (n.d.a.)
Note: National-level data for all countries.



Map 20. *Glaciers in the Caucasus Ecoregion, 2017.*

Table 35. Annual balance of renewable water resources, 2020

Country	Precipitation (km³)	Evaporation (km³)	Total internal flow (km³)	Total inflow (km³)	Renewable freshwater resources (km³)
Armenia	16.0	11.3	4.8	0.9	5.7
Azerbaijan	35.5	10.7	8.1	25.4	32.5
Georgia	71.5	21.7	52.8	8.7	61.45
Islamic Republic of Iran	24.6	13.5	9.2	0	11.1
Russian Federation	80.0	33.6	46.4	18.0	28.4
Türkiye	49.8	24.0	25.83	2.9	28.7

Source: FAO (n.d.a.)
Note: National-level data for all countries.

8.2. Drivers and pressures

Water resources play a fundamental role in societies and ecosystems, both at the national and regional levels. Natural and anthropogenic factors affect hydrological regimes and quality in the freshwater bodies of the Caucasus Ecoregion. Hydroclimatic and socioeconomic factors are drivers of access to, allocation of, and conflicts over water resources (Drenkhan *et al*. 2015). Climate change, including the reduction of glacier areas, as well as socioeconomic forces related to demographics, development of agriculture and industry, and increased use of water as an energy resource impose increasing pressures on water availability in the Ecoregion. Increased water use inevitably leads to more pollution, considering the lack of wastewater treatment facilities and enabling policies at the state level in each country.

8.2.1. Social drivers and pressures

In the Caucasus Ecoregion, recent population growth and expansion of economic activity has impacted water quality and quantity, with increased pressure on the availability of water for drinking, agriculture and hydropower reservoirs. There is also increasing pollution, which is degrading water quality in many catchments and river basins.

Water abstraction for human needs in the Caucasus Ecoregion has been undertaken since ancient times. However, with developing technology and a growing population, anthropogenic pressures have become more evident. The expansion of economic activities after the 1930s, combined with population growth, has increased water use in the Ecoregion, increasing abstractions from rivers and groundwater and in turn reducing river flows (Hannan, Leummens and Matthews 2013). Reservoirs and canals change the physical qualities of drainage areas, estuaries, watercourse margins and beds. They also affect the morphological conditions and hydrological regimes of water bodies. In almost all countries of the Ecoregion, the population has increased compared to 2000 (except for in Georgia and Armenia [World Bank n.d.a.]). According to the World Bank, the urban population in those countries increased by 2–12

Table 36. Annual water use by sector, 2020

Country	Irrigation (percentage)	Industry (percentage)	Household (percentage)	Other types of activity (percentage)	Total (percentage)
Armenia	49	5	13	33	100
Azerbaijan	72	24	3	1	100
Georgia	51	28	18.60	2.40	100
Islamic Republic of Iran	85	2	13	0	100
Russian Federation	47	25	7	21	100
Türkiye	18	0.10	82	0	100

Sources: Statistical Committee of the Republic of Armenia (n.d.); The State Statistical Committee of the Republic of Azerbaijan (n.d.); National Statistics Office of Georgia (n.d.); Iran Data Portal (n.d.); Russian Federation (n.d.). and the Turkish Statistical Institute (n.d.).
Note: Data only from the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye.

per cent during the same period (except in Armenia, where it decreased by 1 per cent) (see chapters 1, 2 and 5).

Population growth leads to increased water use, thus, in the Caucasus part of Türkiye, the population with access to drinking water grew from 2,730,980 in 2000 to 3,233,696 in 2020 (Turkish Statistical Institute, n.d.) and water withdrawal increased from 235.91 million m^3 to 311.64 million m^3. During the same period, the population in Azerbaijan increased by roughly 1.2 times (UNDESA 2022).

The agriculture sector uses the most water resources, amounting to around 49–72 per cent of water resources in different countries, apart from in the Caucasus part of Türkiye (where this figure is 18 per cent). Water consumption at the household level in the Ecoregion accounts for 3–19 per cent of water use, except in the Caucasus part of Türkiye. The industrial sector uses the least water in Armenia (5 per cent) and the Caucasus parts of the Islamic Republic of Iran (2.2 per cent) and Türkiye (0.1 per cent) (see Table 36).

While the Ecoregion's hydropower potential is estimated at about 195 billion kWh, only 23 per cent (45.2 billion kWh) is estimated to be used to generate electricity (Azerenergy 2010; Armenia, Ministry of Energy Infrastructures and Natural Resources n.d.; State Statistical Committee of Azerbaijan n.d.; RusHydro n.d.).

Among the countries of the Ecoregion, water losses for irrigation and drinking water supply are highest in Armenia (45–72 per cent). In Türkiye, this figure is about 50 per cent (Turkish Statistical Institute n.d.) and in Georgia this figure is about 30 to 50 per cent (Georgia 2022) while the lowest losses (24 per cent) are in Azerbaijan (State Statistical Committee of Azerbaijan n.d.). The main reason for water losses is the wear and tear of systems, as well as unmetered water use. Irrigation in the South Caucasus countries is not effective due to inefficient water transportation within irrigation systems and farm irrigation methods. Furthermore, in Armenia, Azerbaijan and Georgia, most canals used for irrigation are unlined and open, leading to water loss through seepage and evaporation (United Nations Development Programme [UNDP] and Global Environment Fund [GEF] 2006).

8.2.2. Climate drivers and pressures

The UNFCCC national communications of all the countries of the Caucasus Ecoregion mention the vulnerability of water resources to climate change, mainly due to reduced precipitation and increased evaporation alongside increasing demand for water use. Climate projection models show an approximately 20 per cent reduction in river flow in most countries in the Ecoregion until 2100 (UNFCCC n.d.a; UNFCCC n.d.b).

Climate change forecasting models predict an increase in the frequency of extreme weather events, which means more abundant but uneven seasonal distribution of precipitation, with potentially drastic consequences. As a result, the frequency of natural disasters is expected to increase (i.e., landslides, avalanches, river freshets, floods, mudslides, and droughts) (Environment and Security Network 2011) (see chapter 9).

8.3. State of and trends in freshwater bodies

8.3.1. Decreasing glaciers and river flow

In the Greater Caucasus, glaciers provide water for agriculture, and run-off feeds into hydroelectric power stations. Most rivers have their sources in the mountains and melting of glaciers or snow make an important contribution to water supply and recreation. On the other hand, glacier hazards such as ice avalanches and glacial lake outbursts are relatively common in the Ecoregion, leading to human casualties (Tielidze and Wheate 2018).

The largest glacier of Türkiye is located on Mount Ararat at 5,137 m. Between 1990 and 2016, the glacier lost about 2.99 km^2 or 29 per cent of its surface area, a dramatically higher decrease than seen in other mountain ranges worldwide (Azzoni 2020). Fragmentation then occurred at lower elevations causing glaciated areas to become isolated from the body of the glacier on the southern and southeastern slopes of Mount Ararat (Yavaşlı 2015). The total amount of water stored in the glaciers was estimated to be 43.5 km^3 (+/- 5 km^3) for the years 2010–2013 (Kutuzov *et al*. 2015) (see chapter 4).

The Transboundary Diagnostic Analysis conducted for the Kura-Aras basin (Leummens and Matthews 2013, p.8), indicated "a notable overall decline in hydrological flows", especially downstream. Furthermore, "the decline in flow metering stations" and "lack of reliable data on past and present water abstractions" are challenges to current and future development that will need to be addressed by the countries.

In general, the Ecoregion cannot be considered to have a water shortage. However, water is unequally distributed among different countries and regions. As compared to the multi-year average, in most rivers of the Ecoregion, the river flow decreased in 2020 by 26 per cent in Armenia (Statistical Committee of Armenia n.d.), 20 per cent in Azerbaijan, 17.3 per cent in the Kuban River, and 6.6 per cent in Terek. Over the last 20 years, the annual flow at the closing section (Salyan) of the Kura River has decreased by 20 per cent and thus has comprised approximately half of the natural flow (425 m^3/s) (Imanov and Aliyeva 2020).

8.3.2. Increasing abstractions for agriculture, industry and drinking

Over the last 20 years, water demand and abstraction both from rivers and groundwater sources has increased in all countries, especially for irrigation purposes. This is due to increased temperatures, number of days without precipitation, and area of irrigated land.

Most abstracted water in the Ecoregion is used for agricultural purposes, followed by industry (24–28 per cent in Azerbaijan, Georgia and the Russian Federation) and domestic/urban needs (82 per cent in Türkiye [ClimateChangePost n.d.]). Azerbaijan has a larger population, more arid conditions and larger areas of irrigated land, thus leading to significantly larger water withdrawals than in Armenia and Georgia. In Georgia, the largest volume of water withdrawal is for the drinking water supply.

Over the last 20–25 years, the yield of the aquifers supplying water to the cities of Baku and Sumgait in Azerbaijan decreased significantly, from about 20–30 l/s to 6–8 l/s in 2017 (Imanov and Aliyeva 2020). In Armenia, the groundwater resources of the artesian basin of the Ararat Valley are used for domestic, irrigation, fish farming and production purposes. Studies have shown that between 2006 and 2016, groundwater levels fell by an average of 6–9 m (up to 15 m in some places) and the artesian zone was reduced by about 67 per cent.

From 2000 to 2017, the annual water withdrawal increased by 32 per cent in Armenia, 22 per cent in Georgia and 10 per cent in Azerbaijan. Most water needs are met by surface water, however, as river flows decreased, water withdrawal from groundwater sources increased. Since 2000, groundwater withdrawals have increased by 25 per cent in Georgia, 100 per cent in Armenia and almost 400 per cent in Azerbaijan. From 2000 to 2020, the annual amount of water withdrawn in the Caucasus Ecoregion of Türkiye increased by 25 per cent, from 235.91 km^3 to 311.64 km^3.

The Islamic Republic of Iran has serious problems with water scarcity. Droughts are common and surface and groundwater have been over-abstracted, bringing the water situation of the country to a crisis level. As Madani, AghaKouchak and Mirchi (2016, p. 997) note, "Iran is mainly suffering from a socioeconomic drought–i.e. 'water bankruptcy', where water demand in Iran exceeds the natural water supply." Groundwater resources have been rapidly depleted in recent years, causing major problems in the agricultural sector. Water stress, the focus of Sustainable Development Goal indicator 6.4.2, is estimated at 81 per cent in the Islamic Republic of Iran, the highest in the Ecoregion. Meanwhile, Georgia has the lowest water stress level in the Ecoregion, at 5.24 per cent in 2021(FAO n.d.b.).

8.3.3. Pollution of freshwater resources

All rivers in the Ecoregion are polluted with biogenic elements (nitrogen and phosphorus compounds), which is a consequence of the insufficient or improper operation of municipal wastewater treatment plants. Sources of water pollution include domestic and industrial wastewater, pesticides, harmful substances and other pollutants. Municipal wastewater is mainly contaminated with biomaterials; industrial wastewater is more often contaminated with petroleum products, phenols, heavy metals (e.g. lead, cadmium, copper, zinc) and complex organic compounds. Domestic wastewater contains pathogenic microorganisms and organic matter (i.e., proteins, fats, urea, starch and suspended matter (Jiao 2021).

Considering anthropogenic pressures on water resources, as well as worldwide climate change and the role of water in sustainable development, water was included as a separate goal in the process of sustainable development for the 2015–2030 period.

In the study area of Türkiye, surface water quality, especially in rivers flowing to the Black Sea, is in Class 1 ("Very Clean"). In the Aras River basin, water bodies in Class 3 "Much Polluted" and Class 4 "Extremely Polluted" can also be observed (Ozis, Nilgun and Ozedemir 2019).

Monitoring carried out at seven observation points of the Aras River on the border between Armenia and the Islamic Republic of Iran in 2021 showed that the concentrations of biogenic elements (biochemical oxygen demand [BOD5], ammonium cation, and nitrogen dioxide) exceeded the permissible values for fisheries by 1.5–2.2 times, and the concentrations of heavy metals (chromium, manganese, iron and aluminium) exceeded these values by 10–60 times (Armmonitoring n.d.).

The Kuban and Terek Rivers are polluted with petroleum products, organic matter, ammonium and nitrate ions, and compounds of iron and other metals, as well as coliform bacteria, which is typical of domestic wastewater pollution.

Organic matter in the Terek River exceeds the permissible limit values by 9.9 times, those of petroleum products by 4.3 times, those of ammonium salts by 3.7 times, and those of metals (manganese, copper and zinc) by 2–6 times.

The Kura River contains pollution from sewage, mining, industry, agriculture, deforestation and flood irrigation practices that can bring hydrocarbons, heavy metals, nutrients, organochlorine pesticides and high sediment loads into the water and river ecosystem (Ismayilov 2016). Pollution of rivers in the territory of Türkiye flowing into the Black Sea is insignificant and concentrations of pollutants do not exceed the permissible limit values. The Aras River is polluted with biogenic elements and organic compounds, as well as pesticides and fertilizers (Ozis, Nilgun and Ozedemir 2019).

8.3.4. Pollution of coastal waters

Most pollution that enters the coastal region of the Black Sea arrives via river transportation (see Map 21). The main sectors contributing to coastal pollution via rivers are agriculture (pesticide and fertilizer run-off), municipal wastewater (detergents and pathogens), shipping activities, energy, and chemical-manufacturing industries (such as food, paper, wood and non-ferrous metal). Recreation and tourism also contribute to the above-mentioned water pollution sources, as well as to the littering of the coastal zone (Mironescu 2008; Bat *et al*. 2018).

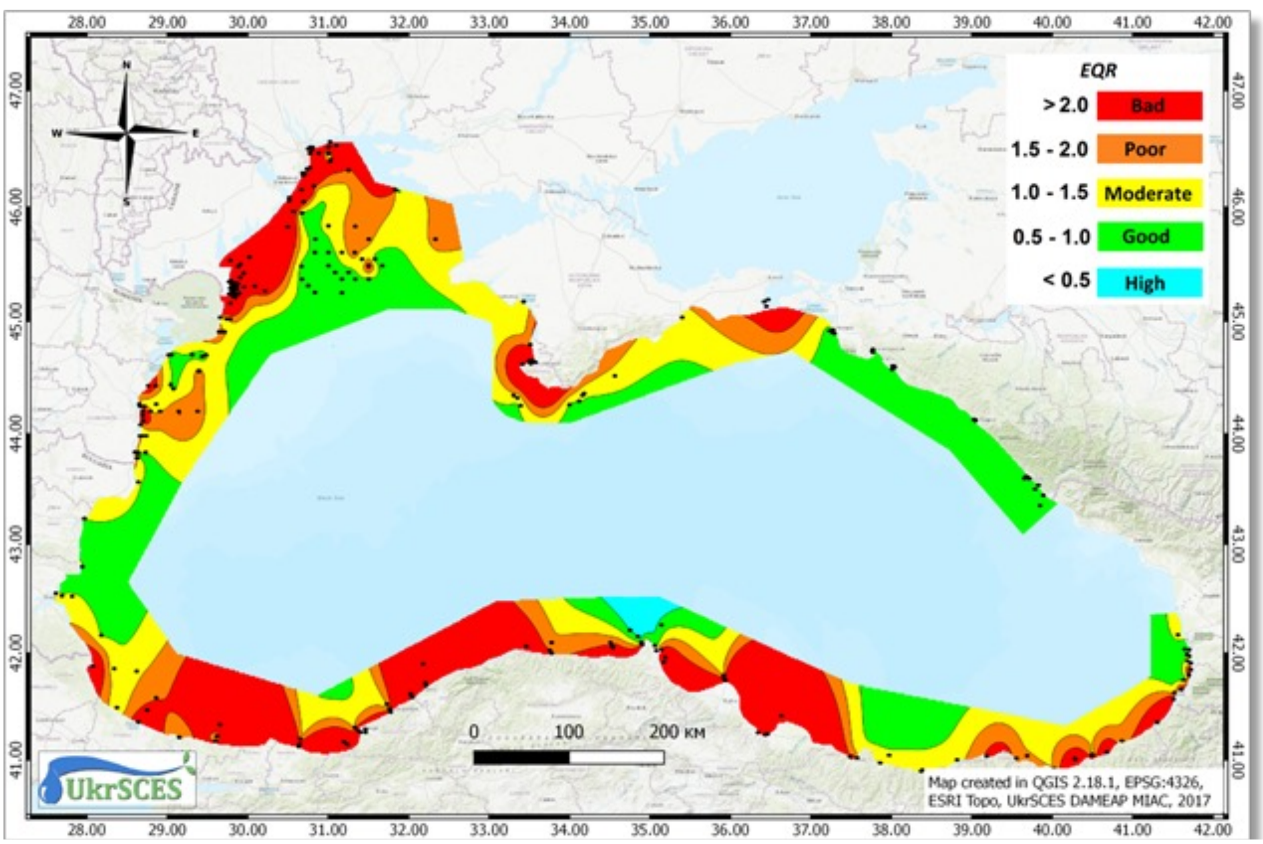
In 1992, six Black Sea basin countries, (Bulgaria, Georgia, Romania, the Russian Federation, Türkiye and Ukraine), three of which are in the Caucasus, signed the Convention on the Protection of the Black Sea against Pollution in Bucharest. In October 1996, the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea was signed in Istanbul.

In places where domestic wastewater is discharged into the Black Sea without treatment, a high concentration of *E. coli* has been observed, the worst of which has been in the Barts Khana River estuary, where the concentration of *E. coli* has been more than double the allowable limit. To reduce the discharge of domestic wastewater and the pressure of biogenic substances to the Black Sea, domestic wastewater treatment plants have been built in multiple Georgian settlements, such as Batumi, Ureki and Kobuleti.

Another problem is marine litter. This problem is mainly caused by illegal landfills located along rivers, as well as waste from peri-urban areas and cargo ships (Machitadze *et al*. 2018).

The Sea of Azov is also polluted by domestic and industrial wastewater as well as petroleum products and solid household waste. The coastal waters of the Caspian Sea are polluted in Azerbaijan, the Islamic Republic of Iran and the Russian Federation. As in the case of the Black Sea, pollution derives from rivers and coastal communities (Commission on the Protection of the Black Sea Against Pollution 2019)

A total of 25 small and 5 large rivers flow from the territory of Azerbaijan into the Caspian Sea, one of which is the Kura River. The Sefidrud River from the Iranian Caucasus, and the Terek, Sulak and Samur Rivers from the Russian Federation also flow into the Caspian Sea. The latter is a transboundary river with



Map 21. *Black Sea coastal water quality assessed using the Black Sea eutrophication assessment tool, 2009–2014.*
Source: Kovalishina *et al*. (2019).

Azerbaijan. Industry and agriculture are developed in the countries of the basin; large cities such as Baku, Reshit and Makhachkala are located in the basin, as are other settlements with populations of 100,000–500,000.

Large investments have been made to manage water pollution in Azerbaijan. Existing wastewater treatment plants have been restored and provided with modern equipment and new wastewater systems, and other treatment plants have been built. Modular-type treatment equipment has been installed throughout the coastal area of the Absheron Peninsula to treat local wastewater not connected to wastewater systems.

According to recent studies, the ecological status of coastal waters in the northern part of Azerbaijan (from Absheron to the border of the Russian Federation) can be described as oligotrophic, while in the southern part (from the Turkish border to the Iranian border) around urban centres, a different ecological status (meso- to extremely eutrophic) was found. The main reason for the low ecological status in places such as Baku Bay is the discharge of industrial and urban wastewater, which strongly influences the dissolved oxygen content and nutrient concentrations.

The Kura River and its tributary, the Aras River, which flow through five of the six countries of the Caucasus Ecoregion (except the Russian Federation), are subject to heavy abstractions for irrigation and a significant amount of different pollution types from the entire catchment. Nevertheless, the first surveys of the ecological status in autumn 2022 and spring 2023 within the EU4Environment Water and Data programme did not detect serious problems in terms of coastal waters (EU4Environment in Eastern Partner Countries 2023).

8.4. Transboundary water resources

All the major rivers, in addition to some reservoirs and lakes in the Caucasus Ecoregion are transboundary. Different countries consequently share water resources, a situation that could fluctuate in the future with societal and climate pressure expected to increase.

Both the Kura (1,515 km) and Aras rivers, the largest in the Ecoregion, have their drainage basins in four different countries. The Kura River source is in Türkiye and Armenia, with water flowing through Georgia and Azerbaijan and ending in the Caspian Sea (Ahmadov 2020). The Aras River upper catchment is in Armenia, the Islamic Republic of Iran and Türkiye, and ends in the Kura River in Azerbaijan, approximately 100 km from the river mouth (Aksoy, Savaş and Dursun 2012; FAO 2009). Reservoirs and lakes can also be shared resources, such as Kartsakhi Lake (53 per cent in Türkiye and 47 per cent in Georgia) and Jandri Lake (67 per cent in Georgia and 33 per cent in Azerbaijan).

8.4.1. Groundwater

The countries of the Ecoregion share groundwater resources and hydrological basins. From the Ararat artesian basin of Armenia (where about 70 per cent of underground water resources are accumulated in Armenia), up to 77 billion m^3 of water flows annually to Türkiye, Azerbaijan and the Islamic Republic of Iran. In the north of the country, 0.1 million m^3 of underground water flows annually into the Kura Basin.

A total of 14 hydrogeological basins are transboundary groundwater bodies in the folded mountain zones of the Greater and Lesser Caucasus and the Kura-Aras Lowland in Azerbaijan, situated on the borders with neighbouring countries (Armenia, Georgia, the Islamic Republic of Iran and the Russian Federation).

In Georgia, there are also several large transboundary aquifers. The Alazani, Iori and Marneuli-Gardabani artesian basins are located within the Azerbaijan border zone. Due to their natural characteristics, groundwater in these aquifers flows from Georgia to Azerbaijan (Buachidze and Zedgenidze 1985). Similarly, in the Samckhe-Javakheti volcanic highland border region between Armenia, Georgia and Türkiye, groundwater flows are shared between these countries (Gaprindashvili 2010).

Türkiye shares groundwater resources with its neighbouring countries. The transboundary groundwater body it shares with Armenia is the Iğdır Plain alluvial aquifer. The Aras River separates the Iğdır Plain in the northeast and the Dil Plain, which is the continuation of the Iğdır Plain in the southeast direction, from Armenia (ORSAM Center for Middle Eastern Studies 2011).

8.4.2. Transboundary reservoirs

Türkiye has built and is building reservoirs and dams on both the Kura and Aras Rivers in the last 20 years. Türkiye is an upstream country responding to the lack of water caused by climate change.

Armenia and Türkiye jointly use water from the Akhuryan reservoir. The countries in the Ecoregion have different water storage capacities. For example, on average, the per capita storage capacity of Armenia is about 450 m^3, which is considered low for a semi-arid country. The per capita storage capacities of Armenia and the Islamic Republic of Iran are less than 20 per cent of that of Azerbaijan and Türkiye and less than 60 per cent of the storage capacity of Georgia.

The Kura Project Master Plan aims to increase irrigated land in the Ardahan Province of Türkiye, bordering Georgia, from 3,000 hectares to 51,000 hectares. Türkiye plans to build five dams on the Kura River, the largest of which is the Besikkaya Dam, with a height of 107 m and a capacity of 211.6 km^3.

Kura river, Tbilisi, Georgia. ©iStock/dvulikaia

Türkiye has many reservoirs on the Aras River, but they have small volumes. From 2012 to 2014, Türkiye built six hydropower plants on the Aras River and has plans to build eight more. Two reservoirs (Karakurt and Alp-Aslan) were built near the Armenian border in Kars and Mush provinces, and the flow of the Aras River has already decreased by 1.6 billion m^3 in Armenia. The construction of the new Soylemez Dam near the city of Erzurum was recently announced. The dam is planned to have a height of 113 m, and a capacity of 1.4 km^3. It will impact the development of agriculture in the Ararat Valley of Armenia, where 36 per cent of agricultural lands of the country are located.

In Armenia, there are also plans to build about 21 reservoirs, albeit with small capacities. The Kaps reservoir, whose construction started at the end of 2021, will have a capacity of 70 million m^3, 20 times smaller than Soylemez.

There are plans to build about 40 hydropower plants in Georgia to ensure the country's energy security. Georgia has not built and does not plan to build reservoirs on the Kura River, other than the Gurturk Dam, which is planned at the point where the river crosses the Turkish-Georgian border.

Azerbaijan and the Islamic Republic of Iran have built the Khudafarin reservoir, with a capacity of 1.6 km^3, on the Aras River. In addition, the Kiz Kalasy (62 km^3) reservoir is under construction, resulting in a 100 m^3/s decrease in the Aras River flow.

Azerbaijan is located downstream in the Kura-Aras basin and is therefore most negatively impacted by reservoir construction upstream. However, Azerbaijan has the highest reservoir volume in the basin, at 21,587 million m^3, while Armenia, Georgia and Türkiye together only have the capacity to store less than half that amount (10,000 million m^3).

Currently, the water use of the Kura-Aras basin is carried out in accordance with the norms of the former Soviet Union, which are not adapted to the current climate change situation and do not consider the interests of downstream countries. The construction of reservoirs and dams must be regulated based on bilateral agreements and treaties concluded between the countries (see Table 38). However, there are no agreements between countries in conflict.

8.5. Key policy responses and outlook

8.5.1. Existing policy and water management principles

All countries in the Caucasus Ecoregion have water policies and strategies in force, either standalone or in national policy and strategic development documents. However, there are two main issues at both the national and transboundary levels. The first is that legal frameworks are often outdated and do not provide sufficient grounding for sustainable management of available resources. The second is the lack of implementation and enforcement of existing policies and legal requirements.

In all countries, water resources are considered state property; their management is carried out by public administration bodies (e.g. ministry, committee, agency). In the countries where the management is carried out at basin level (Armenia, Georgia, the Russian Federation and Türkiye), the basin management bodies participate in the management. Water systems are managed either by the state or on a contractual basis by private sector actors.

The main legal document in the water sector is the national Water Code (Armenia, Azerbaijan and the Russian Federation), or the Law on Water (Georgia, the Islamic Republic of Iran and Türkiye). Within the framework of the Comprehensive Extended Action Agreement with the European Union, four countries of the Ecoregion (Armenia, Azerbaijan, Georgia and Türkiye) are making serious efforts to bring national legislation closer to the European Water Framework Directive.

After its adoption in 2001, the Water Code of Armenia has undergone many changes, the most recent being on 7 July 2022. The Water Code of Azerbaijan (1997), which is outdated and "under revision", is to be replaced by a new Water Strategy whose finalization has been postponed many times over a decade. The new Law on Water Resources Management was adopted by the Parliament of Georgia in June 2023, based on the principles and approaches of the European Union Water Framework Directive. The water law of Türkiye needs to be revised, and a new law is currently being drafted.

In the Caucasus Ecoregion, only the Russian Federation and Azerbaijan are parties to the United Nations Economic Commission for Europe 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) and have ratified the United Nations Economic Commission for Europe and World Health Organization 1999 Protocol on Water and Health (see Table 37).

All countries of the Ecoregion have ratified the 1971 Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention).

All countries in the Ecoregion have bilateral agreements and commissions set up for water resources management, joint use, and joint monitoring (see Table 38). Numerous international and national projects have been implemented in the Ecoregion. These projects are aimed at improving water legislation, developing basin management plans, extending the monitoring network, developing an information exchange system and ensuring public participation in water sector decision-making.

Table 37. Status of Caucasus Ecoregion countries with respect to accession to the United Nations Water Convention and the Protocol on Water and Health

Country	UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (1992)	UNECE and WHO Europe Protocol on Water and Health (1999)	Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971)
Azerbaijan	Acceded in 2000	Joined in 2003	Came into force in 2001
Armenia	Not a party	Signed in 1999	Came into force in 1993
Georgia	Not a party	Signed in 1999	Came into force in 1997
Russian Federation	Accepted in 1993	Accepted in 1999	Came into force in 1977
Islamic Republic of Iran	Not a party	Not a party	Came into force in 1975
Türkiye	Not a party	Not a party	Came into force in 1994

Source: United Nations (n.d.); UNESCO (n.d.).

Box 8. Recent national and international water projects, 2000-2024

- Water Management in the South Caucasus, United States Agency for International Development (USAID), 2000–2004
- Joint River Management Programme on Monitoring and Assessment of Water Quality on Transboundary Rivers, European Union/Technical Assistance to the Commonwealth of Independent States and Georgia, 2002–2003
- South Caucasus Water Program, USAID, 2005–2008
- Reducing Transboundary Degradation in the Kura-Aras River Basin, UNDP, Swedish International Development Cooperation Agency, 2003–2005
- Transboundary Cooperation for Hazard Prevention in the Kura River Basin, The Federal Environment Agency of Germany, 2003–2006
- Critical Ecosystem Partnership Fund (Armenia, Azerbaijan, Georgia, Islamic Republic of Iran), Global Environment Facility (GEF), 2005–2008
- European Union Water Initiative National Policy Dialogues on Integrated Water Resources Management under the European Union Water Initiative, UNECE, OECD
- Creation of Enabling Environment for Integrated Management of the Kura-Aras Transboundary Rivers Basin, EU/Regional Environmental Centre for the Caucasus, 2011
- Support to the Transboundary Management of the Kura River Basin, European Union, Technical Assistance to the Commonwealth of Independent States (TACIS) 2007–2010
- Reducing Transboundary Degradation in the Kura-Aras Basin, UNDP/GEF, 2011–2014
- Advancing Integrated Water Resource Management (IWRM) across the Kura River basin through implementation of the transboundary agreed actions and national plans, UNDP/GEF, 2017–2021
- European Union Water Initiative Plus (EUWI+) for the Eastern Partnership, European Union, 2016–2021
- Management of Natural Resources and Safeguarding of Ecosystem Services for Sustainable Rural Development in the South Caucasus (ECOserve), German Federal Ministry for Economic Cooperation and Development, 2018–2021
- EU4Environment – Water Resources and Environmental Data, European Union, 2021–2024

8.5.2. Changing the approach to freshwater management

Climate change and water pollution increase stress on the world's limited water resources, making the traditional fragmented approach to water management ineffective. A more holistic approach to water management, such as Integrated Water Resources Management (IWRM), is essential to cope with conflicting demands. The Global Water Partnership promotes the coordinated development and management of water, land and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. One of the principles of IWRM is the necessity of public participation in the decision-making process, which can be ensured by representatives of civil society and non-governmental organizations (World Meteorological Organization 1992). IWRM is also a principle of the United Nations Water Convention and of the European Union Water Framework Directive, which requires public participation in these processes for all European Union candidate countries (this includes Georgia and Türkiye in the Caucasus Ecoregion).

Most of the countries in the Ecoregion have already adopted IWRM principles and have changed their strategies and legislation. Still, there is a lack of integrated management within countries in practice. This issue is most severe at the international level, where the needs and priorities of neighbouring countries are not considered.

8.5.2.1. Transboundary water quality monitoring

Within the framework of several regional projects, the countries of the Caucasus Ecoregion have developed their capabilities and technical capacities for monitoring transboundary water bodies. For example, during the implementation of the North Atlantic Treaty Organization (NATO) Science for Peace (2002–2008) project, with additional funding from the Organization for Security and Co-operation in Europe (OSCE), monthly monitoring was conducted for water quantity (discharge) and water quality parameters at 10 locations in each country. Water quality monitoring consists of the usual basic parameters plus heavy metals, radionuclides and persistent organic pollutants.

Since 2005, the Islamic Republic of Iran and Armenia have participated in several sessions investigating and monitoring pollution in the Aras River. In 2005, an agreement was signed by Armenian deputies and the Iranian Minister of Energy. In article 7 of this agreement, both countries insisted on field visits and continuous monitoring, and on the prevention and control of Aras River water quality and pollution. They decided on having common measurements of pollution factors in six stations in Armenia and eight stations in the Islamic Republic of Iran. This ongoing process is the basis of mutual trust between the two countries.

Table 38. Examples of bilateral agreements and commissions among Caucasus countries

Countries	Bilateral agreements and commissions
Armenia and Georgia	• Agreement between the Governments of Georgia and the Republic of Armenia on Cooperation in Environmental Protection (1997) • Agreement on Water Withdrawal from the Debed River (1971) • Agreement between the Governments of Georgia and the Republic of Armenia on Cooperation in Environmental Protection (1997)
Armenia and the Islamic Republic of Iran	• Agreement between the Islamic Republic of Iran and the Soviet Union for the Joint Utilization of the Frontier Parts of the Rivers Aras and Atrak for Irrigation and Power Generation (1957)
Armenia and Türkiye	• Convention between the Republic of Turkey and the Union of Soviet Socialist Republics concerning Water Use of Border Rivers and Streams (1927) • The Agreement for the Cooperation between the Republic of Turkey and the Union of Soviet Socialist Republics for the Construction of the Bridge and the Bridge Lake Formation on the Arpacay River Border (1973)
Azerbaijan and Georgia	• Agreement between the Government of Georgia and the Government of Azerbaijan on Cooperation in Environmental Protection (1997) • Memorandum of Understanding between the Ministry of Environment of Georgia and the State Committee of Ecology and Nature Management of the Republic of Azerbaijan on Cooperation in the Development and Implementation of Pilot Projects for Monitoring and Assessment of the Status of the Kura River Basin (1997) • Agreement on the use of the Jandara Reservoir (1998) • Protocol of Intention between the Ministry of Environmental Protection and Agriculture of Georgia and the Ministry of Ecology and Natural Resources of the Azerbaijan Republic on Cooperation in the Field of Geology, Hydrometeorology and Climate Change (2022)
Azerbaijan and the Islamic Republic of Iran	• Joint use of Aras and Mil-Mugan Reservoir (1971) • Agreement on cooperation in the field of continuation of construction, operation use of energy and water resources of "Khudaferin" and "Giz Galasi" hydroelectric power stations on the River Aras (2016)
Azerbaijan and the Russian Federation	• Agreement on the Rational Use and Protection of Transboundary Water Resources of the Samur River (2010)
Georgia and Türkiye	• Convention between the Republic of Turkey and the Union of Soviet Socialist Republics concerning Water Use of Border Rivers and Streams (1927) • Agreement between the Government of Georgia and the Republic of Turkey on Cooperation in the Field of Protection of the Environment for improving the Condition of • Surface and Sea Waters as well as Exchange of Information on the Condition of the Chorokhi/ Coruh River (1997)
Islamic Republic of Iran and the Russian Federation	• Road Map for Cooperation in the Field of Water Management for 2019–2020
Islamic Republic of Iran and Türkiye	• The Protocol on the Joint Utilization of the Waters of Sarisu and Karasu Rivers (1955)

8.5.2.2. Groundwater monitoring

Quantitative monitoring of water resources is carried out in all countries. However, both surface and groundwater monitoring networks must be expanded and upgraded with modernized equipment enabling automatic data transmission and satellite data analysis.

Groundwater monitoring has been restored in recent years in some countries. Within the framework of different projects (Advanced Science and Partnerships for Integrated Resource Development, EUWI+), monitoring posts have been added, and new equipment has been installed in Ararat Valley in Armenia, Kakheti and Mtskheta-Mtianeti in Georgia, Central Kura and Mingachevir Reservoir district in Azerbaijan, but it is still insufficient for good management of groundwater resources.

8.5.2.3. Reservoir construction

Water storage is of strategic importance for all countries in the Ecoregion to regulate variable flow, especially in the face of climate change uncertainties. This is critical for the irrigation, water supply and energy sectors, particularly in semi-arid regions where rapidly growing populations are facing depletion of groundwater resources.

While all countries have their own reservoir construction strategies and plans, there is a lack of communication, incentives and policy provisions (e.g. bilateral or multilateral agreements, basin commissions, and regular data exchange) for cooperation among the upstream and downstream countries, and poor consideration of safety and environmental standards. This leads to additional water stress situations for downstream countries often facing significant flow changes leading to economic and water security issues due to water deficit.

8.5.2.4. Agriculture and potable water supply and use

The use of water resources in drinking water supply and irrigation systems in the countries of the Caucasus Ecoregion is highly inefficient with large water losses (average 50 per cent). To improve this situation, projects to improve drinking and irrigation water supply systems are being implemented in various countries with the support of international financial organizations (e.g. the World Bank, the European Bank for Reconstruction and Development, and the African Development Bank). The projects are mainly implemented in settlements located in the service area of specialized water supply organizations. Rural areas fed by local sources do not have improved water supply systems and water losses remain large.

Irrigation water losses are a consequence not only of dilapidated irrigation systems, but also of increased evaporation in open systems as air temperatures rise. In parallel with the improvement of irrigation systems, reconstruction of earthen canals, and construction of closed irrigation systems (pipelines) are being carried out in the countries of the Ecoregion. Drip irrigation systems are also being introduced to improve water efficiency (see chapter 5).

8.5.2.5. Transboundary water management constraints

Various water challenges exist at the national or local levels in each country of the Caucasus Ecoregion however, some key problems are transboundary. The Transboundary Diagnostic Analysis Report for the Kura-Aras River Basin (UNDP and GEF 2006) identified four priority transboundary environmental problems: variation and reduction of hydrological flows, deterioration of water quality, ecosystem degradation, and flooding. The cross-cutting climate change issue is also present across the Ecoregion. An analysis of linkages and commonalities of these transboundary issues evaluates the overlaps in causes and impacts of these issues and relevant challenges, such as the lack of reliable data or lack of prioritization by decision makers.

The current constraints in transboundary water management include lack of coordination between agencies and countries, lack of incentives for cooperation, low capacity at the national and regional levels, weak enforcement mechanisms, outdated technologies and lack of reliable, standardized data on water quality and quantity at the regional level (Dilaver 2022).

Differences between the riparian countries – in terms of socioeconomic development, capacity to manage water resources, infrastructure, and institutional and legal contexts – represent challenges to effective and coordinated development as well as to the joint management and protection of transboundary water resources. At the same time, these differences create opportunities for capacity development and technical, social, legal and economic cooperation.

During the past decade, the international technical assistance projects funded by the European Union, United States Agency for International Development, the Swedish International Development Agency, GEF/UNDP and NATO/OSCE have been essential in improving cooperation between Armenia, Georgia and Azerbaijan in water resources management (see Box 8). These international projects have helped build the technical capabilities of water agencies and to establish a dialogue between water management professionals.

> ***In my opinion, in order to implement the joint management of transboundary water basins, it is necessary to have a sustainable water resources management strategy, exchange of knowledge and specialists between the countries of the region, as well as organization of joint workshops and seminars.***
>
> Karina Arzuyan, Researcher, Institute of Hydroecology and Ichthyology, Yerevan State University

At the transboundary level, the establishment of joint bodies with strong enforcement capacity may be fundamental to ensuring cooperation between the various governmental entities and good management of shared resources. Enforcement can only be achieved if those bodies will have strong mandate and political support from the basin Governments. However, this may be challenging due to political tensions and the lack of diplomatic relationships between some countries in the Ecoregion.

8.6. Research and Development, Education and Awareness Raising

Meeting policy challenges in the water sector requires improved and updated water education at all levels, along with scientific progress in the development of innovative adaptation technologies.

Saving water, calculating irrigation, developing modern water supply norms, treating wastewater, improving hydrological calculations and forecasting methods, mathematical and digital modelling, spatial analysis and innovation-technology development and application are crucial aspects of IWRM. To accomplish all this, these subjects need to be addressed in both professional and higher education, as well as training of decision makers. Higher education institutions of the Ecoregion have specializations such as hydrology, water supply and wastewater engineering. However, water management subjects, both at bachelor and master levels, do not address the global perspectives necessary for IWRM. Therefore, graduates are lacking multidisciplinary and interdisciplinary skills, as well as understanding transboundary contexts.

To improve skills and knowledge about water sector management, vocational education programmes should reach not only professionals but also decision makers and the media.

Knowledge and skills in water resources; education and training; awareness-raising on water resources, freshwater ecosystems and water-quality efficiency; and stakeholder awareness play an important role in achieving the SDG 6 indicators.

Sprinklers in Pyatigorsk, Stavropol Krai, Russian Federation. ©iStock/marlenka

8.7. Water and gender

Women and men have different responsibilities for the use of water and water systems. In many countries, women and girls are responsible for collecting the water for cooking, bathing, laundry, maintaining health and hygiene, cultivating crops in farmlands and watering cattle. Although women can be said to have an important role in the management and conservation of water resources, their involvement in the management process is often neglected. Furthermore, while water scarcity and poor quality have dire consequences for all people, they particularly affect the most vulnerable strata of society, mainly women and children (UNEP 2004).

The third of the four IWRM principles is: "Women play a central part in the provision, management and safeguarding of water." In many developing countries, women are the water decision makers within households, whereas water management is male-dominated. Research suggests that if women are part of the water resources management process, their communities receive better economic and environmental benefits (Global Water Partnership and UNEP – Danish Hydraulic Institute 2021).

Women provide invaluable contributions to biodiversity and the management of natural resources. To highlight the important role that women play in sustainable development, UNEP adopted Decision 23/11 on Gender Equality in the Field of Environment. Indeed, in line with SDG 5 on Gender Equality, participation by women in water resource management is essential to prevent gender discrimination. Equal participation by women in decision-making processes (planning and management) in IWRM positively contributes to water resource quality and sustainability (Stockholm International Water Institute 2020).

Although the general public in the countries of the Caucasus Ecoregion support increasing women's roles in decision-making, their actual political representation remains low and faces silent barriers and resistance, especially at the governmental level. The number of female parliamentarians has risen from 6.4 per cent in 2008 to 16 per cent in 2017, but this remains far below equal representation.

The figures in the World Economic Forum Global Gender Gap Report 2023 rank Georgia at 91 out of 144 countries for women's political empowerment (World Economic Forum 2022); Armenia is the highest-ranking county in the Ecoregion at 71, while Türkiye is at 118 and Azerbaijan at 134 are the lowest-ranking.

Conclusions

The Caucasus Ecoregion is generally rich in freshwater resources, although they are unevenly distributed among and within countries. The Ecoregion has average or above-average renewable internal freshwater resources per capita (World Bank [n.d.b]). Water resources here are vulnerable to the impacts of climate change and reduction of glaciers and more intensive agro-industry. Although all countries have significantly invested in building domestic wastewater treatment plants in the last 20 years, the water quality cannot be considered good.

Woman collecting water, Azerbaijan. ©iStock/Juan Alberto Casado

In the countries of the Ecoregion, the demand for total water use has been reduced due to the introduction of new technologies such as drip and rain irrigation; improvement of irrigation and drinking water supply systems; construction of closed irrigation systems; installation of irrigation and drinking water metering systems (i.e. water meters and loggers); introduction of closed/circular water use systems; and use of purified wastewater for irrigation purposes.

The principles of IWRM are accepted by all countries and included in legislative and regulatory documents but not all countries have government-approved river basin management plans at the moment. In Armenia, five out of six river basins already have river basin management plans approved by the Government. Since 2012, the European Union has provided technical assistance to the Government of Türkiye for preparation of river basin management plans for the six basins (Türkiye, Ministry of Agriculture and Forestry n.d.). Management of transboundary water resources is regulated by bilateral agreements and contracts. There is no single water management document for the Caucasus Ecoregion that would regulate water use standards between countries and prevent pollution of water resources.

Only the Russian Federation and Azerbaijan in the Caucasus Ecoregion are parties to the UNECE 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) and have ratified the UNECE/WHO 1999 Protocol on Water and Health. However, all countries have accepted the United Nations SDGs and are making efforts to achieve SDG 6 by 2030.

Box 9. Recommendations for freshwater management

To achieve sustainable management and use of water resources in the Ecoregion and SDG 6 and to adapt to the reduction of water resources in the context of climate change, the following actions must be taken:

- Strengthen existing cooperation between the Caucasus countries within the framework of various projects;
- Develop and adopt bilateral and multilateral agreements for the use, management and data exchange of water resources between countries;
- Develop a cooperation framework on river basin levels, including transboundary river basins, IWRM action plans and adoption of multilateral legally binding documents; and
- Ratify and implement the UNECE Water Convention and the UNECE/WHO Protocol on Water and Health.

Knowledge and information exchange at the regional level:

- Create comparable database(s) on water resource quantity and quality, and introduce transparent management methods;
- Create a biological/ecological monitoring system of transboundary water bodies,
- Establish and implement an early warning system for droughts, floods and other water-related hazards; and
- Exchange knowledge and experience at the levels of state water system employees, scientists, experts and non-governmental organizations.

National level management:

- Adopt legislation addressing the increasing pressures on water resources, and effectively enforce and control its implementation;
- Review and revise periodically (ground)water abstraction permits responding to over-abstraction and changing (often reducing) available (ground)water resources due to climate change effects; and
- Improve or develop quantitative and qualitative monitoring systems for surface and groundwater resources and introduce modern methods.

Improvement of infrastructure and capacity:

- Improve domestic and industrial wastewater treatment, repair and extend wastewater collection systems, and construct new wastewater treatment plants;
- Reduce water losses in drinking and irrigation water supply systems, reconstruct systems, and replace open irrigation systems with closed systems (pipelines);
- Increase water use efficiency (drip irrigation, sprinkling, water circulation and reuse);
- Apply nature-based domestic wastewater treatment solutions where applicable;
- Technically re-equip water resource management bodies, increase employees' knowledge and skills and improve higher education to implement IWRM and transboundary water management;
- Apply the latest/modern technologies and toolkits, with particular emphasis on quality and quantity assurance aspects; and
- Construct new reservoirs for river flow regulation and water storage and reconstructing old reservoirs, ensuring their safety and meeting modern environmental standards.

Approaches:

- Enhance the local and regional natural water cycle restoration, making use of nature-based solutions;
- Ensure transparency of water resource management, public participation, especially of vulnerable groups, such as women and girls, and elderly people, in decision-making;
- Strengthen regional research for development and the science-policy-implementation interface;
- Empower women by recognizing their contributions in water resource management, providing training and education, and promoting gender-inclusive policies and practices; and
- Raise awareness among water users and the public about water problems and their possible solutions, and message to change their behaviour regarding water use, involving civil society organizations in the process.

Chapter 9. Cross-cutting issues

A thorough understanding of cross-cutting issues helps to address environmental problems in a more holistic way by incorporating social and economic factors. This analysis highlights the interconnectedness between nature and human society and can serve as an entry point for key decision makers. The cross-cutting issues discussed here include health, knowledge and education, services and technology, gender and social inclusion, waste and wastewater, energy, and use of resources. The aim of this chapter is to present these cross-cutting issues in a comprehensive way and to illustrate the pace and scale of changes in social and economic factors interrelated with the environment. Additionally, the current positions of each country within the Caucasus Ecoregion concerning these matters will be showcased. The chapter relies on country-level data, and, where applicable, includes international comparisons.

9.1. Health

Air pollution is a leading risk factor in premature death (Health Effects Institute 2020). In 2019, one in every six premature deaths across the world was related to air pollution (Fuller *et al*. 2022). Air pollution – both ambient (outdoor) and household (indoor) – has a disproportionately higher impact on the health of vulnerable groups of society. Such groups include infants, children, women, elderly people, people with chronic diseases, poor people, and individuals lacking access to medical services (Dhimal *et al*. 2021). The economic cost of such health impacts for societies is significant and disease levels are particularly high in low- and middle-income countries (Forounzafar *et al*. 2016). Reducing air pollution decreases cases of respiratory infections (especially in young children), cerebrovascular diseases (strokes), ischaemic heart diseases and lung cancer (in adults), and other diseases, and thus increases society's overall well-being.

Sustainable Development Goal (SDG) indicator 3.9.1, "mortality rate attributed to household and ambient air pollution", tracks mortality from air pollution, and is related to target 3.9, which seeks to reduce deaths attributed to air pollution substantially by 2030. One must interpret data on this indicator with caution, as it combines two opposite trends. Evidence shows that the global burden of ambient air pollution caused by increased urbanization and industrialization has been increasing over the years, while the burden of household air pollution is declining (Dhimal *et al*. 2021). If relevant policy measures are not taken, increases in ambient air pollution will continue to occur with increasing urbanization, the growing number of motor vehicles, greater industrial production, and the proliferation of pesticides and toxic chemicals. To promote better health, societies need to prioritize health protection and pollution prevention nationally and internationally; mobilize, increase and direct funding to prevent and control pollution; establish relevant systems to monitor air pollution and its impact on health; build multisectoral partnerships for pollution control and research; and track awareness of this problem. Modelling the dispersion of atmospheric pollutants is vital in both regulatory and epidemiological contexts since it allows for objective analysis and understanding of the spread and impacts of pollutants. Furthermore, modelling facilitates the identification of potential risks and the development of effective mitigation strategies.

Caucasus Ecoregion country-level data on SDG indicator 3.9.1, based on 2016 figures, was the only data available at the time of writing. The 2016 data show that mortality attributed to ambient air pollution is rather high in the region for all countries, especially in Georgia. If ranked by mortality rate, all countries in the region are in the middle third of the global distribution of countries. All have a mortality rate of 36.3 per 100,000 population, higher than the average of 17.8 for high-income countries and the countries of Europe and Central Asia (World Bank *et al*. 2021). The major contributors to the high mortality rate for Caucasus countries are ischaemic heart diseases and strokes (see Table 39).

Air pollution is associated with high economic losses for societies, including medical expenditures, loss of economic productivity and premature death. It is expected that in the future, with an ageing population and increasing urbanization (which leads to a higher probability of exposure to ambient air pollution), premature deaths and cases of illness will increase in the absence of stricter policies. By 2060, the average global welfare costs of air pollution related mortality and morbidity per capita are expected to increase four to five times, from less than $500 to $2,100–$2,600 per person (OECD 2016). The economic consequences of air pollution are very significant and will increase if proper measures are not in place, but with adequate policies, gender-responsive approaches and participation of women and persons with diverse gender identities in environmental decision-making processes, air pollution can be controlled and related diseases can be prevented. As medical research continues to discover new causalities between pollution and disease, one might reasonably expect that the numbers presented above are moderate and an underestimate of reality. With new discoveries, the magnitude of the impact of air pollution may increase (Global Alliance on Health and Pollution 2019).

The COVID-19 pandemic revealed the weaknesses of the public health system and a lack of readiness for disasters

Table 39. SDG Indicator 3.9.1: Mortality rate attributed to household and ambient air pollution (number of people per 100,000 population, age-standardized)

Country	Lower respiratory infections	Trachea, bronchus, lung cancers	Ischaemic heart disease	Stroke	Chronic obstructive pulmonary disease	Total
Armenia	2	6	34	7	6	55
Azerbaijan	3	2	44	11	4	64
Georgia	3	4	59	27	8	102
Islamic Republic of Iran	5	2	31	8	5	51
Russian Federation	2	3	30	12	2	49
Türkiye	3	6	22	6	9	47

Source: World Health Organization (2018).
Note: National level statistics.

and pandemics in the Caucasus Ecoregion countries. The pandemic also highlighted how responses to mitigate health-related risks differ from country to country. With recent trends in climate change, infectious diseases are expected to spread more easily and rapidly. Exposure to waterborne and vector-borne diseases are impacted by droughts, excess rainfall and flooding, which are associated with increased risk of infections from waterborne diseases, and increased temperatures that could lead to more favourable conditions for certain vector-borne diseases such as malaria (Hunter 2003). Climate change has already resulted in the spread of diseases and their introduction into new geographical areas (Shuman 2010).

In addition, future trends in climate change are expected to affect heat-related mortality, further increasing the incidence of disease. People living in urban areas can be particularly vulnerable to heat because of urban and micro-urban heat islands that experience higher temperatures than their surroundings due to human activities and infrastructure trapping heat (Smargiassi *et al*. 2009); higher air pollution and its interaction with increased temperatures; and poor urban design/planning. Controlling and reducing emission of air particulates becomes crucial with increasing temperatures because they cause more adverse health effects on warmer days (Ren and Tong 2006).

Climate change is also a threat to food security and nutrition. According to World Food Programme (2021) estimates, the risk of hunger and malnutrition could rise by 20 per cent by 2050 if the global community fails to mitigate and prevent the adverse effects of climate change. Children will be particularly vulnerable to undernutrition. Thus, the health impacts of environmental change create further pressure on governments to act. Additional measures should be implemented to mitigate these impacts, and there is a need to address environmental changes and health issues together.

9.2. Knowledge and education

Since environmental issues are closely interconnected with other policy areas, actions that address them separately do not lead to sufficient progress (UNEP 2019a). The integration and coordination of environmental topics with other development areas, such as education, is on the current political agenda. Higher education levels in a society are associated with more concern for social welfare and environmentally friendly behaviours (Meyer 2015).

All countries in the Caucasus Ecoregion enjoy relatively high educational attainment for both men and women, and each country's education level has improved over time. The Education Index, part of the Human Development Index (HDI), measures education in a country using adult literacy rates combined with the primary, secondary and tertiary gross enrolment ratio, thus capturing this trend (see Table 40). This index varies from 0 (minimum) to 1 (maximum). All Caucasus Ecoregion countries were above the world average of 0.64 in 2019. However, in that same year, only Georgia, the Islamic Republic of Iran and the Russian Federation achieved higher rates than the European and Central Asian average of 0.75.

The constitutions of Caucasus Ecoregion countries guarantee the right to education for all and ensure free education for different levels, from elementary and basic education in Georgia to higher vocational education in the Russian Federation. Adult male and female literacy rates in Armenia, Azerbaijan, Georgia and the Russian Federation exceed 99 per cent for 2019 and 2020. However, a gender gap is still visible in the Islamic Republic of Iran and Türkiye. Based on the latest available data, the adult male literacy rate for the Islamic Republic of Iran in 2016 was 90.4 per cent, while for women it was 80.1 per cent. Similarly, in Türkiye, while adult male literacy in 2019 was above 99.1 per cent, for women it was

Table 40. Education index for Caucasus Ecoregion countries

Country	Education index 2019 (0 minimum; 1 maximum)	Change in index 2000–2019
Armenia	0.74	+0.07
Azerbaijan	0.71	+0.07
Georgia	0.86	+0.15
Islamic Republic of Iran	0.76	+0.23
Russian Federation	0.82	+0.10
Türkiye	0.73	+0.24
Europe and Central Asia	0.75	+0.14
World	0.64	+0.12

Source: UNDP (n.d.).
Note: National level statistics.

94.4 per cent (World Bank 2021). Thus, despite high literacy rates, the Islamic Republic of Iran and Türkiye still face gender challenges regarding access to education.

Regardless of relatively high education index scores when measuring enrolment rates in education, countries in the region do not perform as well once the quality of education is considered. According to the latest 2018 results from the OECD Programme for International Student Assessment (PISA), students in Azerbaijan, Georgia, the Russian Federation and Türkiye scored lower than the OECD average on almost all components of the tests (i.e., reading, mathematics and science). An exception was the mathematics average score for the Russian Federation, where student achievement was similar to the OECD average (OECD 2018). Armenia and the Islamic Republic of Iran do not participate in PISA assessments. Qualitative assessments of the education system, such as PISA, provide countries with the possibility to base their education policies on evidence and to tailor reforms to country needs. There is clearly a need to improve the quality of education, particularly in Azerbaijan and Georgia.

Education for sustainable development (ESD) is a useful framework when discussing societal transformation towards sustainable development through better knowledge and education. ESD aims to provide people with the relevant knowledge, skills, attitudes and values necessary to create sustainable development. This means improving current teaching by incorporating sustainable development issues like biodiversity, climate change, pollution, disaster risks and their minimization, and sustainable consumption patterns into syllabi. ESD is "a key area of education, reaching gender equality, healthier and more sustainable lifestyles, and creating more peaceful societies" (UNEP 2019a, p.82). ESD is an integral element of the 2030 Agenda for Sustainable Development (United Nations 2015).

All countries in the Caucasus Ecoregion are committed to implementing ESD. Environmental education, increasing public awareness, promoting environmentally friendly behaviours, and ensuring active public participation in environmental activities are on the political agenda of all countries in the region, although to different extents. For example, in Georgia, the Environmental Information and Education Centre established in 2013 is actively promoting sustainable development by increasing awareness on environmental issues at different levels of education. Azerbaijan has declared that continued environmental education will be ensured at all levels of education, promoting scientific research and practical fieldwork and improving the cooperation of academic and scientific agencies in this field (Hasanova 2019). The country established "Ecoclubs" in 2015 to promote environmental education in schools. In addition, the country has conducted professional trainings for managers, teachers and staff in sustainable development in 2016–2020, together with several awareness campaigns. Armenia has developed a National Strategy on Development of Ecological Education and Upbringing, conducted several information campaigns over the last few years, developed different environmental education programmes, incorporated integrated distance-learning mechanisms into existing training programmes, and has held several trainings on the issue of sustainable development for different stakeholders (teachers, lecturers, civil and community servants, leaders of local communities, the private sector, etc.).

> ***Foster environmental education and awareness programmes at all levels of society. Empower individuals with the knowledge and skills needed to actively participate in sustainable practices and decision-making processes. Involving young people in scientific research, to encourage interest in the field in every possible way.***
>
> Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

Countries in the Caucasus Ecoregion should stay committed to ESD, continue to follow the ESD road map developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2020) and make this framework an integral part of their respective education systems. The road map identifies key priority areas that will facilitate the achievement of the SDGs: (1) advancing policy for transformational change towards sustainability; (2) transforming learning environments; (3) building capacities of educators to facilitate the transformation process; (4) empowering and mobilizing youth; and (5) accelerating local-level actions and utilizing sustainable development in communities' agendas (UNESCO 2020).

9.3. Services and technology

Technology can be both a positive and a negative driver of environmental change (UNEP 2019a). The term "technology" refers to the application of scientific knowledge to the practical aims of society, and the machinery, devices and methods developed as a result. The hazardous effects of e-waste, increased fossil fuel consumption and increased ambient air pollution are some examples of negative environmental impacts of technology. However, the recent focus on sustainable development is leading to new environmental technologies that could lead to positive environmental changes and to the solution of some of the biggest environmental concerns societies face today.

This includes technological innovations increasing energy efficiency, reducing emissions and resource use while continuing productivity growth. These are "crucial to solving many environmental problems" (UNEP 2019a, p.40).

The "technological readiness pillar" of the Global Competitiveness Index (GCI), produced by the World Economic Forum since 2004, captures the availability of the latest technologies, technology absorption at the company level, foreign direct investment and tech transfers, the share of population using the Internet, international Internet bandwidth, fixed broadband Internet subscriptions, and mobile broadband subscriptions. The pillar can also be used as a proxy to measure the innovation capacity of a country, as it reflects the extent to which firms and people can utilize the latest available technologies and thus benefit from innovative activities.

Data show that between 2004 and 2018, technological readiness was increasing all over the world, and countries of the Caucasus Ecoregion were no exception (Schwab 2017). The value of the GCI ninth pillar, technological readiness, over the years for the Caucasus Ecoregion countries ranges from 0 to 7, the latter representing the highest score (see Figure 16). All Caucasus countries are in the middle of the global distribution, characterized by average technological readiness, varying from 3.7 to 4.6 in 2017. They score below the European and Central Asian medians, around 5 in the respective year.

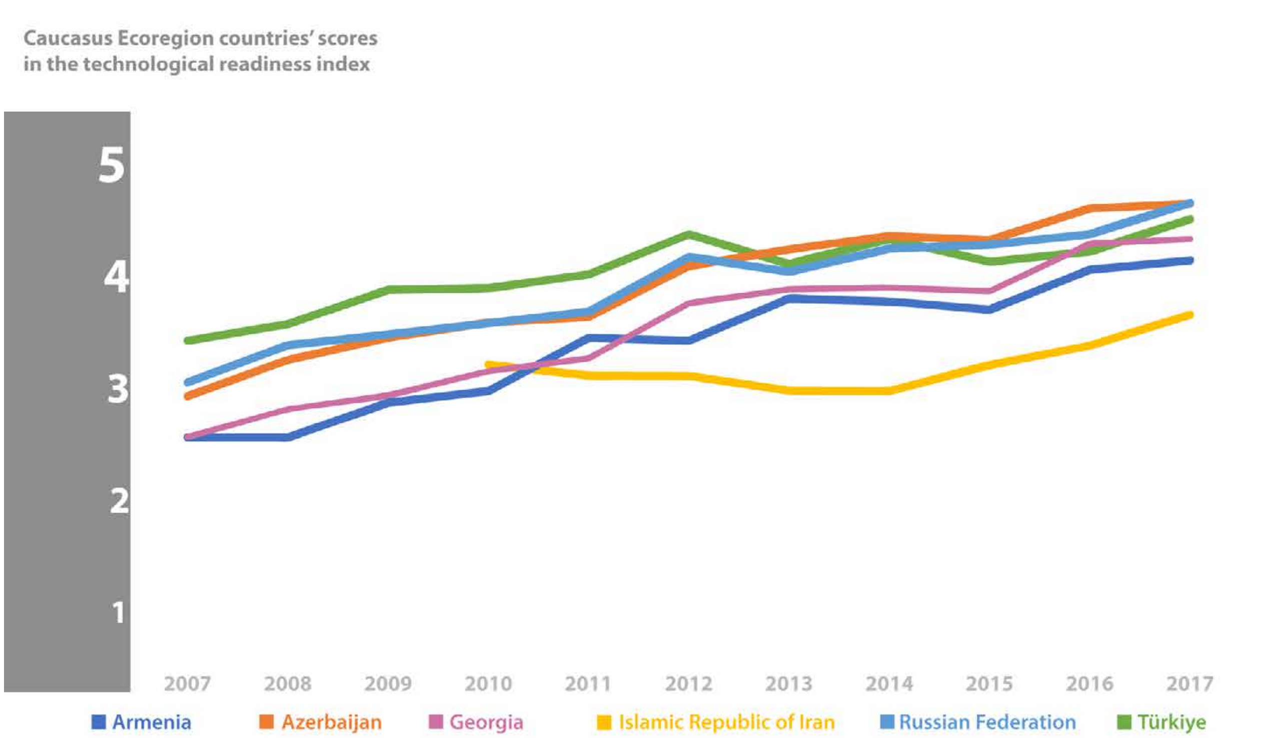


Figure 16. *Scores on the technological readiness index for Caucasus Ecoregion countries, 2007–2017.*
Source: Schwab (2017).

Among the selected countries, Georgia has the highest year-on-year average growth rate at 5.35 per cent, whereas the Islamic Republic of Iran has the lowest year-on-year average growth rate at 1.92 per cent. Such a low performance of the Islamic Republic of Iran in technological readiness can be explained by several factors, including the Western economic and technical sanctions that have impeded access to the latest advanced technology and, in some cases, made their adoption impossible; outward migration of many professionals; and extensive governmental bureaucracy (Soofi and Ghazinoory 2013). However, since 2014, the development trend has shifted from negative to positive, indicating a potential to catch up with other countries.

The indicators of the technological readiness pillar reveal the relatively low availability of the latest technologies in the region, especially in Georgia and the Islamic Republic of Iran. Similarly, Armenia, Georgia, the Islamic Republic of Iran and the Russian Federation have relatively low levels of firm-level technology absorption (Schwab 2017). Societal gains from the innovation of cutting-edge technology do not happen automatically; there is a need for complementary policy measures to ensure that firms and society at large have increased means to access and use new technologies.

In the current globalized world where technological innovation is spreading throughout countries, the availability of the newest technologies, and the speed at which a country is capable of absorbing cutting-edge technology, are key to progress and sustainable development. This is the foundation of new services and technology that could translate into a wide range of economic and social benefits for the country. Facilitating the attraction of cutting-edge technologies will be essential for countries in the Caucasus to ensure their sustainable development.

9.4. Gender and social inclusion

The United Nations Environment Programme (UNEP) has recognized gender inequality as a substantial challenge to progress on the environmental dimension of sustainable development. Gender inequality negatively affects people's access to, use of and control over natural resources and their right to a clean, safe and healthy environment. Gender-responsive approaches enhance the long-term impact and transformation of environmental initiatives concerning climate change, and matters such as energy, water, sanitation, land usage and other natural resources. These approaches should explicitly acknowledge the diverse and gender-specific interests and needs of girls and women, while also guaranteeing their active involvement and leadership in designing, executing and overseeing mitigation and response efforts (UNEP n.d.a). Approaching environmental issues through the perspectives of gender and other existing socioeconomic inequalities, and integrating existing inequalities into the decision-making process, are prerequisites for transformative environmental policies and sustainable development.

> ***By 2050, we hope to see a society where gender and age divisions no longer hinder opportunities for women and young people, resulting in a more inclusive and equal society where such programmes to involve them are no longer necessary.***
>
> Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

Environmental changes and climate-related disasters affect all members of society; however, the degree of impact is not uniformly distributed. Gender is one of the key dimensions to be considered in this regard – environmental change impacts the lives of women and men differently because of existing gender inequalities, gender norms and the division of labour. In addition, the coping strategies of affected populations and the level of adaptation are largely dependent on socioeconomic status and available resources. International evidence shows that adverse impacts can be compounded by age, geographical location, and socioeconomic conditions (UNEP 2019b). Gender inequalities, together with other socioeconomic inequities (income, employment, educational attainment, demographic differences such as age) are also associated with environmental inequities. Social inclusion should be one of the priority areas for policymakers addressing environmental issues. The term "social inclusion" is defined by the United Nations (2016, p.1) as "the process of improving the terms of participation in society for people who are disadvantaged on the basis of age, sex, disability, race, ethnicity, origin, religion, or economic or other status, through enhanced opportunities, access to resources, voice and respect for rights".

The countries of the Caucasus Ecoregion, except for the Islamic Republic of Iran, are committed to gender equality on an international level, and have taken action to ensure gender equality and eliminate gender discrimination. All except the Islamic Republic of Iran have ratified the United Nations General Assembly Convention on the Elimination of All Forms of Discrimination against Women (CEDAW). CEDAW is the convention providing the basis for gender equality, ensuring women's equal access and equal opportunities in political and public life, including the right to vote, and equal access to education, health and employment. The Islamic Republic of Iran is among the very few countries in the world that have not ratified the convention, since "some terms of CEDAW are in conflict with Iran's Constitution and Sharia Law", according to Shokri and Asl (2015, p. 58). The Islamic Republic of Iran does not have a legal framework that ensures gender equality; men and women in the country are therefore not equal before the law. Women do not have the same rights as men in various cultural, social, economic, and political areas, as well as in marriage and family relations. Women are still considered objects and instruments in the context of the family and in the service of husbands (Bakhshizadeh 2018).

The Soviet era had a significant influence on the public position of women in Armenia, Azerbaijan, Georgia and the Russian Federation, as women's roles in political life, education and employment were promoted by the state by expanding educational opportunities, improving the accessibility of childcare, and providing generous labour rights and social welfare programmes (Carnaghan and Bahry 1990). As a result, the female labour force participation rate in former Soviet states is high compared to other countries (Pignatti, Torosyan and Chitanava 2016). However, traditional norms and values regarding the status of women within the family and society still prevail in the Caucasus region (Baskakova 2012; United Nations Entity for Gender Equality and the Empowerment of Women [UN Women] 2020; UN Women and Statistical Committee of Armenia 2020). In the last two decades, the South Caucasus countries, in line with international commitments, have fostered gender equality and reduced gender-based violence. Armenia approved the Law on Ensuring Equal Rights and Equal Opportunities for Women and Men in 2013 and adopted a new Electoral Code in 2016 that increased the quota for women's representation in elective bodies from 20 to 25 per cent, aiming to increase it to 30 per cent by 2021. Azerbaijan adopted a Law on State Guarantees of Equal Rights for Women and Men in 2006 which laid the legal basis for gender equality. Georgia adopted the Law on the Elimination of All Forms of Discrimination in 2014 and the Gender Equality Law in 2021.

In contrast, in 2020 Türkiye withdrew from the Council of Europe Convention on Preventing and Combating Violence against Women and Domestic Violence (the Istanbul Convention), which is an important regional human rights instrument aiming to protect women against all forms of violence. Officially, the decision was defended by the Government with the claim that the Convention was "hijacked by a group of people attempting to normalize homosexuality", and that this was incompatible with the country's social and family values (Türkiye, Presidency, Directorate of Communications 2021). Women's rights are guaranteed in national laws, this official communication continues, and the Government insisted that the decision to withdraw from the Istanbul Convention by no means "compromises the protection of women" (Türkiye, Presidency, Directorate of Communications 2021). However, the withdrawal from the Istanbul Convention is a step backward for addressing the protection gap for women.

The OECD Development Centre Social Institutions and Gender Index (SIGI) measures discrimination against women in social institutions (formal and informal laws, social norms and practices) across 180 countries. It reflects both formal laws and the de facto situation in countries. Countries are classified into five categories by level of discrimination: very low (SIGI<20 per cent), low (20 per cent<SIGI<30 per cent), medium (30 per cent<SIGI<40 per cent), high (40 per cent<SIGI<50 per cent) and very high (SIGI>50 per cent); 100 per cent indicates the highest level of discrimination.

Table 41 presents the SIGI 2019 index and its components for the Caucasus Ecoregion countries. Armenia, Azerbaijan, Georgia, the Russian Federation and Türkiye fall into the category of countries with low discrimination rates against women. The Islamic Republic of Iran has high numbers in the dimension of family-based discrimination, which measures women's decision-making power and status within families. Additionally, the Islamic Republic of Iran exhibits very high discrimination in terms of restricted civil liberties, reflecting the existence of discriminatory laws and practices restricting women's political powers, their access to public space and their participation in other aspects of public life.

Table 41. Social Institutions and Gender Index (SIGI) 2019

Country	SIGI value 2019 (percentage)	Discrimination in the family (percentage)	Restricted physical integrity (percentage)	Restricted access to productive and financial resources (percentage)	Restricted civil liberties (percentage)
Armenia	27.8	33.0	34.5	23.4	19.4
Azerbaijan	28.7	28.2	42.8	20.9	21.4
Georgia	24.8	34.0	18.3	27.3	18.7
Islamic Republic of Iran	58.3	89.9	29.1	22.5	75.1
Russian Federation	22.3	22.6	19.1	15.1	31.5
Türkiye	25.1	33.2	7.8	36.6	20.0

Source: OECD (2019).
Note: National level statistics.

This index helps to monitor progress made towards gender equality in light of the 2030 Agenda, as it sheds light on various structural barriers and presents the situation regarding violence against girls and women, child marriages, women's political and economic empowerment, and access to sexual and reproductive health services (Advancing Learning and Innovation on Gender Norms 2019).

Compared to the rest of the world, all Caucasus Ecoregion countries performed above the world average in 2020 according to the Human Development Index, a composite index of three dimensions: life expectancy, education and income. Countries are ranked into four tiers of human development: very high, high, medium, and low. Georgia and the Russian Federation, according to the 2020 ranking, are in the list of countries with a very high HDI. The rest of the Caucasus Ecoregion countries fall into the category of countries with high HDI (UNDP 2020). Regardless of this relatively good performance, there is still room for improvement in the direction of social inclusion. Accounting for different distributional patterns of environmental impacts and addressing deep-rooted systemic inequalities are essential to narrowing gaps between the most vulnerable groups and the rest.

9.5. Waste and wastewater

Waste and wastewater are other cross-cutting issues that need to be considered when discussing the interconnectedness of nature and human societies. Poorly managed waste contaminates the environment and increases the transmission of contagious illnesses through disease vectors, while airborne particles released in the air during the burning of waste increase the incidence of respiratory diseases. Waste generation is increasing with economic development, urbanization and population growth. By 2030, waste generation is expected to increase to 2.59 billion tons globally per year, and 3.4 billion tons by 2050, compared to 2.01 billion tons in 2016. This increase is expected to come mainly from middle- and low-income countries. According to these projections, daily per capita waste is expected to increase by 19 per cent for high-income countries over the period 2016–2050, while for low- and middle-income countries this increase is expected to be 40 per cent and above (Kaza *et al*. 2018).

The Caucasus Ecoregion countries should be prepared for an increased waste burden in the coming years. Legislation of all countries includes requirements for improvement of environmental performance, environmental health protection and pollution prevention. Caucasus countries are parties to all the main waste-related international conventions, providing policy frameworks and promoting national and regional cooperation to address environmental issues. However, waste management would benefit from additional legislative and institutional efforts that will also require comprehensive and costly investments in institutional capacity and infrastructure. Currently, landfills are operated in all large communities of the Caucasus Ecoregion countries (Kaza *et al*. 2018).

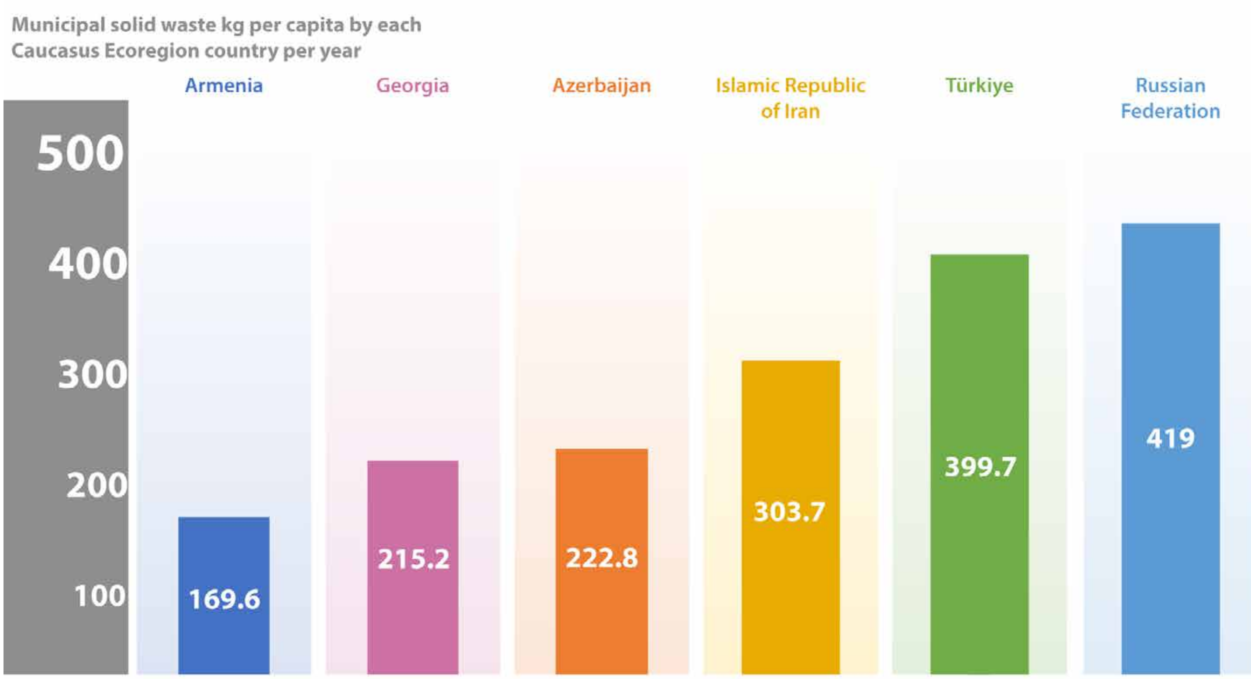


Figure 17. *Municipal solid waste per capita by country.*
Source: Authors' calculations based on World Bank data (n.d.).

Waste management data is critical for evidence-based policymaking but is currently lacking. Well-founded estimates of waste generated per sector are critical for proper waste management and sustainable economic growth through an efficient use of natural resources. Information can allow for effective monitoring mechanisms, facilitate reductions in waste and ensure the use of waste as a resource. The focus should be on the largest waste-generating sectors. Coal extraction is the single largest source of waste, generating an almost equivalent amount of solid waste as the mined coal along with significant quantities of gases and wastewater. The main sources of waste from industrial facilities, excluding the waste sector, are manufacturing, chemicals, energy supply, food and drink, ferrous metal, paper, and wood. Extensive mining and processing activities in the Russian Federation and Türkiye lead to very high total waste generation levels. These countries also generate the highest levels of hazardous waste (United Nations 2018). Armenia and Azerbaijan show quite low average waste amounts, but this may partially be due to the lack of waste statistics, which are not available for Georgia and the Islamic Republic of Iran.

The amount of municipal waste produced in the Caucasus Ecoregion countries (see Figure 17). is estimated by projects whose data are derived from site studies, as well as expert opinions. According to the latest available data, the Russian Federation generates the highest amount of municipal solid waste per capita compared to other countries of the Caucasus Ecoregion. The figures for Armenia, Georgia and the Islamic Republic of Iran are relatively low.

Mismanaged plastic waste (MPW) is another growing environmental concern today. According to estimates, 3.8 million tons of mismanaged plastic waste were produced in Caucasus Ecoregion countries in 2015, and this number is expected to grow to 5.7 million tons in 2040 without changes in behaviours by individuals and countries. However, if the Caucasus Ecoregion countries' waste management infrastructures improve with economic growth, the estimated amount of mismanaged plastic waste could reach only 300,000 tons in 2040 (Lebreton and Andrady 2019).

Recently, many of the largest cities in the Caucasus Ecoregion countries have initiated projects for the sorting and recycling of packaging waste. Regardless of progress in terms of proper solid waste management, countries still face many challenges, particularly a lack of coverage as not all people in the region have access to waste disposal and recycling facilities and services, and a lack of finances for infrastructure and services. The Ecoregion still encounters challenges related to landfilling and waste dumping. It also requires the establishment of new landfills that adhere to contemporary environmental norms, separating the collection of certain recyclables in households and businesses, along with the integration of more sophisticated recycling methods and technologies for certain types of waste (i.e., electronic waste). Residents of Caucasus Ecoregion countries lack incentives for proper waste management: there is no relation between landfill taxes or fees and the recycling of waste, and countries underestimate the environmental benefits of waste management, which are currently calculated based only on greenhouse gas emissions

Waste collectors in Batumi, Georgia. *©iStock/Kutredrig*

(FAO and UNEP 2021). The recent COVID-19 pandemic created new challenges for urban waste management in all the countries of the Caucasus Ecoregion regarding the utilization of large volumes of masks and other medical supplies. Empowering women through training and education is also essential, as they play critical roles in waste management, from households to formal roles in waste treatment. Recognizing their contributions and promoting gender-inclusive policies and practices not only benefits environmental conservation, but also advances gender equality (UNEP 2022). Promoting gender inclusion in waste management, particularly empowering women, enhances its efficiency. Women's insights and roles in waste work are valuable for achieving sustainable and equitable waste management. Inclusivity should also involve men and boys, as gender issues extend beyond women (UNEP n.d.b).

The need for efficient and sustainable water use is currently recognized throughout the countries of the Caucasus Ecoregion. Investments in the water sector are now increasing in some countries. Major water users should be held collectively responsible for their water use and management throughout their operations, including water quality once it is discharged and the use of fresh cooling water in some processes. Water use and management should be considered part of corporate social responsibility. Many large water-consuming industries have begun to accept and act on the fact that they are part of a local community, as well as a global world with water scarcity. Despite large water-using industries moving towards taking water use and management more seriously, there is still a long way to go before sustainable water management becomes the norm. A large share of wastewater in the Caucasus Ecoregion is still released untreated into the environment (United Nations 2022) according to available data estimates in the Caucasus Ecoregion countries (see Table 42).

Table 42. The proportion of wastewater flow (safely) treated by Caucasus Ecoregion countries

Country	Proportion of wastewater flow (safely) treated, 2015–2020, estimates
Armenia	7.5
Azerbaijan	46.0
Georgia	49.6
Islamic Republic of Iran	35.2
Russian Federation	13
Türkiye	81.2

Source: United Nations (2022).
Note: Proportion of wastewater flow (safely) treated 2015–2020 was not available for Georgia and the Russian Federation, hence the numbers provided in the table represent the percentage of domestic water consumption that was treated.

> ***Creating quality and attractive conditions for young professionals in education and health care, combating corruption, and developing intergovernmental cultural, scientific and educational projects, are all key.***
>
> Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

In the Caucasus Ecoregion countries, wastewater treatment receives insufficient investment, resulting in a significant portion of untreated wastewater. However, there is also a growing emphasis on allocating water resources in a way that balances the objectives of economic growth with environmental and health concerns. The practice of reusing water within industries is gaining attention, with a growing focus on industrial water reuse and corporate involvement in initiatives like wastewater treatment, reverse osmosis waste recovery, and rainwater harvesting and reuse. In addition, two parallel developments have the potential to significantly transform water and wastewater systems: renewable energy and decentralization. The growing development of decentralized water supply systems is accelerating intelligent solutions, and the control and monitoring of water resource use is becoming a priority for all countries of the region. The new target of using hydrogen as a liquid fuel in all the countries of the Caucasus Ecoregion also requires large amounts of water. Any new freshwater demand for this clean energy source will also affect the availability of water for other uses and will require governments to make socioeconomic and environmental trade-offs. The main measures and activities in the water sector in all countries of the Caucasus Ecoregion can be classified into three elements: decentralization of water supply systems and implementation of intelligent and smart solutions; reduction of the water sector's energy intensity; and the use of hydrogen as a liquid fuel, which requires large amounts of water.

9.6. Energy and use of resources

An analysis of development scenarios of the energy sector and the use of resources in the Caucasus Ecoregion countries and their alignment to the SDGs, particularly SDGs 6 and 7, are discussed below.

The 2030 Agenda encourages the development of the energy sector by:
- Changing the hierarchy of energy sources, with a shift from fossil fuels to renewable and new energy sources;
- Improving energy efficiency, reassessing traditional energy-production technologies, encouraging energy transformation and innovative consumption;
- "Intellectualizing" energy through a transition away from energy seen simply as "power" to "smart" and "clean" energy.

Regardless of commitments to the SDGs, energy and resource use data of the Caucasus Ecoregion countries show that an energy transformation towards sustainable development still requires considerable time and resources. The Caucasus Ecoregion countries are no exceptions in this regard. According to the 2021 International Energy Agency (IEA) World Energy Outlook, "a new global energy economy is emerging […] but the transformation still has a long way to go" (IEA 2021a, p.15). The renewable share in final energy consumption (excluding traditional uses of bioenergy) is the highest in Georgia at 27.9 per cent according to 2018 data, followed by Türkiye and Armenia, 11.9 per cent and 11.1 per cent respectively, while for the rest of the countries it stands below 3.5 per cent (World Bank *et al*. 2021). With existing resources and adopted policies, Caucasus Ecoregion countries have the potential to increase the share of renewable energy in total energy consumption.

The Governments of Armenia, Azerbaijan, Georgia and Türkiye support the growth of renewable energy sources. Armenia's developmental focus in this sector is outlined in the Law on Energy. This law stipulates that from the point of establishing the initial electricity tariff, there is a compulsory guarantee of electricity purchase by the distribution company for a duration of 15 years for small hydropower plants, and 20 years for other renewable energy sources such as wind, solar, geothermal and biomass power plants. Similarly, the objectives of Georgia's 2030 Climate Change Strategy are to support renewable energy generation (i.e., wind, solar, hydro, and biomass); to improve the average efficiency of thermal power plants; and to strengthen the capacities of renewable energy integration in the transmission network of Georgia. The country's goal is to reduce greenhouse gas emissions to 15 per cent below the baseline scenario projection by 2030 (Georgia 2021). Türkiye, whose energy system is characterized by a large share of fossil fuels (83 per cent of the total primary energy supply and 73 per cent of total final consumption in 2020 [IEA 2021b]), has embarked on an ambitious nuclear power strategy. The country is now constructing its first nuclear power plant, with the objective of limiting the use of imported fuels for power generation. A further three nuclear power plants are planned to reach 12 reactor units. Coal mining and coal-fired generation in Türkiye also have the goal of reducing dependence on imports of natural gas and coal. At the same time, renewable energy in Türkiye has staged an impressive growth of 50 per cent over the last five years, led by hydro, solar and wind (IEA 2021c).

The Islamic Republic of Iran faces several challenges related to energy production and consumption, including air pollution and problems with energy security. While being a leading exporter and consumer of fossil fuels, the Islamic Republic of Iran is also trying to develop renewable energy as part of its energy mix to achieve both energy security and sustainability. Over the years, the share of oil in electricity generation has been decreasing with substitution by natural gas. The country's dependence on these two sources amounts to over 88 per cent of electricity generation (IEA 2021d). Modern renewables contribute less than 1 per cent of final energy consumption. However, the geographic characteristics of the Islamic Republic of Iran would allow for good potential for developing renewable sources and thus creating beneficial preconditions to reduce dependence on fossil fuels. Developing its rich hydropower potential is the main task of the national energy development programme, and the country has set out to encourage the use of renewable energy, especially in electricity production, having introduced fuel-diversification policies and other targeted programmes since the late 2000s and early 2010s (Solaymani 2021).

> ***Developing education for children as a foundation for the sustainable development of local communities is essential.***
>
> Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, the Russian Federation

Electricity produced with coal is the largest contributor of carbon emissions for the electricity sector, which represented 34.8 per cent of electricity generation in 2020 for Türkiye, and 16.2 per cent for the Russian Federation (IEA 2021d). According to the Energy Strategy of the Russian Federation up to 2035, the country is not planning to phase out coal (Russian Federation 2020). According to Climate Transparency (2020, p. 9), the Energy Strategy instead "targets an increase in annual domestic coal consumption of 196 million tons by 2035" for a 12 per cent increase. Indeed, "total domestic production is targeted to double between now until 2035". The Russian Federation has significant renewable energy potential from a variety of sources; however, the development of renewable energy sources is progressing very slowly, apart from hydropower and bioenergy (International Renewable Energy Agency 2017). Recent investments in the energy sector in the Russian Federation and Türkiye provide emission reductions, since they support switching away from coal or oil to less polluting alternatives.

Energy efficiency and energy savings are a priority of energy policies in the Caucasus Ecoregion countries. Azerbaijan prioritizes expanding the use of alternative and renewable energy sources, standardization and compliance in the field of energy saving and energy efficiency and reducing fuel consumption for electricity production (IEA 2021e). Laws and legal acts have been adopted to develop renewable energies in Azerbaijan and to improve the institutional and legislative frameworks in this area. In recent years, the work carried out in the field has been continued, and the Law of the Republic of Azerbaijan on the Use of Renewable Energy Sources in the Production of Electricity, dated 31 May 2021, has been approved, committing the country to the further development of renewable energy. The country aims to increase renewable-energy installed capacity in electricity production to 30 per cent by 2030.

Energy digitalization, clean energy and energy efficiency are among the main priorities of the energy sector in Armenia. In particular, the country's Energy Strategy targets a share of at least 15 per cent production of renewable energy by 2030 (Armenia 2021). Georgia, as part of its candidature for and harmonization process with the European Union, is currently establishing a legal and regulatory framework to transpose the existing European Union acquis on energy efficiency and renewable energy related to electricity, natural gas, and energy statistics. The Energy Strategy of the Russian Federation up to 2035 (Russian Federation 2020) has already moved towards deep and high-quality technological and structural transformation of the industry itself and related segments of the energy and energy-industrial sector. This Strategy aims to develop smart energy and stimulate the production of electricity from renewable energy sources.

A National Energy Efficiency Action Plan was adopted in Türkiye (2018), defining ways to increase energy efficiency in all sectors, to support energy efficiency more effectively; to develop sustainable finance mechanisms; to position energy efficient smart cities and networks; and to increase the use of alternative fuels and resources.

An analysis of the state of the development of the fuel and energy complex of the Caucasus Ecoregion countries shows that steps towards sustainable development of the energy sector are taking place in all the countries, but at different rates and in different directions. In the short and medium terms, the main trends will be the continued modernization of the production base, while in the long term, the development of the energy sector based on new competitive technologies with high export potential, is foreseen.

Conclusion

The cross-cutting issues identified here are entry points to better understand the state of the environment in the Caucasus Ecoregion and should be taken into consideration while formulating climate change mitigation and adaptation policies. These cross-cutting issues demonstrate the interrelatedness of social, economic and environmental issues, and can aid in the formulation of transformative policies for sustainable development. This analysis demonstrates the necessity of prioritizing pollution prevention and health protection in the Ecoregion due to the high health burden associated with pollution. The Caucasus Ecoregion countries perform considerably well in the education sector and have integrated sustainable education into their education systems. Maintaining a focus on education is particularly important, since it can positively impact societal transformation towards sustainable development and enhance resilience to climate change. Although technological readiness has gradually increased in the region over the past decade, societies in this area still encounter obstacles when it comes to accessing and adopting new technologies. This could be a significant impediment to utilizing the advantages of new technologies and accordingly reducing the footprint of technology on the environment. The importance of social inclusion, especially increasing gender equality, is underlined as a priority area for policymakers seeking to strengthen environmental protection. Moreover, all countries in the Caucasus Ecoregion have been promoting the development and implementation of energy security strategies based on the development of a renewable energy system. These strategies are aimed at balancing economic development with environmental sustainability through setting targets for increasing the share of electricity delivered from renewable energy sources. Regarding waste and wastewater, all countries need to allocate more resources to upgrading infrastructure, technologies, and related services and increase the share of treated wastewater and disposed waste.

> ***I think that at the research, practice and policy levels, communication and cooperation between people in these fields in all the countries of the Caucasus Ecoregion should increase.***
>
> Narek Sahakyan, Khachatur Abovian Armenian State Pedagogical University, and Institute of Geological Sciences of the National Academy of Sciences, Armenia

Conclusion

This second edition of the Caucasus Environment Outlook provides a comprehensive assessment of the environmental state of the Caucasus Ecoregion, encompassing Armenia, Azerbaijan and Georgia, and the Caucasus parts of the Islamic Republic of Iran, the Russian Federation and Türkiye. Situated at the crossroads of Europe, Asia and the Middle East, this Ecoregion has witnessed significant changes over the past two decades and is poised for further development. Integrating future developments into sustainability and resilience efforts is imperative, especially in anticipation of the exacerbating effects of climate change.

This publication aggregates the latest information from the six countries within the Ecoregion, offering an overview of the current environmental status and key socioeconomic issues. Utilizing the driver-pressure-state-impact-response (DPSIR) framework, the report identifies and analyses environmental and human drivers, evaluates their impacts, and assesses societal responses to these challenges. The Caucasus Environment Outlook emphasizes the need to enhance efforts towards sustainability, considering increasing population and urbanization trends, and shifting economic dynamics.

The total population in the Caucasus Ecoregion reached close to 42 million in 2020, marking a 0.4 per cent annual increase over the past 20 years. Notably, Azerbaijan and the Caucasus part of the Russian Federation exhibit higher growth rates, while Armenia, Georgia and the Caucasus part of Türkiye have experienced population declines. Urbanization is a prevailing trend, necessitating improved city planning, sustainable transport and green spaces to ensure the well-being of residents. By 2050, the degree of urbanization is projected to exceed 70 per cent in the Caucasus Ecoregion, requiring coherent urban planning to accommodate this growth. Increasing temperatures are expected to particularly affect urban areas, where heat is exacerbated by the presence of buildings and roads.

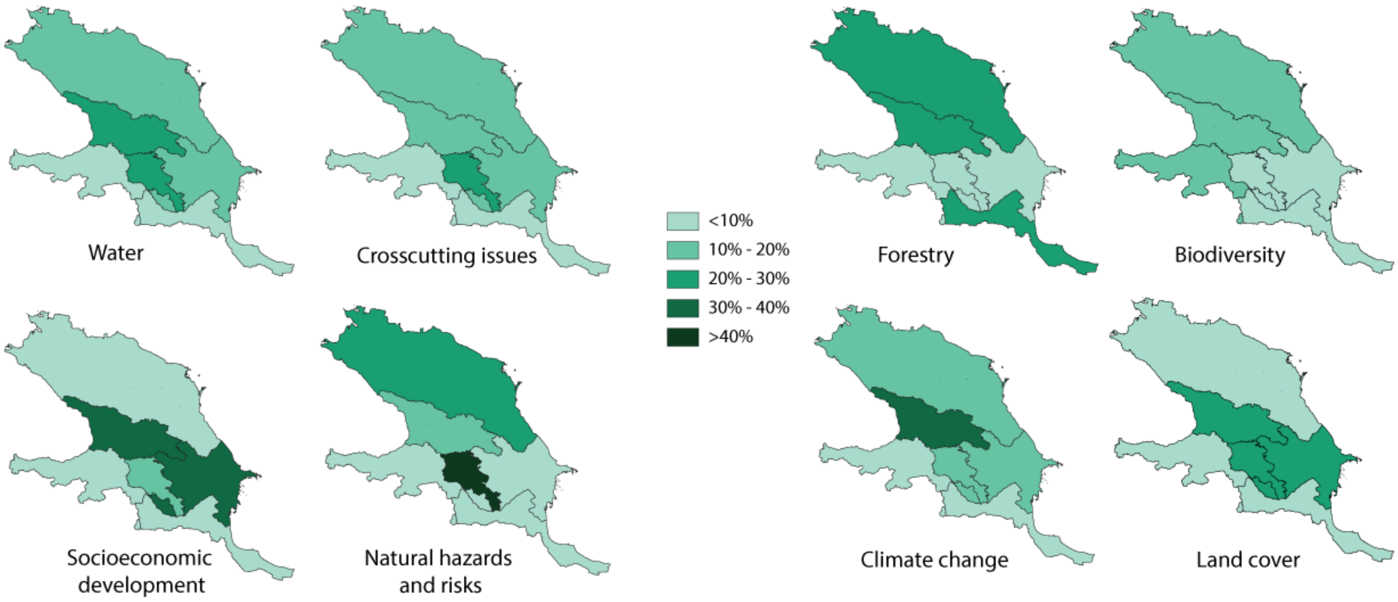
Economic transitions from small-scale agriculture to industry and services are evident, prompting the need for eco-friendly investments. This report underscores the importance of aligning economic strategies with environmental sustainability, advocating for renewable energy, adoption of technology, and public transport. Furthermore, it calls for enhanced environmental monitoring, expanded protected areas to preserve biodiversity, and adherence to international conventions. Improving natural resource monitoring, such as freshwater management, is crucial, to ensure its quality, sustainable use, and fair distribution, particularly given shifting precipitation patterns towards drier and hotter summers and wetter springs. The loss of glaciated areas will also affect water distribution natural disasters are expected to become more frequent and more intense, especially in mountain areas.

Addressing waste and wastewater challenges necessitates increased resource allocation for infrastructure upgrades, technologies and related services, along with efforts to improve wastewater treatment of wastewater and proper waste disposal in all countries. Harnessing the benefits of new technologies, while ensuring their equitable ethical use and minimizing their environmental footprint, is key to responsible and sustainable technological practices. Enhanced management of national and regional water resources, as well as participation in existing treaties and agreements related to freshwater, will be essential for these efforts to succeed.

Developing energy security strategies centred around a renewable energy system is essential for a sustainable and resilient energy future. Lastly, aligning with international biodiversity conservation and greenhouse gas emission reduction targets should be a priority.

Recognizing the interdependence of environmental and social well-being, the CEO 2024 emphasizes inclusive decision-making, particularly involving women. While accounting for a majority of the population, women are not equally represented in the decision-making processes within the Caucasus Ecoregion. Greater consultation with women is necessary to drive the needed change. The report highlights social issues, urban well-being and the need to reduce inequalities arising from societal changes. Focussing on lifelong education and capacity-building is crucial to positively influence societal transformation towards sustainable development. Furthermore, enhancing the role of scientists and scientific institutions in co-creating actionable and relevant knowledge in collaboration with other societal actors, as well as supporting scientific networking and collaboration across the Caucasus Ecoregion, are key to enabling sustainability transformations.

During the data-gathering and analysis process for the second edition of the Caucasus Environment Outlook, the authors identified a need for improved data homogeneity and comparability at regional and national levels. This is further emphasized by the Scientific Network for the Caucasus Mountain Region (SNC-mt) analysis of the scientific research in the countries of the Ecoregion based on major providers of scientific articles (Elsevier, Google Scholar, ScienceDirect, Scopus and ResearchGate). The analysis demonstrates a broad array of topics with varied academic interest and



Map 22. *Share of thematic articles per topic, per country, 2020–2023.*
Source: Shatberashvili *et al*. (2023).

participation within the Ecoregion (see Map 22). Of the 1,650 scientific papers published in the last four years, 166 (10 per cent) focused on socioeconomic development and planning, 143 (9 per cent) on water resources and management, 142 (9 per cent) on natural hazards and risks, 111 (7 per cent) on population and cultural diversity, 102 (6 per cent) on land cover, 75 (5 per cent) on biodiversity, and 75 (5 per cent) on forestry. Only 18 per cent of the total published studies included a regional perspective including two or more countries of the Caucasus Ecoregion.

Therefore, the recommendations of this second edition of the Caucasus Environment Outlook include increasing regional and national research efforts to fill gaps and advance the availability of comparable and homogeneous data on the Ecoregion to support scientifically grounded and justified policy- and decision-making. The editorial team and authors call on the governments of the Caucasus countries to create more opportunities, incentives and support structures for scientists and scientific institutions to engage in socially relevant research at the local, national and regional levels, and to facilitate collaboration between scientists and policymakers. To support this effort, it is essential to improve existing policies across all sectors covered by the report, create new cross-sectoral policies, and foster transboundary cooperation to better prepare for the fluctuating availability of natural resources.

Coordinating the implementation of various measures and objectives is necessary for policy consistency. Such efforts, in line with the International Decade of Sciences for Sustainable Development 2024–2033, will hopefully contribute to evidence-based governance and better decision-making to safeguard the valuable Caucasus Mountain ecosystems and their benefits for the people in the region

What should Governments do to make the Caucasus a more sustainable place to live?

Governments should seek common solutions focused on sustainability. Country-wide climate finance should be established and some of it transferred to projects focusing on the Caucasus Ecoregion. A campaign should be carried out across countries to raise public awareness of project results.

Nuray Çalti, independent researcher, and youth trainer, Türkiye

Ensuring peace and security is a crucial issue for Governments in the Caucasus Ecoregion. The lack of stability and security hinders the development of communities, discourages investments and leads to the migration of young people from rural areas. Governments should prioritize implementing comprehensive strategies for the development of remote villages and border settlements, including initiatives that involve scientists.

Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

Governments could prioritize the protection of the region's natural resources and ecosystems, such as forests, rivers and wetlands, by implementing and enforcing regulations that prevent overexploitation, habitat destruction and pollution. [They should take] further steps to address the impacts of climate change, including the increased frequency of extreme weather events and decreasing water levels in the Caspian Sea. This could involve the development and implementation of climate change adaptation and mitigation strategies. These strategies may encompass initiatives such as promoting drought-resistant agriculture, implementing coastal protection measures, and fostering the growth of low-carbon industries.

Emil Jabrayilov, researcher, Institute of Geography, Baku, Azerbaijan

We need to reduce emissions and pollution from the on-site oil and gas industry. It (would) be more effective to use the alternative energy resources of the area, such as solar, wind and geothermal energy.

Narek Sahakyan, Khachatur Abovian Armenian State Pedagogical University, and Institute of Geological Sciences of the National Academy of Sciences, Armenia

Ensure that decisions are inclusive and relevant to the local context, it is crucial to involve and integrate the perspectives of local communities. We need more research and action regarding governance issues like decentralization, management of protected areas, and so on.

Temur Gugushvili, Assistant Professor, International Black Sea University, Georgia

In my opinion, to make the Caucasus Ecoregion a more sustainable place to live, there should be a focus on improving the social dimensions of nature and landscapes. This can be achieved by enhancing public participation in decision-making processes, strengthening environmental education and awareness, integrating traditional knowledge and local perspectives, incorporating the valuation of ecosystem services, and ensuring equity and justice in conservation efforts. By prioritizing these measures, we can create a more inclusive, participatory and sustainable living environment in the Caucasus.

Gvantsa Salukvadze, senior scientist, Tbilisi State University, Georgia

“ *Cooperation between countries is very important. It is necessary to think about the global environment in all planning. Having long-term goals and plans and developing and adhering to regional and international commitments, strengthens the efforts to achieve these goals and the commitment to fulfill them. Preservation and promotion of resources by gradually changing the methods of development and use of technologies, development of human capital, establishment of social justice, and attracting cooperation and participation in environmental protection, should be prioritized by planners and decision makers.*

Siavash Rezazadeh, Ph.D. Student of Environmental Science, Malayer University, the Islamic Republic of Iran

“ *It is important to properly organize land use.*

Samira Abushova, Ph.D in geography, researcher, Ministry of Science and Education Republic of Azerbaijan, Institute of Geography, Baku, Azerbaijan

“ *Allocating government funds to support the implementation of conservation programmes and measures, as well as creating incentives for cooperation between the private and public sectors. Creating an information exchange system that provides the possibility of monitoring the implementation of programmes and evaluating their effects will provide a basis for the Caucasus to become more stable.*

Elahe Khangholi, PhD student, Malayer University, the Islamic Republic of Iran

What can the publication of the CEO do to facilitate young scientists’ contribution to the future of the Caucasus Ecoregion?

“ *Prompt the implementation of collaborative programmes where there will be opportunities to include young, early career scientists.*

Hayarpi Hakobyan, PhD student, Khachatur Abovian Armenian State Pedagogical University, Armenia

“ *Lead to meetings between representatives of different countries of the Ecoregion, organized within the framework of CEO-2, in order to increase the possibility of their cooperation.*

Narek Sahakyan, Khachatur Abovian Armenian State Pedagogical University, and Institute of Geological Sciences of the National Academy of Sciences, Armenia

“ *Lead to workshops and trainings about the environment and socioeconomic challenges.*

Natia Kekenadze, researcher, Ivane Javakhishvili Tbilisi State University, Georgia

“ *Facilitate development of grant support for research and educational projects and organization of events to foster connections and the development of communities for young scientists in the Caucasus.*

Dmitry Koryukhin, schoolteacher and independent researcher, Republic of Dagestan, Russian Federation

Annex: Territorial units and codes in the Caucasus Ecoregion by country

The Nomenclature of Territorial Units for Statistics (NUTS)[1] is a geographical nomenclature subdividing the economic territory of the European Union (EU)(Eurostat n.d.a.) into regions at four different levels (NUTS 1, 2, 3 and LAU respectively, moving from larger to smaller territorial units) (Eurostat n.d.c.). NUTS is formalized through the regulation EC No. 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (European Council 2024).

Generally, the three NUTS levels and the local administrative unit compare as follows to the administrative divisions (Eurostat n.d.a.):

- **NUTS 1:** Division between the national level and the first sub-national administrative level (e.g. group of regions).
- **NUTS 2:** Division generally corresponding to the first sub-national administrative level (e.g. regions, provinces).
- **NUTS 3:** Division generally corresponding to the second sub-national administrative level (e.g. provinces, rayons, municipalities).
- **LAU** (Local Administrative Units): Lower-level subdivision of NUTS 3 level that changes very frequently.

As noted in the introduction, below are the specific names of the territorial units within each of the Caucasus countries. In order to give each of these sub-national units a unique identifier for data collection and mapping, a specific coding scheme was developed based on the United Nations Second Administrative Level Boundaries project (UN SALB) coding scheme (United Nations Geospatial 2021).

The lists of NUTS 2, NUTS 3 equivalent units used for the Caucasus Ecoregion, along with their respective unique codes are available in the annex.

Armenia: Regions (marzes) were defined as subnational units for data collection, both as NUTS 2 and NUTS 3 equivalent (Government of the Republic of Armenia n.d.).

Azerbaijan: Districts (rayon) and cities (şəhər) were defined as subnational units of both NUTS 2 and NUTS 3 equivalent for data collection.

Georgia: Regions (mkhare) were defined as subnational units of NUTS 2 equivalent and the municipalities (munitsip’alit’et’i) as NUTS 3 equivalent.

Iran (Islamic Republic of): Provinces (ostānhā) were defined as subnational units of NUTS 2 equivalent and districts (shahrestan) as NUTS 3 equivalent.

Russian Federation: “Constituent entities”, republics, krays, oblasts, cities of federal significance, an autonomous oblast and autonomous okrugs, were defined as the NUTS 2 equivalent, districts (rayons) and cities (gorod) as the NUTS 3 equivalent.

Türkiye: Provinces (İlleri) were defined as subnational units of NUTS2 equivalent and the districts (ilçeler) as NUTS 3 equivalent, although this does not align with official NUTS 2 and NUTS 3 in Türkiye, that are Alt bölgeler and İlleri respectively.

[1] NUTS is the acronym for the French title of these units: *Nomenclature des Unités territoriales statistiques*.

Table A-1. NUTS 2- and NUTS 3-equivalent codes and names for administrative units within Caucasus countries and from Caucasus parts of countries

Armenia			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
ARM001	Aragatsotn	ARM001	–
ARM002	Ararat	ARM002	–
ARM003	Armavir	ARM003	–
ARM004	Geghakunik	ARM004	–
ARM005	Kotayk	ARM005	–
ARM006	Lori	ARM006	–
ARM007	Shirak	ARM007	–
ARM008	Syunik	ARM008	–
ARM009	Tavush	ARM009	–
ARM010	Vayotsdzor	ARM010	–
ARM011	Yerevan	ARM011	–

Azerbaijan			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
AZE001	Absheron	AZE001	–
AZE002	Aghdam	AZE002	–
AZE003	Agdash	AZE003	–
AZE004	Agjabedi	AZE004	–
AZE005	Agstafa	AZE005	–
AZE006	Agsu	AZE006	–
AZE007	Astara	AZE007	–
AZE008	Babek	AZE008	–
AZE009	Baku	AZE009	–
AZE010	Balaken	AZE010	–
AZE011	Barda	AZE011	–
AZE012	Beylagan	AZE012	–
AZE013	Bilasuvar	AZE013	–
AZE014	Dashkesen	AZE014	–
AZE015	Fizuly	AZE015	–
AZE016	Gabala	AZE016	–
AZE017	Gadabay	AZE017	–
AZE018	Gakh	AZE018	–
AZE019	Ganja	AZE019	–
AZE020	Gazakh	AZE020	–
AZE021	Goranboy	AZE021	–
AZE022	Gobustan	AZE022	–
AZE023	Goychay	AZE023	–
AZE024	Goygol	AZE024	–
AZE026	Guba	AZE026	–
AZE027	Gubadly	AZE027	–
AZE028	Gusar	AZE028	–
AZE029	Hajigabul	AZE029	–
AZE030	Imishly	AZE030	–

Azerbaijan (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
AZE031	Ismayilly	AZE031	–
AZE032	Jalilabad	AZE032	–
AZE033	Jabrail	AZE033	–
AZE034	Julfa	AZE034	–
AZE035	Kalbajar	AZE035	–
AZE036	Kengerli	AZE036	–
AZE037	Khachmaz	AZE037	–
AZE038	Khankendi	AZE038	–
AZE039	Khojaly	AZE039	–
AZE040	Khojavand	AZE040	–
AZE041	Khizy	AZE041	–
AZE042	Kurdamir	AZE042	–
AZE043	Lachin	AZE043	–
AZE044	Lankaran	AZE044	–
AZE046	Lerik	AZE046	–
AZE047	Masally	AZE047	–
AZE048	Mingechevir	AZE048	–
AZE049	Naftalan	AZE049	–
AZE050	Nakhchivan	AZE050	–
AZE051	Neftchala	AZE051	–
AZE052	Oghuz	AZE052	–
AZE053	Ordubad	AZE053	–
AZE054	Saatly	AZE054	–
AZE055	Sabirabad	AZE055	–
AZE056	Salyan	AZE056	–
AZE057	Samukh	AZE057	–
AZE058	Sadarak	AZE058	–
AZE059	Shabran	AZE059	–
AZE060	Shahbuz	AZE060	–
AZE061	Shamakhy	AZE061	–
AZE062	Shamkir	AZE062	–
AZE063	Sheki	AZE063	–
AZE065	Sharur	AZE065	–
AZE066	Shirvan	AZE066	–
AZE067	Shusha	AZE067	–
AZE068	Siyazan	AZE068	–
AZE069	Sumgait	AZE069	–
AZE070	Terter	AZE070	–
AZE071	Tovuz	AZE071	–
AZE072	Ujar	AZE072	–
AZE073	Yardymly	AZE073	–
AZE074	Yevlakh	AZE074	–
AZE076	Zagatala	AZE076	–
AZE077	Zangilan	AZE077	–
AZE078	Zardab	AZE078	–

Georgia			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
GEO001	Tbilisi	GEO001001	C. Tbilisi
GEO002	Ajara	GEO002001	Khelvachauri
GEO002	Ajara	GEO002002	Keda
GEO002	Ajara	GEO002003	Shuakhevi
GEO002	Ajara	GEO002004	Khulo
GEO002	Ajara	GEO002005	Kobuleti
GEO002	Ajara	GEO002006	C. Batumi
GEO003	Apkhazeti	GEO003001	Gali
GEO003	Apkhazeti	GEO003002	Ochamchire
GEO003	Apkhazeti	GEO003003	Gulripshi
GEO003	Apkhazeti	GEO003004	Sokhumi
GEO003	Apkhazeti	GEO003005	Gudauta
GEO003	Apkhazeti	GEO003006	Gagra
GEO003	Apkhazeti	GEO003007	C. Sokhumi
GEO004	Guria	GEO004001	Ozurgeti
GEO004	Guria	GEO004002	Chokhatauri
GEO004	Guria	GEO004003	Lanchkhuti
GEO005	Imereti	GEO005004	Vani
GEO005	Imereti	GEO005005	Kharagauli
GEO005	Imereti	GEO005006	Baghdati
GEO005	Imereti	GEO005007	Zestaponi
GEO005	Imereti	GEO005008	Samtredia
GEO005	Imereti	GEO005009	Terjola
GEO005	Imereti	GEO005010	Chiatura
GEO005	Imereti	GEO005011	Sachkhere
GEO005	Imereti	GEO005012	Tkibuli
GEO005	Imereti	GEO005013	Tskaltubo
GEO005	Imereti	GEO005014	Khoni
GEO005	Imereti	GEO005015	C. Kutaisi
GEO006	Kakheti	GEO006001	Dedoplistskaro
GEO006	Kakheti	GEO006002	Sighnaghi
GEO006	Kakheti	GEO006003	Gurjaani
GEO006	Kakheti	GEO006004	Sagarejo
GEO006	Kakheti	GEO006005	Lagodekhi
GEO006	Kakheti	GEO006006	Kvareli
GEO006	Kakheti	GEO006007	Telavi
GEO006	Kakheti	GEO006008	Akhmeta
GEO007	Kvemo Kartli	GEO007001	Bolnisi
GEO007	Kvemo Kartli	GEO007002	Marneuli
GEO007	Kvemo Kartli	GEO007003	Dmanisi
GEO007	Kvemo Kartli	GEO007004	Gardabani
GEO007	Kvemo Kartli	GEO007005	Tsalka
GEO007	Kvemo Kartli	GEO007006	Tetritskaro
GEO007	Kvemo Kartli	GEO007008	C. Rustavi
GEO008	Mtskheta-Mtianeti	GEO008001	Mtskheta
GEO008	Mtskheta-Mtianeti	GEO008002	Tianeti
GEO008	Mtskheta-Mtianeti	GEO008003	Akhalgori
GEO008	Mtskheta-Mtianeti	GEO008004	Dusheti
GEO008	Mtskheta-Mtianeti	GEO008005	Kazbegi

Georgia (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
GEO009	Racha-Lechkhum-Kvemo Svaneti	GEO009001	Tsageri
GEO009	Racha-Lechkhum-Kvemo Svaneti	GEO009002	Ambrolauri
GEO009	Racha-Lechkhum-Kvemo Svaneti	GEO009003	Oni
GEO009	Racha-Lechkhum-Kvemo Svaneti	GEO009004	Lentekhi
GEO010	Samegrelo-Zemo Svaneti	GEO010001	Abasha
GEO010	Samegrelo-Zemo Svaneti	GEO010002	Senaki
GEO010	Samegrelo-Zemo Svaneti	GEO010003	Khobi
GEO010	Samegrelo-Zemo Svaneti	GEO010004	Zugdidi
GEO010	Samegrelo-Zemo Svaneti	GEO010005	Martvili
GEO010	Samegrelo-Zemo Svaneti	GEO010006	Chkhorotsku
GEO010	Samegrelo-Zemo Svaneti	GEO010007	Tsalenjikha
GEO010	Samegrelo-Zemo Svaneti	GEO010008	Mestia
GEO010	Samegrelo-Zemo Svaneti	GEO010009	C. Poti
GEO011	Samtskhe-Javakheti	GEO011001	Ninotsminda
GEO011	Samtskhe-Javakheti	GEO011002	Akhalkalaki
GEO011	Samtskhe-Javakheti	GEO011003	Aspindza
GEO011	Samtskhe-Javakheti	GEO011004	Akhaltsikhe
GEO011	Samtskhe-Javakheti	GEO011005	Adigeni
GEO011	Samtskhe-Javakheti	GEO011006	Borjomi
GEO012	Shida Kartli	GEO012001	Khashuri
GEO012	Shida Kartli	GEO012002	Kareli
GEO012	Shida Kartli	GEO012003	Gori
GEO012	Shida Kartli	GEO012004	Java
GEO012	Shida Kartli	GEO012005	Kaspi
GEO012	Shida Kartli	GEO012006	C. Tskhinvali

Islamic Republic of Iran			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
IRN001	Ardabil	IRN001001	Ardabil
IRN001	Ardabil	IRN001002	Aslanduz
IRN001	Ardabil	IRN001003	Bileh Savar
IRN001	Ardabil	IRN001004	Dair/Nir
IRN001	Ardabil	IRN001005	Germi/Moghan
IRN001	Ardabil	IRN001008	Meshgin Shahr
IRN001	Ardabil	IRN001009	Namin
IRN001	Ardabil	IRN001010	Pars Abbad
IRN001	Ardabil	IRN001011	Sarein
IRN002	East_Azerbaijan	IRN002001	Ahar
IRN002	East_Azerbaijan	IRN002010	Horand
IRN002	East_Azerbaijan	IRN002011	Jolfa
IRN002	East_Azerbaijan	IRN002012	Kaleibar
IRN002	East_Azerbaijan	IRN002013	Khoda Afarin
IRN002	East_Azerbaijan	IRN002016	Marand
IRN002	East_Azerbaijan	IRN002021	Varazqhan/Arasbaran
IRN003	Gilan	IRN003001	Astane Ashrafieh

Islamic Republic of Iran (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
IRN003	Gilan	IRN003002	Astara
IRN003	Gilan	IRN003003	Bandar Anzali
IRN003	Gilan	IRN003004	Fuman
IRN003	Gilan	IRN003006	Lahijan
IRN003	Gilan	IRN003007	Langroud
IRN003	Gilan	IRN003008	Masal
IRN003	Gilan	IRN003009	Omlesh
IRN003	Gilan	IRN003010	Rasht
IRN003	Gilan	IRN003011	Rezvan Shahr
IRN003	Gilan	IRN003012	Roudbar
IRN003	Gilan	IRN003013	roudsar
IRN003	Gilan	IRN003014	Shaft
IRN003	Gilan	IRN003015	Siahkal
IRN003	Gilan	IRN003016	Somee Sara
IRN003	Gilan	IRN003017	Tavalesh
IRN004	Mazandaran	IRN004001	Abbas Abaad
IRN004	Mazandaran	IRN004006	Chalus
IRN004	Mazandaran	IRN004011	Kelardasht
IRN004	Mazandaran	IRN004015	Nowshahr
IRN004	Mazandaran	IRN004017	Ramsar
IRN004	Mazandaran	IRN004022	Tonekabon
IRN005	West_Azerbaijan	IRN005002	Chaipareh
IRN005	West_Azerbaijan	IRN005003	Chaldoran
IRN005	West_Azerbaijan	IRN005005	Khoiy
IRN005	West_Azerbaijan	IRN005007	Maku
IRN005	West_Azerbaijan	IRN005012	Poldasht
IRN005	West_Azerbaijan	IRN005016	Showt

Russian Federation			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
RUS001	Krasnodarskiy	RUS001001	Leningradskiy
RUS001	Krasnodarskiy	RUS001002	Pavlovskiy
RUS001	Krasnodarskiy	RUS001003	Tikhoretskiy
RUS001	Krasnodarskiy	RUS001004	Viselkovskiy
RUS001	Krasnodarskiy	RUS001005	Abinskiy
RUS001	Krasnodarskiy	RUS001006	Krimskiy
RUS001	Krasnodarskiy	RUS001007	Armavir
RUS001	Krasnodarskiy	RUS001008	Tbilisskiy
RUS001	Krasnodarskiy	RUS001009	Korenovskiy
RUS001	Krasnodarskiy	RUS001010	Bryukhovetskiy
RUS001	Krasnodarskiy	RUS001011	Timashevskiy
RUS001	Krasnodarskiy	RUS001012	Kalininskiy
RUS001	Krasnodarskiy	RUS001013	Anapskiy
RUS001	Krasnodarskiy	RUS001014	Apsheronskiy
RUS001	Krasnodarskiy	RUS001015	Beloglinskiy

Russian Federation (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
RUS001	Krasnodarskiy	RUS001016	Belorechenskiy
RUS001	Krasnodarskiy	RUS001017	Gelendjik
RUS001	Krasnodarskiy	RUS001018	Goryachiy Klyuch
RUS001	Krasnodarskiy	RUS001019	Gulkevichskiy
RUS001	Krasnodarskiy	RUS001020	Dinskoy
RUS001	Krasnodarskiy	RUS001021	Yeyskiy
RUS001	Krasnodarskiy	RUS001022	Kavkazskiy
RUS001	Krasnodarskiy	RUS001023	Kanevskiy
RUS001	Krasnodarskiy	RUS001024	Krasnoarmeyskiy
RUS001	Krasnodarskiy	RUS001025	Krasnodar
RUS001	Krasnodarskiy	RUS001026	Krilovskiy
RUS001	Krasnodarskiy	RUS001027	Kurganinskiy
RUS001	Krasnodarskiy	RUS001028	Kushevskiy
RUS001	Krasnodarskiy	RUS001029	Labinskiy
RUS001	Krasnodarskiy	RUS001030	Mostovskiy
RUS001	Krasnodarskiy	RUS001031	Novokubanskiy
RUS001	Krasnodarskiy	RUS001032	Novopokrovskiy
RUS001	Krasnodarskiy	RUS001033	Novorossiysk
RUS001	Krasnodarskiy	RUS001034	Otradnenskiy
RUS001	Krasnodarskiy	RUS001035	Primorsko-Akhtarskiy
RUS001	Krasnodarskiy	RUS001036	Severskiy
RUS001	Krasnodarskiy	RUS001037	Slavyanskiy
RUS001	Krasnodarskiy	RUS001038	Sochi
RUS001	Krasnodarskiy	RUS001039	Starominskiy
RUS001	Krasnodarskiy	RUS001040	Temryukskiy
RUS001	Krasnodarskiy	RUS001041	Tuapsinskiy
RUS001	Krasnodarskiy	RUS001042	Uspenskiy
RUS001	Krasnodarskiy	RUS001043	Ust-Labinskiy
RUS001	Krasnodarskiy	RUS001044	Sherbinovskiy
RUS002	Stavropolskiy	RUS002001	Trunovskiy
RUS002	Stavropolskiy	RUS002002	Petrovskiy
RUS002	Stavropolskiy	RUS002003	Grachevskiy
RUS002	Stavropolskiy	RUS002004	Blagodarnenskiy
RUS002	Stavropolskiy	RUS002005	Stavropol
RUS002	Stavropolskiy	RUS002006	Budennovskiy
RUS002	Stavropolskiy	RUS002007	Aleksandrovskiy
RUS002	Stavropolskiy	RUS002008	Novoselitskiy
RUS002	Stavropolskiy	RUS002009	Nevinnomissk
RUS002	Stavropolskiy	RUS002010	Sovetskiy
RUS002	Stavropolskiy	RUS002011	Georgiyevskiy
RUS002	Stavropolskiy	RUS002012	Mineralovodskiy
RUS002	Stavropolskiy	RUS002013	Stepnovskiy
RUS002	Stavropolskiy	RUS002014	Jeleznovodsk
RUS002	Stavropolskiy	RUS002015	Lermontov
RUS002	Stavropolskiy	RUS002016	Pyatigorsk
RUS002	Stavropolskiy	RUS002017	Yessentuki
RUS002	Stavropolskiy	RUS002018	Kislovodsk
RUS002	Stavropolskiy	RUS002019	Andropovskiy
RUS002	Stavropolskiy	RUS002020	Apanasenkovskiy

Russian Federation (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
RUS002	Stavropolskiy	RUS002021	Arzgirskiy
RUS002	Stavropolskiy	RUS002022	Izobilnenskiy
RUS002	Stavropolskiy	RUS002023	Ipatovskiy
RUS002	Stavropolskiy	RUS002024	Kirovskiy
RUS002	Stavropolskiy	RUS002025	Krasnogvardeyskiy
RUS002	Stavropolskiy	RUS002026	Kurskiy
RUS002	Stavropolskiy	RUS002027	Levokumskiy
RUS002	Stavropolskiy	RUS002028	Neftekumskiy
RUS002	Stavropolskiy	RUS002029	Novoaleksandrovskiy
RUS002	Stavropolskiy	RUS002030	Turkmenskiy
RUS002	Stavropolskiy	RUS002031	Kochubeyevskiy
RUS002	Stavropolskiy	RUS002032	Predgorniy
RUS002	Stavropolskiy	RUS002033	Shpakovskiy
RUS006	Chechenskaya	RUS006001	Grozniy
RUS006	Chechenskaya	RUS006002	Shalinskiy
RUS006	Chechenskaya	RUS006003	Urus-Martanovskiy
RUS006	Chechenskaya	RUS006004	Shatoyskiy
RUS006	Chechenskaya	RUS006005	Kurchaloyevskiy
RUS006	Chechenskaya	RUS006006	Achkhoy-Martanovskiy
RUS006	Chechenskaya	RUS006007	Vedenskiy
RUS006	Chechenskaya	RUS006008	Groznenskiy
RUS006	Chechenskaya	RUS006009	Gudermesskiy
RUS006	Chechenskaya	RUS006010	Itum-Kalinskiy
RUS006	Chechenskaya	RUS006011	Nadterechniy
RUS006	Chechenskaya	RUS006012	Naurskiy
RUS006	Chechenskaya	RUS006013	Nojay-Yurtovskiy
RUS006	Chechenskaya	RUS006014	Sunjenskiy
RUS006	Chechenskaya	RUS006015	Sharoyskiy
RUS006	Chechenskaya	RUS006016	Shelkovskoy
RUS007	Dagestan	RUS007001	Kizilyurtovskiy
RUS007	Dagestan	RUS007002	Kumtorkalinskiy
RUS007	Dagestan	RUS007003	Buynakskiy
RUS007	Dagestan	RUS007005	Unsukulskiy
RUS007	Dagestan	RUS007006	Khunzakhskiy
RUS007	Dagestan	RUS007007	Akhvakhskiy
RUS007	Dagestan	RUS007008	Gergebilskiy
RUS007	Dagestan	RUS007009	Levashinskiy
RUS007	Dagestan	RUS007010	Shamilskiy
RUS007	Dagestan	RUS007011	Sergokalinskiy
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RUS007	Dagestan	RUS007013	Akushinskiy
RUS007	Dagestan	RUS007014	Charodinskiy
RUS007	Dagestan	RUS007015	Lakskiy
RUS007	Dagestan	RUS007016	Dakhadayevskiy
RUS007	Dagestan	RUS007017	Kaytagskiy
RUS007	Dagestan	RUS007018	Kulinskiy
RUS007	Dagestan	RUS007019	Tabasaranskiy
RUS007	Dagestan	RUS007020	Agulskiy
RUS007	Dagestan	RUS007021	Khivskiy

Russian Federation (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
RUS007	Dagestan	RUS007022	Suleyman-Stalskiy
RUS007	Dagestan	RUS007023	Kurakhskiy
RUS007	Dagestan	RUS007024	Akhtinskiy
RUS007	Dagestan	RUS007025	Babayurtovskiy
RUS007	Dagestan	RUS007026	Botlikhskiy
RUS007	Dagestan	RUS007027	Gumbetovskiy
RUS007	Dagestan	RUS007028	Derbentskiy
RUS007	Dagestan	RUS007029	Dokuzparinskiy
RUS007	Dagestan	RUS007030	Kazbekovskiy
RUS007	Dagestan	RUS007031	Karabudakhkentskiy
RUS007	Dagestan	RUS007032	Kayakentskiy
RUS007	Dagestan	RUS007033	Kizlyarskiy
RUS007	Dagestan	RUS007034	Magaramkentskiy
RUS007	Dagestan	RUS007035	Makhachkala
RUS007	Dagestan	RUS007036	Novolakskiy
RUS007	Dagestan	RUS007037	Nogayskiy
RUS007	Dagestan	RUS007038	Rutulskiy
RUS007	Dagestan	RUS007039	Tarumovskiy
RUS007	Dagestan	RUS007040	Tlyaratinskiy
RUS007	Dagestan	RUS007041	Khasavyurtovskiy
RUS007	Dagestan	RUS007042	Sumadinskiy
RUS007	Dagestan	RUS007043	Suntinskiy
RUS009	Adigeya	RUS009001	Takhtamukayskiy
RUS009	Adigeya	RUS009002	Maykop
RUS009	Adigeya	RUS009003	Shovgenovskiy
RUS009	Adigeya	RUS009004	Giaginskiy
RUS009	Adigeya	RUS009005	Teuchejskiy
RUS009	Adigeya	RUS009006	Maykopskiy
RUS009	Adigeya	RUS009007	Krasnogvardeyskiy
RUS009	Adigeya	RUS009008	Koshekhablskiy
RUS012	Karachayevo-Cherkesskaya	RUS012001	Malokarachayevskiy
RUS012	Karachayevo-Cherkesskaya	RUS012002	Urupskiy
RUS012	Karachayevo-Cherkesskaya	RUS012003	Adige-Khablskiy
RUS012	Karachayevo-Cherkesskaya	RUS012004	Prikubanskiy
RUS012	Karachayevo-Cherkesskaya	RUS012005	Karachayevskiy
RUS012	Karachayevo-Cherkesskaya	RUS012006	Ust-Djegutinskiy
RUS012	Karachayevo-Cherkesskaya	RUS012007	Zelenchukskiy
RUS012	Karachayevo-Cherkesskaya	RUS012008	Khabezskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013001	Kirovskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013002	Vladikavkaz
RUS013	Severnaya Osetiya - Alaniya	RUS013003	Digorskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013004	Pravoberejniy
RUS013	Severnaya Osetiya - Alaniya	RUS013005	Alagirskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013006	Mozdokskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013007	Prigorodniy
RUS013	Severnaya Osetiya - Alaniya	RUS013008	Irafskiy
RUS013	Severnaya Osetiya - Alaniya	RUS013009	Ardonskiy
RUS014	Ingushetiya	RUS014001	Djeyrakhskiy
RUS014	Ingushetiya	RUS014002	Malgobekskiy

Russian Federation (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
RUS014	Ingushetiya	RUS014003	Nazranovskiy
RUS014	Ingushetiya	RUS014004	Sunjenskiy
RUS017	Kabardino-Balkarskaya	RUS017001	Baksanskiy
RUS017	Kabardino-Balkarskaya	RUS017002	Zolskiy
RUS017	Kabardino-Balkarskaya	RUS017003	Leskenskiy
RUS017	Kabardino-Balkarskaya	RUS017004	Mayskiy
RUS017	Kabardino-Balkarskaya	RUS017005	Nalchik
RUS017	Kabardino-Balkarskaya	RUS017006	Prokhladnenskiy
RUS017	Kabardino-Balkarskaya	RUS017007	Terskiy
RUS017	Kabardino-Balkarskaya	RUS017008	Urvanskiy
RUS017	Kabardino-Balkarskaya	RUS017009	Chegemskiy
RUS017	Kabardino-Balkarskaya	RUS017010	Cherekskiy
RUS017	Kabardino-Balkarskaya	RUS017011	Elbrusskiy

Türkiye			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
TUR004	Agri	TUR004003	Dogubayazi
TUR008	Artvin	TUR008001	Ardanuc
TUR008	Artvin	TUR008002	Arhavi
TUR008	Artvin	TUR008003	Artvin
TUR008	Artvin	TUR008004	Borcka
TUR008	Artvin	TUR008005	Hopa
TUR008	Artvin	TUR008006	Kemalpasa
TUR008	Artvin	TUR008007	Murgul
TUR008	Artvin	TUR008008	Savsat
TUR008	Artvin	TUR008009	Yusufeli
TUR025	Erzurum	TUR025005	Horasan
TUR025	Erzurum	TUR025006	Ispir
TUR025	Erzurum	TUR025008	Karayazi
TUR025	Erzurum	TUR025009	Koprukoy
TUR025	Erzurum	TUR025010	Narman
TUR025	Erzurum	TUR025011	Oltu
TUR025	Erzurum	TUR025012	Olur
TUR025	Erzurum	TUR025014	Pasinler
TUR025	Erzurum	TUR025015	Pazaryolu
TUR025	Erzurum	TUR025016	Senkaya
TUR025	Erzurum	TUR025017	Tekman
TUR025	Erzurum	TUR025018	Tortum
TUR025	Erzurum	TUR025019	Uzundere
TUR028	Giresun	TUR028002	Bulancak
TUR028	Giresun	TUR028004	Canakci
TUR028	Giresun	TUR028005	Dereli
TUR028	Giresun	TUR028006	Dogankent
TUR028	Giresun	TUR028007	Espiye
TUR028	Giresun	TUR028008	Eynesil

Türkiye (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
TUR028	Giresun	TUR028009	Giresun
TUR028	Giresun	TUR028010	Gorele
TUR028	Giresun	TUR028011	Guce
TUR028	Giresun	TUR028012	Kesap
TUR028	Giresun	TUR028013	Piraziz
TUR028	Giresun	TUR028015	Tirebolu
TUR028	Giresun	TUR028016	Yaglidere
TUR029	Gumushane	TUR029001	Gumushane
TUR029	Gumushane	TUR029004	Kurtun
TUR029	Gumushane	TUR029006	Torul
TUR036	Kars	TUR036001	Akyaka
TUR036	Kars	TUR036002	Arpacay
TUR036	Kars	TUR036003	Digor
TUR036	Kars	TUR036004	Kagizman
TUR036	Kars	TUR036005	Kars
TUR036	Kars	TUR036006	Sarikamis
TUR036	Kars	TUR036007	Selim
TUR036	Kars	TUR036008	Susuz
TUR052	Ordu	TUR052002	Altinordu
TUR052	Ordu	TUR052008	Golkoy
TUR052	Ordu	TUR052009	Gulyali
TUR052	Ordu	TUR052010	Gurgentepe
TUR052	Ordu	TUR052012	Kabaduz
TUR052	Ordu	TUR052016	Mesudiye
TUR052	Ordu	TUR052017	Persembe
TUR052	Ordu	TUR052018	Ulubey
TUR053	Rize	TUR053001	Ardesen
TUR053	Rize	TUR053002	Camlihemsi
TUR053	Rize	TUR053003	Cayeli
TUR053	Rize	TUR053004	Derepazari
TUR053	Rize	TUR053005	Findikli
TUR053	Rize	TUR053006	Guneysu
TUR053	Rize	TUR053007	Hemsin
TUR053	Rize	TUR053008	Ikizdere
TUR053	Rize	TUR053009	Iyidere
TUR053	Rize	TUR053010	Kalkandere
TUR053	Rize	TUR053011	Pazar
TUR053	Rize	TUR053012	Rize
TUR061	Trabzon	TUR061001	Akcaabat
TUR061	Trabzon	TUR061002	Arakli
TUR061	Trabzon	TUR061003	Arsin
TUR061	Trabzon	TUR061004	Besikduzu
TUR061	Trabzon	TUR061005	Carsibasi
TUR061	Trabzon	TUR061006	Caykara
TUR061	Trabzon	TUR061007	Dernekpaza
TUR061	Trabzon	TUR061008	Duzkoy
TUR061	Trabzon	TUR061009	Hayrat
TUR061	Trabzon	TUR061010	Koprubasi
TUR061	Trabzon	TUR061011	Macka

Türkiye (continued)			
NUTS 2 code	NUTS 2 name	NUTS 3 code	NUTS 3 name
TUR061	Trabzon	TUR061012	Of
TUR061	Trabzon	TUR061013	Ortahisar
TUR061	Trabzon	TUR061014	Surmene
TUR061	Trabzon	TUR061015	Salpazari
TUR061	Trabzon	TUR061016	Tonya
TUR061	Trabzon	TUR061017	Vakfikebir
TUR061	Trabzon	TUR061018	Yomra
TUR065	Van	TUR065012	Saray
TUR069	Bayburt	TUR069001	Aydintepe
TUR069	Bayburt	TUR069002	Bayburt
TUR069	Bayburt	TUR069003	Demirozu
TUR075	Ardahan	TUR075001	Ardahan
TUR075	Ardahan	TUR075002	Cildir
TUR075	Ardahan	TUR075003	Damal
TUR075	Ardahan	TUR075004	Gole
TUR075	Ardahan	TUR075005	Hanak
TUR075	Ardahan	TUR075006	Posof
TUR076	Igdir	TUR076001	Aralik
TUR076	Igdir	TUR076002	Igdir
TUR076	Igdir	TUR076003	Karakoyunl
TUR076	Igdir	TUR076004	Tuzluca

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Chapter 5

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Chapter 6

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Chapter 9

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Conclusion

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This second edition of the Caucasus Environment Outlook (CEO-2) focuses on the environmental monitoring process at the regional level through a participatory and consultative approach. CEO-2 examines the relationship between policy and the environment, showing how policy can impact the environment and how environmental change can influence policy. The analysis of environmental trends considers a wide range of social, cultural, economic, environmental and political drivers, providing a cross-sectoral overview based on the Driver-Pressure-State-Impact-Response (DPSIR) framework.

The DPSIR Framework is used to describe interactions between societies and environments, enabling a feedback loop between policymakers and environmental quality, especially related to past or future political choices. This framework has been applied in multiple regional and global reports on the environment (Smeets and Weterings 1999; UNEP 2006; UNEP 2019). The ability to integrate knowledge across different disciplines and to formulate various scenarios to support decision-making is essential in linking science to management and policy (Svarstad et al. 2008). Understanding the nature and motivations behind human activities that lead to environmental decline is an important step in enabling the most suitable response.

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