Republic of Armenia

ARMENIA'S 4th NATIONAL COMMUNICATION on CLIMATE CHANGE

Under the United Nations Framework Convention on Climate Change

REPUBLIC OF ARMENIA
MINISTRY OF ENVIRONMENT

FOURTH NATIONAL COMMUNICATION ON CLIMATE CHANGE

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION

ON CLIMATE CHANGE

The Fourth National Communication has been developed by the Ministry of Environment of the Republic of Armenia with the funding of the Global Environmental Facility and support of the United Nations Development Programme in Armenia within the framework of the "Development of Armenia's Fourth National Communication to the UNFCCC and Second Biennial Update Report" project.

Empowered lives.
Resilient nations.

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FOREWORD

Climate change is a complex issue that is both urgent and extremely serious. It poses a worldwide threat to human development and requires ambitious and bold collective climate action.

To cope with the climate change crisis, the international community adopted the Paris Agreement in December 2015, which went into force in November 2016. The Armenian Parliament ratified the Paris Agreement in 2017 and under this Agreement, together with all signatory countries, we work to limit and reduce greenhouse gas emissions.

With its First National Communication submitted in 1998, Armenia embraced a commitment to share the efforts and achievements in responding to climate change through regular development of national communications and later from 2012 to submit biennial update reports.

The Fourth National Communication of Armenia reflects the country's efforts and achievements in mitigating climate change through policies improving investment climate in renewable energy and energy efficiency, improving completeness and transparency of GHG Inventory, as well as reflecting challenges that the country face with vulnerability of economy and ecosystems to climate change.

Armenia is committed to update country's NDC in 2020, with an ultimate goal to identify realistic implementation strategy for limitation of greenhouse gas emissions and prioritization of adaptation measures for coping with risks to country's sustainable development. Armenia is a country with ambitious climate change agenda and puts efforts devoted to low carbon development, increasing the share of renewable energy and promoting energy efficiency, preserving and enhancing forest covered areas. This year, for example, a pan-Armenian large-scale tree planting program will be held, as a result of which 10 million trees are expected to be planted. This is the first significant step taken by Armenia within the frames of the Paris Agreement.

The Government of Armenia, adhering to the concept of protection of nature and ecosystems, through improving the environmental impact assessment, has also initiated other processes, such as the adoption of a decision on exemption of VAT for electric cars import, which contributed to significant increase in the number of electric cars imported to Armenia.

On behalf of the Government of the Republic of Armenia, I express my acknowledgement to the Global Environmental Facility for financial support, to the United Nations Development Programme for assistance in the preparation of the Fourth National Communication, and to specialists in ministries, national experts and professional institutions for their contribution.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
AFOLU	Agriculture, forestry and other land use
AMD	Armenian dram
ANAU	Armenian National Agrarian University
BUR	Biennial update report
CDM	Clean development mechanism
CEPA	Comprehensive and Extended Partnership Agreement
CIF	Climate Investment Fund
CIS	Commonwealth of Independent States
CJSC	Closed joint stock company
CNF	Caucasus Nature Fund
CNG	Compressed natural gas
DNA	Designated National Authority
EAEU	Eurasian Economic Union
EaP	Eastern Partnership
EBRD	European Bank for Reconstruction and Development
EE	Energy efficiency
EEA	European Environment Agency
EIA	Environmental impact assessment
EIB	European Investment Bank
EMEP	European Monitoring and Evaluation Programme
ENI	European Neighborhood Instrument
ENP	European Neighborhood Policy
ENPI	European Neighborhood Partnership Instrument
EPIU	Environmental Projects Implementation Unit
EU	European Union
FAO	Food and Agriculture Organization
FLEG	Forest Law Enforcement and Governance
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographical information system
GIZ	German Agency for International Cooperation
GoA	Government of Armenia
HHP	Hazardous hydrometeorological phenomena
HPP	Hydropower plant
IBRD	International Bank for Reconstruction and Development
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial process and product use
ISTC	International Science and Technology Center
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KCA	Key category analysis
KFW	German Bank for Reconstruction and Development
LULUCF	Land use, land use change and forestry
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoES	Ministry of Emergency Situations
MoH	Ministry of Health
MoTAD	Ministry of Territorial Administration and Development

MoTAI	Ministry of Territorial Administration and Infrastructure
NA	Not available
NE	Not estimated
NO	Not occurring
NAS	National Academy of Sciences
NDC	Nationally determined contributions
NEEAP	National Energy Efficiency Action Plan
NGO	Non-governmental organization
NHMS	State Hydrometeorological and Monitoring Service
NMVO	Non-methane volatile organic compounds
NPP	Nuclear power plant
OECD	Organization for Economic Co-operation and Development
OJSC	Open joint stock company
PCR	Polymerase chain reaction
PPP	Purchasing power parity
PV	Photovoltaic
RA	Republic of Armenia
RE	Renewable energy
RTF	Russian Trust Fund
SC	Statistics Committee
SCJSC	State closed joint-stock company
SDG	Sustainable development goal
SHPP	Small hydropower plant
SNC	Second National Communication
SNCO	State non-commercial organization
SPAN	Specially protected area
SREP	Scaling up Renewable Energy Program
SW	Solid waste
SWDS	Solid waste disposal system
TNC	Third National Communication
TPES	Total primary energy supply
TPP	Thermal power plant
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency of International Development
USD	United States dollar
USSR	Union of Soviet Socialist Republics
VAT	Value added tax
WB	World Bank
WEI	Water exploitation index
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WWF	World Wildlife Fund
YSU	Yerevan State University

Units of Measurement

mm	millimeter
cm	centimeter
m	meter
km	kilometer
m^3	cubic meter
km^2	square kilometer
km^3	cubic kilometer
ha	hectare
g	gram
Gg	gigagram (10^9 g, or thousand t)
t	ton
toe	tones oil equivalent
GJ	gigajoule (10^9 J)
PJ	petajoule (10^{15} J)
kWh	kilowatt hour (10^3 Wh)
MW	Megawatt (10^6 W)
GWh	gigawatt hour (10^9 Wh)
m/sec	meters per second
^0C	degree Celsius

Chemical Combinations

CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
CO	Carbon monoxide
NO_x	Nitrogen oxides
SO_2	Sulfur dioxide
NMVOC	Non methane volatile organic compounds
$CO_{2\ eq.}$	Carbon dioxide equivalent

Energy Units Conversion

1 toe = 41.868 GJ
1 PJ = 277.8 GW h.=23.88 * 10^3 toe

EXECUTIVE ***SUMMARY***

The Fourth National Communication on Climate Change of the Republic of Armenia (RA) was developed in accordance with Articles 4.1 and 12.1 of the UNFCCC and following the Guidelines for National Communications of non-Annex I Parties to the Convention (2003).

Armenia submitted its First National Communication (NC1) in 1998 (covers the period of 1990-1996), the Second National Communication (NC2) - in 2010 (covers the period of 1996-2006) and the Third National Communication (NC3) - in 2015 (covers the period of 2007-2012).

The Fourth National Communication (NC4) covers the period of 1990-2016 for green-house gas (GHG) inventory and climate change mitigation measures assessment based on official statistical data, as well as includes updated information on recent policy, legislative and institutional changes and developments in sectors related to climate change. Within the framework of the NC4, climate change-related studies and assessments have been expanded taking into consideration the developments under the Convention after submission of the NC3, as well as the recommendations made within the framework of international consultations and analyses of the first and second Biennial Update Reports.

Preparation of the NC4 allowed to:

- improve and expand the GHG national inventory database and assess GHG emission trends for the period of 1990-2016;
- adjust baseline scenarios and climate mitigation scenarios for all categories of GHG emission sources with a view of new sector-specific programs and estimate forecasted emission indicators by 2030;
- assess the potential for reduction of GHG emissions across different sectors of the economy;
- review climate change scenarios for Armenia;
- assess the vulnerability of ecosystems and climate change-dependent sectors based on additional studies conducted, and identify priority adaptation measures aimed at mitigating the impacts of climate change;
- assess the impacts of climate change on tourism, in addition to the other vulnerable sectors studied within the previous communications;
- assess the impact of projected intensification of hazardous hydro-meteorological phenomena (HHP) and the needs for early warning and alert information dissemination;
- identify the needs for improvement in the national system of systematic observations and climate monitoring;
- enhance the level of knowledge and public awareness on climate change issues and promote the improvement of qualification among specialists in the area of climate change.

S-1. National Circumstances

Political developments

The year 2018 was remarkable for Armenia in terms of significant political changes: during April-May, the country went through non-violent, velvet national revolution, followed by a peaceful change of the Government. Extraordinary Parliamentary elections were held on December 9, 2018, whereby the Parliament, as well as the Prime Minister, empowered with the authority as the leader of the country, were elected. In 2019, a new Government was formed in the country. On May 8, 2019, the RA Law “On Making Amendments and Addenda to the Law “On the Structure and Activities of the Government” was adopted[1], subsequently followed by changes in the composition and structure of the Government, including mergers and reorganizations between different ministries.

The names of the state administrative bodies and agencies used in the NC4 correspond to the names of the relevant agencies applicable to the given period (2013-2019).

[1] https://www.arlis.am/DocumentView.aspx?docid=130615

Main characteristics of the Republic of Armenia

State structure	After the independence referendum on September 21, 1991, the Republic of Armenia was declared as an independent state. According to the Constitution, Armenia is a democratic state in the form of parliamentary governance (from 2018 onwards) with the separation of legislative, executive and judicial powers. The Head of the State is the President of the Republic with representative powers. The Government is composed of the Prime Minister, two Deputy Prime Ministers and Ministers. The Government composition includes 12 Ministries, 5 State Committees and 6 Inspection Bodies. The administrative-territorial units are the marzes (10 marzes and the capital city of Yerevan) and the communities (502 communities, 48 of which are urban and 454 - rural).
Geographical location	The Republic of Armenia is a mountainous landlocked country, located on the border of the Caucasus and Central Asia on the Armenian Highland. In the north it borders with Georgia, in the east - with Azerbaijan, in the south - with Iran, and in the southwest - with Turkey. The area of the country is 29,743 km^2.
Population	Population of the country is 2,986 thousand (2017)[2], of which - urban population - 64%, rural population - 36%. The average population density is 100 people/km^2.
Economy	GDP in 2017 amounted to AMD 5,564 billion (USD 11,527 million); GDP equivalent to purchasing power parity (PPP) amounted to USD 28,331 million international dollars; GDP equivalent to per capita PPP amounted to USD 9,621 international dollars; inflation - 2.6%, foreign Government debt - USD 5,623 million. GDP structure in 2017: industry, including energy - 18.5%, agriculture, forestry, fishery - 15%, construction - 7.3%, trade - 11.1%, services - 37.8%, net taxes - 10.3%.
Export	USD 2.238 million (2017)
Import	USD 4.097 million (2017)
Climate change trends	Almost all climatic variations can be observed in Armenia - from dry subtropical to cold highland climate. For decades, significant increase in the annual temperature in Armenia has been observed compared to the 1961-1990 annual average (5.5^0C). During the period of 1929-1996 the annual average temperature increased by 0.4^0C, during the period of 1929-2007 - by 0.85^0C, during the period of 1929-2012 - by 1.03^0C, and during the period of 1929-2016 - by 1.23^0C. Precipitations during the period of 1935-2016 decreased by almost 9% compared to the annual average (592 mm) for the period 1961-1990.
Greenhouse gas emissions	National GHG emissions in 2016 comprised 9,801 thousand tons of $CO_{2\ eq.}$ (net emissions). Emissions distribution by sectors: energy - 64.1%, agriculture - 22.3%, industrial processes and products use - 7.5%, waste - 6.0%.

[2] SC, Permanent Population in Armenia, as of January 1, 2017, https://www.armstat.am/file/article/nasel_01.01.2017.pdf

Natural resources

Land Resources. According to 2017 Land Balance[3], agricultural land comprises around 68.7%, forest land - 11.2%, specially protected areas of nature (SPANs) and lands of special significance - 12.3%, wetlands - 0.9%, settlements - 5.1%, lands used for the purposes of industry, mining, energy, communication, transport and utilities - 1.7%, and other lands - 0.02% of the territory of Armenia.

Water Resources. According to the World Resources Institute, Armenia is ranked 34th among the 164 UN member states in terms of water stress, as a country with high baseline level of water stress[4]. According to the RA Statistics Committee (SC), the water stress in 2017 was 57.8%[5].

Around 9,500 small and medium rivers flow through the territory of Armenia with a total length of about 25 thousand km. The longest rivers within the borders of Armenia are Akhurian (186km), Araks (158km), Debed (154km), Hrazdan (141km) and Vorotan (119km).

The density of the river network over the country's territory varies widely - between 0 to 2.5 km/km^2. The rivers of Armenia are characterized by highly disproportionate distribution of flow, both in annual and perennial terms.

The average annual flow of surface water is 6.8 billion m^3, and groundwater reserves are about 4.0 billion m^3. The largest lake in Armenia is Lake Sevan - one of the largest highland freshwater lakes in the world. The Lake level is 1,900.5 m, the surface area is 1,278.7 km^2 and the volume is 38.2 km^3 (2017)[6]. There are also about 100 small mountain lakes in Armenia with a total volume of 0.8 km^3.

According to the official data of the Statistics Committee, in 2017, the Water Exploitation Index (WEI) was 36.9%, compared to 41% of the previous year[7].

All water resources combined in Armenia are sufficient to supply about 3,100 m^3 of water per capita annually. Due to significant seasonal and annual fluctuations in the river flow, the temporal and spatial distribution of water resources is extremely disproportionate.

To address the seasonal fluctuations in the river flow, 87 reservoirs with a total volume of 1.4 billion m^3 have been constructed in Armenia. The average volume of water storage per capita in Armenia is about 465 m^3, which is considered to be a low index for a country with semi-arid climatic conditions. Compared to neighboring countries, Armenia's water storage capacity is close to Iran, but substantially lower than that of Georgia, Azerbaijan or Turkey.

Groundwater resources play an important role in Armenia's overall water balance. About 96% of drinking water and more than 40% of total water intake are comprised of groundwater. The irrigation sector remains Armenia's largest water consumer.

Biological Resources. Due to the vertical zoning and diversity of climatic conditions, Armenia is rich in biodiversity, with more than 100 plant species per 1000 km^2. Armenia's biodiversity is characterized by high endemism - about 500 species of animals and 144 species of plants are considered endemics of Armenia[8]. For the purpose of biodiversity conservation, SPANs have been established, where about 60-70% of Armenia's flora and fauna species are protected, including the vast majority of rare, endangered and endemic species[9].

Biodiversity is predominantly represented by endemic and rare species. SPANs have been established to preserve biodiversity.

Mineral resources. Armenia's mineral base currently comprises about 900 mines and sites with reserves of precious, non-ferrous, black and rare metals, salt, building materials, ground minerals and freshwater, and other minerals. More than 50% of the sites are in exploitation.

[3] https://www.cadastre.am/storage/files/pages/pg_0998130204_voroshum.pdf
[4] https://www.wri.org/blog/2019/08/17-countries-home-one-quarter-world-population-face-extremely-high-water-stress
[5] https://armstat.github.io/sdg-site-armenia/6-4-2/
[6] Armenian statistical yearbook, 2017, General overview, https://www.armstat.am/file/doc/99504338.pdf
[7] https://armstat.am/file/doc/99518218.pdf
[8] 5th National Report on Biodiversity of the Republic of Armenia, 2014, http://www.mnp.am/uploads/1/1551884521pdfresizer.com-pdf-resize.pdf
[9] Ibid.

Energy

Armenia does not have its own industrial fuel resources and fuel demand is met at the expense of imports. Armenia is secured with own primary energy resources (hydro-, nuclear, wind, biomass) by approximately 35%.

In 2016 the total primary energy supply (TPES) amounted to 3,142 ktoe[10], which is 39% of the 1990 supply level.

Electricity is generated in thermal power plants (TPPs), nuclear power plant (NPPs) and hydropower power plants (HPPs). Electricity production in 2016 amounted to 7,315 GWh, with TPPs accounting for 35%, NPPs - 33%, and HPPs - 32% of the total electricity produced.

In 2016 primary sources of energy comprised natural gas (58.9%), nuclear energy (22.7%), petroleum products (9.0%), hydropower (6.4%) and biomass (5.5%). Exported electricity accounted for 2.6% of the total primary energy supply. The large share of natural gas and nuclear energy in the total energy consumption as compared to 1990, as well as 90% decrease in petroleum products and a 17% increase in the share of hydropower indicate that Armenia's energy sector experiences a trend towards clean development.

Industry

Difficulties experienced during the initial phase of transition to market economy and the collapse of the former USSR common economic area have been the main causes of the industrial decline in Armenia. In 1993, the volume of industrial production made up 43% of the level recorded in 1990. In 1994, it became possible to record some success in terms of stabilization of the situation and ensure a slow growth in industrial production. In the period of 2000-2005, the average annual growth of industrial production was 8% and in 2006-2016 - 4%.

In Armenia, the industrial output structure by types of economic activity is as follows: processing industry - 62.5%, mining industry - 20.4%, electricity, gas and steam supply - 15.6%, water supply, sewage and waste management - 1.5% (2017).

In 2017, the processing industry included: food production (28.5%), tobacco production (15.2%), beverage production (14.4%), manufacturing of mechanical systems (16.8%), metallurgical production (4.2%), production of building materials (4.3%), chemical production (4.1%), jewelry (1.5%), light industry (1.3%), other sectors (9.7%).

Transport

During the period of 1991-1994, substantial changes occurred in the country's transport sector as a result of the economic crisis, transport blockade and structural shifts in the economy. Compared to 1990, the volume of cargo transportation in 2017 decreased 11-fold, and passenger transportation fell 2.5-fold. In 2017, the largest share of cargo transportation, i.e. 87.7%, was attributable to the road transport. Ground passenger transportation in urban areas by electric transport decreased more than 11-fold, and its share in total passenger transportation fell to 2.7% from 12.4%. Subway passenger transportation has also decreased - approximately 3-fold, and its share in total passenger traffic went down from 10.3% to 8.1%. In 2017, the share of road transportation in total passenger transportation, compared to 1990, increased from 76.2% to 87.9%.

The construction of the North-South Road Corridor deserves a particular attention, as it will connect the Iranian and Georgian borders of Armenia and reduce travel time almost 2.5-fold. The road stretching from the Armenian town of Meghri to the Georgian port of Poti is of strategic importance. It will connect the northern and southern parts of the country, provide access to the Black Sea and will serve as a link between European and Asian countries.

Buildings

As of 2017, the housing stock of Armenia includes about 19,000 multi-apartment buildings (about 443,000 apartments), comprising around 12,000 buildings in urban areas (64%), approximately 7,000 buildings

[10] RA Energy Balance, 2016

in rural communities (36%) and about 397,000 dwelling houses, out of which approximately 156,000 (39%) - in urban communities and approximately 241,000 (61%) - in rural communities. In the country, 54% of the multi-apartment buildings and total area of housing is attributed to Yerevan.

Percentage distribution of multi-apartment buildings by exterior wall materials is as follows: stone (69.6%), panel (22.8%), monolith (6.6%) and other materials (1.0%).

Agriculture and forestry

Agriculture. As of 2017, the total area of Armenia's agricultural land covers 2,043.8 thousand hectares, including: arable land - 446.0 thousand hectares (21.8%), perennial plantations - 34.8 thousand hectares (1.7%), grassland - 121.0 thousand hectares (5.9%), pastures - 1,050.8 thousand hectares (51.4%) and other lands - 391.2 thousand hectares (19.2%). In 1991-1993, the agricultural sector was also largely affected by the deep economic crisis. Agricultural lands underwent spatial and structural changes. The number of large cattle also decreased: compared to 1990, in 2017, the number of large cattle went down by 5%, sheep and goats - by 44%, swine - by 47% and poultry - by 66%. The area of irrigated land decreased 2-fold and the use of mineral fertilizers – 3-fold. As a result of agrarian reform and land privatization, large agricultural farms were transformed to about 340,000 smallholder farms, with an average of 1.4 hectares allocated to each. The land stock was disaggregated, which impeded effectiveness of logistic management and also negatively affected the production infrastructure. The areas of agricultural land also underwent changes. In 2017, the share of crop production in the gross agricultural production comprised about 52%, and the share of livestock production - about 48%[11].

The main types of agricultural production in Armenia comprise grain and potatoes, vegetables, vegetable crops, grapes, fruit and berries, meat, milk, eggs.

Forestry. As of 2016, the total area of forest lands in Armenia encompasses 334.1 thousand hectares, 86.6% of which are covered by forests[12]. The forest-covered areas in SPANs are 110.3 thousand hectares[13].

Forest areas, depending on climatic conditions and anthropogenic impacts, are unevenly distributed and include 3 forest zones: north and north-east (62%), south-east (36%) and central (2%)[14].

About 270 species of trees and shrubs grow in the forests, of which the main natural forest-forming species are oak, beech, hornbeam and pine.

Armenia's forests and forest lands are state-owned. For the purpose of expanding forested areas, the Forest Code (2005) stipulates also the community and private ownership rights for planted forests.

According to the Forest Code, forests of Armenia, regardless of their form of ownership, are classified into protective, special and productive forest types, depending on their designated purpose. The protective group of forests also includes the 200 m area spanning upper and lower boundaries of the forest, as well as forests growing in semi-desert, steppe and forest-steppe zones. This circumstance is particularly important in terms of mitigating the vulnerability of forests due to climate change, as the types of deforestation in this group are limited.

Waste

Solid waste (SW). As of 2019, the SWs in marzes are being collected, transported and stored in 339 landfills[15]. The total area of landfills, according to the inventory made by the RA Ministry of Territorial Administration and Development (MoTAD) in 2017, was 494 hectares[16].

[11] https://www.armstat.am/file/article/sv_12_q17a_122.pdf
[12] RA Land Code, 2016, https://www.cadastre.am/storage/files/pages/pg_7729855464_KV1059k.voroshum.pdf, https://www.armstat.am/file/article/sv_03_17a_5320.pdf
[13] RA Government Decree No. 1059-A, dated 25.09.2014, https://www.arlis.am/DocumentView.aspx?DocID=93166
[14] Khurshudyan, P., 1999; Makhatadze L.and Hakhinyan H.,1974; Khurshudyan P.A. Armenia's forests in the historical past, present state and vulnerability of forest cenosis to climate change (pp. 110-121). Armenia. Climate Change Issues / Collection of Articles, Editor: A. Gabrielyan-Yerevan, 1999a) - 373 pages.
[15] RA draft strategy on Waste Disposal System Management, https://www.e-draft.am/projects/2003/about
[16] Ibid.

In all landfills waste is disposed without prior classification and sorting. All landfills, except for the largest landfill located in Yerevan, are non-managed. The degradable organic carbon in SW makes up 50-60%.

According to the information provided by the Ministry of Territorial Administration and Infrastructure, about 650,000 tons of SW is generated annually in Armenia[17]. The quantity of SW generated in 2017 has increased by 40%, compared to 1990.

Until 2006, 100% of SW, and from 2006 onwards - 70% of SW in the capital city of Yerevan has been transported to the largest managed landfill in the country – Nubarashen landfill, with anaerobic destruction of SW. Starting from 2006, 30% of Yerevan SW is transported to deep-layered non-managed landfills in Jrvezh, Spandaryan and Sasunik. In the cities of Gyumri and Vanadzor as well, SW is being transported to deep-layered non-managed landfills; in 45 other cities of the country – to non-deep-layered non-managed landfills.

In rural areas of Armenia, vegetable waste (tree branches, dried leaves, grass, etc.) generated by gardens and land plots is burned on the spot, and the rural household-generated domestic waste is mainly disposed in nearby gorges and is periodically burned.

Municipal wastewater includes domestic, commercial and, partly, industrial wastewater. The annual wastewater drainage[18] volume in 2017 was 551 million m^3. In 2017 the volume of wastewater discharged to the sewage system was 102.6[19] million m^3. Until 1990, 20 mechanical wastewater treatment plants were operating in Armenia, with a total capacity of 958 thousand m^3/day. At present, the stations are extremely obsolete, in technical terms, and some of them are in destructed condition. During the period of 2012-2014, new mechanical wastewater treatment plants have been put into operation in 4 cities and in 2016 the mechanical treatment plant of Yerevan “Aeration” was relaunched.

Specific indicators for GHG emissions and energy intensity of GDP

Since 2012, CO_2 emissions per unit of GDP (by PPP) have demonstrated some declining trend due to the widespread use of renewable energy resources, the use of low-carbon technologies, and the implementation of EE measures, which are an evidence of Armenia's low-carbon development trends.

As for GDP (PPP) energy intensity, it has also demonstrated a downward trend, due to structural changes in the economy, in addition to the above-mentioned reasons.

Tourism

In recent years, tourism sector in Armenia has been demonstrating rapid growth. Armenia, being the first country to adopt Christianity in the world, is rich in centuries-old monasteries that are one of the most attractive tourism destinations. According to the “2017 Tourism Competitiveness Report”, Armenia was ranked 84th among 136 countries in terms of tourism competitiveness.

In an effort to ensure a constant growth rate in terms of the number of incoming tourists to Armenia, the Government of Armenia (GoA) will be striving to continuously improve tourism competitiveness of Armenia in the global market. During 2017-2022, the Government aims to increase the number of annual tourist visits to at least 3 million, with a particular focus on a number of tourism sub-sectors, particularly - ecotourism and extreme tourism.

Legal framework and institutional structure for development of National Communications

Armenia ratified the UNFCCC in 1993 and the Kyoto Protocol - in 2002. The RA National Assembly ratified the Paris Agreement and the Doha Amendment to Kyoto Protocol on February 8, 2017.

Obligations of the Republic of Armenia within the framework of the aforementioned international multilateral instruments derive from the status of a developing country

[17] http://mtad.am/u_files/file/2018/P&G%20feasibility%20in%20Armenia_AM.pdf

[18] https://www.armstat.am/am/?nid=12&id=14006&submit=%D5%93%D5%B6%D5%BF%D6%80%D5%A5%D5%AC

[19] https://www.armstat.am/file/article/sv_03_18a_5350.pdf

acting as a non-Annex I party to the UNFCCC. The country's position under the Convention and the Paris Agreement is set out in the "Nationally Determined Contributions" document, approved by the GoA Protocol No. 41, dated September 10, 2015 and submitted to UNFCCC on September 22, 2015.

As of 2018, Armenia has elaborated and submitted to the Convention Secretariat three National Communications (in 1998, 2010 and 2015) and two Biennial Update Reports (BUR) (in 2016 and 2018), as well as separate reports of national GHG inventories submitted in conjunction with BURs[20].

The Ministry of Environment (MoE), as the national coordinating authority of the UNFCCC, is responsible for coordinating the preparation of the RA National Communications and Biennial Update Reports under the Convention. In 2015, within the Ministry of Nature Protection (MNP) administration a Climate Change and Atmospheric Air Protection Policy Division was established as unit within the Environmental Policy Department. To ensure consistent, complete and timely presentation of information pertaining to the implementation of the UNFCCC, the functions of this Division include the coordination of development of national communications and biennial update reports.

Since the entry into force of the UNFCCC, the GoA endorses with a five-year periodicity the list of measures aimed at fulfilling the country's commitments under the Convention. In this context, in 2016, the GoA adopted the Protocol Decree No. 49 "On Approving the List of Activities for the Implementation of RA Commitments Deriving from a Number of International Environmental Conventions Ratified by the RA", which stipulates the list of measures for 2017-2021 and responsible agencies assigned to fulfil the commitments and provisions deriving from UNFCCC and the Paris Agreement. The list of measures includes "the development of the Second Biennial Update Report on Climate Change, as well as subsequent update reports with a biennial periodicity and their submission to the Convention Secretariat in accordance with the established procedure" as a measure.

To ensure coordination of short-term, mid-term and long-term actions and measures related to the fulfillment of the commitments and provisions of RA deriving from the UNFCCC, an Inter-Agency Coordination Council for the Implementation of the Requirements and Provisions of the UNFCCC[21] was established by the Decree of the Prime Minister of the Republic of Armenia No. 955-A of 2012.

In 2015, Armenia joined the Sendai Framework for Disaster Risk Reduction 2015-2030, and accordingly, the National Disaster Risk Management Strategy and Action Plan[22] was developed and adopted by the RA Government Decree of April 6, 2017, with the aim of protecting people, their health, property, livelihoods, as well as their production, cultural and environmental values from disaster risks.

Since 2018, Armenia has been a member of the Nationally Determined Contributions Partnership.

On April 18, 2018 the Armenian Parliament ratified the Comprehensive and Extended Partnership Agreement (CEPA)[23] between Armenia and the European Union, which fosters co-operation on measures taken at national, regional and international levels in terms of research, development and transfer of knowledge in the areas of climate change mitigation, adaptation and innovative low-carbon technology, as well as towards directing general and sectoral policies for climate change monitoring, awareness raising, education and training. The Parties also agreed to expand and strengthen cooperation in the fields of transport and energy, in the framework of which a roadmap and action plan have been developed and approved.

By the Resolution No 10-A of the RA State Council on Statistics, dated February 27, 2020, the "Road Map for Development of the Climate Change-related Statistics" was approved[24].

[20] https://unfccc.int/BURs
[21] https://www.arlis.am/DocumentView.aspx?docID=78543
[22] http://www.irtek.am/views/act.aspx?aid=89604
[23] https://www.mfa.am/filemanager/eu/CEPA_ARM_1.pdf
[24] https://www.armstat.am/en/?nid=787

By the Protocol Decree No. 50 of December 15, 2016, the Government of the Republic of Armenia approved the concept of the draft law "On Atmospheric Air Protection". Among other changes, the Law also envisages the establishment of a unified system for the registration of harmful substances and GHG emissions, which will facilitate the fulfillment of Armenia's obligations under international environmental conventions, as well as ensure the comparability of information presented under different conventions.

Funding of climate-related projects

Over the past 20 years and more, Armenia has received financial assistance from targeted and non-targeted climate funds to support climate change mitigation in Armenia, particularly, reduction of GHG emission, enhancing climate change adaptation potential, disaster risk reduction, as well as technology transfer, education and awareness raising in targeted areas. Specifically, climate-targeted funding has been provided to Armenia by the Global Environmental Facility (GEF) - in the amount of approximately USD 20.5 million, the Climate Investment Fund (CIF) - in the amount of approximately USD 40 million (around USD 14 million of grants and USD 26 million of concessional loans), the Green Climate Fund (GCF) - in the amount of approximately USD 23.3 million, and the Adaptation Fund - in the amount of approximately USD 4 million, for the implementation of national climate change programs.

In addition to climate-targeted funding, grants and loan resources have also been provided to support the country's overall development, which at the same time is expected to contribute to the development of the country's climate change mitigation and adaptation potential. For the period of 2013-2014 the largest amount of funding - about USD 162 million annually, aimed at the country's development, and at the same time, relevant to climate projects, has been provided for energy, agriculture and water sectors[25].

S-2. GHG Inventory

In the course of the preparation of this communication, the National GHG Inventory for 2015 and 2016 was developed, according to the IPCC 2006 Guidelines for National GHG Inventory. The National Inventory includes emissions/removals estimates for four GHGs with direct greenhouse impact: carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (N_2O) and fluorocarbons (HFCs) for 2000-2016 time series, as well as emission estimates for precursor gases - carbon oxide (CO), nitric oxide (NOx), NMVOC and sulfur dioxide (SO_2).

The National GHG Inventory developed under the NC4 has been improved in the following areas: GHG emissions were estimated for two new sub-categories, with the key sources analysis was done a more disaggregated level.

In 2016, the GHG emissions totaled 10,284 Gg $CO_{2\ eq}$. (without the Forestry and Other Land Use sub-sector). The emissions were lower by 1.6% (168 Gg $CO_{2\ eq}$.) compared to those in 2014. In 2016, the GHG emissions were lower by 61% (15.5 million tons) compared to those in 1990 (Table S-2), whereas compared to 2010, the emissions went up by 22%[26].

The distribution of GHG emissions by gases and sectors for 2016 is presented in Table S-1, and the GHG emissions for the period of 1990-2016 are presented in Table S-2.

[25] https://www.oecd.org/environment/outreach/Armenia_Financing_Climate_Action.Nov2016.pdf

[26] RA National GHG Inventory Report, 2016

Table S-1. Distribution of GHG emissions by gases and sectors (Gg) for 2016

Sectors	CO_2	CH_4	N_2O	HFCs $CO_{2\ eq.}$	Total of $CO_{2\ eq.}$
Energy	4,946.62	77.17	0.09	NA	6,594.49
Industrial processes[27]	134.44	NA	NA	NA	134.44
F gases[28]	NA	NA	NA	637.70	637.70
Agriculture	1.03	62.77	3.15	NA	2,295.68
Waste	4.31	26.20	0.22	NA	621.62
Total emissions	**5,086.41**	**166.15**	**3.45**	**637.70**	**10,283.94**
Forestry and other land use	-485.83	NA	0.01	NA	-482.71
Net GHG emissions	**4,600.57**	**166.15**	**3.46**	**637.70**	**9,801.24**

Table S-2. GHG emissions with breakdown by sectors (Gg $CO_{2\ eq.}$), 1990-2016

Sector	1990	2000	2010	2012	2014	2015	2016	Change in emissions in 2016 (%) compared to:		
								1990	2000	2014
Energy	22,712.2	4,299.1	5,829.6	6,916.7	7,013.6	6,730.9	6,594.5	-70.7	53.4	-6.0
Industrial processes and products use	630.3	142.7	555.0	675.8	782.5	766.8	772.1	22.5	441.0	-1.3
Agriculture	1,989.2	1,326.7	1,462.3	1,827.1	2,044.7	2,148.0	2,295.7	15.4	73.0	12.3
Waste	439.0	532.9	582.6	598.6	611.2	615.6	621.6	41.6	16.6	1.7
Total GHG emissions	**25,770.7**	**6,301.4**	**8,429.4**	**10,018.2**	**10,452.1**	**10,261.3**	**10,283.9**	**-60.1**	**63.2**	**-1.6**
Forestry and other land use	-736.0	-454.3	-540.6	-512.7	-477.1	-474.45	-482.7	-34.4	6.3	1.2
Net GHG emissions	**25,034.7**	**5,847.1**	**7,888.9**	**9,505.5**	**9,974.9**	**9,786.8**	**9,801.2**	**-60.9**	**67.6**	**-1.7**

S-3. Policies and Measures to Mitigate GHG Emissions

Armenia ratified the Paris Agreement on February 8, 2017, and, as a developing country, it also undertook quantitative commitments to limit GHG emissions. Armenia's position under the Paris Agreement is set out in the "Nationally Determined Contributions" document (approved by the RA Government Decree No. 41 of September 10, 2015 and submitted to the UNFCCC Secretariat on September 22, 2015).

To achieve the environmental development goals outlined in the Nationally Determined Contributions of the Republic of Armenia, it is necessary to update and address climate change issues in national and sectoral development policies, assess the contribution of different sector strategies towards meeting the country's commitments, and develop a roadmap for evaluation and analysis of mid-term targets.

Energy

The energy sector of Armenia accounts for around 70% of GHG emissions. At the same time, the sector carries the highest potential for reduction of GHG emissions by means of implementation of energy efficiency measures and large-scale use of renewable energy sources.

The development of low carbon emissions development is fully in line with national energy security priorities. By maximizing the effective use of the sector's energy efficiency and renewable energy potential and taking into account the absence of local fossil fuel resources, the RA Government program and the energy development programs at a strategic level are designed to ensure the RA energy security.

Building on the full and efficient use of local primary (renewable) energy resources, further development of nuclear energy,

[27] Excluding F gases
[28] F gases refer to fluorocarbons (HFCs)

diversification of energy supply and introduction of energy efficient and advanced technologies, the Program adopted by the RA Government in 2019 states that the Government policy in the field of energy will be aimed at enhancing the country's energy independence and security, ensuring the regional integration processes and sustainable development of the energy sector.

Legislative changes, strategic planning documents, and tariff policies adopted in recent years are aimed to secure the sustainable development of the energy sector in Armenia based on sustainable development principles and international environmental commitments undertaken by the country.

Agriculture

Agriculture is the second largest sector of GHG emissions accounting for more than 22% of total emissions at national level.

A number of programs and concepts have been endorsed by the RA Government, the implementation of which may contribute to the reduction of GHG emissions from livestock and mitigation of climate change.

As a result of the agrarian reforms implemented in the RA, the entire land stock was privatized, except for pastures. As a result, about 340,000 smallholder farms were formed, each of which, on average, own 1.4 hectares of agricultural land plots which creates serious difficulties in terms of implementing complex and coordinated agrotechnical measures and identifying effective solutions to environmental issues.

Forestry

According to the RA Government Program (2019)[29], forest conservation, sustainable management, expansion of forested areas, reforestation, forestation and continuous capacity building towards their implementation are key priorities in the environmental management context.

By the Protocol Decree No. 50, dated November 30, 2017, the RA Government approved the “Forest Sector Reform Concept, Strategy and List of Measures” aimed at ensuring the balance between social and economic needs, as well as climate-related and environmental requirements.

Starting from January 2020, the Government will launch a National Forest Program, aiming to expand Armenia's forest covered area up to 20.1% of the country's territory by 2050, according to the “Nationally Determined Actions/Contributions of the Republic of Armenia under the UNFCCC” approved by the RA Government in 2015.

F-gases

On March 27, 2019 the Republic of Armenia ratified the Kigali Amendment to the Montreal Protocol on the Protection of the Ozone Layer from the Substances that Deplete the Ozone Layer of the Vienna Convention on the Protection of the Ozone Layer, under which Armenia has committed to gradually limit the use of hydrofluorocarbons (HFCs) starting from 2024, and to achieve their reduction by 80–85% up to the year 2045.

In order to fulfil the HFC emissions reduction commitment, a National Action Plan for reduction of the HFCs use should be developed, with underlying processes in the areas of legislation, licensing, restrictions of HFCs import and registration, training of specialists and awareness raising.

Waste

By the Protocol Decree No. 49 of December 8, 2016, the Government of the Republic of Armenia approved the 2017-2036 Strategy for Development of SW Management System, and by the Protocol Decree No. 13-15, dated March 30, 2017, the 2017-2036 Action Plan was approved to ensure implementation of the Strategy for Development of Solid Waste Management.

As a result of the implementation of the Strategy, the entire territory of the Republic of Armenia will be serviced by a SW management system in line with the EU standards, including for waste management and landfill operation.

Along with the introduction of the new system, landfills in the territory of the Republic of Armenia will be shut down, unless their upgrading is considered feasible.

[29] https://www.gov.am/files/docs/3133.pdf8

S-4. Projections of GHG Emissions and Assessment of Impact of Mitigation Policies and Measures

Development strategies and policies adopted by the country for assessing the potential for GHG emissions mitigation have been considered by sectors that may contribute to the reduction of GHG emissions. These forecasts allow evaluating sectoral investments in implementation of commitments stipulated in the RA "Nationally Determined Contributions".

Three development scenarios by 2030 have been considered for the assessment of the Energy sector mitigation measures: "without mitigation measures", "with mitigation measures" and "with additional mitigation measures" scenarios.

As the new national strategy for the Energy sector is still in the process of development, projections have been made on the basis of the current strategy and the recent developments mainly related to solar energy, which have taken place in the country since the publication of the NC-3.

Additionally, assessment of the reduction of actually measured emissions has been performed and compared with the revised "without mitigation measures" scenario and the national GHG Inventory results for 2016 ("with mitigation measures" scenario). The difference between the scenarios is 417 Gg $CO_{2\ eq}$., which represents the reduction of actually measured emissions.

For assessing the mitigation measures of the Agriculture sector, livestock development scenarios until 2030 have been considered, taking into account the sector development strategy, the policy adopted by the country, programs and measures implemented in the field, as well as production processes that may contribute to the reduction of GHG emissions.

Due to genetic improvement of livestock alone, CH_4 emissions from livestock fermentation in Armenia will be reduced by 128 Gg $CO_{2\ eq}$. up to 2023, and by 260 Gg $CO_{2\ eq}$. up to 2030, compared to the 2016 level.

With efforts towards genetic improvement, premature breeding, operation of slaughter-houses, mushroom production, as well as biogas and bio-humus production, methane and nitrogen oxide emissions from manure management will reduce.

Based on the commitments undertaken by Kigali Amendment to the Montreal Protocol on the Protection of the Ozone Layer from the Substances that Deplete the Ozone Layer to the Vienna Convention on the Protection of the Ozone Layer and the current trends in HFC emissions growth, the HFC emissions projections were made according to their application (Gg $CO_{2\ eq}$.), by maintaining growth rates for each application.

Taking into account that about 71% of the emissions in the Waste sector is attributable to the municipal SW, as well as the fact that there are currently no long-term plans to restructure or modernize wastewater treatment systems in Armenia, GHG emissions forecasts have been performed in relation to the SW only.

Projections of GHG emissions from SW are have been carried out under two scenarios: "without mitigation measures" scenario, which assumes that current trends will continue in the future and projected volumes of SW are determined based on the projected population number, and "with mitigation measures" scenario.

The "with mitigation measures" scenario is based on the 2017-2036 municipal solid waste management system development strategy and projects envisaged within the framework of this strategy: particularly, related to currently launched and ongoing process of new sanitary landfills construction in Yerevan and Hrazdan, where it is planned to introduce a landfill gas capturing system.

Projections show that overall reduction of emissions by 2030 will comprise 212.9 Gg $CO_{2\ eq}$. or 51% of SW emissions for 2016.

S-5. Climate Change Projections, Vulnerability Assessment and Adaptation Measures

Over the past decades a significant increase in temperature has been observed in Armenia. Particularly, over the period of 1929-1996, the annual mean temperature increased by 0.4^0C, during 1929-2007 - by 0.85^0C, during 1929-2012 - by 1.03^0C, and during 1929-2016 - by 1.23^0C.

The ambient air temperature change has had different trends in different seasons. During the period of 1966-2016, the average summer temperature increased by about 1.3^0C; moreover, over the last century, extremely hot summers were observed in Armenia within the last 20 years.

During the period of 1935-1996, the average annual precipitation decreased by 6% and in 1935-2016 - by about 9%. The spatial distribution of precipitation is quite irregular. During the period of 1935-2016 the climate in the north, south and central regions of the country has become more arid, while precipitations have increased in the Shirak plain, in the Lake Sevan basin and in the Aparan-Hrazdan regions.

The frequency and intensity of natural disasters has increased significantly. Over the period of 1975-2016, the total number of observed hazardous phenomena increased by about 40 cases, as compared to the average of 1961-1990 (168 cases). The highest number of hailstorms was observed in the Shirak plain, the maximum number of cases with heavy rainfall occurred in Tashir and Ijevan regions, and frosts - in the Ararat valley and foothill regions.

According to drought indices, the number of days with strong and very strong droughts during the period of 2000-2017 increased by 33 days, as compared to the 1961-1990 average (87). In recent years, the upper boundary of the drought zone has expanded and includes mountainous areas, with an earlier timed start of drought.

Climate change scenarios for Armenia

The results of the CCSM4 Global Climate Model used and reported in the NC3 were reviewed for the projection of changes in air temperature and atmospheric precipitation, as well as high resolution METRAS (12x12 km) regional climate model was applied.

The average annual temperature across the territory of Armenia is projected to increase by up to 1.6^0C by 2040, by 3.3^0C - by 2070 and by 4.7^0C - by 2100, relative to the baseline annual average (5.5^0C) for 1961-1990.

As for atmospheric precipitations, these are projected to decline by up to 2.7% by 2040, 5.4% - by 2070 and 8.3% - by 2100, relative to the baseline annual average (592 mm) for 1961-1990.

It should be noted that there are significant uncertainties in global precipitation assessments due to the high variability of atmospheric precipitation and the large number of affecting factors. The issue related to uncertainties in projecting precipitation changes has also been highlighted in the 5th IPCC Report (IPCC, 2013).

The projected climate change is expected to have negative effects on the country's water resources, energy, agriculture, ecosystems, human health, settlements and infrastructures, as well as a number of other climate-sensitive sectors, including tourism.

Water resources

River flow. Analysis of water resources vulnerability in Armenia was carried out using the CCSM4 model data with the emission scenarios of RCP8.5 and RCP6.0, as well as the METRAS model with the RCP8.5 scenario. The vulnerability of the river flow to climate change varies across different river basins, due to the differences in natural and climatic conditions of the basins, and the various factors that impact on the flow formation.

The vulnerability of the annual river flow assessed with the above-mentioned climate models and scenarios for 2040, 2070 and 2100 are summarized in Table S-3

Table S-3. Vulnerability of the river flow to climate change in Armenia

Scenario	Time period	River flow studied, mln m^3	Change in flow	
			mln m^3	%
	1961-1990	**6,279.9**	**0**	**0**
CCSM4 RCP6.0	2011-2040	5,760.4	-519.5	-8.27
	2041-2070	5,450.5	-829.4	-13.2
	2071-2100	5,037.9	-1,242.0	-19.8
CCSM4 RCP8.5	2011-2040	5,513.5	-766.4	-12.2
	2041-2070	5,148.2	-1,131.7	-18.0
	2071-2100	4,165.1	-2,114.8	-33.7
METRAS RCP8.5	2011-2040	5,433.4	-846.5	-13.5
	2041-2070	4,547.9	-1,732.0	-27.6
	2071-2100	3,832.0	-2,447.9	-39.0

Lake Sevan. The assessment of the water balance of Lake Sevan under the predicted climate change scenarios was implemented through a multifactor correlation analysis of the annual inflow into the Lake and multi-annual observation data of atmospheric precipitation and air temperature at the meteorological stations of the basin. Based on the RCP8.5 and RCP6.0 emission scenarios used with the CCSM4 climate model and the RCP8.5 scenario used with the METRAS model, changes in the river inflow into the Lake Sevan for 2040, 2070 and 2100 were projected.

Table S-4. Projection of the Lake Sevan water balance elements

Scenario	Time period	River flow, mln m^3	Precipitation, mln m^3	Evaporation, mln m^3
	1961-1990	**783.8**	**503.9**	**1074.5**
CCSM4, RCP6.0	2011-2040	712.6	519.0	1194.9
	2041-2070	681.6	513.9	1246.2
	2071-2100	646.4	524.0	1316.9
CCSM4, RCP8.5	2011-2040	693.7	508.9	1203.3
	2041-2070	648.0	529.1	1326.0
	2071-2100	552.8	513.9	1467.1
METRAS, RCP8.5	2011-2040	687.5	488.7	1186.1
	2041-2070	597.0	478.7	1335.4
	2071-2100	519.0	463.6	1467.1

The analysis of climate change scenarios shows a negative impact for the Lake's habitat; and under the pessimistic scenario a decrease in the total river inflow into Lake Sevan by about 34% (265 million m^3) by 2100 is projected. In addition to the anthropogenic impact, the quality of the Lake water is significantly affected by climate change. Along with the air and water temperature increase, the biomass of phytoplankton in the Lake is increasing, which leads to an abrupt deterioration of the Lake's water quality and the acceleration of eutrophication processes[30].

Reservoirs. The vulnerability of the river inflow during spring (April-June) months was estimated for the strategically significant reservoirs - Akhuryan, Aparan, Azat and Marmarik, for 2040, 2070, and 2100.

The impact of climate change on the river inflow into the reservoirs during spring will be particularly significant for the Akhuryan and Marmarik reservoirs. Based on the assessment by the METRAS model and the RCP8.5 scenario, a decrease of around 60% can be projected for the river inflow during the spring months in 2100.

Water quality. The analysis of data at reference observation posts of the studied rivers shows that along with the decrease in the natural flow, the hydro-chemical

[30] More details on the vulnerability assessment of the Lake Sevan ecosystems is presented Chapter 5.5 on Natural Ecosystems.

composition and content of the rivers has also changed. In particular, based on the example of the Hrazdan River, during the period of 2006-2018, an increase in hydro-carbonate, magnesium and calcium ions has been observed. The deviations in the values of hydro-chemical parameters from the baseline period data were especially observed for the month of October, due to the less availability of river flow and precipitation.

In 2015, based on the Voghji River example, projections of water quality were carried out according to predicted climate change scenarios. In case the existing anthropo-genic pressures in the Voghji River basin are maintained, the water in the river will continue to be of poor (V) class quality by up to 2025 under the SRES A2 scenario (equivalent to RCP8.5), due to the high concentration of ammonium ions and copper in the water. Moreover, the nitrate, ammonium nitrogen and zinc concentrations will increase by up to 1.2-1.5 times compared to 2015, the trophic degree of the river will change (towards eutrophication) and the river buffer system may be disrupted, causing consequent disruption in the river's ecosystem, which may potentially lead to decrease in aquatic biodiversity[31].

A number of complex measures have been undertaken to mitigate the impacts of climate change on water resources and to adapt the economy to accommodate new natural conditions, in particular:

Administration and planning. A number of institutional and legislative reforms have been implemented, including adoption of a new methodology for the assessment of environmental flows in the rivers, a new procedure was adopted for the management of the State Water Resources Cadaster, environmental impact assessment (EIA) standards for construction and operation of SHPPs and the hydropower development concept were developed; as well as water basin management plans were elaborated considering the climate change impacts.

Research and information: Assessment of groundwater resources, inventory of Ararat Valley wells, natural springs, and fish farms was conducted, the feasibility of using water from fish farming for irrigation purposes was assessed, and assistance for creation of a decision-support tool through Ararat ground-water basin modeling taking into account the climate change factor was provided. The methodology for evaluation of groundwater natural resources in mountainous regions of Armenia has been developed, which was used in conducting an assessment of groundwater resources of Sevan and Hrazdan basins.

Economic and technical: Irrigation systems are being improved and upgraded to reduce leakage and consumption of electri-city. Construction of the Vedi reservoir dams, preparation of detailed design of the Kaps reservoir and development of construction bidding documents, technical due diligence for construction of the Mastara reservoir are underway.

Agriculture

The vulnerability of the agriculture sector to natural hazards is relatively high, and it considerably varies across land zones and specific crops. It is more evident in low-lying and medium-altitude zones in the country.

About 80% of the territory of Armenia is exposed to various degrees of deserti-fication, which is not only the consequence of anthropogenic activity, but is also affected by natural factors, such as water and wind erosion of soils, hot dry spells, drought, lack of humidity, landslides, natural salinization, alkalization, etc. Climate change, along with various anthropogenic phenomena, contri-butes to the vulnerability of organic carbon reserves in soils.

According to climate change forecasts for Armenia over the next 100 years, the following changes are expected in the field of agriculture:

- Decrease in the level of soil moisture by 10-30%, decrease in soil moisture provision for various agricultural crops by 7-13%[32];

[31] L. A. Margaryan, "Geo-ecological Assessment, Classification and Projection of the Natural Waters", http://etd.asj-oa.am/7204/1/005-Liana_Margaryan.pdf

[32] http://documents.worldbank.org/curated/en/260051468221982009/pdf/733320WP0ARMEN00Armenia0Jun20120Arm.pdf

- Shortage of water for irrigation, increase of soil water deficit by 25-30%;
- Reduced productivity of irrigated land by about 24%[33];
- Degradation of lands and natural pastures; decrease in overall pasture area and productivity by 4-10% by 2030, decrease in pasture yield by 7-10%, decrease in fodder production volumes[34],
- Crop yield decline by 8-14% by 2030[35].

Hailstorms, frosts, heat waves, and drought have a particularly significant impact on the loss of agricultural crop yields due to hazardous hydrometeorological phenomena (HHP). In recent years, annual damage caused to agriculture by drought, hail, floods, spring frosts and mudflows has been estimated at about 15-30 billion AMD[36]. In particular, the largest share in the damage caused is attributable to hailstorms. According to climate change scenarios, the frequency of thunderstorms and weather fluctuations accompanied by hailstorms is likely to increase in spring and summer.

Under the projected climate change, the yields of a range of crops have been estimated by 2070, according to the METRAS climate model data, the results of which are summarized in Tables S-5 and S-6.

Table S-5. The projected changes in wheat yield, by marzes (without agrotechnical measures), %

Marz	2030	2040	2050	2060	2070
Ararat	-4.5	-8.4	-12.2	-16.1	-19.9
Kotayk	-5.0	-10.4	-15.7	-17.0	-19.3
Vayots Dzor	8.3	7.4	6.5	5.5	4.6
Shirak	-5.6	-9.9	-10.2	-12.4	-18.7
Gegharkunik	-6.0	-11.8	-14.5	-13.3	-19.9
Lori	3.2	5.3	5.5	7.5	7.5
Syunik	10.5	12.3	10.0	8.1	7.3

Table S-6. The projected changes in potato yields, by marzes, %

Marz	2030	2040	2050	2060	2070
Gegharkunik	-3.9	-7.0	-10.0	-12.2	-14.2
Kotayk	-4.7	-6.6	-9.5	-12.4	-15.3
Shirak	-7.6	-10.2	-13.4	-16.2	-20.7
Lori	-3.2	-7.3	-9.1	-11.6	-14.0
Syunik	-4.1	-8.4	-10.4	-13.2	-17.7

Changes in the yields of grapes have also been projected; the higher level of decrease - by 15-20%, will be observed in the Ararat Valley. Forecasted climate change will further aggravate food security risks in the country.

Climate change will have a negative impact on beekeeping due to declining honeybee crop yields and transmission and emerging infectious diseases of bees[37].

In the livestock breeding sector, it has been estimated that if the current growth rate of large and small livestock headcount is maintained, and modern scientific standards for pasture utilization are followed, the availability of fodder stock will not cause any concerns until 2030. However, failure to comply with grazing norms and standards and implementation of appropriate remediation measures, the pastures deterioration will accelerate[38]. Climate change can also affect the composition and distribution of natural-focal and communicable infections of agricultural animals[39]. Due to climate change and rising temperatures, some areas previously considered non-vulnerable have now

[33] ibid
[34] ibid
[35] ibid
[36] http://www.irtek.am/views/act.aspx?aid=89460
[37] Climate Change: Impact on Honeybee Populations and diseases. Y. Le Conte & M. Navajas, 2008, p. 506
[38] https://www.undp.org/content/dam/armenia/docs/CE_ProDoc_Arm_Final.pdf
[39] GoA Protocol Decree No. 15, dated April 13, 2017, http://www.irtek.am/views/act.aspx?aid=89460

become vulnerable to bloodborne parasitic disease, blackleg and a number of other diseases.

Various complex measures have been implemented to mitigate the negative impacts of climate change on agriculture, including:

Administration and planning. The concept of preventing damage to agriculture from natural and climate disasters has been adopted, the pilot program for introduction of agricultural insurance has been approved; support schemes for installation of hail-nets and modern irrigation systems, lending program for the establishment of intensive orchards cultivated with modern technologies and subsidized loan interest for greenhouse farms have been endorsed, besides a number of strategic programs have been approved.

Research and information. Several studies have been carried out towards improvement of forecasts of HHP and agrometeorological services, prevention of the spread of plant and animal diseases, as well as agrochemical research studies in the area of agricultural lands. Consultations on topics, such as field cultivation, horticulture, livestock breeding have been conducted.

Economic and technical. Anti-hail measures have been implemented; hail-nets have been installed in a number of regions. By means of loans with subsidized interest rate, intensive orchards have been formed, advanced irrigation technologies have been introduced; modern, high-efficiency crop species with varied maturity have been introduced; and relatively large greenhouse farms have been established. New cattle breeds have been introduced; plant and animal disease prevention measures have been implemented, among others.

Natural ecosystems and biodiversity

Terrestrial ecosystems

According to forecasts, over the next 100 years vertical shift in the existing boundaries of main natural ecosystems will be observed. According to the features of mountain landscapes, they will shift upwards by 250-300 m[40]. Upward movement of climatic zones across the terrain is already observed in some sections of the boundaries of these zones.

It is expected that the surface area of the alpine zone will be reduced by about 22%, and sub-alpine tall-grass and wetlands will expand. It is expected that the surface area of the sub-alpine zones will be reduced by about 21%, and shift to meadow steppes will be observed, with possible expansion of forest ecosystem into the area of current meadows.

It is likely that in humid forests of mid-mountainous zones some xerophytization processes will occur, as a result of which penetration of typical steppe, sparse forest and species characteristic to shiblyak may occur.

It is predicted that transition of meadow-steppes to steppe ecosystems will occur. In some cases, given the increase in the amount of precipitation in some areas, sub-alpine tall-grass may appear, and expansion into forest ecosystems of the current meadow steppe areas may occur.

Expansion of steppe zone by about 4-5% is projected to occur, and steppes are predicted to experience upper boundary shift to the sub-alpine zone, resulting in significant changes in vegetation composition and structure.

Semi-desert vegetation is mainly expected to be preserved by expanding the phryganoid zone.

Emergence of a new desert zone, expansion of desert - semi-desert area by about 33% and expansion of the semi-desert towards south-eastern region are forecast.

In general, it is predicted that conditions for shiblyak and arid sparse forest ecosystems will be preserved and even slightly expanded, but natural growth of trees and shrubs can deteriorate over time.

Soil ecosystems. Changes in natural vegetation due to the impacts of climate change over time will lead to structural shifts in lands forming the particular ecosystem. Areas without vegetation are extremely

[40] Biodiversity and Climate Change: Linkages at International, National and Local Levels, Frank Maes, An Cliquet, Willemien du Plessis, Heather McLeod-Kilmurray, Edward Elgar Publishing, 2013, p. 275

vulnerable to landslides. Loss of topsoil vegetation can have drastic consequences for the health of ecosystems.

Land erosion due to changes in vegetation has been assessed. Currently, the least eroded areas in the country are found in the mountainous meadow soil zone (32%), where 20% of soils are weakly eroded, and 12% - medium and strongly eroded. The total erosion of the forest land zone is 61%, of which weakly eroded - 33%, medium and strongly eroded - 28%. Erosion rate is higher in forest brown soils. The total erosion rate in the steppe natural zone is 39%, of which weakly eroded - 28%, medium and strongly eroded - 11%. Erosion processes are more vividly expressed in the dry steppe soil zone. The total erosion rate here is 87% of the total area, of which 46% is weakly eroded and 41% is medium and strongly eroded. Erosion is observed in both uncultivated and cultivated lands. The overall erosion rate in the semi-arid soil zone is 39%, including weakly eroded - 22%, medium and strongly eroded - 17%.

Thus, in case the current land use practices in different ecosystems are maintained and given the climate change forecasts, the area of eroded soils is expected to expand.

Forest ecosystems. The main climate change impacts on forest ecosystems include upward shifts across vertical zones, determined by development and distribution of other ecosystems, as well as outbreaks of forest fires, various pests and diseases.

According to official sources, there is an increase in the number of forest and field fires, as well as in their coverage in the Republic of Armenia, attributable to both human and climate change factors, such as higher temperature, prolonged dry days and reduced precipitation.

In the last decade, the number of forest fires and the coverage of areas caught by fire has increased, compared to the first decade of the 2000s. Occurrences of forest fires are more intensely observed in years with extreme hot summers.

Climate change also creates favorable conditions for mass spread of forest diseases and pests. According to official statistics, the number of areas infected with forest diseases has increased in the country since 2000.

Under the projected conditions of climate change, given the expected low humidity and less precipitation, the xerophyte vegetation of the southern slopes and the bushes in lower forest zone will be the most vulnerable. Under such conditions, xerophilous plant species will actively penetrate into forest ecosystems, resulting in deterioration of natural forest restoration processes, decreased annual growth rate of trees, which will eventually lead to the replacement of forest ecosystems with sparse forests and, subsequently, with semi-deserts.

Biodiversity. Climate change will lead to changes also in biodiversity. It will have significant effect on phenological and bioecological features of species, as well as their prevalence and can result in extinction of local endemics, as well as of many other rare plant and animal species.

According to conducted studies, 239 out of 452 rare plant species listed in the Armenia's Red Book will bear no significant impact from the projected climate change. For 139 plant species climate change can be a positive factor; these species may even expand their distribution in the country's territory. Only for 74 plants (mainly the mesophilic species of sub-alpine and alpine zones) climate change is likely to pose a very serious threat, as a result of which they will either disappear or appear on the verge of extinction[41].

Overall, xerophytization will be observed, which will bring about significant changes in existing ecosystems, both in terms of structural and species composition.

The spread of invasive species plays crucial importance in terms of risks to natural ecosystems and biodiversity. In particular, *Ambrosia artemisiifolia* has a great potential for spread and can produce hazardous consequences for natural ecosystems, biodiversity, agriculture and human health.

[41] Fayvush G.M., Aleksanyan A.S. Climate change as threat to plant diversity of Armenia \\ Takhtadjania, 2016, 3, p. 112-126.

Aquatic and wetland ecosystems

Projected climate change will also affect all water and wetland ecosystems.

Increase in temperature will primarily affect trophic level of lakes, leading to intensified process of eutrophication and their transition to permanent mesotrophic lakes and ponds. Accordingly, the same processes will result in mesotrophic lakes' transition to eutrophic or even dystrophic lakes.

Decrease in the level of Lake Sevan and changes in the thermal regime of the water are already having a negative impact on the Lake's ecosystems. The increase in the water temperature of the Lake and the massive development of blue-green algae during summer and autumn can lead to even more profound changes in the ecosystems. In particular, the eutrophication processes will accelerate and increase, leading to contamination and changes in the water composition, as well as deterioration of the water quality, changes in phyto-zooplankton and benthos, accumulation of toxic substances in living organisms, etc.

The following measures have been taken to mitigate the impacts of climate change on natural ecosystems and biodiversity:

Administration and planning. A number of legislative changes have been implemented aimed at mitigation of the negative impact of anthropogenic factors on natural ecosystems, protection of SPANs and biodiversity, improvement of forest management, restoration and protection of Lake Sevan ecosystems, including creation of a unified electronic database of the Lake Sevan and its catchment basin monitoring data and channels for information provision.

Research and information. Studies on the impacts of climate change on individual ecosystems, separate flora and fauna species, the spread of invasive species of plants and animals, organic carbon accumulation in various ecosystems, phytoplankton biodiversity of Lake Sevan have been conducted, as well as ecosystem services of existing SPANs and biodiversity have been assessed. Long-term studies are needed for in-depth assessment and forecasting of Lake Sevan's ecological status.

Economic and technical. Measures aimed at forest protection, forest and field fire risk mitigation and other technical activities have been implemented.

Settlements and infrastructure

The settlements and infrastructures throughout the country are exposed to climate induced natural hazards, particularly, floods, mudflows, landslides, rockfalls and avalanches. The latter can not only lead to major devastations and cause damages to settlements, roads, nearby structures and infrastructures in their respective areas, but also cause human casualties.

Floods are mainly caused by heavy precipitations, snow melt, river inundations, as well as damage of hydraulic structures. The year 2007 was marked by abundance of floods in the country. However, in 2012-2018 there has been a significant decrease in the incidence of floods. The highest number of floods was recorded in spring, mainly in Vayots Dzor and Gegharkunik regions.

Most mudflows are caused by mountainous terrain, heavy rainfall, hail, and rarely by snow melt. The highest number of heavy rainfalls, about 80%, was recorded in May-June. As in the case of floods, the year 2007 was also remarkable with the abundance of heavy rainfalls. During the period of 2012-2018 these dangerous phenomena has also shown a downward trend. In Lori, Aragatsotn and Vayots Dzor marzes were notable in terms of abundant rainfalls.

Landslides are widespread in mountainous and foothill regions, where heavy rockslides occur due to heavy atmospheric precipitations and over-humidity of foothills. Most of the landslides are located in Dilijan, Ijevan, Kapan, Vanadzor and in other settlements in the Debed, Aghstev, Vedi, Getik and Vorotan river basins.

The number of rockfalls recorded during the period of 2012-2018 has increased compared to previous years. Only in 2016, 61 cases of rockfalls have been reported. In recent years, cases of rockfalls have been reported predominantly in Lori and Syunik regions, as well as in Yerevan. Frequency of similar incidents has also increased in Tavush and Kotayk marzes.

Avalanches are the main dangerous natural occurrence of the winter season in the mountains. Snow avalanches on the country's territory pose a danger in the highlands of Zangezur, Vardenis, Bazum and Aragats.

Measures have been taken to reduce and prevent the risks of hazardous natural phenomena aimed at identifying, assessing, mapping and preventing hazardous phenomena, as well as developing resilience to such events.

Human health

Temperature increase, changes in precipitation and increased incidence of hazardous hydrometeorological phenomena can have serious adverse impacts on the health of population. The adverse impacts of climate change coupled with high atmospheric pollution contributes to an increase in incidence of cardio-vascular and respiratory diseases.

In Armenia, there is a risk that a number of infectious diseases will spread due to climate change: the structure of infectious diseases will change; water borne diseases will increase, especially in areas where water quality, sanitation and personal hygiene levels are not sufficient.

There are still diseases in Armenia that have a tendency to spread or are already widespread due to climate change. Prevention of and fight against such diseases stands high on the agenda: the list of such diseases includes, among others, leishmaniasis, brucellosis, intestinal, and airborne infections.

Outdoor workers are considered vulnerable in terms of impact of extreme weather conditions. The urban population is particularly vulnerable to cardiovascular and respiratory diseases due to atmospheric pollution associated with climate change. Inhabitants of rural settlements and groups of population that are in direct contact with natural landscapes or natural products are included in the groups susceptible to risks related to infections caused by natural focal infections, including especially hazardous ones. In case of gastrointestinal infections, the vulnerable groups of population include those who live in conditions with low levels of water quality, sanitary facilities and personal hygiene.

In order to prevent and mitigate climate change impacts on the health of population, the following types of measures have been undertaken: assessment of the prevalence of infectious diseases and risk management, provision of early warning to the population on possible adverse weather conditions, natural disasters, and epidemic situations. Anti-epidemic measures against carriers, transmitters of infectious and non-infectious diseases are also conducted. The impact of climate change on especially dangerous infectious diseases and forecast of outbreaks are studied and assessed.

Tourism

Tourism in the Republic of Armenia is one of the most dynamically developing sectors of the country by its development rates and results.

The GoA has set a goal to increase the number of annual tourist visits by at least 3 million through activities and measures to be carried out during 2017-2022.

The lack of statistical data time series related to the tourism sector in Armenia, as well as incomplete data series on snow cover in mountainous areas of the country for winter tourism, however, hinder the possibility to perform adequate assessment of the tourism sector's vulnerability to climate change impacts.

S-6. Other Information

Systematic observations and studies

Systematic observations

In Armenia, the State Hydrometeorological and Monitoring Service (NHMS) provides state agencies, regional and local self-governance authorities, population, different sectors of the economy with information on actual hydrometeorological conditions and their expected changes, current and forecasted climate information.

Ground-based meteorological observation network consists of 47 full-scale observations stations using standard meteorological parameters, which collect meteorological and climatic data.

Agrometeorological observations are conducted at 40 stations of the observation network, monitoring the growth and development of about 30 cultivated agricultural plants as well as agrometeorological conditions over the meadows and pastures. Also, agrometeorological standards in pastures, including soil humidity data, are monitored.

Areological, hydrometeorological and radiation observations are conducted by the Yerevan areological station (located in Davtashen). It is the only operational station in the Caucasus region and is included in the Regional Basic Synoptic Network (RBSN) and in the Global Climate Observation Network. Data from this station are transmitted to the global and regional data centers.

Hydrological observations are conducted through 95 hydrological observation posts, including 86 river, 5 reservoir, 4 lake (Lake Sevan) observation posts.

In recent years, in the framework of international cooperation, some technical upgrade and modernization of NHMS has been implemented, specialized equipment and devices have been procured and installed, training of personnel has been carried out, as a result of which the quality of services provided to the beneficiaries has been improved. However, the traditional network is outdated and needs to be upgraded[42].

Surface water and atmospheric air quality monitoring network. The Environmental Monitoring and Information Center SNCO (reorganized as Hydrometeorological and Monitoring Center SNCO since 2020) carries out hydrochemical regime observations for surface water of the country through 131 observation posts, covering 39 large and medium rivers, 6 reservoirs (Lake Arpi, Akhuryan, Aparan, Azat, Kechut, Lake Yerevan) and Lake Sevan. Ground-layer monitoring of atmospheric air is carried out in 13 different cities of the country (Yerevan, Gyumri, Vanadzor, Hrazdan, Alaverdi, Ararat, Vagharshapat, Sevan, Abovyan, Kapan, Kajaran, Meghri, Areni), using automatic, passive and active sampling methods.

Remote sensing network. Armenia has three (obsolete) meteorological radars, which render images from Hydromet. One of them is for aviation service, and two have an anti-hail designation. Radar systems are one of the vital components of modern weather services for agriculture, transport and water management.

Research and studies

The NHMS carries out research activities through the Hydrometeorology and Ecology Applied Scientific Center, which includes applied climatology, climate research, hydrometeorological model development and testing departments. Research activities are conducted in the following areas: climatology, numerical simulation of meteorological processes, assessment of climate change, national forecasts, using results derived from global and regional climate models.

The number of institutes included in the state research programs for 2018 was 83, out of which 14 were engaged in climate change research projects under the thematic projects' funding mechanism.

Since 2015, the Scientific Center of Zoology and Hydro-ecology of the National Academy of Sciences (NAS) has implemented the project "Study of Lake Sevan water ecosystems and biological resources under the conditions of climate change and water level increase" funded by the targeted project funding mechanism.

In 2015 and 2018, the Scientific Committee has funded 317 projects under the thematic projects' funding mechanism, 51 of which relate to climate change and environmental studies. The funded projects have been implemented by a total of 26 research institutes.

In 2016, within the framework of the Young Scientists' Support Program, the "Forecasting of the inflow of Lake Sevan and largest water basins in Armenia and their maximum levels in the conditions of climate change during the spring floods" project was funded, which was implemented by the NHMS.

[42] http://documents.worldbank.org/curated/en/684751548347371395/pdf/134019-WP-P167315-Hydrometeorological-Report-Armenia-September2018-Final.pdf

In 2017 the Division of Applied Projects was established at NAS. Around 40 innovative research projects have been collected from NAS's Scientific Research Institutes to promote academic research, technology transfer and the needs of commercialization of research results. About 10 of these projects were related to climate change issues and environmental studies.

Number of climate change research projects have been funded within the framework of bilateral and international grant programs. During the period of 2014-2018, several dozens of research projects have been funded by the Science Committee of RA, the Foundation for Fundamental Research of the Republic of Belarus, the Committee on Science and the Federal Ministry of Education and Research of Germany, the Eurasian Association for Scientific Research, and the European Union's Horizon 2020 framework program.

During the period of 2014-2018, within the framework of the programs of the International Center for Science and Technology (ISTC), several environmental research projects have been implemented by Armenian research organizations, with a total funding of approximately USD 1 million.

With the support of the United Nations Industrial Development Organization, the Climate Technology Center and Network of Armenia (ArmCTCN) (2018) has been set up, which is a climate technology platform aimed at introducing innovative technologies in the country, facilitating climate change adaptation and fostering implementation of mitigation technologies.

Education, human resource development and public awareness

Education and human resource development

Environmental education in Armenia is conducted in the frameworks of formal and non-formal education systems. Currently all levels of the education system of the Republic of Armenia are involved in environmental education, namely, general education (preschool and secondary education), preliminary vocational and middle vocational education, higher and postgraduate education institutions.

In the general education area, the issue of climate change is to some extent addressed within the mandatory curriculum (in grades 2-12), as well as in the subjects taught in 11th grade “Geography”, “Biology”, “Social Sciences”. UNDP has launched the implementation of the Climate Box project in 2017. The specialists from the National Institute of Education, involved in the project, have developed recommendations on incorporating climate change issues into various disciplines, meanwhile insuring inter-disciplinary linkages. Within the framework of international programs, educational materials have also been developed to support the implementation of environmental education in the general education sector.

Within the framework of *non-formal education*, every year since 2017, based on the initiative by the United Nations Children’s Fund, the World’s Largest Lesson is held in one of the schools. During the lesson, the Sustainable Development Goals are discussed, including SDG 13, which refers to climate-related issues. Several local and international organizations organize trainings on environmental, including climate change related issues. By the ““Armenian Tree Project-planting” NGO project, eco-clubs have been established eco-clubs in schools, conducting spring, summer, autumn eco-camps, during which events are organized including coverage of climate change-related issues.

Teachers’ training. The process of training of teachers in the country is at an insufficient level. In 2018 the National Institute of Education has elaborated a 30-hour curriculum on environmental education and upbringing for teachers, as well as a manual for teacher. However, due to the lack of financial resources, no training has been carried out yet.

Primary and secondary vocational education. Each professional public educational system includes the “Basics of Landscape Science and Ecology” discipline, which is taught through a 36-hour course. Although it briefly covers climate change topics, however, programs do not meet modern requirements. There is also a need for retraining of lecturers.

Higher education. In all universities the subject of “Basics of Ecology” is taught as a

mandatory subject. The topic of climate change is covered in this training course to some extent. Overall, there are about 180 ecology-related subjects taught in Armenia's higher educational institutions. In recent years, there has been a significant decrease in the number of students in the area of environmental studies. In 2018, 282 students were enrolled in higher educational institutions to study environmental studies.

In 2017, with the joint efforts of a number of universities and organizations, the Armenian Climate Technology Academic Network (ArmCTAN) was established.

Students of the Faculty of Geography and Geology of the Yerevan State University (YSU) have the opportunity to choose the specialization of Hydrometeorology in the 3rd year of their Bachelor's degree, as well as there is biennial admission to the Master's program for this discipline. Faculty of Biology teaches subjects related to the impacts of climate change on flora and fauna.

Climate change related educational programs are included in the Bachelor's and Master's programs of the Armenian National University of Architecture and Construction.

The Chair of Thermal Energy and Environmental Protection at the National Polytechnic University of Armenia teaches courses related to environmental protection and GHG emissions. Students take internships at TPPs and NPPs.

The Armenian Agrarian University, with the support of the Government of the Netherlands, is implementing the "Study and Evaluation of the Agro-ecosystem Adaptation Potential of Khosrov Forest Reserve and Dilijan National Park in the Context of Global Climate Change" project.

The American University of Armenia (AUA) has a mandatory environmental component in its curriculum.

Postgraduate education. Postgraduate education is provided both in universities and in the scientific institutes of NAS. A number of doctoral and post-doctoral theses on climate change issues have been defended in recent years.

Public Awareness

Public awareness on climate change is implemented in the following directions:

- conferences, seminars (for example, Climate Tech Hackathon, which was unique in its kind, enabling participants to present technological and innovative solutions for overcoming challenges posed by climate change on forestry and agriculture);
- development and publication of thematic materials;
- environmental information websites,
- mass media coverage (e.g. "Eco-platform" environmental TV project, launched in 2019);
- exhibitions, drawing competitions, game competitions (actively involving a number of NGOs),
- environmental campaigns.

S-7. Gaps, Constraints and Capacity Development Needs for Implementation of the Convention

Throughout the preparation of Armenia's NC4, certain limitations in terms of national capacities for implementation of the UNFCCC have been identified, including constraints, gaps, as well as needs under the new international requirements set out for implementation under the Convention, which, if adequately prioritized and addressed, will contribute to improvement of national capacities to meet the country's commitments under UNFCCC and enhance the national capacities to address the challenges posed by climate change.

GHG inventory development

In order to ensure transparency, consistent comparability, comprehensiveness and accuracy of the GHG inventory, it is essential to stipulate appropriate functions in the procedures of relevant agencies, ensure provision of continuous training for development of national capacities, adoption of data collection formats. It is also necessary to develop national factors for all carbon pools for application of high-tier methodology for GHG inventory; for improvement of GHG emissions and removals inventory from "Forestry

and Other Land Use" sub-sector, an important precondition is availability of comprehensive forest inventory and improvement of land use data collection and analysis system.

GHG emissions reduction policies and measures

Development of the potential for reducing GHG emissions in all sectors of the economy requires enhancement of analytical capacity building in relation to economic, environmental, social, and financial benefits, opportunities, barriers and risks. Introduction of mechanisms contributing to and promoting public-private, state-community partnerships in the newly developed National Energy Efficiency Program, as well as in agricultural waste management, forested areas expansion and sustainable land management programs is essential. The core needs of the sector also include the development of energy efficiency standards and practical mechanisms to ensure their application in the industry, commercial and public sectors, as well as introduction of monitoring, evaluation and reporting mechanisms for mitigation programs.

Vulnerability and adaptation

For *water resources* vulnerability assessment and risk management, improvement of data collection and analysis capabilities, as well as improvement of surface and groundwater quantity and quality monitoring systems are necessary. It is also important to introduce new methods for calculation of water balance elements and ensure reliable data on actual water use, develop and introduce economic instruments aimed at reduction of leakages in water distribution and water use systems, and promote transfer and application of water-saving technologies to mitigate water stress.

To address the needs in the *agriculture* sector, it is necessary to conduct studies aimed at identification of international models for crop yield projections and vulnerability assessment relevant for adaptation and application in the local context through development of capacities. The needs in the sector also include ensuring implementation of agroclimatic and microclimate zoning, with consideration of climate change scenarios; mainstreaming climate change into agricultural policies and programs; provision of professional consultations to farmers, including mechanisms to support the introduction of new technologies; as well as ensuring state support for introduction of an agricultural insurance system.

For the assessment of vulnerability and conducting monitoring of *natural ecosystems and biodiversity* it is necessary to ensure continuous data collection and creation of a national information system. It is also necessary to perform assessment of changes in the condition of meadows, forests, land resources, conduct assessment of focal areas of pests and diseases, as well fire outbreak risks in forest ecosystems. It is essential to conduct long-term comprehensive studies aimed at vulnerability assessment and forecasting of changes in the Lake Sevan ecosystems.

To manage risks of climate change impact on *human health*, is necessary to expand research on infectious, transmissible, and waterborne diseases. It is important to develop a methodology for assessment of risks of climate change impact and atmospheric air pollution on vulnerable groups, as well as elaboration of an adaptation action plan.

Assessment of economic losses and damages

For assessing economic losses and damages, it is important to ensure systematic data collection and mapping of damages in the vulnerable sectors caused by natural disasters due to HHP, according to an established methodology for data collection and damage assessment, as well as it is desirable to introduce physical and numerical models for long-term climate change impacts assessment.

Studies and systematic observations

For appropriate assessment of climate change impacts, it is essential to upgrade the systemic observations, including hydrometeorological observations networks, it is further essential to ensure introduction of modern equipment and technologies for improvement of hydro-meteorological services and data quality, installation of new hydrological monitoring observation networks, introduction of centralized and automated monitoring system, creation of online moni-

toring and data transfer system, improvement of climate change global and regional model results, reduction of uncertainties, capacity building for early projection of HHP, development of early warning and alerting system for climate risks, as well as improvement of mechanisms and improved technical capabilities for information exchange.

Innovation, technology development, advancement and transfer

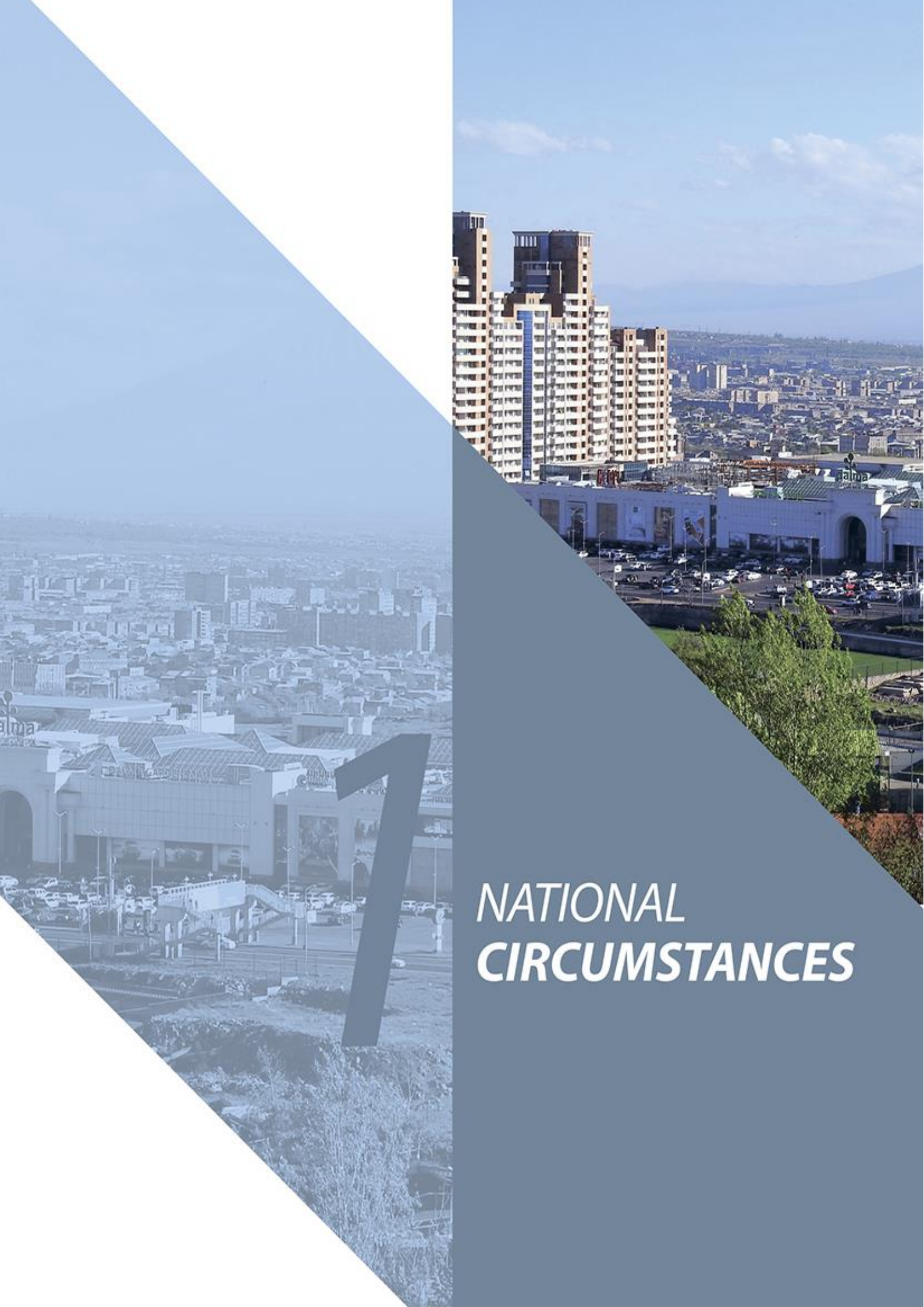
It is necessary to elaborate comprehensive policies for development, advancement and transfer of innovations and technologies, stipulation of privileges for innovative companies, introduction of financial support mechanisms for start-up organizations offering innovative solutions in the field of climate change mitigation; as well as promote private investments for the development of the sector.

Science, education, human resources training, public awareness

It is necessary to increase state financing targeted at research and development in the priority areas of science and technology development; allocate state financial resources towards climate change research and forecasting activities; organize training courses for technical staff employed in specialized institutions; envisage educational programs for climate change specialists within master's degree programs in higher educational institutions; include climate change and disaster risk management-related topics in public education curricula; and organize teacher training courses.

Financing

Strategic action plans in relevant areas need to be developed, funding sources and tools should be identified for implementation of these actions; step-by-step introduction of public expenditure and institutional scrutiny system to address climate change issues need to be implemented.



1 NATIONAL CIRCUMSTANCES

1.1 State Structure

The Republic of Armenia was formed on September 21, 1991. The capital city is Yerevan.

According to the 2015 Amendments to the RA Constitution, Armenia is a democratic state in the form of parliamentary governance (from 2018 onwards) with the separation of legislative, executive and judicial powers. The Head of the State is the President of the Republic with representative powers.

The legislative power is vested in the National Assembly (Parliament). Given the RA Constitution, the National Assembly consists of not more than 12 standing committees and minimum 101 deputies, who are elected for five-year period. Elections to the National Assembly, local self - governance bodies are conducted on the basis of universal, equal and direct election right, by secret poll.

The President of the Republic is the head of the country and is elected by the National Assembly for a period of seven years.

Armenia has adopted a three-tier governance system: centralized state governance, state territorial (marz) governance, and local (municipal) self-governance.

According to the RA Law of 2019 “On the Structure and Activities of the RA Government”, the composition of the RA Government (GoA) includes 12 Ministries, 5 State Committees and 6 Inspectorates. The Government is composed of the Prime Minister, empowered as the country’s head, two Deputy Prime Ministers and Ministers. The Prime Minister is elected by the National Assembly.

The administrative-territorial units of the RA are: 10 marzes; the capital city Yerevan and communities (502 communities, of which 48 - urban and 454 - rural).

Starting from March 2, 1992, Armenia is a member of the United Nations, from December 21, 1991 - a member of the CIS; from May 1, 1999 - a member of the Organization of the Black Sea Economic Cooperation; from January 25, 2001 - a member of the Council of Europe; from February 5, 2003 - a member of the WTO, and from 2015 - a member of the Eurasian Economic Union (EAEU). Since 1993, Armenia has been party to the UNFCCC.

As of December 2018, Armenia has established and maintains diplomatic relations with 175 countries of the world.

The state policy in the field of environmental protection is developed and implemented by the Ministry of Environment. Development of policies, strategies and tactics for the fulfillment of obligations under international environmental conventions is within the scope of the Ministry. The inspection functions in the area of environmental protection are carried out by the Inspectorate for Nature Protection and Mineral Resources.

1.2 Geographical Location, Natural Conditions and Resources

The Republic of Armenia is located on the border of the Caucasus and Central Asia. It borders with Georgia in the north, Azerbaijan in the east, Iran in the south, and Turkey in the southwest.

The territory of the Republic of Armenia is 29,743 km^2. It occupies the 138th place in the world by area.

Relief: Armenia is a landlocked mountainous country. 90% of the area is 1000 m above the sea level, of which 40% is 2000 m above the sea level. The highest point is Mount Aragats (4095 m), and the lowest - the downstream area of the Debed River (375 m), the average absolute altitude is 1830 m. The intermountain Ararat valley, which is an important agricultural region for the country, lies in the southwest of the country. Due to the sharply intersected relief and the development of the slope processes, the nature of Armenia is characterized by a large-scale development of active extraneous processes.

Climate: Armenia is a country of climatic contradictions. Significant differences in climate are observed even in the smallest areas, mainly due to the complex terrain. Almost all climatic variations can be observed in the country - from dry subtropical to cold mountainous.

The average annual air temperature ranges from -8^{0}C in high mountainous areas

(2500m and above) to 12-14^{0}C in low valley regions.

Summer is mild with an average temperature of 16.7^{0}C in July, and in the Ararat Valley it is in the range of 24-26^{0}C.

Winter is quite cold. January is the coldest month of winter, with an average temperature of -6.7^{0}C. In the northeastern and southeastern regions of the Republic, winter is mild.

The climate in Armenia is quite dry. The average annual precipitation is 592 mm. The highest precipitation is observed in high mountainous regions - 800-1,000 mm annually. The most arid regions are Ararat Valley and Meghri region. Annual precipitation here amounts to 200-250 mm. The average precipitation in the Ararat Valley during the summer does not exceed 32-36 mm.

The climate of Armenia is also characterized by the intensity and abundance of solar radiation, which is 1.46 kcal/cm^2 and 2,500 hours, respectively.

The average annual wind velocity in the territory of Armenia is unevenly distributed: 1.0 m/sec (Meghri) up to 8.0 m/sec (Sisian). In summer, the velocity of the mountainous winds can reach 20.0 m/sec or more.

In recent decades, there has been a significant increase in temperature growth rates in Armenia relative to the annual mean for 1961-1990 (5.5^{0}C), whereby in 1929-1996 the average annual temperature increased by 0.4^{0}C, in 1929-2007 by 0.85^{0}C, in 1929-2012 by 1.03^{0}C and in 1929-2016 by 1.23^{0}C. The decreasing trends of precipitation are maintained. Precipitation during the period of 1935-2016 relative to the annual mean (592 mm) decreased by almost 9%.

The territory of Armenia is characterized by high frequency and magnitude of hazardous hydrometeorological phenomena, which trigger the occurrence of emergency situations and inflict significant losses to the population and the economy.

Land Resources. According to 2017 Land Balance[43], agricultural land comprises 68.7%, forest land - 11.2%, SPANs and lands of special significance - 12.3%, wetlands - 0.9%, settlements - 5.1%, lands used for the purposes of industry, mining, energy, communication, transport and utilities - 1.7%, and other lands - 0.02% of the territory of Armenia.

Water Resources. The water resources of Armenia are mainly formed on the territory of the Republic and comprise about 47 billion m^3, of which the national reserve is 35.86 billion m^3 (Table 1-1). The usable part of the water resources of the country is about 9 billion m^3.

Table 1-1. Usable, strategic and national water reserves per water basin, mln m^3

Water basin	Usable water resources	Strategic water reserve	National water reserve
Northern	1,897	59.2	63.3
Hrazdan	733	229.3	254.1
Sevan	2,068	500	34,583.6
Ararat	1,306	229	245.3
Akhuryan	1,602	564	608.2
Southern	1,443	90.5	101.1
Total	**9,049**	**1,672**	**35,855.6**

The rivers in Armenia are the tributaries of the major rivers of the South Caucasus - the Araks and the Kura. Around 9,500 small and medium rivers flow through the territory of Armenia with a total length of about 25 thousand km. 379 of them have a length of 10 km and more, and their total length is 7,565 km. The longest rivers within the boundaries of Armenia are Akhuryan (186 km), Araks (158 km), Debed (154 km), Hrazdan (141 km) and Vorotan (119 km). The density of the river network varies widely in the country - from 0 to 2.5 km/km^2. Both in annual and perennial terms,

[43] https://www.cadastre.am/storage/files/pages/pg_0998130204_voroshum.pdf

disproportionate distribution of flow is characteristic to the rivers in Armenia.

The average annual flow of surface water is 6.8 billion m^3, and groundwater reserves are about 4.0 billion m^3. The largest lake in Armenia is Lake Sevan, one of the largest highland freshwater lakes in the world. The level of the Lake is 1,900.5 m, the surface area is 1,278.7 km^2 and the volume is 38.2 km^3 (2017)[44]. There are also about 100 small mountain lakes in Armenia with a total volume of 0.8 km^3.

According to the Organization for Economic Co-operation and Development (OECD), Armenia is considered a water-stressed country subject to water scarcity[45]. According to the official data of the SC, in 2017 Water stress was 57.8% compared to 64.2% of the previous year[46].

All water resources combined in Armenia are sufficient to supply about 3,100 m^3 of water per capita annually. Nevertheless, due to significant seasonal and annual fluctuations in the river flow, the temporal and spatial distribution of water resources is extremely disproportionate.

The seasonal flow of rivers in the Republic of Armenia is unevenly distributed, with the largest flow (30-90% of annual flow) attributable to spring floods due to the physical and geographical conditions of the country. Snow cover has a substantial role in the formation of the river flow in Armenia. On average, 30-60% of the rivers feed is attributable to snowmelt waters. The main zone of snow accumulation for the formation of river flow lies in the altitudes of 2000-2800 m.

To address the seasonal fluctuations of the river flow, 87 reservoirs with a total volume of 1.4 billion m^3 have been constructed in Armenia, most of which serve for one purpose - irrigation. The average volume of water storage per capita in Armenia is about 465 m^3, which is considered to be a low index for semi-arid climatic conditions in the country.

There are more than 100 small lakes in Armenia, some of which dry out periodically during the dry season. Small lakes are generally located at altitudes of 1500 m and higher above the sea level, with an average surface area of 0.5 - 2.0 km^2.

Armenia's groundwater resources are estimated at 4,017 million m^3, of which the approved exploitable reserves are estimated at 1,200 million m^3. Groundwater resources play an important role in Armenia's overall water balance. About 96% of drinking water and more than 40% of total water intake are comprised of groundwater. The agricultural sector remains Armenia's largest water consumer.

Biological resources. Due to the expressive vertical zoning of the territory and the diversity of climatic conditions, Armenia is rich in biodiversity - more than 100 plant species per 1000 km^2. Armenia's biodiversity is characterized by high endemism. About 500 species of animals and 144 species of plants are considered endemics of Armenia[47]. For the purpose of biodiversity conservation, SPANs have been established, including 3 reserves, 4 national parks and 27 sanctuaries.

Minerals. Armenia's mineral base currently comprises about 900 mines and sites with reserves of precious, non-ferrous, black and rare metals, salt, building materials, ground minerals and freshwater, and other minerals. More than 50% of these sites are in exploitation.

Natural disasters and risks include earthquake, landslides, drought, mudslides, forest fire.

1.3 Population

In 2017, the population of the Republic of Armenia was 2,986 thousand, of which urban population was 1,901 thousand (64%), rural population - 1,085 thousand (36%)[48]. Armenia was ranked the 136th in the world by the number of its population.

[44] https://www.armstat.am/file/doc/99504338.pdf
[45] https://www.oecd.org/env/outreach/AM%20Water%20Value.pdf, p. 13. According to OECD, a country is considered a water stressed country if the water use index is in excess of 40%.
[46] https://armstat.github.io/sdg-site-armenia/6-4-2/
[47] 5th National Report on Biodiversity of the Republic of Armenia, 2014 http://www.mnp.am/uploads/1/1551884521pdfresizer.com-pdf-resize.pdf
[48] SC, Permanent Population in Armenia, as of January 1, 2017, https://www.armstat.am/file/article/nasel_01.01.2017.pdf

Over the past hundred years, the proportion of women in the Armenian population has been steadily increasing, from 49% in the 1920s to almost 53% in 2017. At the same time, the share of women in urban population is higher (comprising 53.6%) than in rural population - 50.8%[49].

The average population density is 100 people/km^2. The resettlement is strikingly disproportionate, due to the country's mountainous terrain and the level of economic development of the territories. The maximum population density is 686 persons/km^2, which is attributed to up to 1000 m high altitude zone, the minimum density is 22 persons/km^2, attributable to 2000-2500 m high altitude zone.

The three largest cities of the republic are Yerevan (1,076,000), Gyumri (116,000) and Vanadzor (81,000), where 67% of Armenia's urban population and 43% of the total population live[50].

Since 1990 a steady decline in population has been recorded in Armenia due to the consequences of the Spitak earthquake, natural growth reduction and emigration.

According to the United Nations Population Fund (UNFPA), 25% of people born in Armenia lived outside their home country in 2015[51].

As of 2017, the population decreased by 542,000 people (17%) and the natural growth decreased by 4.6-fold, compared to 1990 (Figure 1-1). Life expectancy at birth is 75.4 years, whereby 78.7 for women, and 71.9 for men.

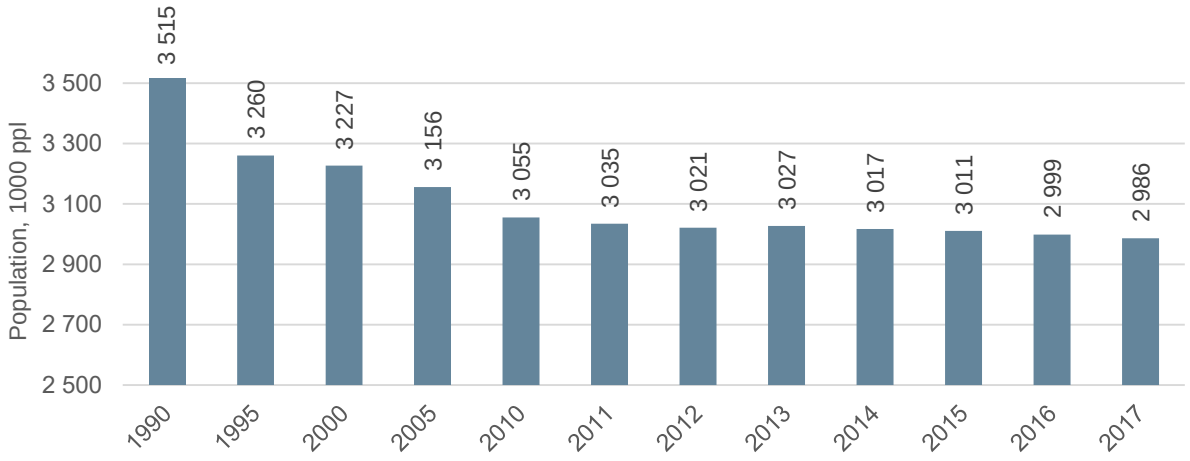


Figure 1-1. Population of Armenia in 1990-2017 (at the beginning of the year)

Source: RA Statistics Committee (SC)

Every fifth household in Armenia has a migrant family member[52]. Almost 90% of the migrants are men. 70% of them are migrant workers, of which more than 90% are relocated to the Russian Federation, 4% - to European countries[53].

By the end of 2017, the population aged 65+ made up 11.6%, of which more than 60% were women[54]. The number of single women-headed households in the 60+ age group is steadily increasing (Figure 1-2). Overall, more than 31% of households in the country are headed by women, and 55% of them are single women over the age of 60[55].

[49] "The Demographic Handbook of Armenia - 2018", SC, 14 December, 2018 https://www.armstat.am/file/article/demog_2018_2.pdf

[50] "The Number of Armenia's Permanent Population, as of January 1, 2017", SC, 2017 https://www.armstat.am/am/?nid=82&id=1916

[51] https://www.weforum.org/agenda/2016/12/fifth-of-people -from-these-countries-live-abroad/

[52] «Armenia's Social Outlook and Poverty», 2018, SC https://www.armstat.am/file/article/poverty_2018_a_2.pdf

[53] "The Demographic Handbook of Armenia - 2018", SC, 14 December, 2018 https://www.armstat.am/file/article/demog_2018_2.pdf

[54] Ibid.

[55] Gender Gap: A Diagnostic Study of Discrimination Against Women, United Nations Population Fund, 2016, https://www.un.am/up/library/Gender-Gap_arm.pdf

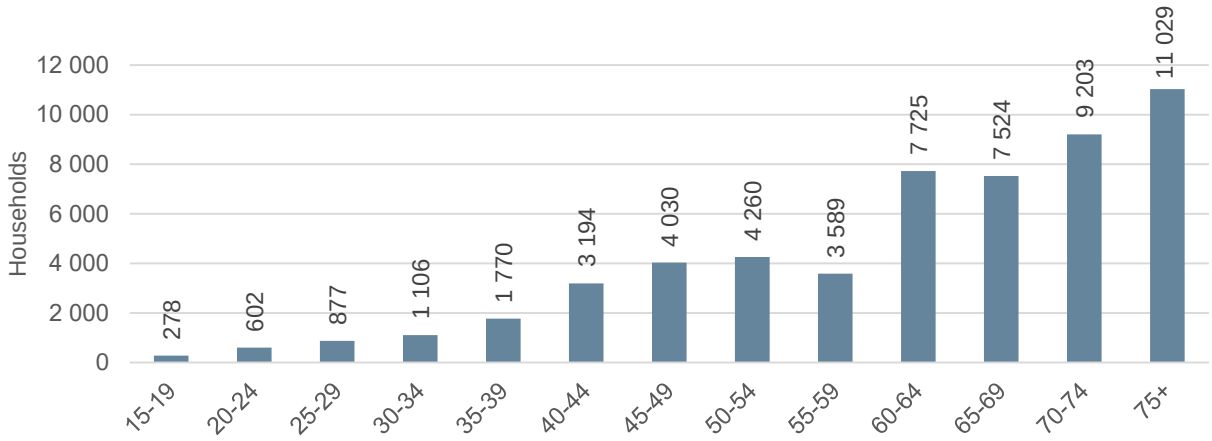


Figure 1-2. Women-led household distribution by age group, 2017

Source: SC, Complex Household Survey (https://www.un.am/up/library/Gender-Gap_arm.pdf)

The GoA has initiated a process of developing a strategy and an action plan to improve Armenia's demographic situation[56].

1.4 Economy

Macroeconomic indicators. As of 2017 Armenia's economy ranks the 134th in the world, with USD 11.5 billion GDP. As of 2015, Armenia is a member of the Eurasian Economic Union, along with Belarus, Kazakhstan, Kyrgyzstan and Russia.

Since the collapse of the USSR and after the economic crisis of 1991-1993, the economy of Armenia stabilized and in 1995-2017 it experienced moderate and rapid growth stages, coupled with cyclical fluctuations, and an average annual growth rate of 6.3% was recorded. The period of 1995-2000 was recorded as an average growth stage with a growth rate of 5.4%; during the period of 2001-2008 the growth rate was 11.8%, conditionally considered to be a period of rapid growth, which was however followed by a sharp economic downturn in 2009, with a 14.1% decline in GDP. Over the period of 2010-2017, the Armenian economy recovered, and the average growth rate was 3.9% (Figure 1-3). Compared to 1990, the GDP has almost doubled in 2017.

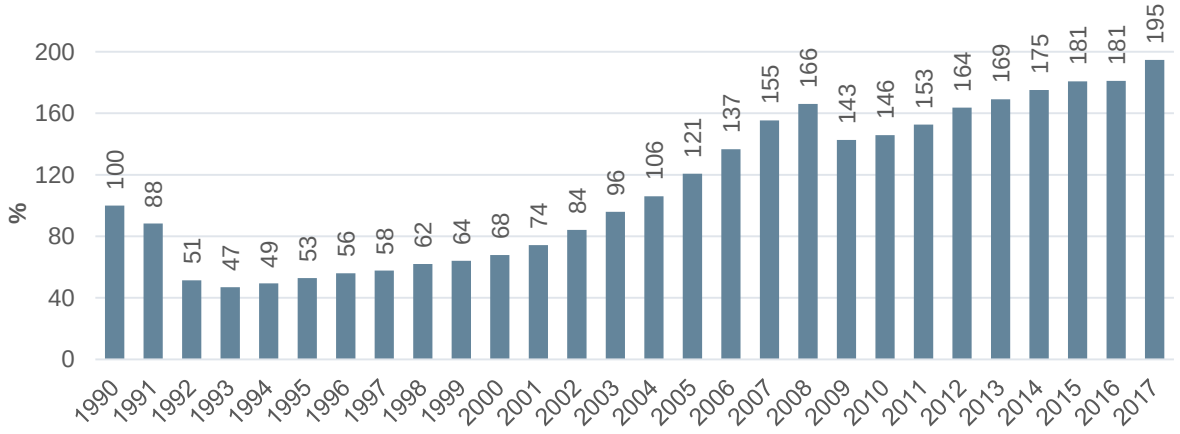


Figure 1-3. Dynamics of GDP of Armenia for 1990-2017 (compared to 1990)

Source: SC

The key macroeconomic indicators of Armenia are presented in Table 1-2.

[56] https://ampop.am/demographic-crisis-in-armenia, https://www.gov.am/am/news/item/13945/

Table 1-2. Key macroeconomic indicators for the period of 1995-2017

Indicator	1995	2000	2005	2010	2015	2016	2017
GDP (AMD billion)	522	1,031	2,243	3,460	5,044	5,067	5,564
GDP (USD million)	1,287	1,912	4,900	9,260	10,553	10,546	11,527
GDP per capita at current prices (USD)	396	595	1,562	3,052	3,505	3,517	3,860
GDP at purchasing power parity (PPP) equivalent (in millions of international dollars, at current prices) *	5,122	7,144	14,228	18,892	25,532	25,863	28,331
GDP per capita equivalent of PPP (in international dollars at current prices) *	1,592	2,327	4,773	6,566	8,727	8,809	9,621
Inflation (%)	32.2	0.4	-0.2	9.4	-0.1	-1.1	2.6
Export (USD million)	271	301	974	1,041	1,485	1,792	2,238
Import (USD million)	674	885	1,802	3,749	3,239	3,274	4,097
Foreign Government Debt (USD million)	373	860	1,096	3,299	4,413	4,885	5,623
External public debt (% of GDP)	29	45	22	36	42	46	49

Source: 1. SC, 2. Central Bank of Armenia
Note. Starting from 2015, the GDP is calculated by the SC in accordance with the 2008 International Standard of National Accounts System (NAS 2008). GDP indicators for 2012-2014, that are not comparable with GDP indicators for 1990-2011 in this table calculated in accordance with National Accounts System 1993 (NAS 1993) standard have also been revised according to NAS 2008.
** Source: WB Database (https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD)*
** Note. The international dollar has the same purchasing power over GDP as the US dollar in the USA. PPP equivalent data were obtained on the basis of the 2011 International Comparison Program (ICP). GDP per capita in purchasing power parity is calculated on the basis of average annual population data.*

During the period of 1995-2017, the GDP per capita has increased 10-fold, and in 2017 reached USD 3,860. In terms of GDP per capita, Armenia is considered a low-average income country, according to the WB classification. In the period under review, Armenia's external public debt, as a proportion of GDP, increased from 29% to 49%, at the end of the year 2017 totaling USD 5.62 billion; import increased by 6.1 and export - by 8.3 times.

Gross budget of the Republic of Armenia for 2017 totaled AMD 1,277 billion (USD 2,645 million) relative to AMD 205 billion in 2000 (USD 380 million). During the period of 2000-2017, the USD/AMD exchange rate has fluctuated significantly, and has relatively stabilized in 2015-2017 (Figure 1-4).

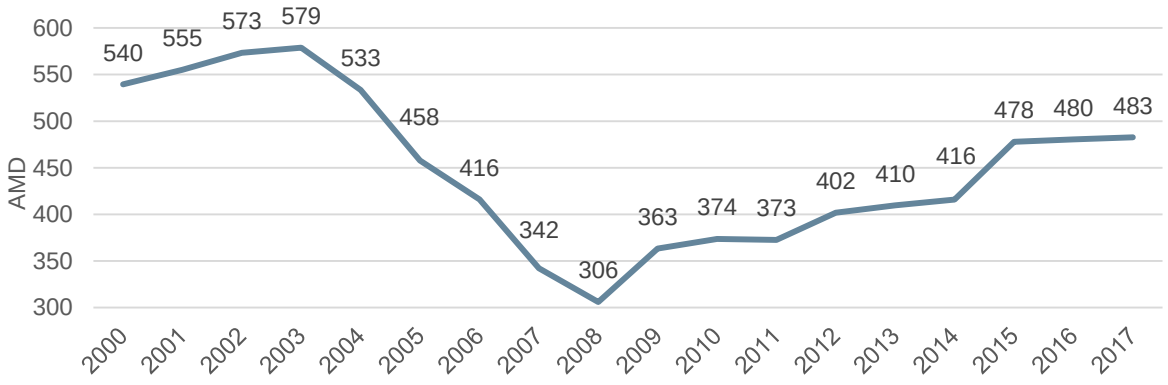


Figure 1-4. AMD/USD average exchange rate fluctuations in 2000-2017
Source: SC, Databases

During the period of 2000-2017, structural changes in the economy led to a decrease in the shares of the following sectors in the structure of GDP: industry – from 25.2% to 18.5%; construction - from 10.2% to 7.3%, agriculture - from 23.2% to 15%, while the share of services sector significantly increased (Table 1 -3).

Table 1-3. Armenia's GDP structure for 2000-2017, %

Sectors of economy	2000	2005	2010	2012	2016	2017
Industry, including energy	25.2	21.7	15.6	16.9	17.9	18.5
Agriculture, forestry, fishing	23.2	19.0	17.0	19.1	16.4	15.0
Construction	10.2	19.6	17.3	12.4	7.8	7.3
Trade (wholesale, retail)	9.9	11.4	12.9	12.7	9.8	11.1
Services	22.4	19.7	26.0	27.4	38.1	37.8
Net taxes	9.1	8.6	11.2	11.5	10.0	10.3

Source: SC (https://www.armstat.am/am/?nid=202, https://www.armstat.am/file/article/azghashiv_90_97_3.pdf)

In 2017, the structure of imported goods was predominantly comprised of mineral products (15.7%), mineral fuels, oil and petroleum products (15.3%), machinery and equipment (15.3%), including nuclear reactors and boilers (9.1%), chemical products (9.9%), victuals (8.6%) and vehicles (6%). The structure of exported goods is predominantly comprised of mineral products (30.2%), especially minerals (26.8%), precious, non-precious and non-ferrous metals (25%), victuals (23.4%) - mainly comprised of cigarettes (10.6%) and alcohol and non-alcoholic beverages (10.8%)[57].

Social indicators. In 2017, the unemployment rate was 17.8%, the average monthly net salary (after taxes) - AMD 102,594 (USD 215), the poverty rate - 25.7% (per capita income below USD 87 per month) (Table 1-4). Human Resource Development Index for 2017 made 0.755, ranking 83rd in the world[58].

Table 1-4. Key social indicators for 2008-2017

Indicators	2008	2010	2012	2014	2015	2016	2017
Unemployment rate, %	16.4	19.0	17.3	17.6	18.5	18.0	17.8
of which - women	18.6	21.2	18.2	18.5	19.5	17.8	17.5
men	14.4	17.0	16.5	15.8	17.6	18.1	18.0
Average monthly net salary, *AMD thousand*	61.0	81.2	89.4	121.7	127.3	128.5	102.6
Average monthly nominal salary, *AMD thousand*	87.4	102.7	140.7	158.6	171.6	174.4	177.8
of which - women	68.0	80.0	107.8	124.4	135.5	138.9	143.0
men	116.8	124.8	169.0	188.8	203.7	209.3	211.7
Gender gap in nominal salary[59], %	41.8	35.9	36.2	34.1	33.5	33.6	32.5
Dependency ratio[60], *%*	50.3	46.9	47.4	48.3	49.4	50.9	53.7
National poverty level, *%*	27.6	35.8	32.4	30.0	29.3	29.4	25.7
International Poverty Index, USD 1.90 per day (by 2011 PPP) and the share of the lower income population, %	1.4	1.9	1.6	2.3	1.9	1.8	1.4

Source: SC, WB database

Gender parity index: In 2017, in the Armenian labor market 53% of women and 71% of men were economically active; these figures in the world are 49% and 76%, respectively[61]. Employment and unemployment rates for women and men and gender parity indices are presented in Table 1-5.

[57] www.armstat.am/file/article/ft_2_nish_2018_9.pdf
[58] http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
[59] https://www.armstat.am/file/article/gender_2018.pdf
[60] https://www.armstat.am/file/article/demog_2018_2.pdf
[61] UNDP Gender Equality Strategy, 2018-2021, p.4

Table 1-5. Gender parity indices for employment and unemployment[62] in Armenia, 2008-2017

	2008	2010	2012	2014	2016	2017
Employment rate for women and men, each relative to their group, %						
Women (W)	41.0	41.1	45.2	44.5	43.2	43.5
Men (M)	60.6	59.9	60.2	61.6	58.4	57.9
W/M	0.68	0.69	0.75	0.72	0.74	0.75
Unemployment rate for women and men, each relative to their group, %						
Women (W)	18.6	21.2	18.2	19.5	17.8	17.5
Men (M)	14.4	17.0	16.5	15.8	18.1	18.0
W/M	1.29	1.25	1.10	1.23	0.98	0.97
Share of unemployed women and men registered in the State Employment Service, %						
Women (W)	75.5	69.3	72.8	71.8	66.0	66.7
Men (M)	24.5	30.7	27.2	28.2	34.0	33.3
W/M	3.08	2.26	2.68	2.55	1.94	2.00

Source: https://www.armstat.am/am/?nid=82&id=2106, http://employment.am/am/38/free.html

According to statistics, 58% of economically active women have higher and postgraduate (32%) and secondary vocational education (26%); for men these indicators are 47%, 28% and 20%, respectively. 47% of economically inactive women are housewives, with 52% of them being 25-44 years old, almost half with higher education (22.4%) and vocational education (27.3%), 87% is married[63].

In the structure of women's employment, the largest share is attributable to the agriculture sector - 34.8%, followed by education - 17.7% and trade - 10.8%. The main areas of employment for men are agriculture - 28.2%, industry (including energy) - 14.8%, public administration - 12.7%[64].

According to statistics, 55% of civil servants are women, including 72% in junior positions[65]. Representation of women in senior legislative, executive and judicial positions in 2017 was as follows:[66] out of 105 deputies of the National Assembly 19 were women (18.1%), out of 18 ministers - 1 woman (5.6%), out of 57 deputy ministers - 2 women (3.5%), out of 226 judges - 59 women (26.1%), and out of 9 members of the Constitutional Court - 2 women (22.2%), out of the 10 governors (marzpets) none were women, and out of 502 community leaders – 8 women (1.6%).

1.5 Energy

The Energy sector is of strategic importance for the country in terms of achieving its national development goals, ensuring security, as well as providing reliability and access to energy services for the population.

As of 2016, GHG emissions in the sector decreased 3.4-fold, compared to 1990, and the total primary energy supply (TPES) - 2.6 times, or total GHG emissions per unit of TPES reduced by 23.5% (from 2.83 Gg $CO_{2\ eq.}$/ktoe to 2.16 Gg $CO_{2\ eq.}$/ktoe) (See Chapter 2). This is due to the structural changes in the economy, the widespread use of renewable energy resources, implementation of low-carbon technologies, introduction of EE measures, and is indicative of Armenia's low-carbon development trends.

Particularly, during the period of 1990-2016, the second power unit of the Armenian Nuclear Power Plant (NPP) was recommissioned, environmentally cleaner fuel - natural gas, was widely used, which almost completely eliminated the use of coal and fuel oil in energy production, as well as reduced gasoline consumption in transportation; small hydropower energy also experienced drastic growth.

[62] Gender parity indices were calculated as the ratio of the corresponding index of women to that of men.
[63] "Labour Market in the Republic of Armenia, 2018", page 44-49: https://www.armstat.am/am/?nid=82&id=2106
[64] Ibid, page 71
[65] "Women and Men in Armenia", 2018», page 96-104, https://www.armstat.am/am/?nid=82&id=2079
[66] According to "UNDP Gender Equality Strategy, 2018-2021", in the world, 24% of parliamentary seats are occupied by women

Total Primary Energy Supply

The total primary energy supply for 2016 was 3,142 ktoe. Armenia does not have its own fuel resources and fuel demand is met at the expense of imports. As of 2016, in terms of energy self-sufficiency, Armenia is secured at approximately 35% (nuclear energy - 22.7%, hydro - 6.4% and biofuels - 5.5%)[67].

Figure 1-5 shows the total primary energy supply for the period of 1990-2016.

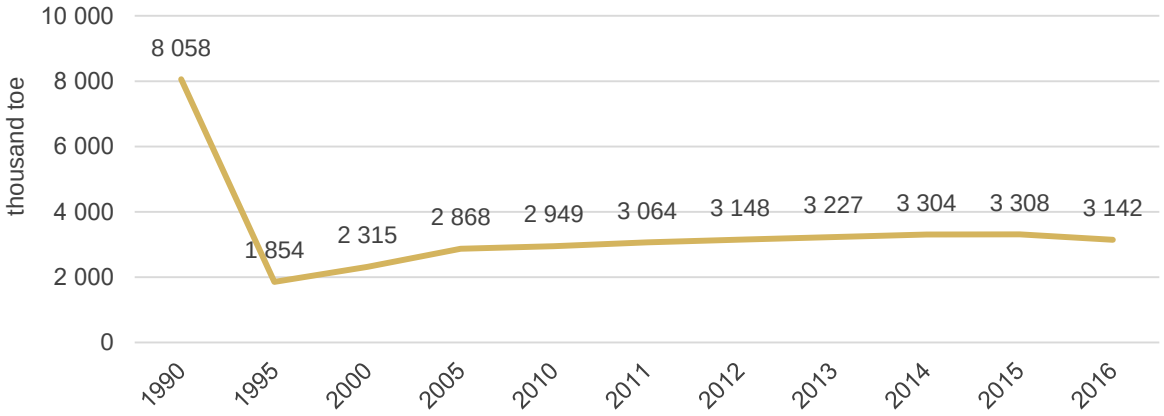


Figure 1-5. Total primary energy supply in 1990-2016

The share of nuclear power for all years has been recalculated on the basis of conventional fuel consumption based on the official data provided by the Armenian NPP.

All types of fossil fuels are imported, including natural gas, which is the main fuel consumed in the country, and as of 2016, it comprised 58.9% and petroleum products comprised 9.0% of primary energy. Armenia exports certain amount of electricity - 2.6%.

The TPES structure is characterized by a predominant share of natural gas (58.9%) and nuclear energy (22.7%). As of 2016, there is a reduction of TPES by about 4.9%, compared to 2014, mainly due to the change in the structure of electricity production, in particular the reduction of TPP production and the increase in hydropower production, which, in turn, led to a reduction of emissions from the Energy sector by 6.0%[68].

Fuel and energy market

Armenia is a well-known international example of comprehensive reforms in the energy sector. Armenia ranks among the countries, where fuel prices are taxed rather than subsidized. As part of the energy sector reforms, refusal to subsidize fossil fuels has contributed to the low carbon development trend of the Armenian economy.

Natural gas is the main fuel consumed in the country. As of 2016, 84.2% of fossil fuel consumption and 83% of CO_2 emissions from fossil fuel combustion are attributable to natural gas. This is explained by the high level of gas consumption in the country - 94.6%, and the fact that 1 kWh of natural gas produced is about 2.6 times cheaper than 1 kWh of electricity.

Petroleum products, namely - diesel fuel, gasoline, liquefied petroleum gas, are fully imported and the market is not regulated. However, the State Commission for the Protection of Economic Competition and the Market Surveillance Inspection Body monitor fuel prices and ensures the absence of entry barriers and attributes of excessive profits in any market segment.

In Armenia, petroleum is not the main source of engine fuel. Compressed natural gas (CNG) makes up more than 60% of the fuel used in road transport[69]. CNG is about 2.5 times cheaper than gasoline. The use of CNGs is encouraged as an environmentally friendly fuel, which also contributes to the development of the public transport.

[67] 2016 Energy Balance of Armenia
[68] 2016 GHG Inventory Report of Armenia
[69] 2016 GHG Inventory Report of Armenia

Energy production

In 2016, 0.63 million toe (7,315 million kWh) of electricity was produced in Armenia, 32.5% of which by nuclear, 35.3% - thermal, 19.1% - large hydro, and 13.1% small (mostly small hydro) renewable power plants; and in 2017, respectively 0.67 million toe (7,763 million kWh) of electricity, 33.7% of which by nuclear, 37.0% - thermal, 18.1% - large hydro, and 11.1% - small (mostly small hydro) renewable power plants.

In recent years similar ratio and quantity of electricity production has been maintained[70]. Although natural gas is predominant in the TPES in Armenia, the energy production structure is diversified.

In the domestic market, with relatively stable energy consumption, the fluctuations in electricity production are mainly driven by the volumes of exported electricity.

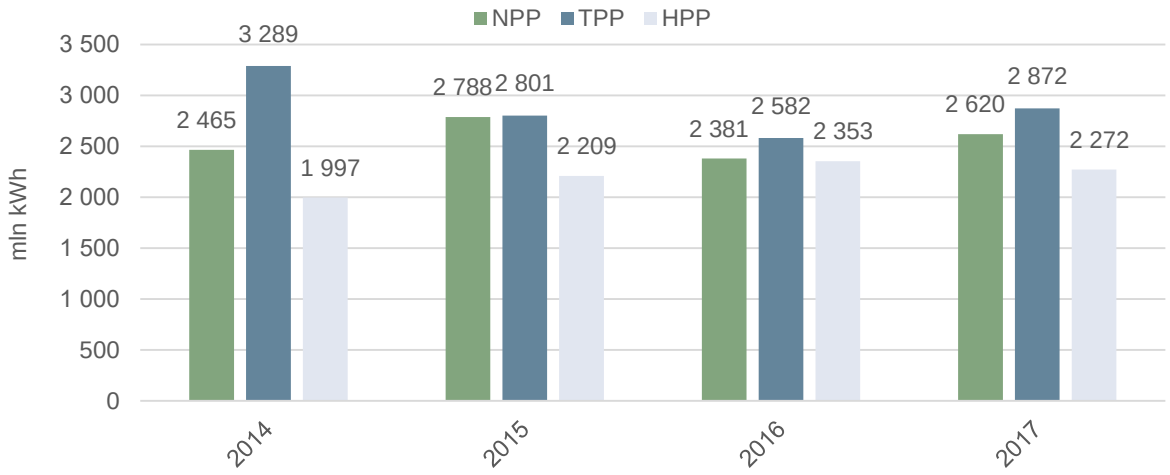


Figure 1-6. Structure of energy production, 2014-2017

Liberalization of the Armenian electricity market

To highlight the importance of gradual liberalization of the electricity market, promotion of interstate trade and taking into account the recommendations made by international organizations, on February 7, 2018, the National Assembly of the Republic of Armenia adopted the draft laws of the Republic of Armenia "On Amendments and Addenda to the RA Laws *"On Energy", "On Licensing", and "On State Duty".* These decisions marked the process of liberalization of the Armenian electricity market.

The "Program-Timeline of Measures towards Liberalization and Interstate Trade Development of the Electricity System of the Republic of Armenia" was adopted by the Government Decree, dated September 14, 2018.

The Armenian electricity market has stepped into a phase of liberalization, which means that the market will move from a "one buyer" model to a free electricity purchase and sale mechanism.

By the Resolution of the Public Services Regulatory Commission (PSRC) No. 344, dated August 9, 2017, the "Temporary commercial rules of the wholesale electricity market of the Republic of Armenia" were approved, which defined the wholesale electricity market participants and the structure, and regulated the commercial relations among wholesale electricity market participants.

By the PSRC Resolutions No. 516-N and N 523-N, dated December 25, 2019, the new trade rules for the RA electricity wholesale and retail markets, as well as the network rules for transmission, distribution, the sample forms of relevant contracts, and the indicators for safety and reliability were approved (amended). These amendments, which are envisaged to be applied from February 1, 2021, should ensure the

[70] In the wind and solar power stations, a very small amount of electricity was produced (0.04% annually) during the mentioned years, for example: in 2017, 2.07 million kWh and 0.54 million kWh, respectively.

introduction of the new model of the electricity market.

Final energy consumption

Final energy consumption in 2016 amounted to 2,142.7 thousand toe, whereby final energy consumption structure is characterized by the largest shares of residential (38.2%) and transport (29.1%) sector consumption (Figure 1-7).

Final energy consumption in 1990-2017 is shown in Figure 1-8.

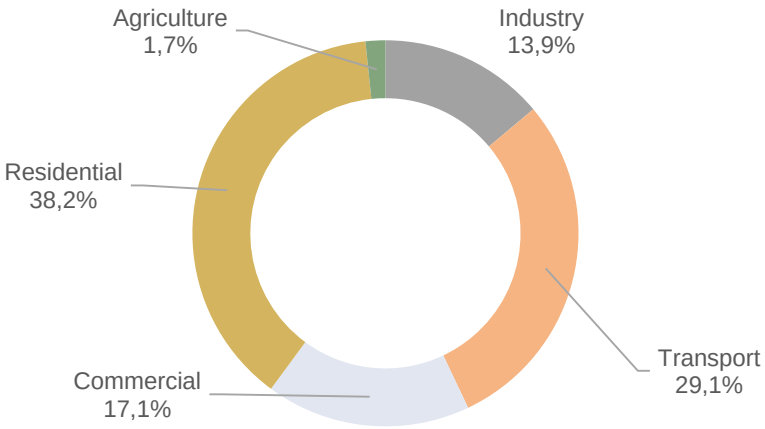


Figure 1-7. Final energy consumption structure, 2016

Source: Energy Balance of Armenia, 2016

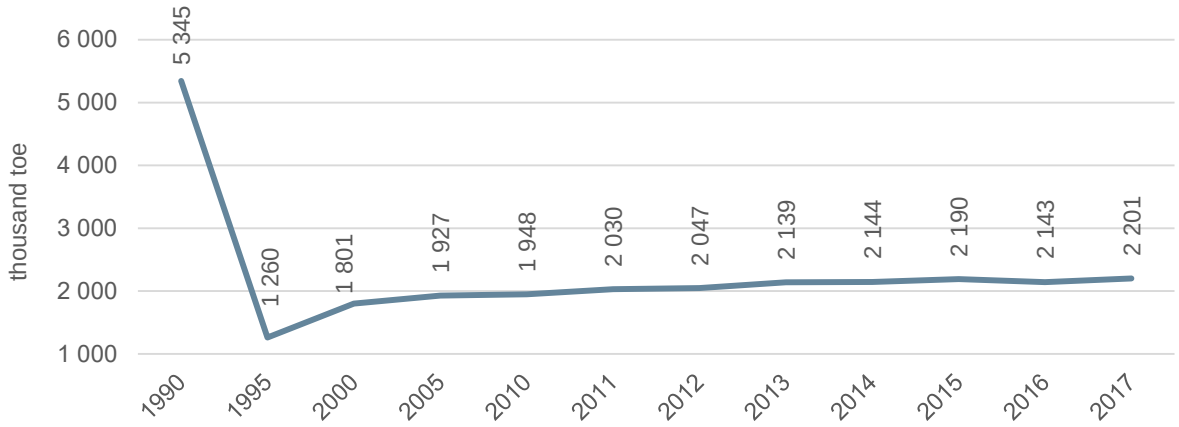


Figure 1-8. Final energy consumption, 1990-2017

1.6 Industry

In the Soviet period, Armenia was ranked among the countries with high industrial potential. The share of industry in gross social output in 1987 was 66.9%[71]. In 1988, following the devastating earthquake, Armenia lost one third of its industrial potential. The difficulties of the early phase of transition to market relations and the collapse of the former USSR unified economic area further aggravated the decline of Armenian industry. In 1993, the volume of industrial production comprised 43% of the 1990 level. In 1994, the situation started to stabilize. During 2000-2005, the average annual growth of industrial output was 8%, and 4% in 2006-2016.

In 2017, the share of industry comprised 20% in added value and 18.5% in gross domestic product. The index of physical output of industrial production in comparison with the previous year made 112.5%.

[71] "The National Economy of the Armenian SSR in 1987" Statistical Handbook, 1988. For comparison, it should be noted that in 1987 the share of agriculture accounted for 12.1%, and construction - 10.3% in the total public output.

The largest share in the sectoral structure of the Armenian industry is attributed to processing industry - 62.5%, followed by mining industry - 20.4%, electricity and gas production - 15.6%, as well as water supply, sewage and waste management - 1.5% (2017).

In 2017, the processing industry was comprised of food production (28.5%), tobacco production (15.2%), beverage production (14.4%), manufacturing of machinery (16.8%), metallurgical production (4.2%), production of building materials (4.3%), chemical production (4.1%), jewelry (1.5%), light industry (1.3%), other sectors (9.7%).

In terms of territorial distribution, industrial production is mainly concentrated in Yerevan (40.8% of total industrial production in 2017), Syunik (16.5%), Ararat (12.4%), as well as in Kotayk (9.6%) and Lori (8.9%) marzes. The share of the remaining 5 regions in the GDP ranges from 0.8% (Tavush marz) to 3.5% (Armavir marz)[72]. About 133,000 people are employed in the industry sector of Armenia, of which 42 thousand are women (31.6%)[73]. The gender breakdown of employment in the industry sector is presented in Table 1-6.

Table 1-6. Employment of women and men in industry sector, 2017

Industry sectors	Employment, %		Segregation of employees by sectors, %		
	Women	Men	Women	Men	GP* ratio (W/M)
Mining	8.7	91.3	1.9	9.3	0.20
Processing	37.4	62.6	82.2	63.7	1.29
Energy	20.5	79.5	12.6	22.5	0.56
Water supply	25.4	74.6	3.3	4.5	0.73
Total			**100**	**100**	**0.46**

** GP-Gender parity*
Source: SC (https://www.armstat.am/file/article/trud_18_4.1.pdf)

Women's employment in the Armenian industry sector is more than twice lower than men's (Gender parity ratio is 0.46). Higher number of women employed relative to men is concentrated in the processing industry, especially in the light and food industries, while in the mining industry higher number of men are employed relative to women.
Since 2000s, the GoA has declared the prospective development of information technology (IT) as a priority and provided certain tax privileges to the sector.
As a result, the IT sector has demonstrated rapid growth, generating around 22,000 workplaces. One of the characteristic aspects of the development of the sector in Armenia is the high proportion of women - about 30% (as of 2017) working in the sector[74], compared to other developed countries.

1.7 Transport

During 1991-1993, substantial changes occurred in the country's transport sector as a result of the economic crisis, transport blockade and structural shifts in the economy. Compared to 1990, the volume of cargo transportation in 2017 decreased 11-fold, and passenger transportation fell 2.5-fold. In 2017, the largest share of cargo transportation, i.e. 87.7% was attributable to road transport. Ground passenger transportation in urban areas by electric transport decreased more than 11-fold, and its share in total passenger transportation fell to 2.7% from 12.4%. Subway passenger transportation in 2017 decreased approximately 3-fold, compared to 1990, and its share in total passenger transportation went down from 10.3% to 8.1%. In 2017, the largest share in total passenger transportation was attributed to road transportation, comprising 87.9% in total passenger transportation (Table 1-7).

[72] Data for 2017 are taken from the "Statistical Yearbook of the Republic of Armenia, 2018", "Industry" section https://www.armstat.am/file/doc/99510793.pdf
[73] "Labour Market in Armenia", 2016-2017, https://www.armstat.am/file//trud_18_4.1.pdf
[74] http://itis.am/womenintech/eng

Table 1-7. Volumes of cargo and passenger transportation for the period of 1990-2017

Cargo transportation							
Type	**Volume**	**1990**	**1995**	**2000**	**2005**	**2010**	**2017**
Railroad	1000 t	15,724.0	2,149.4	1,423.5	2,612.3	3,063.3	2,640.0
	%	5.7	45.7	40.5	36.9	33.0	11.3
Road	1000 t	261,522.0	2,499.0	2,077.0	4,449.7	6,196.0	23,684
	%	94.3	53.2	59.1	63.0	66.9	87.7
Air	1000 t	18.0	51.4	13.8	9.3	8.8	22.4
	%	0	0.1	0.4	0.1	0.1	0.1
Total	1000 t	**277,264.0**	**4,699.8**	**3,514.3**	**7,071.3**	**9,268.1**	**26,346.0**
	%	100	100	100	100	100	100
Passenger transportation							
Type	**Volume**	**1990**	**1995**	**2000**	**2005**	**2010**	**2017**
Vehicle	mln passengers	377.4	81.6	100.4	181.8	206.0	175.7
	%	76.2	46.7	73.9	89	88.3	87.9
Air	mln passengers	1.8	1.0	0.6	1.2	1.7	2.6
	%	0.4	0.7	0.5	0.6	0.7	1.3
Subway	mln passengers	51.1	21.8	16.9	15.8	19.9	16.2
	%	10.3	12.5	12.4	7.7	8.5	8.1
Tram	mln passengers	18.7	11.8	6.0	0	0	0
	%	3.8	6.7	4.4	0	0	0
Trolleybus	mln passengers	42.7	55.4	10.8	4.8	4.9	5.3
	%	8.6	31.7	8.0	2.3	2.1	2.7
Total	mln passengers	**495.2**	**174.6**	**135.8**	**204.3**	**233.3**	**199.8**
	%	100	100	100	100	100	100

Source: SC, Yearbooks (1991, 2001, 2006, 2011, 2018)

The North-South highway construction deserves a particular attention, as it is designed to provide connectivity between the Iranian and Georgian borders of Armenia and reduce travel time almost 2.5-fold. The length of the North-South highway in the territory of Armenia is 527 km[75]. The construction of the highway was launched in 2012. The North-South highway is of strategic importance: it will serve as a link between European and Asian countries, providing access to the Black Sea.

The use of engine fuel in 2017 reduced almost twice, compared to 1990. Since 2000, the share of natural gas in the total volume of engine fuel has recorded rapid growth and in 2017 it reached 61.7%.

Table 1-8. Engine fuel consumption by transportation means

Type	Volume	1990	1995	2000	2005	2010	2016	2017
Gasoline	1000 toe	693.0	276.5	166.8	166.1	169.8	148.7	150.5
	%	55	80.1	74.6	53.1	36.7	24.2	22.8
Diesel	1000 toe	567.0	68.6	31.3	24.1	27.1	75.5	97.0
	%	45.0	19.9	14	7.7	5.8	12.3	14.7
Natural gas	1000 toe	0	0	23.1	118.8	264.9	386.4	408.2
	%	0	0	10.3	38	57.2	62.9	61.7
Liquid gas	1000 toe	0	0	2.4	3.6	1.2	3.5	5.4
	%	0	0	1.1	1.2	0.3	0.6	0.8
Total	1000 toe	**1,260.0**	**345.1**	**223.6**	**312.6**	**463.0**	**614.2**	**661.0**
	%	100	100	100	100	100	100	100

Source: Ministry of Energy and Natural Resources (1990-2001), Gazprom Armenia CJSC (2002-2017), Ministry of Transport and Communication (2010-2016), National GHG Inventory (2016, 2017), RA Energy Balance (2016, 2017)

[75] https://www.northsouth.am/am/categories/44

1.8 Buildings

In 2017, the housing stock of Armenia[76] included about 19,000 multi-apartment buildings (about 443,000 apartments), comprised of around 12,000 buildings in urban areas (64%), approximately 7,000 buildings in rural communities (36%) and about 397,000 dwelling houses, of which approximately 156,000 (39%) - in urban communities and approximately 241,000 (61%) - in rural communities. In the country, 54% of the multi-apartment buildings and total area of housing is attributed to Yerevan.

The percentage distribution of multi-apartment buildings by exterior wall materials is as follows: stone (69.6%), panel (22.8%), monolith (6.6%) and other material (1%)[77].

Although Armenia's housing stock is relatively new (60% operates for less than 45 years), the technical conditions, in particular those of the multi-apartment buildings, raise serious concerns. 30% of the apartments are in poor condition: 50% of power supply systems, 60-75% of roofs and entrances need repair[78].

Buildings in Armenia are among the largest energy consumers. According to 2016 GHG Inventory, 38.2% of the final energy consumption is attributed to residential buildings. The energy consumption in buildings is mainly attributed to heating of apartments.

The annual energy consumption by the housing stock is about 185 kWh/m^2. According to expert judgement, improving EE can provide more than 50% energy savings[79].

In recent years, efforts have been made towards improvement of the legal and regulatory framework in the sector.

1.9 Agriculture and Forestry

Agriculture. As of 2017, the total area of Armenia's agricultural land covers 2,043.8 thousand hectares, including: arable land - 446.0 thousand hectares (21.8%), perennial plantations - 34.8 thousand hectares (1.7%), grassland - 121.0 thousand hectares (5.9%), pastures - 1,050.8 thousand hectares (51.4%) and other lands - 391.2 thousand hectares (19.2%).

In 1991-1993, the agricultural sector was also largely affected by the deep economic crisis. Agricultural lands underwent spatial and structural shifts (Table 1-9). The animal headcount also declined: large cattle went down by 5%, sheep and goats - by 44%, swine by 47% and poultry - by 66% (Table 1-10). The area of irrigated land decreased two-fold and the use of mineral fertilizers - three-fold. In recent years, the share of crop production in gross agricultural output has been about 52%, and of cattle breeding - about 48% (2017)[80]:

Table 1-9. Agricultural land, thousand ha

Lands	1990	1995	2000	2005	2010	2015	2016	2017
Total area	**1,384.0**	**1,391.4**	**1,391.4**	**1,391.4**	**2,100.9**	**2,045.7**	**2,045.5**	**2,043.8**
arable lands	492.0	483.5	494.3	494.3	448.5	446.7	446.4	446.0
perennial plants	83.6	74.1	63.8	63.8	32.9	34.4	34.7	34.8
grasslands	137.5	138.9	138.9	138.9	127.1	121.1	121.1	121.0
pastures	666.1	694.0	694.0	694.0	1,104.3	1,051.3	1,051.3	1,050.8
other lands	-	-	-	-	388.1	392.2	392.0	391.2

Source: SC (1991, 1995, 2001, 2011, 2018 Yearbooks)

[76] https://www.armstat.am/file/article/sv_06_18a_ 5250.pdf
[77] RA Housing Stock and Utilities (2017)
[78] State program for management, exploitation and maintenance of multi-apartment buildings (2008)
[79] http://nature-ic.am/Content/announcements/7478/LL%20Buildings%20Report%20final.pdf
[80] Social-economic Outlook of Armenia in 2016 https://www.armstat.am/file/article/sv_12_17a_122.pdf

Table 1-10. Number of livestock and poultry, thousand heads (as of January 1)[81]

Cattle and poultry	1990	1995	2000	2005	2010	2015	2016	2017
Large cattle	690.0	503.7	478.7	573.3	570.6	688.5	701.5	655.8
Sheep and goats	1,291.0	636.0	548.6	603.3	511.0	745.8	778.1	727.1
Swine	329.3	82.3	70.6	89.1	112.6	142.4	174.8	175.5
Poultry	11,245	2,912.6	4,255.1	4,861.7	4,134.6	4,145.5	3,942.8	3,814.2

Source: SC (1991, 1995, 2001, 2006, 2011, 2018)

The main types of agricultural output in Armenia are presented in Table 1.11.

Table 1-11. Main types of agricultural output in Armenia, thousand t

	1990	1995	2000	2005	2010	2015	2016	2017
Grains	271.0	262.7	224.8	396.2	326.4	601.5	604.2	302.5
Potatoes	212.5	427.7	290.3	564.2	482.0	607.7	606.3	547.4
Vegetables	389.7	450.9	375.7	663.8	707.6	1007.5	968.6	861.0
Melons	31.4	54.0	52.8	117.8	132.5	286.8	236.1	215.8
Fruit and berries	155.5	146.1	128.5	315.6	128.5	377.1	242.6	361.6
Grapes	143.6	154.9	115.8	164.4	222.9	309.2	178.8	210.0
Cattle and poultry for slaughter (live weight)	145.1*	82.4*	85.8**	99.1	124.3	176.1	187.1	192.5
Milk	441.9	428.3	452.1	594.6	600.9	728.6	754.2	758.2
Eggs (million units)	517.9	197.6	385.4	518.2	702.2	659.8	694.6	683.0

Source: SC (1990, 1996, 2001, 2006, 2011, 2016, 2017, 2018)
** https://www.armstat.am/file/article/gyux_90_99_2.pdf, page. 129, **1999*

Forestry. As of 2016, the total area of forest lands in Armenia encompasses 334.1 thousand hectares[82], 86.6% of which are covered by forests[83]. The forest-covered areas in SPANs (335.4 thousand hectares[84]) are 110.3 thousand hectares[85].

Forest areas, depending on climatic conditions and anthropogenic impacts, are unevenly distributed in Armenia: north and northeast (62%), south-east (36%) and central zones (2%)[86].

There are about 270 species of trees and shrubs in the forests, of which the main types of natural forest-forming types are oak, beech, hornbeam and pine. Beech forests are located only in northern Armenia, at altitudes of 800 to 2000 m above the sea level. Oak forests have more complex, diverse structure and composition, as they grow in all regions of Armenia, at altitudes of 600 m to 2200 m above the sea level. Mixed oak-beech and oak-hornbeam forests are common. There are also pine forests that occupy very small areas. The forests of the sub-alpine zone are spread from 1900 to 2300 m above the sea level. The main types found here are *Betula litwinowii Doluch, Acer trautvetteri*, Fraxinus, which are distinguished by low forest basal area.

According to various official sources, the post-independence energy crisis and transport blockade have led to unprecedented mass illegal logging, with volumes estimated to range from 0.7-1.0 million m^3/year in 1992-1995[87]; 1 million m^3/year in

[81] https://www.armstat.am/file/article/f_sec_4_2017_3.pdf
[82] 2016 Land Balance of Armenia https://www.cadastre.am/storage/files/pages/pg_7729855464_KV1059k.voroshum.pdf
[83] https://www.armstat.am/file/article/sv_03_17a_5320.pdf
[84] https://www.cadastre.am/storage/files/pages/pg_772985 5464_KV1059k.voroshum.pdf
[85] https://www.arlis.am/DocumentView.aspx?DocID=93166
[86] Khurshudyan, P., 1999; Makhatadze L.and Hakhinyan H.,1974; Khurshudyan P.A. Armenia's forests in the historical past, present state and vulnerability of forest cenosis to climate change (pp. 110-121). Armenia. Climate Change Issues / Collection of Articles, Editor: A. Gabrielyan-Yerevan, 1999a) - 373 pages.
[87] National Environmental Action Plan for Armenia, 1997.

the 6 years preceding 2002[88]; 847 thousand m^3 in 2003[89] and 457 thousand m^3 in 2010[90].

Mass harvesting of timber has significantly exceeded the rate of natural forest growth and consequently, led to a significant increase in the number of instances of forest ecosystems degradation and adverse effects (erosion, landslides, mudflows, etc.). Degraded forest systems only partially exploit the potential for natural growth. Reduction of forested areas results in fragmentation of vegetation and animal populations areal, loss of biodiversity, increased carbon dioxide in the atmosphere, and diminishes the forests' functionality of absorption and storage of carbon dioxide from the atmosphere.

In 2008-2012, there was a significant decrease in illegal logging due to the development of the gas supply system[91].

According to the 2015 Global Assessment of Forest Resources Report, carbon accumulation rate in the RA for 2015 was estimated approximately 92.4 tons[92] per hectare while in 2010 it was 110 tons[93].

Restoration of forests requires large-scale reforestation and afforestation measures. During the period of 1998-2006, the volume of reforestation and afforestation activities comprised 2,150 hectares[94]; in 2006-2012 - 2,754 hectares and in 2013-2018 – 3,303 hectares[95].

For the purpose of expanding forested areas, the Forest Code (2005) also stipulates the right of community and private ownership of forests founded by them.

According to the Forest Code, forests of Armenia, regardless of their form of ownership, are classified into protective, special and productive forest types, depending on their designated purpose. The protective group of forests also includes the 200 m area spanning upper and lower boundaries of the forest, as well as forests growing in semi-desert, steppe and forest-steppe zones. This circumstance is particularly important in terms of mitigating the vulnerability of forests due to climate change, as the types of deforestation in this group are limited.

Armenia's forests and forest lands are under the state ownership and are managed by the MoE since 2018. Until 2018, 75% of Armenia's forests were managed by the "ArmForest" SNCO operating under the Ministry of Agriculture, and 25% (the forest bulks in SPANs) - by the Ministry of Nature Protection[96].

The RA National Forest Policy and Strategy and the RA National Forest Program (2005) are aimed at the protection, restoration, natural reproduction and sustainable use of forests.

1.10 Waste

In Armenia, the waste sector comprises the following categories: disposal of solid waste (SW), waste incineration and open burning, wastewater treatment and disposal.

Disposal of solid waste. As of 2019, the SWs in marzes are being collected, transported and stored in 339 landfills[97]. The total area of landfills, according to the inventory made by the RA Ministry of Territorial Administration and Development in 2017, was 494 hectares[98].

Waste disposal is carried out in 444 out of 502 communities in Armenia. In 58 rural communities waste disposal services are not yet provided. The population of the 58 rural settlements not included in the waste disposal system is 46,000 or 1.6% of the country's population[99].

According to the information provided by the Ministry of Territorial Administration and Infrastructure, about 650 thousand tons of

[88] http://www.un.org/esa/agenda21/natlinfo/wssd/armenia.pdf
[89] Illegal Logging – Survey and Analysis. Draft Final Report, March 2004. Ministry of Nature Protection /Swedish international development agency, prepared by: Andrew Mitchell.
[90] ICARE foundation, 2011.
[91] 5th National report on biodiversity of Armenia http://www.mnp.am/uploads/1/1551884521pdfresizer.com-pdf-resize.pdf
[92] Country Report FRA - 2015, Armenia
[93] Country Report FRA - 2010, Armenia
[94] http://www.mnp.am/uploads/1/1509988693BUR-Report_arm.pdf
[95] SC, Environment and natural resources in Armenia (2006-2018)
[96] 5th National report on biodiversity of Armenia
[97] RA draft strategy on Waste Disposal System Management, https://www.e-draft.am/projects/2003/about
[98] Ibid.
[99] Ibid.

SW is generated annually in Armenia[100]. There are no direct estimates of the accurate quantity of waste produced in the country. The data presented are based on a theoretical approximate estimate according to the norms established for Yerevan and other urban and rural areas for generated waste per capita and the average number of population[101].

In general, preliminary sorting of waste is not yet practiced in the country[102]. Unsorted and mixed SW is considered hazardous waste[103].

The decomposable organic carbon in SW amounts to 50-60%. In 2017, the amount of waste increased by 40%, as compared to 1990.

Until 2006, 100% of SW, and from 2006 onwards - 70% of SW in the capital city of Yerevan has been transported to the largest managed landfill in the country – Nubarashen landfill, with anaerobic destruction of SW. Starting from 2006, 30% of Yerevan SW is transported to deep-layered non-managed landfills in Jrvezh, Spandaryan and Sasunik. In the cities of Gyumri and Vanadzor as well, SW is being transported to deep-layered non-managed landfills; in 45 other cities of the country – to non-deep-layered non-managed landfills.

Open waste incineration. In rural areas of Armenia, vegetable waste (tree branches, dried leaves, grass, etc.) generated by gardens and land plots are burned on site. In rural communities where no waste disposal services are provided, household waste is incinerated or voluntarily disposed in the areas adjacent to the roads, in one of the nearby gorges and periodically burned.

The amount of open waste incineration was calculated based on the number of the rural population. The national factor of 0.40 kg/person/day (or 0.146 ton/person/year) was used for determining the per capita SW generation ratio for rural population.

Wastewater, includes household, commercial and industrial wastewater. In 2017, the annual wastewater drainage volume[104] was 551 million m^3.

Until 1990, all 48 cities of Armenia were connected to the sewerage system serving 60-80% of the urban population. 20 mechanical wastewater treatment plants were operating in Armenia, with a total capacity of 958 thousand m^3/day and served only cities and neighboring villages. Wastewater from remaining settlements was directly discharged into the surface water basins.

Currently the service area of wastewater system in Armenia is limited, serving only 70% of the population. In 2017, in large and medium cities household and commercial wastewater was discharged through sewerage systems; in rural areas - mainly by drains and wells. In 2017, the volume of wastewater discharged to the sewage was 102.6[105] million m^3.

There are only a limited number of wastewater treatment plants (6) and they perform only mechanical treatment. The treatment plants are extremely obsolete in technical terms, and some of them are in destructed condition. During the period of 2012-2014, new mechanical wastewater treatment plants have been put into operation in 4 cities. Also, the mechanical treatment plant of Yerevan "Aeration" was relaunched in 2016.

In 2020, the RA Law HO-126-N “On Making Addendum and Amendments to the RA Water Code” of March 2, 2018, stipulating the provisions related to wastewater treatment and disposal, which will be mandatory for implementation, as well as the RA Government Decree No. 589-A, dated May 29, 2012, “On Approving the List of Measures to Support the Implementation of the RA Law “On Making Addendum and Amendments to the RA Water Code” deriving from this Law, will enter into force.

Mechanical treatment plants are operating in Martuni, Gavar and Vardenis cities, while the Sevan treatment plant is under construction.

[100] http://mtad.am/u_files/file/2018/P&G%20feasibility%20in%20Armenia_AM.pdf
[101] Ibid.
[102] RA 2017-2036 Strategy for Development of the SW Management System http://www.irtek.am/views/act.aspx?aid=88196 (Part 1), http://www.irtek.am/views/act.aspx?aid=88197 (Part 2)
[103] http://mtad.am/u_files/file/2018/P&G%20feasibility% 20in%20Armenia_AM.pdf
[104] SC, Statistical indicators 2017, https://www.armstat.am/am/?nid=12&id=14006&submit=%D5%93%D5%B6%D5%BF%D6%80%D5%A5%D5%AC
[105] https://www.armstat.am/file/article/sv_03_18a_5350.pdf

According to Point 2.10 of the Appendix approved by the RA Government Decree No. 1239-L of September 30, 2019 "On Approving the 2020 Annual Program of Measures for the Restoration, Conservation, Reproduction, Natural Development and Use of Lake Sevan Ecosystems", it is envisaged to develop the design estimate documents for construction of the biological treatment component to operate within Gavar, Martuni and Vardenis wastewater treatment plants.

1.11 Specific Indicators for GHG Emissions and Energy Intensity of GDP

In 2016, CO_2 emissions per unit of GDP (by PPP) amounted to 0.212 tons CO_2/USD thousand, demonstrating some declining trend since 2012. This is due to the widespread use of renewable energy resources, the use of low-carbon technologies, and the implementation of EE measures, which are an evidence of Armenia's low-carbon development trends.

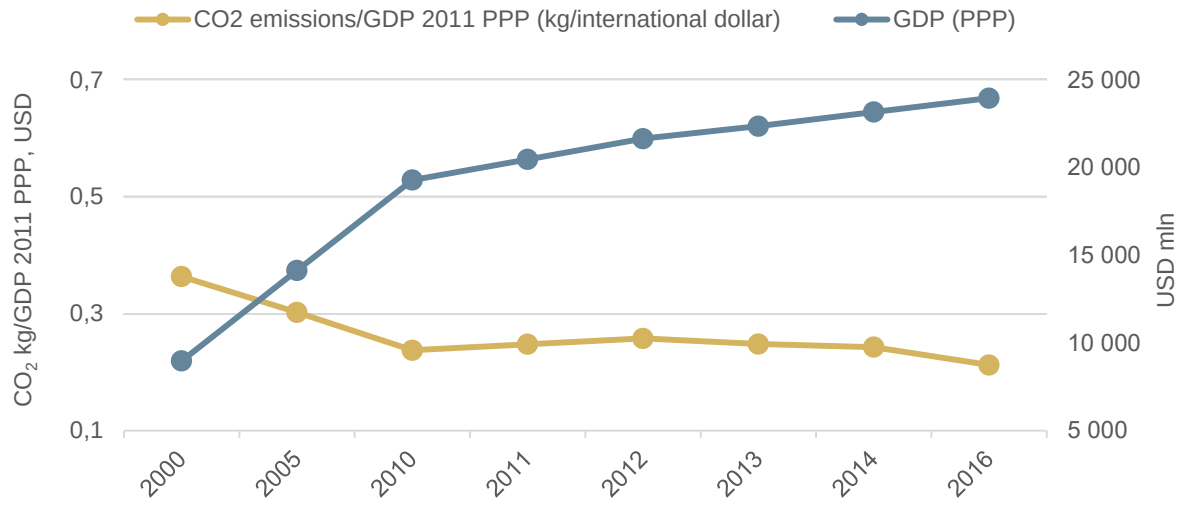


Figure 1-9. Dynamics of GDP and GHG emissions in 2000-2016

As for GDP (PPP) energy intensity, in 2016, it comprised 0.131 ktoe, also demonstrating a downward trend, due to structural changes in the economy, in addition to the above reasons.

1.12 Tourism

Tourism in Armenia is one of the most dynamically developing sectors of the country with its development rates and results. The objectives of the state tourism policy are set out in the RA Law "On Tourism and Tourism Activities" and the Tourism Development Concept approved by the Government of the Republic of Armenia on February 13, 2008.

Armenia has been included in the World Tourism and Travel Competitiveness Report published by the World Economic Forum for the seventh year in a row. According to the 2017 Tourism Competitiveness Report, Armenia ranks 84th among 136 countries in terms of tourism competitiveness.

During its long history of existence (over 3,000 years), Armenia has been at the forefront of various conflicts. Being the first country in the world to adopt Christianity, it is rich in monasteries and churches dating back to thousands of years and by far being among the most attractive tourist destinations. The Government of Armenia will be striving to continuously improve tourism competitiveness of Armenia in the global market to ensure a steady increase in the number of inbound tourists to Armenia[106].

The Government intends to increase the number of tourist visits to at least 3 million annually in the period of 2017-2022. The Government also aims to promote the development of ecotourism and related services, as well as agrotourism in the

[106] RA Government Programme, 2017-2022

Armenian ecosystems, along with a number of other subsectors.

Located in the center of the Caucasus, characterized by its exceptionally rich ecosystems and being one of the 34 hotspots of biodiversity around the world, Armenia has an enormous potential for ecotourism development.

The policy adopted by the GoA to increase the quantity and coverage of protected areas also contributes to the development of ecotourism. The sector has experienced significant upgrades due to the Government's recognition of ecotourism development as a priority area: 549,128 tourists visited protected areas in 2017, 20% of which were from abroad.

1.13 Legal Framework and Institutional Structure for Elaboration of National Communications

Armenia ratified the UNFCCC in 1993 and the Kyoto Protocol in 2002. The RA National Assembly ratified the Paris Agreement and Doha Amendment to the Kyoto Protocol on February 8, 2017.

Obligations of the Republic of Armenia within the framework of the aforementioned international multilateral agreements derive from the status of a developing country acting as a non-Annex I party to the UNFCCC. The country's position under the Convention and the Paris Agreement is set out in the “Intended Nationally Determined Contributions” document, approved by the GoA Protocol Decree No. 41, dated September 10, 2015, and submitted to UNFCCC on September 22, 2015.

As of 2018, Armenia has elaborated and submitted to the Convention Secretariat three National Communications (in 1998, 2010 and 2015) and two Biennial Update Reports (in 2016 and 2018), as well as separate reports of national GHG inventories related to these reports[107].

The MoE is responsible for coordinating the implementation of Convention activities in the country, including RA National Communications and Biennial Update Reports. Since 2017, the Minister of Nature Protection has been acting as the UNFCCC National Focal Point and the Designated National Authority for the Clean Development Mechanism (CDM) of the Kyoto Protocol.

In 2015, within the structure of MNP administration a Climate Change and Atmospheric Air Protection Policy Division was established as a unit within the Environmental Policy Department. To ensure consistent, complete and timely presentation of information pertaining to the implementation of the Convention, the functions of this Division include the coordination of development of national communications and biennial update reports.

A number of steps have been taken to improve the preparation, validation and submission of National Communications and Biennial Update Reports, in view of more stringent national reporting requirements (both in terms of frequency and content) set out for non-Annex I Countries under UNFCCC.

Since the entry into force of the UNFCCC, the GoA endorses with a five-year periodicity the list of measures aimed at fulfilling the country's commitments under the Convention. In this context, in 2016, the GoA adopted the Protocol Decree No. 49 “On Approving the List of Activities for the Implementation of RA Commitments Deriving from a Number of Environmental International Conventions Ratified by the RA”, which stipulates the list of measures for 2017-2021 and responsible agencies assigned to fulfil the commitments and provisions deriving from the UNFCCC and the Paris Agreement.

The list of measures includes “The development of the Second Biennial Update Report on Climate Change, as well as subsequent update reports with a biennial periodicity and their submission to the Convention Secretariat in accordance with the established procedure” as a measure.

By the Decree of the Prime Minister of the Republic of Armenia No. 955-A of 2012, an “Inter-Agency Coordination Council for the Implementation of the Requirements and Provisions of the UNFCCC” was established[108], comprised of 14 ministries

[107] https://unfccc.int/BURs

[108] https://www.arlis.am/DocumentView.aspx?docID=78543

operating in the mentioned period, representatives of two bodies adjunct to the Government, the National Statistical Service[109], the PSRC and the National Academy of Sciences[110]. The Minister of Environment is the Chairman of the Council. The Council is an inter-agency body aiming to ensure inter-sectoral coordination. A Working Group has been set up to support the work of the Council, which is composed of representatives from ministries and government agencies, as well as climate change experts and consultants. The Working Group includes representatives of all agencies included in the Council, which support the fulfillment of Armenia's reporting obligations as a Party, including the development of national GHG inventories.

In 2015, Armenia joined the Sendai Framework for Disaster Risk Reduction 2015-2030, and accordingly, the National Disaster Risk Management Strategy and Action Plan was developed and adopted by the RA Government Decree of April 6, 2017[111], with the aim of protecting people, their health, property, livelihoods, as well as their production, cultural and environmental values from disaster risks.

Since 2018, Armenia has been a member of the Nationally Determined Contributions Partnership. The development and monitoring of the roadmap for the periodic review and implementation of the Nationally Determined Contributions of Armenia under the Paris Agreement requires revision of the functions of the Inter-agency Coordination Council, which is planned to be implemented in 2020.

On April 18, 2018, the Armenian Parliament ratified the Comprehensive and Extended Partnership Agreement (CEPA) between Armenia and the European Union[112], which fosters co-operation on measures taken at national, regional and international levels in terms of research, development and transfer of knowledge in the areas of climate change mitigation, adaptation and innovative low-carbon technology, as well as towards directing general and sectoral policies for climate change monitoring, awareness raising, education and training. The Parties also agreed to expand and strengthen cooperation in the fields of transport and energy, in the framework of which a roadmap and an action plan have been developed and approved.

By the Protocol Decree No. 50 of December 15, 2016, the GoA approved the concept of the draft Law "On Atmospheric Air Protection". Among other changes, the Law also envisages establishment of a unified system for registration of harmful substances and GHG emissions, which will facilitate the fulfillment of Armenia's obligations under international environmental conventions, as well as ensure the comparability of information presented under different conventions. In 2019, the revised draft of the Law was submitted by the MoE to the GoA for approval.

By the law of the Republic of Armenia of 2018 "On the Structure and Activities of the Government", the new structure of the Government was approved, according to which the Ministry of Nature Protection was renamed the Ministry of Environment. By the RA Prime Minister's Decree No. 745-L of June 1, 2018 "On the Approval of the Charter of the Ministry of Nature Protection of the Republic of Armenia", the Charter of the MNP was approved, based on the RA Laws "On Structure and Activities of the Government" and "On the State Administration System Agencies" of March 23, 2018, by which the development and implementation of the Government's policy on addressing climate change, including adaptation measures, as well as ensuring compliance with relevant international obligations was delegated to the MoE, among a number of other functions.

According to the GoA Program (2019)[113], the implementation of measures aimed at mitigation of climate change impact, as well as adaptation measures in line with international treaties is one of the priority areas of environmental management.

[109] National Statistical Service was reorganized into the RA Statistics Committee based on RA Law on Official Statistics, effective April 9, 2018

[110] Following the approval of the new structure of the Armenian government in 2019, there is a need to review the composition of the Council

[111] http://www.irtek.am/views/act.aspx?aid=89604

[112] https://www.mfa.am/filemanager/eu/CEPA_ARM_1.pdf

[113] https://www.gov.am/files/docs/3133.pdf

1.14 Climate-targeted Funding

Over the past 20 years, Armenia has received support from climate targeted funds to address climate change issues in Armenia, including needs assessment, policy development, GHG emission reductions, enhancing potential for adaptation to climate change in vulnerable areas, disaster risk reduction, as well as technology transfer, education and awareness-raising in targeted areas. The funded projects have been implemented by structures, such as UNDP, UNEP, UNIDO, WB, EBRD, IBRD, as well as the German Agency for International Cooperation (GIZ), USAID, MoE Environmental Projects Implementation Unit (EPIU) and a number of NGOs. Below the climate-targeted funds that have supported climate change projects in Armenia are presented.

Global Environmental Facility. The Global Environment Facility (GEF) (established in 1991) serves as an independent financial mechanism aimed at helping tackle the most pressing environmental issues globally, while also contributing to fulfilment of commitments made by countries under signed and ratified Conventions.

Since 2018, the Minister of Environment has been assigned as the GEF Operational Focal Point in Armenia.

During its operations, GEF has provided around USD 43 million grant resources to Armenia to implement 35 national environmental programs, of which 15 (approximately USD 19 million grant resources) have been allocated to support climate change issues in the country. Armenia has also received grant support from GEF in the context of financing 14 regional environmental projects (the total grant budget for regional projects amounts USD 179 million), 5 of which have also been channeled to address regional climate change issues (total grant budget - USD 139 million). Under the Small Grants Programme, the GEF has also provided a USD 1.5 million grant resources to fund climate change mitigation projects, which have been implemented by NGOs/ community-based organizations.

Climate Investment Funds (CIF). The CIF has approved a USD 40 million investment plan for Armenia within the framework of the Scaling up Renewable Energy Program (SREP) comprised of around USD 14 million of grants and USD 26 million of concessional loans. The USD 40 million of SREP funding is expected to catalyze roughly 4.5 times as much investment, most of which from the private sector (as equity or debt), and the commercial lending windows of multilateral development banks, including International Finance Corporation (IFC), ADB, EBRD[114].

Implementation of renewable technologies, geothermal and solar PV pilot projects in Armenia will help reduce investment and implementation risks, develop local markets and expertise, provide incentives and opportunities for conducting government reforms, in particular setting appropriate tariffs. Along with enhanced expertise, it is expected that project development costs will decrease, and some technologies may be possible to produce locally.

Green Climate Fund (GCF). In 2016, the GCF and the GoA signed the GCF Agreement on Privileges and Immunities.

The Designated National Authority of GCF in Armenia is the Ministry of Environment represented by the Minister (since 2018), mandated to approve financing projects in Armenia.

In 2019, the Deputy Minister of MoE was elected as a member of the Board of the GCF Supreme Council which is the decision-making authority for GCF.

The MoE EPIU is the only accredited national body in the region (28.02.2019), which is mandated with "direct access" to implement GCF projects with up to USD 10 million funding.

Armenia is the first country in Eurasia and the 10th in the world to receive a grant from the GCF. With a total of USD 33 million of GCF funding, the country is implementing the “De-Risking and Scaling-up Investment in Energy Efficient Building Retrofits”, “National Adaptation Planning” (UNDP), and

[114] https://www.worldbank.org/en/country/armenia/brief/srep, https://www.worldbank.org/en/news/press-release/2015/06/08/world-bank-supports-exploration-of-geothermal-resources-in-armenia

"Readiness Support" (EPIU) projects on in the country. There are also two ongoing regional projects, financed by the GCF and implemented by EBRD, which are aimed at financing green cities and sustainable energy.

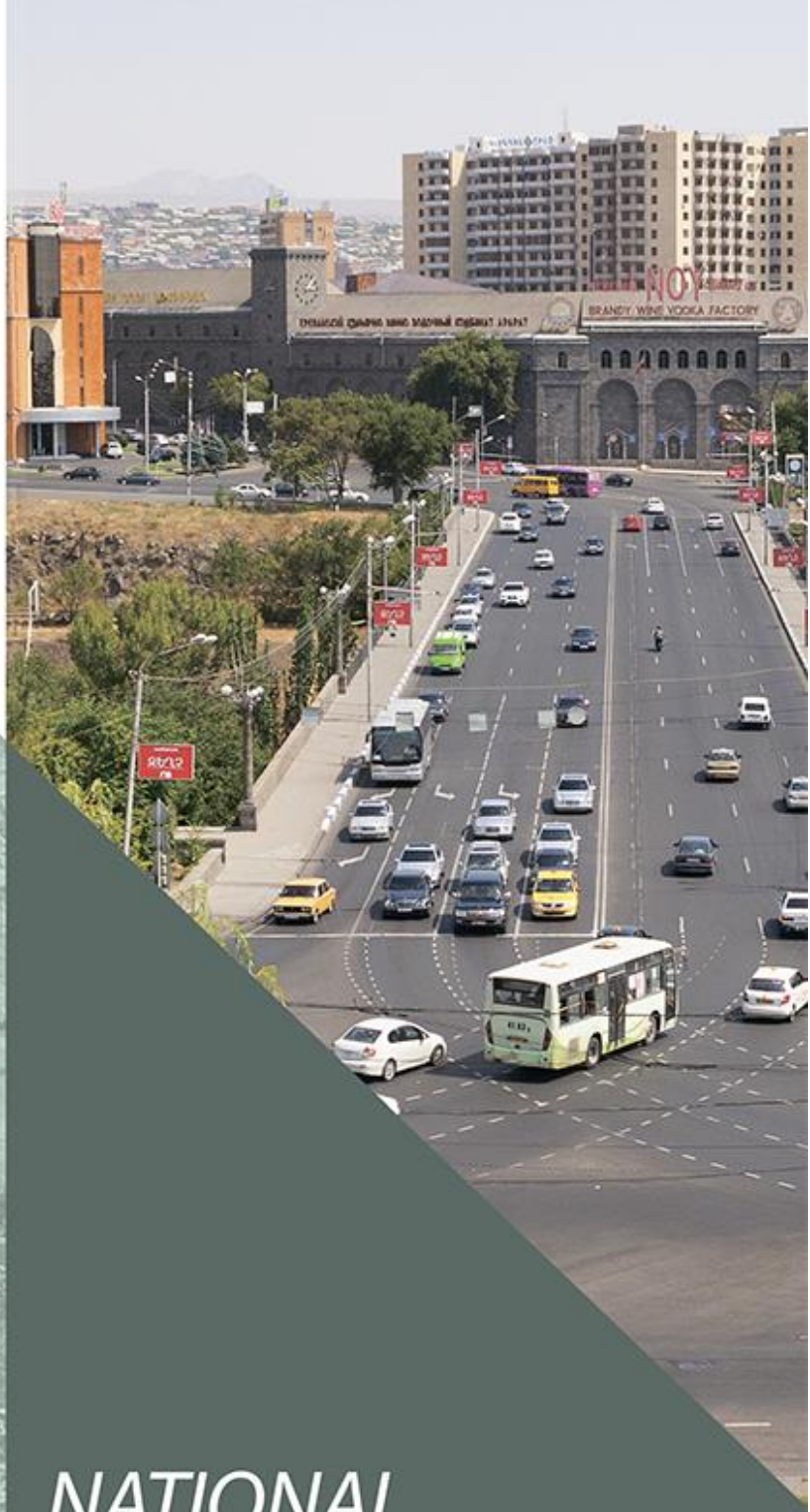
Adaptation Fund. On November 4, 2016, the MoE EPIU was accredited as the 25th National Implementing Body of the Adaptation Fund. Armenia is the first country in Eastern Europe with National Implementing Body having been granted "direct access" to the Fund's resources.

In 2018, the Adaptation Fund has endorsed an investment of approximately USD 4 million for Armenia to support the implementation of 4 projects aimed at urban development, agriculture, disaster risk reduction and in the social, gender, educational target areas.

Other sources of funding for climate projects. In addition to the support from targeted climate funds, Armenia has also received grant resources to implement climate change mitigation and adaptation programs from both bilateral and multilateral funding sources.

According to OECD's 2016 Study on Climate Financing for Armenia, for 2013-2014 about USD 200 million has been committed annually to Armenia to support climate change mitigation and adaptation measures. The main funding for climate-related development projects has been allocated to the energy, agriculture and water sectors - approximately USD 162 million annually (67.8% of total funding). The largest support was provided from the Federal Republic of Germany, WB, ADB and EBRD.

Funding for Armenia has been implemented through grants, concessional and non-concessional soft loans, as well as by means of other financial instruments.



2

NATIONAL GREENHOUSE GAS INVENTORY

2.1 Basic Information on GHG Inventory

After submission of the NC3 to the UNFCCC in 2015, Armenia elaborated its First and Second Biennial Update Reports (BURs), which were submitted to the UNFCCC in 2016 and 2018, respectively.

Within the framework of the BUR1 and BUR2, the National GHG Inventories Reports (NIRs) have been developed and submitted to the UNFCCC, as standalone reports. The inventory of GHGs reported under the BUR1 covered the years 2011 and 2012, and the years 2013 and 2014 were covered under the BUR2.

According to the Decision 1/CP.16 and 2/CP.17, Armenia's BUR1 and BUR2, including the NIRs, went through technical analyses in the framework of the International Consultation and Analysis (ICA) process

The comments and recommendations on the GHG Inventories, received from the ICA process, have been taken into account, to the possible extent, during development of each next inventory aimed at provision of the information in a more accurate, disaggregated and complete way.

Within the framework of the NC4, the GHG Inventory for the years 2015 and 2016 was developed in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The GHG Inventory covers emissions and removals assessment of four gases with direct greenhouse effect: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFC_s) for the time series of 2000 to 2016. The Inventory includes also estimates of gases with indirect greenhouse effect: carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds ($NMVOC_s$) and sulphur dioxide (SO_2).

According to the 2006 IPCC Guidelines, the following sectors were covered by the GHG Inventory: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste. The GHG Inventory also includes a Summary Report, sectoral tables of Inventory, key category analyses (KCA), uncertainty analysis, consistent time series for the years 2000-2016 and summary information on inventories for previous submission years: from 1990 to 2016.

Withing the framework of the NC4, the following improvements were made under the Inventory: GHG emissions were assessed for two new sub-categories in the Agriculture sector and the KCA was done at a more disaggregated level.

2.2 Institutional Mechanisms and Processes for GHG Inventory Development

An Inventory expert group was formed on a competitive basis with the involvement of experts engaged in preparation of the previous inventories and familiar with 2006 IPCC Guidelines and the software to ensure continuity and quality of the assessment process. The expert group worked in close cooperation with the Climate Change and Atmospheric Air Protection Division of the Environmental Protection Policy Department of the MoE. The institutional chart for development of the GHG Inventory is presented in Figure 2-1.

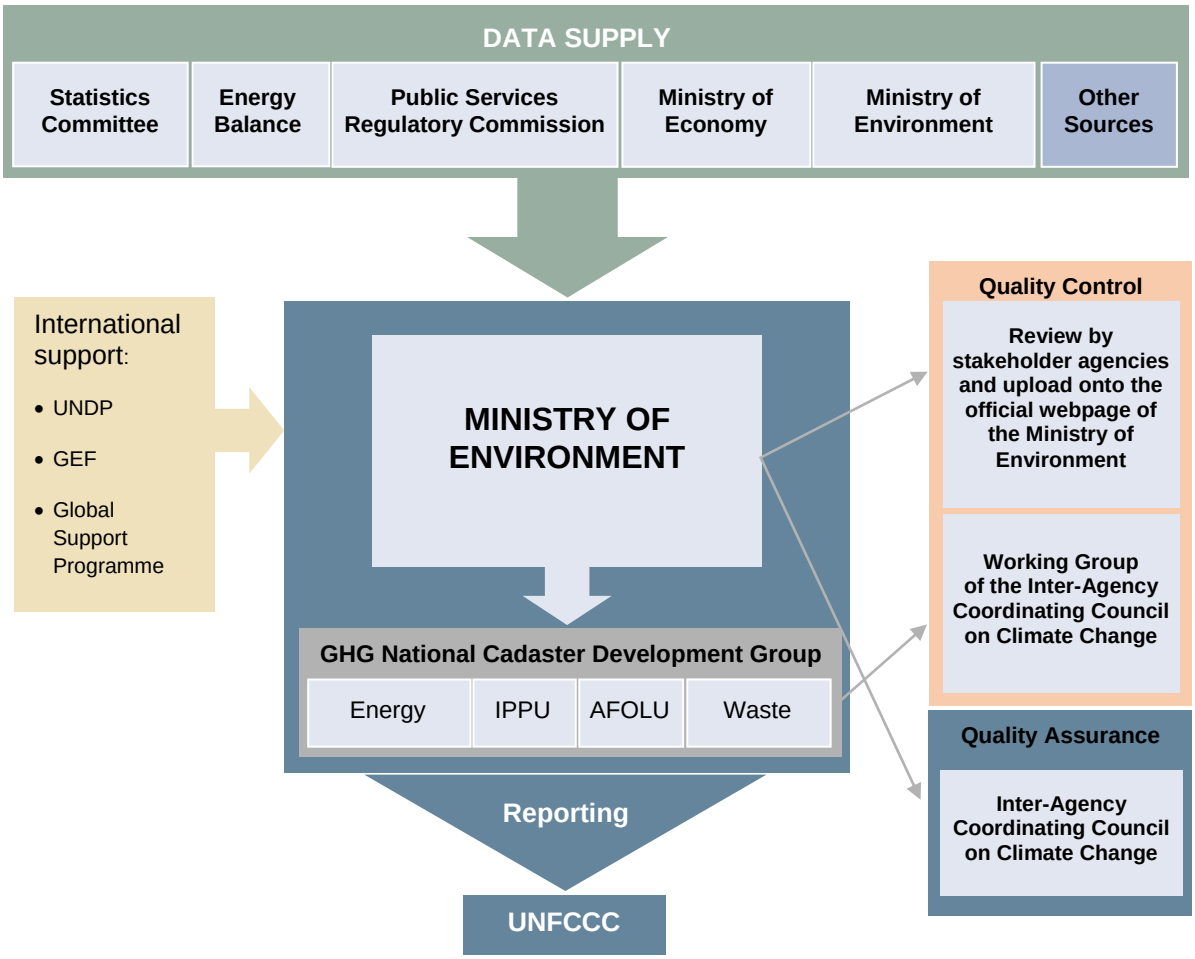


Figure 2-1. Institutional chart for development of the national GHG Inventory

2.3 Overview of the Used Methodology

Guidelines

The GHG Inventory was prepared according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The IPCC 2006 Inventory Software, developed for these Guidelines, was used for data entry, emissions calculation, results analysis and conclusions.

Good Practice Guidelines and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), Good Practice Guidelines for Land Use, Land Use Change and Forestry (IPCC 2003) and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, as well as the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventories were used, when needed, during the preparation of the National Inventory.

Global warming potentials

The estimated CH_4, N_2O, HFCs emissions were converted to CO_2 equivalent ($CO_{2\ eq.}$) using the Global Warming Potential (GWP) values provided by the IPCC in its Second Assessment Report[115] based on the effects of GHGs over a 100-year time horizon (See Table 2-1).

Table 2-1. GWP values

GHG	GWP
CO_2	1
CH_4	21
N_2O	310
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-152a	140
HFC-143a	3,800
HFC-227ea	2,900

[115] 1995 IPCC GWP Values

Methodologies

The national GHG inventory was prepared according to the principles described below:

- clear observation of the logic and structure of the 2006 IPCC Guidelines;
- priority given to the use of national data and factors;
- utilization of all possible sources of information;
- maximum use of the capacities of national information sources.

During the preparation of the GHG Inventory the highest priority was given to the estimation of the emissions of gases with direct greenhouse effect: CO_2, CH_4 and N_2O from the key categories, as well as the emissions of hydrofluorocarbons (HFCs).

Estimations were also made for emissions of gases with indirect greenhouse effect: CO, NO_x, NMVOCs and SO_2.

Emission estimates were based on the sectoral approach applying Tier 1, Tier 2 and Tier 3 methods.

Country-specific approaches were used for key categories, wherever possible, to produce more accurate emissions estimate than Tier 1 method.

The Tier 3 method was used for estimating emissions of CO_2 in the following key categories due to availability of disaggregated data:

- Energy sector - from electricity generation by natural gas fired thermal power plants (TPP); and
- IPPU sector - from cement production.

The Tier 2 method was used for estimating emissions from the following key categories:

- Energy sector – for estimating emissions of CO_2 from stationary (with the exception of electricity generation) and mobile combustion of natural gas (for the emission estimates from liquid fuel combustion the Tier 1 method was used), and CH_4 from fugitive emissions of natural gas;
- IPPU sector – for estimating emissions of HFCs from refrigeration and air-conditioning (RAC) applying the method 2A (estimation performed at a disaggregated level with country-specific data by sub-application and a default emission factor selected by sub-application from the 2006 IPCC Guidelines);
- AFOLU sector - for estimating emissions of CH_4 from cattle enteric fermentation and net CO_2 removals from "Forest Land Remaining Forest Land" category;
- Waste sector - for estimating emissions of CH_4 from solid waste disposal.

Other emissions were estimated with the Tier 1 method with default estimation parameters from the 2006 IPCC Guidelines and country-specific activity data.

In addition to assessments based on Sectoral Approach, the emissions of CO_2 from fuel combustion were also assessed by Reference Approach and the results were compared for checking purposes.

2.4 Activity Data Sources

The Energy sector emissions predominate in the country's total emissions. Hence, the development of the Energy Balance on a continuous basis along with measures aimed at its improvement is essential to ensure the enhancement of the emissions inventory, in terms of completeness, transparency, accuracy and comparability.

The RA Law on Making Amendments and Addenda to the Energy Saving and Renewable Energy Law was adopted in 2016, setting out the mandatory requirement for running, development and publication of the RA Energy Balance on annual basis by the Statistics Committee and the Ministry of Energy Infrastructures and Natural Resources, which is responsible for the development and implementation of the state policy on energy saving and renewable energy.

In 2017-2020, the Statistics Committee published the Energy Balance of Armenia for 2015, 2016, 2017 and 2018, which serve as the most important source of activity data for assessment of the Energy sector GHG emissions.

However, considering that the elaboration of energy balances is a new process and with the aim to improve accuracy of data in the Energy sector, activity data have been

collected from initial sources, including the PSRC and "Gazprom Armenia" CJSC and cross-checked with the Energy Balance data.

Besides, the expert team involved in the preparation of GHG inventory collaborated with the 2017 Energy Balance compilers for ensuring accuracy and consistency of the data reported.

The Statistics Committee has served as a main source of activity data for estimation of emissions from other sectors. Data were provided also by the Ministry of Finance, Ministry of Agriculture, the Ministry of Nature Protection, State Revenue Committee, State Committee of Real Estate Cadaster, as well as various private enterprises.

2.5 Main Outcomes of the GHG Inventory

Armenia's GHG emissions in 2016 totaled 10,283.94 Gg $CO_{2\ eq.}$ (without Forestry and Other Land Use). The emissions were approximately lower by 1.6% (168 Gg $CO_{2\ eq.}$) than those in 2014. The Summary Report for National GHG Inventory for 2016 is provided in Annex I.

Table 2-2 below provides GHG emissions estimates for 2015 and 2016. The data provided in Table 2-2 are summarized in Figures 2-2 and 2-3.

Table 2-2. GHG emissions by sectors and gases for 2015 and 2016, Gg

Sectors	CO_2		CH_4		N_2O		HFC		$CO_{2\ eq.}$	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Energy	5,137.32	4,946.62	74.55	77.17	0.09	0.09	NA	NA	6,730.94	6,594.49
Industrial Processes	193.45	134.44	NA	NA	NA	NA	NA	NA	193.45	134.44
F-gases	NA	NA	NA	NA	NA	NA	573.36	637.70	573.36	637.70
Agriculture	0.69	1.03	63.70	62.77	2.61	3.15	NA	NA	2147.96	2295.68
Waste	4.34	4.31	25.91	26.20	0.22	0.22	NA	NA	615.58	621.62
Total GHG Emissions	**5,335.79**	**5,086.41**	**164.16**	**166.15**	**2.92**	**3.45**	**573.36**	**637.70**	**10,261.27**	**10,283.94**
Forestry and Other Land Use	-477.57	-485.83	NA	NA	0.01	0.01	NA	NA	-474.45	-482.71
Net GHG Emissions	**4858.22**	**4600.57**	**164.16**	**166.15**	**2.94**	**3.47**	**573.36**	**637.70**	**9,786.83**	**9,801.24**

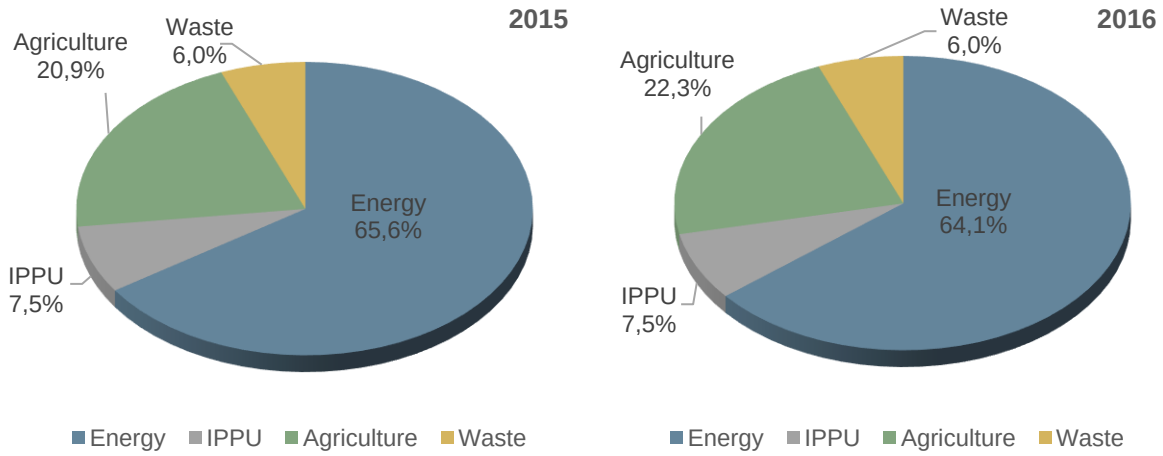


Figure 2-2. GHG emissions by sectors (without Forestry and Other Land Use sub-sector) in 2015, 2016, $CO_{2\ eq.}$

The Energy sector is by far the largest producer of GHG emissions. In 2015 and 2016, the Energy sector accounted for 65.6% and 64.1% respectively, of Armenia's total GHG emissions (Figure 2-2). The

Energy sector includes emissions from all use of fuels to generate energy, including fuel used in transport and fugitive emissions related to the transmission, storage and distribution of natural gas.

The second largest source of emissions is Agriculture sub-sector with a share of 20.9% and 22.3% in 2015 and 2016, correspondingly, followed by IPPU and Waste sectors. Their share did not change in 2015 and 2016 and amounted to 7.5% and 6.0%, respectively.

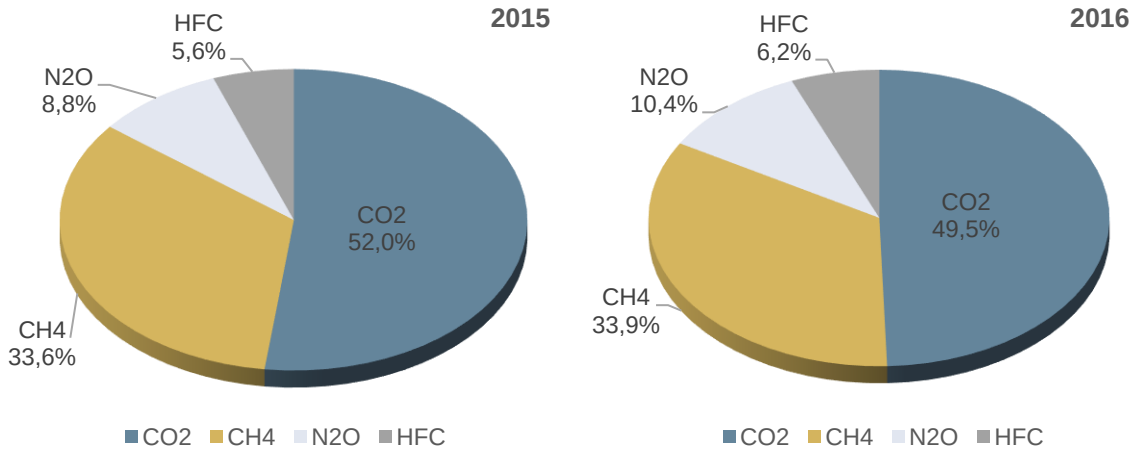


Figure 2-3. GHG emissions by gases in 2015, 2016 (without Forestry and Other Land Use sub-sector), $CO_{2\ eq.}$

The most significant GHG in Armenia's Inventory is carbon dioxide (CO_2), with a share of 52.0% and 49.5% in the total emissions in 2015 and 2016, correspondingly.

Figure 2-4 provides GHG emissions by sectors and gases for 2016.

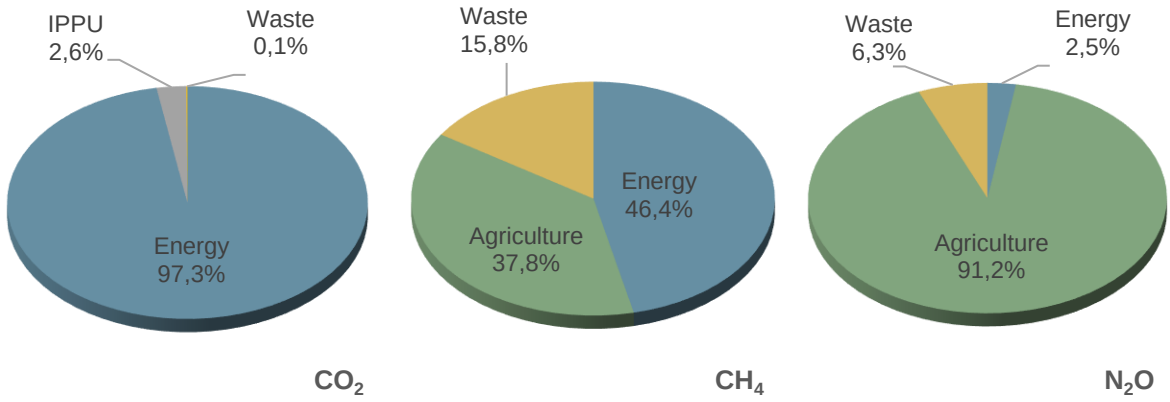


Figure 2-4. GHG emissions by sectors and gases (without Forestry and Other Land Use sub-sector), 2016

Most of the CO_2 emissions, about 97.3%, were emitted from the Energy sector in 2016 (Figure 2-4) because of the high emissions volume from thermal power plants, Residential and Road Transportation sub-sectors.

CO_2 emissions from the IPPU sector were significantly less and made up 2.6% of total carbon dioxide emissions, CO_2 emissions from Waste sector were negligible.

CH_4 emissions accounted for about 34% of the total emissions in 2016. Methane emissions are also mostly generated from the Energy sector (46.4%) due to the fugitive emissions from the natural gas system. The second one with its share of CH_4 emissions is the Agriculture sub-sector (37.8%) due to the emissions from enteric fermentation and the Waste sector is the third (15.8%).

Nitrous oxide emissions in 2016 made up 8.8% of total emissions. The prevailing part of nitrous oxide emissions (91.2%) was generated from the AFOLU sector mainly due to the direct and indirect emissions from managed soils.

F-gases in 2016 accounted for 6.2% of total GHG emissions, but their share has been growing continuously.

2.6 GHG Emissions Trends

Table 2-3 and Figure 2-5 present GHG emissions trends by sectors for 1990 and 2000-2016 in Gg $CO_{2\ eq.}$. Figure 2-5 shows the contribution of the sectors to the total GHG emissions and highlights the absolute predominance of energy-related emissions.

Table 2-3. GHG emissions by sectors from 1990 to 2016, Gg $CO_{2\ eq.}$

Sectors	1990	2000	2010	2012	2014	2015	2016	2016 emission change (%) compared to		
								1990 levels	2000 levels	2014 levels
Energy	22,712.16	4,299.08	5,829.59	6,916.70	7,013.63	6,730.94	6,594.49	-70.96	53.39	-5.98
IPPU	630.33	142.72	555.00	675.81	782.54	766.80	772.14	22.50	441.03	-1.33
Agriculture	1,989.21	1,326.67	1,462.26	1,827.11	2,044.72	2,147.96	2,295.68	15.41	73.04	12.27
Waste	438.99	532.94	582.61	598.55	611.19	615.58	621.62	41.60	16.64	1.71
Total GHG Emissions	**25,770.69**	**6,301.41**	**8,429.46**	**10,018.17**	**10,452.08**	**10,261.27**	**10,283.94**	-60.09	63.20	-1.61
Forestry and Other Land Use*	-736.00	-454.33	-540.59	-512.68	-477.14	-474.45	-482.71	-34.41	6.25	1.17
Net GHG Emissions	**25,034.69**	**5,847.09**	**7,888.86**	**9,505.50**	**9,974.94**	**9,786.83**	**9,801.24**	-60.85	67.63	-1.74

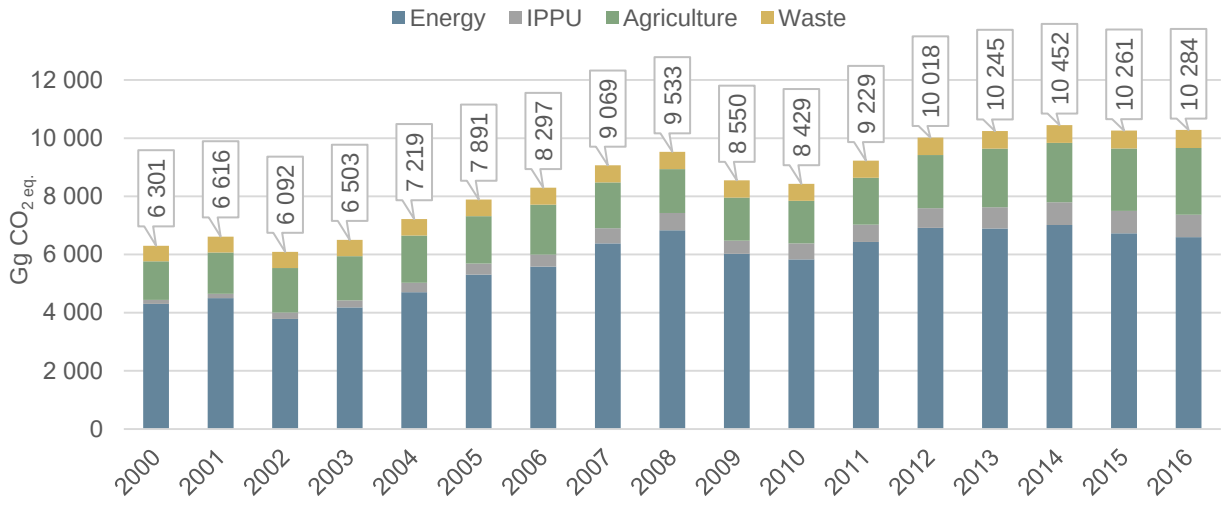


Figure 2-5. GHG emissions by sectors (without Forestry and Other Land Use sub-sector), 2000-2016, Gg $CO_{2\ eq.}$

As a whole, Armenia's total GHG emissions in 2016 decreased by 61% compared to 1990 levels. This was largely due to reduction of emissions from the Energy sector.

In 2016, the Energy sector emissions decreased by 3.4 times compared with the year 1990, while Total Primary Energy Supply (TPES) decreased by 2.6 times. These data can serve as an evidence of low-carbon development trends in Armenia. This was due to the structural changes in the economy, i.e. decreased share of energy intensive industries, increased share of the service sector, wide use of eco-friendly fuel – natural gas in transport and for energy production (which replaced mazut), recommissioning of the Armenian NPP, commissioning of the energy efficient TPPs, and strong growth of the SHPPs (as of 2018, 186 SHPPs were commissioned with a total installed capacity of 366.4 MW).

The increase of emissions in the Energy sector since 2000 is due to the economic growth, leading to increased traffic volume and improved household living conditions due to the wide use of natural gas for space heating. It became possible because of the unprecedented level of natural gas deliverability (nearly 95%) reached in the country since 2004. During 2000-2016, emissions from road transport increased by 130%, and emissions attributable to energy used by households increased over 5-fold.

In 2009, the financial and economic crisis affected the energy consumption, however, in 2010 emissions increased again as a result of economic recovery.

Annual emissions from electricity production vary considerably due to changes in electricity exports. The sharp increase of GHG emissions from the Energy sector in 2012, in comparison with 2010, was caused by the high export growth and increased power production by TPPs. Similarly, about 6% reduction of emissions from the Energy sector in 2016, compared to 2012, was caused by the electricity export reduction (by 40% or 644 GWh), as well as, to some extent, due to the decrease of losses in the distribution network (243 GWh). These variations have been the principal feature of CO_2 emissions trends in the Energy sector since 2010.

In addition, the Energy sector emissions are influenced each year by the economic situation in the country's energy intensive industries, weather conditions and the volumes of energy produced by the Armenian NPP and hydropower plants.

In industrial processes, the most significant source of emissions is CO_2 generated in cement production. A small amount of CO_2 emissions is also generated in non-cement clinker production and glass production. Emissions from industrial processes are mostly affected by changes in the production volumes. After the sharp decline of GHG emissions from the IPPU sector in 2009, due to the economic recession, which resulted in decrease of construction volumes and, consequently, cement production, starting from 2010, the construction volumes and cement production increased leading to subsequent increase in GHG emissions. However, since 2014, some reduction in the construction volume was recorded, which consequently led to reduction of CO_2 emissions from the cement production.

The increase of emissions from the IPPU sector since 2011 is primarily due to the increase of emissions of F-gases. F-gases form a category of their own under industrial processes. In 2016 the emissions from these gases accounted for 6.2% of total national emissions and 82% of the emissions from the IPPU sector. In the period from 2010 to 2016, the emissions of F-gases increased 2.4 times, mainly due to the wide use of F-gases in refrigeration and cooling devices.

Emissions from the Agriculture sector accounted for 22.3% of Armenia's total GHG emissions in 2016, showing a continuous upward trend since 2010. As a whole, emissions from the Agriculture sector in 2016 increased by about 73%, compared with the year 2000, which is primarily due to the increase in livestock population and nitrous oxide emissions from managed soils because of the use of fertilizers.

The Waste sector emissions accounted for 6% of the country's total emissions in 2016. During 2000-2016, the Waste sector emissions increased by 16.6% due to the growth in methane emissions from solid waste disposal, because of higher inertia and cumulative effect of organic matter decomposition process in anaerobic conditions.

Time series for 2000-2016 GHG emissions by gases are provided in Figure 2-6 below.

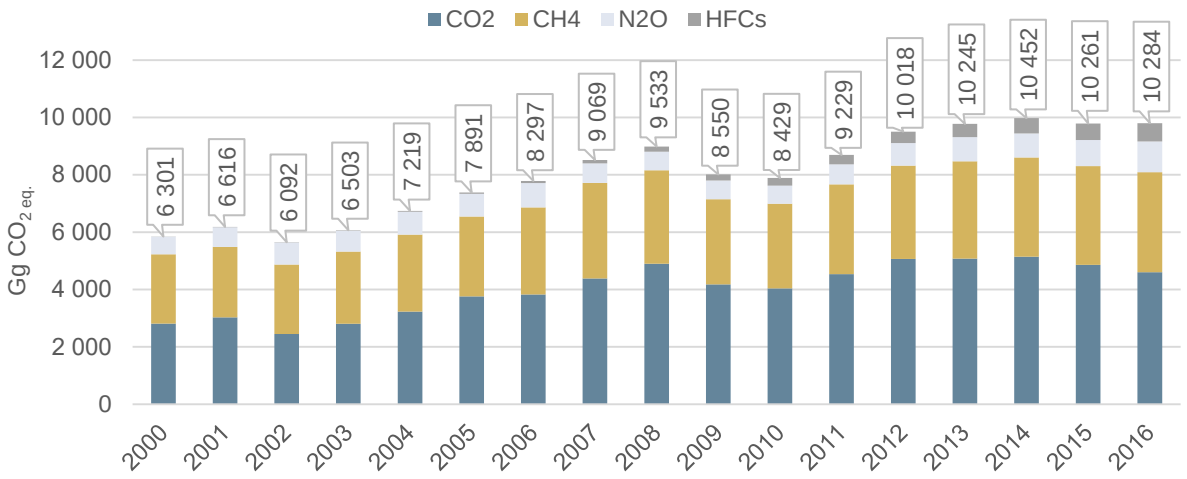


Figure 2-6. GHG emissions by gases (without Forestry and Other Land Use sub-sector), 2000-2016, Gg $CO_{2\ eq.}$

Each variation of GHG emissions is largely influenced by specific developments in a certain category.

Emissions of CO_2, most of which is caused by stationary and mobile fuel combustion processes, predominate in the overall GHG emissions, making up nearly 50% of total emissions in 2016, while the Energy sector produced roughly 97% of all CO_2 emissions in 2016.

The increase of overall emissions in 2016, compared to 2000, amounts to about 63%, which is mainly due to the increase of CO_2 emissions. The amount of CO_2 emissions is closely linked with the trends in the Energy sector, mainly caused by changes in electricity exports, consequent increase of thermal power generation, as well as road transport development and wide use of natural gas for space heating.

CH_4 emissions have increased by 44%, compared to 2000, which is primarily the result of the increase in the natural gas consumption and in livestock population.

N_2O emissions are closely linked with the developments in the Agriculture sector. The Agriculture sector accounted for approximately 91% of Armenia's total N_2O emissions in 2016, primarily due to the use of nitrogen-containing fertilizers and animal husbandry. Smaller amounts of N_2O emissions were caused by wastewater treatment. Since 2000, N_2O emissions have increased by about 74%.

In the period from 2005 to 2016, the biggest change occurred in the F-gases emissions: the emissions increased approximately 14 times, compared to 2005 (when Armenia started importing substitutes for ODS). Since 2005, the emissions of F-gases have increased continuously, which is due to substitution of the ODSs with HFCs. The dynamics of sustainable annual growth of emissions is observed in all applications, with the exception of aerosols. However, the emissions caused by refrigeration systems predominate in the overall picture of HFC emissions with a share of 95% in 2016.

2.7 Sectoral Inventories

2.7.1 Energy

The Energy sector is by far the biggest source of GHG emissions in the country: in 2016, its share in the country's total GHG emissions was over 64%. The emissions from the sector amounted to 6,594.5 Gg $CO_{2eq.}$ in 2016 (6,730.9 Gg $CO_{2\ eq.}$ in 2015), which were by 6.0% lower than those from the 2014 level and made up 29% of 1990 emissions level. The Energy sector emissions can be divided into two categories: emissions resulting from fossil fuel combustion (76% of sector emissions in 2016) and fugitive emissions from natural gas system (24% of sector emissions in 2016)[116].

[116] Public Services Regulatory Commission, 2016.

Armenia mainly relies on electricity and gas to meet the most of its energy consumption needs. Imported natural gas predominates in total primary energy supply in Armenia accounting for 59% of Armenia's TPES (2016) and 84.2% of the fossil fuel consumption. In 2016, nearly 83% of CO_2 emissions originated from fuel combustion, comprised emissions generated from natural gas combustion. This is due to a very high level of gas deliverability in the country – nearly 95%, as well as due to the widespread use of natural gas for heating purposes, because it is almost twice less expensive than using electricity for heating. Natural gas is also widely used in transport, since it is less expensive than petrol or diesel.

Armenia is ranked among the countries, where fuel prices are taxed rather than subsidized. There is no cross-subsidies from industrial to household consumers in Armenia, as opposed to a number of other countries in Eastern Europe, the Caucasus and Central Asia.

Emissions

GHG emissions in the Energy sector in 2016 by categories and sub-categories are presented in Figure 2-7.

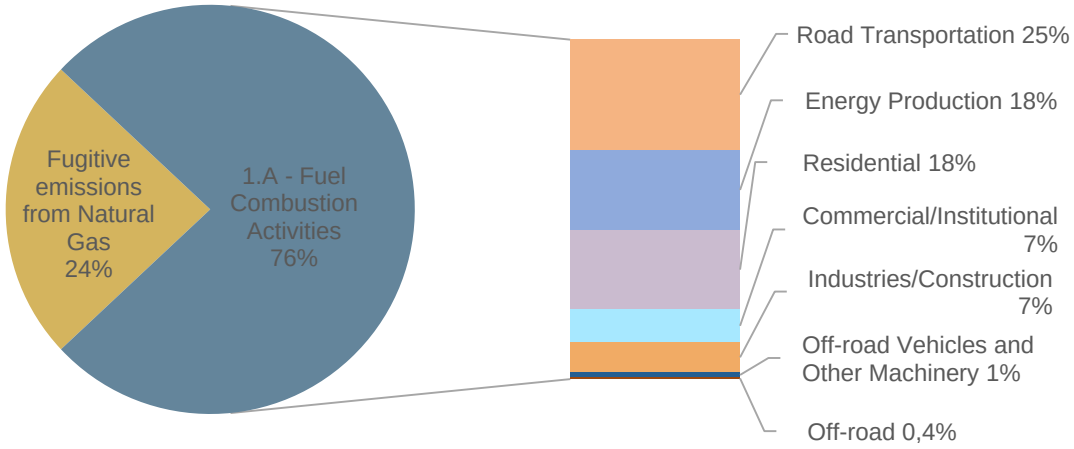


Figure 2-7. GHG emissions from the Energy sector, 2016

As of 2016, road transportation is the leading source of GHG emissions within the Energy sector, generating 25% of the sector emissions followed by fugitive emissions from natural gas, the share of which is 24%. The share of emissions from energy production and energy use by households are equal - 18% each. Emissions from industries and construction, as well as from commercial/institutional organizations make roughly 7% each. Emissions from off-road vehicles and machinery in agriculture are even smaller - make 1%, and emissions from off-road were negligible – 0.4%.

Since 2010, the emissions from electricity production have had considerable annual variations due to changes in electricity exports and production of electricity by natural gas fired TPPs, which have results in the Energy sector emissions variations, as a whole. The sharp increase in GHG emissions from the Energy sector in 2012, compared to 2010, was caused by high export growth and, subsequently, increased power production by TPPs. Similarly**,** nearly 27% of emissions reduction from electricity generation in 2016, compared to 2012, is caused by the electricity export reduction by 40% or 644 GWh (and to some extent – by reduction of losses in the distribution network (by 243 GWh) and corresponding reduction of electricity generation by TPPs by 24%.

The fuel consumption in industry and construction comprises mostly natural gas: as of 2016, its share was 88.2%, followed by diesel fuel in a much smaller quantities - 11.7%, and the share of coal consumption was negligible.

GHG emissions generated from industry and construction in 2016 amounted to 440.8 Gg $CO_{2\,eq.}$ and made up 7% of the Energy sector emissions.

Fuel consumption structure is quite specific, considering the absolute predominance of natural gas, which accounted for nearly 63% of the total fuel consumption in the road transport in 2016. GHG emissions generated from road transport in 2016 amounted to 1,628.8 Gg $CO_{2\ eq.}$ or made up about 25% of emissions from the Energy sector and about 16% of country's total emissions.

Road transport absolutely predominates in the total domestic transport emissions accounting for more than 98.8%. The emissions from road transport have grown since 2000 (with the exception of 2009, when the recession also affected the road transport and, subsequently, led to lower CO_2 emissions). During the period of 2000-2016, road transport emissions increased by about 130%, due to the growth in traffic volume.

Residential sector emissions amounted to 1,169.6 Gg $CO_{2\ eq}$. in 2016. During the period of 2000-2009, the emissions from the residential sub-sector have grown steadily (with the exception of 2010) because of the improved households' living conditions and unprecedented level of gasification in the country (about 95%) that led to widespread use of natural gas for space heating.

Natural gas is the main fuel consumed by households, making up nearly 72% of the total fuel consumption. As for the recent years, the decrease of emissions from households is largely due to the reduced natural gas consumption resulting from the increase in gas tariffs. However, in 2016 gas consumption and, consequently, the emissions from households increased because of gas tariff reduction.

Figure 2-8 provides Energy sector CO_2 emissions time series from fuel combustion per sub-categories.

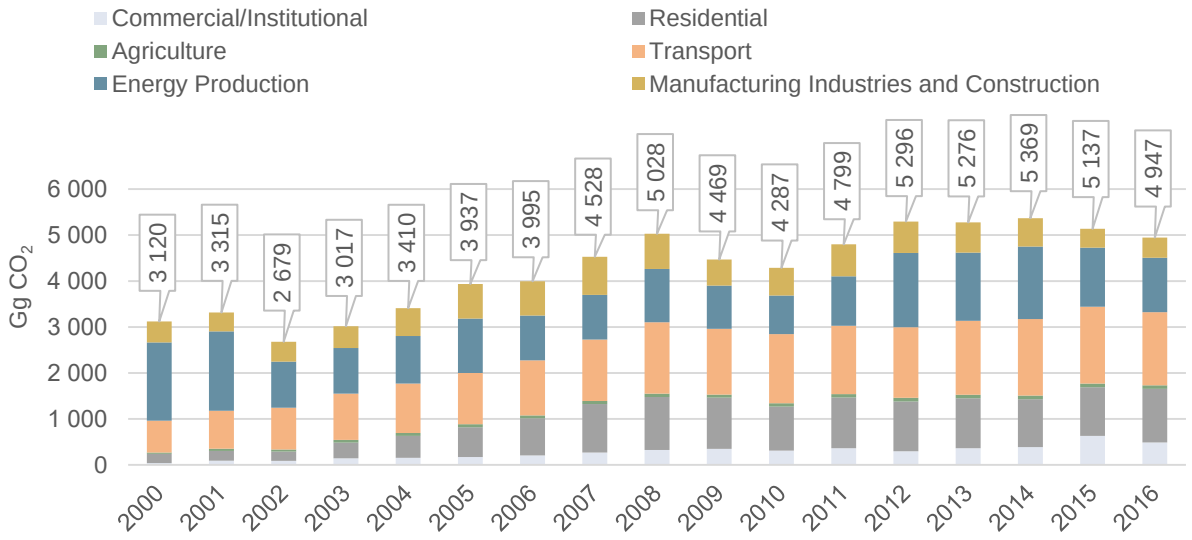


Figure 2-8. CO_2 emissions time series from fuel combustion, 2000-2016, Gg

Fugitive emissions have been estimated for natural gas transmission and distribution systems, which amounted to 1,580.7 Gg $CO_{2\ eq}$. in 2016. Methane fugitive emissions in Armenia are mainly due to the exploitation of natural gas systems (emergency leaks, leakages from technological measures, technological losses). The emissions have grown continuously since 2000 due to the gradual expansion of the natural gas distribution network, however, since 2008, they are in a relatively stable condition. Most of the methane emissions were recorded in 2007-2008, when the level of gasification in the country reached nearly 95%.

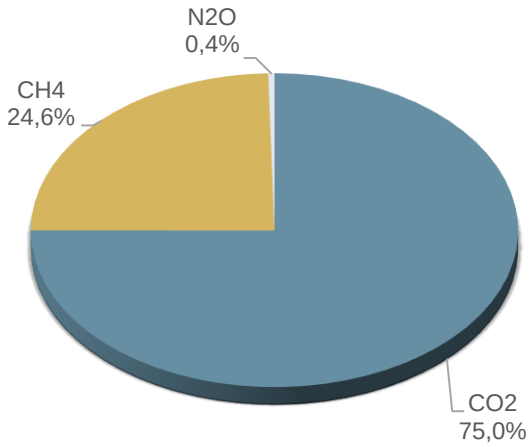


Figure 2-9. Energy sector emissions per GHGs, 2016

The main GHG in the Energy sector is carbon dioxide (Figure 2-9). In 2016, 75% of the emissions from the Energy sector comprised CO_2, 24.6% - CH_4 and N_2O emissions were negligible - 0.4%. Also, small amounts of other gases with indirect greenhouse effect are emitted, including CO, NOx, SO_2 and NMVOC.

Energy sector emissions time series per categories are provided in Figure 2-10.

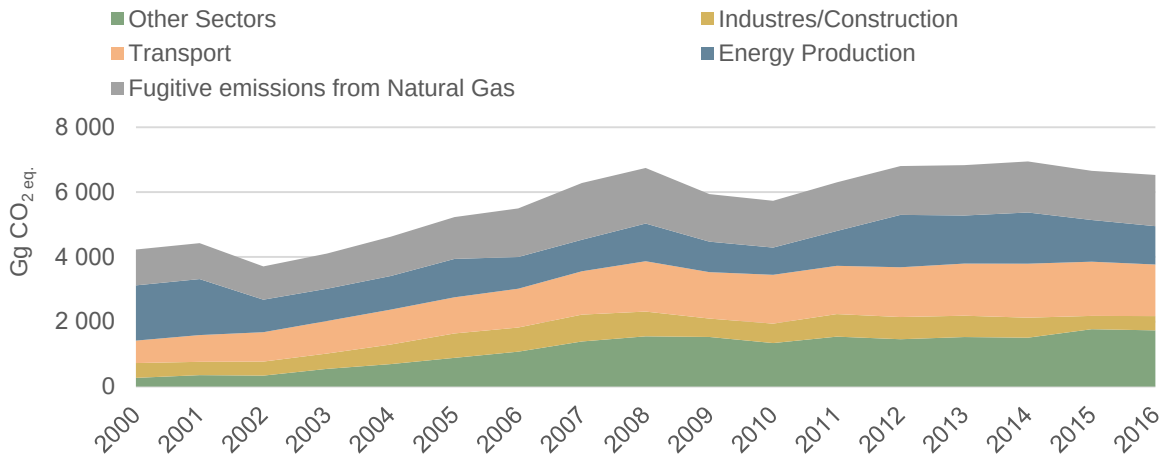


Figure 2-10. Energy sector emissions for per categories, 2000-2016, Gg $CO_{2\ eq.}$

Summary report on Energy sector green-house gas emissions is provided in Annex I.

2.7.2 Industrial Processes and Product Use

Emissions from this sector include non-energy related CO_2 emissions from cement production, non-cement clinker and glass production, SO_2 emissions from metal production, NMVOC emissions from solvent use, asphalt production and food and beverage industry, as well as emissions of F-gases from refrigeration, air conditioning, foam production and other products use.

Emissions from the IPPU sector amounted to 772.14 Gg $CO_{2\ eq.}$, which made up 7.5% of country's total emissions in 2016. CO_2 emissions from the Mineral Industry (cement and glass production) amounted to 134.44 Gg CO_2, while F-gases accounted for 637.7 Gg $CO_{2\ eq.}$ in 2016.

The prevailing part of CO_2 emissions is generated from cement production, which made up 16.9% of the emissions from the sector and about 1.3% of Armenia's total emissions in 2016. CO_2 emissions from glass production were negligible.

Figure 2-11 provides 2000-2016 CO_2 emissions time series from Mineral Industry category (cement and glass production).

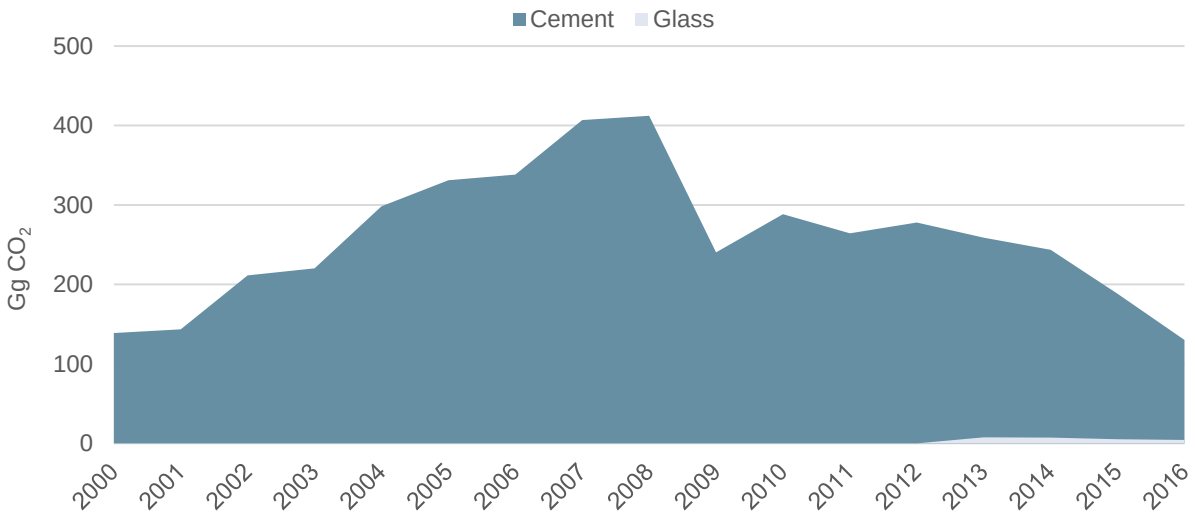


Figure 2-11. CO_2 emissions from Mineral Industry (cement and glass production), 2000-2016

Decline in CO_2 emissions in 2015 and 2016 is conditioned by the decrease in cement demand due to reduced construction volumes.

After the economic recovery, SO_2 emissions from metal copper and ferromolybdenum production have maintained a slight upward trend since 2010.

Some quantity of non-methane volatile organic compounds is emitted during asphalt paving, as well as resulting from the use of solvents, however, during 2015-2016 these emissions decreased as a result of reduced construction volumes.

F-gases accounted for nearly 82% of the emissions in the IPPU sector and over 6% of the total national GHG emissions in 2016. HFCs emissions, which are caused by refrigeration systems, predominate in the overall picture of HFC emissions with a share of over 95% in 2016. The share of emissions from other applications is about 5%.

In Armenia, as well as worldwide, HFCs came to replace ozone-depleting chloro-fluorocarbons (CFCs) and hydrochloro-fluorocarbons (HCFCs). Thus, after Armenia ratified the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol to the Convention on Substances that Deplete the Ozone Layer, the country committed to gradually abandon the use of ozone-depleting substances.

From F-gases Armenia largely uses Hydrofluorocarbons (HFCs).

HFCs and HFC-containing products began to be imported into Armenia mainly after 2005, when the first National Plan to replace the CFCs was launched in the country. In particular, following the adoption of the RA Law on Ozone Depleting Substances and the subsequent legislative acts to ensure its implementation, the import of CFCs into Armenia was gradually restricted and eventually banned in 2010. Simultaneously, a program was launched in the country aiming to ensure substitution of HCFCs. All of these circumstances led to drastic increase in the volume of imported HFCs after 2010.

Armenia has never had domestic production of HFCs. The country imports them as chemicals mainly from the United Arab Emirates, sometimes also from Iran and Turkey, while they come contained in products or equipment (sub-application) from a large number of other countries.

From all HFCs, HFC-134a has the widest application area, which is due to its multifunctional character: it is widely used as both an individual chemical and a blend (R-404A, R-410A, R-407C) component in all sub-applications of RAC, which is the country's HFCs key application area, and is also contained in aerosols as a propellant and in foam blowing as a foam blowing agent.

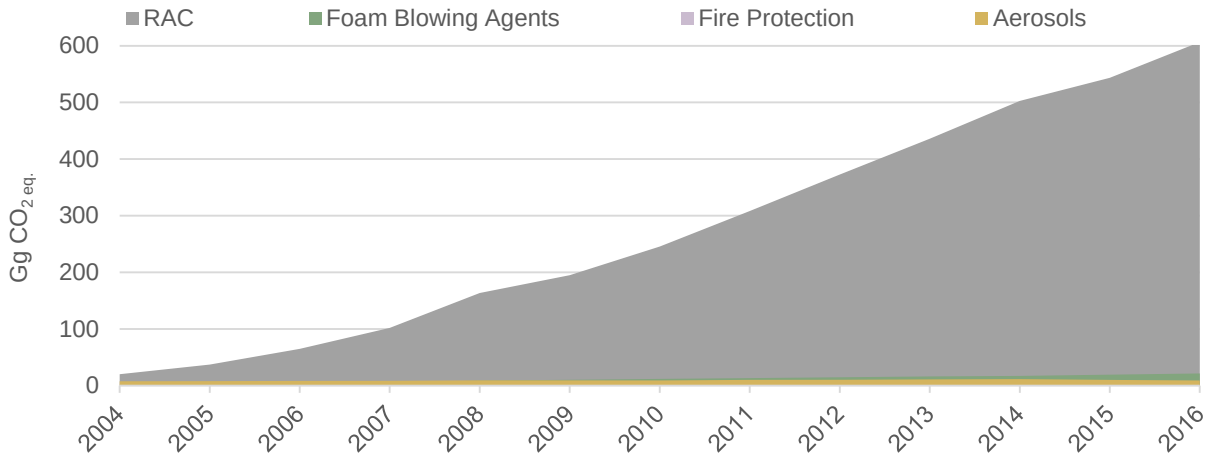


Figure 2-12. HFCs emissions per application, 2004-2016, Gg $CO_{2\ eq.}$

Figure 2-12 shows the sustainable annual growth of HFCs emissions, which have been used to replace ozone depleting compounds in many refrigeration and cooling devices and applications. This has been the main reason for the increase of F-gases.

The summary table on HFCs emissions and GHG emissions from the IPPU sector are provided in Annex I.

2.7.3 Agriculture, Forestry and Other Land Use

Agriculture

Emissions from the Agriculture sub-sector made up 2,295.68 Gg $CO_{2\ eq.}$ in 2016 or 22.3% of country's total emissions. Agricultural emissions include methane (CH_4) emissions from enteric fermentation of domestic livestock, manure management and biomass burning, as well as nitrous oxide (N_2O) emissions from manure management and direct and indirect emissions from managed soils following additions of urea-containing fertilizer and crop residue.

In 2016, 53.1% of the total emissions from the Agriculture sub-sector comprised CH_4 emissions from enteric fermentation, 4.3% - the CH_4 emissions from manure management, 35.9% - the N_2O emissions from manure management, and 6.6% - the N_2O emissions from managed soils. The share of emissions from biomass burning was negligible.

The prevailing part of CH_4 emissions from enteric fermentation (90%) was generated by cattle, and most of the N_2O emissions (84.4%) were direct and indirect N_2O emissions from managed soils.

The emissions from the Agriculture sub-sector increased by about 73% in 2016, compared to 2000, which was primarily due to the increase in livestock populations.

Emissions in the Agriculture sub-sector in 2016 increased over 12%, compared to 2014, primarily due to increase in cattle live weight and milk production, as well as due to increased N_2O emissions from managed soils resulting from the use of fertilizers.

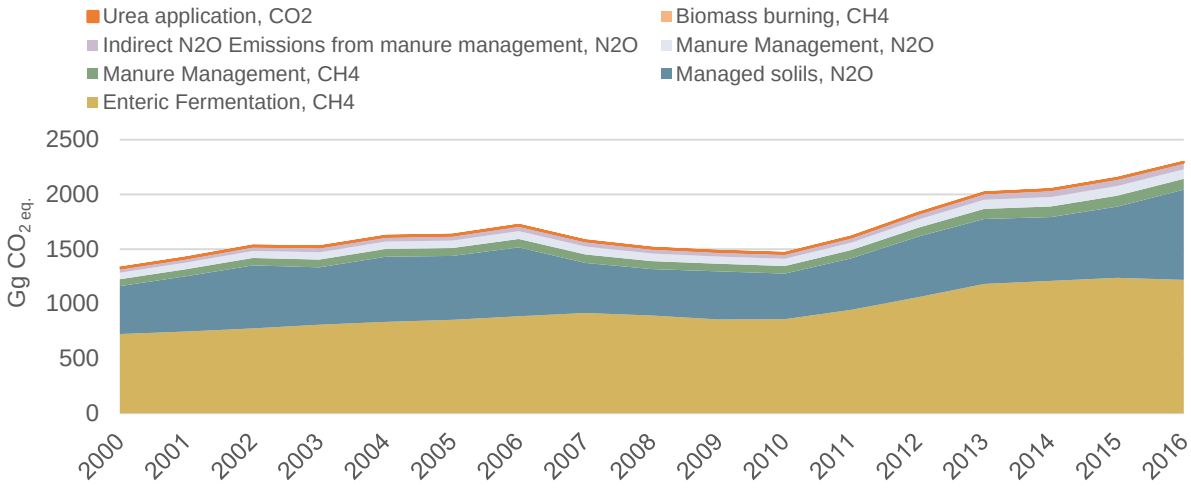


Figure 2-13. GHG emissions from the Agriculture sub-sector, 2000-2016, Gg $CO_{2\ eq.}$

Forestry and Other Land Use

Both GHG emissions and removals in the Forestry and Other Land Use sub-sector have been estimated. Removals refer to the absorption of CO_2 from the atmosphere by carbon sinks, such as plant biomass. Changes in carbon stocks in six land-use categories have been estimated according to the 2006 IPCC Guidelines.

Due to the lack of complete data, estimation of changes in carbon stock in the "Forest Land Remaining Forest Land" category was done only in the living organic matter (above-ground and below-ground biomass), and estimation of changes in carbon stock in the "Land Converted to Forest Land" and "Other Land-Use" categories was done also in the dead organic matter and soils.

The emissions/removals from forestry were estimated using official data on annual volume of harvested fuelwood (including illegal harvest discovered as a result of annual inspections) and annual volume of harvested timber, provided by the Bioresources Management Agency and Forestry Committee of the MoE.

However, these data on annual volume of harvested fuelwood strongly differ from volumes of the fuelwood consumption by households received from the household surveys implemented by the Statistics Committee. Therefore, to ensure consistency of data on removals, and consequently, the accuracy of estimation of GHG removals in forestry, there is a serious need to conduct studies and analysis considering involvement of both official and independent sources.

The Forestry and Other Land Use sub-sector in 2016, as a whole, acted as a CO_2 sink for removal of – 482.74 Gg CO_2, since the total emissions resulting from the sector were smaller than the total removals. The removal of GHG emissions in 2016 was 4.7% of the total national emission. In forest land, the largest sink is "Forest Land Remaining Forest Land" sub-category: by -541.07 Gg CO_2 removal. The prevailing part of the annual carbon loss is caused by harvested fuelwood. In general, carbon absorption by forests is relatively constant in recent years.

Even though the Forestry and Other Land Use sub-sector has clearly been a net carbon sink, this sub-sector also produces some emissions. The largest emissions are generated from "Other Lands" and "Grasslands" sub-categories. Other sources of emissions in the Forestry and Other Land Use sub-sector include "Settlements" and "Wetlands" sub-categories. Emissions from "Croplands" are negligible.

Energy crisis of the 1990s resulted in a widespread harvesting of trees and economically undesirable change in the tree species, i.e. high-value species (beech, oak) have been replaced with low-value and low-productivity species.

The trend in emissions and removals from the Forestry and Other Land Use sub-sector is presented in Figure 2-14

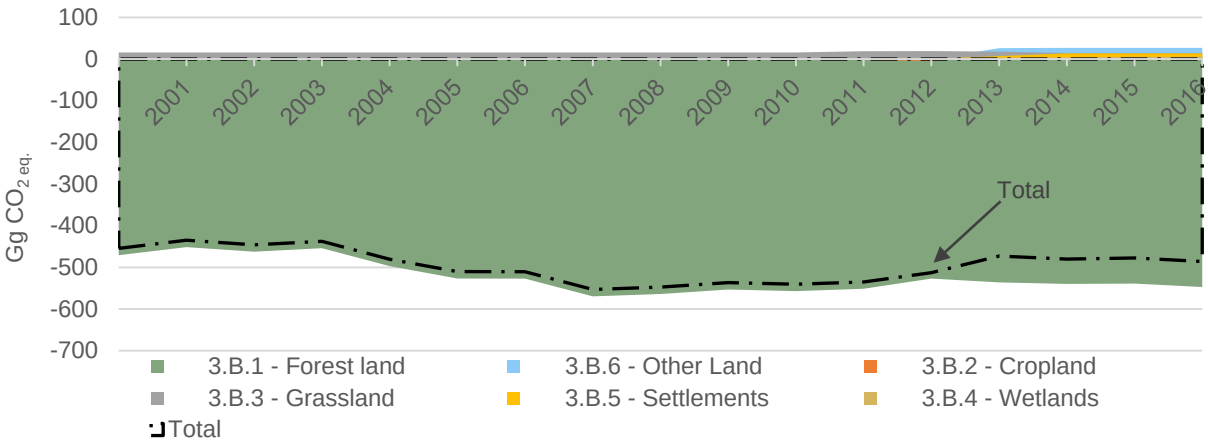


Figure 2-14. GHG emissions (positive values) and removals (negative values) in the Forestry and Other Land Use sub-sector, 2000-2016, Gg $CO_{2\ eq.}$

Summary report on the GHG emissions from the AFOLU sector is provided in Annex I.

2.7.4 Waste

Methane, nitrous oxide and carbon dioxide emissions from landfills, combustion of solid waste and wastewater treatment and discharge are reported under the Waste sector.

In 2016, the Waste sector emissions amounted to 621.62 Gg $CO_{2\ eq.}$, which accounts for approximately 6% of Armenia's total emissions.

CH_4 emissions from landfills predominate in the Waste sector emissions accounting for 419.32 Gg $CO_{2\ eq.}$ in 2016, which makes 67.5% of all Waste sector emissions and 4% of the country's total emissions. The emissions from the combustion of waste are insignificant and comprise 3.3% of sector emissions. The CH_4 and N_20 missions from waste water treatment comprised 29.2% of the Waste sector emissions in 2016.

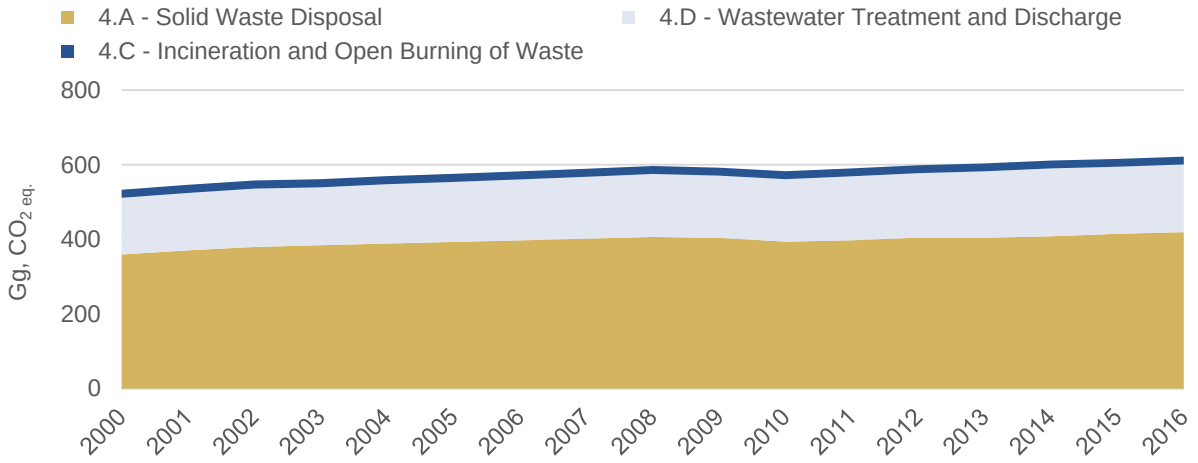


Figure 2-15. GHG emissions from the Waste sector, 2000-2016, Gg $CO_{2\ eq.}$

During 2000-2016, emissions from the Waste sector have increased by 16.6% primarily due to the growth in methane emissions from solid waste disposal because of higher inertia and cumulative effect of organic matter decomposition process in anaerobic conditions.

Summary report on the GHG emissions from the Waste sector is provided in Annex I.

2.8 Key Category Analysis

The Approach 1 analysis - Level Assessment was applied to identify key categories in 2016. The assessment results by application of the Approach 1 to the Armenia's GHG Inventory for the reporting year is provided in Table 2-4. The Approach 1 analysis has identified 17 key categories. Some changes have occurred in comparison with the results of 2014.

Key Category Analysis was performed at a more disaggregated level:

- "Other sectors - Gaseous Fuel" sub-category was split to sub-categories considering that emissions contribution from "Residential-Gaseous Fuel" sub-category to the key category is more than 67%;
- "Enteric Fermentation" sub-category was split to sub-categories considering that emissions from "Enteric Fermentation from Cattle" sub-category make up 90% of the key category emissions;
- "Electricity and Heat Production" sub-category dropped from its first place to the third one due to decreased electricity export volumes, while "Natural Gas Fugitive Emissions" sub-category shifted to the first place. "Manufacturing Industries and Construction - Gaseous Fuels" and "Cement Production" sub-categories are at lower place, compared to 2014, due to the decline in production volumes. And, on the contrary, "Direct N_2O Emissions from Managed Soils" shifted from the 9th place to the 6th due to increased volumes of fertilizer use.

2.9 Uncertainty Assessment

Key sources uncertainty estimate was done using Approach 1 and is presented in Table 2-5.

Activity data are the primary source of uncertainty in the GHG emission estimates because country-specific emission factors have been developed for the majority of the key sources.

A large proportion of activity data are those on fuel combustion.

Considering that in Armenia data on natural gas combustion at large sources are obtained from direct measurement and obligatory are reported, the uncertainty of activity data on natural gas combusted is within 3%, while data on natural gas combusted in other categories, including transport, are within 5%. The collection of natural gas combustion data through official statistics strengthened the confidence in the data and formed the basis for the low uncertainty in the GHG emissions caused by natural gas combustion. Activity data on liquid fuel consumption by subcategories have higher uncertainty.

Non-energy sector categories have high uncertainties for GHG emission estimates, even when a higher Tier method is used, as in the case with cement production category and RAC application in Armenia.

Estimation of GHG emissions/removals from AFOLU sector has high uncertainty, especially in the N_2O (direct and indirect) Emissions from Managed Soils and Forest Land Remaining Forest Land sub-categories.

Table 2-4. Approach 1 Analysis (Level Assessment), 2016

A	B	C	D	E	F
IPCC Category code	**IPCC Category**	**Green-house gas**	**2016 Ex,t (Gg $CO_{2\ eq.}$)**	**Level Assess-ment**	**Cumula-tive Total of Column E**
1.B.2.b	**Fugitive Emissions from Natural Gas**	**CH_4**	**1,580.59**	**0.145**	**0.15**
1.A.3.b	**Road Transportation**	**CO_2**	**1,568.16**	**0.144**	**0.29**
1.A.1.a	**Electricity and Heat Production**	**CO_2**	**1,182.60**	**0.109**	**0.40**
1.A.4.b	**Residential - Gaseous Fuels**	**CO_2**	**1,139.52**	**0.105**	**0.50**
3.A.1.a	**Enteric Fermentation from Cattles**	**CH_4**	**1,097.16**	**0.101**	**0.60**
3.C.4	**Direct N2O Emissions from Managed Soils**	**N_2O**	**637.32**	**0.058**	**0.66**
2.F.1	**Refrigeration and Air Conditioning**	**HFCs**	**606.67**	**0.056**	**0.72**
3.B.1.a	**Forest Land Remaining Forest Land**	**CO_2**	**-541.07**	**0.050**	**0.77**
1.A.4.a	**Commercial/Institutional - Gaseous Fuels**	**CO_2**	**481.11**	**0.044**	**0.81**
4.A	**Solid Waste Disposal**	**CH_4**	**419.32**	**0.038**	**0.85**
1.A.2	**Manufacturing Industries and Construction - Gaseous Fuels**	**CO_2**	**375.00**	**0.034**	**0.88**
3.C.5	**Indirect N2O Emissions from Managed Soils**	**N_2O**	**187.33**	**0.017**	**0.90**
2.A.1	**Cement Production**	**CO_2**	**130.15**	**0.012**	**0.91**
4.D	**Wastewater Treatment and Discharge**	**CH_4**	**117.84**	**0.011**	**0.92**
3.A.1.c	**Enteric Fermentation from Sheep**	**CH_4**	**103,25**	**0.009**	**0.93**
3.A.2	**Manure Management**	**CH_4**	**99.31**	**0.009**	**0.94**
3.A.2	**Manure Management**	**N_2O**	**87.23**	**0.008**	**0.95**
1.A.4.c.ii	Off-road Vehicles and Other Machinery	CO_2	78.88	0.007	0.96
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	65.25	0.006	0.96
3.C.6	Indirect N_2O Emissions from manure management	N_2O	64.57	0.006	0.97
4.D	Wastewater Treatment and Discharge	N_2O	63.62	0.006	0.98
1.A.3.b	Road Transportation - Gaseous Fuels	CH_4	31.26	0.003	0.98
3.B.6.b.i	Land Converted to Other land	CO_2	26.90	0.002	0.98
1.A.4.b	Residential - Liquid Fuels	CO_2	26.23	0.002	0.98
1.A.3.e.ii	Off-road	CO_2	23.42	0.002	0.99
2.F.2	Foam Blowing Agents	HFCs	21.40	0.002	0.99

Table 2-5. Uncertainty assessment of GHG emissions from key sources

IPCC Category code	IPCC Category	GHGs	2016			
			Emissions	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty
			(Gg CO_2 eq.)	(%)	(%)	(%)
1.A.1a	**Main Activity Electricity and Heat Production - Gaseous Fuels**					
1.A.1.a.i	Electricity Generation - Gaseous Fuels	CO_2	579.16	3	3	4.24
1.A.1.a.ii	Combined Heat and Power Generation (CHP) - Gaseous Fuels	CO_2	603.44	3	3	4.24
1.A.2	**Manufacturing Industries and Construction - Gaseous Fuels**					
1.A.2.a	Iron and Steel	CO_2	29.42	5	3	5.83
1.A.2.b	Non-Ferrous Metals	CO_2	29.03	5	3	5.83
1.A.2.c	Chemicals	CO_2	3.73	5	3	5.83
1.A.2.d	Pulp, Paper and Print	CO_2	8.24	5	3	5.83
1.A.2.e	Food Processing, Beverages and Tobacco	CO_2	148.47	5	3	5.83
1.A.2.f	Non-Metallic Minerals	CO_2	127.88	5	3	5.83
1.A.2.h	Machinery	CO_2	1.76	5	3	5.83
1.A.2.i	Mining (excluding fuels) and Quarrying	CO_2	13.73	5	3	5.83
1.A.2.j	Wood and wood products	CO_2	0.20	5	3	5.83
1.A.2.k	Construction	CO_2	8.63	5	3	5.83
1.A.2.l	Textile and Leather	CO_2	0.98	5	3	5.83
1.A.2.m	Non-specified Industry	CO_2	2.94	5	3	5.83
1.A.3.b	**Road Transportation**					
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	651.65	20	5	20.62
1.A.3.b	Road Transportation - Gaseous Fuels	CO_2	916.51	5	3	5.83
1.A.4	**Other sectors - Gaseous Fuels**					
1.A.4.a	Commercial/Institutional	CO_2	481.11	5	3	5.83
1.A.4.b	Residential	CO_2	1,139.51	5	3	5.83
1.A.4	**Other sectors - Liquid Fuels**					
1.A.4.a	Commercial/Institutional	CO_2	1.76	15	5	15.81
1.A.4.b	Residential	CO_2	26.23	20	5	20.62
1.A.4.c.ii	Off-road Vehicles and Other Machinery	CO_2	78.88	20	5	20.62
1.B.2.b	**Fugitive emissions from Natural Gas**					
1.B.2.b.iii.4	Transmission and Storage	CH_4	1,097.25	7	5	8.6
1.B.2.b.iii.5	Distribution	CH_4	483.34	5	5	7.07
2.A.1	**Cement Production**	CO_2	130.15	19.5	3	19.73
2.F.1	**Refrigeration and Air Conditioning**	HFCs	606.67	30	25	39.05
3.A.1	**Enteric Fermentation**	CH_4	1,097.16	10	20	22.36
3.A.2	**Manure Management**	CH_4	68.13	22	35	41.34
3.C.4	**Direct N_2O Emissions from managed soils**	N_2O	637.32	32	212	214.40
3.C.5	**Indirect N2O Emissions from managed soils**	N_2O	187.33	32	229	231.22
4.A	**Solid Waste Disposal**	CH_4	419.32	68.56	28.72	74.33
4.D	**Wastewater Treatment and Discharge**					
4.D.1	Domestic Wastewater Treatment and Discharge	CH_4	86.19	36.4	58.31	68.74
4.D.2	Industrial Wastewater Treatment and Discharge	CH_4	31.65	75	58.31	95.00

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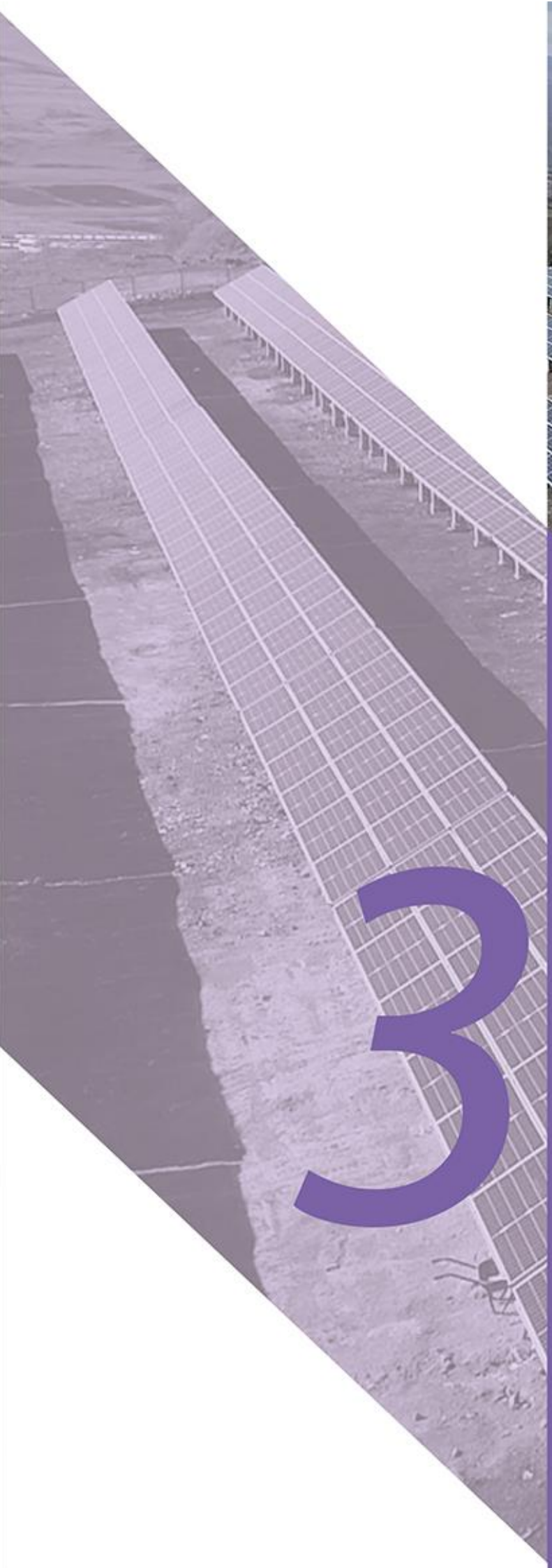


3

POLICIES AND MEASURES FOR GHG EMISSIONS REDUCTION

3.1 Energy

Strategic Documentation

Low carbon emission development of the country is fully in line with national energy security priorities. The RA Government Programme and the strategic programs for energy sector development are aimed at ensuring the energy security of the Republic of Armenia in accordance with the provisions of the National Security Strategy by maximizing the energy efficiency and renewable energy potential.

Adopted in 2019, the RA Government Programme stipulates that the main objectives of the energy policy shall ensure independence and increased security of the energy sector, guarantee the implementation of the regional integration process and sustainable development of the energy sector based on full and efficient use of local primary (renewable) energy resources, further development of the nuclear energy sector, diversification of energy supply sources and introduction of energy efficient and advanced technologies.

The Republic of Armenia Energy Security Concept (2013)

The RA Energy Security Concept seeks to identify the main ways for the achievement of the defined level of energy security by compensating for the lack of local industrial fossil fuel reserves, providing uninterrupted power supply with economically appropriate prices and acceptable quality.

One of the objectives of the Concept is to provide environmentally sustainable power supply based on sustainable development principles and the international environmental commitments of Armenia.

The Concept states that promoting renewable energy, increasing energy efficiency, saving energy and developing nuclear energy sector are key components of energy security.

Legislative changes

Recent legislative reform efforts in the country were aimed at enhancing the development and large-scale utilization of renewable energy sources, in particular, increasing the level of generation of electricity in solar power plants.

Amendments and supplements to the RA Law on Energy (2014, 2016, 2017, 2018) are aimed at creation of conditions conducive to the advancement of renewable energy sources:

- a purchase guarantee provision is established for the electricity produced within a period of twenty years (against 15 years in the past) from renewable sources (excluding small hydroelectric power plants) (2014);
- activities which are not subject to regulation include only the production of electricity exclusively for self-consumption purposes, as well as the production of electricity by autonomous producers with an installed capacity of up to 150 kW during the production period (2016);
- for autonomous solar power plants, the activities of which are not subject to regulation during the construction and production periods (2017), the 150 kW capacity limit has been replaced by 500 kW capacity limit for the period from January 1, 2018 to December 31, 2022,

The amendments and supplements to the Law on Energy are aimed at gradual liberalization of the electricity market, in particular, the introduction of competitive mechanisms in the unregulated segment of the market, the unimpeded entry of new participants into the market, promotion of regional trade, including creation of less expensive electricity import opportunities following the liberalization of licensing (2018).

Amendments and supplements to the Law on Energy Saving and Renewable Energy (2016, 2017, 2018) are intended to create an enabling environment for the operation of solar power plants by establishing a procedure for interconnections between an autonomous power generator and an electricity distribution license-holder:

- the generated electricity, which exceeds the volume sufficient to cover self-consumption needs, can be obtained by distribution license-holders for the monthly distribution to the respective

consumer group at a discount of 50% of the tariffs set by the PSRC (2016);

- since January 1, 2018, calculations between an autonomous power generator and a distribution license-holder shall be made annually against the monthly basis in the past (2017).

Legislative changes define energy saving and energy efficiency mandatory technical requirements for residential multi-apartment buildings under construction, as well as state-budgeted facilities under construction (reconstruction, renovation) (2018).

Technical rules and regulations for energy saving and energy efficiency requirements in residential multi-apartment buildings under construction, as well as facilities under construction (reconstruction, renovation) by state funds (2018). The regulations set out the following requirements:

- publication of the list of standards enforcing the requirements of the technical rules and regulations and voluntary for application;
- definition of the template of conformity certificate (energy efficiency certificate) for residential multi-apartment buildings under construction, as well as state-funded facilities under construction (reconstruction, renovation) and rules for its completion;
- formulation and application of normative technical instruments for ensuring energy efficiency of buildings and estimating energy efficiency indicators within a twelve-month period.

The RA Law on Making Addendum and Amendments to the RA Water Code (2019):

- specifies zones where construction and operation of SHPPs is prohibited;
- establishes grounds for refusing applications to receive water use permits for newly constructed SHPPs.

The Government hereby reserves the authority to define the list of rivers, which provide habitats for spawning of endemic fish species, included in the Red Book. The list of rivers is to be approved by the end of the first half of 2020.

The RA Law on Making Addendum to the RA Tax Code (2019) is intended to reduce hazardous emissions. According to the Law, starting from July 1, 2019, import and sale of vehicles powered by electric motors has been fully exempted from VAT until January 1, 2022.

The RA Law "On Making Amendments and Addenda to the RA Law on Energy Saving and Renewable Energy" (2020) defines the energy efficiency requirements for power consuming devices purchased in the framework of state procurement.

Tariff policy

The regulation of the energy sector is implemented by the PSRC. The PSRC-adopted tariff policy seeks to promote the implementation of strategic documents and perspective development plans, in particular development of renewable energy sources and, more specifically, in recent years, electricity generation at photovoltaic (PV) solar plants. The selective policy implementation has already had significant success, as evidenced by recent rapid development of PV solar plants.

The implemented tariff policy is based on the principle of ensuring the necessary revenue levels and is aimed at sustaining the normal economic activity of the businesses operating in this sphere, as well as balancing the interests of consumers and regulators, at the same time enabling the implementation of modern and prospective development projects.

A fixed tariff system is applied for stations using renewable energy resources (up to 5 MW for solar power plants and up to 30 MW for other stations), within the framework of which the tariffs are adjusted every year, taking into account inflation and Armenian dram/ US dollar exchange rate fluctuations. At the same time, in some cases, the tariffs for electricity supplied from the stations and the mechanisms for their adjustment are formed within the framework of public-private sector transactions and are accordingly stipulated in respective agreements.

Solar Energy

PV power stations are conditionally divided into the following groups by the capacity installed in the territory of the Republic of

Armenia and by the field of legislative regulation:

- industrial PV solar power plants;
- solar PV power plants with an installed capacity of up to 5 MW (inclusively) and whose license for production of electricity was granted during the period from November 2, 2018 to December 31, 2020, inclusively;
- solar PV power plants with an installed capacity of up to 1 MW (inclusively) and whose license for production of electricity was granted before November 1, 2018, inclusively;
- PV solar power plants with a capacity of up to 500 kW - autonomous power generators.

Industrial PV power plants. The first phase of the Investment Program for Construction of PV Power Stations provides for building an industrial-scale solar power station "Masrik-1" in Gegharkunik region, with a peak capacity of 55 MW (about 90 GWh of annually produced electricity).

As a result of an international competition, the winner was announced to be the consortium of two companies – Dutch Fotowatio Renewable Ventures, B.V. and Spanish FSL Solar, which had proposed the lowest tariff, 4.19 USD cent per 1 kWh (or about AMD 20.11), VAT excluded.

In 2018, the RA Government signed a state assistance agreement, providing the developer with an electricity production license. The size of investments was estimated at about USD 58 million or USD 1,025/kW.

Five more solar power stations will be constructed in the future with a total capacity of about 60 MW.

Solar PV power plants with an installed capacity of up to 5 MW (inclusively) and whose license for production of electricity was granted during the period from November 2, 2018 to December 31, 2020, inclusively. According to the procedure of licensing in the power sector, stipulated by the PSRC Resolution No. 374-N, dated November 1, 2013 (the latest amendment made by the Resolution No. 371-N, dated 09.10.2019), it is envisaged to grant relevant licenses for construction and operation of solar power plants with a capacity of up to 5 MW for the period up to December 31, 2020, inclusively, for a total capacity of 200 MW. The tariffs for electricity supplied by the mentioned power plants are set equal to the tariffs for SHPPs built on natural water flows, provided that the first tariff setting should be adopted by December 31, 2021 (inclusively). As a result of further adjustments, the tariff for electricity supplied from these power plants currently amounts to AMD 24.233/kWh, excluding VAT.

As of April 1, 2020, licenses for production of electricity have been granted to 49 solar power plants with a capacity of up to 5 MW, the total installed capacity of which amounts to 199.82 MW.

Solar PV power plants with an installed capacity of up to 1 MW (inclusively) and whose license for production of electricity was granted before November 1, 2018, inclusively. The construction of the solar PV power plants of this group was limited to a total capacity of 10 MW. All 12 solar power plants, whose licenses for production of electricity with an installed capacity of up to 1 MW and within the limits of total capacity of 10 MW were granted during the period from November 2016 to November 1, 2018, have progressed to the production and operation stage.

Solar PV power plants with up to 500 kW capacity – autonomous power generators. As of January 1, 2020, 2,067 autonomous power generators with up to 500 kW capacity have been given technical conditions with a total capacity of about 38.26 MW, from which 1,944 (with a total capacity of 32.9 MW) have already been connected to the grid.

Hydropower

Currently, the foremost used renewable energy resources in Armenia are hydro resources. Figure 3-1 shows production of SHPPs during 2003-2017.

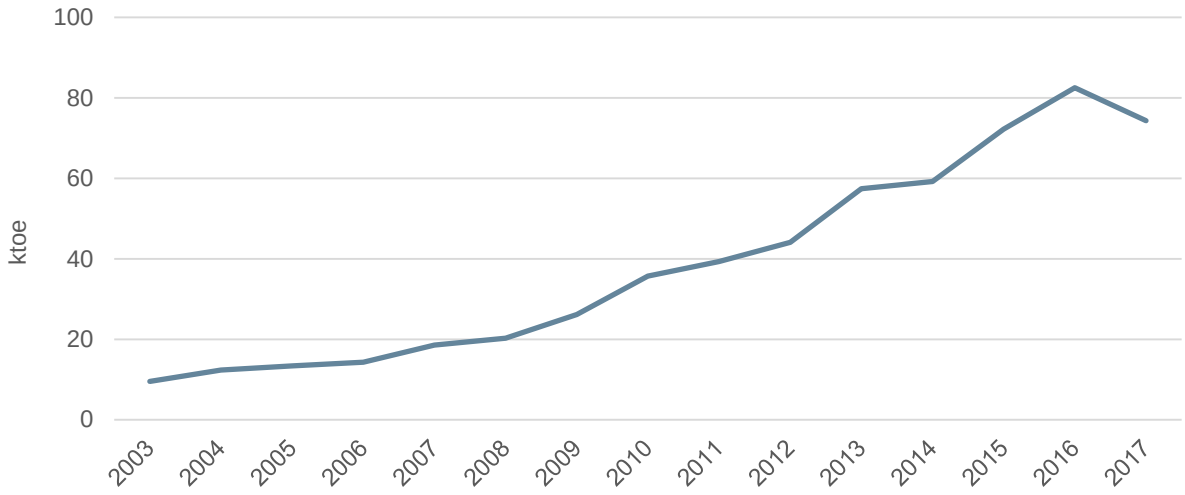


Figure 3-1. Electricity produced by SHPPs during 2003-2017

In 2017, there has been an eightfold increase in the volume of electricity produced by SHPPs, as compared to 2003, and the capacity of operating SHPPs and those under construction was 353 MW and 70 MW, respectively.

The RA Law on Energy adopted on March 7, 2001 created an incentive for development of SHPPs. According to the Law, all the electricity (capacity) produced by SHPPs is subject to purchase within a period of 15 years.

By creating an environment conducive to construction of SHPPs, the PSRC, however, monitors the process of construction, applying appropriate sanctions to companies that fail to achieve proper fulfilment of their obligations.

Although the development of SHPPs is an important source of alternative energy, the construction and operation thereof is often carried out in violation of environmental norms, adversely affecting water and land ecosystems.

National Projects

Renewable Energy Expansion Project (2014)

The project outlines renewable energy technologies and plans that can best contribute to the country's energy, economic and environmental development goals, as well as the steps that need to be taken. In 2014, the renewable energy produced (without considering the energy produced by large HPPs) comprised 8.9% of total energy production in 2014[117]. The Armenian Government is committed to increasing it to 21% by 2020 and to 26% by 2025.

The program is funded by the CIF. Within the framework of the Renewable Energy Expansion Program, funded by the GCF and with USD 2 million grant resources allocated by the WB, the Renewable Resources and Energy Efficiency Fund of Armenia implemented the Project Preparation activities and developed the solar map of Armenia.

Action Plan on Implementation of the Provisions of the RA Energy Security Concept for 2014-2020 (2014)

The Plan outlines specific actions to be taken to achieve the objectives of the RA Energy Security Concept and the Renewable Energy Expansion Project.

Paths to the long-term development (up to 2036) of the RA Energy System (2015)

The program is aimed at ensuring the sustainable development of the energy sector based on the development of nuclear energy, the efficient use of renewable resources, the construction of TPPs employing combined cycle and the diversification of energy resources import.

In 2018, the Ministry of Territorial Administration and Infrastructure (MoTAI), with the support of USAID, launched a new

[117] Settlement Center CJSC, Technical Report, 2014

long-term strategy to develop the country's energy system with a view to devising more ambitious plans of development of renewable energy sources, diversification of fuel supply chains through regional cooperation and integration projects.

Investment Program for Construction of PV Power Stations (2016)

For the enhancement of solar energy, it is intended to build PV power stations with a total installed capacity of about 110 MW.

The first phase of the investment program envisages the construction of Masrik-1 industrial-scale solar power plant with a peak capacity of 55 MW in, Gegharkunik region.

According to the Investment Program for Construction of PV power Stations approved by the RA Government Protocol Decree No. 53 of December 29, 2016, construction of industrial solar power stations will stimulate research and development, facilitate the transfer of allocation, generation and exploitation capabilities and increase the economic security, energy independence and system reliability.

Hydro Energy Development Concept (2016)

The Concept highlights the hydro energy sector development vision of the RA Government and the need both for boosting cooperation of the state with the private sector to create a more attractive investment climate, and for enshrining specific legislative guarantees.

Second National EE Action Plan (NEEAP) (2017)

The NEEAP defines the energy efficiency targets for 2017-2018 and the actions to achieve them. The Plan envisages measures to improve energy efficiency by economic sectors.

Concept of Alternative Energy Storage and Management (2018)

Storage plants are an important and integral component of the renewable energy system. For solving the problems set out in the Concept, over the next decade the RA energy system will need storage plants with 300 MWh of total storage capability to enable rapid and efficient access to the system and safe disconnection therefrom in the face of unforeseen and adverse fluctuations inherent with renewable energy sources. It is recommended to build and commission a pilot storage plant with 14 MWh of total storage capability and up to 3 MW of capacity.

International agreements and projects

Intended Nationally Determined Contributions of RA (2015)

The RA position under the Paris Agreement is enshrined in the “Intended Nationally Determined Contributions” instrument (now renamed Nationally Determined Contributions), which was approved on September 10, 2015 by the RA Government Protocol Decree No. 41 and submitted to the UNFCCC Secretariat on September 22, 2015.

This document builds on the principle of "green economy" and an ecosystem-based approach towards mitigation and adaptation actions. According to the document, the country's total emissions for the period between 2015 and 2050 should not exceed the equivalent of 633 million tons of carbon dioxide (tons of $CO_{2\ eq}$.).

EU-Armenia Comprehensive and Extended Partnership Agreement (CEPA) (2017)

Within the framework of the EU-Armenia CEPA, Armenia is committed, among other measures, to taking joint actions stemming from multi-lateral environmental agreements, including the UNFCCC and the Paris Agreement. This partnership at the local, regional and international levels will promote climate change mitigation and adaptation, lead to the mainstreaming of climate change-related issues into general and sectoral policies and create market and non-market mechanisms for coping with climate change.

Implementation of the Agreement will serve as an incentive for development of cleaner energy sources. It will also increase the level of supply security and reduce dependence on energy imports.

Under the Comprehensive and Enhanced Energy Partnership Program signed in 2017 between Armenia and the EU, Armenia has committed to start implementation of about 65 EU directives in the next eight years.

EU-Armenia CEPA Roadmap (2018)

The document is a CEPA joint action plan signed between the EU and Armenia. It is targeted at protection, improvement and restoration of environment quality, human health protection, sustainable use of natural resources, as well as promotion of measures to address regional and global environmental issues at the international level.

Agreement on Accession to the Treaty on Eurasian Economic Union of May 29, 2014 (2015)

Under this Agreement, the Republic of Armenia joined the Treaty on Eurasian Economic Union (EAEU) of May 29, 2014, as well as other international treaties, concluded within the framework of the formation of the contractual and legal base of the Customs Union and the Common Economic Space, and which form part of the legal framework of the EAEU. Armenia has become a member of the EAEU since the day this Agreement entered into force.

In 2017, the Regulatory Framework for Energy Efficiency Promotion in the EAEU regional program has been launched funded by the Russian Trust Fund for Development to promote energy efficiency technologies by means of development and introduction of energy efficiency requirements aimed at reduction of energy consumption and GHG emissions in the EAEU.

The project supported harmonization of the technical regulation “Energy Efficiency Requirements for Energy-Consuming Devices” and its approval by the Eurasian Economic Commission (ТР ЕАЭС 048/2019).

The Technical Regulation sets out the mandatory energy efficiency requirements for energy consuming devices, as well as their labelling rules and procedures. According to the RA Law on Technical Regulation, the requirements of the EAEU Technical Regulation are mandatory for implementation.

EU Eastern Partnership Program (2014)

Currently, a number of projects are implemented in the framework of the Eastern Partnership Program aimed at climate change mitigation, covering a wide range of different sectors of the economy, as well as regions and towns of the Republic of Armenia.

EC “Eastern Partnership Covenant of Mayors East II” Regional Program (2011-2020). The overall objective of the Program is to support and encourage local and regional authorities in the Eastern Partnership region, having joined the Covenant of Mayors, to achieve and implement a more sustainable local energy policy, reducing their dependency on fossil fuels, improving security of their energy supply, and allowing them to contribute more actively to climate change mitigation and adaptation. By joining the Covenant of Mayors, communities voluntarily commit to reduce GHG emissions and improve climate resilience through the implementation of a Sustainable Energy (and Climate) Action Plan. As of March 2020, 26 Armenian municipalities have joined the Covenant, 18 have developed GHG mitigation strategies, while one community has approved an adaptation action plan.

In particular, a number of projects aimed at mitigating climate change are being implemented in the city of Yerevan, including the Yerevan Sustainable Energy Development Action Plan (SEDAP), developed by the municipality within the framework of technical assistance provided by UNDP (2016), and is aimed at reducing energy consumption and prevention of GHG emissions. Within the framework of the “EU4Yerevan: Solar Community" project, it is planned to reduce the energy consumption and decrease GHG emissions in multi-apartment buildings through the use of renewable energy sources and implementation of energy saving measures.

Within the framework of the UNDP GCF project grant and EBRD loan programs, projects aimed at enhancing energy efficiency of outdoor lighting in the city of Yerevan are being implemented.

Based on the EBRD methodology, the "Green City" Action Plan has been developed. It is a strategic document for implementation of green activities to be carried out by 2030 and is aimed at ensuring sustainable development of the city of Yerevan by mitigating the negative anthropogenic impacts on the environment, through implementation of a set of measures

including landscaping, public transport reform, optimization of road infrastructure, disaster risk reduction and enhanced resilience.

The five-year (2019-2023) plan of the city of Yerevan also envisages restoration of the city's buffer forest layer by almost 40 hectares.

EU for Environment (EU4Environment) Regional Program (2019). The Program will support policy development and legislative reforms in six Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine) through making "green" plans and contributions, incorporating leading-edge technology, adopting new business models, providing "green" employment.

EU for Climate (EU4Climate) Regional Program (2019). The goal of the Program is to support the development and implementation of the climate policy in the six Eastern Partnership countries, which will boost the sustainable development of countries in low emission and climate change settings and the implementation of the UNFCCC commitments under the Paris Agreement.

EU for Energy (EU4Energy) Regional Program (2017). The Program seeks to improve the quality of energy data and statistics in six beneficiary countries, to shape regional policy discussions, to consolidate legislative and regulatory frameworks and to improve access to information in partner countries. In addition, the program provides technical assistance to the six countries of the Eastern Partnership on key investments in legislative and regulatory field and energy infrastructures.

Eastern European Energy Efficiency and Environment Partnership Program (E5P) (2015). To join the E5P Fund, in 2015, the RA Ministry of Energy and Natural Resources and the EBRD signed an investment agreement. It enables implementation of energy saving and renewable energy projects in various sectors of the economy with E5P grant resources and soft loans from international financial institutions. Armenia has been provided with roughly € 20 million in grants, and an additional € 3 million was provided in 2018 by the EBRD to support the projects' implementation.

Currently, solid waste disposal in Kotayk, Gegharkunik regions and Yerevan, municipal lighting in Gyumri and Yerevan, and Yerevan energy efficiency projects are under implementation with the funding from E5P Fund and EBRD and European Investment Bank (EIB) loans.

"De-risking and Scaling-up Investment in Energy Efficient Building Retrofits" UNDP-GCF Project (2017). The USD 20 million GCF grant under this Project comprises financing of technical assistance for carrying out energy efficient modernization of buildings and addressing the market and policy barriers, as well as reducing investment risks in energy efficient retrofit of buildings through financial incentives.

Armenia is also in the list of beneficiary countries of two regional programs funded by GCF under EBRD, namely: the "Green Cities" and "Sustainable Energy Financing Opportunities" Programs.

"Green City" Yerevan Action Plan (2017). EBRD's "Green Cities" approach was first applied in this action plan developed for Yerevan. Such kind of groundwork will help other major towns in the region to develop a "green growth"-oriented action plans. The program is based on the Sustainable Energy Action Plan developed under the "Covenant of Mayors" EU initiative in 2016, approved by the Yerevan City Council, and complies with the provisions set out in the Plan. A similar action plan is developed also for Gyumri city (2020).

Sustainable Energy Financing Opportunities (2016). The GCF-EBRD co-funded Project is aimed at promoting financing for private sector investments through local financial institutions.

"Yerevan Energy Efficiency Program" (2017). The program funded by EIB loan, E5P grant and co-funded by Yerevan municipality is aimed at energy effective reconstruction of about 60 kindergartens. The UNDP-GCF project provides technical assistance to the program. The global environmental goal is to reduce GHG emissions in the public sector by eliminating obstacles to investing in energy efficiency sector.

Market Liberalization and Electricity Trade Project in Armenia funded by USAID (2018)

The Project envisages liberalization of the electricity market, introduction of new mechanisms and institutions, regulation of interstate trade issues and reform of the legislative field. The Project will assist Armenia in diversification of energy sources, liberalization of the energy market, and will enhance the energy independence of the country. The goal of the Project is to make the RA energy sector attractive to investors by increasing its transparency, accountability and competitiveness. The Project will assist the Government of Armenia in the review of the energy strategy and design of a long-term development of the energy sector.

"Nationally Determined Contributions" Partnership (2018)

Armenia joined the Partnership in August 2018. The goal of the Partnership is to assist Armenia in the process of development and effective implementation of nationally determined contributions. The assistance will be provided through targeted and coordinated technical assistance including design of climate change national and sectoral development policy, implementation and monitoring of mitigation and adaptation projects, as well as access to financial support in bilateral and multilateral formats.

3.2 Agriculture, Forestry and Land Use

Agriculture is one of the key sectors of the economy of Armenia, contributing around 15-16% of GDP in recent years. In 2016, 42.8% of Armenia's gross agricultural product is attributable to animal husbandry[118]. At the same time, the sector is the second largest in terms of emissions accounting for about 22% of emissions at the national scale (2016).

3.2.1 Animal Husbandry

Sector development strategy and state-adopted policy

Animal husbandry development policy is implemented through regulation of the legislative field and targeted strategic measures. A number of projects and concepts have been approved by the Government to promote animal husbandry separate branches, including those, which contribute to reducing GHG emissions from farm animals and mitigating climate change, in particular:

- Stockbreeding Development Program (approved by the RA Government Decree No. 336-A, dated March 22, 2007);
- Sheep Breeding Development Concept (approved by the RA Government Protocol Decree No. 33, dated August 25, 2011), which specifies the nature of planned breed selection in sheep breeding in Armenia and defines the optimal number of sheep to crossbreed the most expedient breeds;
- Strategy for Agricultural and Rural Sustainable Development (approved by the RA Government Decree No. 1476-N, dated November 11, 2010), which sets out the tactical planning for animal husbandry development.

Along with regulation of the legislation on animal husbandry and veterinary medicine, the RA Government has also taken practical steps towards the development of pedigree animal breeding and the establishment of pedigree farms.

Projects and activities implemented, which can contribute to GHG emissions reduction from enteric fermentation

Methane emissions from enteric fermentation are attributable to the type of farm animals, their genotype (breed, race), live mass, feed composition, care conditions, climate, as well as methods of manure preservation and processing. Although no specific measures are yet implemented in Armenia for the reduction of methane emissions from ruminant enteric fermentation and manure accumulation, the recent projects supported by the RA Government have been indirectly contributing to the reduction of emissions from animal husbandry. These include:

[118] https://www.armstat.am/file/article/sv_12_16a_122.pdf

Stockbreeding Development Program (2007)

In recent years, about 7,000 head of heifers have been imported from European countries under this project, with an increasing number of offspring produced each year. While in 2007 98% of the livestock population in the republic was made up of native Brown Caucasian breeds, they comprised 93% as of January 1, 2019 due to the increase in the number of highly productive and bloodstock breeding.

Cattle Breeding Development Program (2019-2023)

In April 2019, the RA Government approved the "Cattle Breeding Development Project for 2019-2023", which provides for state-subsidized soft loans with 2% annual interest and interest-free loans in border communities for importing high producing beef breeds from foreign countries. The project intends importing up to 3,000 head of bloodstock annually. According to expert estimates, the number of high-yielding cows in the herds of the republic will make more than 110 thousand heads by 2030.

Program on Establishment of Slaughter-houses (2008-2015)

The project was implemented with the support of the UN Food and Agriculture Organization (FAO), within the framework of which 5 new slaughterhouses equipped with European equipment were built in 5 regions of the country. In addition, 7 more slaughter-houses were built by private investments, including by soft loans subsidized by the RA Government.

Taking into account that each year 230,000 heads of cattle and 450,000 heads of sheep and goat are slaughtered in Armenia, it is anticipated that production capacities of planned slaughterhouses will allow full implementation of slaughtering, and more than 8,000 tons of contents of intestinal tracts will be completely processed, thus contributing to the reduction of methane emissions.

Reduction in the duration of animal exploitation due to premature breeding

In breeding of early maturing and high producing animals the same or larger volume of production is obtained in a shorter time period or in a shorter animal lifespan. Imported cows are exploited for a maximum of 4-5 lactations producing 2-3 times more milk than local breeds giving the same amount of milk produced during 5-6 (and even more) lactations. Imported animals will therefore be exploited for a shorter time period (20% less), thus emitting less methane into the atmosphere.

Besides, early maturing breed calves reach slaughter weight faster and are slaughtered 3-4 months earlier than local breeds, having 25% shorter breeding and feeding period which results in less methane emitted. Estimates show that in 2023, about 20,000 heads of early maturing breed bull calves will be fed for annual meat production and will be fed and slaughtered in a 25% shorter time period than local breeds.

Thus, the projects implemented in animal husbandry by the assistance of the Government will indirectly contribute to the gradual reduction of volumes of methane emissions from enteric fermentation.

Manure management

Individual farmers and enterprises carry out certain operations or production processes, which involve manure processing. This, in its turn, contributes to the reduction of emissions from the manure.

Mushroom production

The volume of mushroom production in Armenia has tripled over the last 5 years. "Healthy Mushroom", "Biga" and "Jonnar-hov" LLCs alone produce about 3,000 tons of mushrooms per year, with more than 10,000 tons of manure /poultry manure/ being used for composting, and "Orvako" Armenian-Norwegian joint company is turning the compost generated by mushroom production into an organic fertilizer. More than 20 smaller mushroom production enterprises use 5-6 thousand tons of manure/poultry manure per year. The mushroom production alone accounts for 15,000 tons of recycled manure thus reducing emissions.

Biogas production

In recent years, more than 100 farmers have begun to operate small-scale biogas production equipment, most of which are

homemade machines capable of processing about 10,000 tons of manure annually.

Bio-humus (vermicompost) production

It has grown rapidly in recent years. Recycling manure with Californian worms produces organic fertilizer bio-humus, as well as protein-rich poultry feeds – worms. Nearly 300 Armenian farmers grow Californian worms for which they process 5-6 thousand tons of manure annually.

Thus, due to certain operations or production processes performed by individual farmers and enterprises, more than 30,000 tons of manure will be recycled annually, contributing to reduction of GHG emissions.

3.2.2 Forestry

Policy

Since 2018, Armenia's forests and forest lands are under the state management by the Ministry of Environment, previously, they were under the management of the Ministry of Agriculture.

According to the Government Programme (2019)[119], conservation and sustainable management of forests, expansion of forested areas, reforestation, afforestation and continuous development of the capacities to deliver on the above-mentioned actions are among the priorities of environmental management.

According to the GoA Decree No. 81-N (dated January 31, 2020), the Forest Monitoring Centre, Environmental Monitoring and Information Centre and Service of the Hydrometeorology and Active Impact on Atmospheric Phenomena SNCOs were merged and reorganized into "Hydrometeorology and Monitoring Centre" SNCO, which is based on the idea of having a joint environmental monitoring, and development and implementation of a joint policy.

The *Forest Sector Reform Concept, Strategy and List of Measures* were approved by the GoA Protocol Decree No. 50 (dated November 30, 2017) to balance social and economic needs and the requirements related to climate and environmental protection.

The State Forest Committee, established by the President's Decree NH-922-A (dated December 19, 2017), aims at provision of sustainable forest management, including conservation, protection, restoration, afforestation and effective use of forests.

Optimal forest coverage of the territory of the Republic of Armenia, around 20.1%, is anticipated to be achieved by 2050 as an objective for increasing the carbon sinks within the *Intended Nationally Determined Actions/Contributions under the UNFCCC* (GoA Protocol Decree No. 41, dated September 10, 2015).

For consolidating forest protection measures, it is also envisaged to carry out technical upgrading of the forestry workforce, create prompt fire response teams, among other activities. By the Decree No. 45-A (dated January 22, 2015), the RA Government approved the *"National Policy on management of wildfire in forest lands, specially protected areas, agricultural lands and settlements, the strategy for its implementation and the list of measures".* The purpose of the Strategy is to enhance the domestic capacity of prevention and response to wildfire by establishing an integrated monitoring and information system, introducing prompt response mechanisms, organizing rapid fire prevention measures, enhancing prompt fire response capacities, and expanding international cooperation in the field of wildfire management.

On May 29, 2013, the RA Government adopted the Decree No. 563-A "*On Approving the National Action-oriented Program for Improvement of Fire Safety in Forests and Vegetated Areas and the List of Complex Measures Aimed at Improving Fire Safety in Forests and Vegetated Areas*". The program is aimed at reducing the risks of forest and other vegetation fire (number of occurrences and their consequences) and climate change impacts on forest ecosystems, as well as significant enhancement of forest and other vegetation fire management.

National Projects

Following the massive deforestation that took place during the energy crisis of 1992-

[119] https://www.gov.am/files/docs/3133.pdf

1995, the reforestation and afforestation measures conducted in 1998-2006 comprised an area of around 2,150 hectares[120]; in 2006-2012, the forestry measures, including reforestation and afforestation, comprised 2,754 hectares, and in 2013-2018 - 3,303[121] hectares.

The volume of forestry measures, including afforestation, reforestation and coppicing, implemented in the country in recent years, in 2015-2018 is summarized in Figure 3-2.

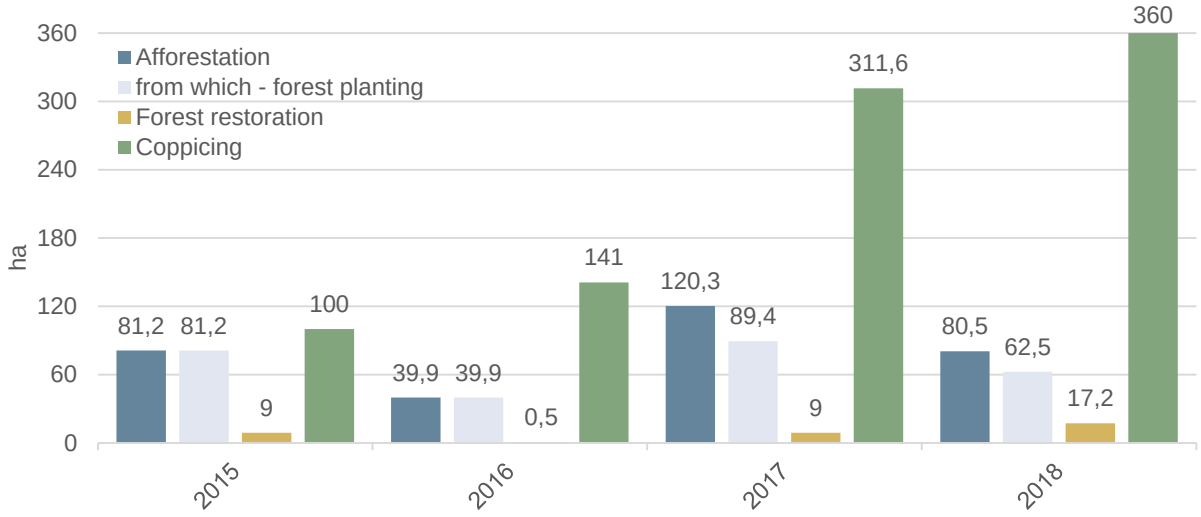


Figure 3-2. Areas of afforestation, reforestation and coppicing coverage in the Republic of Armenia, 2015-2018

Source: SC Data (Environment and Natural Resources in Armenia, 2015-2018)

There is a need for extensive afforestation and reforestation work to improve the condition of forests and increase the area under forest land.

In January 2020, the development of the National Forest Program will be launched. The program shall include all the challenges that need to be addressed to expand the forest covered area to 20.1% of the RA territory by 2050.

In 2019, the state budget allocated AMD 11,975 million for forest inventory management and AMD 1,171,656 million for forest protection. Additionally, respective efforts are undertaken to increase incomes from non-timber products by development of ecotourism, creation of ecosystem services, development of hunting farms, establishment of forest by-product recycling workshops, etc.

International projects

In 2018, FAO applied to the GCF with a proposal to finance the "Forest Resilience of Armenia, Enhancing Adaptation and Rural Green Growth Via Mitigation" project.

Currently, with the support of UNECE/FAO, indicators and benchmarks for sustainable forest management are developed, aiming at promoting better control and targeted efforts towards forest management processes.

Since 2016, "Mainstreaming Sustainable Land and Forest Management in Mountain Landscapes of North-Eastern Armenia" UNDP-GEF Project (2016-2020) has been implemented involving development of management plans of three forestry branches of "Hayantar" SNCO in Tavush and Lori regions. Currently, development of management plans for three additional forestry branches is underway.

"Mitigation of Climate Change Impact in Armenia through Enhanced Capacity for Wildfire Management" UNDP-RTF Project's (2017-2020) efforts are aimed at addressing the urgent problem of mitigating forest and wildfire risks in a changing climate, improving and consolidating early warning

[120] http://www.mnp.am/uploads/1/1509988693BUR-Report_arm.pdf

[121] SC, Environment and Natural Resources in the RA (2006-2018)

and monitoring systems, providing national and regional stakeholders with modern equipment and technology designed to extinguish or suppress surface fires.

In 2017, within the framework of the "Integrated Biodiversity Management, South Caucasus" Project implemented by GIZ, 200 hectares were treated with coppice in Lori and Kotayk forest enterprises of "Hayantar" SNCO. The Forest Management Information System (FMIS), developed by GIZ, is currently at the implementation stage at the "Forestry" branches and head office of "Hayantar" SNCO. It is expected to serve for creation of electronic databases, data analysis and informed decision-making.

During 2013-2016, the UNDP-EU "Sustainable Management of Forests and Pastures in Armenia to Demonstrate Climate Change Mitigation and Adaptation Benefits and Dividends for Local Communities" Project was implemented aimed at demonstration of the sustainable natural resource management model in degraded mountainous pastures and forests of Armenia to increase ecosystems capacity for carbon sequestration under climate change, at the same time retaining biodiversity and economic values. In the framework of the Project, rehabilitation of mountain pastures (2000 ha) and forest (60 ha) was implemented.

In 2008-2016, in the framework of the GIZ "Sustainable Management of Biodiversity in the South Caucasus" Project, technical support to "Forest Monitoring Centre" and "Hayantar" SNCOs was provided, and an area of about 20 hectares was reforested and 350 hectares were treated with coppicing.

In 2011-2015, the WWF implemented the EU-funded "Transformation of Forest Plantations in the Southern Caucasus to Increase their Resilience to the Impacts of Climate Change" Project, in the framework of which transformation of areas and planting of approximately 250 thousand trees was carried out. Transformation of forest ecosystems is seen as a means of fostering resilience of natural forests to climate change and increasing the environmental value of homogeneous forests[122].

In 2012-2015, the WWF implemented the "Forest Landscape Restoration in Northern Armenia" Project, funded by Switzerland, which was aimed at restoring habitats for endangered plant and animal species through reforestation[123]. A plantation site in Yerevan Botanical Garden was established for cultivation of rare and endangered forest species, and the seedlings later were re-planted in Armenia's natural forest area[124].

A modern nursery has been established at the Hrazdan Forestry Branch of "Hayantar" SNCO with the support of FAO. The planting material of forest tree species (pine, ash, maple, etc.) is grown with closed root system.

The ATP Charitable Foundation has been conducting reforestation and other activities for about 25 years.

3.2.3 Land use

Following the agrarian reforms implemented in the Republic of Armenia in 1990s, the agricultural land was privatized (except for pastures) resulting in development of about 340 thousand agricultural holdings, each having on average 1.4 hectares of agricultural parcel, including 1.1 hectares of arable land. The privatized land area comprises 1.2 million of small plots, which creates major challenges for implementing complex and coordinated agro-technical activities and addressing environmental problems. The current situation requires appropriate steps to be taken to enable the use of modern, effective land use technologies, along with contributing to the reduction of GHG emissions.

Sector development strategy, legislation and state policy

Increasing the efficiency of land use is one of the most important issues in the agriculture sector. It has been stipulated in the Sustainable Agriculture Development Strategy of RA (2015-2025). The strategy envisages to include at least 10 thousand hectares of unused arable land in crop rotation per annum. As of 2017, the area of

[122] 6th National Biodiversity Report, 2019
[123] RA 5h National Report on Biodiversity, 2014
[124] 6th National Biodiversity Report, 2019

unused arable land in the country comprises over 200,000 hectares.

The Government is developing a relevant legislative package aimed at the inclusion of unused arable land into crop rotation. To this end, it is envisaged to put an instrument in place to oblige the landowners to cultivate the land under their possession or to lease it, if own cultivation is not practicable.

At the same time, actions are taken towards adjusting the scope of degraded lands and preventing desertification. In 2015, the proportion of degraded lands comprised 1.67% (or 472.5 km^2) of total terrestrial land area (excluding inland reservoirs)[125].

Currently, a decrease in soil fertility, reduction in carbon stocks and activation of erosion processes is observed in all the natural zones of Armenia. This is explained by the influence of anthropogenic, as well as natural innate factors. Semi-desert, dry steppe, steppe and forest zones are particularly vulnerable.

On May 27, 2015 the National Strategy for Combating Desertification and the National Action Plan was ratified by the GoA Decree No. 23, which emphasizes the importance of legislative improvements related to desertification issues, increasing the effectiveness of land management, raising public awareness on desertification issues and their solutions, as well as international cooperation.

On June 13, 2018, the RA Law on Making Amendments to the RA Land Code was adopted by the National Assembly, according to which the terrestrial land cover of the country is classified in 6 diverse classes:

1) cultivated lands;

2) meadows;

3) wooded areas;

4) bushy areas;

5) waterlogged areas;

6) areas devoid of vegetation.

According to the GoA Decree No. 431-N, dated April 11, 2019, “On Approving the Procedure for Classification of Terrestrial Area Coverage in the Republic of Armenia”, it is envisaged to have data on terrestrial land area coverage at the community level with annual breakdown. The enforcement of the Decree will contribute to the sustainable use of land resources.

3.3 F-gases

The Republic of Armenia ratified Kigali Amendment to the Montreal Protocol on “Substances that Deplete the Ozone Layer” to the Vienna Convention on the “Protection of the Ozone Layer” on March 27, 2019.

By this ratification, Armenia has committed to phase-out the use of HFCs from 2024 onwards, seeking a total reduction by 80-85% by 2045 as set out in the schedule below:

- 2024 - use of HFCs halted at the base level,
- 2029 - 10% reduction,
- 2035 - 30% reduction,
- 2040 - 50% reduction,
- 2045 (target) - 80% reduction

This process requires certain efforts. It will be necessary to develop a national plan on reduction of HFCs use, including corresponding changes in legislation, licensing, HFCs import restrictions, recording, training of personnel, and awareness raising. In particular, the following will be required:

- legally stipulating the commitment for the phase-out of the use of HFCs and anchoring the quotas set for the country in a relevant legal act;
- regulating quota control by licensing the relevant processes;
- transferring “best experience” for substitution/restriction of HFCs already available in the country and training appropriate human resources.

The recommended measures can be implemented both as climate change mitigation measures and as a commitment under Kigali Amendment.

[125] RA SC, 2016

3.4 Waste

On December 8, 2016, by the Protocol Decree No. 49, the RA Government approved the Strategy for the Development of the Solid Waste Disposal System (SWDS) for 2017-2036, followed by the GoA Protocol Decree No 13-15 (dated March 30, 2017), which approved the list of measures under the Strategy for Development of the SWDS for 2017-2036.

The implementation of the Strategy is expected to yield the following results:

- the waste management and landfill exploitation on the territory of the Republic of Armenia to be complaint with the EU indicators;
- the SWDS will consist of a limited number of regional subsystems (operation of no more than 10 regional landfills compliant with the EU standards and waste management in communities covered by the subsystem) and will serve the entire territory of the country;
- at least 95% of the waste generated in the country will be collected;
- the subscribers will sort out up to 20% of the waste generated by themselves;
- the landfills operating in the RA territory will be closed along with introduction of the new system (if no upgrade is considered necessary).

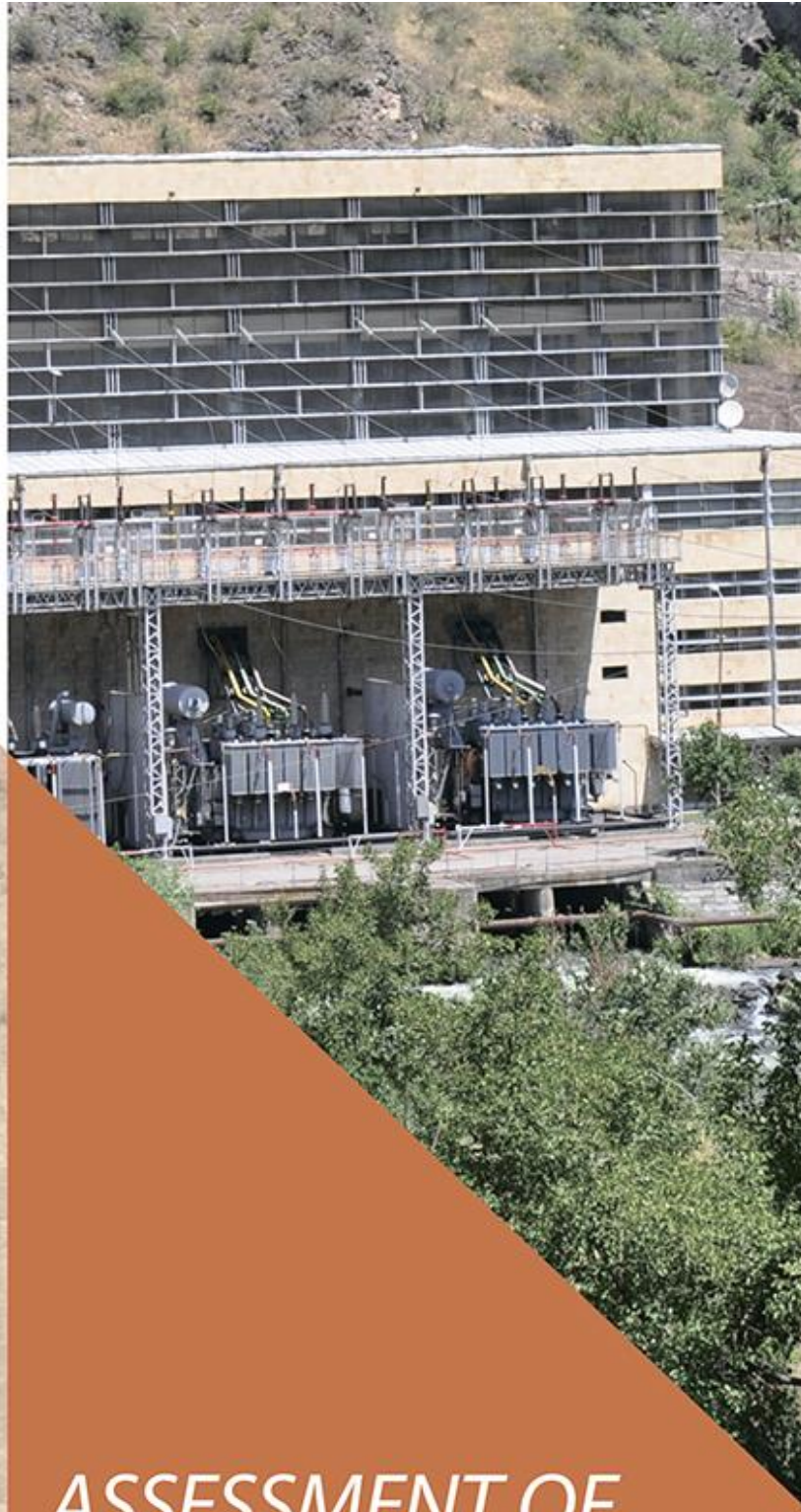
Construction of new sanitary landfills in Yerevan and Hrazdan has been launched within the framework of this Strategy with the EU financial support.

In the framework of the “SWDS in Yerevan” project, it is envisaged to construct a new landfill in compliance with international standards, examine the need for construction and efficient operation of a waste sorting and recycling plant, isolate and improve the operating landfills of Nubarashen and Ajapnyak, build a gas capture and combustion station for new and existing landfills. The project will be implemented with the support of the EIB and EBRD loan funds, the EU Neighbourhood Investment Facility and E5P Fund grants. The third phase of the SW Management Reform Project - the construction of a waste sorting and recycling plant, is envisaged to be implemented among communities in partnership with the private sector, following a multilateral evaluation of its feasibility and efficiency. The construction of the new landfill and the closure of the existing one will be carried out within the same project period. The landfill is expected to be fully operational by 2022.

In the framework of the “SWD in Kotayk and Gegharkunik regions” Project an EU compliant sanitary landfill is envisaged to be constructed near Hrazdan town with the introduction of landfill gas capture system. Waste generated by all settlements in Kotayk and Gegharkunik regions shall be placed in this landfill. It will be put into operation in 2021. The tender documentation package is currently being prepared.

Under the “Clean Armenia” Project, 1,692 uncontrolled landfills or 83% of inventoried landfills have been closed and their operation suspended.

Within the framework of the Government's Action Plan for 2019-2023, the “Concept Paper on Waste Management” has been developed, which outlines the following types of waste: industrial, agricultural, medical, construction and demolition, as well as waste management approaches aimed at preventing or reducing the generation of such waste, its subsequent recycling and disposal.



4 ASSESSMENT OF THE POTENTIAL **FOR MITIGATION OF GHG EMISSIONS**

4.1 Energy

The development scenarios of the Energy sector up to 2030 have been considered for assessing mitigation measures, given the strategic role of the sector for Armenia's economy and, at the same time, the maximum potential available for mitigation.

Since the new national Energy strategy is currently under development, the projections have been made based on the existing strategy. This includes also the commitments under the Iran-Armenia Inter-governmental Agreement, the recent developments, mostly in the solar energy sector, which have taken place after the publication of the BUR2, as well as commissioning of the new thermal power plant in Yerevan, scheduled in 2021. The average GDP growth rate is projected at 5% according to the Government Program (2019)[126], and the average annual economic growth for 2027-2030 is projected at 3%, according to the World Bank estimate and population growth rate[127].

Scenarios

The impact of the Energy sector mitigation actions for the period of 2016-2030 is assessed for the following scenarios:

Scenario 1 (without mitigation measures) considers the GHG emissions growth risks in case of a delay of the new unit of the nuclear plant construction. The scenario does not consider any new sources of renewable energy and mitigation measures on the demand side. The growing demand for electricity is fully met by construction of new thermal power plants, including contractual obligations under the Iran-Armenia Electricity-for-Gas Swap Agreement.

Scenario 2 (with mitigation measures) considers mitigation measures for both generation and demand sides with high probability of implementation. The measures include ones, which are prioritized in sectoral strategy or planning documents and/or have secured sources of funding. On the generation side, with the current pace of development, the scenario has taken into account the construction of a new 600 MW power unit of NPP (which will replace old units), construction of new renewables – small and medium-size hydropower plants (HPPs), wind farms, a geothermal station, construction of PV plants - utility scale solar PVs with up to 5 MW installed capacity, autonomous power producers with up to 500 kW capacity.

Scenario 3 (with additional mitigation measures) includes measures (both on generation and demand sides), which can ensure the maximum of the mitigation potential: ambitious development of renewable energy generation, although with relatively high degree of uncertainty for implementation. The mechanisms for implementation of those measures are not yet clear and not initiated either.

The Energy sector development scenarios projections were done using the LEAP (v.2017.0.11.0) model, which was applied also within the first and second BURs. It enables to:

- compare the emissions projected for 2015-2016 under the BUR2 and the actual emissions for the same period;
- make projections for GHG emissions for the period between 2016 and 2030 based on the scenarios considered.

In order to compare the projected and observed emissions:

- the projections for 2015-2016 made under the "without mitigation measures" scenario have been reevaluated with updated data on actual exogenous factors - GDP, actual population growth rate, actual electricity export/import volumes and actual structure of electricity generation;
- the emissions for 2015-2016 under the *"with mitigation measures"* scenario have been verified based on the GHG inventory data.

The difference between the ex-post evaluation of *"without mitigation measures"* scenario and the 2016 GHG Inventory data (*"with mitigation measures"* scenario) shows the actual reduction of emissions achieved, which is 417 Gg $CO_{2\ eq}$. The latter is mainly

[126] https://www.gov.am/files/docs/3133.pdf
[127] Long Term (up to 2036) Development Pathways for the Armenian Energy Sector http://www.minenergy.am/page/493

due to the launch of new small hydro power plants (SHPPs) and the reduction of emissions from the demand side mitigation measures in the commercial/institutional and residential sectors.

The projections since 2016 have been reassessed taking into account the updated data on GDP, population growth, as well as the impact of various mitigation measures. The actual values of GDP, population and electricity export have been used in the assessment for 2015 and 2016 emissions, whereas the assessment for 2017 has been carried out based on the projections thereof.

Figure 4-1 shows the updated ex-post estimations of scenarios for 2015-2016 and the emissions projected for the period of 2016-2030 according to the mitigation scenarios.

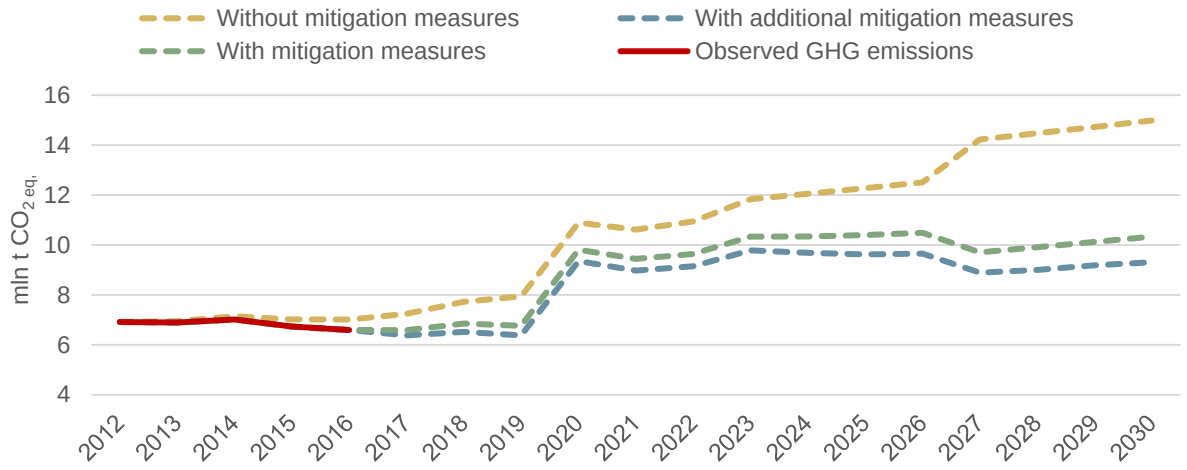


Figure 4-1. Projections of emissions from the Energy sector by scenarios

Table 4-1. Mitigation potential in the Energy sector, Gg $CO_{2\ eq.}$

Mitigation measures	2016*	2020	2025	2030
Scenario 2 (with measures)				
Reductions from generation side measures, including:	-190	-380	-894	-3420
new nuclear power unit - 600 MW	0	0	0	-2375
new small and medium HPPs	-190	-338	-592	-643
wind farms	0	2	-7	-79
geothermal PPs	0	0	-97	-105
solar-PVs	0	-40	-197	-218
Reductions from demand side measures	-227	-708	-986	-1,231
Total	***-417***	***-1,088***	***-1,880***	***-4,651***
Scenario 3 (with additional measures)				
Reductions from generation side measures, including:	-190	-407	-1,096	-3,772
new nuclear power unit - 600 MW	0	0	0	-2,400
new small and medium HPPs	-190	-361	-627	-649
wind farms	0	2	-77	-297
geothermal PPs	0	0	-103	-106
solar-PVs	0	-44	-290	-320
Reductions from demand side measures	-227	-1,132	-1,562	-1,907
Total	***-417***	***-1,539***	***-2,659***	***-5,679***

** ex-post estimations.*

Table 4-2. GHG emissions reduction potential for 2030

Mitigation measures	Gg $CO_{2\ eq.}$	%
New unit of NPP	-2,400	42.3
New renewable energy sources	-1,045	18.4
Demand side mitigation measures	-1,231	21.7
Additional renewable energy sources	-327	5.8
Additional demand side mitigation measures	-676	11.9
Total	***-5,679***	***100.0***

The total potential for GHG emissions reduction in the Energy sector for 2030 is summarized in Table 4-2.

Table 4-3 provides projection of energy consumption indicators resulting from the implementation of mitigation measures.

Table 4-3. Projections of energy consumption indicators under the "with mitigation measures" scenario

Indicators	2012*	2016*	2020	2025	2030
GDP, million USD (constant 2010 USD)	10,394	11,480	13,954	17,470	20,253
Population, million people	3.03	2.99	2.94	2.93	2.91
Total primary energy supply (TPES), ktoe	3,311	3,243	4,532	4,802	5,128
GDP energy intensity, toe/thousand USD	0.32	0.28	0.32	0.27	0.25
Per capita primary energy consumption, toe/person	1.09	1.09	1.54	1.64	1.76
GHG emissions in the Energy sector, thousand t $CO_{2\ eq.}$	6,915	6,594	9,805	10,398	10,337
GHG emissions per unit of primary energy supply, t $CO_{2\ eq.}$ /toe	2.09	2.03	2.16	2.17	2.02

** actual indicators.*

The projections allow estimating the contribution of the Energy sector, having the largest share of national GHG emissions and, at the same time, sector with the highest mitigation potential, in fulfilment of obligations under Nationally Determined Contributions.

4.2 Agriculture

The enteric fermentation and manure management from domestic livestock are key sources of CH_4 and N_2O emissions in the Agriculture sector. In fact, 90% of CH_4 emissions from enteric fermentation is attributable to cattle, and significant portion of indirect N_2O emissions is generated from the management of cattle manure.

The assessment of mitigation measures has been done considering animal husbandry sector development scenarios up to 2030, taking into account the sector development strategy, state adopted policies, the projects and measures implemented in the sector, as well as production processes that may contribute to the GHG emission reduction.

The effect of the measures has been assessed by application of the IPCC 2006 Guideline software package.

Reduction of GHG emissions from animal husbandry and manure management has been assessed for 2023 and 2030 using 2016 as the baseline year.

The number of cattle by breeds projected from the implementation of the Cattle-breeding Development Program of the RA is shown in Table 4-4.

According to estimates, the emission factor from enteric fermentation of high producing dairy cows is 80.3 kg CH_4/head/year, which is lower than the figure attributable to the local breed cows (82.5 kg CH_4/head/year) due to higher digestibility factor, despite the higher rates of live-weight and milk yield.

Table 4-4 Average annual number of cattle heads

	2016	2023	2030
Cattle	841,530	739,157	648,951
Cows, of which	360,461	324,461	270,628
local breed cows	360,461	284,461	160,628
high producing dairy cows	0	40,000	110,000
Bulls	29,206	29,206	29,206
Young bulls, of which	451,862	385,490	349,117
local breed bulls	451,862	355,490	259,117
high producing dairy bulls	0	30,000	90,000

According to estimates, only due to genetically improved cattle, CH_4 emissions from cattle enteric fermentation in Armenia will be reduced by 6.1 Gg by 2023 and by 12.3 Gg by 2030, since the same outputs of the animal husbandry (in meat and milk production) will be obtained by a smaller population of cattle.

Genetic improvement, premature breeding, operation of slaughterhouses, mushroom farms, as well as biogas and bio humus production will result in reduction of CH_4 and N_2O emissions from manure management (Table 4-5). Such a change is attributable to rearrangement in the proportions of manure management systems and the introduction of new systems, in particular by:

a/ "Manure" management system improvement aimed at reducing the proportion of the manure not collected and left in pastures and fenced enclosures;

b/ reducing the proportion of “Daily spread” system;

c/ increasing the proportion of “Solid storage” system;

d/ increasing the proportion of “Liquid manure” system;

e/ replenishing the existing systems with “Composting in stockpiles and anaerobic fermentation” systems.

The projected reforms will also contribute to the reduction of indirect N_2O emissions from manure management (3.C.6) by 0.075 Gg and 0.082 Gg by 2023 and 2030, respectively.

The dynamics of gradual reduction of GHG emissions from the implementation of animal husbandry programs supported by the RA Government is summarized in Table 4-5 and Figure 4-2.

Table 4-5. GHG emissions from the Agriculture sector by sources, Gg $CO_{2\ eq.}$

IPCC code	IPCC categories	GHG	2016	2023	2030
3.A.1	Enteric fermentation	CH_4	1,219	1,090.94	959.53
3.A.2	Manure management	CH_4	99.31	91.11	80.17
3.A.2	Manure management	N_2O	87.23	53.98	50.54
3.C.6	Indirect N_2O emissions from manure management	N_2O	64.57	41.33	39.06

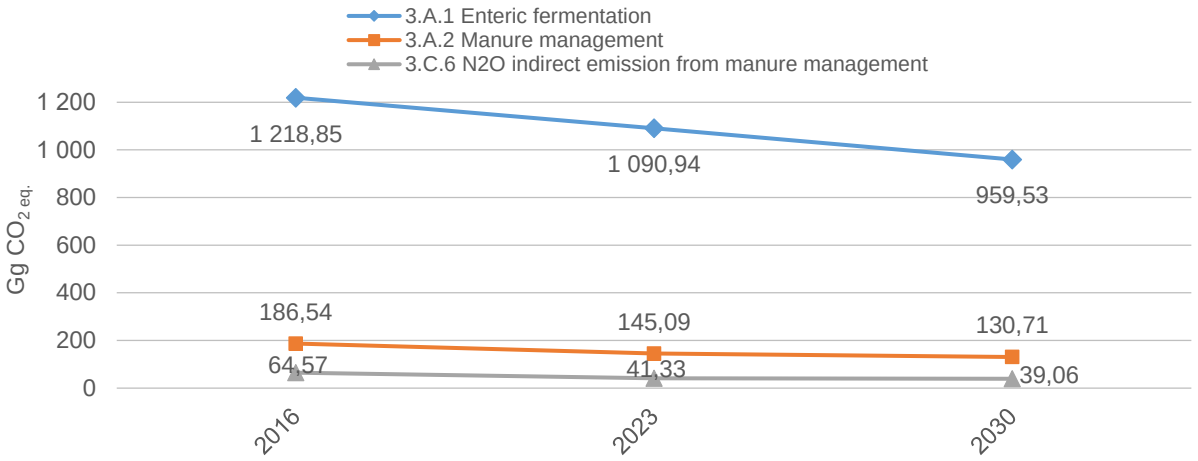


Figure 4-2. Projections of GHG emissions from cattle enteric fermentation and manure management in the Agriculture sector, Gg $CO_{2\ eq.}$

Recommendations for GHG emissions reduction-oriented actions

Due to the awareness raising activities carried out among farmers about feed digestibility, it is feasible to implement certain actions in the nearest future aimed at increasing feed digestibility and thereby resulting in reduction of GHG emissions, in particular:

- Expand cropland for herbaceous crops mixed with valuable forage - the ryegrass, as the latter has a high sugar content, which contributes to increased feed digestibility. By 2030, it is feasible to expand the land for herbaceous crops mixed with ryegrass to 4,000 hectares or to expand it by almost 5 times.
- Increase the proportion of easily digested feed in formulating the feeding ration for the cattle.
- Add clover to the ration of cows, as it produces less gases in the stomach of ruminants due to a low fiber content.
- Omega-3 unsaturated fatty acids suppress methane release processes. Therefore, by increasing the proportion of herbaceous plants - lucerne and melilot containing omega-3 unsaturated fatty acids in the ration of ruminants. Also, combined feeds should be mixed with animal and vegetable fats containing omega-3 unsaturated fatty acids, such as fish oil and linseed oil produced in Armenia from locally grown linseed.
- If cattle consume 2.5–3.0 kg or more of concentrated feedstuff per feed, their digestibility drops sharply, therefore, it would be appropriate to reduce their intake at each feed.
- Tannin, which is stored in large amounts in grape seeds, also has a moderating effect on intestinal processes. Each year, thousands of tons of dry grape pulp and seed residue are obtained as a byproduct of spirit and winemaking in Armenia, which is mainly fed to poultry and swine. Whereas, they should be included in the composition of condensed feeds for cattle and sheep by preparation of combined feeds up to 15% of which will consist of winemaking byproduct containing grape seed
- Garlic also has a moderating effect on intestinal processes, therefore low marketable garlic, as well as the dried over-ground part of the plant may be included in the diet of cows.
- 25-30% of feedstuff given to cattle during stabling constitutes straw which has low digestibility factor, whereas pre-treatment of straw with limewater or a sodium base destroys the link between cellulose and lignin, significantly increasing digestibility of the straw.
- Some of the CH_4 present in rumens of cattle can be absorbed by adsorbent materials. Bentonite, which has an adsorption property, also serves as a source of minerals for animals and is given to animals as a mineral supplement. Therefore, 3-5% of the portion of ruminants should consist of bentonite, which is produced by the Ijevan Bentonite Plant.

4.3 F-gases

Hydrofluorocarbons (HFCs) emissions have been projected by their application types based on the current growth trends of HFCs emissions (Table 4-6).

Starting from 2024, HFCs emissions are projected to gradually reduce according to the following schedule:

- 2024 - use of HFCs halted at the base level;
- 2029 - 10% reduction;
- 2035 - 30% reduction;
- 2040 - 50% reduction;
- 2045 (target) - 80% reduction.

Table 4-6. Projections of HFCs emissions by their application, Gg $CO_{2\ eq.}$

Year	Refrigeration and Air Conditioning	Aerosols	Foam Blowing	Fire Protection	Total
2015	543.44	10.06	19.29	0.57	573.36
2016	606.67	9.03	21.40	0.60	637.70
2017	677.26	8.11	23.74	0.63	709.73
2018	756.06	7.28	26.34	0.66	790.33
2019	844.02	6.53	29.22	0.70	880.47
2020	942.23	5.86	32.41	0.74	981.24
2021	1,051.86	5.26	35.96	0.78	1,093.86
2022	1,174.24	4.72	39.89	0.82	1,219.68
2023	1,310.87	4.24	44.26	0.86	1,360.22
2024	1,463.39	3.81	49.10	0.90	1,517.20
2029	2,537.26	2.22	82.50	1.17	2,623.15
2035	4,911.00	1.16	153.80	1.59	5,067.55

Table 4-7. Projections of HFCs emissions by the reduction schedule, Gg $CO_{2\ eq.}$

Year	Refrigeration and Air Conditioning	Aerosols	Foam Blowing	Fire Protection	Total
2024	1,463.39	3.81	49.1	0.9	**1,517.2**
2029	1,317.05	3.43	44.19	0.81	**1,365.48**
2035	1,024.37	2.67	34.37	0.63	**1,062.04**

Below are projections of HFCs emissions without implementation of measures and with envisaged policy.

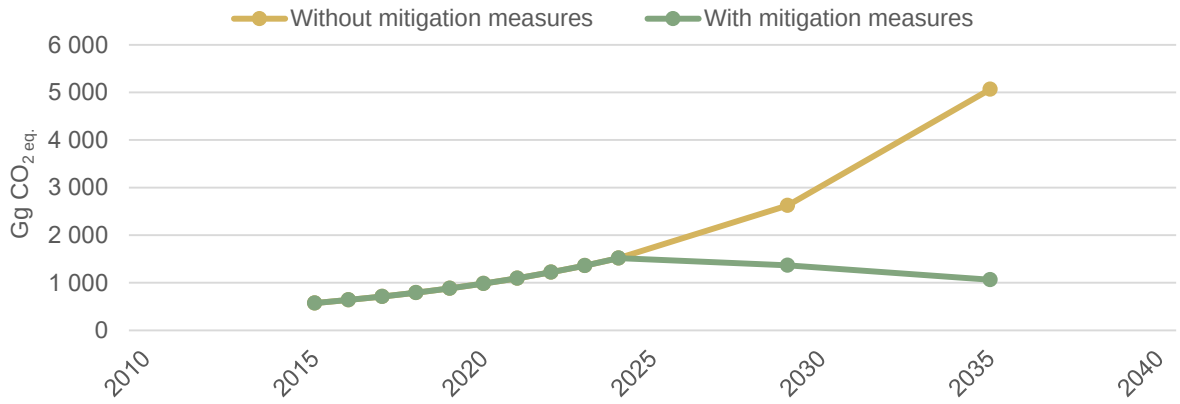


Figure 4-3. Projections of HFCs emissions *"without mitigation measures"* and *"with mitigation measures"* scenarios, Gg $CO_{2\ eq.}$

4.4 Waste

As of 2016, around 6% of the total GHG emissions are attributable to the Waste sector. Emissions from solid waste account for approximately 71% and those from wastewater - roughly 29% of emissions in the Waste sector.

Considering that currently there are no long-term comprehensive programs for reconstruction and modernization of wastewater treatment systems in Armenia, the projections of GHG emissions in the sector have been done for solid waste only.

Projections of GHG emissions from solid waste have been carried out for two scenarios. "*Without mitigation measures"* is the baseline scenario, which implies maintaining current trends in the future, and solid waste volume projections are made based on the projected number of the population.

"With mitigation measures" projections are done based on the RA SWDS Development Strategy for 2017-2036 and planned projects for construction of new sanitary landfills in Yerevan and Hrazdan communities, currently underway, which envisage the introduction of landfill gas capture and utilization system.

Since there is currently no progress towards implementation of the project on "Comprehensive SW Management in Vanadzor" and construction of other landfills set out in the Strategy, projections are based only on the outputs of the construction of new sanitary landfills in Yerevan and Hrazdan.

Calculations of emissions reduction have been carried out based on the volumes of emissions per urban dweller assessed by the national GHG Inventory of 2016, as well as population number of cities generating the solid waste intended for disposal in soon-to-be-built sanitary landfills in Yerevan and Hrazdan. Calculations of emissions reduction have been carried out in the following steps:

- emissions reduction from closed landfills, where CH_4 emissions are not captured (total waste generated by population of cities in Kotayk and Gegharkunik marzes and 30% of waste generated in Yerevan);
- emissions reduction from closed landfills, where CH_4 emissions are captured and flared (70% of waste generated in Yerevan)[128].

Reduction in emissions from closed landfills and from landfills without CH_4 combustion has been calculated based on the average annual reduction trends - 7.1%, published in the monitoring reports under Nubarashen CDM Project.

The emissions calculation has been done considering Nubarashen CDM project data related to the incomplete burning of methane during flaring, which makes 5%. CO_2 emissions from methane combustion have also been estimated.

By 2030, the total emissions reduction projected from solid waste sector will amount to 212.9 Gg $CO_{2\ eq.}$ or 51% of solid waste generated in 2016 (419 Gg $CO_{2\ eq.}$).

Table 4.8. Projections of methane emissions from solid waste, Gg

Year	2010*	2015*	2020	2025	2030
Without measures scenario					
Emissions	18.80	19.80	20.60	21.10	21.60
With mitigation measures scenario					
Emissions	18.80	19.80	20.60	13.23	11.46

** actual indicators (https://cdm.unfccc.int/Projects/DB/JQA1116316762.57/view).*

[128] Capture and use of methane emitted at the new Hrazdan landfill will commence 2-3 years after commissioning, and the impact of the methane combustion during this period will be limited and can be regarded as negligible.

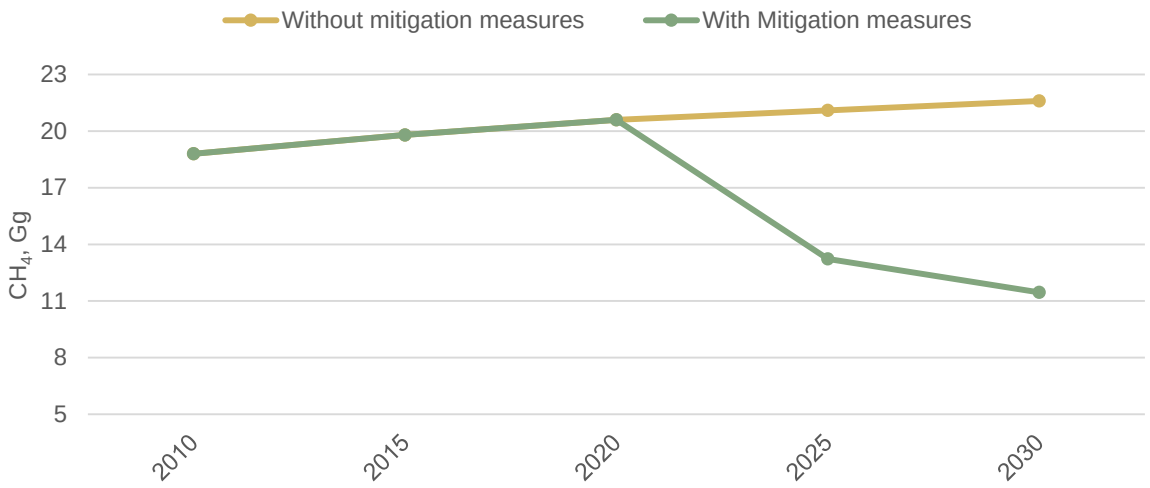
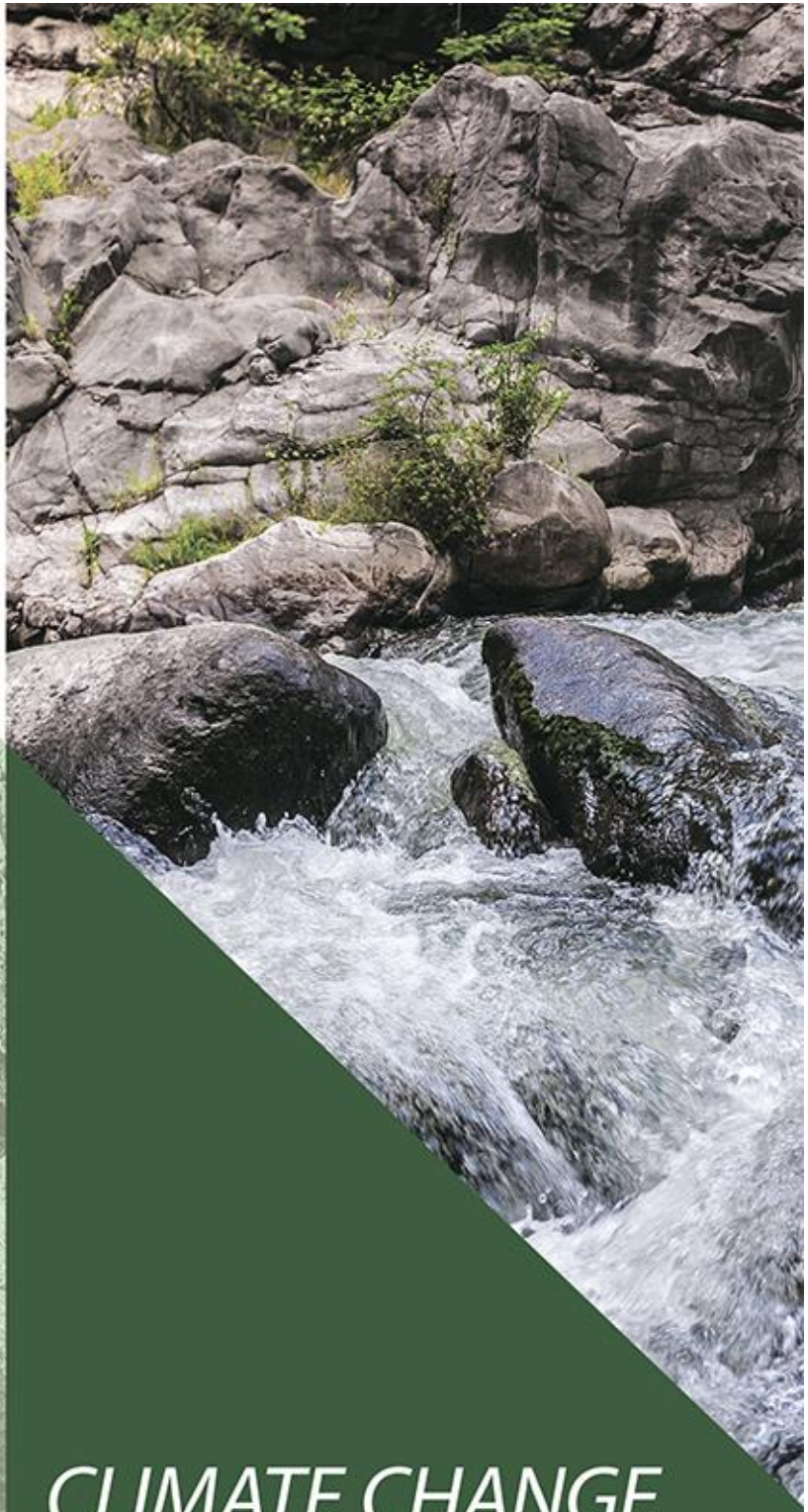


Figure 4-4. Projections of CH_4 emissions from the Waste sector under *"without mitigation measures"* and *"with mitigation measures" scenarios*, Gg



5

CLIMATE CHANGE IMPACTS. ***VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES***

As a mountainous country with arid climatic conditions, Armenia is considered to be highly susceptible to climate change across its entire territory and vulnerable eco-systems. In recent years, along with the increase in air temperature and decrease in precipitation, also a significant increase in frequency and intensity of extreme weather events (droughts, heat waves, frost, hail, strong winds and precipitation) and natural disasters (floods, inundations, forest fires etc.) has been observed, which have a negative impact on ecosystems, economy, human welfare and health.

Subsequent to the preparation of the NC3 on climate change, the projections of climate change and assessment of its impacts have been updated within the NC4, taking into account the impact of global anomalies observed in recent years and the changes occurred in the local climate regime.

Additionally, vulnerability assessment has been performed and adaptation measures have been developed for various sectors of the economy sensitive to climate change.

5.1 Observations on Climate Change in Armenia

Trends in air temperature and precipitation changes

Changes in annual air temperature and precipitation in the territory of Armenia have been estimated for different periods, the results of which have been used in Armenia's first, second and third national communications on climate change. The results show that during the last decades there has been a significant increase in ambient air temperature in the country (Table 5-1, Figure 5-1); moreover, during the period of 1929-1996, average annual temperature has increased by 0.4^{0}C, during the period of 1929-2007 - by 0.85^{0}C, during the period of 1929-2012 - by 1.03^{0}C, and during the period of 1929-2016 - by 1.23^{0}C.

Table 5-1. Changes in average annual air temperature and precipitation during the period of 1929-2016 from the baseline average of 1961-1990

Period	Air temperature, ^{0}C	Period	Precipitation mm, (%)
1929-1996	+0.4	1935-1996	-35 (-6)
1929-2007	+0.85	1935-2007	-41 (-7)
1929-2012	+1.03	1935-2012	-59 (-10)
1929-2016	+1.23	1935-2016	-50 (-9)

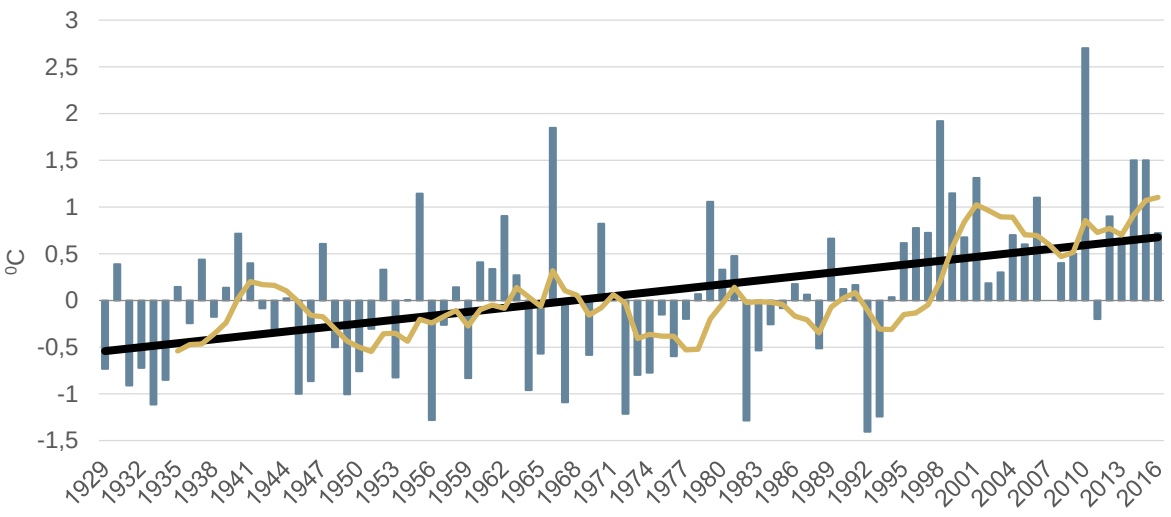


Figure 5-1. Deviation of the average annual temperature (^{0}C) in the territory of Armenia from the baseline average for 1961-1990

Figure 5-1 shows that during the period of 1994-2016, annual average temperature deviations from the average values for the baseline period of 1961-1990 (5.5^{0}C), have been mainly positive (except for 2011). The year 2010 was the warmest in Armenia, and 1998 and 1966 - the next warmest years throughout the entire observation period; deviations from the norm were 2.7^{0}C, 2.0^{0}C and 1.9^{0}C, respectively, and during the years 2014 and 2015 - 1.5^{0}C. On July 31, 2011, 43.7^{0}C was recorded in Meghri, which is the absolute maximum temperature in Armenia for the entire monitoring period; it exceeded the previously observed maximum by 0.7^{0}C.

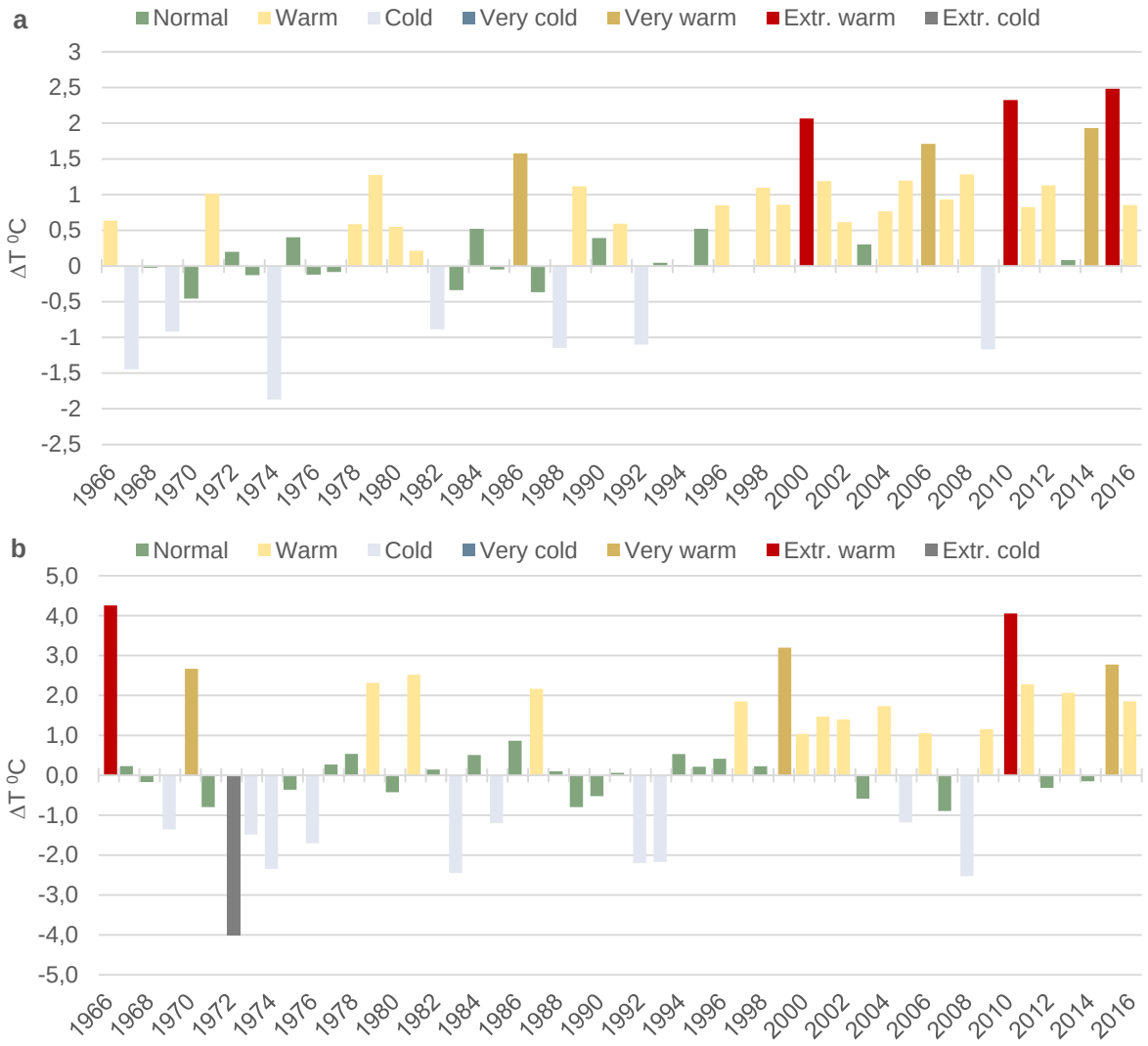


Figure 5-2. Deviation of average seasonal temperature (ΔT) in the territory of Armenia during 1966-2016 from the baseline average for 1961-1990, in summer (a) and winter (b) months

Changes in air temperature at different seasons have different trends. During 1966-2016, the average summer temperature has risen by about 1.3^{0}C, with extreme hot summers observed in Armenia during the last 20 years (2000, 2010, 2015) (Figure 5-2a). Changes in winter temperature demonstrate a completely different trend with very slight upward movement - 0.4^{0}C (Figure 5-2b). Extreme warm winters were observed in 1966 and in 2010, and extreme cold winter - in 1972.

Starting from 1935, comparison of estimated changes in the amount of precipitation over different periods shows that the decreasing trend in precipitation is maintained (Table 5-1). Over the period of 1935-1996, the average annual precipitation decreased by 6%, and during the period of 1935 to 2016 - by about 9% (Figure 5-3).

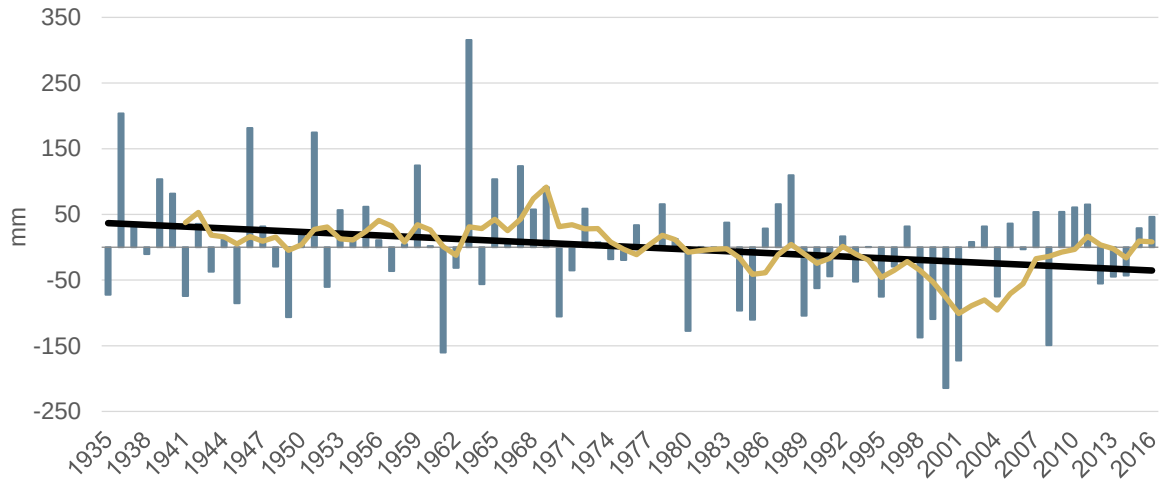


Figure 5-3. Deviation of average annual precipitation in the territory of Armenia from the baseline average for 1961-1990

During the period of 1935-2016, the average annual value of precipitation in the territory of the Republic of Armenia was 558 mm or 94% of the norm (592 mm) for 1961-1990 period. The spatial distribution of precipitation is quite irregular. During 1935-2016, the climate in the northern (Vanadzor, Stepanavan), southern (Meghri) and central (Ararat valley) regions became more arid. Precipitation increased in the Shirak plain, in the Lake Sevan basin, and in Aparan-Hrazdan regions.

Changes in atmospheric circulation

Atmospheric circulation is one of the key factors in the formation of climate, which is expressed in the territory of Armenia by the influence of western air currents specific to the sub-tropical zone. As a result of global climate change, the processes of general circulation in the atmosphere are changing, too. Due to recent changes in global atmospheric circulation, climate risks and the incidence of hazardous hydro-meteorological (HHP) phenomena have increased. To this end, the regional thermobaric fields have been studied on a daily, monthly and annual basis during 2008-2016, and 14 types of processes have been identified, which determine the climate in Armenia.

Cyclones penetrate the territory of the RA mainly from the Mediterranean Sea, Asia Minor, Syria and Iraq's northern regions, and sometimes from northeast of Africa. During the cyclone journey, cloudiness increases with wind intensification of up to 25-30 m/s. In the cold half of the year, the cyclone journey is accompanied by heavy snowfall, fog, black ice, and in the hot half of the year - by rains, thunderstorms, and sometimes hail. The abrupt changes in air temperature (cold waves) are most often due to the anticyclone peaks transitioning into the RA territory from west and northwest due to intrusions of cold atmospheric fronts.

The outflow of the southern cyclone to the territory of Armenia is accompanied by thunderstorms, heavy rainfall and intensified southern winds. During the period of 1948-2016, the average value of events of southern cyclones' penetration has remained merely unchanged. The number of heat depression instances has increased by 20.6 cases (by 128.8%), hence recurrence of summers with high thermal background and low precipitation has increased.

Late spring and early autumn frosts, as well as strong winter frosts and strong winds in winter are mainly due to the Scandinavian and Western European anticyclone, the frequency of which has increased by 80% and 153.8%, respectively, indicating that the recurrence of HHP on the territory of Armenia due to the above-mentioned has increased as well.

The number of Iranian anticyclone formation cases in the territory of Armenia has increased by approximately 71.4%, which has led to higher recurrence of heat waves. The weakly expressed stable pressure field

does not result in any dangerous meteorological phenomena in the territory of Armenia. The recurrences of these atmospheric conditions decreased by 15% during the observation period.

Hydrometeorological hazardous phenomena

The frequency and intensity of natural disasters has increased dramatically due to climate change over the last decades, both around the world and in Armenia; the threshold values adopted so far to characterize those phenomena, have modified as well. To identify the trends in the change of the HHP, the most commonly observed hazardous phenomena in Armenia during the period of 1975-2016 were analyzed: frostbite (decrease in air and/or soil surface temperature below 0^0C during the vegetation period), hailstorm (20 mm or more in diameter), strong winds (25 m/s and more) and the dynamics of heavy rainfall (30 mm and more within 1 hour).

The NC3 of RA provided an overview of the changes in these hazardous phenomena during the period of 1980-2011, using data from about 7-10 different meteorological stations for each hazardous phenomenon. Whereas, observation data from 20 meteorological stations were used in the course of preparing this communication.

The number of cumulative cases of HHP observed on the territory of the RA during the period of 1975-2016 increased by about 40 cases from the baseline average (168 cases) for the period of 1961-1990 - constituting 23.5% of the multi-annual average value (Figure 5-4). Hailstorm cases were mostly observed in the Shirak plain, heavy rainfall cases - in Tashir and Ijevan regions, frost cases - in the Ararat valley and foothill regions.

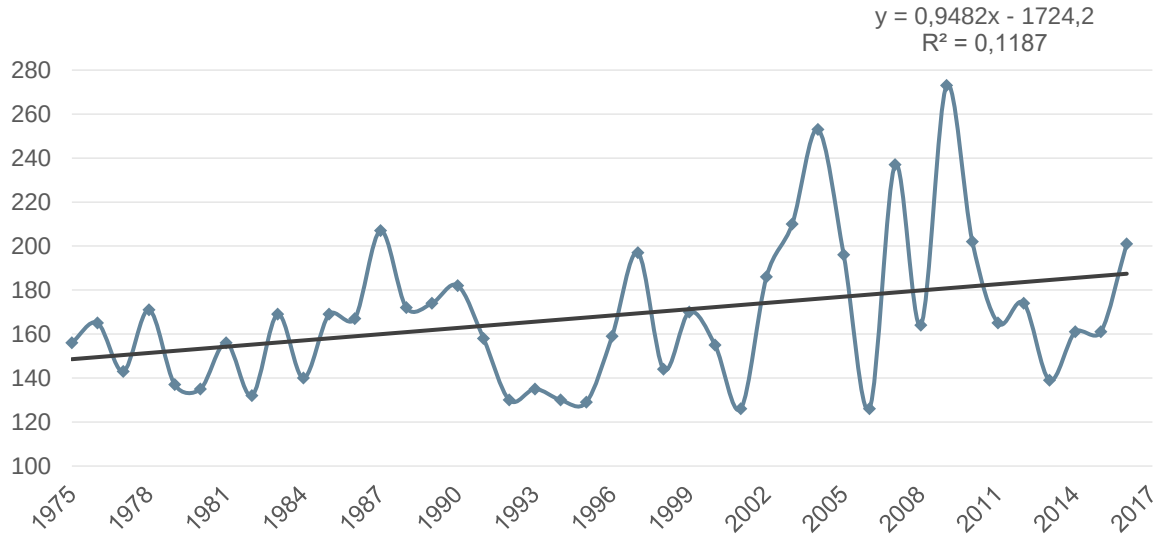


Figure 5-4. Cumulative number of cases of HHP, such as frostbite, hail, strong wind and heavy precipitation, observed during the period of 1975-2016 on the territory of Armenia

Studies have shown that droughts are observed in the lower regions of Armenia almost every year, and in the foothill regions recurrence of droughts is about 50%.

According to drought indices, the number of strong and very strong droughts during the period of 2000-2017 increased by 33 days relative to the baseline average (87) for 1961-1990.

Based on the data from meteorological stations, positioned according to the zoning, drought assessment results show that in recent years the upper boundary of the drought zone has expanded to include mountainous areas, and the droughts start earlier.

Climate extremes indices

The increase in the frequency of extreme climate phenomena is one of the main manifestations of climate change. According to the data from 45 meteorological stations, about 27 indices proposed by the World Meteorological Organization (WMO) were estimated in the whole territory of Armenia for the period of 1935-2016, which can be

applied in a number of sectors: health, agriculture, water resources, etc.

The indices were calculated for each station according to their observation data series. The number of summer days (Tmax> 25°C) increased at all altitudes during the observed period (1935-2016), and substantially increased at altitudes of 1000-1500m (by 4.3 days/10 years); the increase in the number of tropical nights is higher in the zone up to 800m - by 2.2 days/10 years. The number of cold days decreased by 1.4-3.5 days/10 years during the same period, while the number of extreme cold days decreased by 0.4-2.3 days/10 years. The duration of the heat waves accordingly increased by 2.0-7.6 days, while the cold waves at the altitudes of up to 2000 m decreased by 0.7-1.4 days/10 years, and at altitude above 2000 m increased by 1 day/10 years.

The following indices characterizing the extreme climatic conditions were also evaluated based on altitudes: number of consecutive dry days, number of humid days, duration of rainless season. Number of consecutive dry days in the observed period of 1935-2016 increased by 0.3-1.6 days/10 years; the number of days with heavy precipitation (R10mm) at altitudes up to 2000 m increased by 0.7 days, while at altitudes above 2000 m - decreased by 1 day/10 years.

Indices of consecutive days with less than 1 mm precipitation (CDD) and days with temperature above 25^{0}C (SU25) were estimated for all meteorological stations in Armenia using 1935-2016 data. The results were mapped (Figure 5-5).

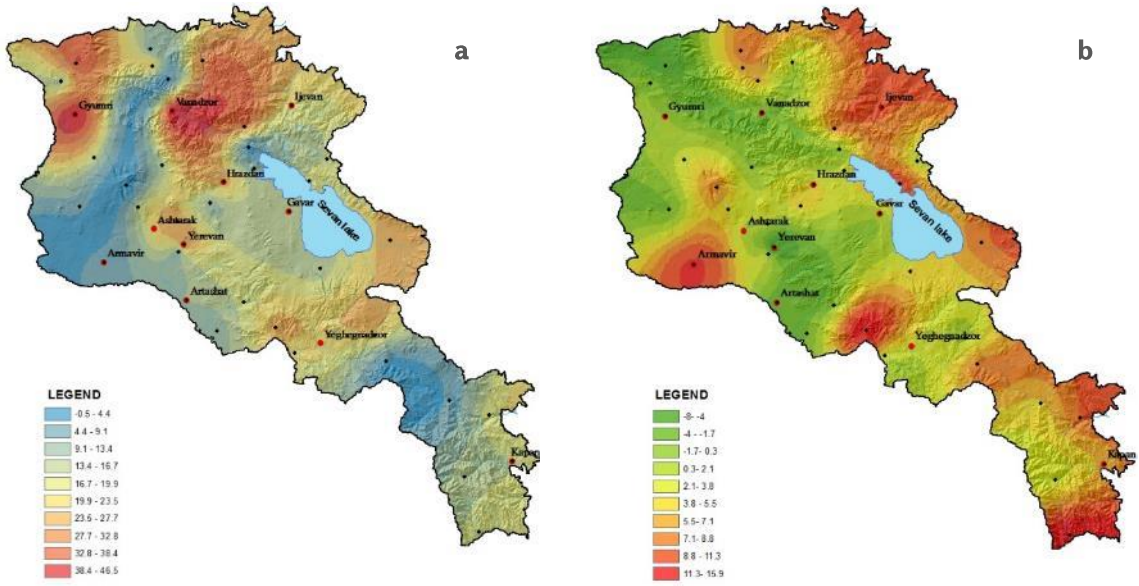


Figure 5-5. Spatial distribution of changes in a) SU25 and b) CDD indices in Armenia during the period of 1935-2016

The analysis of climate indices from the stations of Yerevan, Vanadzor and Gyumri for the whole observations period revealed trends of increasing and decreasing indices and quantitative changes.

In Yerevan, according to May-October data for the period of 1966-2017, the number of heat wave recurrences has increased by 3.4 cases over 52 years, and the number of corresponding days increased by 17.6 days.

The thermal index calculation reveals that the number of days with extreme thermal indices in Yerevan in 1991-2015 increased significantly compared to the period of 1966-1990; and the number of hazardous days has increased by 20% over the last 25 years. As for the moisture index, during the period of 1991-2015, the number of days of comfort decreased by 30% compared to the period of 1966-1990. The number of days with some discomfort during the period of 1991-2015 increased by 46% relative to the period of 1966-1990. The number of days characterized by high discomfort over the same period increased by 251 cases, i.e. by

418% relative to 1966-1990 (60 cases in total). The number of days with average temperatures above 25^{0}C (SU25 Tmax>25^{0}C) significantly increased in Vanadzor, Gyumri and Yerevan by 45, 44 and 27 days, respectively (comprising 50 in Vanadzor, 72 in Gyumri, and 122 in Yerevan). Frost days manifest the opposite trend, with the highest decrease being observed in Gyumri and Vanadzor for 18 and 15 days, respectively, and 8 days in Yerevan. In Yerevan and Vanadzor decrease in dry days is observed - by 9 and 2 days, respectively; while in Gyumri a slight increase was observed. Increase in the duration of vegetation period is observed in Vanadzor – by 22 days, in Gyumri – by 13 days and in Yerevan – by 9 days, which corresponds to the number of summer days conditioned by the thermal regime.

The results of the analysis show that over the period of 1935-2016, the afore-mentioned indices demonstrate upward trends throughout the entire territory of the country. These indices are highly charac-teristic for the increased drought recurrence, which, in turn, is caused by heat depression.

5.2 Climate Change Scenarios for Armenia

In the course of development of the NC4, in addition to reviewing the results and uncertainties of the CCSM4 global climate model used in NC3 for climate change projections, the high resolution METRAS (12x12 km) regional climate model was also used. The model is based on the results of the ACCES, CNRM, MPIM, GFDL global circulation models. The METRAS regional model enables dynamical downscaling of the results of these global models for the territory of Armenia, reducing the errors due to the rough model resolution, given the complex mountainous terrain conditions of Armenia. Using the aforementioned high-resolution model, projections of average air temperature and atmospheric precipitation in Armenia were conducted based on different altitude zones, deriving from the pessimistic RCP8.5 scenario.

Figures 5-6a and 5-7a show the annual distribution of air temperature and precipi-tation in Armenia in the period of 1961-1990 according to the METRAS model. Figure 5-6 shows that, in general, the METRAS model successfully reproduces the spatial patterns of the mean annual air temperature distribution in Armenia. In particular, low annual temperatures correspond to the temperature of mountainous regions (-2^{0}C and lower), and high annual temperatures - to the temperature of relatively low valley regions (10^{0}C and higher). On the other hand, the annual precipitation in humid mountainous areas is generally above 700-800 mm, according to the model data, and in arid regions the precipitation does not exceed 300 mm (Figure 5-7a).

Figure 5-6b shows the projected change in spatial distribution of mean annual air temperature in Armenia for the period of 2071-2100. As shown in the temperature distribution maps, the color shades corresponding to high temperatures are expanding and intensifying by the end of the 21st century, and cold zones characterized by low temperatures are shrinking. While for the period of 1961-1990 the average annual temperature in the Ararat valley, and in Tavush and Syunik valleys is 10-14^{0}C, during the period of 2071-2100 it is projected to reach 16-18^{0}C (Figure 5-6 a, b). The average temperature during the summer season can reach up to 27^{0}C (Table 5-3c). It should be noted that these regions represent the main agricultural zones of Armenia, which are highly vulnerable to climate change. The anticipated increase in temperature in these areas will further exacerbate various issues related to arid conditions and water scarcity, which will consequently have an adverse impact on agriculture.

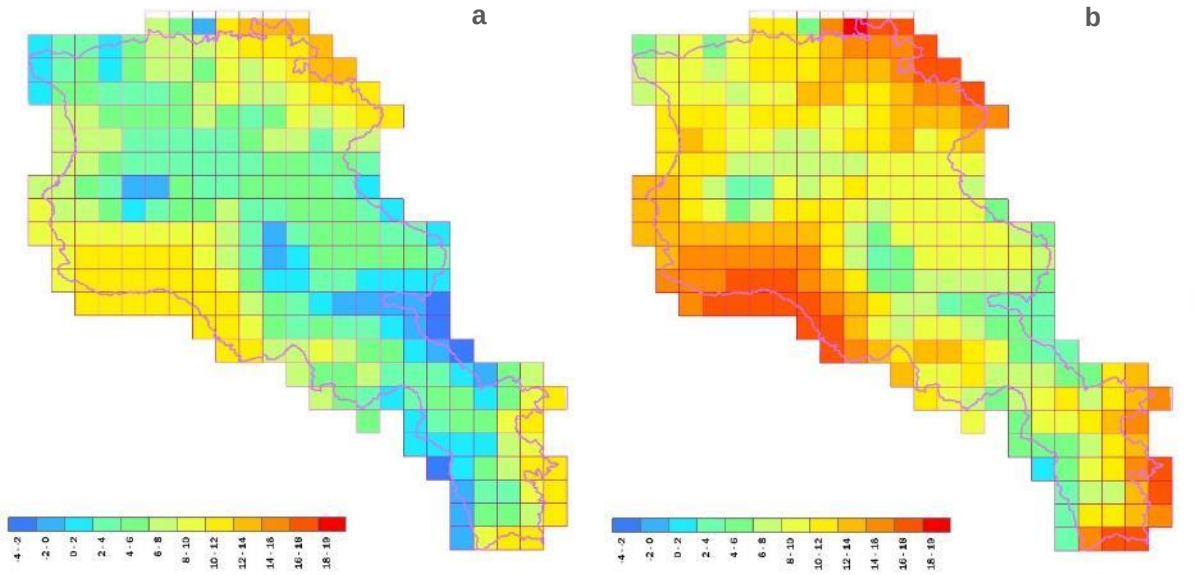


Figure 5-6. Distribution of average annual temperatures (^{0}C) in Armenia for the periods of 1961-1990 (a) and 2071-2100 (b) based on the METRAS model and RCP8.5 scenario

Figure 5-7a shows the distribution of average annual precipitation in Armenia for the periods of 1961-1990 and 2071-2100 based on the METRAS model and the RCP8.5 scenario. A comparative analysis of atmospheric precipitation maps shows that by the end of the 21st century, some decline - about 8.3%, in average annual precipitation is expected in Armenia from the baseline period values (Table 5-2). However, the METRAS model does not show a significant decrease in annual precipitation. Additionally, given also the considerable uncertainties in the global CCSM4 model in relation to the results of precipitation estimates, which were applied in the assessments under the NC3, the overall conclusions on future changes in precipitation are estimated with significant limitations and it is recommended to consider them with caution.

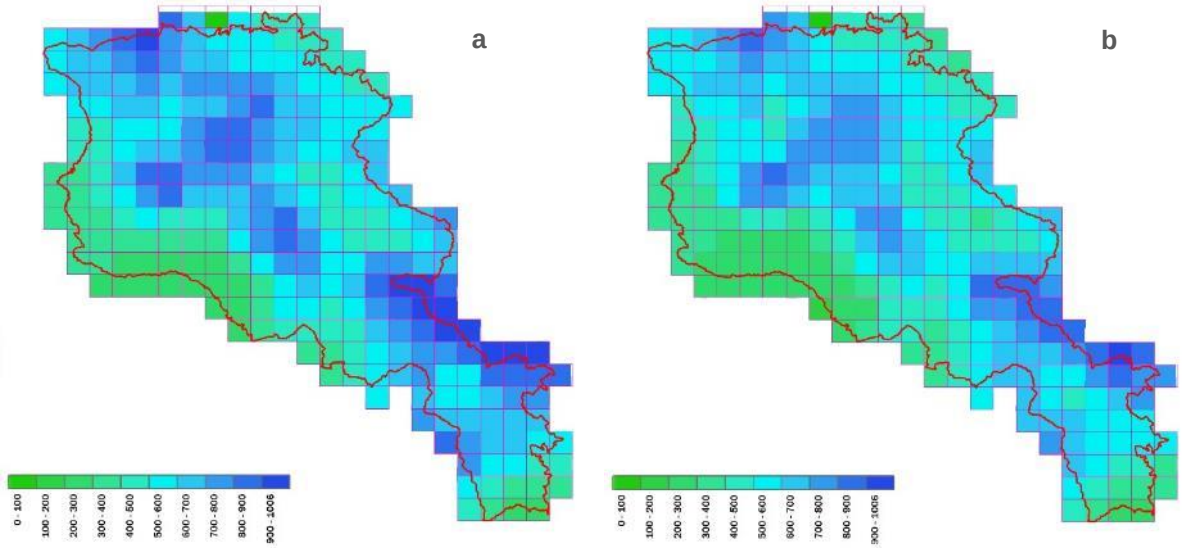


Figure 5-7. Distribution of average annual precipitation (mm) in Armenia for the periods of 1961-1990 (a) and 2071-2100 (b) according to the METRAS model and RCP8.5 scenario

Table 5-2. The projected values of average annual air temperature (T, ^{0}C) and precipitation (P, mm) in the territory of Armenia by different altitudinal zones (m), according to the METRAS model and RCP8.5 scenario

Altitudinal zones, m	1961-1990		2011-2040		2041-2070		2071-2100	
	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm
< 800	11.2	467	12.8	452	14.5	439	15.9	426
800 - 1000	10.8	343	12.4	332	14.1	322	15.5	313
1000 - 1500	8.4	502	10	486	11.7	472	13.1	458
1500 - 2000	5.5	592	7.1	573	8.8	557	10.2	540
2000 - 2500	3.3	660	4.9	640	6.6	621	8	603
2500 - 3000	1.6	732	3.2	713	4.9	692	6.3	671
> 3000	-0.7	800	0.9	776	2.6	753	4	731
Armenia	5.5	592	7.1	576	8.8	560	10.2	543

Table 5-3 presents the projected seasonal estimates of average air temperature and atmospheric precipitation for Armenia by different altitudinal zones, according to the METRAS model and the pessimistic RCP8.5 scenario.

Table 5-3. Seasonal projections of annual average air temperature and precipitation for Armenia

A – Winter Altitudinal zones, m	1961-1990		2011-2040		2041-2070		2071-2100	
	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm
< 800	0.2	90	1.7	87	3.0	75	4.5	74
800 - 1000	-0.2	66	1.3	64	2.6	55	4.1	55
1000 - 1500	-2.6	97	-1.1	94	0.2	80	1.7	80
1500 - 2000	-5.5	114	-4.0	110	-2.7	95	-1.2	94
2000 - 2500	-7.7	127	-6.2	123	-4.9	106	-3.4	105
2500 - 3000	-9.6	142	-8.1	137	-6.8	118	-5.3	117
> 3000	-11.7	154	-10.2	149	-8.9	128	-7.4	128

B – Spring Altitudinal zones, m	1961-1990		2011-2040		2041-2070		2071-2100	
	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm
< 800	10.1	166	11.7	156	12.5	144	14.0	155
800 - 1000	9.7	122	11.3	115	12.1	105	13.6	114
1000 - 1500	7.3	179	8.9	168	9.7	155	11.2	166
1500 - 2000	4.4	211	6.0	198	6.8	182	8.3	196
2000 - 2500	2.2	235	3.8	221	4.6	203	6.1	219
2500 - 3000	0.3	262	1.9	246	2.7	226	4.2	244
> 3000	-1.8	285	-0.2	268	0.6	247	2.1	265

C – Summer Altitudinal zones, m	1961-1990		2011-2040		2041-2070		2071-2100	
	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm
< 800	21.4	117	23.4	102	24.8	102	27.4	103
800 - 1000	21.0	86	23.0	75	24.4	74	27.0	76
1000 - 1500	18.6	125	20.6	110	22.0	109	24.6	111
1500 - 2000	15.7	148	17.7	130	19.1	129	21.7	131
2000 - 2500	13.5	165	15.5	145	16.9	144	19.5	146
2500 - 3000	11.6	184	13.6	161	15.0	160	17.6	162
> 3000	9.5	200	11.5	176	12.9	174	15.5	177

D – Autumn Altitudinal zones, m	1961-1990		2011-2040		2041-2070		2071-2100	
	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm	T, ^{0}C	P, mm
< 800	12.9	94	14.7	107	16.1	108	17.5	95
800 - 1000	12.5	69	14.3	78	15.7	79	17.1	70
1000 - 1500	10.1	101	11.9	115	13.3	116	14.7	102
1500 - 2000	7.2	119	9.0	135	10.4	136	11.8	120
2000 - 2500	5.0	133	6.8	151	8.2	152	9.6	134
2500 - 3000	3.1	148	4.9	168	6.3	170	7.7	150
> 3000	1.0	161	2.8	183	4.2	185	5.6	163

As can be seen from Table 5-3, in summer the average air temperature in the lower zones (up to 1000 m) can reach up to 27^{0}C and more and precipitation is expected to decrease by approximately 12%.

It should be noted that there are significant uncertainties in global precipitation estimates due to the high variability of atmospheric precipitation and the large number of affecting factors. This issue related to uncertainties in estimating precipitation changes has also been highlighted in the 5th IPCC Report (IPCC, 2013).

Taking into account Armenia's mountainous terrain and wide range of altitudinal fluctuations, assessment of temperature and precipitation changes by altitudinal zones may be of significant practical importance for perspective development and organization of different sectors of economy and planning adaptation measures.

5.3 Water Resources

Appropriate water resource management has a key role for Armenia's socio-economic development. Water resources available in Armenia are sufficient to supply about 3,100 m^3 of water per capita annually. However, the distribution of water resources in time and space is fairly irregular due to considerable seasonal and annual fluctuations in the river flow.

Despite the fact that the river network is dense, most of the rivers in Armenia do not have a constant flow and dry up in the summer. About 50% of the total river flow is subject to significant annual fluctuations, and the ratio of maximum to minimum flows is 10:1 for some rivers. About 55% of the total annual river flow is formed by snowmelt and precipitation in spring. Therefore, regulation of seasonal flow of rivers is one of the priorities of the sector.

During the period of 2013-2017, the annual abstraction[129] of water from water sources was 3,027 million m^3, of which about 1,251 million m^3 or 41% from groundwater sources. Actual annual water use[130] constituted about 2,249 million m^3. The actual water use, by sectors, is provided in Figure 5-8.

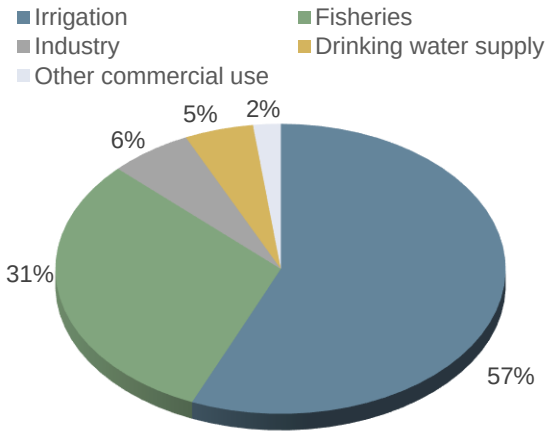


Figure 5-8. Actual water use by sectors

Since 2015, by the support of various international programs and initiatives in Armenia, a number of water basin management plans have been developed and adopted by the Government (Figure 5-9). They serve as the main instrument for decentralized water resources management and are aimed at balancing the interrelationships of water users, including communities, the sectors of energy, industry, agriculture and the environment, and assisting informed decision making by bodies responsible for water resource management.

[129] https://www.armstat.am/am/?nid=12&id=14004&submit=%D5%93%D5%B6%D5%BF%D6%80%D5%A5%D5%AC

[130] Ibid.

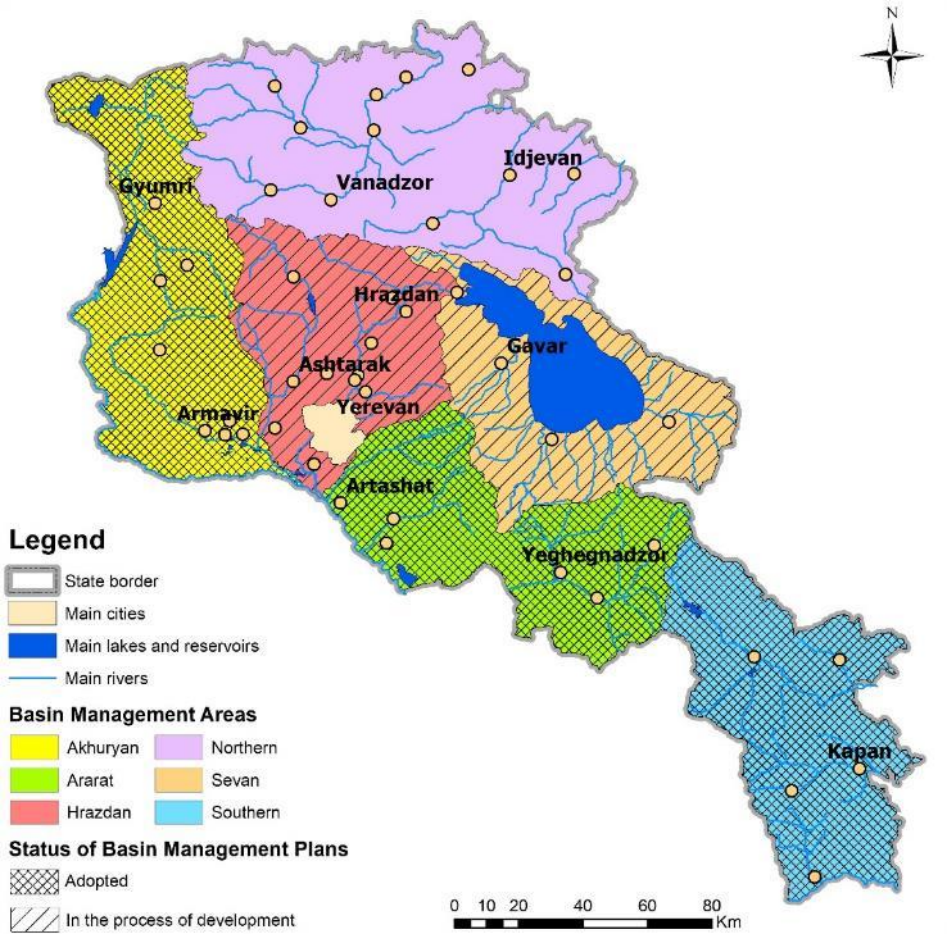


Figure 5-9. Water basins and the status of water basin management plans

Since the publication of the NC3 on Climate Change in 2015, a number of legislative, policy, and institutional developments have taken place in the water sector of the country, which are summarized below, in Table 5-4. As a result of the institutional reforms, the functions of water management bodies have changed. In particular, the control for the use and protection of water resources is carried out by the Inspectorate for Nature Protection and Mineral Resources under the RA Government. Previously, this body operated under the MoE. Based on the Government Decree No. 81, dated January 30, 2020, the "Environmental Monitoring and Information Center", the "Service of Hydrometeorology and Active Influence on Atmospheric Phenomena" and the "Forest Monitoring Center" SNCOs were merged and reorganized as "Hydrometeorology and Monitoring Center" SNCO, which operates under the auspices of the MoE. This reform was aimed at laying a ground for implementation of integrated quantitative and qualitative monitoring of surface and groundwater resources, and development and implementation of their policies.

Table 5-4. Main functions of water sector regulating state bodies

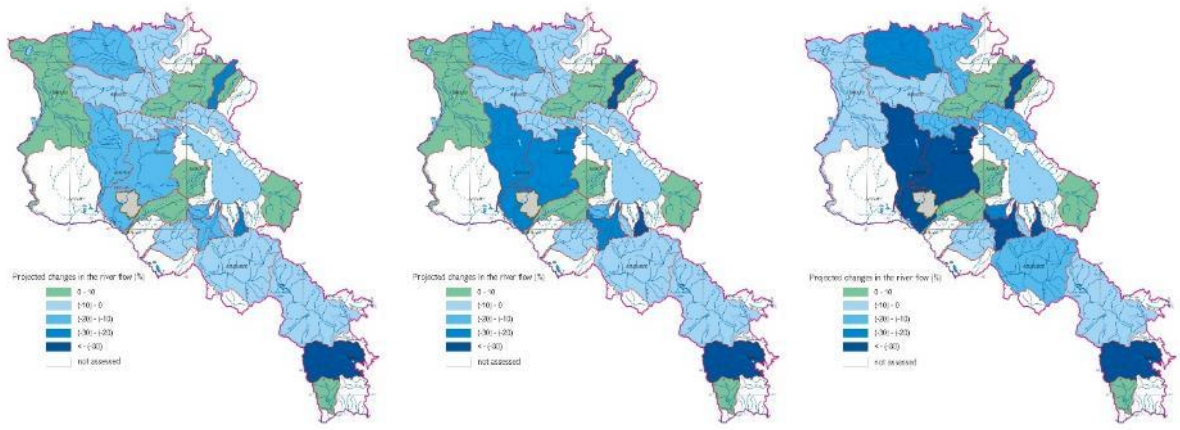
Water resources management and conservation	Water quality monitoring and inspection		Tariff regulation	Water systems management
Authorized bodies				
Ministry of Environment	Ministry of Health	Ministry of Economy	PSRC	MoTAI Water Committee
Main Functions				
• Water resources distribution; • Water resources strategic management and conservation; • Water use permits issuance; • Monitoring of water resources quantity and quality.	• Sanitary-hygiene control of supplied drinking water quality; • Quality control of drinking water sources.	• Classification of irrigation water according to Sodium adsorption ratio (SAR) index and degree of mineralization.	• Regulation of tariffs for non-competitive water supply and drainage services in drinking water and irrigation sectors; • Issuance of licenses for drinking water supply and drainage (wastewater treatment) services; • Issuance of water system use permits.	• Management of state-owned water systems; • Support to creating Water User Associations (WUA), organization of tenders for management of water systems; • Issuance of management lease contracts.

5.3.1 Vulnerability Assessment

As part of development of the NC4 on Climate Change, analysis of water resources' vulnerability in Armenia has been carried out using the CCSM4 model (spatial resolution - 100 km) and the emissions scenarios of RCP8.5 and RCP6.0, as well as the METRAS model (spatial resolution - 12 km) and the emissions scenario RCP8.5. Vulnerability of the annual river flow, Lake Sevan, as well as projected changes in river inflow into the Akhuryan, Aparan, Azat and Marmarik reservoirs for the period up to 2040, 2070 and 2100 have been assessed. The actual river flow data have been used to evaluate changes in water resources, since existing methods for natural flow restoration are not sufficiently accurate.

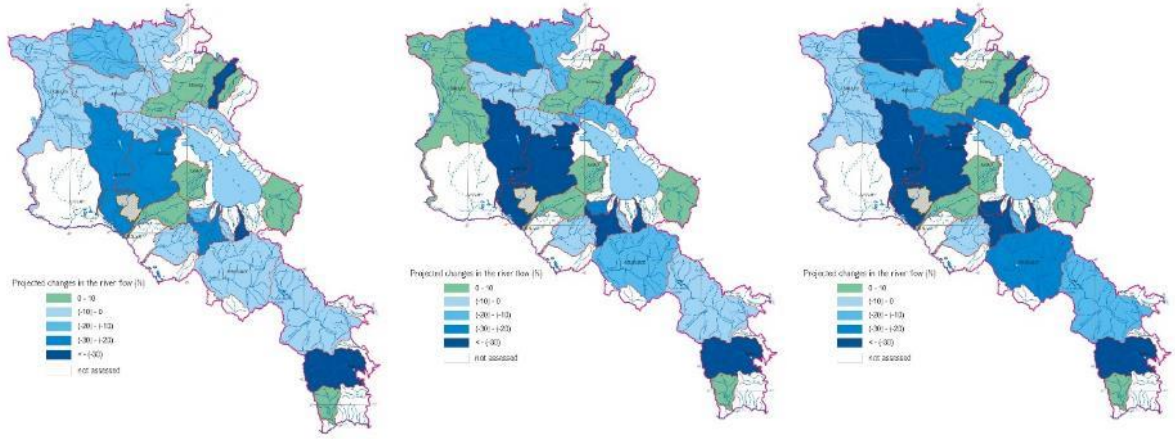
The vulnerability of the annual river flow has not been assessed for the basins of the Metsamor River, some Kura tributaries, Azat River, and some of the rivers flowing into the Lake Sevan, since a multifactor correlation has not been established between the multiannual observation data of precipitation and air temperature at the meteorological stations for these river basins.

As a result of the assessment, the climate change vulnerability maps of Armenia's water resources have been updated (Figures 5-10, 5-11).



2011-2040 2041-2070 2071-2100

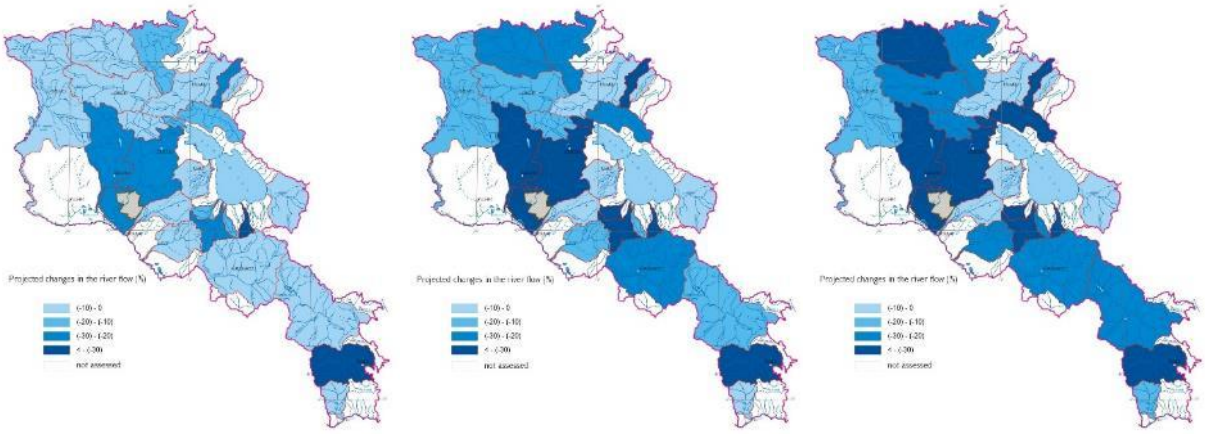
a/ CCSM4 model, RCP6.0 scenario



2011-2040 2041-2070 2071-2100

b/ CCSM4 model, RCP8.5 scenario

Figure 5-10. Projected changes in river flow in Armenia under the CCSM4 model and (a) RCP6.0 and (b) RCP8.5 scenarios



2011-2040 2041-2070 2071-2100

Figure 5-11. Projected changes in river flow in Armenia under the METRAS model and RCP8.5 scenario

According to the results, the impact of climate change on the river flow in different river basins of the country varies. Even under the same scenario, the vulnerability of the flow in different river basins varies. The difference of the degree of vulnerability in

different river basins is attributable to the natural and climatic conditions of the given basin and the various flow formation factors.

The table below summarizes vulnerability estimates for annual river flow in 2040, 2070 and 2100 based on the applied climate models under RCP8.5 and RCP6.0 scenarios (Table 5-5).

Table 5-5. Vulnerability of Armenia's annual river flow to climate change

Scenario	Time period	River flow studied, mln m^3	Change in flow	
			mln m^3	%
	1961-1990	6,279.9	0	0
CCSM4 RCP6.0	2011-2040	5,760.4	-519.5	-8.27
	2041-2070	5,450.5	-829.4	-13.2
	2071-2100	5,037.9	-1,242.0	-19.8
CCSM4 RCP8.5	2011-2040	5,513.5	-766.4	-12.2
	2041-2070	5,148.2	-1,131.7	-18.0
	2071-2100	4,165.1	-2,114.8	-33.7
METRAS RCP8.5	2011-2040	5,433.4	-846.5	-13.5
	2041-2070	4,547.9	-1,732.0	-27.6
	2071-2100	3,832.0	-2,447.9	-39.0

Based on the worst scenario, a decrease in the river flow by about 39% by 2100 is projected, which gives a great urgency to the development and implementation of relevant adaptation measures.

Lake Sevan

The Lake Sevan water balance assessment under the projected climate change scenarios was implemented through establishing a multifactor correlation between the annual inflow into the Lake and multi-annual observation data on atmospheric precipitation and air temperature at the meteorological stations of the basin (Figure 5-12).

The climate change scenarios show a negative impact on the conditions for life in the Lake, and the pessimistic (the worst) scenario suggests a decrease in the total river inflow into the Lake Sevan by about 34% (265 million m^3) by 2100[131] as compared to the baseline conditions (1961-1990).

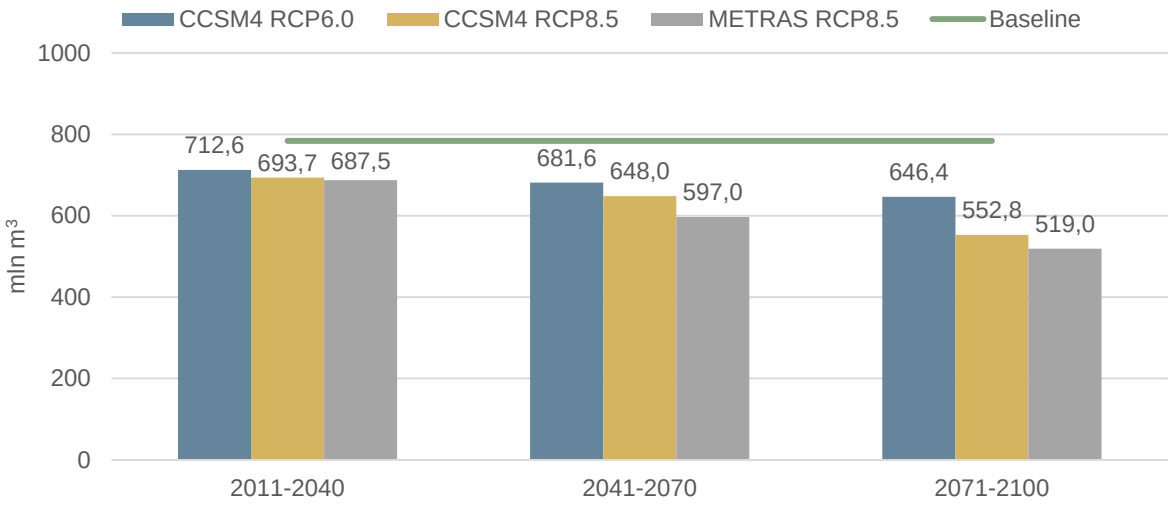


Figure 5-12. Vulnerability of the total annual river inflow into the Lake Sevan

[131] Sevan Basin Management Plan (Part 1), 2018.

Using a multifactor correlation between the annual river inflow into the Lake and the multi-annual observation data of atmospheric precipitation and air temperature at the meteorological stations of the basin, as well as the projected climate change scenarios, the changes in values of the basic elements of the Lake Sevan water balance for 2040, 2070 and 2100[132] were assessed (Figure 5-13).

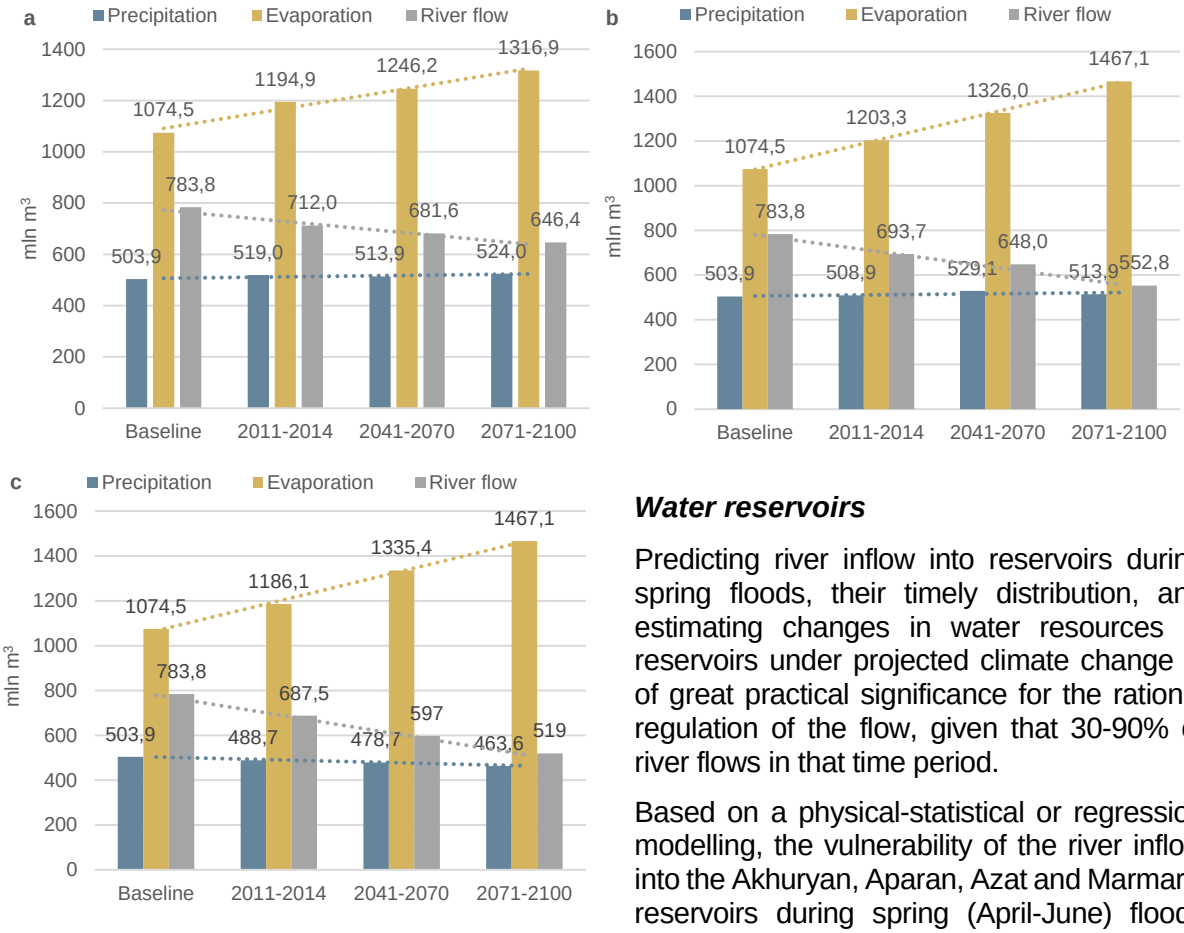


Figure 5-13. Projection of the Lake Sevan water balance elements for (a) CCSM4 model, RCP6.0 scenario, (b) CCSM4 model, RCP8.5 scenario, and (c) METRAS model, RCP8.5 scenario

Water reservoirs

Predicting river inflow into reservoirs during spring floods, their timely distribution, and estimating changes in water resources in reservoirs under projected climate change is of great practical significance for the rational regulation of the flow, given that 30-90% of river flows in that time period.

Based on a physical-statistical or regression modelling, the vulnerability of the river inflow into the Akhuryan, Aparan, Azat and Marmarik reservoirs during spring (April-June) floods was estimated for 2040, 2070, and 2100 (Figure 5-14).

[132] Ibid

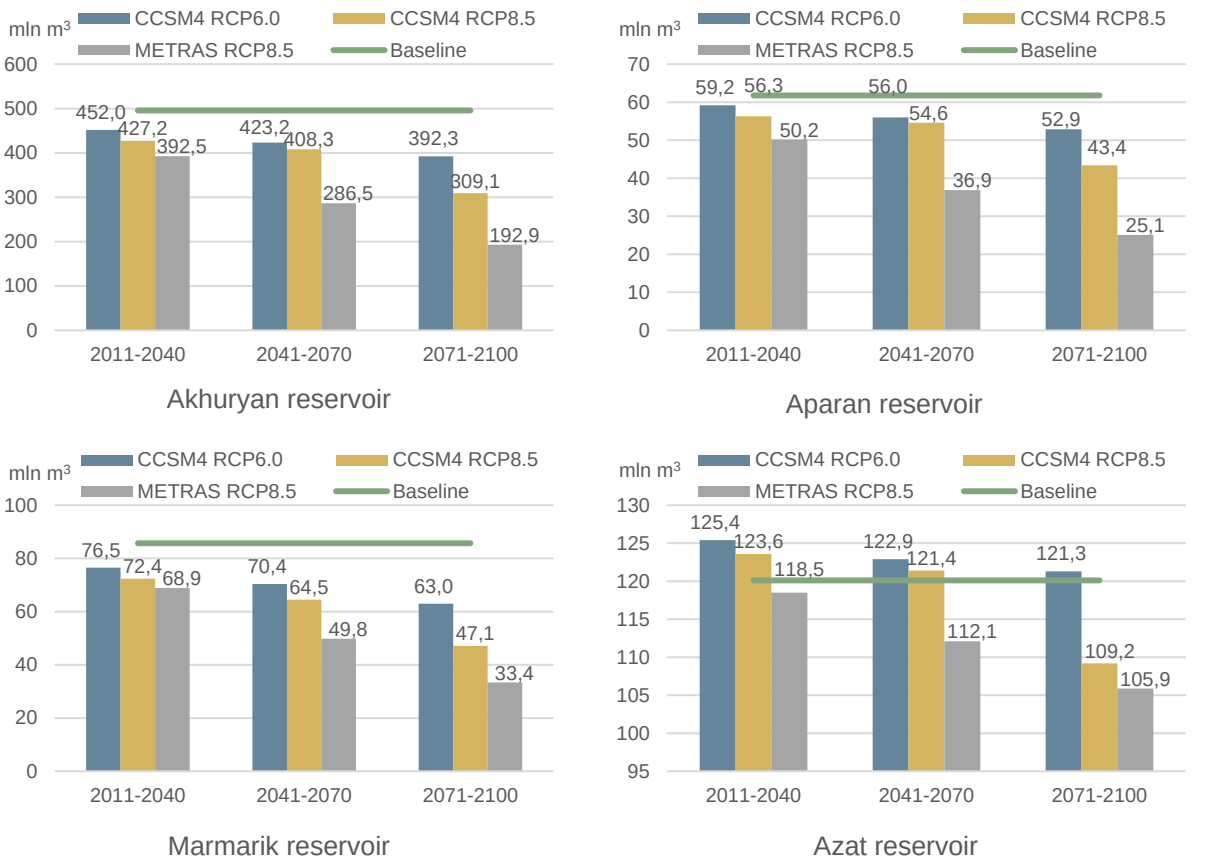


Figure 5-14. Vulnerability of the river inflow during spring floods

The impact of climate change on river inflow during spring floods will be particularly significant for the Akhuryan and Marmarik reservoirs. Based on the METRAS model RCP8.5 scenario, a decrease of about 60% is projected for river inflow during the months of April-June in 2100.

Water quality

Rivers

In recent years, a number of projects have attempted to quantify the impact of climate change on water quality, given that changes in the climate, which is an important indirect natural factor in the formation of the chemical composition of water, not only lead to obvious hydrological modifications, but also inevitably bring about hydrochemical changes, particularly related to the mineral composition of water.

Assessment of climate impact on river water quality has been carried out through a comparison of multi-annual average values for river flow and mineral, oxygen regime elements (correspondingly, for the time periods from 1960–1990 and 1980–1990) and the annual average values for 2007-2018.

Hydrological and hydrochemical studies at the reference observation posts of the studied rivers show that the hydrochemical composition and content of rivers have also changed along with the decrease in the natural flow. In particular, on the example of the Hrazdan River, during the period of 2006-2018, an increase in hydrocarbonate, magnesium and calcium ions was observed. In order to evaluate the seasonal changes of hydrochemical parameters of the River, multi-annual values average for the months of April-May (flood period for the river) and October[133] (relatively low river flow period) for the years 1980-1990 and 2006-2018 have been compared. The study shows that the deviations in the values of the hydrochemical parameters were higher, compared to the 1980-1990 period, especially for the month of October, due to the low river flow and limited rainfall.

[133] Due to the lack of hydrochemical data from July to September for the period of 1980-1990, the comparison was done with average data for October - as a period for relatively low water flow.

For the first time in the country, projection of water quality changes was implemented in 2015 for the Voghji River according to the projected climate change scenarios. According to the SRES A2 emissions scenario (equivalent to RCP8.5), if the existing anthropogenic pressures on the River are maintained, the quality of Voghji River water will continue to be of poor class (V) up to 2025 due to high concentrations of ammonium ion and copper. Moreover, nitrate, ammonium nitrogen and zinc concentrations will increase up to 1.2-1.5 times compared to 2015. As a result, the trophic degree of the river will alter (result in increased eutrophication) and the river buffer system may be disrupted, damaging the River's ecosystem, including a possible decrease in aquatic biodiversity[134].

Lakes

For the first time, the hydrochemical composition of four highland lakes of Armenia was studied within the framework of the Armenian-Russian joint research project "Paleolimnological Aspects of Highland Lakes' Ecosystems Evolution Study in Russia and Armenia". The hydrochemical studies were carried out in July-August, 2018 for 41 hydrochemical indicators at reference observation posts of the Lakes Umro, Kari, Akna and Sev[135].

According to preliminary results, there is no anthropogenic impact on the water quality of the studied highland lakes; the hydro-chemical state of the Lakes' water is attributable to the natural factors and the hydrological regimes of the Lakes, as well as to the chemical composition of the surface water and groundwater flowing into the Lakes. The results show that the water in the Lakes contains hydrocarbon-calcium-sulfates, with low mineralization and hardness. The water of the Lakes Umro, Akna and Sev was slightly alkaline, while it was neutral in the Lake Kari. The Lakes Umro and Akna were characterized by a normal oxygen regime for biodiversity, in contrast to the other two Lakes, where oxygen deficiency was observed. The water of the Lakes Kari and Sev was also characterized by relatively high turbidity. Despite some similarities, all four studied Lakes differed in their particular hydrochemical regimes. The results/data obtained from the studies of these Lakes can serve as baseline indicators for further climate change impacts assessments.

5.3.2 Adaptation Measures

Objective - rational and sustainable water use.

Type	Name of action	Activities implemented (or in progress)
Administration and planning	International agreements	Within the framework of the Comprehensive and Enhanced Partnership Agreement (CEPA) signed between the RA and the EU on November 24, 2017, approximation of the following directives in the areas of water quality and resource management over the next 4-5 years is planned: • Directive 2007/60/EC, dated 23 October 2007 (Floods Directive); • Directive 2000/60/EC, dated 23 October 2000 (Water Framework Directive); • Directive 98/83/EC, dated 3 November 1998 (Drinking Water Directive); • Directive 91/676/EEC, dated 12 December 1991 (Nitrates Directive); • Directive 91/271/EEC, dated 21 May 1991 (Urban Wastewater Treatment Directive).
	Legal reforms	RA Law on "Environmental Impact Assessment and Expertise" was adopted in 2014. RA Law on "Making Addendum and Amendments to the Water Code" was adopted in 2018. It establishes the promotion of secondary or re-use of water resources. A number of Government Decrees regulating the sector have been approved: • New Methodology for Estimating Rivers' Environmental Flow (Decree No. 57-N, dated 25.01.2018);

[134] L. A. Margaryan "Geo-ecological assessment, classification and projection of the quality of natural water" 2018. http://etd.asj-oa.am/7204/1/005-Liana_Margaryan.pdf

[135] https://ges.rgo.ru/jour/article/view/920?locale=en_US

Type	Name of action	Activities implemented (or in progress)
		• Concept Paper for Development of the State Environmental Monitoring (Protocol Decree No. 3-16, dated 25.01.2018); • Environmental Impact Assessment Indicators for Construction and Operation of Small HPPs (Protocol Decree No. 8, dated 01.03.2018); • New Procedure for State Water Cadaster Management (Decree No. 68-N, dated 02.02.2017); • Content of the Basin Management Model Plan (Protocol Decree No. 45, dated 26.10.2017); • Concept Paper for Hydropower Development (Protocol Decree No. 53-36, dated 29.12.2016). The following reports on water sector legislation improvement were developed within the framework of the USAID funded Project "Participatory Utilization and Resource Efficiency of Water" (PURE Water) (2017-2020): • Evaluation of Water Resources Management Policy, Legal Regulation Framework Assessment and Development of Improvement Pathways, 2017; • Strategy for Improving Participatory, Transparent, Accountable Water Resources Management Legislation, 2018.
	Institutional reforms	There have also been a number of institutional reforms that have resulted in changes in the functions of water management bodies (Table 5-4). Based on the GoA Decree No. 81, dated January 30, 2020, an integrated state monitoring system was established by merging the "Environmental Monitoring and Information Center", the "Service of Hydrometeorology and Active Influence on Atmospheric Phenomena" and the "Forest Monitoring Center" SNCOs and reorganizing the "Hydrometeorology and Monitoring Center" SNCO, which operates under the MoE. Since 2018, enforcement of water use permits is ensured by the Inspectorate for Nature Protection and Mineral Resources, which is no longer under the MoE, to avoid potential conflicts of interest. As part of the EU Water Initiative Plus Project (2016-2020), support has been provided for water resources management: institutional and legislative reforms have been implemented for the water sector, based on the EU Water Framework Directive and the integrated water resources management principles. In particular, the country's surface and groundwater monitoring system has been strengthened, and international accreditation of the laboratory of the EMIC SNCO has been achieved. As part of the EU Program for Environmental Protection of International River Basins (2012-2016), support has been provided to strengthening and development of hydrobiological, chemical and hydromorphological monitoring in Armenia.
	Development of water basin management plans considering climate change	The Ararat, Southern and Akhuryan water basins management plans with their program of measures have been developed and officially approved by the Government (Decrees No. 388-N, dated 31.03.2016; No. 539-N, dated 26.05.2016; and No. 240-N, dated 09.03.2017, respectively). The management plans for the Sevan and Hrazdan water basins are currently under development and the final drafts will be submitted to stakeholders in May-June 2020.
Economic and technical activities	Programs to improve irrigation	A number of programs are being implemented for the improvement of irrigation systems, with the assistance of the WB, the Eurasian Development Bank, the French Development Agency (Agence Française de Développement) and the German Development Bank (KfW). Within the framework of the implemented projects, mechanical irrigation systems are being replaced with gravity irrigation systems (Meghri, Geghardalich, Kaghtsrashen, Norakert), irrigation systems are being improved and modernized by decreasing operating and maintenance costs, leakage losses, as well as reducing electricity costs. The construction of dams and ancillary structures for the Vedi reservoir (with a total capacity of 29 million m^3) (2017-2021), the detailed design and preparation of construction tender documents for the Kaps reservoir (2016-2020), as well as the feasibility study for the construction of the Mastara reservoir (with a total capacity of 10.2 million m^3 total, 2017-2020) are underway.

Type	Name of action	Activities implemented (or in progress)
		The introduction of non-traditional irrigation systems is planned in the republic. A pilot project was implemented in 2017 in the Hayanist village with the financial support of USAID, Coca-Cola Hellenic Armenia (CCHBCA) and UNDP GEF Small Grants Program, targeted at the use of water from fish farms for community irrigation needs. The Government has developed a program for subsidizing interest rates on loans for the installation of drip irrigation systems, whereby the interest rate on such loans is less than 2%. The Program aims to promote the introduction of advanced irrigation methods for perennial plants – fruit orchards and vineyards, high value crops. Within the framework of the Program, it is envisaged to install drip irrigation systems over 1.6-1.7 thousand hectares of land annually in 2018-2022.
	Programs aimed at improvement of drinking water supply and drainage services	Programs aimed at improvement of the drinking water supply and drainage services are being implemented by the financial support of the EBRD, EIB, KfW and the EU Neighborhood Investment Facility. In the framework of the projects under implementation, the water supply and drainage network of Yerevan is being improved, the sections of the water supply and drainage systems of 6 towns and 37 villages that need urgent intervention, are being restored, and a program for restoration of water supply and drainage systems for 560 self-serviced rural settlements is being developed.
Research and information	Assessment of groundwater resources	As part of the USAID-funded advanced Science and Partnership for Integrated Resource Development (ASPIRED) Project (2016-2020), an inventory of the boreholes, natural springs and fish farms in the Ararat valley has been conducted, the possibility of using the water from fish farms for irrigation purposes has been assessed. Also, support is being provided for installation of an automated, centralized, online system for fish farm management, as well as for development of a decision support tool for Ararat valley ground water basin modelling. In the framework of the EU program on Environmental Protection of International River Basins (2012-2016), an assessment of the surface and groundwater bodies of the Akhuryan water basin has been carried out. In 2019, within the framework of the EU Water Initiative Plus Program a methodology for assessing the natural groundwater resources in mountainous regions was developed for Armenia, which has been used to assess the groundwater resources of the Sevan and Hrazdan basins.
	Study related to integrated water resources management (IWRM)	As part of the SevaMod Armenian-German Joint Research Program (2017-2019), a model for Lake Sevan has been developed as a tool for sustainable natural resource management and use, as well as for better understanding of the ecological state of the Lake. In the framework of the Project, available data on the Lake Sevan, its tributaries and catchment basin have been collected and evaluated, regular measurements of water temperature at different depths of the Lake, a geochemical survey of the Lake sediment to study phosphorus and its behavior, as well as an evaluation of the aquaculture has been conducted. Within the framework of the Armenian-Russian Joint Research Program on the Paleolimnological Aspects of the Study of the Evolution of Ecosystems of the Highland Lakes in Russia and Armenia (2018-2020) the paleolimnological, geomorphological, hydrological, geochemical, hydrochemical and biographic characteristics of four lakes (Kari, Akna, Umro, Sev) located at over 3000 m above the sea level in Armenia were studied. The results of the study can serve as baseline indicators for further climate change impacts assessments. Within the framework of the EU Project “Implementation of the Principles and Practices of the Shared Environmental Information System in the Eastern Partnership Countries” (2016-2020), support has been provided for strengthening the national decision-making capacity through support for water sector data, statistics and information management and use. In 2015, with the support of the World Bank, a study titled “Armenia: Towards Integrated Water Resources Management” was published, which summarizes the successes and challenges of introducing IWRM principles in the country, as well as recommendations for the following five areas: improvement of surface and groundwater monitoring, strengthening water basin management and planning, improvement of water use permits administration and regulation system, introduction of a system for adequate management of water resources in the Ararat valley, increase in water storage volumes, and solution of issues related to transboundary water resources.

5.4 Agriculture

Agriculture is one of the key sectors of the economy of the Republic of Armenia. It has a strategic importance for the country's gross domestic product, for ensuring macro-economic stability and improving the external trade turnover balance. Agriculture ensures food security of Armenia and income generation among economic entities operating in the agricultural sector and safeguards the sustainability and development of rural settlements.

Out of 502 communities in the Republic of Armenia, 454 are rural; around 36.0%[136] of the population of Armenia lives in villages (2017). Around 317,000 people[137] are employed in the agricultural sector (around 168,000 females and 149,000 males) making up 31.3% of the overall employed population of Armenia and around 62% of the population employed in rural communities. The overwhelming part of the income earned by rural population in Armenia is generated through agricultural production and paid employment in the agriculture sector. Consequently, the poverty level in rural settlements largely depends upon the development level of agriculture.

Agriculture is the very sector of the economy, which has the highest dependence upon weather conditions. The most frequently observed and long lasting hydro-meteorological hazards, such as hailstorms, early frost, spring floods, heavy rainfall, landslides and drought, have serious negative impact on agriculture every year. This causes not only shrinking of production volumes and bankruptcy among economic entities, but also rural inhabitants' refusal to be employed in the agricultural sector, outflow of the population from rural areas to urban communities, and in some cases, it causes migration of the rural population from the country.

During recent years, the volume of damage caused by drought, hailstorms, spring frost and inundations to agriculture is estimated around AMD 15-30 billion annually. In particular, hailstorms are the main cause of registered damages. Only in 2014-2017, the total damage caused by hailstorms to agriculture in Armenia is estimated around AMD 61.2 billion (approximately USD 128 million). The above-mentioned phenomena and the unusually high temperature observed during recent years, are clear signals of climate change manifestations and require alignment of the agrarian policy with the listed challenges through appropriate strategies, legislation and institutional framework.

5.4.1 Vulnerability Assessment

Plant farming

Because of highly expressed vertical zoning, scarcity of land resources, fragmentation of the mountainous terrain of the territory of the Republic, and the dry, continental climate, the exposure of the agriculture to natural hazards is quite high and vulnerability of the sector considerably varies across land zones and crops. Vulnerability of agriculture is more evident in low-lying and medium-altitude zones in Armenia, while in the high-land mountainous zone risks associated with climate change are comparatively less apparent. The high risks in agriculture are also due to insufficient availability of land resources (0.16 hectares of arable land per capita), significant losses in the irrigation system (around 80%) and unsatisfactory state and operation of risks prevention systems.

Climate change contributes to intensification of land degradation and desertification processes. Almost 80% of the territory of Armenia is subject to various degrees of desertification, which is not only the consequence of anthropogenic activity (inefficient exploitation of land resources and improper farming practices), but is also affected by natural factors, such as water and wind erosion, hot dry winds, droughts, lack of humidity, landslides, heavy rainfall, floods, natural salinization and alkalization, waterlogging and eutrophication, along with geomorphological peculiarities (fragmented landscape, slope degree of inclination, altitude, geographic position).

Climate change, along with various anthropogenic phenomena, affects the organic carbon content in soils (Figure 5-15).

[136] "Number of de jure population of the Republic of Armenia as of January 1, 2017", SC, 2017.

[137] "Statistical Yearbook of Armenia. Employment", 2018, p. 63, https://www.armstat.am/file/doc/99510748.pdf.

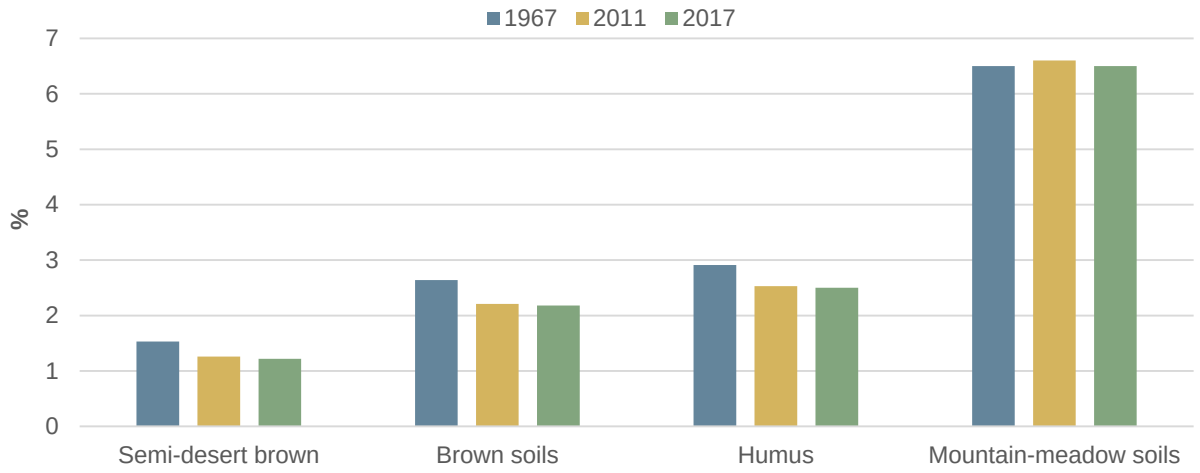


Figure 5-15. Organic carbon content in 0-25 cm soil layer

Data source: Publications of the Scientific Center of Soil Science, Melioration and Agrochemistry after H. Petrosyan, ANAU[138]

As shown in Figure 5-15, the organic carbon stock is declining in all soil types, except for mountain meadow soils, where the impact of natural and anthropogenic factors is insignificant due to their location in highland mountainous zone. These soils are comparatively better sustained and the degree of erosion is low, since these lands are almost not cultivated due to the short vegetation period.

According to forecasts, during the upcoming 100 years, the agricultural sector is likely to undergo significant changes due to climate change. In particular:

- the projected high temperature will contribute to the increase of evaporation, which, in turn, will result in reduction of soil humidity by 10-30% and soil moisture reserves for various agricultural crops by 7-13%[139];
- more frequently observed droughts and low soil moisture will be combined with a lack of irrigation water, the water deficit of lands will increase by 25-30%[140];
- the decline in river flows by 25% will result in decrease of productivity of irrigated land plots by approximately 24%;
- the degradation of lands and natural pastures will intensify. By 2030, the total area of pastures and the level of crop yield thereof will be reduced by 4-10%, while, in case of more valuable pastures located in sub-alpine and alpine zones, the yield will decrease by 19-22%. It is also forecast that the level of crop yields in grasslands will decrease by 7-10%, which, in turn, will result in reduction of fodder production volumes[141].
- By 2030 the expected unstable weather conditions, combined with strong storms, winds and downpours will damage crops, crop yield and will reduce the crop yield volume by 8-14%[142]. Strong storms can also cause natural disasters, such as soil erosion, mudflows and floods, which, in turn, may result in damage of agricultural lands and irrigation infrastructure.

The rate of utilization of arable lands in Armenia has gradually risen up till the year 2016; however, it has decreased during the subsequent years (Figure 5-16). It is the consequence of a range of underlying problems, among which the inefficient or less efficient cultivation of lands has a significant role. It is due to climate risks (hails, frosts, droughts), losses and damages caused by these phenomena, which sometimes lead to farmers' reverting from cultivation of lands.

[138] Global Climate Change and Land Degradation in Armenia, 2017.
[139] http://documents.worldbank.org/curated/en/260051468221982009/pdf/733320WP0ARMEN00Armenia0Jun20120Arm.pdf
[140] Ibid
[141] Ibid
[142] Ibid

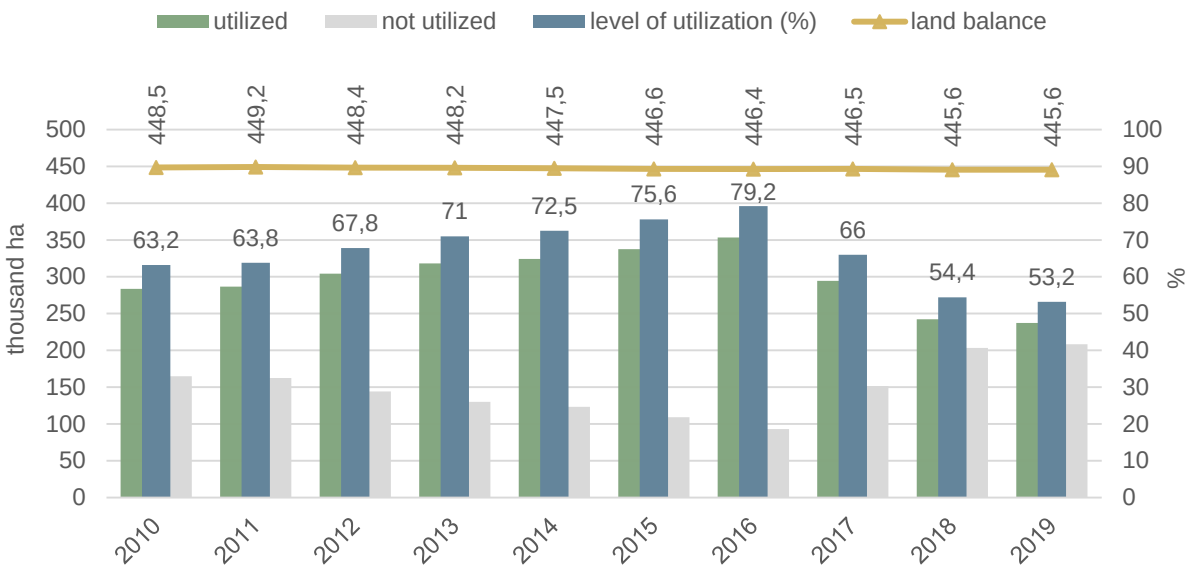


Figure 5-16. The level of utilization of arable lands in Armenia

The reduction of the share of agriculture in the GDP of Armenia observed during recent years is predominantly caused by unfavorable climate conditions. It has negatively affected especially the plant farming sector. In particular, in 2017, because of unfavorable climate conditions, significantly lower output was registered in the crop cultivation sector, where cereal crops and grain legumes have the largest shares (Table 5-6). However, in the same period, the levels of production of fruits and berries, as well as grapes increased by 49.1% and 17.4%, respectively, compared to 2016.

Table 5-6. Changes in the production of agricultural crops in 2012-2017, thousand tons

Crops and perennial plants	2012	2013	2014	2015	2016	2017
Cereals and grain legumes	456.1	548.8	580.1	601.5	604.2	302.4
of which - wheat	243.1	311.6	338.2	362.7	350.4	176.4
Potato	647.2	660.5	696.1	607.7	606.3	547.4
Vegetables	849.0	876.0	954.6	1,007.6	968.6	861.0
Melons	205.1	208.1	245.8	286.8	236.1	215.8
Fruits and berries	331.7	338.1	291.0	377.1	242.6	361.6
Grapes	241.4	240.8	261.3	309.2	178.8	209.9

The negative impact of climate change on the yield levels of agricultural crops is mainly due to changes in temperature and precipitation, increase in the demand for irrigation water and decrease in the volume of irrigation water reserves because of reduced precipitation and increased evaporation. It is also attributable to the increase in frequency, intensity and duration of climate hazards and expansion of the spatial distribution thereof. The impacts are more evidently manifested during summer vegetation periods.

An assessment of changes in the yield levels of a range of crops under projected climate change has been conducted. Based on the values of major climatic parameters affecting crop yield levels, and the METRAS climate model data, a statistical correlation was established between crop yield levels and the climatic parameters (including temperature, precipitation and evapotranspiration). For the calculation of evapotranspiration, Agrometshell and AquaCrop software developed by FAO were used. The assessment results are summarized in Tables 5-7, 5-8 and 5-9.

Table 5-7. Projected changes in wheat yield levels, by marzes (without agrotechnical measures) (%)

Marz	2030	2040	2050	2060	2070
Ararat	-4.5	-8.4	-12.2	-16.1	-19.9
Kotayk	-5.0	-10.4	-15.7	-17.0	-19.3
Vayots Dzor	8.3	7.4	6.5	5.5	4.6
Shirak	-5.6	-9.9	-10.2	-12.4	-18.7
Gegharkunik	-6.0	-11.8	-14.5	-13.3	-19.9
Lori	3.2	5.3	5.5	7.5	7.5
Syunik	10.5	12.3	10.0	8.1	7.3

Table 5-8. Projected changes in potato yield levels, by marzes (%)

Marz	2030	2040	2050	2060	2070
Gegharkunik	-3.9	-7.0	-10.0	-12.2	-14.2
Kotayk	-4.7	-6.6	-9.5	-12.4	-15.3
Shirak	-7.6	-10.2	-13.4	-16.2	-20.7
Lori	-3.2	-7.3	-9.1	-11.6	-14.0
Syunik	-4.1	-8.4	-10.4	-13.2	-17.7

Table 5-9. Projected changes in grape yield levels, by marzes (%)

Marz	2030	2040	2050	2060
Armavir	-5	-9.3	-12.5	-19.7
Vayots Dzor	5.3	9.1	10	11.8
Ararat	-3.7	-5.6	-10.4	-14.8

According to forecasts, in 2070 the predicted wheat yield in Armenia in natural conditions will decrease mostly in mountainous regions by 19%, while in Lori marz an increase by around 8% is predicted. The potato crop yields will decrease by 21%, and the highest level of reduction is expected in Shirak and Syunik marzes. The largest decline in the grape yields will be recorded in the Ararat Valley - by 20%. The projected climate change will further aggravate food security risks in Armenia.

Among the climate change induced hydrometeorological hazards, hailstorms, frosts, heat waves and droughts have the biggest impact on the loss of agricultural crop yields. Studies indicate that drought conditions during the last two decades are predominantly widespread, while the start dates and durations periods differ. During the recent years, the start date of drought has moved to earlier dates by 20 days. The drought-prone zone has expanded, encompassing the foothill zones and, for a short period of time, also the mountainous zone. In these zones, although the drought duration is short, the vegetation period is short as well.

Through analyzing satellite data, an assessment of the frequency of severe drought cases observed in Armenia during 1984-2017 (when the territories of cultivated crops were damaged by more than 30% and 50%) was conducted (Figure 5-17). In 25% of drought cases, the level of damage caused to the crops in the Ararat Valley and south-western areas of Gegharkunik marz comprised 30%; the same level of damage was recorded in 15-20% of drought cases that occurred in some parts of Ararat Valley, in most of the territory of Aragatsotn marz and Kotayk marz, in the southern part of Gegharkunik marz, as well as in north-eastern parts of the territory of the Republic of Armenia. In other marzes of the country, the frequency of damage to 30% of crops is below 10% (Figure 5-17a). Cases, when 50% of crops were damaged because of severe droughts were more frequently observed in Kotayk and Gegharkunik marzes (Figure 5-17b).

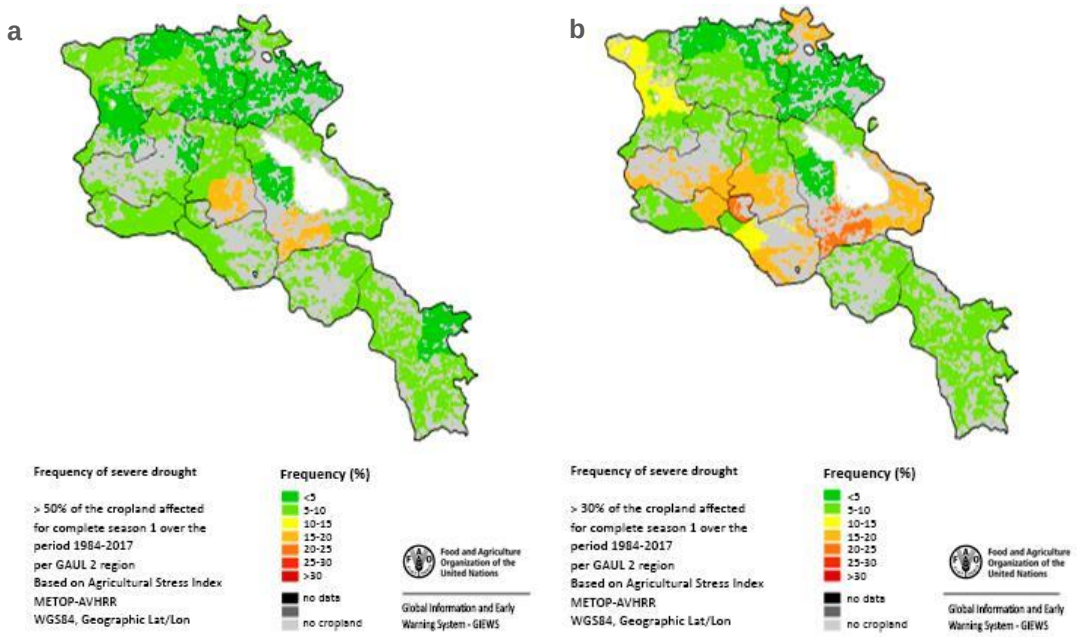


Figure 5-17. Frequency of damages caused by severe droughts in 1984-2017

Source: UN FAO

Hailstorms also cause significant damage to agriculture. The scale of damages caused by the latter depends upon both the intensity of a hailstorm and the size of hailstones. Hailstones with diameter sizes of 20 mm and larger are especially dangerous; these can totally destroy cropland and damage poultry and small cattle. Significant damage is caused also by small but intensive hail. Intensive hailstorms are frequently observed in Lori and Shirak marzes and in the Ararat Valley. Although in recent years some decrease in the number of hailstorm cases has been observed, the intensity and the size of hailstones has increased.

Each year hailstorms damage 10-15% of the country's orchard areas, and in some cases crop loss in the hailed areas amounts to 80-100%[143].

After the onset of vegetation, spring frosts pose a high risk.

Figure 5-18. Hailstorm, Syunik marz, September 2019

Despite the increase in the average temperatures and in the number of days with heat waves, the risk of frostbite has not decreased; moreover, it has increased due to the early onset of vegetation. Frequency of frosts has increased; although the number of frosts with the intensity from -3^0C to -5^0C has decreased, the number of frosts with the intensity from -1^0C to -2^0C has increased (Figure 5-19).

[143] GoA Protocol Decree, dated 13 April 2017, http://www.irtek.am/views/act.aspx?aid=89460 (Part 1)

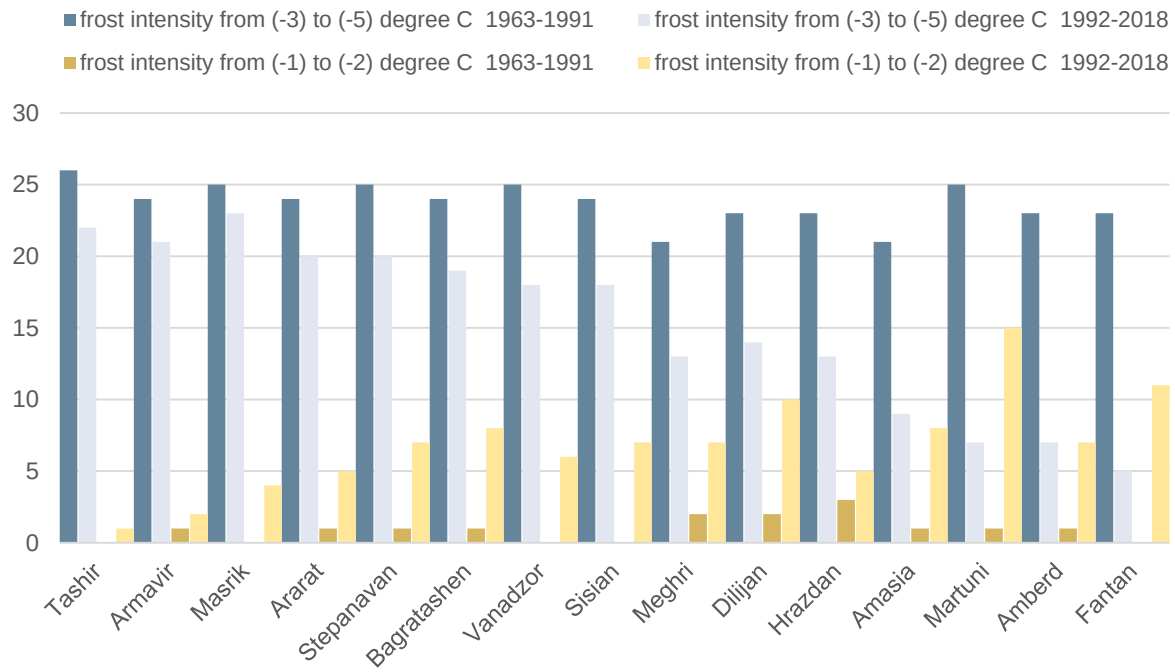


Figure 5-19. Changes in the number of frostbite cases by intensity

Vulnerability of Armenia's marzes to hydrometeorological hazards by their degree of severity is provided in Figure 5-20.

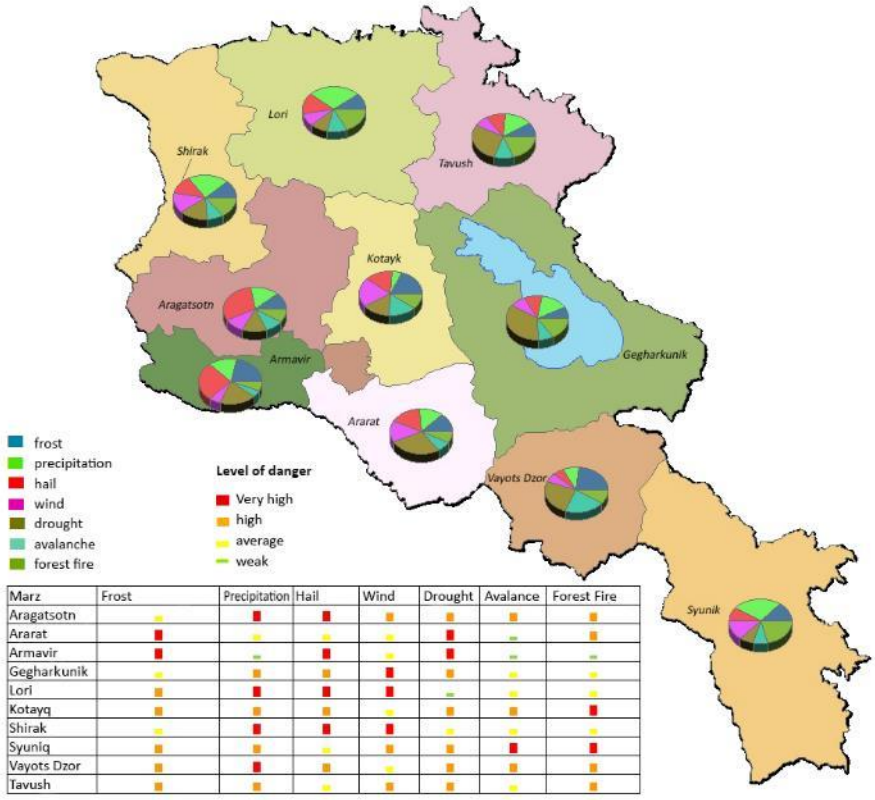


Figure 5-20. Vulnerability of Armenia's marzes to hazardous hydrometeorological phenomena

In 2015-2017, the annual damage to agriculture from hail, floods and spring frosts alone is estimated at about 8-34 billion Armenian drams, and the damaged areas of agricultural crops and perennial plantations are estimated at 9-23 thousand hectares

(Table 5-10). According to climate change scenarios, the frequency of unstable weather conditions accompanied by thunderstorms and hailstorms may increase in spring and summer. In this case, the agricultural areas in mid-altitude mountainous zones of the northern and southern regions of Armenia will be the most vulnerable.

Table 5-10. Land areas damaged due to natural disasters (hailstorms, floods, frostbites) in 2015-2017, and the amount of damage[144]

Marzes	2015		2016		2017	
	Damaged territory /hectares/	Amount of damage /thousand AMD/	Damaged territory /hectares/	Amount of damage /thousand AMD/	Damaged territory /hectares/	Amount of damage /thousand AMD/
Aragatsotn	379	208,336	3,560	7,142,050	5,712	3,681,035
Ararat	808	1,669,695	125	194,930	2	8,772
Armavir	1,497	3,149,850	11,408	23,008,132	1,989	4,950,225
Gegharkunik	1,350	535,600	237	109,520	651	155,073
Lori	1,383	1,032,907	613	356,124	115	109,273
Kotayk			1,267	778,747	44	29,995
Shirak	2,732	692,364	4,199	1,350,306	3,177	658,323
Syunik			253	125,555	2,350	1,561,119
Vayots Dzor	275	242,200			201	126,193
Tavush	345	293,764	1,456	503,445	1,363	926,883
Total	**8,768**	**7,824,716**	**23,118**	**33,568,809**	**15,605**	**12,206,891**

Livestock breeding

48% (or AMD 438.36 billion)[145] of Armenia's gross agricultural output derives from livestock breeding (2017). The leading branch in livestock breeding in the republic is cattle breeding, which provides over 75% of the gross agricultural product[146], and the rest, in almost equal shares, is provided by pig, sheep and poultry farming.

Increase in the livestock population and application of intensive measures have contributed to increased production of basic livestock products (Figure 5-21).

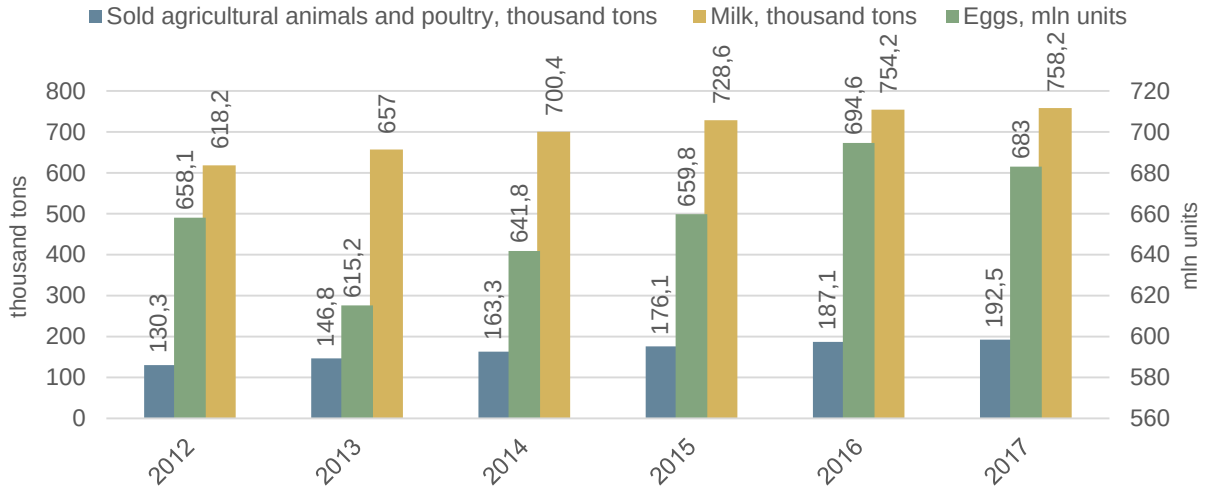


Figure 5-21. Volumes of production of basic livestock products in Armenia in 2012-2017

Source: https://www.armstat.am/am/

[144] RA Government Decree No. 15, April 13, 2017 http://www.irtek.am/views/act.aspx?aid=89460 (Part 1), http://www.irtek.am/views/act.aspx?aid=89461 (Part 2)
[145] https://www.armstat.am/file/article/sv_12_17a_122.pdf
[146] RA Cattle-Breeding Development Program for 2017-2022

According to the Armenian Statistical Yearbook 2017, in the past 5 years, the production volumes of animal products, animal and poultry productivity rates, as well as the number of agricultural animals and poultry have increased yearly in Armenia, and only in 2017 some decrease in livestock number was observed.

Generally, increase in the volumes of livestock products has been recorded. Specifically, the sales volume of meat in 2017 exceeded the rate of 2012 by 47.7%. The volumes of milk and egg production in the same period increased by 22.6% and 3.8%, respectively. From the point of view of food security of animal origin, Armenia is self-sufficient in terms of eggs and lamb, while self-sufficiency with regard to poultry amounts to 24.2%, pork - 38.3%, and beef - 89.1%.

Natural meadows and pastures are key preconditions for the development of cattle breeding. According to climate change scenarios, the total area of Armenia's pastures will be reduced by 2030. The most valuable pasture areas of the sub-alpine and alpine zones will be reduced by 19-22%, and the volume of crop yields - by 4-10%, which, in turn, will lead to reduction in the volumes of fodder production.

It is estimated that if the current growth rate of cattle and small cattle is maintained, based on modern scientific standards of pasture load, the availability of fodder stock will not cause any concern until 2030. However, failure to comply with grazing norms and standards and to respond appropriately to improve pasture conditions will accelerate their deterioration.

Lasting droughts, anticipated due to climate change, can create a serious problem for the livestock sector, particularly for field fodder production. Climate change may affect also the composition and spread of diseases of agricultural animals, in particular, that of natural-focal and communicable infections.

Studies show that the country is still prone to such diseases, as brucellosis, tuberculosis, anthrax, tetanus, blackleg (*Gangraena emphysematosa*), bloodborne parasitic diseases, pasteurellosis, classical and African swine fever, paratyphoid fever, avian flu and variola, varroatosis of bees and a number of other diseases. Some of them are associated with climate change, and over the coming decades, some regions of the country may be among the areas most vulnerable to these diseases. From this point of view, especially bloodborne parasitic diseases are of particular importance.

More frequent incidence of blackleg disease of cattle also gives rise to concern. In June-July of 2017 and 2018, unprecedented high temperatures from $+41^0$C to $+42^0$C were recorded in the country. In those months, the incidence of cattle falling sick with blackleg was 20-25% higher than in the years with lower summer temperatures.

Due to climate change and rising temperatures, some areas previously considered non-vulnerable have now become vulnerable to bloodborne parasitic disease, blackleg and a number of other diseases. In this regard, new vulnerable regions may emerge in the areas of Syunik, Shirak, Gegharkunik, as well as Aragatsotn marzes, which are located at 1600 m to 2000 m above the sea level.

Beekeeping

Beekeeping is one of the important sectors of agriculture. It is distinguished by its high profitability. In Armenia, there are about 500,000 bee families[147]; average 3.5-4 thousand tons of honey is produced annually, which fully meets the requirements of domestic consumption. According to expert estimates, one bee family, in addition to 8-10 kg of merchantable honey, can produce 300 grams of beeswax annually, one gram of bee venom, bee pollen, royal jelly, as well as propolis, which are widely used in pharmaceutical production.

Bees, as the major pollinators of a number of agricultural crops, increase the productivity and germination of fruit trees, herbs, vegetables and cotton.

The diversity of agro-climatic conditions in the landscape of Armenia and the rich wild vegetation of the country make the

[147] GEF-UNEP publication "The role and significance of apiculture in agriculture," "Enhancing livelihoods in rural communities of Armenia through mainstreaming and strengthening agricultural biodiversity conservation and utilization," 2018

production of the best high-quality honey possible.

At the same time, the honey vegetation, which is prevalent mainly in meadows and grasslands, is vulnerable to climate change, in particular, adverse weather conditions (frequency, intensity, duration of rainfalls and windy days during the vegetation period, lack of days with temperatures over 10°C, etc.) and frequent hydrometeorological hazards (frostbite, hailstorms, heat waves, drought, etc.). This does not allow the creation of a stable honey flow during the vegetative phase and cause decline in honey volumes. According to the data of the National Association of Beekeepers, due to the adverse climatic conditions in 2012 honey production in the country dropped more than 10 times. At temperatures above 30^0C, the work speed of bees also decreases, as the most intensive work is done by bees at 18-25^0C.

Climate change can also contribute to the transmission and spread of pathogens of infectious diseases of bees[148]. Recent studies have shown that *Varroa jacobsoni* mite is the main cause of decline of bee families in Armenia in autumn, winter and spring[149]. In case of the incidence of varroatosis, the percentage of fall of the bee family can make up to 100%.

5.4.2 Adaptation Measures

The adaptation measures presented are designed to reduce the adverse impacts of climate change and climate induced natural hazards on the agricultural sector.

Type	Activity title	Activities implemented (or in progress)
Administration and planning	Legislative reforms aimed at reducing climate change risks on agriculture	On December 19, 2019, by the Decree No. 1886-L, the GoA approved the Strategy of the Main Directions for the Economic Development of the Agricultural Sector of the Republic of Armenia for 2020-2030, the vision of which is to have sustainable, innovative, high value-added agriculture in a harmony with the environment, ensuring care of natural resources, producing organic products and creating conditions for well-being of the people living in the village. On November 14, 2019, by the Decree No. 1612-L, the GoA approved the State Support Program for Introduction of Small and Medium Sized Greenhouses. On October 24, 2019, by the Decree No. 1485-L, the GoA approved the State Assistance Program for Implementation of the Pilot Program of Agricultural Insurance System. On April 04, 2019, by the Decree No. 362-L, the GoA approved the Program on Subsidizing Interest Payments on Loans Provided for Introduction of Hail Protection Nets in the RA Agriculture Sector. On March 7, 2019, by the Decree No. 212-L, the GoA approved the Co-financing Program for Introduction of Modern Irrigation Systems, aimed at promoting introduction of effective irrigation systems for high-quality croplands. On March 29, 2019, by the Decree No. 361-L, the GoA approved the State Support Program for Establishment of Vineyards, Intensive Orchards and Berry Orchards Developed in Armenia with Modern Technologies. The intensive garden, established based on the Program, should be equipped with drip irrigation and hail protection net systems. On November 30, 2017, the GoA approved the Program of Measures for the Concept of Prevention of Damage to Agriculture from Climatic Disasters. On March 16, 2017, the GoA adopted the Protocol Decree No. 11 on Approving the State Assistance Program for the Lease of Agricultural Machinery in the Republic of Armenia, to support the upgrade and refurbishment of machinery-tractor fleet. On December 1, 2016, by the Protocol Decree No. 48, the GoA approved the Activities Deriving from the RA Food Security Concept 2017-2021. Since January 1, 2015, Armenia has officially become a member of the Eurasian

[148] "Climate change: impact on honey bee population and diseases". Y. Le Conte & M. Navajas, 2008, p. 506

[149] "Reasons for massive decline of honey bees in various countries of the world and Armenia", 2011, ANAS, Armenian Biological Journal http://biology.asj-oa.am/4840/1/88-90_Tsarukyan._Arm.pdf

		Economic Union (EAEU) and has acceded to the EAEU Treaty. Article 95 of the aforementioned document, "The main directions of agreed (coordinated) agro-industrial policy and the means of state assistance to agriculture", and Annex 29 to the Treaty set out the peculiarities and important provisions of the agrarian policy of the EAEU countries.
Economic and technical measures	Government support through the increase of state budget allocations	In the recent years, there has been an increase in the implementation of programs on leasing of agricultural machinery and equipment, subsidies of loan interests, preferential lending for hail-protection nets and drip irrigation measures, installation of anti-hail rocket stations, lending for procurement organizations, assistance to cooperatives, and other directions. In particular: • On September 14, 2017, by the Protocol Decree No. 39, the GoA approved the Program for Subsidizing Interest rates on Loans to the Agricultural Sector[150], by which large farms had the opportunity to use concessional loans, as it was intended for loans amounting AMD 3-10 million. • On December 1, 2016, by the Protocol Decree No. 48, the GoA approved the Concept for Agricultural Subsidies' Directions. In 2012-2017, the budgetary allocations from the GoA for agriculture and irrigation systems increased by around 79.3%.
	Institutional reforms	On December 21, 2015, the National Assembly adopted the RA Law on Agricultural Cooperatives, which enables to regulate the relations associated with creation, membership, operation, management, termination, reorganization, liquidation of agricultural cooperatives and their associations, to define the rights, obligations and responsibilities of their participants, as well as the directions of state assistance to agricultural cooperatives.
	Launch of pilot crop insurance programs	Since March 2018, a pilot project has launched covering Shirak, Armavir and Ararat marzes. Potato and cereals will be insured against the risks of hail and frost in Shirak, and fruit and grapes in Armavir and Ararat marzes.
	Installation of hail-protection nets	On around 60-70 ha areas hail-protection nets have been installed due to which adverse effects of hailstorms are completely prevented. In 2013, with joint efforts of "Markets for Meghri" project of Center for Agribusiness and Rural Development (CARD) Foundation, UNDP and the National Disaster Risk Reduction Platform a similar effort was made in Alvank community of Meghri region, where 400m^2 string vineyard was netted. The UNDP Disaster Risk Reduction Programme carried out netting of 0.45 ha vineyard in Tavush community of Tavush marz. Based on the positive results of the pilot programs in 2017 the GoA has adopted a program to subsidize interest rates on loans for the introduction of hail-protection nets[151]. In the framework of projects implemented by the UNDP/ Bureau for Crisis Prevention and Recovery, 13 farms in Tavush and Artsvaberd communities in Tavush marz were provided with hail nets for the protection of around 3 ha vineyards from the impacts of hailstorms.
	Installation of new hail-protection stations	Since 2018, work has been carried out to introduce hail-protection rockets to prevent further development of atmospheric frontal processes penetrating the territory of the country. In 2014-2017, works were carried out towards modernization of the "Service of Hydrometeorology and Active Influence on Atmospheric Phenomena" SNCO and regional units of the MES. In particular, in 2014, 80 Zenith hail-protection stations controlled by GSM-SMS messages were installed in Aragatsotn, Armavir, Ararat and Lori marzes. With the purpose of ensuring the full functioning of the integrated management system, a unified management system for hail-protection stations was established, which significantly increased the effectiveness of hail-protection influence. At the beginning of 2014 there were 154 hail-protection stations functional in the country; in 2015 the number of such stations increased to 435, in 2016 to 496, and in 2017, 51 new gas-generating hail-protection stations were installed in Aragatsotn, Armavir, Ararat, Shirak, Kotayk and Lori marzes of the Republic of Armenia to minimize the damage caused to agriculture by hailstorms.
	Establishment of intensive orchards	In 2016, the Infrastructure and Rural Finance Support Programme funded by the International Fund for Agricultural Development (IFAD) was launched. Within the framework of the Programme, "Fruit Armenia" OJSC was established for intensive orchards development. The company plans to

[150] http://www.irtek.am/views/act.aspx?aid=91470
[151] http://www.irtek.am/views/act.aspx?aid=91410

		establish intensive, dwarf orchards on 306 ha area in Tavush, Vayots Dzor and Aragatsotn marzes of the country, ensuring application of modern state-of-the-art technologies, drip irrigation systems, hail-protection nets, modern varieties with high-efficiency and varied terms of maturity.
	Replenishment and upgrading of the technical pool of agricultural machinery	In 2013-2015, on the initiative of the RA Ministry of Agriculture, 292 units of "MTZ 82.1" tractors, 20 units of hay balers, 20 units of cultivators, 40 units of plows, 34 units of potato planters and potato harvesters, 16 units of sowing machines were imported to the country from the Republic of Belarus, which were provided to legal entities and individuals through SME Development National Center by direct sale and leasing at prices below the market.
	Development of cattle-breeding through the introduction of new breeds	As part of the 2007-2015 cattle-breeding program, 2,506 head heifers of high-value Holstein, Simmental and Schwyz breeds were imported to Armenia from Austria, the Czech Republic, Lithuania and Federal Republic of Germany, which were allocated to cattle-breeding farms at affordable terms and with payment by installments.
	Rehabilitation of pastures	Within the framework of the Community Agricultural Resource Management and Competitiveness (CARMAC) project, (2011-2016) pasture irrigation systems were built in 6 marzes of Armenia, as well as about 121.5 thousand ha formerly not-utilized or underutilized pastures were irrigated. Due to improvement of natural pasturelands and organization of pasture utilization on cooperative bases, in these communities, cow milk yield (by about 26%), livestock growth, farm income (by 128%) and grazing fees paid to the community budget for pasture utilization (58%) have increased.
	Introduction of the best agricultural practices, modernization of technologies	In 2015-2018, the EU funded the implementation of "European Neighborhood Programme for Agriculture and Rural Development" (ENPARD), aimed at supporting the sustainable development of agriculture in Armenia. One of the programme components was implemented by UNIDO and UNDP in Shirak, Lori, Gegharkunik, Aragatsotn, Kotayk and Vayots Dzor marzes of the country. The programme supported the creation of agricultural cooperatives, as well as strengthening of existing cooperatives, business capacity building, increase of production volumes, expansion of product mix, upgrading of technology, marketing, as well as introduction of best agricultural practices (drip irrigation, etc.) and disaster risk reduction (hail-protection nets, anti-frost measures) systems.
	Prevention of spread of plant and animal diseases	In 2012-2017, the "Plant Protection" centralized state program for combating the most dangerous and quarantine diseases of plants was implemented. During the mentioned period "Agricultural Livestock Vaccination" program was funded from the state budget, in the framework of which preventive and diagnostic measures for diseases (foot-and-mouth disease, anthrax, tuberculosis, brucellosis, leucosis, etc.), essential for animal welfare and human health, were taken. Implementation of these programs ensured stable phytosanitary and animal-epidemic situation in the country.
Research and information	Improvement of forecasts of hydro-meteorological hazards	In recent years, the Hydromet Service has been working with the Institute for Informatics and Automation Problems to improve the accuracy of forecasts of HHP. The American WRF (Weather Research and Forecasting) model was introduced, and the model's sensitivity for the forecast of certain HHP (heavy rains, hailstorm, mountain and valley breezes, etc.) were tested. In 2019, with the support of the World Bank, the Hydromet Service was provided with a "server" on which the software and corresponding resources/libraries were installed, and work on operational forecasts of hydrometeorological hazards commenced.
	Improvement of agro-meteorological service	In the recent years, satellite data have been used for monitoring, analysis and forecast of crop growth, stress and productivity. Information on forecasts of hazardous agro-meteorological phenomena is provided to the farmers through mass media and text messages (SMS).
	Agro-chemical examination of agricultural lands	About 88,000 ha of agricultural land of 157 communities are examined annually within the framework of the Agro-chemical Examination and Soil Fertility Improvement Program. An expert examination is carried out on a soil sample taken from the area under examination. The program enables agro-chemical examination of the soil in all communities of the country within 5 years, compilation of large-scale agro-chemical maps, development of scientifically sound recommendations on the cost-effective and efficient use of fertilizers, and provision thereof to the communities.

Provision of extension services on field crop farming, horticulture and livestock breeding	In the framework of Community Agricultural Resource Management and Competitiveness (CARMAC) second and third loan projects (2015-2020), under the agreement signed with the IBRD in 2014, "Community Pasture Users' Association" consumer cooperatives were established in 8 marzes of the country in 3 ways: group-, program- and individual-based. Extension services are provided in various directions, including field crop farming, horticulture, livestock breeding, use of agricultural machinery, etc.
Collection and study of agricultural monitoring data	In the framework of the above-mentioned CARMAC program, it is envisaged to obtain information on the condition of lands, especially pastures, sown areas and orchards, occurring natural phenomena, as well as data for agricultural monitoring and assessment of climate change impacts by application of agricultural drones and geographic information system (GIS).

5.5 Natural Ecosystems and Biodiversity

5.5.1 Vulnerability Assessment

Climate change affects natural ecosystems, causing different types of changes. In particular, it affects their composition, structure, productivity, relationships among species and with the environment and causes territorial redistribution of natural ecosystems by changing natural habitats of certain species of plants and animals, as well as contributes to the spread of invasive species.

In recent years, changes in components of natural ecosystems and biodiversity in Armenia have been studied and assessed in the climate change context, the results of which are summarized below:

Terrestrial ecosystems

According to forecasts, over the next 100 years vertical shift in the existing boundaries of main natural ecosystems will be observed. According to the features of mountain landscapes, they will shift upwards by 250-300m[152]. Climate change will lead to significant deterioration of fragile mountain ecosystem (soil erosion, productivity decrease of pastures and meadows, decline in the level of forests flexibility and productivity).

Upward shift of climatic zones across the relief is already observed in some sections of the boundaries of these zones.

Alpine meadows: it is expected that the surface area of the alpine zone will be reduced by about 22% and sub-alpine tall-grass and wetlands areas will expand.

Sub-alpine meadows: it is expected that the surface area of the sub-alpine zones will be reduced by about 21%, and shift to meadow steppes will be observed, with possible expansion of forest ecosystems into the area of current meadows. In forested areas, it is likely that the upper boundary of forests may shift vertically up, and for non-forested areas, shift to meadow steppe ecosystems is likely to occur.

Forests: in humid forests of mid-mountainous zone some xerophytization processes will likely occur, as a result of which penetration of typical steppe, sparse forest and species characteristic to shiblyak may occur. Over time, the sub-alpine zone forests will be replaced by wet forests, upper boundary of the forest vegetation will shift vertically up.

Meadow steppes: it is predicted that transition to steppe ecosystems will occur. In some cases, given the increase in the amount of precipitation in some areas, sub-alpine tall-grass may appear, and expansion into forest ecosystems of the current meadow steppe areas may occur.

Steppes: it is projected that expansion of steppe zone of about 4-5% will occur, and steppes will experience upper boundary shift to the sub-alpine zone, resulting in significant changes in vegetation composition and structure. The general direction of ecosystem change is xerophytization; dry steppes may be replaced by phryganoids, whereby the area of tragant steppes will expand. Relatively mesophilic steppe ecosystems can be replaced by more dry versions.

[152] Biodiversity and Climate Change: Linkages at International, National and Local Levels, Frank Maes, An Cliquet, Willemien du Plessis, Heather McLeod-Kilmurray Edward Elgar Publishing, 2013, p. 275

Semi-deserts: semi-desert vegetation is mainly expected to be preserved by expanding the phryganoid zone. It is expected that the desert ecosystems area, particularly the salt marshes and saline deserts, will expand.

Deserts: the desert is not observed as a separate vertical zone in the territory of the Republic of Armenia. It meets at altitudes 400-1000 m above sea level as separate sections within semi-desert vegetation. It occurs in sandy and salt marsh settlements. There are a number of endemic and rare plants and animal species, which are observed only here, e.g. here only the Armenian cochineal can be observed. Emergence of a new desert zone, expansion of desert – semi-desert area by about 33% and expansion of the semi-desert zone towards the forests' lower boundary are projected.

Shiblyak and arid sparse forests: it is predicted that, in general, conditions for these ecosystems will be preserved and even slightly expanded, however natural growth of trees and shrubs can deteriorate, and over time these ecosystems, especially in the lower mountainous zone, can be replaced by phryganoids.

Thus, in general, there will be a total xerophytization that will bring about significant changes in existing ecosystems, both structurally and in species' composition, as well as modification in their altitudinal zones and distribution.

Soil ecosystems

The impact of climate change on the components of soil is taking place slowly, making it difficult to estimate the changes in soil mass. Soils - the basis of natural landscapes, retain their characteristics in the long run due to their natural buffering. Possible changes in soil properties occur within the boundaries of changes typical to given geographical units.

Changes in natural vegetation due to the impacts of climate change will lead over time to structural shifts in lands forming the particular ecosystem. Areas without vegetation are extremely vulnerable to landslides. Loss of topsoil vegetation can have drastic consequences for the health of ecosystems. In areas with extremely low vegetation and very poor soil, dead zones are likely to appear, which do not allow water to infiltrate into the soil and hinder groundwater supply.

According to the Scientific Center of Soil Science and Agrochemistry, the annual soil erosion in arable lands located in the mountainous steppe zone of the country is from 1.5 to 24.0 t/ha. The loss of this amount of eroded soil means a loss of 60-960 kg/ha of humus (4% humus content).

An assessment of land erosion due to the changes in vegetation has been conducted. Currently, the least eroded lands in the country are found in the mountainous meadow soil zone (32%), where 20% of soils are weakly eroded, and 12% - medium and strongly eroded. The total erosion of the forest land zone is 61%, of which weakly eroded - 33%, medium and strongly eroded - 28%. Erosion rate is higher in forest brown soils. The total erosion rate in the steppe natural zone is 39%, of which weakly eroded - 28%, medium and strongly eroded - 11%. Erosion processes are more vividly expressed in the dry steppe soil zone. The total erosion rate here is 87% of the total area, of which 46% is weakly eroded and 41% is medium and strongly eroded. Erosion is observed in both uncultivated and cultivated lands. The overall erosion rate in the semi-arid soil zone is 39%, including weakly eroded - 22%, medium and strongly eroded - 17%.

The high level of soil erosion is primarily attributable to anthropogenic factors, in particular, to irrational use of lands. This impact is more observed in ecosystems where the natural topsoil vegetation is scarce, i.e. in the semi-desert and desert zone, and is less observed in meadow zones.

Thus, in case the current land use practices in different ecosystems are maintained, and given the climate change forecasts, the area of eroded soils is expected to expand.

Forest ecosystems

Conservation and sustainable management of forest ecosystems is seen as a guarantee for the country's sustainable development. Forests, as natural ecosystems representing rich and diverse ecosystem services, require a special attention. In Armenia, with its

scarce and, at the same time, large diversity of forest co-habitats (with around 100 levels of ecosystems), their protection, assessment of vulnerability to climate change and undertaking adequate adaptation and mitigation measures are highly relevant and urgent.

During 2014-2019, a number of scientific studies have been carried out to select rare forest ecosystems and carry out their vulnerability assessment (details on these studies are provided in the section 5.5.2). The main climate change impacts on forest ecosystems include upward shifts across vertical zones, determined by development and distribution of other ecosystems, as well as outbreaks of forest fires, various pests and diseases.

According to official sources, there is an increase in the number of forest and field fires as well as in their coverage of areas in the Republic of Armenia, attributable to both human and climate change factors, such as higher temperature, prolonged dry days and reduced precipitation.

According to the Statistics Committee data, the total number of forest fires (419 cases) in 2010-2018 exceeds the number of registered forest fires (72 cases) registered during 2001-2009 by about 6 times (Figure 5-25). For comparison, in 2001-2009 on average 8 cases of wildfire were annually recorded, whereas during 2010-2018, an average of 47 cases were detected per annum. During 2001-2009 the total forest area caught by fire was about 732 hectares, while in 2010-2018 it was about 6,108 hectares, exceeding the indicator of the previous decade by more than 8 times. In recent years, major forest wildfires broke out in the country; such as those in 2017 in "Khosrov Forest" State Reserve, Vayots Dzor and Aragatsotn forestry areas.

The analysis of individual years shows that steady increase in the number of forest fires was recorded in 2007-2012, but in the following years there has been a decrease in the number of cases, due to public awareness raising activities, as well as regularly conducted adaptation measures, aimed at prevention and extinguishing of forest fires and elimination of their consequences (Figure 5-22).

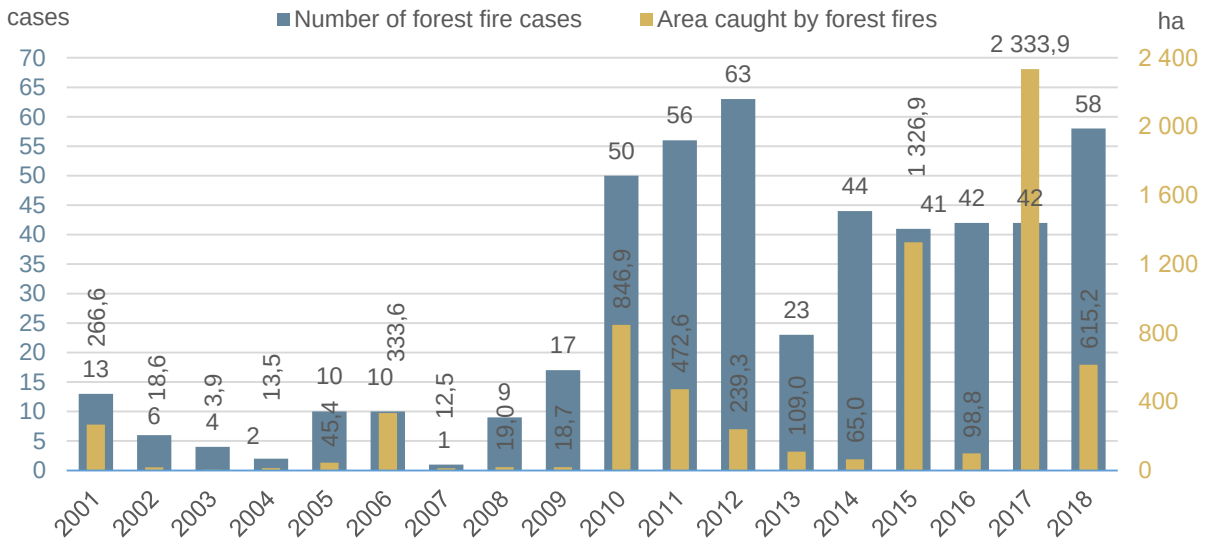


Figure 5-22. Number of forest fires and areas caught by forest fire, 2001-2018

Source: SC data, 2001-2018 (Environment and Natural Resources in RA)

Despite the increase in the number of forest fires within the period 2010-2014, there is a decrease in the area caught by forest fires, from 847 hectares to 65 hectares, due to the above-mentions factors. However, in 2015 and 2017 unprecedented large-scale forest fires were recorded, which covered an area of about 3,661 hectares (it should be noted that the years 2015 and 2017 are among the six years with extreme hot summers occurred in the last 20 years over the last century, when extreme hot summers were ever recorded).

Climate change also creates favorable conditions for the massive spread of forest diseases and pests. The official statistical data indicate that areas infected by forest diseases recorded growth since 2000 (Figure 5-23).

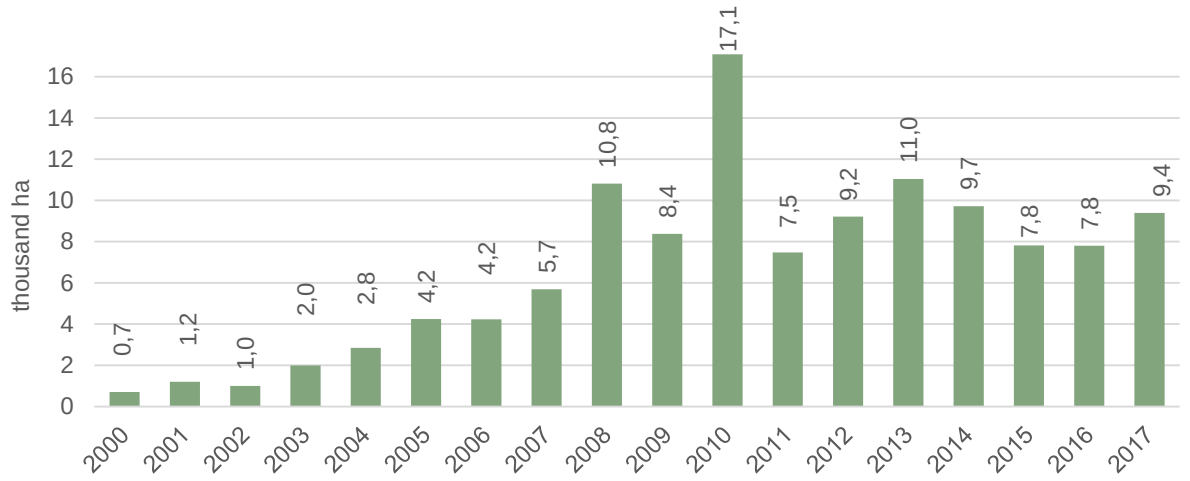


Figure 5-23. Areas infected with forest diseases, 2000-2017

Source: SC data (Environment and Natural Resources in the Republic of Armenia, 2000-2017)

Figure 5-24 shows the forest areas jointly infected both by diseases and pests over the period 1995-2018, as well as areas, where preventive measures against disease and pest outbreaks were undertaken (based on officially available statistical data). As can be seen from the chart, in the years following 2006-2007 there was some decline in the spread of forest diseases and pests due to the substantial control measures undertaken.

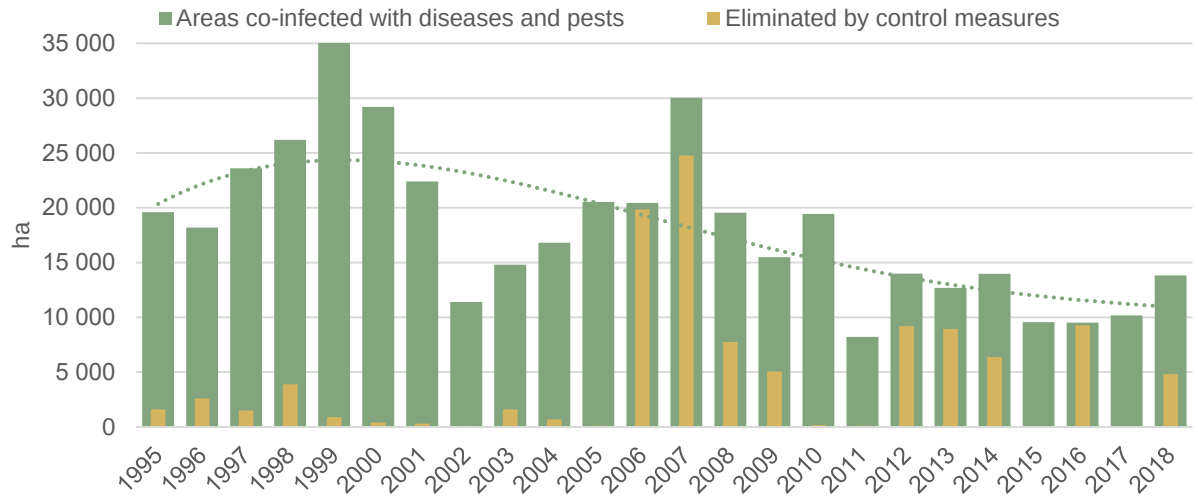


Figure 5-24. Areas co-infected with diseases and pests and eliminated by control measures, 1995-2018

Source: SC data (Environment and Natural Resources in the Republic of Armenia, 1995-2018)

The majority of measures taken to combat forest diseases and pests is based on aerial application of chemical sprays, which in many cases are fatal for survival of some forest animal species[153].

The increased number of forest fires, their coverage, intensity, as well as increase in areas with forest pest and disease infections is an evidence of increased vulnerability of forest ecosystems under climate change.

[153] RA 5th National Report on Biodiversity, 2014, http://www.mnp.am/uploads/1/1551884521pdfresizer.com-pdf-resize.pdf

Evidently, xerophyte vegetation on southern slopes, as well as the bushes in lower forest zone will be more vulnerable to climate change, due to expected lower humidity and less precipitation. In such circumstances, xerophilous vegetation types will start to actively penetrate into forest ecosystems, and as a result, this will lead to deterioration of natural reforestation processes, annual growth rate of trees will fall, which will result in forest ecosystems' replacement by sparse forests and, eventually, by semi-deserts.

Biodiversity

Climate change brings about changes in biodiversity. It has significant effect on phenological and bioecological features of species, as well as their prevalence. On one hand, emergence of new, often unwanted species is observed, on the other hand – extinction of some species, and in some cases, redistribution of roles of certain species within the ecosystems takes place. However, not all species within the same area are exposed to the same level of impact.

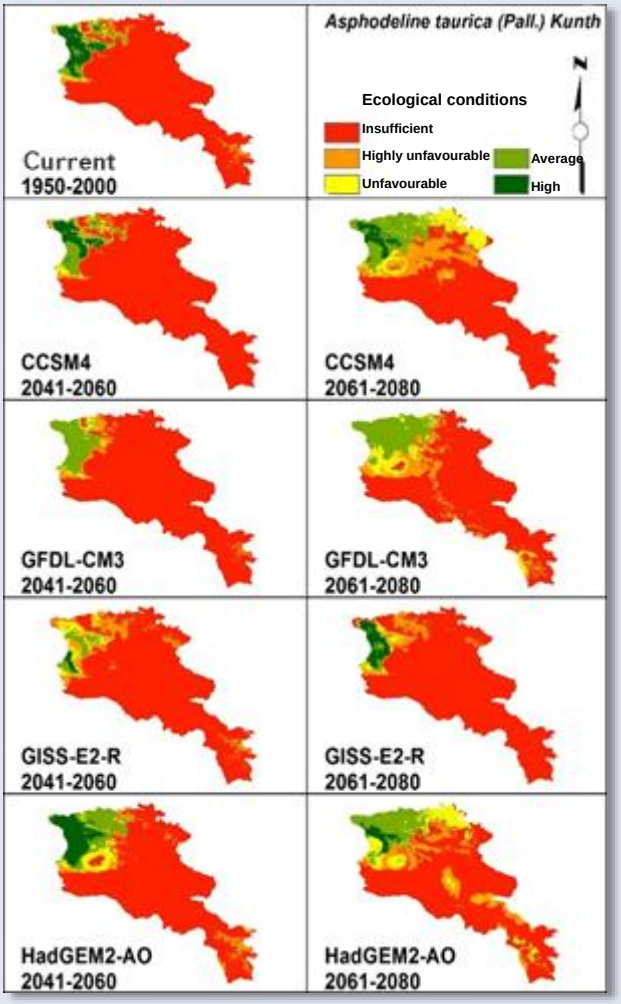
Climate change can cause extinction of not only local endemics, but also many other rare plant and animal species. Specialists from RA NAS Botanical institute after L. Takhtajyan have performed a climate change vulnerability assessment of 452 rare plant species listed in the Armenia's Red Book of plants. According to the results of this study, 239 of the species will bear no significant impact from the expected climate change. These species are, as a rule, characterized by great ecological flexibility and are adapted to ecosystems that will undergo minor changes. For 139 plant species, climate change can be a positive factor. These species may even expand their distribution on the country's territory; these are mainly heat-loving species that grow in lower and middle mountain zones. Only for 74 plants, climate change is likely to pose a very serious threat, because changing conditions do not allow these species to adapt to the new conditions and find favorable habitats. As a result, they will either disappear or appear on the verge of extinction. These are mainly the mesophilic species of the sub-alpine and alpine zones.

Rare and endangered ecosystems

In this context, preservation of rare ecosystems gains utmost importance. Based on priorities for preservation of biodiversity and protection of wildlife at international and national levels, 2 rare ecosystems on the territory of Armenia were selected for pilot study to illustrate the expected threats and ways of their prevention. For this purpose, different computer simulation models were used, the results of which are summarized below:

Pilot Study 1

Asphodeline taurica steppe bushes were selected as a pilot ecosystem for the study. In Armenia, this ecosystem is encountered on the southern slope of Shirak mountain-chain, on average altitudes of 2150 m above the sea level. Although occupies a relatively small area, this ecosystem, however, comprises 11 rare species included in the Red Book of Armenia, and Asphodelina taurica species is considered the dominant type in this ecosystem. Based on simulations carried out for all rare species, the most favorable and unfavorable areas of their future growth were identified. The respective maps for Asphodeline taurica species are presented in this Box. Based on the projections made, climate change can be a serious threat for Allium rupestre, Tragopogon armeniacus and Asperula affinis species. Given the projected climate change, this ecosystem is expected to expand its prevalence, and its composition and structure may undergo significant changes.

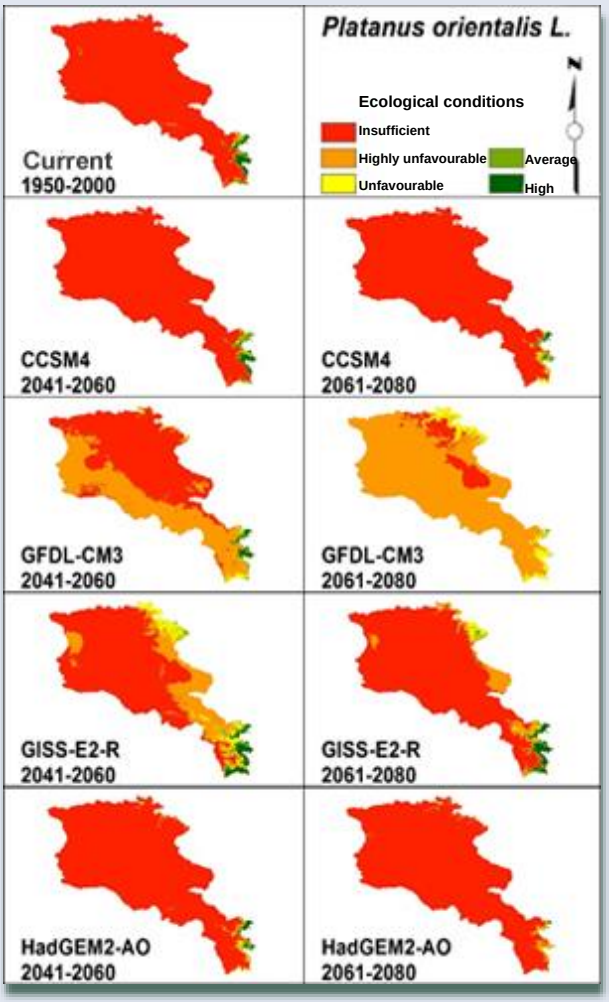


Specially Protected Areas of Nature

Climate change, first, will have impact on ecosystems and biodiversity in Specially Protected Areas of Nature (SPANs) and in locations proposed for Emerald Ecological Network, which is of environmental interest in Armenia. Currently, studies are being carried out and an optimization recommendation is being developed for the location areas of Emerald Ecological Network. As a result of the studies conducted in 2016, it was suggested to include about 30% of the total territory of the Republic in this Network. In recent years, efforts have been undertaken to reduce and change the structure of these areas, while, at the same time, increasing ecosystem diversity. It will be a very important measure towards adaptation of natural ecosystems and biodiversity to climate change.

Pilot study - 2

"Sosi Park" has been selected as a pilot ecosystem. It is located in the Syunik region, in the Tsav River Basin, 650-750 m above the sea level, and is dominated by the Platanus orientalis. This area is the only section for the given ecosystem in the Caucasus and is designated as a Specially Protected Area of Nature of the Republic of Armenia. According to computer modeling results, for 6 out of 9 mesophilic species included in the Armenian Red Book (Carex pendula, Euonymus velutina, Platanus orientalis, Pteridium tauricum, Pyrus raddeana and Ranunculus cicutarius) reduction of favorable habitats is expected in the future. For rare, drought resistant species (Lathyrus cassius, Medicago arabica, Nonea rosea, Lens ervoides, Thlaspi umbellatum) ecological conditions will be favorable, and for Calendula persica, Galanthus artjuschenkoae, Lathyrus sylvestris, Trifolium angustifolium species the favorable areas for growth will even expand.



Invasive species

Currently the spread of invasive species plays a crucial importance in terms of risks to natural ecosystems and biodiversity, therefore, it is very important to evaluate their potential for expansion, penetration into natural ecosystems, based on projected climate change. The issue of invasive species is even more relevant for Armenia, given the larger number of ecosystems available for these species and already tangible impact of climate change. Currently, scientists are intensively engaged in simulating the future distribution of invasive plant species. As an example, below picture shows predictions of future prevalence of *Ambrosia artemisiifolia* invasive plant, based on the projected climate change. Modeling of the potential spread of this species has been carried out under the RCP 8.5 climate change scenario for different bioclimatic models (CSM4, GISS-E2-R, HadGEM2-AO and GFDL-CM3). In Armenia, *Ambrosia artemisiifolia* has a great potential for spreading and is expected to become even more dangerous to natural ecosystems, biodiversity, agriculture and human health.

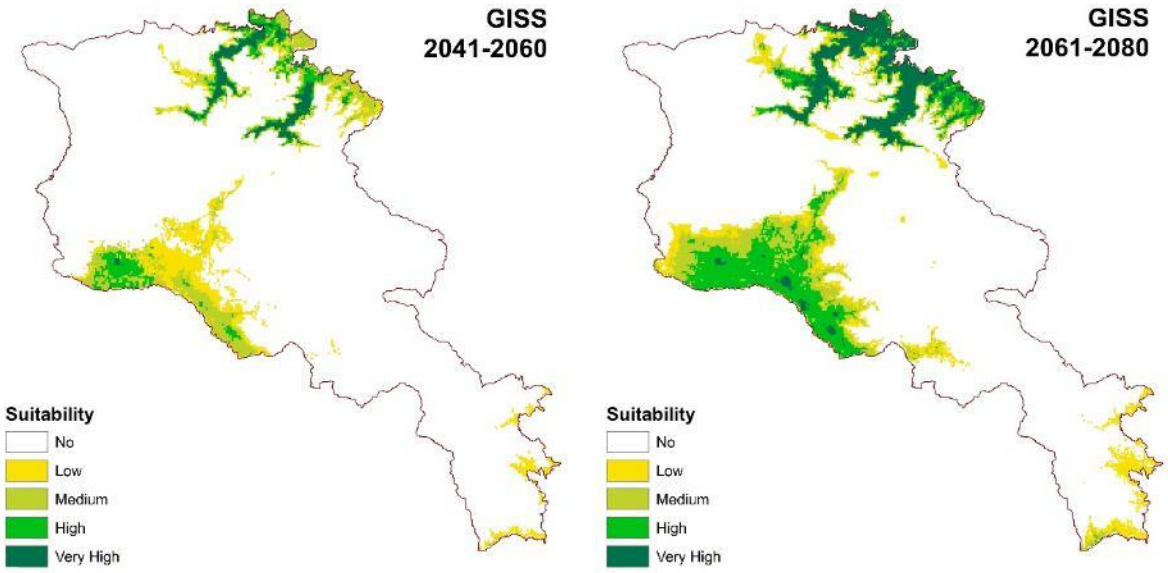


Figure 5-25. Forecast of *Ambrosia artemisiifolia* species' prevalence under the projected climate change

Aquatic and wetland ecosystems

Lake Sevan ecosystem. Lake Sevan is Armenia's most important water ecosystem. Under the influence of anthropogenic factors, for many years, the water level of the Lake was diminished from normal level: as of 2002 the level had dropped down by 20.2 meters, and the volume had decreased by more than 42%, leading to significant changes in the Lake ecosystem and thermal regime. Current anthropogenic impacts on Lake Sevan ecosystem do not allow for more accurate prediction of the changes taking place in the Lake ecosystem and biodiversity.

For assessment of the state of the Lake Sevan ecosystem and its vulnerability to climate change, the 2013-2018 hydro-chemical monitoring data from the MoE EMIC SNCO, the "Lake Sevan Water Basin Management Plan: Part 1" report from the EUWI+ program, and the results from scientific research programs of the NAS Scientific Centre Zoology and Hydroecology were used.

According to the 2013-2018 hydro-chemical monitoring data from the EMIC SNCO of the MoE, 7 out of the 11 studied rivers flowing into Lake Sevan, contaminated with domestic wastewater and under the direct and indirect impact of agricultural water runoff, had brought significant amounts of biogenic materials (ammonium and phosphate ions) into the Lake, resulting in a slow increase in the content of inorganic nitrogen and phosphorus in the Lake.

In addition to annual changes, seasonal changes have also been observed. The levels of biogenic material increase mainly in May and October (up to 2 times) and decrease again in the rest of the months to the standard level. The content of biogenic materials is unequally distributed in the Lake. Compared to the Greater Sevan, the content of inorganic nitrogen compounds is about 1.5-2.0 times higher in the Lesser Sevan. The increase in the levels of biogenic materials inevitably affects not only the water ecosystems of the rivers and the normal processes of spawning by fish, but also contributes to the process of eutrophication of the Lake Sevan. The water quality of the 11 rivers flowing into Lake Sevan for 2013-2018, by water quality classes, is presented in Table 5-11.

Table 5-11. Water quality of 11 rivers flowing into the Lake Sevan, 2013-2018

River	Observation post location (observation post number)	Water quality class	Main indicators (water quality class indicator)	Cause of main pressure
Dzknaget	Whole river	Good (II)	-	No significant pressure
Masrik	0.5 km upstream the Verin Shorja village (#62)	Good (II)	-	No significant pressure
	River mouth (#63)	Average (III)	Phosphate ions (III) Vanadium (III)	Domestic wastewater, agricultural runoff, mining runoff
Sotk	1.5 km upstream the mine (#64)	Good (II)	-	No significant pressure
	River mouth (#65)	Average (III)	Nitrate ions (III), KM (III), Vanadium (III)	Domestic wastewater, mining runoff
Karchaghbyur	Whole river	Good (II)	-	No significant pressure
Vardenis	0.5 km upstream the Vardenik village (#69)	Good (II)	-	No significant pressure
	River mouth (#70)	Unsatisfactory (IV)	Nitrate ions (III), Phosphate ions (III), Ammonium ions (IV)	Domestic wastewater, agricultural runoff
Martuni	0.5 km upstream Geghhovit village (#71)	Good (II)	-	No significant pressure
	River mouth (#72)	Unsatisfactory (IV)	Phosphate ions (III), Ammonium ions (IV)	Domestic wastewater, agricultural runoff
Argichi	Whole river	Good (II)	-	No significant pressure
Shoghvak	River mouth (#75)	Unsatisfactory (IV)	Phosphate ions (III)	Domestic wastewater, agricultural runoff
Bakhtak	River mouth (#76)	Unsatisfactory (IV)	Phosphate ions (III)	Domestic wastewater, agricultural runoff
Gavaraget	0.5 km upstream Tzaghkavan (#77)	Good (II)	-	No significant pressure
	River mouth (#78)	Poor (V)	Phosphate ions (IV), Ammonium ions (III), TP (III), Nitrate ions (III)	Domestic wastewater, agricultural runoff
Lichk	Whole river	Good (II)	-	No significant pressure
Arpa-Sevan channel	0.7 km upstream the Tzovinar village (#68)	Average (III)	Nitrate ions (III)	Impact of groundwater

Source: MoE EMIC SNCO, "Lake Sevan Water Basin Management Plan: Part 1", 2018

In addition to anthropogenic impact, the water of the Lake is significantly affected by climate change. In parallel to the increase in air and water temperature, the biomass of phytoplankton in the Lake is increasing, which is leading to a rapid deterioration of the Lake water quality and the acceleration of eutrophication processes. This is confirmed by satellite images analyzed from 2016 (Figure 5-26).

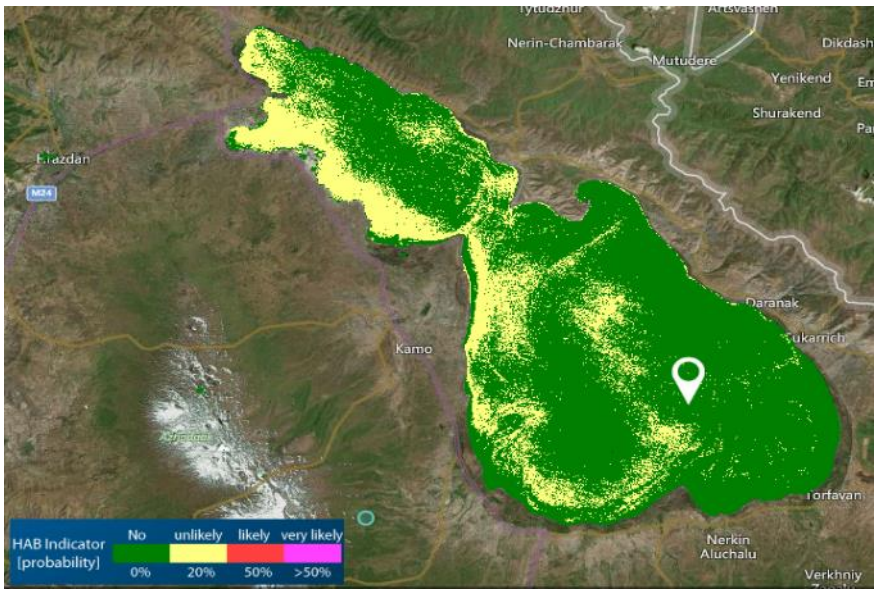


Figure 5-26. Blooming of harmful algae in Lake Sevan (*HAB*), August 2016

Source: UNESCO, World Water Quality Portal, 2016 http://46.16.74.57/

According to a study carried out for May-December 2016, values for water temperature in the Lake Sevan fluctuated within the range of 4.6-19.4°C, with peak values observed in the second half of August. As a result of the maintenance of maximum water temperature, after an interval of a few days, an increase was seen in the levels of the Lake water turbidity and chlorophyll A. The "blooming" of the Lake in September-October coincided with a prolonged maintenance of relatively high temperatures: from 10 August to 13 October, the water temperature fluctuated between 12.0^{0}C and 19.4^{0}C.

According to the preliminary data from studies conducted by the NAS Scientific Centre of Zoology and Hydroecology, the dependence of phytoplankton biomass on air temperature has been revealed. Phytoplankton biomass in the Lake during the oligotrophic period (up to the 1930s) averaged at 0.32 g/m³, while in 2011 it was 6.4 g/m³, and in 2018 (in October, during the "blooming") it reached 20 g/m³. During the "blooming" period, a sharp increase in nitrate ions was seen in the surface layer of the water. The intense "blooming" of the Lake seen in July 2018 was due to the genus Anabena; levels of *Anabaena flos-aquae* reached 66 g/m³. The "blooming" in the autumn was due to diatoms of *Melosira granulata* and *Oocystis solitaria* in the fishery sections.

According to research data, the ecological state of the Lake Sevan in 2019 was characterized as mesotrophic with symptoms of eutrophication (an increase in "blooming" due to cyanobacteria, an increase in quantity of biogenic material, a decrease in water permeability).

The AUA Acopian Environmental Center and the NAS Center for Ecological Noosphere Studies conducted an observation over space and time of Lake Sevan water quality and changes in climatic conditions based on analyzed data for phytoplankton biomass, temperature and satellite imaging (Landsat 8 OLI / TRS) of water turbidity (Figure 5-27).

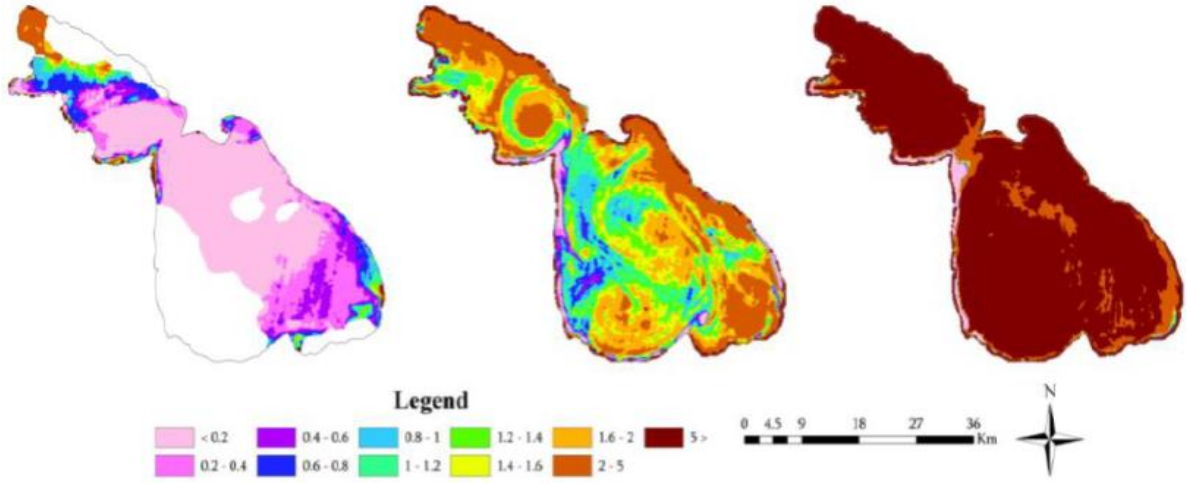


Figure 5-27. Changes in plankton in the Lake Sevan water in spring, summer and autumn based on satellite images, 2018

Source: NAS Center for Ecological Noosphere Studies

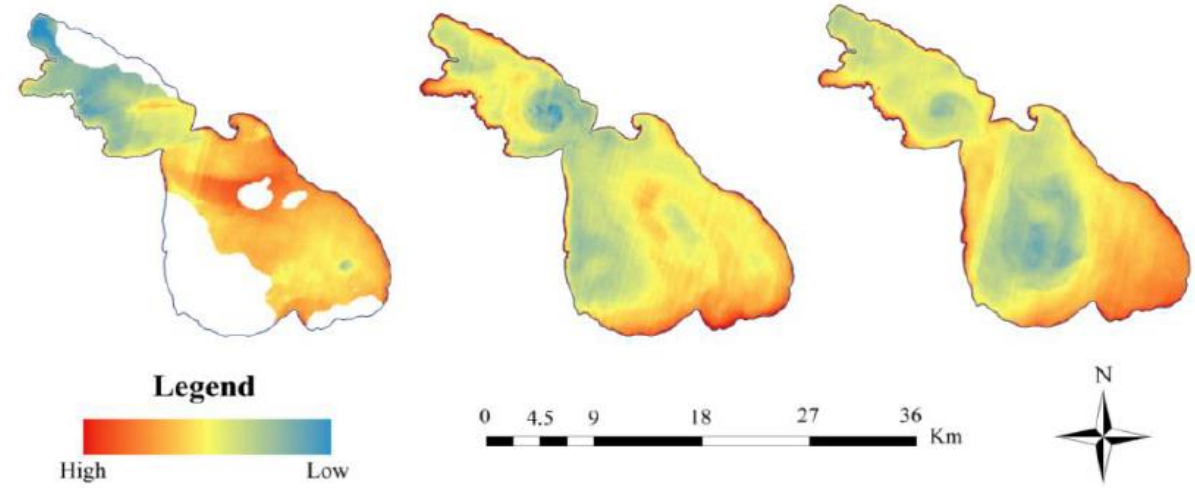


Figure 5-28. Fluctuations of water temperature in the Lake Sevan in spring, summer and autumn based on satellite images, 2018

Source: NAS Center for Ecological Noosphere Studies

Based on the obtained data, an increase in phytoplankton biomass in the summer is obvious, which then scales up in the autumn (the second “blooming” period of the Lake).

Long-term and more comprehensive studies are needed to make a more profound evaluation and forecast of the ecological state of the Lake.

According to forecasts, it is expected that by 2070 the water temperature will increase by 2^0C and by 2100 - by 4^0C in Armenia. Based on these data various forecasts were made in relation to changes estimated in primary products (phytoplankton and phytobenthos or macrophyte products) and secondary products (zooplanktons and zoobenthos communities co-inhabitance products, fish products) inherent in Lake Sevan ecosystem chain (Figures 5-29 and 5-30).

As per the estimates, it is anticipated that the increase in temperature will have a negative impact on Salmonidae species. Salmonidae lose mobility at temperatures above 18^0C and cease eating. They are very sensitive to dissolved oxygen in the water, which means that during the summer their habitat zone is limited by a top water layer above 18^0C and by lower level of dissolved oxygen at the bottom. This zone tends to increasingly narrow and eventually may disappear. Nutritional regime changes also lead to the deterioration of oxygen conditions. The Cyprinidae species, by contrast, prefer

higher water temperatures and are less sensitive to the content of dissolved oxygen in the water. It is very likely that the Lake Sevan will shift from a trout reservoir to a carp reservoir, which is characterized by higher fish productivity, but lower quality.

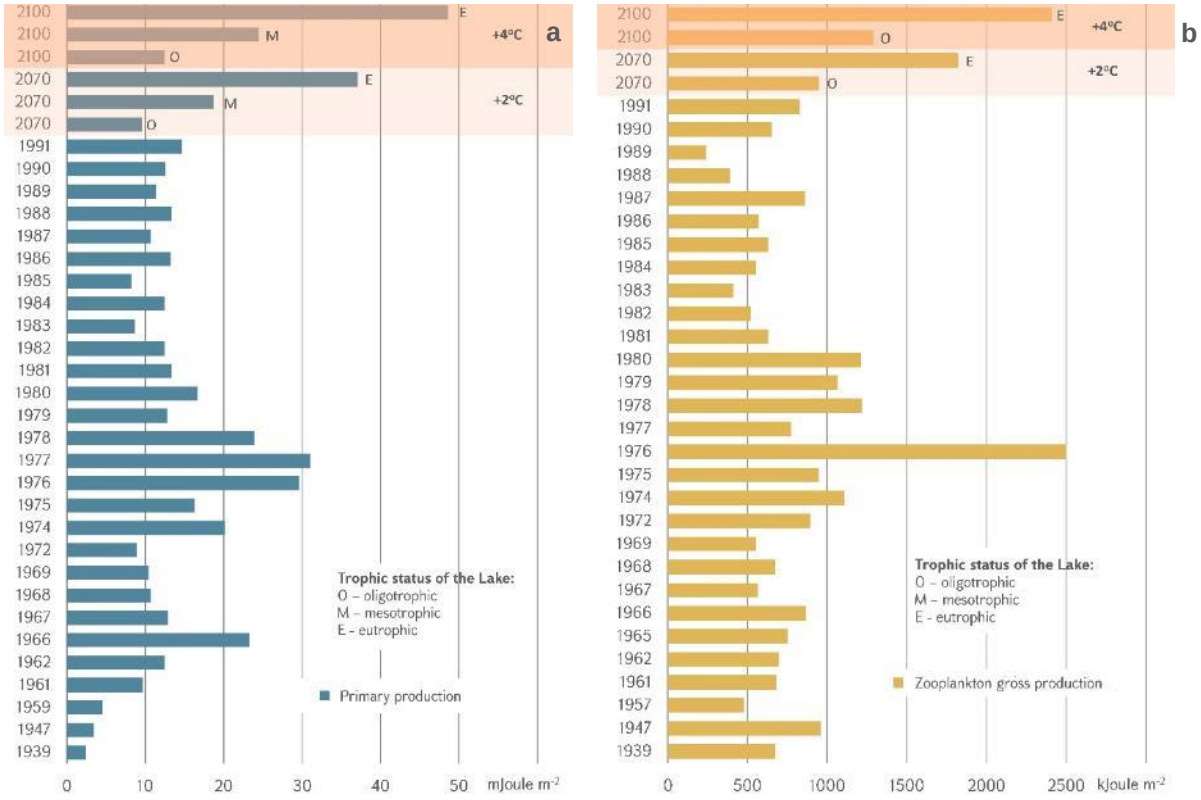


Figure 5-29. Actual (1939-1991) and projected (2070-2100) volumes of annual primary (a) and secondary (b) production

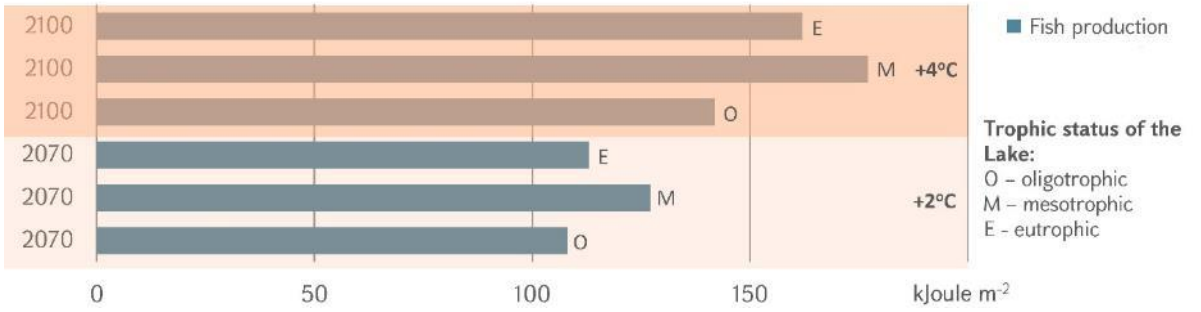


Figure 5-30. Estimated annual gross output of fish in the Lake Sevan for 2070-2100 under different nutritional conditions

In addition, the increase in the Lake water temperature and the mass development of blue-green algae in summer (due to "water blooming") may lead to deeper ecosystem modifications. In recent years this phenomenon has already been observed in the Lake Sevan. According to projections, unless corresponding measures are taken, these phenomena will persist and result in significant changes of environmental factors affecting biodiversity of the Lake. In particular, eutrophication processes will accelerate and increase, resulting in changes in water composition and pollution, deterioration of water quality, changes in phyto- and zooplanktons and benthos and accumulation of toxic substances in living organisms, etc. In order to prevent all these phenomena, it is necessary to ensure further increase of the water level, which will help keep the water temperature lower in summer months. Additionally, large-scale artificial water treatment activities are needed to eliminate blue-green algae from spreading.

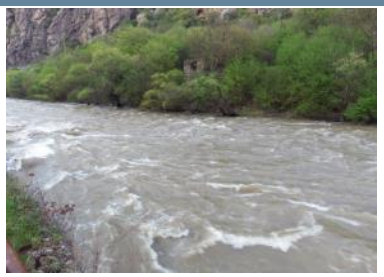
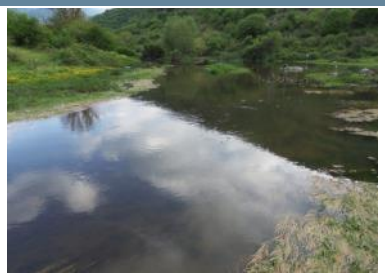
Other aquatic and wetland ecosystems. The projected climate change will also affect all aquatic and wetland ecosystems. Changes in precipitation and seasonal regime will, first of all, result in changes in river flows and watercourses. In particular, there will be replacements of ecosystems with one another.

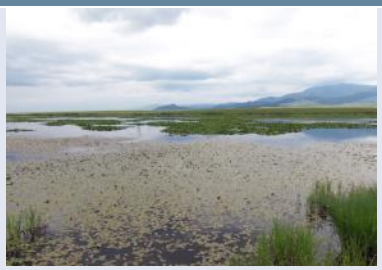
Constant non-periodic rapid turbulent water flows will be replaced by constant non-periodic steady water flows and even with temporary water flows. During flooding, the majority of water flows will be attributable to constant non-periodic rapid turbulent water flows.

Increase in temperature will primarily affect trophic level of lakes. Currently, almost all oligotrophic lakes in Armenia are at an altitude of 3000 m and above the sea level, therefore the increase in temperature will intensify the process of eutrophication and their transition to permanent mesotrophic lakes and ponds. Accordingly, the same processes will result in mesotrophic lakes' transition to eutrophic or even dystrophic lakes.

Such processes can already be observed today in the lakes of the Lori plateau. As a result of lake stagnation and the rise in temperature and changes in precipitation regimes, changes in coastal zone ecosystem may lead to transition of inland surface water ecosystems to marshes and super-humid habitats. In addition, many lakes may shift to temporary lakes and ponds category, in parallel to decrease in precipitation levels. As a result of reduction in precipitation saline marshes at the lower mountain zone can switch to herbal ecosystems, in all likelihood to continental saline steppes.

Table 5-12. Expected changes in aquatic and wetland ecosystems

Current ecosystem	Implied changes	Implied ecosystem
 Permanent non-periodic fast turbulence water flows	Precipitation reduction and regime change	 Constant non-periodic steady flow water streams
 Constant non-periodic steady flow water streams	Precipitation reduction and regime change	 Temporary water flows
 Permanent oligotrophic lakes	Increase in temperature	 Permanent mesotrophic lakes

Current ecosystem	Implied changes	Implied ecosystem
 Permanent mesotrophic lakes	Increase in temperature	 Permanent eutrophic lakes
 Permanent eutrophic lakes	Increase in temperature	 Permanent dystrophic lakes
  Permanent mesotrophic lakes	Precipitation reduction	 Temporary lakes, ponds  *Typha latifolia shrubberies*
 *Juncus acutus* dominated salt marshes	Precipitation reduction and increase in temperature	 *Cynodon dactylon* dominated ecosystem

5.5.2 Adaptation Measures

Objective: preserving biodiversity and natural ecosystems

Type	Activity name	Activities implemented (or in progress)
Administration and planning	Legal reforms	By RA Government Protocol Decree No. 50, dated November 30, 2017, the Forest Sector Reform Concept, Strategy and the List of Measures was approved, aimed at ensuring, among other issues, the balancing of climate and environmental requirements, in particular mitigating the negative impact of climate change, anthropogenic factors on forest ecosystems. Strategic and legal documents aimed at improving the forest management sector have been adopted, including: • RA Biodiversity Conservation, Use and Reproduction Strategy and State Program of Measures (2015); • RA Strategy for Specially protected Areas of Nature, State Program on Conservation and Use, and Measures (2014), in the framework of which a number of activities have been implemented, including improvement of legislation, management system, institutional, technical upgrading and research. The following has been approved by Government Decrees: • 2018 Annual Program of Measures on Lake Sevan Ecosystems Recovery, Conservation, Reproduction, Natural Development and Utilization (Decree No. 1187-N of 08.09.2017), • Procedure for Creation of a Shared Electronic Database, Collection, Registration, Summarization and Provision of Information for Monitoring of Lake Sevan and its Catchment Basin (Decree No. 947-N of 04.09.2014).
	Institutional reforms	Some structural changes have taken place in the forest sector of the Republic of Armenia. The forests and forest lands of the Republic of Armenia have been handed over for management to “Hayantar” SNCO and SPANs, which operate under the management of the RA MoE. By the Government Decree No. 81, dated January 30, 2020, the “Forest Monitoring Center” SNCO merged with the "Service of the Hydrometeorology and Active Influence on Atmospheric Phenomena" and EMIC SNCOs, and was reorganized as “Hydrometeorology and Monitoring Center” SNCO, which operates under the MoE. By the Government Decree No. 182-N, dated February 22, 2018, the State Forest Committee within the MoE was established, under the management of which “Hayantar” SNCO operates. The Department on Biodiversity and Forest Policy, with its Divisions of Biodiversity and Biosafety Policy, Forest and SPANs Policy, was established within the MNP. In 2016, within the framework of the FLEG program, the World Wildlife Fund (WWF-Armenia) with the funding of the EU, carried out technical upgrading of the MNP’s SPANs Management Division by providing an all-terrain vehicle, a number of relevant equipment. The Division was equipped, maps of SPANs together with their GIS data were provided, staff training was conducted on the GIS application.
	Development of forest mana-gement plans	A number of management plans have been developed with the funding of the Caucasus Nature Fund (CNF) and the German Development Bank (KfW). In the framework of the UNDP-GEF “Sustainable Land and Forest Management Implementation in the North-Eastern Mountain Landscapes of Armenia” Project (2016-2020), forest management plans for Tavush and Lori regions have been developed to expand protected forest areas and improve forest ecosystem services. The ten-year forest management plans are in the process of being updated.

Type	Activity name	Activities implemented (or in progress)
Economic and technical activities	Implementation of forest protection measures	Through the UNDP-Russia "Addressing Climate Change Impact through Enhanced Capacity for Wildfires Management in Armenia" Project (2017-2020), it is planned to improve and strengthen early warning and monitoring systems, provide stakeholders access to state-of-the-art equipment and technology designed to extinguish and suppress on-ground fires, as well as protective uniforms to ensure the health and safety of firefighters. Under the EU-funded ENPI, the Black Sea Basin Program “Utilizing Stream Waters in the Suppression of Forest Fires with the Help of New Technologies” (2013-2015) was implemented, which was aimed at development of a comprehensive fire extinguishing system for the protection of SPANs from fires with the use of innovative approaches and technologies.
	Restoration of degraded forest ecosystems, and afforestation of forest lands	With the joint efforts of GIZ and the German Ministry of Development (BMZ) the “Integrated Biodiversity Management in the South Caucasus” Project is being implemented, with various components aimed at reforestation activities. UNDP-GCF, WWF-Armenia, CNF are implementing the "Sustainable Land and Forest Management in Northeast Armenia" Program, with primary objective to promote sustainable forest management and continuous flow of ecosystem services. WWF-Armenia has implemented the “Forest Landscape Restoration of Northern Armenia” Project. The EU Clima East Pilot Project “Sustainable Management of Pastures and Forest in Armenia to Demonstrate Climate Change Mitigation and Adaptation Benefits and Dividends for Local Communities” was implemented.
	Conservation of habitats for existing rare plant species and development of SPANs	Works to create the Emerald Ecological Network are underway. WWF-Armenia is conducting a feasibility study on the opportunities for creation of ecological corridors. The Michael Succow Foundation together with the NAS Centre for Ecological-Noosphere Studies is implementing the "Supporting the Process of UNESCO Biosphere Reserves Establishment in Armenia" Project. WWF-Armenia, with the support of the IDeA Charitable Foundation of Armenia, is carrying out a project on development of a National Park in the Tatev region. With the support of “Treweek Environmental Consultants” and “Lydian-Armenia” companies, activities are underway aimed at establishment of a national park in the Jermuk region.
	ex-situ conservation of rare plant and animal species	The following initiatives are ongoing: • Seed Bank (Institute of Botany of NAS), • Bank of crops and their wild varieties (ANAU, Agro-biotechnology Research Center branch), • Plots for growing rare flora species in Armenia (Botanical Garden of the NAS of Yerevan) • Scientific Research Laboratory of Plant Genetic Conservation and Breeding (ANAU).

Type	Activity name	Activities implemented (or in progress)
	Climate change impact assessment in relation to ecosystems, specific flora and fauna species	The Takhtajyan Institute of Botany at the NAS performs: • computer modeling of indicative species for the current and future distribution, vulnerability assessment of individual rare ecosystems; • environmental impact assessment and safeguards for rare and extinct plant species, the results of which have been used to predict threats to populations of the rarest species of Armenian flora. Research activities are carried out within the framework of the thematic, basic and international studies of the GLORIA international network and the institutes of the NAS. The Scientific Center of Zoology and Hydroecology of the NAS continues to collect data on the distribution of various vertebrate and invertebrate animals, which are expected to be used to assess changes in natural ecosystems and biodiversity driven by climate change impact. The Center regularly records fish stocks in the Lake Sevan. In 2019, the Center has carried out preliminary work on determining the species composition of fish in the Lake Arpi and assessing fish stocks; these activities are expected to continue in 2020. In December, 2016, the “Monitoring of the Bezoar Goat Population in “Khosrov Forest” State Reserve and the Monitoring of Forest Ecosystems of the “Dilijan” National Park in “Khosrov” Forest State Reserve” Project was initiated, which was funded by the CNF and implemented by the WWF-Armenia in collaboration with the MoE. Assessment and forecasting of climate change impacts has been conducted in relation to rare and endangered plant and animal species, individual ecosystems and areas of particular interest to Emerald Ecological Network of Armenia.
Research and information	Assessment of ecosystem services	Within the framework of the "Forest Law Enforcement and Governance" (ENPI FLEG II, EU/WB, IUCN, WWF) Project (2012-2016), framework assessment of the ecosystem services was implemented and a roadmap for the forest sector was developed.
	Study and monitoring of distribution of invasive plant and animal species	The Takhtajyan Institute of Botany of the NAS has carried out research and adaptation of the methodology for assessment of invasive potential of introduced species, depending on various environmental factors, including climate change. With joint efforts of MIREN International Network and Takhtajyan Institute of Botany of the NAS, research is being carried out in relation to invasive plant species.
	Monitoring and assessment of rare plant and animal species’ populations	The Takhtajyan Institute of Botany of the NAS and the Scientific Center of Zoology and Hydroecology carry out monitoring of rare species populations in areas heavily affected by the anthropogenic factor (Teghut, Amulsar, etc.). WWF-Armenia carries out monitoring of leopard, bezoar goat and mouflon populations.
	Assessment, development and monitoring of existing SPANs’ ecosystems and biodiversity	Since 2012, with the support of the CNF, the Transboundary Joint Secretariat of the South Caucasus (TJS) and the German Development Bank (KFW) capacity building programs are underway for the existing SPANs, including ecosystems and biodiversity assessment, development and monitoring.
	Assessment of hazardous diseases’ threats	In 2019, AMD 43,710.9 thousand was allocated from the RA state budget (the same amount is envisaged for 2020-2022) for implementation of forest pathological research. The National Center for Disease Control and Prevention, has carried out the forecast of prevalence of *Microtus arvalis* in Armenia, as the main carrier and transmitter of dangerous infections/diseases, according to climate change projections.
	Studies on accumulations of organic carbon	During the studies of ecosystem services carried out under various scientific and international programs, special attention has been paid to the accumulation of organic carbon in different ecosystems.

5.6 Settlements and Infrastructure

The highly fragmented and complex terrain of Armenia and the spatial distribution of settlements and infrastructure are attributable to the mountainous nature of the country - around 80% of the territory of the Republic of Armenia is covered by mountains. Most of the urban and rural settlements are located in the low-lying areas of the terrain: the absolute majority of the population is concentrated here, while most of the roads of the country pass along river valleys and across mountain slopes. The geological and climate conditions of the terrain characterrize the level of vulnerability of settlements and infrastructure.

A number of climate induced natural hazards are observed on the territory of the Republic, including floods, river inundations, mudflows, landslides, rockfalls and avalanches, which can result in considerable destruction and damages to the settlements, roads, different nearby facilities and infrastructure located in a particular territory, and cause also human casualties.

Identification and forecast of the impact of global warming and climate change on such natural hazards as, for example, floods, landslides or drought, is not straightforward.

The dangerous natural phenomena, which have intensified in Armenia in recent years, could directly or indirectly be associated also with climate change. As a consequence of climate change, significant increase in the number of cases of heavy rainfalls, fast snowmelt and non-seasonal overflow of rivers is observed in the country, in addition to other natural extreme events, which, in turn, contribute to a more intensive occurrence of floods and mudflows.

Thus, it may be concluded that climate induced changes in terms of intensity and frequency of anticipated extreme events, most probably will have a significant impact on the level of vulnerability of a large number of settlements and infrastructure and the degree of risks associated with dangerous natural phenomena will increase.

5.6.1 Vulnerability Assessment

Floods. Heavy precipitation, snowmelt, river inundations, as well as damages of hydrotechnical installations are the main reasons for the occurrence of floods on the territory of the Republic. The year 2007 was notable in terms of excessive floods (86 cases were recorded during that year); this phenomenon was especially significantly observed in Vayots Dzor and Gegharkunik marzes (22% and 15%, respectively)[154]. During 2012-2018, a considerable decrease in the number of cases of floods was observed: in average, the annual number of cases was seven, in contrast with over 30 registered cases annually during 2005-2011. The highest number of floods was recorded in spring months.

Mudflows. The majority of mudflow-related phenomena on the territory of the Republic of Armenia are caused by the mountainous terrain, heavy rainfalls, and rarely by snowmelt. The highest number of cases of mudflows, around 80%, was registered in May and June. As with the case of floods, the year 2007 was also notable in terms of excessive mudflows: the number of registered cases of mudflows was 38 (MoES, 2018). During 2012-2018, the number of cases of this dangerous phenomenon has shown a decreasing trend: the annual average number of cases was 1-2, in contrast with the figure of around 9-10 cases annually registered in average in 2005-2011. The highest number of mudflows were observed in Lori (26%), Aragatsotn (24%) and Vayots Dzor (20%) marzes.

Mudflows, as well as floods, result in considerable material losses and can also cause human casualties. In 2012, the first victim of a mudflow was recorded in Aragatsotn marz, who had fallen into the gully and was carried away by the torrent. In June 2016 alone, the estimated damage caused by mudflow in Artik community, Shirak marz, amounted to more than AMD 605 mln (Marz Committee, 2016).

The mudflow-prone settlements located in the Republic of Armenia, by the threat level, are presented in Table 5-13 and in Figure 5-31 (MoES, 2018).

[154] MoES, 2018; http://mes.am

Table 5-13. Mudflow-prone settlements, by the level of assessed risks

Risk level*	Number of settlements									
	Aragatsotn	Ararat	Armavir	Gegharkunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor
First (R=6)	-	-	-	4	7	7	8	15	-	10
Second (R=3)	8	10	-	24	2	10	3	16	10	10
Third (R=1)	5	1	-	-	-	4	2	2	3	7

** The value of the risk (R) is the product of maximum probability of occurrence of an outcome and the damages caused.*

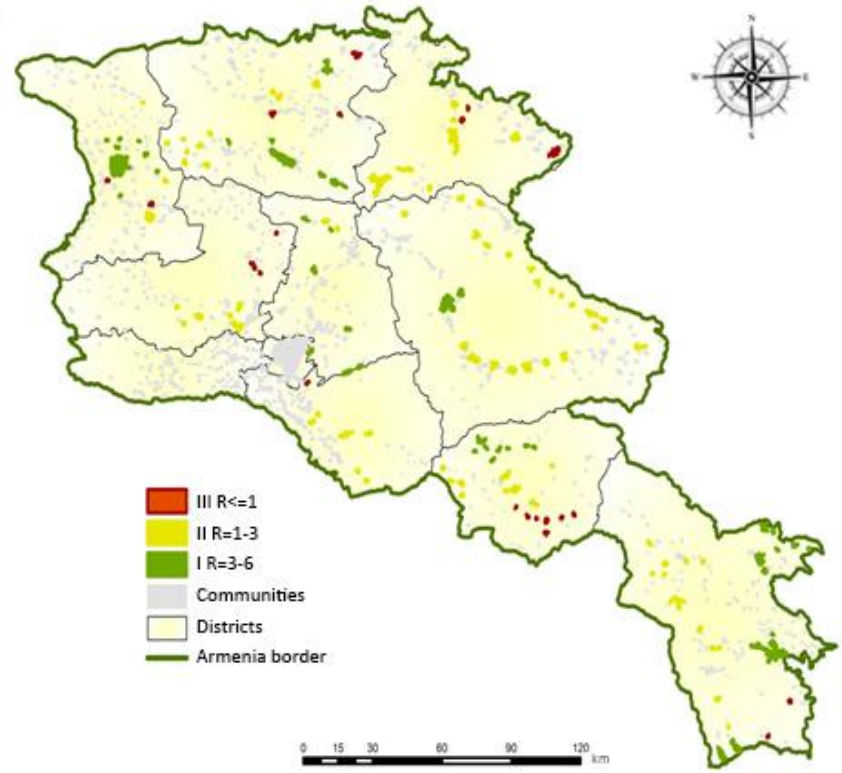


Figure 5-31. Mudflow-prone settlements, by risk level (R-I-III)

Fact sheet 1

In June 2016, as a result of a drastic increase in the temperature and heavy rainfall, heavy mudflow was detected in Artik community, Shirak marz. It rapidly filled and later destroyed the mudflow conduit located in Movrovents gorge in Artik town and afterwards continued flowing on the surface of the ground in the western part of the town. Fragments of tuff contained in the flows destroyed and seriously damaged several streets, nearby residential buildings, facilities, communication networks and backyard farm lands located in the town. The mudflow emerged as a consequence of intensive melting of the snow and hail accumulated during the previous days on the slopes of the Mount Aragats, as well as was a consequence of a heavy rainfall.

Landslides. The territory of the Republic of Armenia is prone to highly active landslide processes. In 2010, 19 cases of activation of landslides were registered in the country, of which 9 cases occurred in Tavush marz, and 6 cases - in Lori marz (MoES, 2018). In the period of 2012 - 2018, 14 landslide phenomena were recorded in 2016 alone. According to the results of a comprehensive study aimed at landslide disaster management conducted in 2005 (JICA, 2005), more than 2,500 landslide-prone sites were identified on the territory of the Republic of Armenia, with a total area comprising around 4.1% of the total territory of the country. Around 3.2% of the roads and 0.5% of the railway in the country are damaged by landslides. According to various calculations, 15% of the population of Armenia (around 470,000 people) is subject to landslide risks, while the amount of damage caused by landslides has reached AMD 2.13 billion (Georisk, 2000; Jrhan, 2009). Irrespective of all the protection measures undertaken, so far landslides cause significant damages to facilities and the economy of the country

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Fact sheet 2

On January 21, 2018, as a result of an outflow of groundwater or water artificially soaked up in the soil in Tumanyan community, Lori marz, a landslide occurred, which caused a collapse of a large section of a hillside, creating an emergency situation for the railroad and M6 highway connecting Armenia to the outside world. The large amount of the landslide body created a threat of damming Debed River with landslide masses, whereas the consequences thereof, in case of a possible further breakage of the dam, would have disastrous impact on the infrastructure and local population. In order to prevent the activation of the landslide in the future, it is necessary to carry out preventive measures.

Landslide-prone sites are located mainly in mountainous areas and on the foot of the mountains, where given the force of gravity on the slopes, rock sliding occurs. Landslides are caused not only by geological factors and human economic activity, but also by climate factors. They are often triggered by heavy atmospheric precipitation, intense water-saturation and over-humidity of slopes.

The majority of landslides is located within the administrative borders of Dilijan, Ijevan, Kapan, Vanadzor and other communities, and in the basins of Debed, Aghstev, Vedi, Getik and Vorotan Rivers. The distribution of landslide phenomena, by marzes of the Republic of Armenia, is presented in Table 5-14 and in Figure 5-32 (JICA, 2005; Nippon Koei Co., 2015).

Table 5-14. Distribution of landslide phenomena, by marzes

Marz	Area of the territory (km^2)	Number of landslides	Total area of landslides (km^2)	Relative area of landslides, %
Aragatsotn	2,763.37	19	75.50	3
Armavir	1,191.59	0	0.00	0
Yerevan	222.35	152	13.03	6
Kotayk	2,034.00	110	77.81	4
Tavush	2,740.67	151	210.62	8
Shirak	2,682.64	23	20.58	1
Ararat	2,090.16	142	143.94	7
Gegharkunik	5,369.62	126	202.81	4
Lori	3,851.97	217	234.82	6
Syunik	4,492.21	289	246.67	5
Vayots Dzor	2,287.92	184	242.36	11

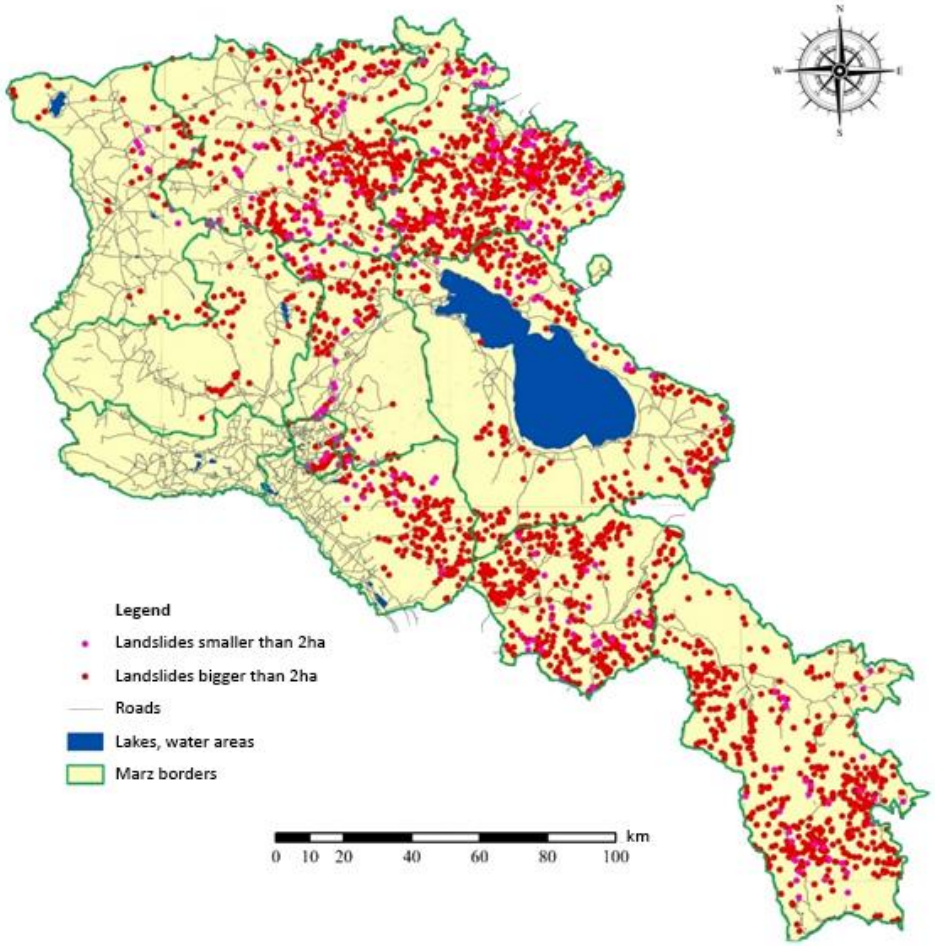

Figure 5-32. Distribution of landslides on the RA territory

Source: MoES/JICA, RA Disaster Management Program, 2017, https://openjicareport.jica.go.jp/pdf/12290862_01.pdf

Rockfalls. The number of cases of rockfalls recorded in 2012-2018 has increased in comparison with the figures registered during previous years. In 2016 alone, the highest number of rockfall cases was registered - 61 (MES, 2018). Periodically and frequently activating cases of major rockfalls, when massive and heavy rocks collapse, pose threat to road transport users by completely obstructing the traffic and by damaging the road surface. In the above-mentioned period, cases of rockfall were registered predominantly in Lori and Syunik marzes (more than 30 cases), as well as in Yerevan (more than 20 cases). Rockfalls frequently occur also in Tavush and Kotayk marzes. In recent years, the phenomenon of spontaneous rockfall have been detected also in non-characteristic periods for rockfalls: even in wintertime (on average, 13 cases annually). This fact is alarming in terms of possible economic consequences.

Avalanches. Avalanches, to a certain extent, are widespread in all mountainous regions and are the main dangerous natural phenomenon in mountains during the winter season sometimes causing major and irreversible consequences. Across the territory of the Republic of Armenia, avalanches pose threat in Zangezur, Bazum and Aragats highland zones. Although avalanches are not widespread on the territory of the Republic, these phenomena can cause great destruction to settlements and communication channels, and result in human losses. For example, on January 28, 2018, as a result of an avalanche on Arayi mountain in Aragatsotn marz, a tragic event happened on a rocky hillside: one person died and two were injured.

5.6.2 Adaptation Measures

The goal: identification and prevention of dangerous natural phenomena.

Type	Activity title	Activities implemented (or in progress)
Administration and planning	Legal reforms	GoA Decrees: • In 2015, Armenia joined the 2015-2030 Action Plan for the Sendai Framework for Disaster Risk Reduction, according to which the National Disaster Risk Management Strategy and Action plan was developed and approved by the GoA Decree No. 14, dated 06.04.2017. • By the Decree No. 111-N, dated 15.01.2015, the 2015-2025 Funding Strategy for the Maintenance of State Roads for General Use in the Republic of Armenia was approved. • By the Annex of the Decree No. 515-A, dated 16.05.2013 , the 2014-2017 Social-Economic Development Program for RA Syunik marz was approved, which defined the functions of Syunik Marz's Regional Administration to address the issue of preventing the rockfalls, as well as it also stipulated the planned activities to be conducted in order to prevent landslides, mudflows and floods occurring as a result of springtime river inundations. • By the Protocol Decree No. 27, dated 10.07.2013 protocol, the Landslide Disaster Management Concept was approved, which specified the functions of stakeholder state bodies, in order to mitigate the damages caused by landslide disasters in Armenia. • By the Decree No. 281-N, dated 07.03.2012, the RA Disaster Risk Reduction National Strategy and Disaster Risk Reduction National Strategy Action Plan were approved.
Research and information	Assessment and mapping of dangerous natural phenomena, development of resilience capacities	In 2018, based on an order from the MoES, the Institute of Geological Sciences of the RA NAS conducted engineering, geological, hydrogeological and geophysical surveys and drilling works, as well as laboratory tests of groundwater and types of soil. In 2018, MoES adopted the methodology for "Regional risk management". The Community Risk Testimonials have also been developed, according to which consideration of community risks during community development programs, will ensure safer development of the community. The aforementioned documents have been developed with the support of UNDP. In 2017-2018, by the request of the WB, the Geocom Company implemented the "Hazard and Risk Assessment of Rock Slope Failures in the Republic of Armenia" project, which was aimed at the analysis of the existing situation, elaboration and recommendation of a methodology for hazard and risk assessment and classification, assessment of the costs and benefits of proposed protective measures, based on the example of the Lori marz. In January 2016, the WB-funded National Disaster Risk Management Program was launched. It was aimed at supporting the Government to strengthen disaster preparedness and, in particular, develop capacities at national, local and community levels to enhance resilience to earthquakes, drought, hail, landslides and floods. In 2014-2015, UNDP Armenia Country Office commissioned Georisk Company to conduct an assessment and mapping of dangerous natural phenomena occurring in Shatin, Martiros, Chiva and Rind communities in Vayots Dzor marz as a consequence of climate change. Landslide inventory has been carried out by the MoE in 8 SPANs. Digital maps of SPANs have been developed, information on locations, coordinates, areas and the level of activeness has been summarized, and landslides, which threaten the rare and endangered species in SPANs (including forest reserves) have been identified.

Technical and preventive	Training, restoration of infrastructure, improvement of outreach, strengthening disaster preparedness	In August 2016, a major reconstruction of Vanadzor - Alaverdi road was initiated by the Ministry of Transport, Communication and Information Technologies. In March 2015, the five-year "Integrated Support to Rural Development: Building Resilient Communities" project was launched, funded by the Government of the Russian Federation and implemented by UNDP, in close partnership with the MoTAD. The project aimed at assisting 45 borderline communities of Tavush marz in development of community development projects through involvement and training of the local population, restoration of infrastructure, etc. In 2014, the OSCE funded a project aimed at disaster prevention and mitigation of risks of natural hazards in 10 communities of Tavush marz.

5.7 Human Health

5.7.1 Vulnerability Assessment

Climate change, among a number of impacts on the environment, aggravates the situation with diseases that are sensitive to the climate change. In particular, increase in air temperature, variability in the amount of precipitation and increase in the number of extreme hydro-meteorological phenomena can have serious negative consequences on human health. As a result of extreme weather conditions and increase in the number of occurrences of dangerous hydro-meteorological phenomena (heat waves, wildfires, floods), morbidity risks, including risks of injuries and mortalities (cases of intoxication, water drowning, etc.), will increase.

The negative impact of climate change, combined with atmospheric air pollution, in particular, high levels of concentration of ground-level ozone, solid particles (dust) and plants' pollen, result in increased number of occurrences of cardio-vascular and respiratory systems related diseases.

In Armenia, there is a risk that a number of infectious diseases will spread due to climate change. There are already signs of expansion of the coverage of certain diseases, or presence of certain types of disease vectors that were formerly undetected in the RA.

Certain types of diseases are still detected in Armenia, which tend to spread or have high incidence as a result of climate change. Prevention of and fight against such diseases stands high on the agenda: the list of such diseases includes, among others, leishmaniasis, brucellosis, intestinal, and airborne infections.

Because of climate change, the structure of infectious diseases will change; in particular, this will occur due to the type of disease vector (ticks, mosquitoes, rodents, midges, tropical and subtropical species) and the food factor. The morbidity rate conditioned by the water factor will rise, especially in territories, where there are already insufficient levels of water quality, sanitation and personal hygiene conditions.

Malaria

In 1994-2005, outbreaks of malaria (exclusively *Plasmodium vivax* cases) were registered in the Republic of Armenia. In 2006, thanks to efficiently coordinated and complex measures, the local transmission of the disease was interrupted, and nowadays only some unique imported cases of the disease are revealed occasionally. In 2011, the Republic of Armenia was certified by the World Health Organization (WHO) as a malaria-free territory. Although afterwards some imported cases of malaria were registered in the country, these were quickly diagnosed, quarantined and treated. Despite the fact that malaria vector mosquitoes were found in the Republic of Armenia, the disease has not become rooted in our country, and no indigenous cases of malaria were detected. In the current phase, the main objective of malaria surveillance is the prevention of reintroduction of malaria in the country.

Leishmaniasis

During the Soviet period, numerous cases of visceral and cutaneous Leishmaniasis were registered on the territory of the RA. Since 1999, new cases of visceral Leishmaniasis have been periodically detected in the Republic, which were the consequence of

survival of the infection in the organisms of animals (such as canines) as natural reservoir hosts, and the transmission from animals to humans through infection from ticks that breed in dumps with organic wastes. According to the Ministry of Health (MoH) data, in the period from 2010 to 2014, 7-9 cases of visceral Leishmaniasis occurred in Armenia annually, while in 2015, 18 cases were detected, in 2016 - 10 cases, and in 2017 - 17 cases. In 2015, surveys were conducted with the purpose of assessment of the real scope of incidence of Leishmaniasis in various marzes of the RA and the risk factors contributing to the spread of the disease. The surveys were based on the methodology of systematic sampling of the population in Syunik, Tavush, Lori, Ararat and Armavir marzes of Armenia and Kanaker-Zeytun, Nor Nork, Avan, Arabkir, Erebuni, Nubarashen and Shengavit administrative districts of the City of Yerevan. The surveys were conducted among children aged 1-5 (in total, 1,238 children) and dogs found on the territory of the same settlements (in total, 146 dogs) with the use of rK39 tests provided by the WHO. As a result, it was found that the morbidity rates were higher in Syunik, Tavush and Lori marzes and in Yerevan city. In 2017-2018, the geographic coverage of the disease incidence expanded: cases were also detected in Aragatsotn and Kotayk marzes.

Anthrax

During recent years, sporadic cases and local outbreaks of anthrax were registered in the RA resulting from cases of the disease spread among animals. During the recent decade, the highest numbers of cases of anthrax were registered in 2012 and 2013, with 11 and 19 cases respectively.

Thus, from time to time, cases of anthrax are detected in the Republic of Armenia, while the vectors create spores in the environment that survive for 100-150 years. Taking this circumstance into consideration, it can be forecast that cases of anthrax will occur in future as well.

Leptospirosis and tularemia

Monitoring of especially dangerous and natural-focal infections is conducted on the territory of Armenia. Comparison of the results of a study on Leptospirosis conducted in 2017 with those of previous years shows that the positive results registered among rodents have decreased by 1.5 times in comparison with 2015, and by 1.3 times in comparison with 2016. Only sporadic unique cases were detected among humans, and the number thereof has been less than five cases in the course of 2003-2017.

More than 95% of the territory of RA is a natural reservoir for tularemia. Local or widespread epizootics of tularemia are detected in almost all marzes of Armenia, occasionally accompanied also by outbreaks of sporadic cases of morbidity among humans.

During 1996-2017, a trend of increase in the number of epizootics was observed in the county, while the number of cases among humans had a decreasing trend. The infected mammals and ticks of the given territory may function as transmission reservoirs of *F. tularensis* to humans.

Spreading the vectors of infectious diseases

A considerable part of the territory of the Republic of Armenia is a natural foci for a number of dangerous infectious diseases: in particular, in the case of plague, 75% of the territory is under risk, in the case of tularemia - 90%, in the case of mad cow disease - 20%, while 60% of the territory is enzootic to Leptospirosis. The vectors of these diseases are periodically detached from the external parasites of natural reservoirs (rodents). The insects and ticks transmitting infectious diseases that are widespread in the Republic can become the reason for the aggravation of the current epidemiological situation in the country by spreading both diseases that were widespread in the past (malaria, leishmaniasis, tularemia, Lyme disease, plague, typhus fever, relapsing fever, Q fever, Lyme borreliosis), as well as diseases that are new for the country. The territory of Armenia is unfavorable also in terms of cholera disease. As a consequence of climate change, especially as a result of an increase in the air temperature, the geographic range of the above listed disease vectors, as well as transmitters of diseases (ticks, mosquitoes, rodents, midges, tropical and subtropical species), can possibly expand. For the same reason,

such tropical and subtropical species that were not found in the country in the past, can penetrate into the territory of the Republic. In 2016, a number of research studies were conducted on arthropods that transmit infectious diseases: 10 species of mosquitoes were identified, which had never been found on the territory of the Republic of Armenia before, including the invasive mosquito *Aedes Albopictus*.

In 2016, Aedes Albopictus invasive species was first discovered in Armenia, which is essential in terms of public health, given its ability to transfer arbovirus diseases (Dengue, Chikungunya, Yellow Fever, Zika).

Crimean-Congo hemorrhagic fever and Western tick-borne encephalitis

Outbreaks of vector-borne serious diseases such as the Crimean-Congo hemorrhagic fever, West Nile fever and others have already been detected in the countries bordering Armenia. The insects and ticks transmitting infectious diseases can also transmit new diseases in Armenia, i.e. Crimean-Congo hemorrhagic fever, West Nile fever, tick-borne encephalitis. The probability of spreading of the above-mentioned diseases in the Republic was already indicated in NC2 and NC3.

Cases of gastrointestinal and other infections, 2012-2017

According to the NC3, the annual dynamics of cases of infectious diseases proves the forecast that climate change would have serious impact on the morbidity situation of acute gastrointestinal infections and would result in increase in the number of cases. The 2012-2017 data basically confirm the mentioned forecast, despite the fact that the number of detected cases in 2017 decreased (Table 5-15). It is expected that the trend of increase in the number of cases of morbidity related to the mentioned diseases will sustain in the future as well, in parallel with climate warming.

Table 5-15. The number of registered cases of diseases in 2012-2017

Disease name	Number of registered cases					
	2012	2013	2014	2015	2016	2017
Typhoid fever	0	0	0	0	1	0
Paratyphoids	0	0	1	0	0	0
Salmonella infections	460	300	404	397	361	254
Acute gastrointestinal diseases	8,352	8,238	9,452	12,268	9,628	6,465
including bacterial dysentery	733	459	688	1881	728	682
Yersiniosis	4	4	6	1	6	0
Enteritis, colitis, food toxic infections and gastrointestinal infections borne by other proven vectors	3,206	3,059	3,532	3,748	2,706	2,712
Acute gastrointestinal infections borne by putative vectors	4,409	4,722	5,226	6,638	4,990	3,328
Tularemia	1	1	1	1	9	1
Anthrax	11	19	0	2	5	0
Brucellosis (newly diagnosed cases)	227	218	381	309	276	362
Meningococcal infection	8	4	8	6	3	7
Malaria (newly diagnosed cases)	4	0	0	2	2	1
Leptospirosis	0	0	4	0	0	0
Leishmaniasis	7	8	9	18	18	17
Mad cow disease	0	0	0	0	0	0
Acute upper respiratory tract infections	113,748	157,999	128,202	124,088	184,987	120,822

Combination of atmospheric air pollution and climate change

The combined negative impact of climate change and atmospheric air pollution, especially in urban communities, contributes to the increase of occurrences of non-communicable disease, in particular cardiovascular (blood circulatory) and respiratory systems' diseases. This is attributable to the impact of particulate matters (PM) of extremely small sizes (2.5 micron or smaller), which cause cardiovascular, respiratory and oncological diseases. In addition, short-lived climate pollutants (SLCPs) account for mortality and morbidity cases related to air pollution. There is an increase in the number of morbidity cases of cardiovascular and respiratory systems. According to the results of a preliminary study, only in case of the mortality rate a very weak correlation with the average annual air temperature was identified.

Vulnerable groups of population

Based on the results of an analysis of available data, it is possible to identify the groups of population in Armenia that are mostly vulnerable to climate change. The groups of population that work outdoors and perform heavy physical duties (such as constructors, including road constructors, farmers and others) are the most vulnerable groups of population in terms of the impact of extreme weather conditions (severe heat, heat waves, fires, floods). Urban population is vulnerable due to the combination of the impacts of climate change and air pollution that cause diseases of cardiovascular (blood circulation) and respiratory systems. Population of rural settlements and those that are in direct contact with natural landscapes (because of the type of their occupation or for other reasons) or with natural products are included in the risk groups susceptible to natural foci of infections, including especially dangerous ones. In case of gastrointestinal infections, the vulnerable groups of population include those who live in conditions with poor water quality, sanitary facilities and personal hygiene (such as population of rural settlements that are out of the scope of services provided by specialized water supply organizations, among others).

5.7.2 Adaptation Measures

The goal is to ensure the health of population under the projected climate change.

Type	Activity title	Activities implemented (or in progress)
Administration and planning	Assessment of the spread of infectious diseases and risk management	The RA Law on "Ensuring the Sanitary-Epidemiological Safety of the Population of the Republic of Armenia" (adopted in 1992) was amended on 21.03.2018; the authorities of the MoH, as well as the concepts of prevention of diseases and epidemiological monitoring were defined. The content of and functions for the fulfillment of inspection control in the sector were also defined. The following GoA Decrees were adopted: • Approving the Procedure of Monitoring in the RA Territories with High Level of Environmental Pollution (in particular, in the territories adjacent to mines) (08.07.2015, No. 762-N); • Approving the Concept of Protection Against Especially Dangerous Pathogens and the List and Schedule of Activities for Implementation of the Concept (14.08.2014, No. 34). RA Prime Minister Decrees No. 728-L, No. 740-L, No. 745-L, No. 727-L (11.06.2018): the functions of the MoE and the Ministry of Territorial Administration and Development in relation to climate change were specified; the functions of the Ministry of Emergency Situations aimed at protection of the population on emergency situations were defined. According to the RA Government Decree No. 1088-N (adopted on 07.09.2017), the RA National Center for Disease Control and Prevention SNCO of MoH, which performs disease prevention and epidemiological monitoring, was merged with RA Research Institute of Epidemiology, Virology and Medical Parasitology named after A.B. Alexanian SNCO of the MoH.

		During recent years, laboratory tests and studies based on the method of polymerase chain reaction (PCR) were introduced in the above mentioned SNCO. This involves diagnosing of more than 20 diseases, which previously were not covered, identification of the level of stability of microbes against antimicrobial medicine, detection of pathogens in arthropod vectors (for instance, detection of Crimean-Congo hemorrhagic fever in ticks and detection of West Nile fever in mosquitoes).
	Early notification of population about possible unfavorable weather conditions	For the purpose of prevention of morbidity and mortality cases caused by severe heat and heat waves, the MoH carries out large-scale public awareness campaigns. Via all possible mass media formats and social networks, the population is informed about possible risks associated with high temperature, behavioral patterns for the protection against these risks, appropriate hygiene practices and other related topics. The number of such publications has doubled during the recent couple of years.
	Early response to natural disasters and epidemic situations	The following capacities were developed at the National Center for Disease Control and Prevention SNCO of the MoH: detect, as early as possible, biological, chemical and radiation factors threatening human health and ensure quick response to threats caused by such factors. With regards to issues related to the protection of population in emergency situations and civil defense of population, training of and joint exercises with specialists employed in the health care system were conducted. For the implementation of fieldwork and ensuring early response, two mobile laboratories were established, which conduct studies and tests of human and animal samples of especially dangerous infections.
	Fight against carriers and vectors of infectious diseases	The National Center for Disease Control and Prevention SNCO of the MoH conducts specialized and continuous monitoring of stocks of infectious disease vectors and carries out activities aimed at fighting against infection vectors across the territory of Armenia. The area of research on vectors and transmitter of infectious diseases, as well as the area of epidemiological monitoring of diseases caused by transmitters and parasitic diseases have been regulated; sanitary rules and regulations, methodological guidelines, standard operating procedures have been elaborated and adopted, which have contributed to the increase in early detection of diseases. A system for epidemiological monitoring of Lyme disease was established; in addition, a system for monitoring of cases of legionellosis, influenza and acute respiratory diseases, rotaviruses and unknown fevers was introduced.
	Fight against non-communicable diseases	In 2015, for the first time in the RA, epidemiological monitoring of chemical intoxications was introduced. In 2018, epidemiological monitoring of children injuries was introduced.
Research and information	Studies on dangerous infectious diseases	The National Center for Disease Control and Prevention SNCO of the MoH conducts analyses on the results of continuous specialized monitoring of infectious disease vectors, detects trends and develops forecasts.
	Public awareness raising activities	Awareness raising activities on risks of infectious diseases and intoxications typical to their living places, as well as on prevention thereof and fight against these threats are consistently carried out among population.

5.8 Tourism

The overall goal of the state policy in Armenia's tourism industry is to increase its contribution to the national economy and ensure equal regional economic growth, while at the same time improving the living standards of the population and alleviating poverty.

The direct contribution of the travel and tourism to the GDP in Armenia in 2017 was around AMD 231.7 billion (USD 477.7 million) or 4.4% of the GDP. It is projected that the share of this sector in the GDP will increase by 4.2% from 2018 -2028 reaching AMD 380.4 billion (USD 784.3 milion) in 2028[155]. The direct contribution of the sector

[155] World Travel and Tourism Council: Travel and tourism economic impact 2018, Armenia

to the employment made 3.9%, ensuring 44,500 jobs.

Since 2007, the number of tourists in Armenia has been steadily increasing. According to the Travel and Tourism Competitiveness Index Ranking for 2017, Armenia occupies the 84th position out of 136 countries.

The state policy objectives in the field of tourism are defined by the RA Law on Tourism and Tourism Related Activities and by the Tourism Development Concept approved by the Government of Armenia on February 13, 2008. The overall goal of the Concept document is to assess and describe tourism resources, development trends and perspectives of the country, define the main objectives of the state policy in the field of tourism, assess challenges and obstacles and identify main directions and issues in implementing the state policy.

The RA Government aims to increase the number of annual tourist visits to at least 3 million through actions and measures to be undertaken during 2017-2022.

In parallel, it is planned to identify tourism sub-sectors with high potential, such as ecotourism, gastro-tourism, extreme tourism, ethno-tourism, for targeted positioning of Armenia in the global market and making the country more attractive to tourists with respective interests.

The development of ecotourism is also facilitated by the policy adopted by the Government of the Republic of Armenia to increase the number, as well as the coverage of protected areas. Due to the Government's acknowledgement of ecotourism development as a priority, the sector has experienced significant growth in Armenia: in 2017, 549,128 tourists visited the protected areas, 20% of which were from abroad.

The MoE has initiated implementation of measures in forests and SPANs to develop and popularize ecotourism, which is currently gaining increasing popularity globally. Currently, 5 routes have been developed and designed for further operation in SPANs. The 6th route is currently at the design stage.

In addition, the Government also views airfare reduction efforts as highly important in terms of tourism development.

Though relatively small in size, Armenia has four UNESCO World Heritage sites, which are among the most visited tourist destinations in Armenia.

The most popular mountainous resorts in Armenia are Tsaghkadzor, Jermuk and Dilijan. Lake Sevan is considered as a top destination and is usually combined with other site visits. The classical sightseeing trips to Armenia are popular not only among tourists, but also among the local population. Mountaineering, camping, birdwatching and other kinds of active leisure are also common.

Tsaghkadzor ski resort, due to climate change, suffers from shrinking of the skiing season from year to year. This endangers investments made into the existing winter-sport oriented infrastructure, and urges for alternative solutions for the resort.

Dilijan is a spa town situated within the Dilijan National Park attracting the visitors to enjoy the beauty of the National Park, as well as the historical sites.

Jermuk is a mountainous spa town in Vayots Dzor province famous for its natural hot springs and mineral water. Jermuk now also offers winter entertainment for the fans of skiing and can be regarded as an alternative to Tsaghkadzor.

The shores of Lake Sevan, the largest freshwater high-altitude lake in Eurasia, are a popular destination among locals and tourists equally. During 2018-2019, tourism in Lake Sevan suffered from extensive blooming of blue-green algae due to decrease in water level, pollution from sewage from surrounding settlements and climate change.

Lack of disaggregated data on tourism sector, as well as data on snow cover in high altitudes in Armenia is a major barrier to assess the vulnerability of the tourism sector to climate change impacts.

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6

OTHER ***INFORMATION***

6.1 Studies and Systematic Observations

In Armenia, hydro-meteorological observations are carried out by the “State Hydrometeorological and Monitoring Service" SNCO (NHMS), which operated within the system of the Ministry of Emergency Situations (MoES) from 2008. In 2016 it was renamed to “Service of the Hydrometeorology and Active Influence on Atmospheric Phenomena” SNCO. By the GoA Decree No. 81, dated January 30, 2020, the SNCO was merged with the “Environmental Monitoring and Information Center" and "Forest Monitoring Center" SNCOs and reorganized as “Hydrometeorology and Monitoring Center” SNCO, which operates under the auspices of the MoE.

The NHMS, among other functions, performs meteorological, climatic, hydrological and geophysical observations for the whole territory of the Republic of Armenia. The NHMS provides state agencies, regional and local self-governance bodies, population, different sectors of the economy with information on actual hydrometeorological conditions and their expected changes, current and forecasted climate information, with the objective to undertake measures to protect the population and economy from unfavorable hydrometeorological conditions, to reduce the inherent risks and potential harm to human life and property and to prevent adverse anthropogenic impact on environment.

The NHMS is comprised of 4 main Departments: Meteorology, Hydrology, Applied Scientific Center for Hydrometeorology and Ecology, and Active Influence on Atmospheric Phenomena, and is supported by a number of services and divisions, including the Technical, Database, Telecommunications, Material Logistic Supply Services and Meteorological Information Service and Marketing Divisions.

Observations system

Meteorological and hydrological stations record temperature, precipitation, pressure, humidity, evaporation, wind speed, solar radiation, soil moisture, snow cover depth, density and hydrological regime parameters (water level, drain and water filling level of reservoirs).

Ground-based meteorological observation network

The observation network consists of 47 full-scale observations stations[156] (Figure 6-1) using standard meteorological parameters, which collect meteorological and climatic data. Out of these, 10 stations perform automatic monitoring, 3 are specialized stations, and 20 stations transmit data for global exchange.

The meteorological observation network includes 6 high-mountain (remote) stations, one of which - Aragats station (established in 1929), is located at 3229 m above the sea level and is the only station in the Caucasus region located at such an altitude. It has a long time series of data on precipitation, temperature and other meteorological elements, and, therefore, plays an important role for regional climate change studies. From 2008, the Aragats high-mountain station is included in the global ground-based network of Global Climate Observation System and has since been providing monthly updated historical data and information to the Network.

[156] The following elements are monitored at full-scale service stations: horizontal visibility, cloudiness, atmospheric phenomena, soil temperature at surface and in different depths, air temperature and humidity, atmospheric pressure, wind direction and velocity, precipitation, duration of sunshine.

Figure 6-1. Meteorological observation network in Armenia

Source: NHMS

The number of stations is proportional to the area of each zone. However, there are certain gaps in terms of vertical distribution of stations. There are not enough stations at altitudes of 2500-3000 m above the sea level, which comprise 13% of country's territory. Observation data from this zone, where snow accumulation takes place, are important for assessment of the level of water filling of reservoirs during spring run-off. It is, therefore, extremely important to address this gap by reopening stations, which previously operated at such altitudes.

Until 1935 measurements were taken twice per day, from 1936 to 1965 the frequency increased up to four times, and starting from 1966 meteorological observations at all stations are conducted 8 times a day.

Agrometeorological observations are conducted at 40 stations of the observation network, monitoring the growth and development of about 30 cultivated agricultural plants, as well as agrometeorological conditions over the meadows and pastures. Also, agrometeorological parameters in pastures, including soil moisture, are monitored. Agricultural research and academic institutions use this information mainly to monitor crop growth conditions. Basic evaporation/ evapotranspiration measurements are performed at 5 stations.

Yerevan aerological station (established in 1973), located at an altitude of 1134 m above the sea level, conducts *aerological, meteorological and radiation observations*. It's the only operational aerological station in the Caucasus region and is included in the Regional Basic Synoptic Network (RBSN) and in the Global Climate Observation Network. Aerological data from this station are transmitted to the global and regional data centers. These data are used to study the upper atmospheric layers and the weather forecasts on the territory of the Republic, as well as for aviation service. Within the studies of climate change, not only ground-based but also upper atmospheric layers' research is conducted with the use of aerological observation data.

The *monitoring of the ozone layer* is conducted at two locations: "Amberd" high mountainous and Yerevan "Arabkir" stations. The data collected from Amberd hydrometeorological station are processed and regularly transmitted to the WMO World Ozone and Ultraviolet Radiation Data Centre (WOUDC). These ozone measurements are of regional importance, since these are

the only two stations over the entire South Caucasus region.

Despite the lack of adequate financing, NHMS provides important information for the entire region. Observations are decoded from encrypted format to a text format and once every 10 days are provided to the relevant subdivisions of the Ministry of Economy dealing with Agriculture issues, and on a quarterly basis, to the Statistics Committee.

Ground-based hydrological observation network.

Hydrological observations are conducted at 95 observation posts (including 4 lake and 5 reservoir observation posts) by monitoring water flows in and out of the Lake Sevan, water inflow into large reservoirs and river flow in hydrological stations of river basins (Figure 6-2), as well as monitoring of water level, temperature and freezing conditions (if any) is carried out twice a day. Discharge measurements at all gauging stations with current meters ensure a regular updating of water level and discharge dependence curves and estimate daily discharge according to the observed water level.

Figure 6-2. Hydrological observation network in Armenia

Source: NHMS

About 60 observation posts provide data on a daily basis, while others only send monthly summaries to the NHMS. Only 18 gauging stations are equipped with automatic water level meters. Out of these, only 3 (Akhuryan-Akhurik, Atarbekyan HPP Canal-Geghamavan, Arpa-Sevan tunnel-Tsovinar tunnel) are in proper condition. All other ribbon meters need to be repaired or replaced. At most of gauging stations, staff measures water level manually by means of a measurement rod.

Due to the mountainous nature of the rivers in the Republic of Armenia, the change in flow at the observation posts requires frequent control of water level and discharge dependence curves. Discharge calculation is made by a “speed-area” method, and to determine the water flow speed, 86 water meter pinwheels are used. 75 out of these water flow meters (Soviet type GR-21M and GR-55) are over 35 years old. Due to intensive use and problems associated with the calibration of these water flow meters there is a need to replace these devices. In the past decade, only two of them have been fully refurbished/ replaced within the

framework of the EU's European Research Infrastructure Consortium project (ERIC).

Water and air temperatures are measured twice daily at all observation posts. Currently the "TM-10" type 70 mercury thermometers and the "TM-8" type 52 mercury thermometers are used, which are not designed to measure water temperature and are not equipped with metallic box and lid. As a result, the water temperature data measured at the observation posts are questionable. The monitoring network should be equipped with new spirit-based water and air thermometers.

The Lake Sevan meteorological observatory was created in 1955, at 1917 m above the sea level and is a part of the Regional Basic Climate Network and the Regional Basic Synoptic Network. In addition to hydrological observations, the station conducts agrometeorological, meteorological and solar radiation observations. In 2008, the NHMS purchased a boat equipped with anemometer and 4 water meters for the Lake Sevan monitoring.

Surface water and atmospheric air quality monitoring network. Assessment of pollution of surface water, including rivers, lakes and reservoirs, as well as air of settlements has been implemented in the country since the 1960s. This activity is currently implemented by the Hydrometeorological and Monitoring Center (formerly the Environmental Impact Monitoring Center) SNCO, reorganized under the MoE. Hydrochemical regime observations are carried out for surface waters of the country through 131 observation posts, covering 39 large and medium rivers, 6 reservoirs (Lake Arpi, Akhuryan, Aparan, Azat, Kechut, Lake Yerevan) and Lake Sevan.

Ground-layer monitoring of atmospheric air is carried out in 13 different cities of the country (Yerevan, Gyumri, Vanadzor, Hrazdan, Alaverdi, Ararat, Vagharshapat, Sevan, Abovyan, Kapan, Kajaran, Meghri, Areni), using 3 different methods of automatic, passive and active 24/7 sampling observation (Figure 6-3).

Figure 6-3. Surface water and atmospheric air monitoring network in Armenia

Source: EIMC SNCO, http://armmonitoring.am

Remote sensing network. Armenia has three (obsolete) meteorological radars, which provide images for NHMS. One of them is for aviation service, and the other two - for anti-hail monitoring. Radars are vital components for modern agriculture, transport and water management services.

Satellite images are obtained from two sources: from EUMETSAT - through EUMETCast - EUMETSAT data distribution system and DAWBEE station for data accessibility for Western Balkans, Eastern Europe and Caucasus countries, and from SRC of Space Hydrometeorology PLANETA. However, training of staff is necessary to ensure better use of these images.

Research activities. *Hydrometeorology and Ecology Applied Scientific Center of the* NHMS carries out research activities, which includes applied climatology, climate research, hydrometeorological model development and testing departments. Research activities are conducted in the following areas: climatology, numerical simulation of meteorological processes, assessment of climate change and national forecasts using results derived from global and regional climate models.

6.2 Studies and Programs Contributing to Addressing Climate Change

Legislation and policy

Over the past decade, a number of legal acts have been adopted in Armenia regulating policies in the fields of science, technology and innovation.

In 2010, the Government approved *2010-2020 Strategy for the Development of Science in the Republic of Armenia*, which outlines the main directions of actions:

- improvement of science and technology management system and provision of adequate conditions for sustainable development;
- increase in the number of young and talented professionals involved in research, education and technological development, modernization of research infrastructures;
- creation of adequate conditions for development of an integrated system for science, technology and innovation;
- expansion of international cooperation in the areas of research and technological development.

In 2014, the Government approved the *New Priorities in the Area of Science and Technology Development for 2015-2019*[157], which include 6 key research directions, in particular:

- life sciences;
- efficient and safe energy;
- space exploration, earth sciences, sustainable use of nature;
- fundamental research to address the key issues for scientific-technical and socio-economic development.

Priority areas of research are very broad, and the majority of them may include research topics related to climate change.

In 2015, the National Assembly adopted the RA Law *"On Scientific and Scientific-Technical Expertise",* which regulates the legal and organizational framework for scientific and scientific-technical expertise.

The main stakeholders in science, technology and innovation policy development in Armenia include the Ministry of Education, Science, Culture and Sport and its subordinate Science Committee; the Ministry of Economy, the Ministry of High-tech Industry, and the National Academy of Sciences of RA, which is the main body carrying out research activity with 35 research institutes and centers, and acts as the official consultant for supreme governance authorities in scientific and technological affairs. The Academy is also the focal point empowered to coordinate fundamental research activities throughout the entire country.

Scientific research and programs

State funding

Over the last decade, gross domestic expenditure on research and experimental work in Armenia has made up about 0.9% of

[157] RA Government Decree No. 54, dated 25.12.2014.

total state budget expenditures: in 2014 amounting to AMD 10.91 billion, and in 2018 - AMD 10.53 billion. No statistical data are available on funding of exclusively climate change-related research topics. However, according to expert estimates, 15-20% of funding has been directed to environmental and climate change research topics based on the analysis of the results of the funded thematic programs in 2015 and 2018 (Annex II).

The number of staff engaged in research and experimental development has declined in recent years, reaching 4,822 in 2017 compared to 5,627 in 2014.

In 2018, the number of institutions involved in public research programs was 83, out of which 14 were engaged in climate change research projects under the thematic programs' funding mechanism.

In 2011, the RA Science Committee introduced an additional funding program for applied research projects, aimed at fostering innovation and science-industry collaboration, which requires a partnership between a research institute and an industrial enterprise that is stipulated by the project terms of reference and requires a 35% co-financing by an industrial partner.

In recent years, some stabilization and diversification of funding for research and experimentation has been observed through the use of basic, thematic (programmatic) and targeted funding by the Science Committee.

Within the mechanisms mentioned above, there are no specific programs focusing exclusively on research in the area of climate change, however, all programs are open to incorporate climate change-related research.

The targeted projects funding mechanism is aimed at supporting applied innovation projects and addressing specific problems and challenges currently facing the society.

Starting from 2015, the Scientific Center of Zoology and Hydroecology of the National Academy of Sciences has implemented the *"Study of Lake Sevan Water Ecosystems and Biological Resources under Climate Change and Increase of Water Level"* project funded by the targeted projects funding mechanism. For the period of 2015-2018, the annual budget of the program amounted to AMD 16 million, and in 2019 – AMD 12 million.

In 2015 and 2018, the Science Committee funded 317 projects under the thematic projects' funding mechanism, 51 of which were related to climate change and environmental studies. The funds allocated for these projects amounted to more than AMD 460 million. The funded projects have been implemented by 12 (2015) and 14 (2018) research institutes.

In 2016, "Forecasting of water inflow and maximum levels of water in Lake Sevan and largest water basins in Armenia during spring inundations under climate change" project, implemented by NHMS, was funded within the framework of the Young Scientists' Support Program.

In 2017, the Division of Applied Projects was established at the NAS to promote academic research, technology transfer and foster commercialization of research results. A package of about 40 innovative research projects from research institutes of the NAS were selected to be presented to state bodies and potential investors. About 10 of the projects were related to environmental studies and climate change issues.

International cooperation and financing

In recent years, measures have been undertaken to promote international research and cooperation in the field of innovations. In particular, starting from 2015, the national project-based funding mechanism enables funding of foreign experts' travel costs to Armenia, and Armenian scientists were provided access to funds from national programs for participation in international scientific events. The Science Committee and the NAS also support short-term travel grant schemes.

Many climate change research projects have been funded under bilateral and international grant programs. In particular:

- In 2014, under a joint call for program proposals announced by the Science Committee and the Foundation for Fundamental Research of the Republic of Belarus, 5 climate change projects, out of total 17 projects, were funded.

- In 2016, under the joint call for proposals by the Science Committee and the Federal Ministry of Education and Research of Germany, 10 projects were funded, one of which was related to sustainable development issues and was implemented in collaboration with the Yerevan State University (YSU) and the Humboldt University of Berlin.
- During 2014-2018, 10 projects related to climate change research were funded within the framework of the joint programs implemented by the Science Committee and various Russian organizations funding research activities.
- In 2018, a joint call for research projects was announced by the Science Committee and the Eurasian Association of Scientific Research, within the framework of which funding for the *"Development of methods and technologies for assessing the geo-ecological impact of energy on the region"* project of the State Engineering University of Armenia was approved.
- In 2016, Armenia's accession to the EU's Horizon 2020 framework program was a major step towards the internationalization of research and innovation efforts. Horizon 2020 is the largest research and innovation project ever implemented by the EU, with almost 80 billion Euros of funding made available over a 7-year timespan (2014-2020) and is the key financing instrument for European collaborative research projects. One of the major public challenges of Horizon 2020 is "Climate Action, Resource Efficiency and Raw Materials".
- During the period of 2013-2019, Armenian institutions participated in about 70 collaborative projects funded under the EU's 7th Framework Program and Horizon 2020, 5 of which were related to environmental and climate change issues. In particular:

- *FP7 ECOARM2ERA* project (2011-2014) focused on capacity building of the NAS Center for Environmental Noosphere Research in the area of and environmental studies and GIS technologies through fostering connection and closer collaboration with the school of Natural Sciences at University College Dublin and Geneva University's Environmental Sciences Institute.
- "Horizon 2020: Connecting Nature" (2017-2022) program, in which the Center for Environmental Noosphere Research of NAS is involved, is a partnership of 31 organizations from 16 different countries. The main objective of the partnership is to measure the impact of natural resource-based projects on climate change adaptation, health and well-being, social cohesion and sustainable economic development in cities involved.
- *ENER2I* project (2014-2017) was aimed at strengthening cooperation with the European Neighborhood Policy (ENP) countries towards the elimination of gaps between countries in energy research and innovation areas. Armenia was represented by the NAS and the Technology Transfer Association NGO. The project aimed at strengthening cooperation between scientific research and business structures in the area of energy efficiency and renewable energy sources, facilitating cooperation between EU and ENP stakeholders.
- INNOVER-EAST project (2014-2017) was aimed at development of new skills and qualifications in terms of innovative services within Eastern Partnership (EaP) organizations, as well as promoting synergies between knowledge and business in the field of EE. Within the framework of this program, the Science Development Foundation of NAS has attached great importance to activities that will accelerate the training of specialists in the field of technology transfer, science and technology management, intellectual property rights and development of venture funds.
- IncoNet EaP project (2013-2016) was aimed at fostering dialogue on science, technology and innovation policies between EU member states and associated countries, as well as EaP countries, focusing on the challenges facing society, in particular deriving from climate change, energy and healthcare. Within the framework of the program, in 2014 "EU/EaP cooperation in the areas of science, technology and innovation for

climate change resilience" international conference was hosted in Yerevan, involving more than 100 delegates engaged in policy-making and research activities to discuss climate change issues and cooperation opportunities between EU member states and EaP member countries.

In 2014-2018, within the framework of the International Science and Technology Center (ISTC) programs, several environmental research projects have been implemented by Armenian research organizations with a total funding of approximately USD 1 million.

A number of conferences, as well as round tables have been held within the framework of international cooperation, aimed at discussing technologies and innovative approaches, in particular:

- In 2018, the UNDP Wildfire Management Project, in collaboration with the UNDP Impact Aim Venture Accelerator and Innovative Solutions and Technologies Center, organized the Climate Tech Hackathon, the first of its kind in Armenia. It enabled formulation of innovative solutions to address the challenges posed by climate change in forestry and agriculture. The participating teams presented technological solutions aimed at addressing the current environmental challenges.
- In 2018, with the support of the UNDP-GEF Project (within the framework of NC4), YSU published the "Contemporary Issues of Geography and Geology" conference proceedings, which incorporated a number of scientific articles on climate change, desertification, meteorology, changes in rivers' inflow to the Lake Sevan, changes in water demand patterns for crops and other topics.

The relevant thematic sections dedicated to climate change vulnerability and adaptation (Chapter 5) present in detail the research and studies conducted in each target area with the support of national and international projects.

The United Nations Industrial Development Organization (UNIDO) has supported the establishment of the Climate Technology Center and Network in Armenia (ArmCTCN) (2018). ArmCTCN is a climate technology platform aimed at promoting climate change adaptation and mitigation technologies, identifying the needs for preferred technologies, developing and implementing technology roadmaps, knowledge transfer, as well as introducing local technologies and internationalizing thereof.

ArmCTCN facilitates the accelerated transfer of environmentally sound technologies developed in Armenia for low carbon and climate resilient development, as well as introduction of innovative technologies to Armenia. It is aimed at enhancing the effectiveness of the national process of climate change mitigation and adaptation.

International cooperation and joint efforts to address innovation and climate change issues have enabled Armenian organizations to become more actively involved in international professional networks and public-private partnerships, including in the European Knowledge and Innovation Communities, European Technology Platforms, Joint Technology Initiatives and more. For example, the European Institute of Innovation and Technology is supporting the European Climate Knowledge and Innovation Community (EIT Climate-KIC)[158], which brings together partners from almost all EU member states and associated countries to establish expert networks to foster development of innovative products, services, and systems, to commercialize them in the market and extend their coverage for enhanced impact.

Membership in these structures can promote the recognition of Armenian research organizations, companies and universities in the international arena, as well as facilitate technology transfer, development of partner networks and establishment of partnerships to develop joint proposals under different funding opportunities.

[158] https://www.climate-kic.org/

6.3 Education, Human Resources Development and Public Awareness

6.3.1 Education and Human Resources Development

Legislation

The RA Law on Environmental Education and Upbringing (adopted in 2001) is the key legislation pertaining to environmental education and upbringing. The legislation regulating environmental education and upbringing includes the RA Laws on Education (1999), Preschool Education (2005), General Education (2009).

A new draft Law on Preschool Education (2019) has been developed, which stipulates "introduction to the elements of the nature and protection of the environment, history and national culture of the homeland", as one of the issues to be addressed by preschool education. The importance of environmental education and upbringing was also highlighted in the "State Education Development Programs of the Republic of Armenia", the most recent of which was implemented in 2001-2015.

Based on a Government decree, a comprehensive study of the situation of environmental education in Armenia was conducted, which laid the ground for the elaboration of the RA Strategy for the Development of Environmental Education and Upbringing. The latter was approved on 22 February 2018, by the GoA Decree No. 7. The purpose of the Strategy is the improvement of the national system for environmental education, upbringing and awareness in Armenia, enhancement of harmonious and mutually beneficial cooperation in these areas among state institutions, public in large and international agencies. The cooperation is aimed at advancement of the quality of environmental education, increase in public awareness level, shaping of pro-environment mentality in the society. The latter is to ensure self-conscious and responsible attitude towards environment among individuals and the society and contribute to the improvement of the quality of life and realization of the right to live in a healthy environment.

The draft law of the Republic of Armenia "On Making Amendments and Addenda to the RA Law "On Environmental Education and Upbringing" is under development. It envisages improvement of the legislative framework regulating the sector, integration of the concepts and principles of the "Education for Sustainable Development" strategy in the field of environmental education, review and clarification of the powers of relevant state governing bodies.

Education management system

The Ministry of Education, Science, Culture and Sport of the Republic of Armenia is the authorized body for public administration of the education sector.

The Ministry of Environment has a special role in the management structure of environmental education and upbringing; the Ministry, in line with its functions elaborates and implements a joint state policy on environmental science, education and awareness raising, and, jointly with the authorized entity, develops the main strategic directions for environmental science, education and awareness raising.

By the Decree No. 464 of the RA Prime Minister (dated August 3, 1998), an Interagency Commission on Environmental Education was established with a special role and responsibility to ensure collaboration among different actors in the system of environmental education in Armenia.

Environmental education within educational systems

Environmental education in Armenia is conducted in the frameworks of formal and non-formal educational systems. Formal education is provided on the basis of mandatory documents - educational standards, programs and textbooks - approved by the Ministry of Education, Science, Culture and Sport for the use in educational institutions. Non-formal (non-official) education is conducted through both educational institutions and non-governmental organizations outside the framework of formal education systems and vocational training. Sometimes it is conducted in parallel to the above-mentioned systems, and normally no official diploma is provided after the completion of non-formal education. Currently all the levels of the educational systems of the RA, namely, general education (preschool and secondary school education), preliminary

vocational and middle vocational education, higher and postgraduate education, are involved in environmental education.

Preschool education

Within the framework of several national and international projects, handbooks and manuals related to climate change topics have been developed to support environmental education in the pre-school system.

In 2017, the UNICEF supported installation of PV systems in 3 preschool centers, and trainings on alternative energy sources and energy saving were conducted for children. However, the lack of a regular system of kindergarten educators' training undermines the continued process of environmental education and upbringing.

General education

In the framework of mandatory courses defined by the curriculum for the 2nd to the 12th school grades, there are only limited references to the climate change issue. The above-mentioned courses are fragmented and inconsistent. There is a lack of interlinks between courses taught, while such interlinks would enable perceiving the problem of climate change in a more holistic and profound way.

References to the topic of climate change can mostly be found in the following courses taught in the 11th grade: "Geography," "Biology" and "Social Sciences." References in the remaining mandatory courses are insufficient. Since 2017, the "Climate Box" project has been implemented by the UNDP, financed by the Russian Federation. Specialists representing the National Institute of Education are involved in this project as experts. They have elaborated recommendations on including climate change materials in certain sections of various courses taught, meanwhile ensuring linkages among different courses. It is envisaged to publish translated and adapted educational materials, methodological guidebooks and share them with all schools.

In terms of inter-disciplinary linkages, a remarkable collaboration has been established between the Armenia Tree Project and Yerevan School No 78. Every year, pupils from this school visit the Ohanian Family Environmental Education Center for a summary lesson dedicated to discussion of environmental issues.

Handbooks on climate change topics have been developed to support the implementation of environmental education in the public education sector, in particular:

- "ABC" educational manual related to climate change was translated, supplemented and published within the UNDP-GEF projects;
- "Global climate change and agro-biodiversity issues" and "Adaptation and mitigation in adverse environmental conditions" are published within the framework of the "Enhancing Livelihoods in Rural Communities of Armenia through Mainstreaming and Strengthening Agricultural Biodiversity Conservation and Utilization" GEF-UNEP project.

Teachers' training

Teachers' training system is at an insufficient level. The Environmental Education and Upbringing Strategy, adopted in 2018, states that "there is a lack of training programs for professional development of teachers providing environmental education". Based on this, in 2018, the National Institute of Education has elaborated a 30-hour curriculum and a manual on environmental education and upbringing for teachers. One of the sections of this manual focuses on the topic of climate change. Despite the fact that the manual and the training model are ready, no training courses have been conducted yet due to lack of financial resources.

In the framework of "the Climate Box" project, 54 teachers and methodologists have been trained. On November 1-2, 2018, the First International Conference on Addressing Climate Change through Education for countries of Eastern Europe, the Caucasus and Central Asia was held in Yerevan. Around 50 representatives from 8 countries (Armenia, Turkmenistan, Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan, Moldova and Russia) participated in the Conference.

A 4-day training program for 1,600 teachers (including teachers in natural sciences, form masters, headmasters) was provided by the Armenia Tree Project. The program, among

other issues, also covered climate change, as well as film-watching on this topic.

Non-formal general education

The "Climate Box" project was piloted in 15 schools in Armenia. A competition on environmental initiatives was organized among school children of 12-17 age. 15 project proposals were submitted, 3 of which were announced as winners and took part in an international contest that was held in Kazakhstan. One of the Armenian schools won the first prize.

Each year, since 2017, based on the initiative of the UNICEF, the "World's Largest Lesson" is held in one of the schools. During the lesson, the Sustainable Development Goals (SDG) are discussed, including SDG 13.

During 2013-2019, the SPARE (School Project for Application of Resources and Energy) training course continued to be implemented by the funding of the Norwegian Society for the Conservation of Nature and American and Canadian embassies in Armenia. The "Tapan Eco-Club" environmental NGO was the coordinator of the project.

The curriculum for this course is comprised of five main sections, which include both theoretical and practical exercises. The topic of "Climate" is a separate section, which features factors influencing global climate change, with a focus on man-made or anthropogenic triggers and the complex consequences that these factors have. Importance is given to transition to alternative or renewable energy sources. In the overall content of this training course, a waste-free and energy-saving type of behavior has been taught. Armenia Tree Project NGO has launched eco-clubs in schools, conducting spring, summer, autumn eco-camps. Activities conducted during these camps also include climate change related topics. Within the open-air class of the Environmental Education Center, set up by the organization, there is also a section dedicated to climate change.

Preliminary vocational and middle vocational education

The "Study of Landscape and Basics of Ecology" course is included in every state educational system for vocational education. The course is taught based on a 36-hour curriculum. There is an overview of the topic of climate change in the course. Nevertheless, the education programs do not comply with the present day requirements. In addition, there is a need for training of lecturers.

In 2018, a new specialty has been introduced in 3 secondary vocational educational institutions of Armenia to train specialists in the field of ozone-friendly maintenance of air conditioning and ventilation systems. The project is implemented with the support of the UNDP.

In 2016, the system of dual education was piloted in Armenia and, in the framework of this initiative, training courses on topics such as solar energy production, renewable energy and nature protection are conducted in Kotayq regional college and Gyumri city Craftsmanship College No. 4.

Learning materials on environment, including on climate change, are posted on an online educational platform: www.armedu.am. In particular, a manual on climate[159], published by the World Vision organization, and an online learning material on the global climate change[160] are available on the platform.

Higher education

In recent years there has been a significant decrease in the number of students in the areas of environmental studies. For comparison, in 2013 the number of students studying in these specialties in universities was 1,105, while in 2018 this number reduced to 282.

In accordance with a requirement stipulated in the Law on Environmental Education and Upbringing, the "Basics of Ecology" course is taught as a mandatory subject in all higher educational institutions in the country. The topic of climate change is covered in this training course, to some extent. In general, around 180 courses related to environment and ecology are taught in higher educational institutions of Armenia.

In the past, the specialization of Hydrometeorology was included in the Faculty of Geography and Geology. Since 2013, however, it

[159] https://lib.armedu.am/resource/1018

[160] https://lib.armedu.am/ resource/27739

has closed down because of insufficient number of applicants. Currently, Hydrometeorology is a specialization in the Bachelor's programs, which can be selected by students starting from the 3rd year of study. In Master's degree programs, admission for this specialization opens only once in two years.

In the Faculty of Biology of the YSU some courses are taught, which are related to the impacts of climate change on the flora and fauna.

In 2017, with the joint efforts of a number of universities and organizations, the Armenian Climate Technology Academic Network (ArmCTAN) was established, which is aimed at promoting cooperation for development, transfer and introduction of climate technologies.

"Basics of Ecology" is taught at the Armenian State Pedagogical University as a mandatory course. In the framework of this course, topics, such as global environmental issues, environmental law, convention on climate change, impact of climate change on the population's health situation are covered. The Yerevan State University of Architecture and Construction has the Chair of Ecology, where the "Basics of Ecology" course is taught. In the past, the specialization on Ecology was also available within the above-mentioned Chair. Around 10 students used to study here annually. Currently, however, there is no more admission for this specialization. The Chair has published a textbook on Ecology. At this University, the "Heat and Natural Gas Supply and Air Conditioning" study program is conducted for the Bachelor's degree program students. The mentioned curriculum is also adopted and instructed in the framework of the Master's degree programs. Students in the Master's degree programs are taught courses, which include also the following: "Issues of Environmental Protection and Climate Change"; "New Methods for Improving the Energy Efficiency of Heat and Natural Gas Supply and Air Conditioning Systems"; "Contemporary Methods of Utilization of Non-traditional Sources of Energy". Two laboratories operate in the framework of the University - the Laboratory of centralized multi-zone (VFR) systems for cooling and heating freon-based systems and the Laboratory of the Heat and Natural Gas Supply and Air Conditioning. The course on "Green Architecture" is included in the curriculum, which covers such topics as energy saving and the use of renewable energy sources in the processes of design and construction of buildings.

The National Polytechnic University of Armenia has the Chair of Thermal Energy and Environmental Protection, where the subjects taught include the following: "Technologies for Protection of the Environment"; "Tools and Equipment for the Protection of Environment". In the Master's degree programs, the "Environmental Expertise", "Mapping", and "Environmental Audit" courses are taught, which cover the topic related to GHGs. Students take their internship at Thermal Power Plants and the Nuclear Power Plant.

At the Agrarian University, the Chair of Forest Sciences and the Chair of Agroecology have recently merged. The "Basics of Ecology", as well as "Forest Science", "Forest Preservation", "Forest Management", "Landscapes Research", "Safe Food", "Environmental Assessment", "Agroecology" and "Biodiversity" courses are taught at the Agrarian University. With the support from the Government of the Netherlands, the University is implementing the "Study and Evaluation of the Agroecosystem Adaptation Potential of Khosrov Forest Reserve and Dilijan National Park in the Context of Global Climate Change" project.

The AUA has a mandatory environmental component in its curriculum. Selection of a 1-credit environmental subject is mandatory in the Master's degree program offered by the University. With the support of the UNDP, the University specialists have developed and published bilingual textbooks on Green Architecture and Green Lighting.

Postgraduate education

Postgraduate education is conducted both in higher educational institutions and in the scientific institutes of the NAS. In recent years, a number of PhD and doctoral theses have been defended covering various climate change related topics.

Additional and continuous professional education

Under the GEF-funded UNDP project, 11 environmental education modules have been developed for municipal and civil servants, as well as representatives of business community. These modules include topics related to climate change. Training of teachers has been conducted, and 18 out of the 45 participants have been qualified as trainers. In total, the courses are designed to cover 1,000 decision-makers.

With the support of the EU, WWF-Armenia has developed and published a "Climate Change and Forest Transformation in the South Caucasus" training manual for forestry specialists and governing bodies (2015).

6.3.2 Public Awareness

In 2016, the European Environment Agency, together with the EU Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine), has launched the implementation of the second phase (2016-2020) of the EU-funded European Neighborhood Instrument (ENI) II EAST Shared Environmental Information System (SEIS). The project, in line with EU/EEA best practices, aims to achieve:

- Improvement of regional/international environmental reporting obligations;
- Strengthening the national governance capacity for better management and use of environmental statistics and information to support informed decision-making;
- Preparation of regular environmental progress reports.

Within the framework of the project, small-scale integrated information system (SEIS)[161] was also launched and made available to public, covering information on the Lake Sevan basin. A background paper on the Lake Sevan has been prepared to provide baseline information and data flows available for the basin, and to develop and implement small scale SEIS for the Lake Sevan in Armenia.

With the technical support of the European Environment Agency in the framework of the EU-funded "Implementation of the Principles and Practices of the a Shared Environmental Information System in the Eastern Partnership Countries" Program, the Armenian eco-portal[162] was developed (2018-2020) in accordance with the requirements of the European Shared Environmental Information System, which aims at strengthening the environmental governance.

In 2019, the MoE has launched awareness raising and social media campaigns supported by UNDP. In particular, the "Eco-platform" environmental TV project transmitted by the 1st public television channel, covers various environmental issues, including climate change.

In 2019, "Boon TV" sponsored by the German Heinrich Böll Foundation has aired a series of lectures, titled "Green Series", one of which was dedicated to climate change[163].

In 2019, with the joint efforts of the "Regional Center for Human Capital Development" NGO, "Women in Climate and Energy" NGO and "Support to Reforms" NGO, a youth game-competition and a drawing competition were organized under the slogan "Sustainable Energy", with participation of around 40 children aged 11-16 from a number of communities in Shirak and Aragatsotn marzes.

In 2018, the Swedish Embassy in Armenia, together with the UNDP Armenia, the MoE and the Union of Cartoonists of Armenia, organized an exhibition of works by Swedish and Armenian cartoonists to express their perception of climate change through humor and satire.

During 2016-2017, in coordination by the Armenia Tree Project, Armenia participated in the "Ecopreneurs for Climate" program, in the framework of which business people and public had an opportunity to present their ideas.

For the last 10 years, Armenia has been participating in the Earth Hour World Environmental Campaign, by switching off electricity for one hour. By the decree of the Government of Armenia, March 23 is celebrated as the Meteorologist's day, since 2004.

[161] http://www.seis-sevan.am/
[162] http://ecoportal.mnp.am:92/
[163] http://boon.am/climate-change/

Within the framework of the “Building Bridges” project, Armenia Tree Project NGO has published a series of educational materials, one of which is entirely dedicated to climate change.

During 2017-2018, “Armenian Women for Health and Healthy Environment” NGO implemented the “Solar Energy for Low-Carbon Sustainable Lifestyles in Solak, Aygavan and Malishka Rural Communities of Armenia” project. During the project, awareness-raising was conducted for the people of the above-mentioned communities, particularly on the topics of solar dryers, use of solar water heaters, energy-efficient lighting of outdoor areas and streets, and solar energy heaters.

“Khazer” Ecological and Cultural NGO has continued its large-scale public awareness campaigns to ensure coverage of various aspects of climate change. In particular, regular public awareness-raising activities have been performed to inform the public on the progress of the intergovernmental negotiations carried out within the framework of the UNFCCC, and to present the position of Armenia's delegation during these negotiations; more than 50 informative and educational events have been conducted for students and teachers; a number of conferences and meetings have been organized with the distribution of “We and Our Planet”, “Let's Protect Our Climate” posters and booklets published by the NGO. During these events, the harmful effects of Armenia's large and small HPPs on water ecosystems and the perspective implementation of the “Ecosystem services” instrument aimed at elimination of these damages have been discussed. In a number of rural communities, as a result of large-scale post-educational awareness and training campaigns, “Civil Climate Revolving Investment Funds” have been established, aimed at financing CC mitigation and adaptation projects.

Environmental information websites www.econews.am and www.ecolur.org are dedicated to the coverage of various topics in Armenian, Russian and English languages related to environmental protection, including climate change.

Since 1996, collection, coordination, exchange and access to information related to climate change for local and international partners has been provided by the Climate Change Information Center, through its bilingual website (http://nature-ic.am).

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7

GAPS, CONSTRAINTS AND CAPACITY BUILDING NEEDS **FOR CONVENTION IMPLEMENTATION**

The Convention implementation processes in the Republic of Armenia are set out in the Government Protocol Decree No. 49, ratified on December 8, 2016 "On Approving the List of Activities for Implementation of the RA Commitments Deriving from a Number of Environmental International Conventions". The country's position under the UNFCCC Paris Agreement is formulated in the "Intended Nationally Determined Contributions" document, which was approved by the Government Protocol Decree No. 41 of September 10, 2015.

Throughout the preparation of this national communication, certain national capacity development needs for implementation of the Convention have emerged, including needs related to legislative, regulatory, technical, technological, institutional, financial, human resources aspects; needs in data and information, as well as gaps in a number of other aspects, which, if adequately addressed, will contribute to the improvement of national capacities in terms of meeting the country's commitments under the UNFCCC. Additionally, country's needs have been identified under the new international requirements set out for implementation of the Convention (Table 7-1).

Overall, a shortage of specialized human resources, knowledge and necessary financial resources is observed in all areas.

Table 7-1. Gaps, barriers, limitations and needs for addressing climate change related issues

Gaps, barriers, limitations	Comments	Needs
GHG inventory		
Lack of institutional, legal mechanisms and arrangements for development of GHG inventory on a continuous basis.	There are no adequate institutional arrangements to ensure data collection on a continuous basis. Lack of approved standard templates for data collection and established timelines hinder phase-by-phase preparation of GHG inventory (data collection, emissions assessment, QA/QC, key category analysis, validation).	Develop legal regulatory framework for institutions and agencies providing data, to ensure that the data are collected according to the established templates, and within the specified frequency and timelines.
Inconsistencies among the data obtained from different sources.	There are issues related to data accuracy, as well as imperfections in QA and QC systems.	Organize discussions aimed at improvement of administrative registries, which will contribute to better accuracy of data, in line with legislative/regulatory changes.
In order to ensure application of a higher-tier methodology in "Forestry and other land use" subsector, there is a need to develop national emissions factors.	Continuous quality improvement of GHG national inventories is crucial both in terms of fulfilling Armenia's commitments under the Convention, and in terms of sectoral policy development.	Based on the data collected within the framework of field studies under UNDP-GEF program and under the newly developed forest management plans, it is necessary to develop national factors for all 5 carbon pools.
Absence of reliable data in relation to current volumes and changes in forest resources, as well as over a 25 -year gap in forest inventory, resulting in obstacles in terms of completeness and accuracy of data.	Missing or incomplete data hinder the assessment of emissions/removals in all pools, and data inaccuracies result in high uncertainty in terms of emissions/ removals assessments.	Stipulate the importance of comprehensive forest inventory in the legislation and introduce guidelines for applying comparative analysis of satellite data and field studies for adequate evaluation of changes in vegetation and land use.
Policies and measures for GHG emissions reduction		
Lack of institutional mechanisms/ assignment of responsibilities for data collection on mitigation measures.	In the absence of institutional mechanisms and reporting commitments, not all mitigation measures are identified, and not all organizations provide information on the projects progress and mitigation impacts. There is also a high probability of duplications in records.	Define by legislation and introduce institutional mechanisms and processes for data collection, analysis, QA/QC procedures, which will enable presenting comprehensive, transparent and reliable information on mitigation measures.

Gaps, barriers, limitations	Comments	Needs
Lack of coherent approach/ methodology for assessment of impact of mitigation measures in the “Energy” sector.	Assessment of mitigation measures impact under different projects are not comparable.	Develop a common approach/ methodology, which will allow assessing GHG emissions reduction resulting from renewable energy and energy efficiency projects, providing comparability and reliability of mitigation projects assessments.
Lack of official/ institutional arrangements for collection of information on financial and technological resources obtained for climate change related mitigation measures.	Absence of official/ institutional arrangements makes it impossible to collect and present comprehensive information related to support received.	Examine other countries' best practices, taking into account specific national conditions, national capacity and implement institutional mechanisms and processes to enable data collection on an ongoing basis.
Assessment of the Second National Energy Efficiency Action Plan results has been carried out only in relation to legislative and regulatory framework development.	Lack of clear accountability and monitoring mechanisms has not made it possible to carry out a comprehensive assessment of the project implementation progress and outcomes.	It is necessary to include clear monitoring and evaluation mechanisms in the newly developed projects in the future.
Assessment of GHG emissions/ removals from the forestry sector was done based on the legally extracted and illegally harvested timber volume data, which were provided by the Forest Committee and Bioresources Management Agency of the MoE.	The mentioned data on forest logging are drastically different from those obtained from Statistics Committee in relation to the volumes of firewood use, obtained within the framework of comprehensive research on household living standards.	In order to perform accurate counting of forest timber stock collected for GHG inventory management purposes, it is highly recommended to carry out thorough studies, as well as analysis of official and independent data sources in relation to estimated volumes of illegal logging.
Lack of effective policy implementation mechanisms contributing to sustainable land use for carbon storage and accumulation in land.	Development of economic incentive mechanisms to promote consolidation of lands and cultivation of idle land plots is one of the crucial issues requiring immediate attention in terms of sustainable land management.	It is necessary to legislatively regulate the issue of consolidation of fragmented small land plots, which will contribute to sustainable land management, as well as soil carbon conservation.
Need for establishing norms for fertilizer use and changes in their standard composition.	In the RA, on average about 30 thousand tons of nitrogen fertilizer is used annually, as well as large amounts of carbamide /urea/, which dramatically increase the nitrous oxide emissions from the soil.	Use of alternative mineral fertilizers containing nitrogen, i.e. ammonium sulfate, leads to relatively lower emission of nitrous oxide. It is appropriate to reduce carbamide usage volumes, by channeling state subsidy resources exclusively towards imports of ammonium sulphate fertilizer.
Vulnerability and Adaptation		
Insufficient input data for application of vulnerability assessment models.	Quantitative vulnerability assessments are necessary in terms of corroboration and planning, as well as justification and funding of adaptation projects.	Identify input data required by relevant national/ international models of vulnerability assessment in each area and strengthen national capacities for continuous collection of these data.
Inadequate level of regional cooperation in the field of climate change adaptation.	Active and participatory regional cooperation is important in the context of an ecosystem-based approach to adaptation, as the vulnerability of ecosystems is not limited within state boundaries.	Develop and implement regional programs for research, systematic observation, vulnerability assessment and adaptation to climate change.
Water Resources		
Incomplete system of surface and ground water quantity and quality monitoring.	The current legislative framework in the RA water sector practically does not promote reliable, timely and high-quality data collection in relation to integrated systems of water management and	Specify in the legislation the requirements for monitoring of water resources’ quantity and quality. Establish quantitative measurement stations for monitoring at all downstream sections of river

Gaps, barriers, limitations	Comments	Needs
	planning. Due to the above-mentioned reasons, the information on water resources in the country is often contradictory and not reliable.	basins and the flow formation zones, as well as respective sections of groundwater aquifers, and specify a mandatory provision for conducting groundwater exploration works at certain periodicity. Upgrade the surface and groundwater monitoring network.
Hydrobiological monitoring of water resources is not conducted in the country.	Despite the observed stresses on river ecosystems and biodiversity loss, no hydrobiological monitoring of the surface waters is carried out. With the support of international donor organizations, MoE obtained laboratory equipment, acquired skills and international methodology for implementation of hydrobiological monitoring of surface water.	Stipulate by legislation the requirement and introduce a system for hydrobiological monitoring of surface water resources. Introduce institutional and financial mechanisms for continuous implementation of hydrobiological monitoring.
Incomplete database of water resources in the State Water Cadaster.	There are serious gaps in the RA Government Decree No. 68-N, dated 02.02.2017, “On Approving the Procedure for Running the State Water Cadaster”.	Develop and adopt a new GoA Decree “On Approving the Procedure for Running the State Water Cadaster” to regulate the structure and content of the State Water Cadaster, as well as coordinate relationships in the areas of data collection, information sharing and provision processes.
Lack of reliable data on actual water use.	Lack of data on actual water use is a major obstacle for restoration of natural river flow, due to significant differences in permitted and actual water intake.	In order to improve availability of data on actual water use, it is necessary to install overall automated measurement devices for water intake, in order to ensure relevant data transfer to appropriate agencies in real time mode, as well as encourage and enhance implementation of self-monitoring system and strengthen law enforcement mechanisms in relation to water use.
Shortcomings in existing water resource vulnerability assessment methodology, lack of effective and reliable methodology.	There are gaps in the current methodologies used for water resource vulnerability assessment. For restoration of natural river flow, “standard” factors are applied for calculation of return flow after water use. There are also significant gaps in terms of calculation of other water balance elements, such as monthly evaporation.	To ensure accurate assessment of water resources’ vulnerability to climate change, it is necessary to develop new methodologies and approaches for restoration of natural river flow and calculation of water balance elements.
Gaps in historical time series of hydro-chemical data for water quality vulnerability assessment.	The digitized historical data on the quality of water resources, (hydro-chemical data) require a review and an adjustment, as a number of technical errors are observed in the course of digitization process. The archival data for Lake Sevan hydro-chemical monitoring are only partially digitized, and there is a risk for loss of historical data.	Make relevant adjustments in the historical data and create a comprehensive archival repository for data on the quality of surface and groundwater resources.
Lack of methodology for water quality vulnerability assessment and forecasting.	No specific methodology is in place for conducting water quality vulnerability assessment based on changes in hydrological and meteorological parameters. Fort the first time, assessment of changes in water quality due to climate change impacts was reflected in Southern basin management plan and in a number of scientific works, which, however, are not sufficient to ensure the	The interdependency between natural changes in water quality and hydrological parameters requires more in-depth studies. It is necessary to develop and introduce methodologies for water quality vulnerability assessment due to climate change, as well as water quality forecasting, based on best international practices.

Gaps, barriers, limitations	Comments	Needs
	comprehensive water quality assessment and forecasts covering the country's entire water resources.	
Pollution of water resources with municipal wastewater, lack of treatment plants.	One of the main sources of surface water contamination in the country is the municipal wastewater. About 90% of this wastewater, due to the absence or destroyed conditions of treatment plants, is discharged into the adjacent water body without treatment, thus, contaminating it with ammonium, nitrate and phosphate ions, organic contaminants, and so on.	It is necessary to construct wastewater treatment plants in large settlements, in accordance with the requirements of the EU Municipal Wastewater Directive.
Deficiencies in the currently applied irrigation norms and regimes, developed in 2007 and not revised to consider current shifts in temperature regimes.	The irrigation norms in Armenia are established based on long-term measurements, taking into account the soil-climatic conditions of the irrigated region, biological characteristics of crops, cultivation and irrigation methods. The parameters for the irrigation regime are calculated taking into consideration surface irrigation method and rainfall probability for 50% and 75%, which does not accurately represent irrigation scheduling requirements for a particular year, often leading to over-watering. Because of the projected climate change and increased evaporation, updating irrigation norms and the data of irrigation regime becomes prerogative.	It is necessary to update the "Irrigation Norms and Regimes of Agricultural Crops for Irrigated Lands in the Republic of Armenia", developed by the Water Problems Institute of the RA Ministry of Agriculture in 2007, based on crop water requirement model available at the FAO Irrigation and Drainage Paper No. 56 ("Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements").
Absence of irrigation water quality norms.	Currently, there are no norms or restrictions on irrigation water quality established in the country. Often surface water, which is not suitable for irrigation purposes, is used for the said purpose. Occasionally, international water quality norms adopted by FAO are used for water quality assessments, however, these are not stipulated by legislation.	It is necessary to define by legislation groundwater quality norms and water quality classification methodology based on FAO requirements.
Large quantity of leakages in water distribution and water use systems.	Water intake rates established by the RA Government Decree No. 864 dated 19.07.2018 "On Rates of Nature Use Fees" do not, in any way, contribute to efficient use of resources and reduction of leakages (up to 80% in drinking water supply and around 50% in irrigation water supply) in water supply and water use systems.	Thoroughly review the mechanisms of defining natural use fees, which will contribute to investments in leakage reduction in water supply and water use systems, as well as efficient use of resources by consumers.
Lack of norms and methodologies for groundwater quality assessment and classification.	Groundwater quality is assessed only on the basis of water supply. For example, in the case of groundwater used for drinking water supply, water quality is assessed by drinking water norms, which do not reflect the ecological condition of the groundwater resources and changes in water quality. In this case, it is not possible to assess the impact of climate change on groundwater quality.	It is necessary to define groundwater quality norms and water quality classification methodology based on the requirements of the EU Water Framework Directive and Groundwater Directive.
Lack of studies related to climate change impacts on the quantity of groundwater resources.	Due to the lack of structured monitoring of groundwater resources and data sets, inconsistencies of data presented in various assessments (official data are based on 1984 estimates made by the State Commission on Mineral	It is necessary to: • stipulate by legislation the mandatory provision for having groundwater quantity monitoring stations at respective sections of groundwater aquifers, as well as a provision for conducting

Gaps, barriers, limitations	Comments	Needs
	Resources), as well as the lack of methodology for climate change impacts assessment and forecasting, it has not been possible to study the impacts of climate change on groundwater resources.	groundwater exploration works at certain periodicity; • collect data on groundwater resources and update the available database; • explore international best practices and introduce a methodology and approaches for assessing climate change impacts on groundwater resources.
Significant reduction of current river flow projected in Armenia due to transboundary impacts.	In recent years, as a result of large-scale reservoir construction works in the area neighboring with the Aras River basin, transboundary river flow of Aras river is expected to reduce by about 56% (from 2.7 billion m^3 to 1.2 billion m^3). This will cause many serious issues in the coming years for the irrigated agriculture of the Ararat valley, as well as for the Ararat artesian basin.	Take into account the cross-border effects in the course of water resources strategy development and implementation processes.
Lack of professional and technical skills.	State agencies for water resources management, conservation and monitoring lack sufficient professional and technical capacity to use modern technology in the course of qualitative and quantitative assessments of water resources, including capacities to analyze and use satellite images.	Conduct training courses for employees of the relevant agencies in the water sector to strengthen their capacities in terms of application of modern technology in the process of assessments of water resources.
Agriculture		
The efficiency of crop yield forecasting and vulnerability assessment methodology is not adequate for appropriate policy development for adaptation.	Sector-specific vulnerability assessment is important from the point of view of identification and mitigation of climate change-induced risks, as well as development of adaptation measures. The current methodology for yield forecasting is based on statistical methodologies.	It is necessary to: • develop and introduce new methodologies and approaches for crop yield forecasting with proven high level of efficiency; • explore the possibility of adapting relevant existing models, based on local knowledge, as well as technological innovations, such as information obtained from satellite images and drones; • develop manuals and methodology guidebooks on crop yield forecasting.
Armenia's agroclimatic and microclimatic zoning is incomplete.	Adequate agroclimatic and microclimatic zoning and mapping will serve as a solid base for efficient management of natural resources, as well as for more productive use of land and agricultural activities. It will enable to assess and reduce farmers' risks, allowing them to select and effectively develop the crops that are most suitable for the particular climatic zone and conditions.	It is recommended to: • digitize information on agricultural lands; • clarify the methodology for defining agroclimatic zones, considering the projected climate change and crop phenological data; • implement agroclimatic and microclimatic zoning and mapping with the use of high technologies, including drone systems, satellite imagery and GIS systems; • create an electronic platform and provide farmers with relevant information; • develop guidelines for cultivation of both traditional crops, and those, which are most suitable for the given climatic conditions.
Inadequate water supply for crops.	As a result of global climate change, unprecedented consumption of the Ararat Valley groundwater resources, as	It is necessary to: • encourage the use of water-saving systems;

Gaps, barriers, limitations	Comments	Needs
	well as physical and moral wear and tear of the irrigation system, problems related to the supply of the required quantity of irrigation water to farmers have emerged.	• increase awareness among water users; • initiate comprehensive works on reservoir construction; • apply diversified approach to irrigation water allocation and payments, based on equitable principles.
Lack of modern and effective institutional system for infrastructures management serving the agrarian sector.	There are serious issues in relation to institutional systems, infrastructure and technology for effective use of irrigation water resources. Irrigation water lines are obsolete in substantial part and are mainly in technically inadequate condition.	It is necessary to improve, modernize the institutional system in the field of agriculture, infrastructures, introduce innovative technologies, repair and reconstruct the irrigation networks and irrigation water lines.
Natural ecosystems and biodiversity		
Lack of data on natural ecosystems is obstacle for appropriate analysis of climate change impact.	In practice, there is no systematic observation of climate change impacts on natural ecosystems. No indicators for assessment of ecosystem conditions are used.	Develop indicators for assessing the condition of ecosystems. Conduct research on introduction of a system for monitoring of changes in natural ecosystems.
Majority of data on biodiversity covers a fairly short period of 2-5 years, and the time series are not sufficient to conduct statistically reliable analysis.	Biodiversity management should be based on accurate scientific and reliable monitoring data on individual plant and animal species. Relatively comprehensive information is available in relation to invertebrate animals, especially insects, which will allow to subsequently carry out assessment of climate change impacts on respective species of biodiversity.	It is necessary to: • introduce a biodiversity monitoring system; • proceed with data accumulation to provide multi-year data time series for statistical estimates - both in explored and in new areas; • establish a national biodiversity information system.
There are no adequate and accurate data on forest inventory, current changes, potential climate change impact and other observations.	Specific scope of complex actions on forest regeneration, forest restoration, particularly – on seed cultivation, soil preparation, forest planting, irrigation, agrotechnical service, care and other measures is not at sufficient level yet.	It is necessary to carry out national inventory of all forests, obtain updated information not only in relation to forests technical specifications and wood resources, but also on biodiversity, ecosystem services provided by forests, which will, subsequently, serve as a basis for continuous monitoring. Inventory should be carried out once every 10 years.
Lack of risk assessment on the occurrence and spread of fire in forest and vegetated areas. Absence of actual data required for modeling of naturally emerged fires and assessment of risk of their emergence and spread.	Burning crop residues in arable lands adjacent to forest ecosystems increase the risk of unforeseen wildfires, which can have a significant and prolonged impact on environmental, social and economic systems.	It is necessary to identify and evaluate risks resulting from fires, as well as to further develop cost-effective risk mitigation strategies. There is a need to review requirements set for development of forest management plans, provide a more detailed description of the plant coverage reflecting it in the GIS systems. Develop complex measures for reduction and prevention of risk of occurrence of natural forest fires, taking into account the possibility of animal grazing in areas adjacent to forests and grassplots.
Lack of research on pest and disease focal areas in forests.	Data on spread of forest pests and pathogens of forest diseases, per years, are available at “ArmForest” SNCO, however not backed up by respective analysis.	Pests and disease control will not have sufficiently preventive and coordinated effect unless backed up by adequately regular forest pathological studies. It is necessary to regularly carry out appropriate studies, which will enable their early detection and effective elimination.

Gaps, barriers, limitations	Comments	Needs
Shortage of specialized human resources, technical capacity, knowledge and state funding in forestry sector.	There is a lack of forestry management, forestry-related educational institutions. There were no high schools specialized in forest science and forestry in Soviet Armenia; training in these areas was conducted in Moscow and Georgia. The state does not provide vocational training opportunities for “ArmForest” SNCO staff, and the staff has no access to the required technical equipment.	To ensure sustainable forest management, there is a need to attract highly qualified specialists, as well as to provide adequate staff training, and appropriate sectoral infrastructure and technical equipment.
Lack of studies and data on the amount of organic carbon, accumulation patterns and dynamics of change.	Absence of the mentioned data does not allow assessing their changes under CC scenarios.	It is necessary to accumulate sufficient scope of data to enable projection of potential future changes and to develop and implement adaptation measures.
Lack of threat assessment for medicinal and edible plants.	The assessment of the vulnerability of these plants is extremely important given the following wildlife conservation principles, namely: conservation of genetic resources, sustainable use of wild plants, conservation of natural ecosystems providing ecosystem services, as well as due to the fact that these plants are widely used by the population.	It is necessary to: • establish a database of the most widespread and most used medicinal and edible plants in the country; • based on the vulnerability assessment for rare species, perform an assessment of the selected species as well; • develop appropriate recommendations for restriction of their future use, as well as their coverage area expansion and preservation.
Lack of monitoring data related to aquatic ecosystems and humid wetland areas (except for Lake Sevan).	The lack of data hinders the assessment of the vulnerability of aquatic ecosystems to climate change.	It is necessary to: • introduce and implement biological monitoring of surface waters, in order to assess ecosystem’s ecological status and vulnerability to climate change; • use satellite observation data to fill in the data gaps or to obtain historical data, which will enable recovery of data time series dating back up to year 1984; • include assessment of wetland ecosystems in river basin management plans.
Increase in Lake Sevan water temperature in summer leads to mass development of blue-green algae (“water blooming”), which may trigger deeper changes in the ecosystems.	According to projections, in the absence of adequate measures, such phenomena will be repeated and will trigger significant changes in environmental factors. Such factors will impact the lake's biodiversity, in particular, in terms of acceleration and deterioration of eutrophication processes, changes in water structure, pollution, quality deterioration, changes in phyto- and zooplankton and benthos, accumulation of toxic substances in living organisms, and so on.	To prevent the above-mentioned phenomena, it is necessary to: • improve legal and institutional framework for Lake Sevan ecosystem conservation (amend the RA Law “On Lake Sevan”, with due consideration of the projected climate change impacts); • maintain the increase trend of the Lake’s level, aiming to reach at least the designed level or implement measures for maintenance of the current level; • minimize the pollution of the Lake Sevan with municipal wastewater, as well as with sewage from the Lake's coastal areas; • carry out artificial water treatment activities to eliminate blue-green algae.

Gaps, barriers, limitations	Comments	Needs
Settlements and infrastructure		
Incomplete databases on data and information related to climatic disasters and risks.	Deficient system of data collection and gaps in data create challenges for vulnerability assessment of the sector towards climatic disasters. Convergence of technologies and development of advanced methodologies for collection, analysis and documentation of data related to climate change are becoming increasingly more imperative.	It is necessary to develop and introduce a unified system of data collection, including economic indicators of damage caused by climate-related disasters.
Lack of experience in modeling the vulnerability of settlements and infrastructures to climatic risks.	To ensure efficient management of climate-induced disaster risks, it is necessary to evaluate vulnerability of settlements and infrastructure to projected climate change.	Explore a methodology for assessment of climate change risks for settlements and infrastructure (floods, inundations, mudflows, landslides), as well as international best practices for modeling and mapping, opportunities for adaptation and introduction of appropriate tools (e.g., AWARE for InvestmentsTM tool, Infrastructure Planning Support System) for assessment of vulnerability to climate change-induced risks.
Human health		
There are no sufficient studies on climate change impact on human health.	Due to the lack of air pollution monitoring data and evaluation capacity, no adequate research has been conducted yet aimed at identification of the impact of climate change on cardiovascular and respiratory system diseases.	For assessment of climate change impact on human health, there is a need to strengthen the system aimed at monitoring of environment factors, in particular, atmospheric air pollutants, as well as to introduce monitoring of coarse particles (PM10 and PM2,5), to develop and introduce risk assessment methodology to estimate the impact of atmospheric air pollutants and chemical substances.
Inadequate resources to carry our vulnerability assessment of human health to climate change and develop adaptation programs.	Climate change impacts on human health are complex and combined with the influence of other environmental factors. There is a lack of adequate environmental data to undertake scientifically justified vulnerability assessment and develop adaptation programs. At the same time, there is a need for resources and other support for development of methodology, its application, training and development of corresponding documents.	Adequate resources should be allocated for enabling human health vulnerability assessment and development of adaptation action plan, as well as for capacity building and technical assistance in this direction.
Inadequate sanitary-hygiene conditions in a number of regions of the country.	Inadequate sanitary-hygiene conditions contribute to emergence and spread of climate change-induced diseases.	Implement continuous sanitary-hygienic and epidemiological monitoring and appropriate preventive measures. Raise public awareness for proper maintenance of hygiene and sanitary conditions in order to reduce emergence and spread of health risks associated with climate change.
Lack of statistics and assessment of cardiovascular diseases among population due to climate change induced heat waves.	Despite the lack of relevant statistics in the country, international experience shows that increase in the frequency and duration of heat waves may lead to potential growth of cardiovascular diseases and mortality.	It is necessary to: • introduce specific vocational training regimes to adapt to heat waves; • develop awareness raising mechanisms for vulnerable groups, • install drinking water fountains in crowded places.

Gaps, barriers, limitations	Comments	Needs
Tourism		
Lack of comprehensive statistical data for assessment of climate change impacts on the tourism sector.	Lack of long-term time series of statistical data in the tourism industry, in particular – number of visiting tourists, their age, travel purpose, preferred season of the year, duration, and so forth, do not allow assessing vulnerability of the tourism sector to climate change.	Perform continuous data collection. Continue to implement polls at checkpoints to identify the purpose of visits among the tourists visiting the country.
Lack of comprehensive databases on snow cover in the mountainous areas.	Absence of data on snow cover prevents implementation of tourism sector vulnerability assessment in terms of winter tourism, including skiing and other winter sports.	Enhance snow measurement observations in alpine expeditions and carry out continuous collection, review and projection of snow cover data to assess risks and vulnerability of winter tourism from climate change.
Estimation of economic losses and damages		
Lack of systematically collected data on damages in vulnerable sectors caused by climate change induced hazardous hydrometeorological phenomena (HHPs) and natural disasters.	Lack of unified taxonomy/streamlined approach for collection of data on damages caused by HHP and natural disasters broken down by the country's regions and vulnerable areas.	Define by legislation the approach and methodology for systematic collection of data on damages in vulnerable areas.
Lack of methodology for quantitative assessment of damages.	Damage assessment is a complex issue, and approaches may vary. There is no defined single methodology for quantitative assessment of damages in the vulnerable sectors.	Define by legislation the methodology for assessment and estimation of damages in each vulnerable area due to the impacts of climate change. Develop a digital system for automation of the assessment process.
Lack of actual estimates of economic losses due to the absence of appropriate vulnerability assessment to climate change.	There is no precise methodology for estimating economic losses in the country, which would take into account the existing and forecasted impacts of climate change on vulnerable sectors.	Establish an inter-agency damage assessment working group(s), develop a methodology for assessment of losses, taking into account the available international scientific and practical experience.
Lack of physical models to assess long-term impacts of climate change impacts on vulnerable sectors.	Lack of the aforementioned models hampers long-term impact assessment on the economy, which should be based on justified calculations of the physical and quantitative changes.	Study the existing international models and the possibility of their in-country adaptation.
Lack of economic models for climate change impact assessment.	The integrated "climate change-economy" model can be a powerful tool for development of cost-benefit analysis scenarios of climate change mitigation and adaptation.	Establish a multi-disciplinary task force to carry out research and assessments on applicable models for economic impact assessment of climate change.
Studies and systematic observations		
Degraded hydrometeorological monitoring observation networks, predominance of inefficient technologies in observation networks and lack of modern tool sets.	The capacities of Hydromet Service to perform climate forecasts are limited. Data collection in observation networks is not conducted comprehensively, which prevents proper implementation of future projections and delivery of reliable data. Digital weather forecasts are not conducted, the Service is not properly equipped to carry out weather forecasting of up to 6 hours in advance, which is crucial in terms of identifying HHP (hail, floods, strong winds).	Modernize the observation network of the Hydromet Service, introduce modern equipment and technologies to improve the quality of hydrometeorological services and data.

Gaps, barriers, limitations	Comments	Needs
Insufficient number of high-mountainous meteorological stations.	13% of the territory of the Republic of Armenia occupies the zone at an altitude of 2500-3000 m, which plays an important role in snow formation and assessment of water filling of reservoirs. However, there are not enough stations representing the mentioned zone.	It is necessary to reopen and re-equip the previously operating meteorological stations at the mentioned altitudes.
Insufficient number of hydrological monitoring observation posts.	The observation networks for monitoring the quantity and quality of surface water resources do not provide comprehensive coverage of country's water basins. The sampling frequency is still based on the Soviet time methodology and principles. In addition, due to permanently insufficient state funding, the monitoring observation stations were reduced by approximately 40% in 2016.	Define installation locations and install new hydrological observation posts. Implement centralized and automated system for hydrological monitoring, which will allow automating and adequately expanding the hydrological observation network coverage at significantly lower costs.
Low credibility of results derived from global and regional climate change models.	Uncertainties in precipitation projections by global and regional models often result in lower credibility of vulnerability assessment / modeling results in a number of sectors.	There is a need to direct further efforts towards correction of model uncertainties and enhancement of models' spatial resolution aiming to improve forecasts of seasonal and annual average temperatures and precipitation.
Incomplete climate risk alert and warning system.	The system for reliable assessment and forecasting, as well as the alerting systems for risks, HHP caused by climate change is inadequate, and the quality of services provided is insufficient. An agrometeorological website was created by Hydromet Service, which, however, does not operate due to some service issues.	It is necessary to: • develop capacities for well-in-advance HHP forecasting, • ensure more targeted/area specific alert mechanisms on occurrences of HHP; • improve the mechanism for information exchange, relaunch the NHMS website by incorporating an early warning system, and potential activities for mitigating the impacts of projected HHP.
Lack of technical capacity for long-term and seasonal weather forecasts.	Technologies for long-term and seasonal forecasts continuously evolve. Regional climate and empirical statistical dynamic downscaling models are capable of providing information at a much smaller scale, which can contribute to enhanced quality of projections. However, the Hydromet Service has limited capacities to apply such technologies.	It is necessary to provide NHMS with powerful information systems, software packages and servers to ensure accurate forecasting and research.
Innovation, technology development, advancement and transfer		
Policy development in the areas of science, technology and innovation is disintegrated. Collaboration between stakeholder organizations is at poor level.	In recent years, positive trends have been observed in science, technology and innovation sector policies, as well as in research and technology development areas, however, the measures undertaken are still insufficient to ensure advancement of science, technology and innovation in the country.	Development of comprehensive policies in the mentioned areas will enable coordination of efforts and adequate channeling of funding resources throughout the entire cycle, from research to innovation. It is necessary to define and introduce incentives for innovative companies aimed at the promotion of private sector investment in research and technology development areas.
Problems related to financing of new (start-up) companies offering innovative solutions for mitigation of climate change impacts.	There are a number of start-up companies, which offer innovative solutions for adaptation measures. Involvement of companies offering affordable technological solutions for climate change adap-	Create, introduce financial mechanisms for start-up companies offering innovative solutions for mitigation of climate change impacts, by establishing cooperation with the Ministry of High-tech Industry of RA.

Gaps, barriers, limitations	Comments	Needs
	tation in the agriculture, energy, infra-structure sectors may be a mutually beneficial activity.	
Science, education, human resources training, public awareness		
Underfinancing of research activities by the state.	Priority areas in science and technology development are quite broad, and the majority of them can involve research topics related to climate change issues. Priority areas for scientific research in Armenia in 2015-2019 included energy efficiency and sustainable use of natural resources. Nevertheless, the Government has not provided adequate support or financial resources targeted to the advancement of research in priority areas.	Provide mechanisms to promote and increase state funding for conducting research activities in priority areas. Ensure state thematic financing for implementation of research works in the areas of climate change studies, assessments and forecasts.
Inadequate application of scientific research results in the decision-making process.	Scientific research activities have been implemented in a variety of subjects related to climate change, however, the results of these studies are not sufficiently used in management and decision- making processes, due to lack of access to the research results.	Provide state management agencies and stakeholder organizations access to the results of research activities conducted within the framework of state and international cooperation projects.
Lack of specialized human resources in the Hydromet Service.	Occasional training courses offered to the staff (locally or abroad) are not suffi-cient to meet staff capacity development and service improvement needs. In particular, lack of English language knowledge among the current staff is a barrier in terms of access to international training.	Arrange on-the-job training courses for the Hydromet Service technical staff with the involvement of international experts.
Trainings for students to become climate change specialists are not provided.	In the past the “Hydrometeorology” discipline was included at YSU Faculty of Geography and Geology, but due to the insufficient number of applicants it was discontinued in 2013.	It is necessary to introduce “Environmental management” master’s program to prepare environment management specialists, including with specialization on climate change.
Climate change issues are only partially covered within the framework of compulsory subjects included in school educational plans.	The inadequate and fragmented nature of the material presented, as well as the lack of interdisciplinary links, do not allow students to fully understand the issue of the climate change.	Provide comprehensive inclusion of climate change issues into public education programs, as well as provide adequate interdisciplinary links.
Teachers’ trainings on environmental/ climate change/ issues is not at a satisfactory level in the country.	In 2018, the National Institute of Education developed a 30-hour training program /module on environmental education and upbringing, and a teachers' manual. However, due to the absence of financial resources, the trainings have not been conducted yet.	Allocate financial resources and implement environmental education courses for schoolteachers, with particular focus on climate change issues.
Other information		
The RA Law “On Environ-mental Impact Assess-ment (EIA) and Expertise” lacks the requirements of considering the impacts of projected CC on the envi-ronment and incorporating climate change impacts mitigation and adaptation measures in the EIA process.	The EIA is one of the instruments for planning, decision-making and environ-mental protection and management, which will allow mitigation of forecasted climate change impacts and adaptation to climate change.	Make addenda to the Law by defining the requirement for considering climate change risk at each stage of the EIA process. Develop sectoral guidelines and/ or assessment methodology, to support the assessment of climate change risks/ impacts and development of climate change mitigation/ adaptation measures in the EIA processes.

Gaps, barriers, limitations	Comments	Needs
Inadequate system of collaboration and information exchange among ongoing projects/ programs.	As a result of incomplete exchange of information, there is a risk of overlaps in implementation of identical projects/ programs, which may lead to non-efficient use of existing resources, and in some cases - to contradictory data and results.	Enhance information exchange and strengthen cooperation between national and international projects/ programs.
Funding		
Lack of comprehensive list of actions at national level results in a challenge of identification of financial needs for implementation of climate-action in the country, as well as pre-vents exploring possible financial sources and instruments.	Strategic documents related to climate change impacts are planned to be developed, including: National Adaptation Plan; the implementation plan for Nationally Determined Contributions document, as well as the NDC Partnership plan. However, there are still a number of areas where comprehensive action plans and their implementation road maps are missing.	Based on elaborated strategic plans, it is necessary to identify: • national actions for the subsequent 5-10 years, adopted by the Government, • the framework for implementation of these actions or technologies, • relevant funding sources and instruments, which are aimed at supporting the implementation of these actions.
Disintegrated and incom-plete strategic planning framework in the area of climate change resilience, mitigation and adaptation does not allow identifica-tion of all efforts, to the fullest extent, in these areas at national level and to assess effectiveness of climate-related policies implemented.	Policy documents, in particular, the development (including sectoral) strategies are not clearly addressing climate policies and objectives. In this regard, the resources allocated for implementation of the policies (especially from the state budget) are difficult to identify, which, in turn, leads to uncertainties in cost-benefit evaluation and hinders the process of monitoring policy implementation results.	It is necessary to gradually (phase-by-phase) introduce the Climate Public Expenditures and Institutional Review (CPEIR) system, which will provide a comprehensive and streamlined solution to the issue.

ANNEXES

Annex I. National inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol for the year 2016

Energy Sectoral Table, 2016

Categories	Emissions (Gg)			
	CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1 - ENERGY SECTOR	**4,946.62**	**77.1727**	**0.0879**	**6,594.49**
1.A - FUEL COMBUSTION ACTIVITIES	**4,946.53**	**1.9063**	**0.0879**	**5,013.80**
1.A.1 - ENERGY PRODUCTION	**1,182.60**	**0.0209**	**0.0021**	**1,183.69**
1.A.1.a - Main Activity Electricity and Heat Production	1,182.60	0.0209	0.0021	1,183.69
1.A.1.a.i - Electricity Generation - Gaseous Fuels	579.16	0.0103	0.0010	579.69
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	603.44	0.0106	0.0011	603.99
1.A.2 - MANUFACTURING INDUSTRIES AND CONSTRUCTION	**440.25**	**0.0093**	**0.0011847**	**440.81**
1.A.2.a - Iron and Steel	29.44	0.000520	0.000052	29.47
1.A.2.b - Non-Ferrous Metals	41.29	0.001009	0.000151	41.36
1.A.2.c - Chemicals	3.73	0.000066	0.000007	3.73
1.A.2.d - Pulp, Paper and Print	8.24	0.000145	0.000015	8.25
1.A.2.e - Food Processing, Beverages and Tobacco	150.30	0.002695	0.000277	150.45
1.A.2.f - Non-Metallic Minerals	129.25	0.002311	0.000236	129.37
1.A.2.h - Machinery	1.84	0.000032	0.000000	1.85
1.A.2.i - Mining (excluding fuels) and Quarrying	60.84	0.002146	0.000405	61.01
1.A.2.j - Wood and wood products	0.20	0.000003	0.000000	0.20
1.A.2.k - Construction	11.19	0.000255	0.000036	11.21
1.A.2.l - Textile and Leather	0.98	0.000017	0.000002	0.98
1.A.2.m - Non-specified Industry	2.95	0.000052	0.000005	2.95
1.A.3 - TRANSPORT	**1,591.58**	**1.7155**	**0.0808**	**1,652.66**
1.A.3.b - Road Transportation	1,568.16	1.7143	0.0796	1,628.83
1.A.3.e - Other Transportation	23.42	0.0012	0.0012	23.83
1.A.3.e.ii - Off-road	23.42	0.0012	0.0012	23.83
1.A.4 - OTHER SECTORS	**1,732.10**	**0.1606**	**0.0038**	**1,736.65**
1.A.4.a - Commercial/Institutional	486.55	0.0430	0.0009	487.74
1.A.4.b - Residential	1,166.66	0.1070	0.0022	1,169.60
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	78.88	0.0106	0.0006	79.30
1.A.4.c.ii - Off-road Vehicles and Other Machinery	78.88	0.0106	0.0006	79.30
1.B - FUGITIVE EMISSIONS FROM FUELS	**0.096**	**75.2664**	**NA**	**1,580.69**
1.B.2.b - Natural Gas	0.096	75.2664	NA	1,580.69
1.B.2.b.iii.4 - Transmission and Storage	0.002	52.2502		1,097.26
1.B.2.b.iii.5 - Distribution	0.094	23.0162		483.43

Categories	Emissions (Gg)		
	CO_2	CH_4	N_2O
Memo Items			
1.A.3.a.i - International Aviation (International Bunkers)	136.61	0.000976	0.003903
Information Items			
CO_2 from Biomass Combustion for Energy Production	727.8		

IPPU Sectoral Table, 2016

Categories	Gg			Emissions CO_2 eq. Gg	Emissions, Gg	
	CO_2	CH_4	N_2O	HFCs	NMVOCs	SO_2
2 - INDUSTRIAL PROCESSES AND PRODUCT USE	**134.438**	**NA**	**NA**	**637.704**	**8.427**	**43.763**
2.A - MINERAL INDUSTRY	**134.438**			**NA**	**NA**	**NA**
2.A.1 - Cement production	130.146			NA	NA	NA
2.A.3 - Glass production	4.291			NA	NA	NA
2.C - METAL INDUSTRY					NA	**43.763**
2.C.2 - Ferroalloys Production					NA	6.880
2.C.7 - Other - Copper Production					NA	36.883
2.D - NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE					**7.557**	**NA**
2.D.3 - Solvent Use					5.957	NA
2.D.4 - Other - Bitumen Use					1.6	NA
2.F - PRODUCT USES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES				**637.704**	**NA**	**NA**
2.F.1 - Refrigeration and Air Conditioning				606.670	NA	NA
2.F.1.a - Refrigeration and Stationary Air Conditioning				517.284	NA	NA
2.F.1.b - Mobile Air Conditioning				89.387	NA	NA
2.F.2 - Foam Blowing Agents				21.403	NA	NA
2.F.3 - Fire Protection				0.600	NA	NA
2.F.4 - Aerosols				9.030	NA	NA
2.H - OTHER					**0.870**	**NA**
2.H.2 - Food and Beverages Industry					0.870	NA

Emissions from product uses as substitute for ozone depleting substances for 2016 Gg CO_2 eq.

Categories	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	Total HFCs
2.F - Product Uses as Substitutes for Ozone Depleting Substances	22.719	211.749	223.141	1.371	178.124	0.600	**637.704**
2.F.1 - Refrigeration and Air Conditioning	22.719	211.749	194.079	NA	178.124	NA	**606.670**
2.F.1.a - Refrigera-tion and Stationary Air Conditioning	22.719	211.749	104.692	NA	178.124	NA	**517.284**
2.F.1.b - Mobile Air Conditioning	NA	NA	89.387	NA	NA	NA	**89.387**
2.F.2 - Foam Blowing Agents			20.431	0.973		NA	**21.403**
2.F.3 - Fire Protection		NA	NA			0.600	**0.600**
2.F.4 - Aerosols			8.632	0.398		NA	**9.030**

AFOLU Sectoral Table, 2016

Categories	Net CO_2 emissions / removals	Emissions, Gg		
		CH_4	N_2O	Total CO_2 eq.
3 - AGRICULTURE, FORESTRY, AND OTHER LAND USE	**-484.801**	**62.772**	**3.160**	**1,812.98**
3.A - LIVESTOCK	**NA**	**62.769**	**0.281**	**1,405.39**
3.A.1 - Enteric Fermentation	**NA**	**58.041**	**NA**	**1,218.85**
3.A.1.a - Cattle	NA	52.246	NA	1,097.16
3.A.1.a.i - Dairy Cows		29.738		624.50
3.A.1.a.ii - Other Cattle		22.508		472.66
3.A.1.b - Buffalo		0.039		0.81
3.A.1.c - Sheep		4.917		103.25
3.A.1.d - Goats		0.204		4.28
3.A.1.f - Horses		0.198		4.16
3.A.1.g - Mules and Asses		0.025		0.51
3.A.1.h - Swine		0.404		8.49
3.A.1.j - Other - Rabbits and Fur Bearing Animals		0.009		0.18
3.A.2 - Manure Management	**NA**	**4.729**	**0.281**	**186.54**
3.A.2.a - Cattle	NA	3.725	0.199	139.85
3.A.2.a.i - Dairy cows		3.244	0.134	109.68
3.A.2.a.ii - Other cattle		0.481	0.065	30.17
3.A.2.b - Buffalo		0.001	0.000	0.06
3.A.2.c - Sheep		0.098	0.048	16.95
3.A.2.d - Goats		0.004	0.002	0.67
3.A.2.f - Horses		0.012	0.002	0.90
3.A.2.g - Mules and Asses		0.002	0.000	0.13
3.A.2.h - Swine		0.809	0.024	24.53
3.A.2.i - Poultry		0.069	0.006	3.26
3.A.2.j - Other - Rabbits and Fur Bearing Animals		0.009	NA	0.18
3.B - LAND	**-485.832**	**NA**	**0.010**	**-482.71**
3.B.1 - Forest Land	**-547.242**	**NA**	**NA**	**-547.24**
3.B.1.a - Forest land Remaining Forest land	-541.072			-541.07
3.B.1.b - Land Converted to Forest land	-6.170	NA	NA	-6.17
3.B.1.b.i - Cropland converted to Forest Land	-6.170			-6.17
3.B.2 - Cropland	**0.779**	**NA**	**NA**	**0.78**
3.B.2.a - Cropland Remaining Cropland	0.670			0.67
3.B.2.b - Land Converted to Cropland	0.109	NA	NA	0.11
3.B.2.b.ii - Grassland Converted to Cropland	-7.438			-7.44
3.B.2.b.iv - Settlements Converted to Cropland	0.907			0.91
3.B.2.b.v - Other Land Converted to Cropland	6.640			6.64
3.B.3 - Grassland	**14.525**	**NA**	**NA**	**14.52**
3.B.3.a - Grassland Remaining Grassland	14.525			14.52
3.B.4 - Wetlands	**5.647**	**NA**	**0.010**	**8.77**
3.B.4.a.i - Peatlands Remaining Peatlands	5.647		0.010	8.77
3.B.5 - Settlements	**13.564**	**NA**	**NA**	**13.56**
3.B.5.b - Land Converted to Settlements	13.564	NA	NA	13.56
3.B.6 - Other Land	**26.895**	**NA**	**NA**	**26.90**
3.B.6.b - Land Converted to Other Land	26.895	NA	NA	26.90
3.B.6.b.ii - Cropland converted to Other Land	26.895			26.90
3.C - AGGREGATE SOURCES AND NON-CO_2 EMISSIONS SOURCES ON LAND	**1.030**	**0.002**	**2.868**	**890.30**
3.C.1 - Emissions from biomass burning	**NA**	**0.002**	**NA**	**0.04**
3.C.1.a - Biomass burning in forest lands		0.002	NA	0.03
3.C.1.c - Biomass burning in grasslands		0.001	NA	0.01
3.C.3 - Urea application	**1.030**			**1.03**
3.C.4 - Direct N_2O Emissions from managed soils			**2.056**	**637.32**
3.C.5 - Indirect N_2O Emissions from managed soils			**0.604**	**187.33**
3.C.6 - Indirect N_2O Emissions from manure management			**0.208**	**64.57**

Waste Sectoral Table, 2016

Categories	Emissions, Gg			
	CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
4 - WASTE	**4.314**	**26.201**	**0.216**	**621.62**
4.A - SOLID WASTE DISPOSAL	**NA**	**19.968**	**NA**	**419.32**
4.C - INCINERATION AND OPEN BURNING OF WASTE	**4.314**	**0.621**	**0.011**	**20.83**
4.C.2 – Open Burning of Waste	4.314	0.621	0.011	20.83
4.D - WASTEWATER TREATMENT AND DISCHARGE	**NA**	**5.612**	**0.205**	**181.47**
4.D.1 – Domestic Wastewaster Treatment and Discharge		4.104	0.205	149.81
4.D.2 - Industrial Wastewater Treatment and Discharge		1.507		31.65

Summary report for national greenhouse gas inventory, 2016

Categories	Emissions, Gg			Emissions $CO_{2\ eq.}$ (Gg)			Emissions, Gg			
	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NOx	CO	NMVOCs	SO_2
Total National Emissions and Removals	4,600.575	166.145	3.464	637.704	NA	NA	11.884	26.165	11.042	43.817
1 - Energy	4,946.624	77.1727	0.088				11.884	26.165	2.615	0.054
1.A - Fuel Combustion Activities	4,946.528	1.90632	0.088				11.884	26.165	2.615	0.054
1.A.1 - Energy Industries	1,182.599	0.02091	0.002				1.861	0.815	0.054	NA
1.A.2 - Manufacturing Industries and Construction	440.249	0.00925	0.001				0.942	0.25	0.174	NA
1.A.3 - Transport	1,591.581	1.71551	0.081				7.547	24.222	2.326	0.053
1.A.4 - Other Sectors	1,732.099	0.16065	0.004				1.534	0.878	0.061	0.001
1.B - Fugitive emissions from fuels	0.096	75.2664	NA				NA	NA	NA	NA
1.B.2 - Oil and Natural Gas	0.096	75.2664	NA				NA	NA	NA	NA
2 - Industrial Processes and Product Use	134.438	NA	NA	637.704	NA	NA	NA	NA	8.427	43.763
2.A - Mineral Industry	134.438						NA	NA	NA	NA
2.A.1 - Cement Production	130.146						NA	NA	NA	NA
2.A.2 - Lime Production	4.291						NA	NA	NA	NA
2.C - Metal Industry	NA						NA	NA	NA	43.763
2.C.2 - Ferroalloys Production	NA						NA	NA	NA	6.88
2.C.7 - Other - Copper Production	NA						NA	NA	NA	36.883
2.D - Non-Energy Products from Fuels and Solvent Use	NA						NA	NA	7.557	NA
2.D.1 - Lubricant Use	NE						NE	NE	NE	NE
2.D.2 - Paraffin Wax Use	NE						NE	NE	NE	NE
2.D.3 - Solvent Use							NA	NA	5.957	NA
2.D.4 - Other - Bitumen Use	NA						NA	NA	1.6	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances				637.704			NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning				606.670			NA	NA	NA	NA
2.F.2 - Foam Blowing Agents				21.403			NA	NA	NA	NA
2.F.3 - Fire Protection				0.600	NA		NA	NA	NA	NA
2.F.4 - Aerosols				9.030			NA	NA	NA	NA
2.F.5 - Solvents				NE	NE		NE	NE	NE	NE
2.F.6 - Other Applications				NE	NE		NE	NE	NE	NE
2.H - Other	NA	NA	NA				NA	NA	0.87	NA
2.H.2 - Food and Beverages Industry	NA	NA					NA	NA	0.87	NA

Categories	Emissions, Gg			Emissions $CO_{2\ eq.}$ (Gg)			Emissions, Gg			
	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NOx	CO	NMVOCs	SO_2
3 - Agriculture, Forestry, and Other Land Use	-484.801	62.772	3.160				NA	NA	NA	NA
3.A - Livestock	NA	62.769	0.281				NA	NA	NA	NA
3.A.1 - Enteric Fermentation		58.041					NA	NA	NA	NA
3.A.2 - Manure Management		4.729	0.281				NA	NA	NA	NA
3.B - Land	-485.832	NA	0.010				NA	NA	NA	NA
3.B.1 - Forest land	-547.242						NA	NA	NA	NA
3.B.2 - Cropland	0.779						NA	NA	NA	NA
3.B.3 - Grassland	14.525						NA	NA	NA	NA
3.B.4 - Wetlands	5.647		0.01				NA	NA	NA	NA
3.B.5 - Settlements	13.564						NA	NA	NA	NA
3.B.6 - Other Land	26.895						NA	NA	NA	NA
3.C - Aggregate sources and non-CO_2 emissions sources on land	1.030	0.002	2.868				NA	NA	NA	NA
3.C.1 - Emissions from biomass burning		0.002	NA				NA	NA	NA	NA
3.C.3 - Urea application	1.030						NA	NA	NA	NA
3.C.4 - Direct N_2O Emissions from managed soils			2.056				NA	NA	NA	NA
3.C.5 - Indirect N_2O Emissions from managed soils			0.604				NA	NA	NA	NA
3.C.6 - Indirect N_2O Emissions from manure management			0.208				NA	NA	NA	NA
4 - Waste	4.314	26.201	0.216				NA	NA	NA	NA
4.A - Solid Waste Disposal	NA	19.968	NA				NA	NA	NA	NA
4.C - Incineration and Open Burning of Waste	4.314	0.621	0.011				NA	NA	NA	NA
4.D - Wastewater Treatment and Discharge	NA	5.612	0.205				NA	NA	NA	NA
Memo Items										
International Bunkers	136.615	0.001	0.004				NA	NA	NA	NA
1.A.3.a.i - International Aviation (International Bunkers)	136.615	0.001	0.004							
Information Items										
CO_2 from Biomass Combustion for Energy Production	727.8									

Annex II. List of climate change and environmental topics related scientific research works in 2015-2018

List of scientific topics for climate change and environmental studies, funded in the framework of the "Contractual (Thematic) funding competition of scientific and scientific-technical activities - 2015"

	Project title	Organization
1.	Towards green electronic infrastructures	Institute of Informatics and Automation Problems, RA NAS
2.	Structural and stratigraphic peculiarities of the south-western section of Sevan basin from the perspective of tectonic development	Institute of Geological Sciences, RA NAS
3.	Assessment of the impact of mining industry on the water quality of surface springs of drinking water supply in the towns of Kapan, Kajaran, Meghri and Agarak	Ecological-Noosphere Research Centre, RA NAS
4.	Radioecological monitoring in the RA territory	Ecological-Noosphere Research Centre, RA NAS
5.	Development of a methodology for geochemical exploration of the potential of natural resources of raw material of rare metals and their mines in the RA	YSU, RA Ministry of Education and Science
6.	Development of a new measuring method of electrical prospecting for the studies of mineral geological objects	Institute of Geological Sciences, RA NAS
7.	Problems of effective use of groundwater in Armenia and ways of their solution	Institute of Water Problems and Hydro-Engineering named after I.V. Yeghiazarov CJSC
8.	Risk assessment of mercury pollution in the territory of Armenia	Ecological-Noosphere Research Centre, RA NAS
9.	Assessment of small hydropower plant impact on river ecosystems in Armenia (by the example of Arpa River catchment basin)	Scientific Centre of Zoology and Hydroecology, RA NAS
10.	New approach to the use of carbon-containing products and wastes: hydrogen production in separate and mixed cultures of dark- and light-fermentative bacteria	YSU, RA Ministry of Education and Science
11.	In situ and ex situ assessment of adaptive bioecological characteristics of some of the rare plant species in the Ararat Valley	Institute of Botany, RA NAS
12.	The importance of Armenia's cultivated and wild grapevine biodiversity in the environmental balance	Branch of Scientific Centre of Viticulture, Fruit-Growing and Wine-Making, ANAU, RA Ministry of Education and Science
13.	Study of anthropogenic factor on biodiversity in northern regions of Armenia	YSU, RA Ministry of Education and Science
14.	Ecological-biological aspects of assessment of decorativeness of tree plants and their usage in landscaping	Institute of Botany, RA NAS
15.	Study of the dynamics of populations of some invasive and expansive plant species in Armenia	Institute of Botany, RA NAS
16.	Landscape degradation processes in Armenia and development of preventive measures under the conditions of desertification	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
17.	Migration of heavy metals and assessment of pollutions in the water-soil-plant chain by use of phyto-indication	National Polytechnic University of Armenia, RA Ministry of Education and Science

	Project title	Organization
18.	Development of measures for the establishment of hydraulic design condition for complex gravitation pressure sewers	Institute of Water Problems and Hydro-Engineering named after I.V. Yeghiazarov CJSC
19.	Study of environmental objects in urban areas of Armenia for parasitic contamination posing danger for animal and human health	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
20.	Study of the peculiarities of application of vegetable crop vaccination method in greenhouse conditions	Scientific Centre of Vegetables and Industrial Crops, RA MoA
21.	The problems of improving natural grasslands in current conditions	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
22.	Reduction of pollution of ecologically vulnerable land areas and their quality improvement through plants in mining regions of the RA Syunik marz	YSU, RA Ministry of Education and Science
23.	Reclamation of weak saline-alkali soils with ammonium sulphate	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
24.	Study of deterioration processes of the meliorative condition of the Ararat Valley soils due to the decline in groundwater level	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
25.	In vitro restoration and preservation of endangered and rare species of plants of local origin	Branch of Scientific Centre of Agrobiotechnology, ANAU, RA Ministry of Education and Science
26.	Prediction of mudflows and floods in Armenia, ways of protecting agricultural areas and settlements from them	Pascal LLC

List of scientific topics for climate change and environmental studies funded in the framework of the "Contractual (Thematic) funding competition of scientific and scientific-technical activities - 2018"

	Project title	Organization
1.	Development of remote sensing method for the study of thermic fields in the territory of Yerevan	Ecological-Noosphere Research Centre, RA NAS
2.	Radioecological monitoring in the territory of the Republic of Armenia: stage 2	Ecological-Noosphere Research Centre, RA NAS
3.	Ecological-geochemical research as a basis for decision-making (by the example of Alaverdi town)	Ecological-Noosphere Research Centre, RA NAS
4.	Ecological peculiarities of backwaters of Lake Sevan under water level fluctuations	Scientific Centre of Zoology and Hydroecology, RA NAS
5.	From organic waste to biohydrogen: waste pre-processing and regulation of the processes of triggering H2 production in bacteria	YSU, RA Ministry of Education and Science
6.	Hydroponic production of juniper and plane tree (Juniperus, Platanus) seedlings and its prospects	Institute of Hydroponics Problems named after G. Davtyan, RA NAS
7.	Determination of bioindicators for implementation of biodiversity monitoring programs of YSU Foundation in protected areas of Armenia	YSU, RA Ministry of Education and Science

	Project title	Organization
8.	Ex situ conservation of some endangered species of the flora in Armenia through micro-propagation and creation of seed collections	Institute of Botany, RA NAS
9.	Biodiversity and ecological function of Archaeans in geothermal springs of Nagorno Karabakh	YSU, RA Ministry of Education and Science
10.	Perspective developments of the RA fuel and energy complex in the context of large-scale integration of renewable energy sources	Scientific Research Institute of Energy CJSC of the RA Ministry of Energy Infrastructures and Natural Resources
11.	Solar equipment heat accumulator-air heater	National Polytechnic University of Armenia, RA Ministry of Education and Science
12.	Modelling and development of automated cleaning systems for solar panels	National Polytechnic University of Armenia, RA Ministry of Education and Science
13.	Comprehensive method of cultivation of plant raw materials for the production of ecologically pure foodstuff, food additives and halide preparations	Armbiotechnology Scientific and Production Centre, RA NAS
14.	Ways of reducing carbon dioxide emissions from gas-powered motor vehicles under the Armenian exploitation conditions	ANAU, RA Ministry of Education and Science
15.	Risk assessment of heavy metals in food products sold in the city of Yerevan	Ecological-Noosphere Research Centre, RA NAS
16.	Development of complex measures for the propagation of organic seeds of vegetable crops (tomatoes, bell pepper, cucumber)	Scientific Centre of Vegetables and Industrial Crops, RA MoA
19.	Evaluation of resistance of new varieties of cereal grains (barley, spelt, wheat, rye) to abiotic factors under conditions of climate change	ANAU, RA Ministry of Education and Science
20.	Compatibility study of pesticides used against agricultural crop pests and diseases and publication of consultation materials	Food Safety Risk Assessment and Analysis Scientific Centre, RA MoA
21.	Assessment of groundwater quality and its impact on soil salinization in the Ararat Valley by using Irrigation Water Quality Indicator (IWQI) and geostatistical methods	YSU, RA Ministry of Education and Science
22.	Opportunities of waste utilization of cement and copper produced in Armenia in the context of chemical amelioration of saline-alkaline soils of the Ararat Valley	Branch of Scientific Centre of Soil Science, Agrochemistry and Melioration named after H. Petrosyan, ANAU, RA Ministry of Education and Science
23.	Development and introduction of a new and effective technology for the control of the harmful flora of irrigation and drainage systems of the Ararat Valley	Food Safety Risk Assessment and Analysis Scientific Centre of the, RA MoA
24.	Production of phylloxera-resistant rootstock of grapevine by application of biotechnological methods	Branch of Scientific Centre of Agrobiotechnology, ANAU, RA Ministry of Education and Science
25.	Key standards of the “soil-plant” system of rural pastures and the possibility of prediction of vegetation restoration	Ecological-Noosphere Research Centre, RA NAS
26.	Problems of enhancing automation efficiency and ecological safety of technological processes in the control of crop diseases and pests	ANAU, RA Ministry of Education and Science

List of projects related to climate change issues implemented in the framework of "SCS-BRFFR-2014"[164] competition held with the funds allocated from the RA state budget for international scientific cooperation

	Project title	Organizations Involved
1.	Examination of microalgae and cyanobacteria producing unsaturated fatty acids under the influence of 5-aminolevulinic acid esters from ecological and biological perspective	Armbiotechnology Scientific and Production Centre, RA NAS Institute of Bioorganic Chemistry of the National Academy of Sciences of Belarus
2	Comparative analysis of microbial flora of trout fish produced in Armenia and Belarus for the development of rapid identification methods	YSU, RA Ministry of Education and Science Belarusian Research and Design Institute of Fish Industry
3	Promotion of plant growth and development by using bacterial melanin synthesized by insecticidal strain of Bacillus thuringiensis K1	Armbiotechnology Scientific and Production Centre, RA NAS Central Botanical Garden of the National Academy of Sciences of Belarus
4	Evaluation of productive capacity and resource potential of long-clawed crayfish in the ponds of Armenia and Belarus	Institute of Hydroecology and Ichthyology of the Scientific Centre of Zoology and Hydroecology, RA NAS Scientific and Practical Centre for Bioresources of the National Academy of Sciences of Belarus
5	Development of a method for generation of new bactericides for the control of infectious diseases of agricultural animals and birds	Armbiotechnology Scientific and Production Centre, RA NAS Institute of Physical and Organic Chemistry of the National Academy of Sciences of Belarus

[164] State Committee of Sciences, Belarusian Republican Foundation for Fundamental Research

Annex III. Hydrological observation network of NHMS, 2017

№	River/channel name	Observation post	Coordinate	
			Latitude	Longitude
1	2	3	4	5
1	Pambak	Shirakamut	40.8511	44.2350
2	Pambak	Vanadzor	40.8233	44.4635
3	Pambak	Gugarq	40.8160	44.5441
4	Pambak	Tumanyan	40.9373	44.6291
5	Debed	Ayrum	41.1904	44.8985
6	Lernajur	Lernapat	40.8293	44.3893
7	Tandzut	Vanadzor	40.8069	44.4993
8	Alareqs	Debet	40.9187	44.6442
9	Dzoraget	Stepanavan	41.0134	44.3823
10	Dzoraget	Gargar	40.9555	44.5935
11	Tashir	Saratovka	41.0732	44.3132
12	Gargar	Kurtan	40.9599	44.5517
13	Marciget	Tumanyan	40.9862	44.6531
14	Aghstev	Fioletovo	40.7172	44.7303
15	Aghstev	Dilijan	40.7621	44.9152
16	Aghstev	Ijevan	40.8784	45.1437
17	Getik	Gosh	40.7450	45.0247
18	Paghjur	Getahovit	40.9023	45.1386
19	Kiranc	Acharkut	41.0348	45.0829
20	Hakhum	Tsaghkavan	40.9359	45.3345
21	Tavush	Berd	40.8759	45.3982
22	Araks	Surmalu	40.0694	43.7970
23	Akhuryan	Paghakn	41.0651	43.6621
24	Akhuryan	Amasya	40.9490	43.7901
25	Akhuryan	Kaps	40.8878	43.4082
26	Akhuryan	Akhurik	40.7369	43.7782
27	Akhuryan	Haykadzor	40.5386	43.6506
28	Akhuryan	Bagaran	40.1369	43.6506
29	Dzknut	Zorakert	41.0949	43.6605
30	Ashocq	Krasar	41.0301	43.8206
31	Illiget	Jradzor	40.9098	43.7656
32	Karkachan	Gharibjanyan	40.7343	43.7874
33	Jajur	Jajur	40.8476	43.9474
34	Metsamor	Taronik	40.1239	44.1868
35	Metsamor	Ejmiatsin	40.0674	44.2859
36	Metsamor	Ranchpar	40.0307	44.3679
37	Qasakh	Vardenis	40.5711	44.4094
38	Qasakh	Hartavan	40.4788	44.4411
39	Qasakh	Ashtarak	40.2901	44.3587
40	Gegharot	Aragats	40.4872	44.3677
41	Shaghvard	Parpi	40.3351	44.3138
42	Channel HPP	Geghamavan	40.5680	44.8995
43	Hrazdan	Hrazdan	40.5224	44.7682
44	Hrazdan	Argel	40.3809	44.6054
45	Hrazdan	Yerevan	40.1593	44.4898
46	Hrazdan	Hovtashen	40.0228	44.4419
47	Marmarik	Hanqavan	40.6351	44.4863
48	Marmarik	Aghavnadzor	40.5715	44.6910
49	Gomraget	Meghradzor	40.6019	44.6554
50	Tsaghkadzor	Tsaghkadzor	40.5364	44.7198
51	Dzknaget	Tsovagyugh	40.6176	44.9619
52	Drakhtik	Drakhtik	40.5462	45.2122
53	Pambak	Pambak	40.3849	45.5341

№	River/channel name	Observation post	Coordinate	
			Latitude	Longitude
1	2	3	4	5
54	Masrik	Tsovak	40.2189	45.6523
55	Karchaghbyur	Karchaghbyur	40.1792	45.5822
56	Channel Arpa Sevan	Tsovinar	40.1563	45.4947
57	Vardenis	Vardenik	40.1328	45.4428
58	Martuni	Geghhovit	40.0971	45.2831
59	Argichi	Verin Getashen	40.1312	45.2549
60	Tsaghkashen	Vaghashen	39.9980	45.2109
61	Lichq	Lichq	40.1669	45.2432
62	Bakhtak	Tsakqar	40.1683	45.2207
63	Gavaraget	Noratus	40.3775	45.1711
64	Azat	Garni	40.1097	44.7345
65	Vedi	Urcadzor	39.9230	44.8264
66	Arpa	Jermuk	39.8378	45.6767
67	Arpa	Eghegnadzor	39.7412	45.3247
68	Arpa	Areni	39.7322	45.2005
69	Vayq	Zaritap	39.6289	45.5071
70	Gladzor	Vernashen	39.7905	45.3605
71	Eghegis	Hermon	39.8765	45.4274
72	Eghegis	Shatin	39.8208	45.2964
73	Artabun	Artabuynq	39.8554	45.3179
74	Salimaget	Shatin	39.8305	45.2961
75	Meghriget	Meghri	38.9149	46.2314
76	Voghji	Qajaran	39.1499	46.1545
77	Voghji	Kapan	39.2050	46.4121
78	Geghi	Kavchut	39.2065	46.2474
79	Vachagan	Kapan	39.1985	46.3956
80	Vorotan	Gorayq	39.6865	45.7758
81	Vorotan	Vorotan	39.4881	46.1371
82	Vorotan	Tatev Hydro power	39.4273	46.3733
83	Tsghuk	Tsghuk	39.6684	45.8443
84	Gorisget	Goris	39.5192	46.3329
85	Sisian	Ashotavan	39.4665	45.9875
86	Araks	Meghri	38.8851	46.2635

№	Lake/reservoir name	Observation post	Coordinate	
			Latitude	Longitude
1	3	4	5	6
87	Arpilich reservoir	Paghakn	41.0674	43.6532
88	Akhuryan reservoir	Jrapi	40.5626	43.6455
89	Aparan reservoir	Hartavan	40.4848	44.4382
90	Lake Sevan	Sevan	40.5628	45.0084
91	Lake Sevan	Shorja	40.4972	45.2700
92	Lake Sevan	Karchaghbyur	40.1783	45.5644
93	Lake Sevan	Martuni	40.1623	45.3076
94	Marmarik reservoir	Artavaz	40.6228	44.5616
95	Azat reservoir	Lanjazat	40.0655	44.5960

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