REPUBLIC OF ARMENIA

THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

UNDER THE UNITED NATIONS
FRAMEWORK CONVENTION
ON CLIMATE CHANGE

REPUBLIC OF ARMENIA
MINISTRY OF NATURE PROTECTION

THIRD NATIONAL COMMUNICATION

ON CLIMATE CHANGE

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION

ON CLIMATE CHANGE

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FOREWORD

One of the biggest challenges faced by mankind is global climate change, which can be addressed by joint efforts made by all countries.

The Republic of Armenia ratified the UN Framework Convention on Climate Change in May 1993, and the Kyoto Protocol in December 2002. Armenia as a Non-Annex I Party to the Convention, and is regularly implementing obligations pursuant to its status.

The development of the Third National Communication of the Republic of Armenia on Climate Change and submission to the Conference of the Parties to the Convention is the country's basic obligation. This Communication includes information on emission of greenhouse gases in the country and their removal from the atmosphere for the period covering 2007-2012.

The share of emissions of the Republic of Armenia to global emissions is small, and it is currently estimated to be around 0.017% of the global level. As a Non-Annex I party to the Convention, Armenia does not have quantitative commitments for reducing greenhouse gas (GHG) emissions. However, in responding to global efforts to reduce GHG emissions, the Republic of Armenia is voluntarily implementing activities to reduce GHG in particular and mitigate climate change; for that purpose, the country is consistently including climate change issues in national development programmes.

Climate change adaptation is a priority issue for the Republic of Armenia. As a mountainous, landlocked country it is characterized by the vulnerability of ecosystems, arid climate, active exogenous and desertification processes, and frequent natural disasters. These make Armenia more sensitive to current and projected climate change impacts.

The Republic of Armenia continues to implement awareness-raising campaigns among the general public on climate change issues, aimed at reducing climate change risks for the country and enhancing capacity building for adaptation to projected climate change.

This National Communication also describes the position of the Republic of Armenia for addressing climate change issues and measures implemented and planned, as well as the country's needs for further steps and activities.

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 Third National Communication, and to national experts and professional institutions for their contributions.

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ABBREVIATIONS

AFOLU	Agriculture, forestry and other land use
AKC	Analysis of key categories
AMD	Armenian Dram
CDM	Clean development mechanism
CIS	Commonwealth of Independent States
CJSC	Closed joint stock company
EBRD	European Bank for Reconstruction and Development
EU	European Union
FNC	First National Communication
GCOS	Global Climate Observing System
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GPG	Good practice guidance
HPP	Hydropower plant
Hydromet Service	"Armenian State Hydrometeorological and Monitoring Service" of the Ministry of Emergency Situations of the Republic of Armenia[1]
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial process and product use
KfW	German Bank for Reconstruction and Development
LULUCF	Land use, land use change and forestry
MSW	Municipal solid waste
N/A	Not available
N/E	Not estimated
NAMA	Nationally appropriate mitigation actions
NAP	National adaptation plan
NEEAP	National energy efficiency action plan
NGO	Non-governmental organization
NPP	Nuclear power plant
NSS	National Statistical Service
RA	Republic of Armenia
RE	Renewable energy
SNC	Second National Communication
SNCO	State non-commercial organization
SPAN	Specially protected area of nature
SW	Solid waste
TNC	Third National Communication
TPP	Thermal power plant
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency of International Development
USD	United States Dollar

[1] TNC information is as of January 2013. According to the amendment of the RA law on "The structure of the RA Government", dated 17 November 2014, the RA Ministry of Territorial Administration and the RA Ministry of Emergency Situations have been united and the RA Ministry of Territorial Administration and Emergency Situations has been formulated.

USSR	Union of Soviet Socialist Republics
WB	World Bank
WMO	World Meteorological Organization
WTO	World Trade Organization

Units of Measurement

mm	millimetre
m	metre
m^3	cubic metre
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
ha	hectare
Gg	gigagram (10^9 g)
t	tonne
toe	tonnes oil equivalent
PJ	petajoule (10^{15} J)
GWh	gigawatt hour (10^6 kWh)
MW	megawatt
m/sec	metres per second
^0C	degree Celsius

Chemical Combinations

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

Energy Units Conversion

1 toe = 41.85 GJ
1 PJ = 277.8 GWh=23.88 * 10^3 toe

EXECUTIVE SUMMARY

The Third National Communication (TNC) on Climate Change of the Republic of Armenia (Armenia) was developed according to Articles 4.1 and 12.1 of the United Nations Framework Convention on Climate Change (UNFCCC) and the Guidelines for national communications of Non-Annex I Parties to the Convention (UNFCCC 2003).

The First National Communication (FNC) on Climate Change was submitted by Armenia in 1998, which covered the period of 1990-1996. The Second National Communication (SNC) on Climate Change was submitted in 2010, which covered the period of 1996-2006.

TNC covering the period of 2007-2012 has extended the studies on and assessments of climate change-related issues. Recent developments in the country, as well as under the Convention, that took place after SNC submission were also considered in TNC.

Actions implemented under the Third National Communication enable Armenia to:

- Improve and expand the database of the national GHG inventories and analyze the emission trends for 1990-2010;
- Make corrections in baseline and climate-mitigation scenarios and assess future indicators until 2030 under new sectorial programmes facilitating reduction in emissions for all categories of GHG emission sources;
- Assess the potential for reducing GHG emissions from various sectors of the economy;
- Make corrections in climate change scenarios for Armenia;
- Assess, based on additional studies, the vulnerability of ecosystems and climate-dependent sectors of the economy and identify priority adaptation measures for mitigating the consequences of climate change impact;
- Assess the impact of the projected intensification of hazardous hydrometeorological phenomena and the related early warning and notification needs;
- Identify improvement needs for the national system of systematic observation and climate monitoring;
- Enhance knowledge and public awareness on climate change issues and promote expertise improvement for climate change specialists.

S-1. National Circumstances

State structure

The Republic of Armenia was established on 21 September 1991.

Yerevan is the capital city of the Republic of Armenia.

According to the Constitution (1995), the Republic of Armenia is a sovereign, democratic, and social state governed by the rule of law. State power exercised in the Republic of Armenia is based on the principle of the separation and balance of the legislative, executive and judicial powers.

The president of the Republic of Armenia is the head of state. The president of the Republic is elected by the citizens of the Republic of Armenia for a five-year term of office.

Legislative power in the Republic of Armenia is vested in the National Assembly, elected for a five-year term.

The government is comprised of the prime minister, deputy prime minister and ministers. Currently, the government includes 19 ministries and 10 government agencies – services, departments, and committees.

The Republic of Armenia has a three-tier governance system – central state governance, regional state governance (marzes), and local self-governance (communities).

The administrative-territorial units of the Republic of Armenia are marzes and communities. The Republic of Armenia is divided into 10 marzes and 931 communities: 60 urban and 871 rural (2012).

The Republic of Armenia is a member state of the United Nations since 2 March 1992. It is a member of: the Commonwealth of Independent States (CIS) since 21 December 1991; the Black Sea Economic Cooperation (BSEC) since 1 May 1999; the Council of Europe since 25 January 2001, and the World Trade Organization (WTO) since 5 February 2003. Since 1993, the Republic of Armenia is a party to the United Nations Framework Convention on Climate Change (UNFCCC). In 2002, Armenia ratified the Kyoto Protocol.

As of 2013, the Republic of Armenia has established and is maintaining diplomatic relations with 160 states around the world.

Geographical position and natural resources

The Republic of Armenia is located in the northeast of the Armenian Highlands, at the border of the Caucasus and Western Asia. In the north, Armenia borders with Georgia, in the east – Azerbaijan, in the west and southwest – Turkey, and in the south – Iran.

The territory of the Republic of Armenia covers 29,743 km^2.

Armenia is a mountainous country: 76.5% of the territory is in the altitudes of 1,000-2,500 metres above sea level.

According to the 2006 Land Balance of Armenia, agricultural land accounts for 69%, forest – 11.5%, specially protected areas of nature – 12.4%, wetlands – 0.9%, settlements, industries, communications, transport and utility infrastructure – 5.4%, and other land types – 1.7% of the territory of Armenia.

The biodiversity of Armenia is rich. There are more than 100 species per square kilometre. Specially protected areas of nature (SPAN), including 3 state reserves, 4 national parks, and 26 reservations are established for the conservation of biodiversity in Armenia.

Armenia's rivers are influents of the largest rivers of the South Caucasus: Araks and Kura. About 9,500 small and medium rivers flow in Armenia, with a total length of 25,000 kilometres. The longest rivers are: Akhurian (168 km), Araks (158 km), Vorotan (119 km), Debed (154 km), and Hrazdan (141 km). Distribution of river network density in the country varies within the range of 02.5 km/km^2. The distribution of river flows in Armenia is highly uneven in terms of both annual and multiyear balance.

The average annual flows of surface waters amount to 6.8 billion cubic meters; the stock of ground water resources is about 4.0 billion cubic metres.

The largest lake in Armenia is Lake Sevan – one of the highest mountain freshwater lakes in the world. In 2012, the level of the lake reached 1,900.13 metres; the surface area was 1,276 km^2, and the volume 37.9 km^3. There are also about 100 small mountain lakes in Armenia with a total volume of 0.8 km^3.

Armenia is peculiar for its high seismic and exogenic processes, which provoke landslides and erosion. The frequency and intensity of hydro-meteorological phenomena also trigger emergencies, causing significant damage to the population and the economy.

Climate

Armenia is a country of climatic contrasts: because of intricate terrain, one can find high climate diversity over even a small territory. The country has almost all types of climate, from arid subtropical to cold high mountainous climates.

The average annual ambient air temperature is 5.5°C. The highest annual average temperature is 12-14°C. The average annual temperature is below zero in altitudes above 2,500 m.

The summer is temperate: the temperature at the end of July is 16.7°C, while in Ararat valley it ranges between 24-26°C. The recorded absolute highest temperature is 43.7°C.

Winters are cold. January is the coldest winter month, with an average temperature of -6.7°C. The recorded absolute lowest temperature is -42°C. Winters in the northeastern and southeastern parts of the country are temperate.

The average annual precipitation amounts to 592 mm. The most arid zones are the Ararat Valley and Meghri region, with annual precipitation of around 200-250 mm. The highest precipitation is observed in high mountainous areas: about 1000 mm per year. The average precipitation in Ararat valley does not exceed 32-36 mm in summer months.

The average annual wind velocity in the territory of Armenia is unevenly distributed, in the range of 1.0-8.0 m/sec. Mountain winds are quite common for some regions, particularly for Ararat valley. In summer their velocity reaches to 20 m/sec and over.

Population

The population of the Republic of Armenia as of the end of 2012 was 3,027 thousand, and the average population density was 102 persons/km^2.

The distribution of the population is very uneven, which is due to the mountainous terrain of the country and various levels of regional economic development. The maximum popu-

lation density is 686 persons/km^2 living in altitudes up to 1,000 m, while the minimum (22 persons/km^2) is recorded in altitudes of 2,000-2,500 m.

The urban and rural population is 63.3% and 36.7% respectively (2012).

The largest cities include Yerevan (1,066.3 thousand residents), Gyumri (121.3 thousand residents), and Vanadzor (87.7 thousand residents). These cities account for 66.4% of the urban and 42% of the total population of Armenia.

Men and women constitute 48% and 52% of the population respectively (2012). The average life expectancy is 74.3 years: 70.9 years for men and 77.5 years for women.

The number of the economically active population is 1,173 thousand (2012).

Economy

By overcoming the difficulties of the transition period after the dramatic economic decline in 1991-1993, Armenia was able to ensure economic stability and growth. Annual economic growth in 1995-2000 was 5.4%, and in 2001-2006 it was 12.4%. The economy declined by 14.1%, caused by the 2009 global economic crisis. The average annual economic growth in 2007-2012 was 3.3%.

Armenia's gross domestic product (GDP) in 2012 amounted to AMD 3,998 billion (USD 9,950 million, equivalent to USD 19,700 million in purchasing power parity (PPP)); per capita PPP was USD 6,508. Structural changes of the economy resulted in changes in GDP structure, with a decrease in manufacturing and an increase in services. In 2012, GDP had the following structure: manufacturing – 17.9%, agriculture – 19.1%, construction – 13.2%, services – 42.7%, and net taxes – 7.8%.

Priority issues for the economic development of the country are addressed in the 2012-2025 Strategy Programme for Long-term Development of the Republic of Armenia.

Energy

There are no local fuel resources in Armenia and the country meets its fuel demand through imports. Primary energy resources available in the country (hydro-energy and nuclear energy) meet about 36% of total demand.

The main fuel is natural gas. In 2000-2010, the share of natural gas in total fuel consumption amounted to 68-74%. Natural gas (50.4%) and nuclear energy (22.4%) prevail in the structure of total energy consumption.

In 2010, total energy consumption in Armenia amounted to 121.3 PJ (36% of the 1990 level). The main fuel consumers include housing (31.3%), transport (26.3%), and power generation (20.1%).

Power is generated by thermal power plants (TPP), and nuclear power plant (NPP) and hydro-power plants (HPP). Power generation in 2012 totalled 8,036 GWh, including: 42% generated by TPPs, 29% generated by NPP, and 29% generated by HPPs.

The economic and energy crisis in 1992-1994 and the cancellation of subsidies resulted in the collapse of the heat-supply system. In 2010, the total heat-energy production for industrial and municipal needs amounted to only 15% of the 1990 volume. Apartment-level gas-fired and electrical appliances are mainly installed for heating and hot water in the housing sector. Implementation of programmes for phased rehabilitation of district heating systems using energy-efficient technologies started in 2005. Rehabilitation of heat-supply systems of the public/commercial sector has been restored at fast rates. In the period of 2000-2010, the generation of thermal energy doubled.

The rapid rate of gas-supply/distribution-system development is an important factor in sustainable energy supply. In 2010, gas-supply/distribution-system coverage reached 96%.

The *Concept for Ensuring Energy Security of the Republic of Armenia* (2013) and a number of programme documents define Energy sector development strategy and the means for creating safe, effective and sustainable operating conditions. The strategy is envisaged to develop renewable, alternative, and nuclear energy, and ensure energy saving.

Industry

In 2012, industrial output in Armenia amounted to 102% of the 1990 level.

The structure of industrial output of Armenia by types of industry includes: processing industries – 62.3%; mining – 17.8%; electricity, gas and steam supply – 18.3%; water supply,

sewage, and waste management – 1.6% (2012).

The processing industry includes: food production (54%), metallurgy (23.5%), production of construction materials (6.95%), production of chemicals (4.1%), machine building (4.4%), jewellery products (1.5%), light-industry products (1.1%), and other industries (4.5%).

The share of manufacturing in total fuel consumption is 9.5%.

Transport

The Transport sector in Armenia includes railways, road, air, and pipeline transportation mains.

Since 1990, the Armenian Transport sector has undergone significant changes as a result of the collapse of USSR, the poor economic environment, significant structural changes in the economy, and the transport blockade. Compared to 1990, cargo transportation in 2012 (without pipeline mains) was 27-fold less, and the overall cargo turnover less by factor of 7.3. Overall passenger transportation fell by a factor of 2.7.

In 2012, the share of main pipeline transportation in the total volume of cargo turnover amounted to 69.1%, railway transport – 20.9%, road transport – 9.6%, and air transport – 0.5%. For overall passenger transportation, the share of road transport was 70.6%, air transport – 20.9%, and rail transport – 1.5%.

The Transport sector accounts for 26% of total energy consumption in the country.

Agriculture

The total area of agricultural land in Armenia covers 2,052.4 thousand hectares (2012), including: arable land – 448.4 thousand hectares (21.9%), perennial plantations – 33.4 thousand hectares (1.6%), grasslands – 121.6 thousand hectares (5.9%), pasture – 1,056.3 thousand hectares (51.5%), and other land – 392.7 thousand hectares (19.1%). The surface area of perennial plantations in gardens and orchards in settlements amounts to 23.8 thousand hectares.

Farming in Armenia is irrigation based: more than half of agricultural land is irrigated. The main agricultural crops are cereals, potatoes, fruits, grapes, and vegetables. Main livestock production covers large and small cattle (sheep and goats).

Due to the agrarian reform and land privatization, large agricultural farms have been broken down into 340 thousand small family farms. The areas and structure of agricultural lands has changed: croplands and perennial plantations have been reduced by around 40% each. The livestock population is also lower. The area of irrigated land has been halved and the use of mineral fertilizers has declined threefold.

In 2000-2006 and in 2007-2012 the average annual growth in agricultural production amounted to 7.7% and 2.2% respectively. In recent years, the share of crop production is 60%, while the share of livestock production makes up 40% of gross agricultural production.

The share of agriculture in GDP in 2007-2012 is 18% on average (19.1% in 2012). Family farms employ 516 thousand people, or around 44% of the economically active population.

Key directions for agricultural development are defined in the *2010-2020 Strategy for Rural and Agricultural Sustainable Development of Armenia*.

Forestry

At present, forest land (including forests in SPAN) in Armenia covers an area of 457.5 thousand hectares, of which about 350 thousand hectares (ha) are forest-covered areas. Dependent on climatic conditions and anthropogenic factors, forest land in Armenia is distributed unevenly and includes 4 zones. 62.2% of forest is in the north-eastern forestry zone, 12.6% in the large central forestry zone, 2.2% in the southern forestry zone, and 23% in the southeastern forestry zone.

More than 270 tree and bush species grow in Armenian forests. Oak, beech, hornbeam, and pine are the main natural forest-forming species of tree.

As a result of the energy crisis in 1992-1995, illegal mass logging led to extremely negative consequences for forest ecosystems. Reforestation and forest conservation activities implemented in 1998-2006 covered 2,150 ha, while in 2006-2012 it covered 2,754 ha.

Forests and forest land in Armenia are state property. To enlarge forest-covered areas, the Forest Code of Armenia provides for commu-

nity and private ownership rights for planted forests.

According to the Forest Code (2005), forests in Armenia are divided into the following categories in terms of their purpose: protective, special and productive purpose.

The *National Forest Policy and Strategy of the Republic of Armenia* and "National Forest Programme of the Republic of Armenia" (2005) are aimed at ensuring the conservation, restoration, natural reproduction, and sustainable use of forest.

Waste

Solid Waste (SW). SW is collected, transported and disposed of in 48 municipal landfills. The total area of solid waste disposal sites is 219 ha.

SWs include municipal, commercial, and other waste. For all sources, waste is piled without prior classification and sorting. The annual accumulated amount of SW is around 700 thousand tonnes, while the amount of collected and stored SW is about 510 thousand tonnes (241 kg per urban resident). Not all landfills (other than the largest one in Yerevan) are managed. The share of degradable organic carbon in SW is around 50-60%. The storage of large amounts of SW results in the anaerobic degradation of organic compounds and methane emissions.

Current programmes being implemented in Armenia are envisaged to enhance SW management systems. In particular, a landfill gas recovery and flaring system is being introduced in the Yerevan landfill within the framework of the clean development mechanism (CDM) under the Kyoto Protocol.

Municipal wastewater. Municipal wastewater includes domestic, commercial, and partly industrial wastewaters. The amount of wastewater discharge is 431 million m^3 per year, of which: polluted – 190 million m^3; standard clean – 241 million m^3. Wastewater discharged into sewer systems totals 86.6 million m^3.

In the past there were 20 wastewater treatment stations operating in Armenia, with a total capacity of 958 thousand m^3/day. At present these stations are technologically ancient, non-operational and or even destroyed.

As for mechanical treatment, wastewater treatment stations are reconstructed in the littoral towns of the Lake Sevan basin.

Legal and Institutional Bases for Implementation of UNFCCC

The Republic of Armenia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 as Non-Annex I Party and the Kyoto Protocol in December 2002. By a Decree of the Government of the Republic of Armenia, No. 974, adopted on 13 July 2006, on "Implementation of Projects in the Framework of Clean Development Mechanism (CDM) under the Kyoto Protocol", the Ministry of Nature Protection was appointed as the designated national authority (DNA) for CDM under the Kyoto Protocol. The procedure for submission and approval of CDM projects has been approved, according to which projects should be in line with the sustainable development strategy and criteria of the country. As of 2014, the CDM Executive Board has approved 6 projects in Armenia.

The Ministry of Nature Protection of RA is the authority in charge of coordinating actions for the implementation of the Convention in the country. The Ministry is developing a long-term action plan, subject to approval by the government. The Government of Armenia adopted the following decisions for the implementation of the Convention: "On approval of the procedures of the forecasting, warning and response on dangerous meteorological phenomena related to atmosphere excessive pollution, climate change and ozone layer condition" (Decree No. 1186-N, dated 16 October 2008); "On approval of the Action Plan of the Republic of Armenia Obligations Emanated from a Number of RA Environmental Conventions" (No. 1594-N, dated 10 November 2011). These decisions also define the measures and responsible parties for the implementation of Armenian obligations under the Convention. On 2 October 2012, the Armenian prime minister adopted Decree No. 955-A on «Approval of the composition and functions of the Interagency Coordinating Council for the implementation of requirements and provisions of the UNFCCC» (Annex II).

The Council is composed of representatives from 14 ministries, 2 state commissions under the government, the Armenian State Statistical Service, PSRC, the National Academy of Sciences, and the UNFCCC national f. The

Council is chaired by the Armenian Minister of Nature Protection. The Council was established to ensure Armenia's implementation of UNFCCC provisions in general, for activities emanating from Decree 1594-N, and for efficient participation in new developments under the Convention.

In 2012 the Armenian government approved "National strategy on disaster risk reduction of the RA and the action plan for of the national strategy on disaster risk reduction" (Decree No. 281-N, dated 7 March 2012).

In 2010, the Armenian government approved "The main directions of the RA Ministry of Nature Protection for the provision of RA national security strategy" (Decree No. 387-N, dated 8 April 2010).

The Republic of Armenia submitted a statement to the Convention Secretariat for association with the Copenhagen Accords (2010). This statement presents the position of the Republic of Armenia on the continuation of the Kyoto Protocol and the limitation of GHG emissions. It serves as a basis for developing nationally appropriate mitigation actions (NAMAs). NAMAs will be submitted for the Armenian government's consideration in 2015. By that time, the country will have also developed the Climate Change Adaptation Concept and National Adaptation Programme, and submitted them to the Armenian government for approval.

S-2. Greenhouse Gas Inventory

The national inventory includes assessments for GHG emissions and removals compared to a 2010 baseline and trends for 2000-2010. Unlike previous inventories, the *Third GHG Inventory Report* has considered the emissions of F-gases (HFC_s), as well as SO_2 emissions from copper and ferromolybdenum production.

According to IPCC 2006 guidelines, the third national GHG inventory includes the following sectors:

- Energy;
- Industrial processes and product use (IPPU);
- Agriculture, forestry and other land use (AFOLU);
- Waste;

GHG emissions for 2010

Total GHG emissions in Armenia in 2010 make up 7,463.6 Gg CO_{2eq} (see table S-1). GHG emissions in 2010 fell by 70% compared to 1990, but increased by 26% compared to 2000 (Annex I).

Table S-1. Greenhouse gas emissions in Armenia by sectors for 2010, Gg*

Sectors	CO_2	CH_4	N_2O	HFC	$CO_{2\,eq}$
Energy	4,231.0	35.64	0.094	0	5,008.6
Industrial processes and product use	225.9	0	0	0.133	481.1
Agriculture	0	44.26	1.26	0	1,320.5
Waste	7.64	27.77	0.202	0	653.4
Total	**4,464.54**	**107.67**	**1.556**	**0.133**	**7,463.6**

**without forestry and other land use*

GHG emissions in 2010 were: carbon dioxide – 59.8%, methane – 30.3%, nitrous oxide – 6.5%, and F-gases – 3.4%. Emissions breakdown by main sectors was: energy – 67%, IPPU – 6.4%, AFOLU – 17.9%, and waste – 8.7%.

Most CO_2 emissions are generated by the Energy sector – 84%; the share of CH_4 and N_2O generated by the AFOLU sector is 41% and 81% respectively.

The total 2010 emissions of gases with indirect greenhouse effects and SO_2 include: CO – 66.8 Gg, NOx – 17.2 Gg, NMVOC – 22.9 Gg, and SO_2 – 31.1 Gg.

GHG Emission Trends in 2000-2010

Table S-2. Greenhouse gas emissions in Armenia for 2000-2010, Gg $CO_{2\ eq}$

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO_2	3,207.0	3,405.0	2,821.2	3,181.9	3,566.8	4,077.7	4,181.5	4,997.6	5,109.1	4,357.8	4,464.6
CH_4	1,844.7	1,883.6	1,800.6	1,869.1	1,966.3	2,097.5	2,163.9	2,414.5	2,458.0	2,272.3	2,261.0
N_2O	479.8	544.2	616.0	569.4	640.5	632.1	681.4	513.2	483.9	502.7	482.8
HFCs	3.7	8.1	11.3	17.8	27.8	45.0	73.2	110.5	173.0	204.5	255.2
Total	**5,535.2**	**5,840.9**	**5,249.1**	**5,638.2**	**6,201.4**	**6,852.3**	**7,100.0**	**8,035.8**	**8,224.0**	**7,337.3**	**7,463.6**

In general, there was an increase in GHG emissions in 2000-2008, due to high rates of economic development. The decrease in 2009-2010 was mainly in the energy and IPPU sectors, caused by the global economic crisis (see tables S-2 and S-3, and figure S-1).

The increase in F-gas (HFC) emissions, used as substitutes for ozone layer depletion substances, is mainly due to increased development of cooling and air-conditioning equipment.

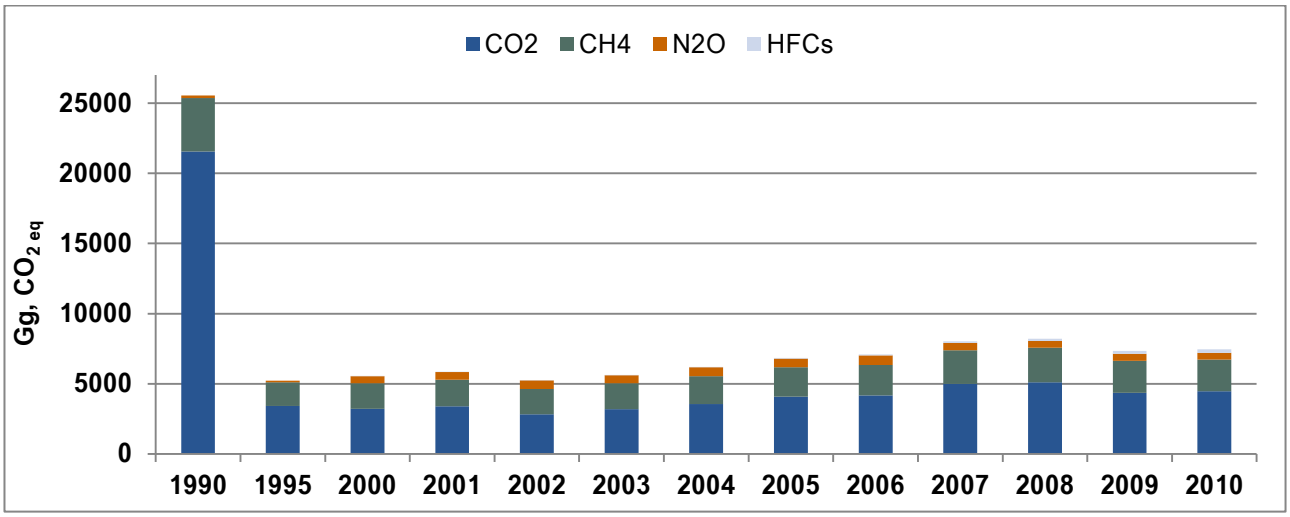

Figure S-1. Total greenhouse gas emissions, 1990-2010

Table S-3. Greenhouse gas emissions by sectors for 2000-2010, Gg $CO_{2\ eq}$

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy	3,601.4	3,798.0	3,050.7	3,417.8	3,795.1	4,367.6	4,493.8	5,480.0	5,671.6	4,932.6	5,008.6
IPPU	123.4	132.8	176.6	209.2	296.5	362.7	397.0	477.2	542.8	413.5	481.1
AFOLU	1,195.0	1,282.2	1,385.4	1,372.6	1468	1,478.1	1,562.9	1,430.4	1,357	1,338.4	1,320.5
Waste	615.4	627.9	636.4	638.5	641.8	643.9	646.2	648.2	652.9	652.8	653.4
Total	**5,535.2**	**5,840.9**	**5,249.1**	**5,638.1**	**6,201.3**	**6,852.3**	**7,099.9**	**8,035.8**	**8,224.0**	**7,337.3**	**7,463.6**

GHG emissions in the Energy sector show a declining trend in power generation (from 46% to 16.5%) and in manufacturing and construction (from 12.4% to 10.6%). There was an increase in transport (from 18.3% to 24.9%) and in other sub-sectors (residential, public, commercial) – from 9.6% to 34% respectively. The share of methane emissions from natural gas transmission and distribution systems remained almost unchanged.

Carbon dioxide is the dominant GHG emission from the Energy sector: in 2000-2010 it totalled 84-86%; the share of methane was 13-14%, and nitrous oxide was 0.4-0.6%.

In 2000-2008 there were regular increases in CO_2 emissions from cement production in the "Industrial Processes and Product Use" sector. In 2009-2010 there was a reduction in CO_2 emissions as a result of the rapid decline in construction. The rapidly rising trends in emis-

sions of F-gases (HFCs) are linked to the development of cooling and air-conditioning systems.

The AFOLU sector includes both GHG emissions (livestock production and land use) and their removal (forestry, land use). There is no logical regularity in GHG emissions and removal in the AFOLU sector for 2000-2010.

GHG emissions from Waste sector showed minor changes in 2000-2010.

Per capita GHG emissions ($CO_{2\ eq}$) decreased from 3.9 t (in 1990) to 1.6 t (in 2000) and then went up to 2.4 t (in 2010).

S-3. Policies and Measures to Mitigate GHG Emissions

As a UNFCCC Non-Annex I country, Armenia does not have quantitative commitments for GHG emission reduction. However, to support the objective of the Convention and, given that slowing GHG emissions is in line with the country's economic, energy, and environmental objectives, Armenia is implementing and, in its development perspectives, is planning climate change mitigation measures.

In recent years, Armenia has adopted a number of laws and regulations, and elaborated and implemented national and sectorial programmes based on sustainable and low-carbon development principles. Although neither of the aforementioned documents explicitly refers to climate change mitigation measures, the enforcement and implementation of these laws and programmes facilitate reducing GHG emissions, as well as forging a path to develop of NAMAs.

Legislation

Laws:

- RA Law "On Atmospheric Air Protection" (1994, amended in 2008)
- RA Law "On Energy" (2001)
- RA Law "On Energy Efficiency and Renewable Energy" (2004)
- RA Law "On Waste" (2004)
- Forest Code of RA (2005)

Armenian Government Decisions

- "On the approval of norms for maximum permissible concentrations of air-polluting substances in settlements, and maximum permissible concentrations of dangerous substances in exhausts from motorized transport operating in the territory of the Republic of Armenia" (No. 160-N, 2 February 2006);
- "On the implementation of projects within the clean development mechanism (CDM) of the Kyoto Protocol under the UN Framework Convention on Climate Change (UNFCCC)" (No. 974-N, 13 July 2006);
- "On the approval of the procedure for the examination of norms of maximum permissible emissions design documents for organizations with stationary sources of atmospheric air pollutants and on the granting of emissions permits" (No. 953-N, 21 August 2008);
- "On the approval of the procedures of the forecasting, warning and response on dangerous meteorological phenomena related to atmosphere excessive pollution, climate change and ozone layer condition" (No. 1186-N, 16 October 2008);
- "On the approval of the action plan of the Republic of Armenia's obligations emanated from a number of RA environmental conventions" (No. 1594-N, 11 October 2011).

National programmes

Strategic Development Programme of the Republic of Armenia for 2012-2025 (2014). This programme sets out the consolidated priorities for the socio-economic development of the country, its goals, the main barriers and constraints to development, and the key reforms and policy instruments needed for achieving priority goals. The programme makes 2012-2025 macroeconomic projections and presents projected indicators for the economy and infrastructure. The projected economic growth for 2012-2014 and 2015-2025 is 6.5% and 6.4% respectively. Realization of these priorities will be in line with addressing issues on environmental protection and the sustainable management of natural resources.

Sectorial Programmes

Sectorial measures contributing to the mitigation of climate change are being implemented in key programmes, including:

Energy

Strategy for the Development of the Energy Sector in the Context of Economic Development of RA (2005). This is planned until 2025 and addresses the facilitation of sustainable economic development and energy security in Armenia, including: diversification of imported and domestic energy resources; maximum utilization of the potential of renewable and non-traditional sources of energy; promotion of energy efficiency/conservation; environmentally viable power supply in line with Armenian international obligations. The strategy describes projected indicators for energy consumption in different sectors of the economy, and plans to create power, gas and heat supply projects according to the implementation timeline.

Action Plan of the Government of Armenia towards Implementation of the National Security Strategy of Energy Efficiency and Renewable Energy (2007). This is based on the provisions of the energy strategy and plans to put into operation and implement measures by 2025, including: construction of new 540 MW capacity HPPs (including 260 MW small HPPs); upgrading of the existing two TPPs (648 MW total capacity) through the installation of gas-fired units; construction of new 1000 MW unit in the Armenian nuclear power plant (ANPP); upgrading of the power transmission and distribution network for energy loss reduction; construction of Iran-Armenia gas pipeline; rehabilitation of 150 million m^3 in underground natural-gas storage; rehabilitation of heat-supply systems with the maximum use of geothermal, biogas, solar and other possible sources of renewable energy; continuous implementation of large-scale energy-efficiency measures.

RA National Programme for Energy Saving and Renewable Energy (2007). This programme provides assessment for energy-saving potential in electric and thermal energy, gas-supply systems, manufacturing, transport, and residential and public buildings, as well as assessment of renewable-energy potential and measures for the effective utilization of the energy-saving potential.

RA Government Action Plan for the Implementation of the RA National Programme for Energy Saving and Renewable Energy (2010). The overwhelming goal of this document is to contribute to the further development of energy-saving policy of Armenia, and to finalize the specific measures for its implementation. This action plan provides for specific sectorial actions, including: residential buildings; services; manufacturing; transport; water economy.

RA Renewable Energy Development Roadmap (2011). This document describes the technical accessibility, and the economic and financial feasibility and benefits of renewable-energy (RE) potential, and evaluates RE potential in transport and electrical- and thermal-energy generation in the short term (until 2013), mid term (until 2015), and long term (2020 and after). The roadmap refers to investment needs and costs according to RE types and sector. The future share of RE generation in long-term plans is estimated at 16.3%.

Energy Security Concept of RA (2013). Tasks include: the creation of preconditions for Armenia's sustainable economic development; energy system self-sufficiency and export potential of Armenia in the region; an attractive environment for investments both in renewable and alternative energy, as well as in nuclear energy; effective and efficient energy use; a reduction in GHG emissions; the development of provisions for ensuring the energy-security level set forth for Armenia.

Financial Mechanisms for Renewable Energy and Energy-efficiency Development

Tariff policy. Armenia is pursuing a tariff policy to support the creation of favourable conditions for developing RE and attracting investment. There are purchase guarantees and feed-in tariffs set for power generated by small HPPs, wind turbines, and biogas plants.

Renewable Resources and Energy Efficiency Fund of Armenia (R2E2). R2E2 is implementing loan and grant projects with World Bank (WB) and Global Environmental Facility (GEF) funds, to develop renewable energy and energy efficiency in line with strategic priorities set forth by the Government of Armenia.

Renewable energy and energy efficiency loans. International financial institutions (WB, EBRD, KfW, IFC, ADB) provide low-interest loans through local commercial banks and special credit institutions to private enterprises and entrepreneurs.

Transport

Action plan for the reduction of dangerous exhaust substances from motorized transport (2005). This document includes measures for improving legal frameworks for the environmental monitoring and accounting of dangerous substances, improving of traffic and transport flows, developing public transport (including electric transport), and promoting clean-engine fuel use.

Yerevan Master Plan (2006-2020). The master plan provides for a 20% reduction in exhaust gases from motorized transport by 2020, by developing an electric transport system, implementing new city transport schemes, and applying catalytic converters to exhausts.

Projects intended to increase the use of natural gas as engine fuel and the use of biofuel after 2020, as well as improve the country's roads, will support efforts to reduce GHG emissions from motorized transport.

Forestry

RA National Forest Policy and Strategy (2004) and *RA National Forest Programme* (2005). The main goals of these programmes are targeted at rehabilitating degraded forest ecosystems and ensuring the sustainable use and development of the useful properties of forests. The issues on illegal logging, solutions to the problem, reduction and exception of the illegal logging are also revealed in the document.

The adopted forest management plans envisage the rehabilitation of degraded forest ecosystems and the reforestation of forest lands: 1,983 ha in 2015, 947 ha in 2020, 3,750 ha in 2025, and 3,750 ha in 2030.

Waste

Armenia is cooperating with international organizations on implementing projects aimed at improving SW management systems.

Programme for Improving Solid Waste Comprehensive Management System in Lori Marz (EU). This is designed to develop a comprehensive waste management strategy for Vanadzor and the surrounding communities. This strategy includes measures for closing the current Vanadzor SW landfill, and a feasibility study for the proposed measures to introduce a new SW management system.

ADB technical assistance project. This will develop a waste-management national strategy, which will define technical, institutional and financial conditions, as well as issues for private sector participation in the implementation of this strategy. The project includes the closure of 48 existing SW landfills, the identification of 5 new regional SW landfills, and the creation of 10 sorting and transfer stations. The project plans to organize gas capture and flaring in closed large landfills (in Yerevan, Gyumri, and Vanadzor).

Wastewater mechanical treatment stations in littoral towns of the Lake Sevan basin (Martuni, Vardenis, Gavar) are reconstructed in 2013.

Kyoto Protocol

As of 2014, the CDM international executive board has registered 6 CDM projects in Armenia.

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

GHG emission projections and calculations for 2010-2030 are based on the expected scope of respective measures in various sectors of the economy: annual average economic growth for 2010-2015 – 6.1%; for 2015-2025 – 6.4%.

Two GHG emission scenarios for all categories of emission sources were considered:

Baseline (business as usual) scenario. This scenario assumes maintaining business-as-usual practices and ratios on the national level. However, it also includes modernization processes reflecting international trends.

Mitigation (with measures) scenario. This scenario includes activities to be implemented under the GHG reduction measures included in sectorial development programmes.

The projected scope of activities and measures contributing to emissions reduction are considered in compliance with sectorial development programmes.

Table S-4. Greenhouse gas emissions by gas types in 2010 and projections for 2030, Gg

	2010	2015	2020	2025**	2030**
Business as usual *					
CO_2	4,464.6	5,421.4	8,947.0	11,567.1	14,299.3
CH_4	107.7	123.7	150.7	189.0	216.5
N_2O	1.556	2.0	2.26	2.34	2.514
HFC_s	0.133	N/E	N/E	N/E	N/E
With measures *					
CO_2		4,933.8	7,454.4	9,056.2 7,841.2	10,597.4 9,164.4
CH_4		106.7	128.5	156.1 146.5	180.7 169.3
N_2O		0.53	0.436	0.473 0.457	0.534 0.516
HFC_s		N/E	N/E	N/E	N/E

** Without forestry and other land use*
*** In the 'with measures' scenario, the denominator indicates emissions with a new ANPP unit*

In the event of a 'with measures' scenario by 2030, GHG emissions for carbon dioxide are calculated at 72.2% (from energy – 67.2%, methane – 27.4%, and nitrous oxide – 0.4%).

Table S-5. Greenhouse gas emissions by sectors 2000-2010, and projections for 2030, Gg $CO_{2\ eq}$*

Scenario / Sector	1990	2000	2005	2010	2015	2020	2025**	2030**
Business as usual								
Energy	22,777	3,601.4	4,367.6	5,008.6	5,939.2	10,103.7	13,109.1	16,219.7
Industrial processes and product use	630.3	123.4	362.7	481.1	231.2	289.1	356.8	453.1
Agriculture	982.6	1,195.0	1,009.4	1,320.5	1,599.3	1,784.1	2,024.5	2,260.9
Waste	564.9	615.4	643.9	653.4	663.5	690.4	707.5	724.6
Total	**24,954.8**	**5,535.2**	**6,383.6**	**7,463.6**	**8,433.2**	**12,867.5**	**16,197.4**	**19,658.7**
With measures								
Energy	22,777	3,601.0	4,367.0	5,008.6	5,504.5	8,653.0	10,531 9,072	12,304 10,579
Industrial processes and product use	630	123.4	362.7	481.1	222.0	228.0	291.8	377.5
Agriculture	982.6	1,195.0	1,009.4	1,320.5	1,599.3	1,700.3	1,924	2,146
Waste	564.9	615.4	643.9	653.4	663.5	493.9	614.0	668.8
Total	**24,954.8**	**5,535.2**	**6,383.6**	**7,463.6**	**7,989.4**	**11,075.6**	**13,361.1** **11,878.6**	**15,496.8** **13,771.5**

** Without forestry and other land use*
*** In the 'energy' and 'total' rows, the denominator indicates emissions with a new ANPP unit*

In the event of a 'with measures' scenario, GHG emissions in 2030 will account for 68% with NPP unit and 55% without NPP unit of the 1990 level (79% in baseline scenario). Note that the Energy sector will again have the biggest share (77%) of GHG emissions.

The assessment of the impact of GHG emission-reduction projections are described in Table S-6.The dominating part (79-97%) of mitigation potential will be generated from measures implemented in the Energy sector.

Table S-6. Greenhouse gas emissions reduction potential by sectors, Gg $CO_{2\ eq}$

Sector	2015	2020	2025	2030
Energy	384.2	1,265.0	4,119.6	5,436.0
Industrial processes and product use	9.2	61.1	65.0	75.6
Agriculture	0	83.8	100.7	114.6
Waste	0	196.5	93.5	55.8
Total	**393.4**	**1,606.4**	**4,378.8**	**5,682.0**

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

Climate Change Observed in Armenia

Trends in ambient air temperature and precipitation changes

In the recent decades, there has been a significant temperature increase in Armenia: in 1935-1996, the annual mean temperature increased by 0.4^{0}C; in 1935-2007 by 0.85^{0}C; in 1935-2012 by 1.03^{0}C.

Over the various seasons, the ambient air temperature change shows different trends. In 1935-2011, the summer average temperature increased by about 1.1^{0}C. Winter temperature changes look different: trends in seasonal mean temperature increases are insignificant at 0.4^{0}C.

There is decreasing trend in precipitation. Observations showed that, in 1935-1996, there was a 6% decrease in annual precipitation; in 1935-2012, it was close to 10%.

The spatial distribution of changes in precipitation is irregular. Over the last 80 years, the climate in the northeastern and central (Ararat Valley) regions of the country has turned more arid, while precipitation has increased in the southern and northwestern regions, as well as in the western part of the Lake Sevan basin.

Hazardous hydro-meteorological phenomena (HHMP)

Over recent decades, climate change has significantly increased the frequency and intensity of HHMP in Armenia. The maximum aggregate number of 245 HHMP was observed in 2004, and the minimum number, 106 events, in 2006. The number of events with extreme frost has significantly increased. The number of days with heavy rainfall and hailstorms has increased, caused by the recurrence high cyclones.

Climate Change Projections for Armenia

Climate change in Armenia is assessed using the CCSM4 model in accordance with IPCC-recommended RCP8.5 (A2) and RCP6.0 (B2) scenarios for emissions. Future climate change projections for temperature and precipitation have been developed up until 2100. Average annual temperature increase projections in the territory of Armenia related to the 1961-1990 average show that, in an A2 scenario, the temperature will increase by 1.7^{0}C in 2040, by 3.2^{0}C in 2070, and by 4.7^{0}C in 2100. In a B2 scenario, the temperature will increase by 1.3^{0}C, 2.6^{0}C, and 3.3^{0}C respectively.

Summers in most of the regions of the country are usually characterized by hot and dry weather conditions. According to the model predictions, these conditions will worsen, leading to negative impacts on water resources, agriculture, energy, health, and other sectors.

Water Resources

In an A2 scenario, the aggregate volume of river flow in the territory of Armenia will decrease by 11.9% by 2030, by 24% by 2070, and 37.8% by 2100 (compared to the 1961-1990 baseline period).

The vulnerability assessment for a number of rivers, reservoirs, and Lake Sevan resulting from anticipated climate change is assessed.

Table S-7. Projected changes in aggregate river flows

Year	Flow, million m^3	Flow change	
		million m^3	%
1961-1990	5,797.0	0	0
2030	5,141.6	-655.0	-11.9
2070	4,405.6	-1,391.5	-24.0
2100	3,602.2	-2,195.0	-24.4

Table S-8. Arpa river flow projection

River – observation point	Scenario	1961-1990		2030		2070		2100	
		million m^3	%	million m^3	%	million m^3	%	million m^3	%
Arpa-Areni	**A2**	728.8	100	578.9	-21	532.8	-27	489.1	-33
	B2	728.8	100	604.0	-17	573.5	21	513.7	-30

Table S-9. Debed and Aghstev river flow projection

River – observation point	Flow change							
	1961-1990		2030		2070		2100	
Debed-Ayrum	1054	100	937	-11	669	-37	402	-62
Dzoraget-Gargar	480	100	427	-10	343	-29	215	-55
Pambak-Tumanyan	336	100	300	-11	240	-29	160	-53
Aghstev-Ijevan	286	100	255	-11	196	-31	108	-62
Voskepar (with its tributary Kirants)-Voskepar	67	100	58	-14	42	-37	19	-72

Table S-10. Vorotan river flow projection

River – observation point	Scenario	Flow change							
		1961-1990		2040		2070		2100	
Vorotan-Gogkayk	**A2**	131.9	100	137.9	5	145.0	10	152.8	16
	B1	131.9	100	136.7	4	141.4	7	148.3	12

It is assumed that the Vorotan river's annual natural flow will increase by about 3%. In seasonal terms, by 2100 the projected increase of the flow at the Vorotan-Goghayk observation point will be 21.4 million m^3 (16%) according to the A2 scenario, and by 16.8 m^3 (13%), according to the B1 scenario.

The vulnerability of the Araks, Akhurian, Hrazdan, Azat, and Vedi river flows for 2040, 2070, and 2100 is projected through CCSM4 model data and for the A2 and B2 emission scenarios. According to the assessments, there will be no significant change in flow in the Akhurian river basin by 2040; in 2071-2100 it is expected that the flow will reduce by 10.5% (A2) and 5.7% (B2) respectively. For both scenarios there will be some increase in the Araks river flow: 3-4% in 2041-2070, and 1-2% in 2071-2100. It is projected that, according to the A2 scenario, in 2017-2100, the flows in the Azat and Vedi river basins will fall by 12-14%; in the Hrazdan river basin it will fall by 15-20%.

According to the A2 scenario it is expected that, in 2100, the water level in the Aparan reservoir will go down by 11 metres which, in terms of volume, means that the maximum quantity of water during the year will be 25-36 million m^3 (the capacity of the reservoir is 90 million m^3). The projected data for the Akhurian reservoir will be 405 million m^3 (the capacity of the reservoir is 525 million m^3); for the Azat reservoir it will be 45 million m^3 (the capacity of the reservoir is 70 million m^3).

Table S-11. The projection of inflows in Arpi reservoir and Lake Sevan according to A2 scenario, million m^3

Water body	1961-1990	2030	2070	2100
Arpi reservoir	60.15	56.12	51.43	45.47
Lake Sevan	787.00	734.00	673.00	595.00

In 2100, the water temperature in the Arpi Lake reservoir is expected to increase by 6.6^{0}C against the baseline (12.4^{0}C). The maximum reservoir inflow will be reduced by about 4 million m^3 in 2030 related to the baseline, in 2070 by about 9 million m^3, and in 2100 by about 15 million m^3.

In 2030, the Aparan reservoir water temperature will rise by 1.2^{0}C against the baseline (16.9^{0}C), and in 2070 and 2100 it will rise by 3.7^{0}C and 6.8^{0}C respectively. The maximum inflow into the Aparan reservoir against the 2030 baseline (56.54 million m^3) will fall by 4 million m^3, in 2070 by approximately 8 million m^3, and in 2100 by about 14 million m^3.

By 2100, the water temperature of Lake Sevan will increase by 4^{0}C against the baseline (9.4^{0}C). In 2030, the Lake Sevan inflow will decrease by more than 50 million m^3 against the baseline (787 million m^3), in 2070 by about 110 million m^3, and in 2100 by about 190 million m^3; the water level will start going down by about 16 cm per year.

In order to mitigate against climate change impacts on water resources and adapt the economy to new natural conditions it is recommended to implement the following complex measures:

Administration and planning: (1) In developing plans for the management of all major river basins of Armenia, consideration should be given to the climate change; (2) Optimization of the hydrological observation network and upgrading with modern equipment; (3) Provision of water-use permits with due consideration to climate change risks; (4) Creation of hydrological reserves in all river basin watershed areas.

Research and information: (1) Assessment of climate change impacts on all high-mountain lakes' water resources; (2) Assessment of snow stock change in the territory of Armenia; (3) Application of a Water Evaluation and Planning (WEAP) software for the management of resources in all large water bodies; (4) Assessment of climate change impacts on ground waters; (5) Modification of environmental flow assessment methods.

Economic and technical: (1) Construction of new small water reservoirs and rehabilitation of non-operational ones; (2) Resumption of ground water monitoring; (3) Reduction of leakage from drinking-water supply and irrigation systems; (4) Development of economic mechanisms for promoting the application of advanced water-saving irrigation methods in agriculture.

Agriculture

The geographical position of Armenia, the expressed vertical zonation of the country, abrupt mountainous terrain, active exogenic processes, land shortage, and insufficient moisture supply in the soil make Armenia an extremely risky country in terms of crop production. Agricultural risks increase due to the shortage of land (per capita 0.14 ha of arable land). Almost 80% of land show notable desertification features and are suffering from various level of degradation as a result of irrational use of land resources. Projected climate change will further worsen the situation.

Major negative consequences under projected climate change for Armenian agriculture include: (1) Agro-climatic zones will shift 100 m upward by 2030, and 200-400 m by 2100; (2) Reduced crop yields as a result of temperature increases, reduced rainfall, and increasing evaporation from the soil surface; (3) Reduced productivity and degradation of agricultural land; (4) Increasing negative impact of extreme weather events due to expected increases in their frequency and intensity; (5) Expansion of irrigated land areas and the need for additional irrigation water; (6) More intensive degradation of land, including natural grazing land.

As a result of the projected temperature rise and intensification of evaporation of moisture from the soil surface, the additional demand for irrigation water will total about 202 million m^3.

It is projected that in 2040-2050 there will be a reduction in main agricultural crop yields due to climate change (see table S-12).

Table S-12. Projected impact of climate change on crop yields

Crop	Cultivation zones		
	Lower	Middle	Upper
Irrigated land			
Alfalfa	-5%	-7%	-2%
Apricot	-5%	-5%	-5%
Grapes	-7%	-5%	-5%
Potatoes	-12%	-9%	-5%

Crop	Cultivation zones		
	Lower	Middle	Upper
Tomatoes	-16%	6%	50%
Watermelon	-12%	10%	Not cultivated
Wheat	-6%	1%	38%
Rain-fed land			
Alfalfa	-3%	-8%	-1%
Apricot	-28%	-7%	-5%
Grapes	-24%	-12%	-1%
Potatoes	-14%	-14%	-8%
Tomatoes	-19%	-8%	34%
Watermelon	-18%	0%	Not cultivated
Wheat	- 8%	1%	38%

Source: WB, 2014.

Agriculture is suffering serious damage as a result of extreme weather events; climate change tends to result in their increased intensity and frequency. 2009-2013 estimates show that the damage from extreme weather events amounted to AMD 72.71 billion (about USD 177 million).

As a result of shifts in natural zones, areas of more valuable alpine and sub-alpine grazing land will be reduced by 19 and 22% respectively, while semi-desert and meadow-steppe areas will increase by 17%, and grazing lands with relatively low productivity will increase by 23%. Because of structural changes in natural zones, milk production will fall by 52.4 thousand tonnes, meat production by 15.1 thousand tonnes, and wool production-by 116.4 tonnes.

In order to mitigate climate change impacts on agriculture the following measures are recommended:
Administration and planning: (1) Creation of risk-preventing infrastructure for agricultural producers, and supporting implementation of measures for reduction of agricultural dependence on climate variability and adaptation to slow onset changes.
Research and information: (1) Prevention of crop and animal diseases, and pest control; (2) Selection and cultivation of more drought-resistant hybrids adapted to local conditions, including maintenance and dissemination of traditional crop varieties; (3) Inventory making and improvement of grasslands and pasture land.

Natural Ecosystems and Biodiversity

Major ecosystems will undergo changes as a result of climate change, including:

Alpine meadows: full conversion to sub-alpine tall grasses and expansion of super-humid areas.

Sub-alpine meadows: conversion to meadow-steppe, probable expansion of forest ecosystems.

Meadow-steppe: conversion mostly to steppe ecosystems.

Steppe: arid steppe will be converted to phryganoids, and tragacanth steppe areas will be expanded. Steppe mesophilous ecosystems will be replaced by more arid versions.

Semi-desert: survival of semi-desert plants by expansion of phryganoids zone, and expansion of desert ecosystem areas (alkaline lands and saline deserts).

Shibliak and arid open forests: these will remain unchanged and expand; however, the natural reproduction of trees and shrubs may deteriorate and, over time, these ecosystems may be converted to phryganoids.

Forest ecosystems: a shift in boundaries associated with the development and spread of other ecosystems, forest wildfires, diseases and mass generation of pests that may lead to 14 to 17 thousand hectares of forest loss by 2030.

Aquatic ecosystems of Lake Sevan: the recent rise of water level is characterized by a decline of phytoplankton diversity and growth of blue-green algae, as well as unpredictable changes in species. It can be expected that the impact of climatic factors will also increase the vulnerability of macrophytes. A forecast lake water-temperature increase of 3-4^{O}C will lead to shifted seasonal migration and spawning and feeding areas for cold-water fish, particularly for whitefish. Climate warming will have a positive impact on the population of

omnivorous thermophilic carp species; however, their rapid growth may significantly affect other native species by reducing the availability of feed for other species.

The *Plant Red Data Book of Armenia* (2010) includes 452 higher-class plant species, of which 72 plant are on the verge of extinction as a result of climate change. In order to mitigate climate change impacts on natural ecosystems and biodiversity the following measures are recommended:

Administration and planning: (1) Measures aimed at reduction of anthropogenic impacts on natural ecosystems; (2) Assessment, monitoring and development of ecosystems and biodiversity in existing SPANs; (3) Conservation of existing rare plant habitats; (4) Conservation of Lake Sevan ecosystems by increasing or stabilizing the lake's water level; (5) Implementation of forest-conservation activities (integrated control of leaf-eating beetles by aviation), fire protection of forests, and combatting illegal logging.

Research and information: (1) Assessment of population status for rare plant and animal species; (2) Studies on climate change impacts on ecosystems, individual species of flora and fauna; (3) Studies and monitoring on the spread of invasive plant and animal species.

Economic and technical: (1) Ex-situ conservation of rare species of plants and animals; (2) Restoration of degraded forest ecosystems, reforestation of forestlands.

Settlements and Infrastructures

A high degree of settlement and infrastructure vulnerability in Armenia is due to abrupt terrain, critically steep slopes, and unfavourable soil conditions.

Settlements and infrastructure in Armenia are exposed to hazardous natural phenomena, including: landslides, rock falls, flash floods, mudflows, flooding, and avalanches. The development of extreme weather events, and their increasing scale and intensity, leads to the increased frequency of high-risk situations. In this regard, the Government of Armenia recently adopted a number of decisions that have served as basis for the development of programmes and projects aimed at risk assessment, the development of forecasting and prevention methods, and the implementation of protective engineering measures in the territory of Armenia.

Landslides: There are more than 2,500 landslide-prone sites in Armenia, covering a total area of about 1,221 km^2 (4.1% of the country's total territory). In recent years, the frequency of landslides is increasing over large areas. This is associated with the pressure of changing exogenic factors, including meteorological conditions. Almost 233 of 960 communities in Armenia suffer damage from landslides.

Mudflow activation is due to the presence of denuded and weathered matter on steep slopes, and abundant precipitation. The cities of Yerevan, Vanadzor, Gyumri, Kapan, Goris, Alaverdi and a number of other settlements, rural communities, motorways and railways periodically suffer from mudflows.

River high water and flooding cause significant damage to almost all marzes of the republic and to the economy of the northern marzes in particular.

Flooding is directly associated with a high level of ground water and hydrodynamic features formed under the influence of atmospheric precipitation. Flooding largely occurs in the Ararat and Shirak valleys. It also occurs in some areas of Tavush, Vayots Dzor and Syunik marzes.

The reactivation of landslides is associated with changes in the water balance circulating in the ground massive. Landslides mainly develop in the Yeghegis, Azat and Vedi river valleys, on northeastern shore of Lake Sevan, around Ijevan city, and other areas of the country.

Rock fall: The number of settlements suffering from rock falls has reached 45, including: Vanadzor, Alaverdi, Akhtala, Gavar, Kapan, Meghri, and Agarak.

Measures to be implemented for the reduction and prevention of risks of hazardous natural phenomena include:

Administration and planning: Identification and prevention of hazardous natural phenomena, then mapping and planning.
Research and information: (1) Prediction of spring floods for major rivers; (2) Analysis of the probability of flooding risks for settlements and communication routes located in river valleys in the northern marzes, and the development of protective measures;

Economic and technical: (1) Design and construction of landslide-protective dams and engineering facilities for settlements and infrastructure; (2) Installation of bank-protection

hydraulic-engineering facilities in riverbeds, the application of phyto-melioration measures in flood-prone river basins, and construction of flood-protective dams for preventing heavy rain, flooding and spring floods.

Human Health

An increase in the frequency and duration of hot days and heat waves over the entire territory of Armenia was observed. Cardiovascular diseases cause most of the mortality cases in hot seasons. Increased mortality is also observed in patients with respiratory and chronic diseases. Observations in 2007-2012 show that there is a significant growth in acute intestinal infections and upper respiratory morbidity rates, which in part, may be due to a warmer climate. It is projected that plague and tularemia risks will decrease, as the habitats of major transmitters will move to higher zones (2500-3000 m above sea level). No Crimean-Congo hemorrhagic fever or Western tick-borne encephalitis has been recorded in Armenia, yet the probability of incidence is possible as a result of climate change.

Measures to be implemented to mitigate against/prevent climate change impacts on human health include:

Administration and planning: (1) Early notification of population on probable unfavourable weather conditions; (2) Assessment of infectious disease incidence and risk management; (3) Infectious-disease carrier and transmitter control; (4) Preparedness of rapid response to disaster and epidemiological situations.

Research and information: (1) Implementation of programmes for contagious-disease carrier and transmitter control; (2) Studies on climate change impact on especially dangerous diseases and the development of relevant projections for the country; (3) Preparedness of the population for possible natural disasters and epidemiological situations.

S-6. Any Other Information for Achieving Convention Goals

S-6.1. Research and Systematic Observation

Systematic observation

The Armenian State Hydrometeorological and Monitoring Service (Hydromet Service) is the state-authorized entity in charge of hydrometeorological observations in the country. Hydromet Service carries out regular atmospheric, surface-water, soil, agricultural crop, background-radiation, heliogeophysical-phenomenon (UV-radiation, ozone layer), actinometric, and aerological observations.

At present, Hydromet Service is carrying out 47 full-scale standard hydrometeorological observations. Data from three stations (located in Yerevan, Sevan, and Gyumri) are shared with global and regional data centres.

Agro-meteorological observations are made in 40 stations and 2 observation points. In 2011-2012, automatic soil-humidity meters were installed in 10 stations.

The monitoring of total ozone content is conducted by the Amberd high-mountainous, and Yerevan Arabkir meteorological stations. In 2000, the Amberd station was included in the WMO Global Ozone Observation Network. The ozone content observed by this station characterizes ozone-layer condition in the entire South Caucasus region, and data is communicated to the World Ozone and Ultraviolet Radiation Data Centre (WOUDC).

Actinometric measurements of solar-radiation balance, direct solar radiation, and diffused and reflected solar radiation are taken by the Tashir, Gyumri, Sevan, Martuni, Yerevan-agro, and Amberd meteorological stations.

Aerological observations are made once a day by the Davtashen aerological station in Yerevan, which is included in the GCOS Global Upper Air Network (GUAN).

Hydrological observations are conducted in 94 observation points (including 86 rivers, 4 reservoirs (Arpi, Akhurian, Azat, Aparan), 4 Sevan lake points) of the seven river basin hydrological stations.

Hydromet Service has recently modernized its equipment and updated the methodologies it uses. Within the framework of international cooperation, Hydromet Service has purchased and installed new professional devices and equipment.

Research

Research work for Hydromet Service is conducted by the Applied Hydrometeorological and Environmental Research Centre, which includes divisions of applied climatology, climate studies, and hydrometeorological modelling. Fields of study tested include: climatology, digital modelling of hydrometeorological

processes, climate monitoring, climate change assessment, and national-level forecasting (using global and regional climate change model results).

S-6.2 Education, Training, and Public Awareness

Education and training

Since 2009 the Armenian government has been financing 58 scientific research themes on nature protection from the state budget. The majority of these themes are associated with biodiversity and desertification, as well as climate change-related issues.

Programmes and studies on climate change issues conducted in Armenia mostly deal with vulnerability, climate change impact assessment, and the development of adaptation measures.

Seven scientific research projects work on the assessment of ecosystems, water resources, and the identification of climate risk-prone zones. These have been funded under 2011-2012 competitive contracts granted for scientific and technological activities.

In 2010-2014, eight demonstration projects have been implemented, covering climate change impact assessment on different sectors, and the development of mitigation actions (assisted by UNDP and other international organizations).

In 2010-2014, six studies were conducted dealing with the assessment and application of renewable energy sources in order to reduce fossil fuel use and GHG emissions.

Education, capacity building and public awareness

After the submission of *Second National Communication on Climate Change (SNC)*, Armenia has demonstrated notable progress in environmental education, both in legislation and practical implementation.

The *Concept for the Creation of a Comprehensive and Unified National System for Environmental Education, Upbringing, and Awareness* was adopted in 2010. The 2011-2015 action plan under this concept includes institutional and legislative improvements to environmental education and awareness.

Environmental education in Armenia has been introduced into the educational system at all levels – from preschool to postgraduate. The policy and coordination of environmental education are implemented by the Armenian Ministry of Education and Science and Ministry of Nature Protection.

Preschool education level: to guide environmental education at this level, manuals have been compiled within the framework of local and international projects, reflecting climate change-related issues. Current local educational programmes, such as “Environmental Education at Preschool Age”, “Educational Programme for 5-6-year-old children”, “Little Lover of Nature”, and “Behaviour”, as well as UNICEF-implemented environmental programmes, are also promoting preschool environmental education in Armenia.

At the secondary education level, environmental protection topics are included in the natural science curricula. Secondary school curricula include the “Nature Protection and Nature Use” course. Topics covering climate change issues are taught in biology and geography classes.

Higher education system includes 72 state and non-state vocational schools (colleges) and 25 primary professional/trade/vocational institutions. Students in almost all institutions of the vocational education system attend the “Basics of Ecology” course, which teaches the basics of climate change-related issues.

Higher education in Armenia includes 26 state and 41 private institutions. All universities, regardless of professional orientation, teach “Ecology and Nature Protection” courses. These courses deal with climate change-related issues.

Students at Yerevan State University majoring in hydrometeorology (to become climatology specialists) study a special course on climate change. The State Engineering University of Armenia provides courses on “Use of the Clean Development Mechanism in Energy Projects” for students majoring in several different professions. In 2013, the Armenian National University of Architecture and Construction Foundation (ANUAC) established an energy efficiency laboratory. ANUAC curricula include “Green Architecture” courses, which cover energy efficiency and renewable energy use in building design and the construction process.

Postgraduate education is provided by universities and scientific research institutes of the

Armenian National Academy of Sciences, where the number of specialists dealing with climate change issues is growing. In recent years, several candidate and doctorate dissertations have been defended on climate change.

Public awareness

Public awareness campaigns on climate change cover the following activities:

- *Organization of seminars and conferences:* more than 10 seminars and 15 conferences are organized in 2010-2013.
- *Publication and distribution of thematic materials:* in 2009-2013, publications within the framework of UNDP-GEF projects include: 11 proceedings of collected articles, booklets, manuals and posters, as well as materials on renewable energy, energy efficiency and climate change mitigation from national, regional and international conferences intended for specialists, lecturers, and decision makers. These materials also serve as measures for increasing public awareness (www.nature-ic.am).
- *Mass media:* Two films were produced and broadcast on TV channels. The Climate Change Information Centre website was improved and regularly updated. The electronic periodical *Climate Change Newsletter* was launched in 2009. The TV Programme "Eco Logic", broadcast since 2005, periodically covers climate change-related issues. Printed and electronic media have increased the number of topics covering climate change issues.

Non-governmental Organizations

Environmental non-governmental organizations (NGOs) have launched active campaigns to promote environmental education and public awareness in the country. A number of manuals published with the support of NGOs have been approved as additional handbooks for environmental education in secondary schools. These publications are distributed to schools, and complementary training seminars are organized for school teachers, students, lecturers of higher education institutions, and secondary vocational schools.

Since 2002, 14 public Environmental Information (Aarhus) Centres have been functioning in different regions of the country. The activities of these centres are aimed at promoting public participation in public-awareness processes and environmental decision making.

Climate change processes observed in Armenia are periodically reflected in the *Environment and Natural Resources in Armenia* statistical yearbook.

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

During the preparation of SNC a number of constraints and gaps were identified with regard to national capacity building (institutional, organizational, technical, informational, financial and professional) for the implementation of the Convention. In parallel, additional needs for new phases of international efforts and initiatives related to the Convention were also identified.

GHG inventory: Major capacity-building needs include: procedure for the development of GHG inventories and the establishment of a respective sustainable inter-agency mechanism; accurate estimation of fugitive emissions (methane) from natural gas transmission and distribution system; development of national factors for carbon emissions, removals, and sinks in the AFOLU sector; periodical development and publishing of the country's energy balance.

GHG emissions-reduction policy and measures: Key needs for the development of this sector include: development of GHG emissions-reduction concept; analysis of the applicability of recommended models for the projection of GHG reduction potential; adaptation and application of relevant models.

Vulnerability and Adaptation

General provisions: Development of comprehensive climate change adaptation concept based on ecosystem approach; development of a methodology for harmonizing inter-sectorial vulnerability-assessment and adaptation measures.

Water resources: Key capacity-building needs include: development of new water-use principles and a new system for water-intake regulation; elimination of huge water losses from the water distribution system; development of modern methods for the assessment of natural flows based on actual flow data; introduction of a monitoring system for ground

water resources; upgrading of current vulnerability-assessment models and projection scenarios, including regional context.

Agriculture: Key capacity-building needs include: assessment of risks and losses caused by climate change impact; improvement of data-collection systems for crop- and grazing-land yields; research on projection models and agro-climatic redistribution of crops; development of mechanisms for introducing agricultural insurance systems.

Biodiversity and natural ecosystems: Key capacity-building needs include: establishment of a system to monitor changes in natural ecosystems; data-collection studies for model natural ecosystems; development of a concept for the restoration and conservation of natural ecosystems; development of an ecosystem approach programme for the restoration of ichthyofauna in aquatic ecosystems; introduction of the concept of optimum forestation in the National Forest Policy.

Human health: Major needs in this sector include: identification of diseases and risk groups most sensitive to climate change; creation and registration of a database for specific disease incidence during hot seasons; development of the concept and programme for human health vulnerability and adaptation as a result of climate change; regional analysis of diseases; identification and mapping of the most vulnerable areas.

Research and systematic observation: Capacity-building needs include: conducting research for increasing the reliability of climate change scenarios for Armenia through the development of regional scenarios in cooperation with neighbouring countries.

Major needs for systematic observation include: full-scale restoration of hydrometeorological stations and observation points; refurbishment of observation systems; upgrading of the communications, telecommunications and radiolocation networks; resumption of snow cover measurements and monitoring, water layer in snow cover, and snow-melt properties.

Technology transfer: Capacity-building needs include: creation of a database on environmentally sound technologies, based on the CTCN arrangement and principles of operation and functions; establishment of a national-level “Technological Mechanism” and the Technology Transfer Centre and Network.

Science, education, public awareness, and training: Needs include: capacity building on regular basis; enhancement of activities; development of a comprehensive programme for the sector.

1

NATIONAL CIRCUMSTANCES

1.1 State Structure

The Republic of Armenia was established on 21 September 1991. The capital of the Republic of Armenia is Yerevan**.**

According to the Constitution (passed on 5 July 1995), the Republic of Armenia is a self-governing, democratic, social and juridical state.

State power in the Republic of Armenia is exercised based on the principle of separation and balance of legislative, executive and judicial powers.

The head of the state is the president of the Republic. The president is elected by citizens of the Republic of Armenia for a five-year term in office.

Legislative power in the Republic of Armenia is vested in the National Assembly (parliament). The National Assembly is comprised of 131 deputies, elected for a five-year period.

Election of the president of the Republic, the National Assembly, and local self-governing bodies is carried out by secret voting, on the basis of general, equal and direct electoral rights.

The executive power of the Republic of Armenia is exercised by the government, the responsibilities of which include development and implementation of country's internal policy. The external policy of the Republic of Armenia is developed and implemented jointly by the government and the president of the Republic.

The government comprises the prime minister, vice prime-minister and ministers.

The structure of the government includes 18 ministries and 10 state management bodies adjunct to the government, which include committees, services and administrations.

The Republic of Armenia employs a three-tiered governing system: centralized state governing, regional (marz) state governing, and local (community) self-governing.

The administrative-territorial units of the Republic of Armenia are marzes and communities. The Republic of Armenia consists of 10 marzes, including Yerevan. It has 931 communities, of which 49 are urban and 871 rural (2012).

Since 2 March 1992 the Republic of Armenia has been a member to the United Nations; the CIS from 21 December 1991; the Black Sea Economic Cooperation from 1 May 1999; the Council of Europe from 25 January 2001; the WTO from 5 February 2003. Since 1993, the Republic of Armenia has been a party to the UNFCCC and, from 2002, to the Kyoto Protocol.

The Republic of Armenia has established and is maintaining diplomatic relations with 160 states (as of 2013).

State environmental policy on the protection and use of natural resources has been developed and implemented by the Ministry of Nature Protection of the Republic of Armenia. Among the functions of the ministry is the development of policy, strategy and tactical approaches to the implementation of commitments under international environmental conventions.

1.2 Geographical Location and Natural Resources

The Republic of Armenia is located in the northeast of the Armenian Highlands on the border of the Caucasus and southwestern Asia.

The length of Armenia's state borders is 1,479 km. It borders with Georgia in the north, Azerbaijan in the east, Turkey in the west and southwest, and with Iran in the south.

Armenian territory comprises 29,743 km^2. The greatest extension of the territory from south to north is 360 km and 200 km from west to east.

Armenia is a mountainous country, and 76.5% of its area is 1,000-2,500 m above sea level.

According to the land balance data of 2012, 69% of the territory of Armenia is agricultural land, 11.5% is forest (discounting SPANs), 12.4% is SPANs, 0.9% is under water, 5.4% covers settlements, industry, transportation and communications, and 0.9% covers other areas.

Due to vertical alternation, 10 landscape zones have been formed in Armenia – from semi-desert to snowy highlands, including 6 climate patterns and from dry sub-tropical to frosty highlands. These natural conditions have enabled the existing, varied biodiversity. The territory of Armenia is inhabited by 3,600 plant species (almost half of the whole Caucasian flora), around 450 species of vertebrate animals, and 17,000 species of invertebrates.

Most biodiversity is represented by endemic and rare species. To preserve it, SPANs have been created, including 3 reserves, 4 national parks, and 27 sanctuaries.

Armenia is rich in copper molybdenum, polymetallics, constructional stone, mineral water, precious metals and semiprecious stones; these are the base of industrial production.

The rivers of Armenia are the confluents of the large rivers in Southern Caucasus – the Araks and Kura. Armenia has around 9,500 small and medium rivers, the total length of which is 25 thousand km. The longest rivers are: Akhuryan (186 km), Araks (158 km), Debed (154 km), Hrazdan (141 km), and Vorotan (119 km). The density of the river network varies significantly across the country (0-2.5 km/km^2). The irregularity of river flow distribution (both annually and multi-annually) is typical for the rivers of Armenia.

The average annual flow of surface waters is about 6.8 billion m^3. The flow of ground waters is approximately 4.0 billion m^3.

The greatest lake of Armenia is Sevan – one of the largest high-mountain fresh-water lakes of the world. In 2012, the level of the lake was 1900.13 m, the surface area 12,74.99 km^2, and the volume 37.71 km^3. Armenia also has 100 small mountain lakes, with a total volume of 0.8 km^3.

The territory of Armenia is characterized by high seismic activity and intensive exogenous processes; these contribute to landslide occurrence and erosion. The frequency and magnitude of hazardous hydrometeorological phenomena also contribute to emergencies and incur significant losses to the population and the economy.

According to the National Action Plan to Combat Desertification (2002), 81.9% of the current territory of Armenia is prone to various degrees of desertification – 26.8% (extremely high), 24.6% (high), 19.6% (medium), and 8.8% (low). Additional concerns arise due to the projected intensification of hazardous phenomena due to forecast global climate change.

1.3 Climate

The climate of Armenia is highly variable, even on small territories, due to the country's complex relief. Almost all types of climatic patterns can be observed in Armenia – from dry subtropical to severe alpine.

The average annual temperature ranges from -8^{o}C in high-altitude mountainous regions (2,500 m and higher) to 12-14°C in low-traced valleys.

Summer is temperate. The average temperature in July is 16.7°C, although in Ararat valley it varies between 24-26°C. The absolute maximum temperature is 43.7°C (recorded in Meghri in 2011).

Winter is cold. January is the coldest month of winter with an average temperature of -6.7°C. The absolute minimum temperature, -42°C, was recorded in Paghakn and Ashocq in 1961. Winter is temperate in the northeastern and southeastern regions of the country.

The climate of Armenia is rather dry. The average annual precipitation in Armenia is 592 mm. The most arid regions are Ararat valley and Meghri region. The annual precipitation there is 200-250 mm. The highest annual precipitation, 800-1000 mm, is observed in high-altitude mountainous regions. In Ararat valley, the average precipitation during summer does not exceed 32-36 mm.

The average annual wind speed is not evenly distributed across the country and ranges from 1.0 m/s in Meghri to 8.0 m/s in the Sisian mountain pass. In some of the regions, particularly Ararat valley, mountain-valley winds are well monitored. The wind speed in summer can reach 20m/s and more.

1.4 Population

As of the end of 2012, the population of the Republic of Armenia was 3,027 thousand people, with an average density of 102 person/km^2.

The distribution of the population is extremely disproportionate due to the country's mountainous relief and the varying level of economic development. The maximum density of population, 680 person/km^2, is characteristic of zones of up to 1,000 m in height; the minimum density, 22 person/km^2, is observed in high-altitude zones of up to 2,000-2,500 m in height.

The urban population is 64%, and the rural population is 36% (2012).

The largest cities are Yerevan (1066.3 thousand people), Gyumri (121.3 thousand peo-

ple), and Vanadzor (85.7 thousand people). 66.4% of the urban population and 42% of the total population live in these three cities. 48% of the total population is male, and 52% is female (2012). The average life expectancy is 74.3 years (men – 70.9 years; women – 77.5 years (2012)).

The number of employed people was 1,173 thousand people (2012). Figure 1.1 demonstrates data on population numbers.

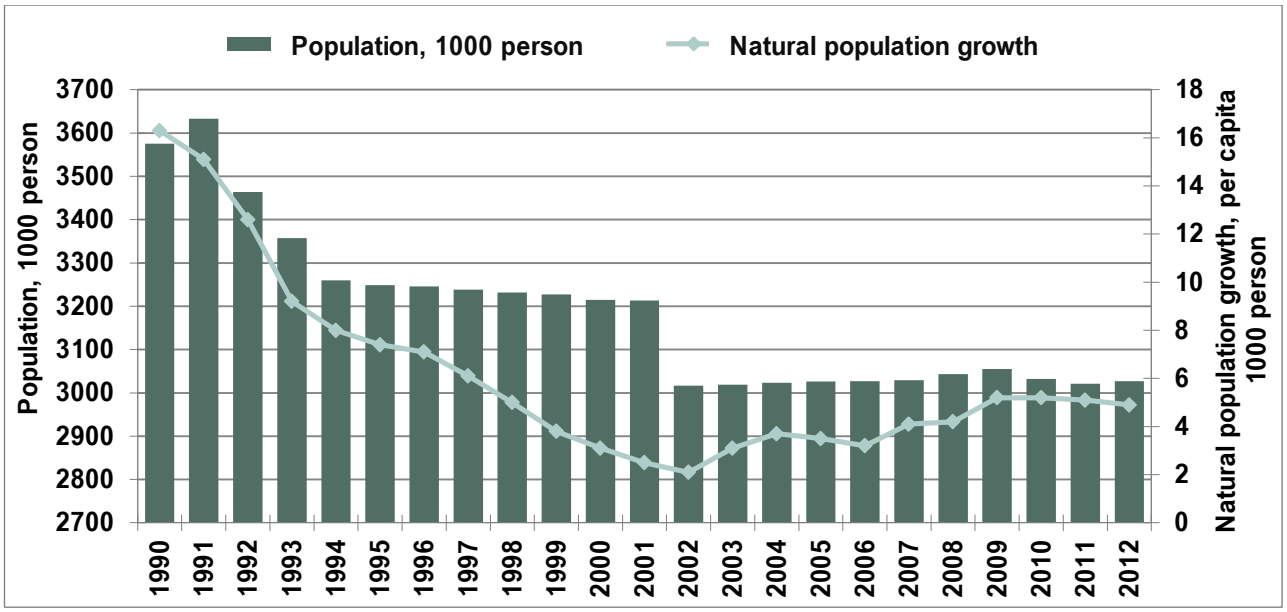

Figure 1-1. Armenian population and natural growth, 1990-2012

Source: Armenian National Statistical Service (1990-2013)

1.5 Economy

Microeconomic indicators. Following the sharp economic recession of 1991-1993, Armenia successfully passed through transition economy hardship and reached economic stability and economic growth (see table 1-1). Average annual economic growth was 5.4% in 1995-2000 and 12.4% in 2001-2006. In 2009, because of the global financial crisis, the economy decreased by 14.1%. The average annual economic growth for 2007-2012 was 3.3%.

Table 1-1. Main macroeconomic indicators of Armenia, 1995-2012

Indicator	1995	2000	2005	2010	2011	2012
GDP (billion AMD)	522	1,031	2,243	3,460	3,778	3,998
GDP (million USD)	1,287	1,912	4,900	9,260	10,142	9,950
GDP in purchasing power terms (billion USD)	6.9	7.3	12.6	20.4	17.9	19.7
GDP per capita in purchasing power terms (billion USD)	2,115	2,260	4,164	6,728	5,925	6,508
GDP index in comparison to the previous year (million USD)	106.9	105.9	113.9	102.2	104.7	107.2
Inflation (%)	32.2	0.4	2.2	8.2	7.7	2.6
Export (million USD)	271	300	974	1,041	1,334	1,380
Import (million USD)	674	885	1,801	3,749	4,115	4,261
External state debt (million USD)	373	860	1,093	3,300	3,570	3,739

Source: Armenian National Statistical Service (1995, 2001, 2006, 2011, 2013)

Structural economic changes brought about respective changes in GDP structure, i.e. decreases in industry and increases in construction (2005-2008) and services (see table 1-2).

Table 1-2. Structure of the GDP of Armenia for 1990-2012, %

	1990	1995	2000	2005	2010	2011	2012
Industry	44.0	24.3	21.9	18.8	15.5	17.1	17.2
Agriculture	13.0	38.7	23.2	18.7	17.0	20.3	19.1
Construction	18.0	8.5	10.3	21.7	17.3	13.0	13.2
Services	25.0	24.8	35.5	32.3	40.8	41.2	42.7
Net Taxes	-	3.1	9.1	8.5	9.0	8.4	7.8

Source: Armenian National Statistical Service (1990, 1995, 2006, 2011, 2013)

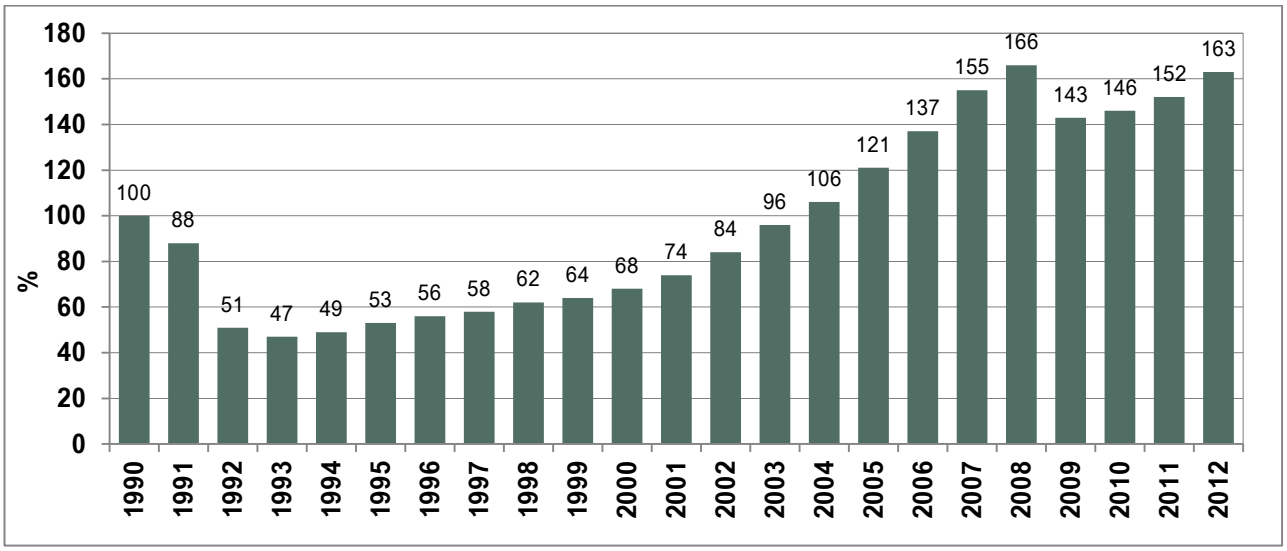

Figure 1-2. GDP dynamics of Armenia for 1990-2012 compared to 1990, %

Source: Armenian National Statistical Service (1990-2013)

Social indicators: The official unemployment rate is 7% (according to the International Labour Organization's methodology it is 17.3%). The monthly average nominal salary is AMD 113.163 (USD 281). The poverty rate (monthly income per person less than USD 92) is 32.2%. The potential human development index is 0.729 (87th in global rankings).

Priority issues for economic development are addressed in the Armenian Perspective Development Strategic Programme for 2012-2025.

1.6 Energy

Due to the economic recession and energy crisis, the demand for energy fell sharply in 1992-1994. However, since 1995, Armenia has recorded stable growth in energy consumption (see table 1-3).

Table 1-3. Energy consumption in Armenia for 1990-2012, PJ

Energy carriers	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Natural Gas	151.4	43.1	47.0	47.0	38.2	42.6	47.0	58.4	61.5	62.8	69.7	61.4	61.1	72.0	87.4
Oil Products	162.8	21.2	12.9	14.8	14.7	15.7	16.2	14.7	15.0	15.2	16.8	14.5	16.0	15.4	14.4
Coal	13.4	0.4	-	-	-	-	-	-	0.0	0.03	0.03	0.04	0.03	0.1	0.09
Firewood	0.1	3.5	3.4	3.3	3.1	2.8	2.6	2.3	1.8	0.4	0.4	0.5	0.5	0.4	0.7
Manure	-	-	5.4	5.6	5.8	6.1	6.3	6.4	6.7	6.4	6.2	5.9	5.9	6.2	6.8
Liquid gas	0.0	0.1	0.6	0.8	0.9	0.9	1.0	0.9	0.7	0.5	0.4	0.4	0.3	0.3	0.3

Energy carriers	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Hydro energy	6.7	7.1	4.5	3.5	6.0	7.1	7.3	6.4	6.6	6.7	7.3	8.2	10.3	8.9	8.32
Nuclear energy	-	2.2	21.7	21.5	24.8	21.7	26.1	29.4	28.6	27.7	26.9	27.2	27.2	27.8	25.4
Total	**334.4**	**77.6**	**95.5**	**96.5**	**93.5**	**96.9**	**106.5**	**118.5**	**120.9**	**119.7**	**127.7**	**118.1**	**121.3**	**131.1**	**143.4**

Source: Armenian Ministry of Energy and Natural Resources (1990- 2001); "ArmRosgasprom" CJSC (2002-2012), Armenian National Statistical Service (1990, 1995, 2000, 2005, 2007); Armenian Customs Service (2007-2012)

Armenia does not possess significant fuel resources and satisfies its demand for fuel through imports. Its own primary energy resources (hydro, nuclear energy, biomass) cover 36% of the country's total energy consumption.

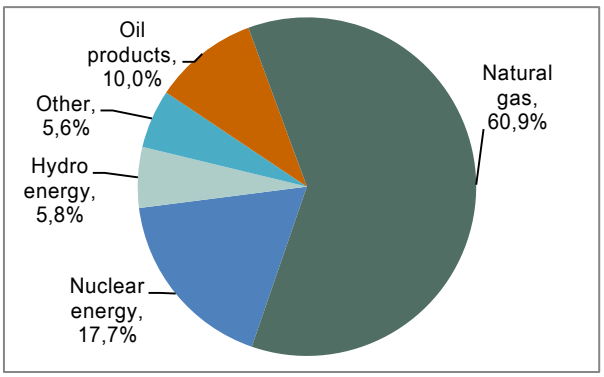

Figure 1-3. Total primary energy consumption in Armenia, 2012

The principal fuel is natural gas. In 2000-2010, the share of natural gas in total fuel consumed reached 68-74%. With regard to primary energy demand, the shares for natural gas and nuclear energy are the front runners (see figure 1-3).

Electrical energy is produced in thermal, hydro, and nuclear power plants. As of 2010, the total installed capacity of electrical energy systems is 3,521 MW, including 1,561 MW from thermal power plants, 1,145 MW from hydro power plants (including small HPP), and 815 MW from the nuclear power plant. Electrical energy production dynamics is demonstrated in figure 1-4.

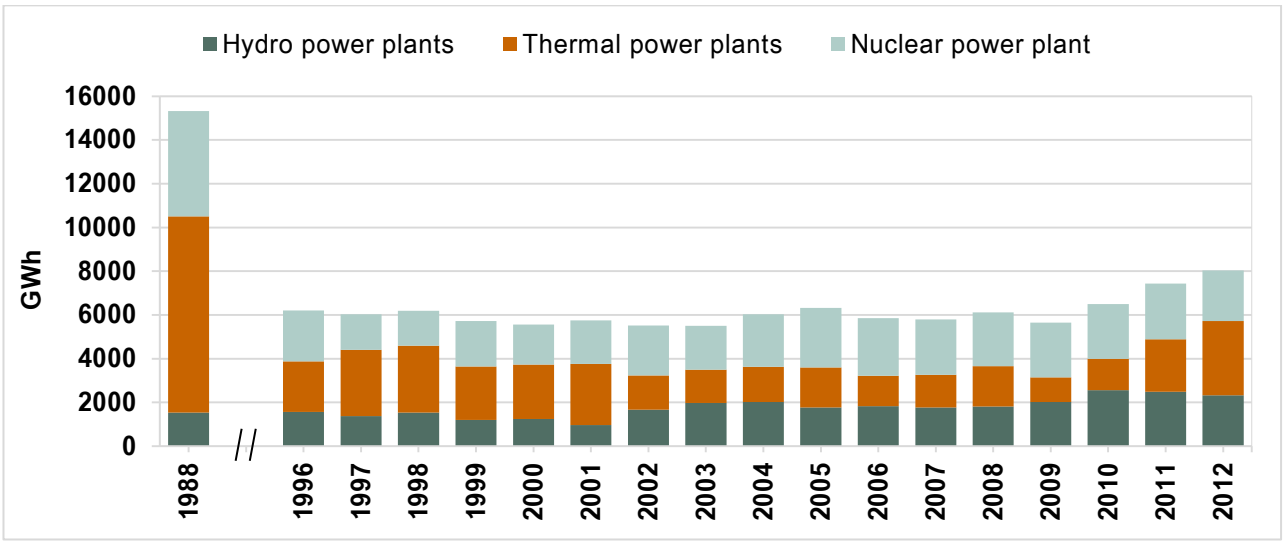

Figure 1-4. Power production of Armenia, 1988-2012

Source: Armenian Ministry of Energy and Natural Resources (1988-2011); Armenian Statistical Yearbook (2002-2011)

In 2010-2012, highly efficient gas-fired power units were installed in thermal power plants of Armenia: 206 MW in Yerevan TPP; 440 MW in Hrazdan TPP. This enables reduction in fuel consumption and GHG emissions in TPPs.

Thermal energy is produced in boiler houses in residential and public/commercial sector buildings. The economic and energy crisis of 1992-1994, together with the destruction of the subsidization system, caused devastation to centralized heat-supply systems. In 2010, the total production of thermal energy for in-

dustrial and urban needs fell to 15% of the 1990 level. In the residential sector, apartment-level devices for gas and electricity are mainly used for space and water heating. In 2008, a district heating system was reconstructed on a co-generation-based unit in only one residential district of Yerevan. Heating systems in public/commercial buildings have recovered quite quickly through the installation of efficient, heat-only gas boilers. The generation of thermal energy increased twice over the period of 2000-2010.

The energy crisis brought about a decline in the gas supply. Since 2000, the system has recovered extensively. In 2010, the level of gasification was more than 96%, an important factor for a stable energy supply. For the diversification of the gas supply sources, the Iran-Armenian pipeline was opened in 2007. At the moment, the gas supply from Iran is done via power-supply exchange – 3 kWh of energy for 1 m^3 of supplied gas. Fuel consumption by sectors is provided in table 1-4.

Table 1-4. Fuel consumption by sector for 2000-2012, PJ

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Electrical energy	29.8	30.2	17.5	17.2	18.1	20.7	17.1	17.0	20.4	16.5	14.8	21.2	28.7
Industry/ construction	7.6	6.4	6.8	7.3	9.6	12.1	12.0	13.6	12.3	9.0	9.5	8.8	8.0
Transport	10.9	13.0	15.5	15.6	17.5	17.1	19.8	17.1	20.2	18.6	19.4	19.6	20.0
Agriculture	0.7	2.1	4.3	1.7	1.6	1.7	1.7	5.3	5.8	5.3	5.8	5.5	6.0
Residential	9.1	9.2	8.6	10.2	11.3	13.7	16.3	17.8	19	19.9	17.8	19.4	14.9
Public/ commercial	2.5	2.6	2.5	3.1	2.6	2.9	7.3	5.4	5.7	5.6	5.8	5.3	9.4
Total	**60.6**	**63.5**	**55.2**	**55.1**	**60.7**	**68.2**	**74.2**	**79.9**	**83.4**	**74.9**	**73.1**	**79.8**	**87.0**

Source: Armenian Ministry of Energy and Natural Resources (2000-2002); "ArmRosgasprom" CJSC (2002-2012); Armenian Statistical Yearbook (2001-2013); "ArmForest" SNCO (2000-2012)

The Energy Sector Development Strategy (2005) has served as a basis for the development of long-term energy policy in Armenia. The strategy defines ways to develop renewable and alternative energy, energy savings, and nuclear energy.

1.7 Industry

Hardships of the initial transition period to a market economy and the collapse of the former USSR were among the main reasons for industrial failure in Armenia. In 1993, industrial production fell to 43% of the 1990 level. Since 1994, the situation has stabilized and slow growth in industrial production has been achieved. In 2010, the volume of the industrial production was 82.6% of the 1990 level (see figure 1-5).

While adapting to new conditions, significant changes in the sectorial composition of industrial production took place. Compared to 1990, the share of previously prominent sectors, such as machine building and light industry, sharply declined (from 34% to 4.4% and 24.9% to 1.1% respectively); non-ferrous metallurgy and food processing grew from 8.8% to 31% and from 16.3% to 54% respectively.

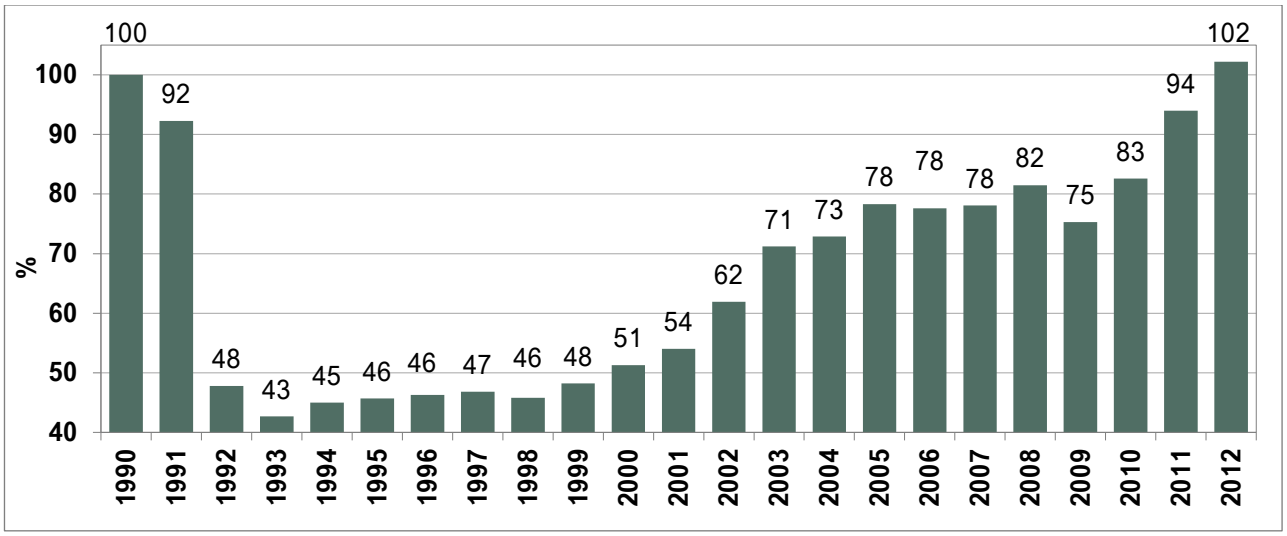

Figure 1-5. Dynamics of industrial production for 1990-2012 compared to 1990 level, %

Source: Armenian National Statistical Service (1990-2013)

The structure of industrial production is demonstrated in figures 1-6 and 1-7.

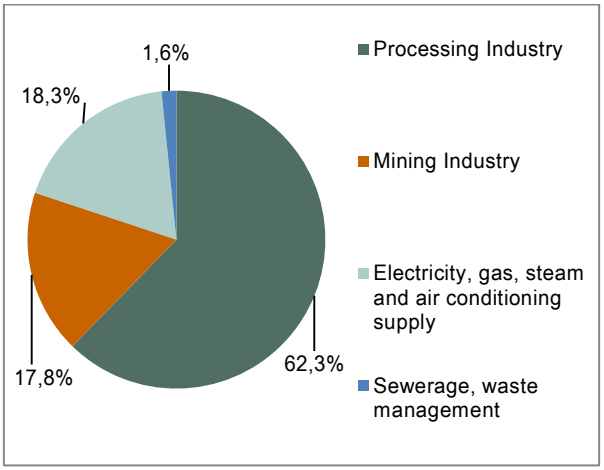

Figure 1-6. Structure of industrial output by types of economic activity, 2012

Source: Armenian National Statistical Service (2013)

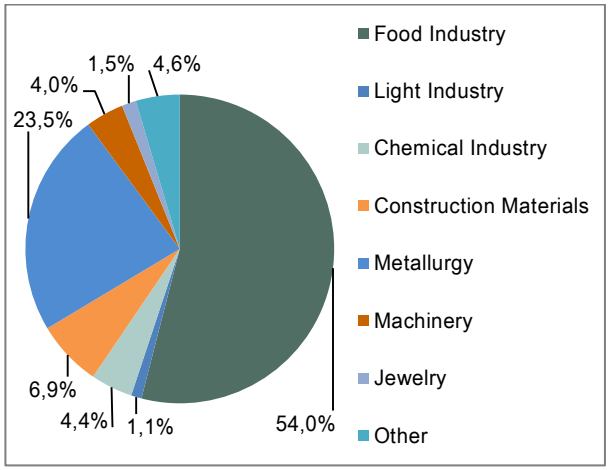

Figure 1-7. Structure of processing industry, 2012

Source: Armenian National Statistical Service (2013)

1.8 Transport

The transport sector in Armenia includes railways, road, air and pipelines (see figure 1-8).

As of 2012, the length of routes reached: 703 km of railways (general usage), 7,789 km of roads (general usage), and 1,584 km of pipelines.

After 1990, as a result of significant structural changes in the economy and transportation blockade, the transport sector underwent substantial transformation. Compared to 1990, goods turnover (without pipelines) fell 27 times in all types of transportation in 2012. The total goods turnover fell 7.3 times, including railways (5.6 times), roads (11), and air (4.4). Total passenger turnover decreased by 2.7, with 6 for railways, 1.4 for roads, and 7.6 for air. Since 2000, in line with economic development, increase in passenger and goods turnover has been recorded (see table 1-5).

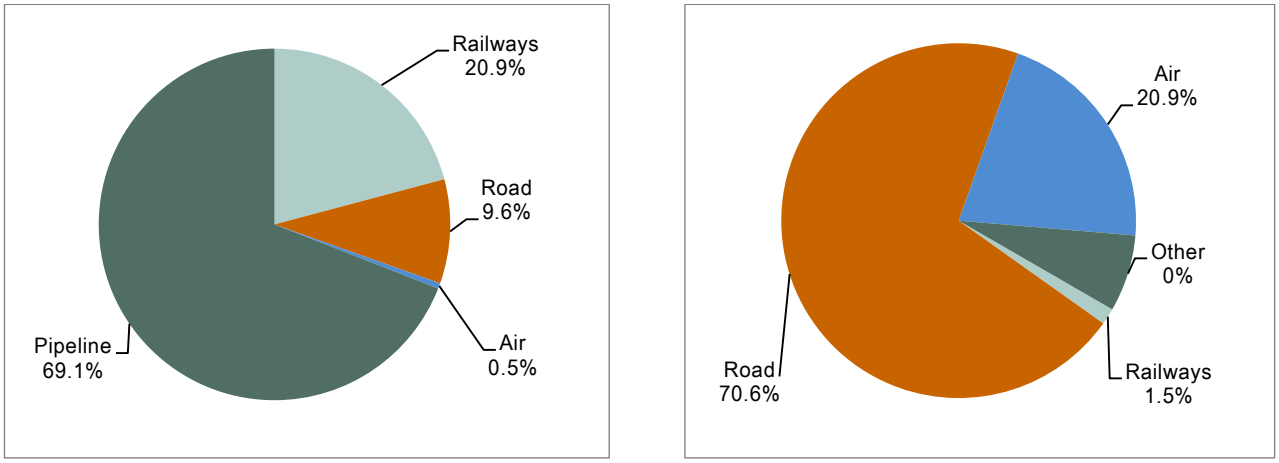

Figure 1-8. Means of transportation in goods and passenger turnover, 2012

Source: Armenian National Statistical Service (2013)

Table 1-5. Transport sector indicators, 1990-2012

	1990	2000	2005	2010	2011	2012
Freights shipped (million tonne)	227.3	4.5	8.3	10.5	9.7	12.1
Freight turnover (million tonne-km)	9,410	1,705.1	2,300.9	3,091.5	3,581.7	4,159.8
-railways	4,884	353.6	654.1	743.2	815.9	867.3
-road	4,477	40.0	55.5	235.8	287.0	400.1
-air	49	9.6	10.7	9.7	9.1	11.2
-pipeline	-	1,301.9	1,580.6	2,102.8	2,469.7	2,876.4
Passenger turnover (million passengers-km)	495.2	135.8	204.3	233.3	231.6	230.7
-railways	9,512	2,063	3,199	3,938	3,631	3,471
-road	316.0	46.8	26.6	50.1	49.4	53.0
-air	3,526	1,310	2,072.4	2,344.3	2,379.7	2,449.7
-pipeline	5,557	579.2	959.5	1,278.6	951.3	725.5
-other types of transport	112.5	127.4	140.9	264.8	250.9	242.9

Source: Armenian National Statistical Service (1991, 2000, 2005, 2013)

1.9 Agriculture

According to the land balance of 2012, agricultural land in Armenia occupies 2,052.4 thousand ha, including plough lands (448.4 thousand ha – 21.9%), perennial plantings (33.4 thousand ha – 1.6%), hayfields (121.6 thousand ha – 5.9%), pasture (1,056.3 thousand ha – 51.5%), and other land (392.7 thousand ha – 19.1%). The territory covered by perennial plantings and garden plots of households in settlements covers 23.8 thousand ha.

Armenia's agriculture has also suffered the consequences of the severe economic crisis of 1991-1994. As a result of agrarian reform and land privatization, major agricultural farms were transformed into about 340 thousand small farms, each with a land share of approximately 1.4 ha. The land fund was divided into parts, impeding the efficiency of its management and production infrastructure. The area and structure of agricultural land changed as well: crops fell by approximately 30% (see figure 1-8). Livestock numbers also went down (see table 1-6). Irrigated land halved, whilst the use of chemical fertilizers fell threefold.

Table 1-6. Numbers of livestock and poultry, thousand heads

Livestock/poultry	1990	1995	2000	2005	2010	2011	2012
Cattle	690.0	507.5	478.7	573.3	570.6	571.4	599.2
Sheep and goats	1,291	603.2	548.6	603.3	511.0	592.5.	590.2
Pigs	329.3	79.6	70.6	137.5	192.6	114.8	108.1
Horses	-	-	11.5	10.8	10.1	12.1	9.9
Poultry	11245	3100	4255.1	4861.7	4134.6	3462.4	4023.5

Source: Armenia National Statistical Service (1990, 1995, 2001, 2006, 2013)

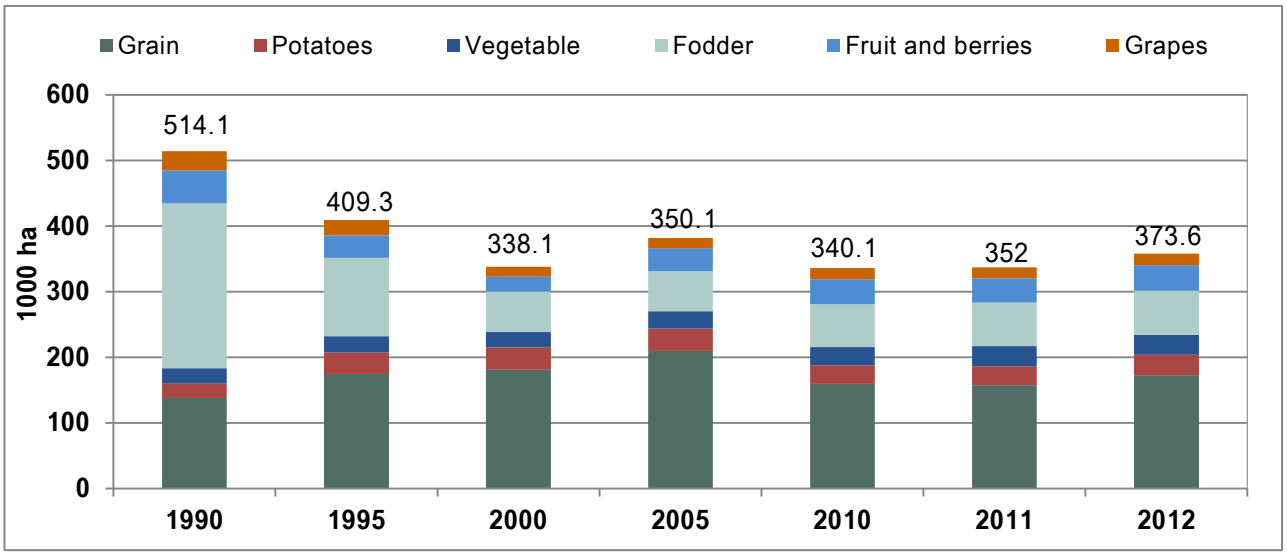

Figure 1-9. Areas of agricultural land by crops, 1990-2012

Source: Armenian National Statistical Service (1990, 1995, 2001, 2006, 2013)

Preventing further decline in agricultural production and ensuring stabilization and further development required tremendous effort and the implementation of various programmes. Slowly but steadily, agricultural production grew (see table1-7). From 2000-2006, average the annual growth of agricultural production was 7.7%; for 2007-2012 it was 2.2%. In the same period, the average share of plant growing in aggregate agricultural production reached 60% (40%livestock breeding).

Table 1-7. Production of main types of agricultural output, thousand tonne

Agricultural output	1990	1995	2000	2005	2010	2011	2012
Grain	271.0	262.7	224.8	396.2	326.4	440.7	456.1
Potatoes	212.5	427.7	290.3	564.2	482.0	557.3	647.2
Vegetables	389.7	450.9	375.7	663.8	707.6	787.1	849.0
Watermelons	31.4	54.0	52.8	117.8	132.5	180.9	205.1
Fruit and berries	155.5	146.1	128.5	315.6	128.5	239.4	331.7
Grapes	143.6	154.9	115.8	164.4	222.9	229.6	241.4
Meat (slaughter weight)	145.0	82.4	49.3	56.0	69.5	71.7	73.9
Milk	432.0	428.3	452.1	594.6	600.9	601.5	618.2
Eggs (million pieces)	606	518	385.4	518.2	702.2	633.6	658.1

Source: Armenian National Statistical Service (1990, 1995, 2001, 2006, 2013)

The average share of agriculture in Armenia's GDP was 18% in 2007-2012 and 19.1% in 2012. 516 thousand people are employed on farms, making up to 44% of the total workforce.

The main directions of agriculture development are defined in the Armenian Strategy of Sustainable Agricultural Development for 2010-2020.

1.10 Forestry

According to the new forest management plans, forest lands currently cover about 457.5 thousand ha (including forest lands of SPANs), with 350.5 thousand hectares covered in forest. Forest-covered territories are distributed unevenly and include 4 forest enterprise zones. 62.2% of forests (217.34 thousand ha of forest-covered areas) are in the northeast (Tavush and Lori); 12.6% (44.22 thousand ha)- in the central forest enterprise zone (Aragatsotn, Kotayk, Gegharkunik, Ararat); 2.2% (7.7 thousand ha) in the south (Vayots Dzor); 23.0% (80.38 thousand ha) in the southeast (Syunik) marzes.

About 270 tree and bush species grow in Armenian forests: oak, beech, hornbeam and pine are the major natural components of these forests.

As a result of the energy crisis in 1992-1995, massive illegal logging brought about negative impacts on forest ecosystems. Degraded forest ecosystems only partially reduce carbon absorption from the atmosphere. Intensive afforestation and reforestation efforts are required to promote forest regeneration. 2,150 ha of area underwent reforestation and afforestation activities in 1998-2006, and 2,754 ha in 2006-2012.

According to the Forest Code of 2005, Armenia's forests are classified as important for protective, special and production purposes. Protective forests include upper and lower belts with 200 m forest width, as well as forests growing in the semi-desert, steppe and forest-steppe zones. This fact is very important for reducing forest vulnerability under climate change, as logging is limited in this type of forest.

Armenia's forests and forest lands are the property of the state. To increase forest cover, the Forest Code defines the right for community and private ownership over self-established forests.

Armenia's forests and forest lands are regulated by two state agencies: the Armenian Ministry of Agriculture (Armforest SNCO) and the Armenian Ministry of Nature Protection (SPANs).

The preservation, rehabilitation, natural reproduction and sustainable use of forests are ensured according to Armenia's National Forest Policy and Strategy, as well as Armenia's National Forest Programme (2005).

1.11 Waste

Municipal solid waste (MSW) is collected, removed and stored in 48 landfills. The total area covered by landfills is 219 ha: the largest are located in Yerevan (30 ha), Vanadzor (13 ha), Gyumri (10 ha), Armavir (8 ha), Etchmiadzin (7 ha), and Hrazdan (6 ha).

MSW includes domestic, commercial, and other types of waste. In none of the landfills is waste preliminarily classified or sorted.

The annual average amount of MSW generation is 700 thousand tonnes; about 510 thousand tonnes of it is transferred and deposited in landfills (241 kg per city dweller). All landfills, except the largest one in Yerevan, are not managed.

In MSW decomposable organic carbon reaches 50-60%. Dumping of MSW in landfills results in anaerobic decomposition and methane emissions.

Currently, various projects are being implemented in Armenia aimed at improving MSW systems. In the Yerevan landfill a landfill gas-utilization and -combustion system was installed under a CDM project.

Urban wastewater includes domestic, commercial, and partially industrial wastewater. In 2010, water discharge decreased 1.7 times compared to 1990 (740 million m3), reaching 431 million m3. 190 million m^3 was polluted and 241 million m^3 standard clean.

The amount of wastewater discharged through sewers 86.6 million m^3. The reduction of wastewater is the result of population decreases, increases in water-use efficiency, and a decline in industry.

In Armenia, there used to be 20 wastewater treatment plants with a total capacity of 958 thousand m^3/day. Currently, these wastewater treatment stations, except those in Martuni, Vardenis and Gavar, are in extremely poor technical condition and practically non-operational – wastewater flows into surface-water basins without any treatment. At Aeratsia station, the largest, wastewater undergoes partial mechanical cleaning. In Armenia there is, as yet, no biological cleaning, sludge removal or methane extraction during wastewater treatment. Stations are merely shallow pools from which large amounts of organic materials and GHGs are released and emitted. That said. wastewater treatment plants have been restored and modernized in the Lake Sevan Basin.

1.12 Legal and Institutional Bases for the Implementation of UNFCCC

The Republic of Armenia ratified the UNFCCC in 1993 as a Non-Annex I Party and Kyoto Protocol in 2002.

The Armenian Ministry of Nature Protection is the responsible body for coordinating activities to implement the Convention in the country. The ministry is developing long-term action plans approved by the Government of Armenia. To implement the Convention, the following legal acts have been adopted by the Government of Armenia: "On approval of the procedures of the forecasting, warning and re-

sponse to dangerous meteorological phenomena related to atmospheric excessive pollution, climate change and ozone-layer condition" (Decree No. 1186-N, dated 16 October 2008), "Approval of the action plan on implementation of RA obligations emanating from a number of international environmental conventions" (Decree No. 1594-N, dated 10 November 2011) which defines the measures and responsible agencies for implementation.

The amendment of the law on "Atmospheric air protection" was done, prohibiting burning vegetable residues and areas with dry vegetation in pastures and grasslands, as well as in agricultural, forested, and specially protected areas. This provision is aimed at restoring and storing organic carbon in soil and ground vegetation, as well as protecting the soil and soil layer from erosion and desertification. The Decree "On approval of land monitoring procedure" (Decree No. 276, dated 19 February 2009) also has this purpose. This Decree requires state monitoring procedures to define organic carbon content, among 15 important indicators of soil and soil-layer protection.

In 2012 the Armenian Government approved the decree on "National strategy on disaster risk reduction of the RA and the action plan for of the national strategy on disaster risk reduction" (No. 281-N, dated 7 March 2012).

Armenia submitted its statement to the UNFCCC Secretariat on its association with the Copenhagen Accords (2010). This statement is Armenia's position on continuing the Kyoto Protocol and limiting GHG emissions. The statement indicates priority sectors for GHG emission reduction and measures for sinks development.

The Copenhagen Accords is the base for developing NAMAs to be submitted to the Armenian government for approval in 2015. Within this timeframe development and submission of the Climate Change Adaptation Concept and the National Adaption Plan (NAP) is also envisaged.

The Armenian prime minister adopted Decree No. 955, dated 2 October 2012, "On the establishment of an Inter-Agency Coordinating Council on the implementation of requirements and provisions of the UNFCCC and the approval of the composition and rules of procedures of the Inter-Agency Coordinating Council". The council is composed of representatives of 14 ministries, 2 state agencies adjunct to government, the Armenian Public Services Regulatory Commission, the Armenian National Academy of Sciences, and the UNFCCC National Focal Point. The chairman of the council is the Minister of Nature Protection.

The council was establish to implement UNFCCC provisions, in particular, measures defined by the Decree No. 1594, Armenia's productive participation in the Convention developments.

The council will ensure cooperation between regional, intergovernmental and international organizations, of participatory approaches to communities, civil society and the scientific community, and of capacity building. The council meets twice a year and, between meetings, uses formal channels of intergovernmental cooperation.

To support the operations of the Council, there is also a working group comprising representatives of state agencies, as well as climate change experts and consultants.

The Armenian government adopted Protocol Decree No.16, dated 25 April 2013 "On approval of the concept of the establishment of innovative financial-economical mechanisms in the field of environment". On this basis, the government adopted Protocol Decree No. 47, dated 14 November 2013, "On approval of the concept of the establishment of innovative financial and economical mechanisms in the field of environment". These documents show the Armenian government's commitment to developing proposals on establishing a civic revolving investment fund. The fund is aimed at establishing the relevant financial mechanism for climate change mitigation (GHG emissions reduction and sinks development) and adaptation (combating climate change impact) measures. Fund resources should be created through companies' environmental fees (those using natural resources and having an impact on the environment).

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3. Socio-economic Conditions of Armenia (1990-1996). Armenian Service of Statistics, State Registry and Analyses.
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2

GREENHOUSE GAS INVENTORY

2.1 Background

The first greenhouse gases national inventory in Armenia was developed in 1996-1998 within the framework of preparations for First National Communication on climate change. The estimation of GHG emissions and removals in this inventory was carried out for 1990 (baseline year) and 1994-1996 using IPCC's 1995 *Guidelines for National Inventories*.

Under the UNDP-GEF "Regional Programme on Capacity Building for Quality Enhancement of GHG Inventories", 2004 the country improved the first GHG national inventory, trained national experts, defined some of the emission factors, carried out analysis of key categories, and identified sources where inventories needed further improvement. The inventory data on methane emissions from SW disposal sites and enteric fermentation of agricultural animals was revised. The *Manual for National Inventory of GHGs* was developed and it was widely used to develop Second National Inventory of greenhouse gases.

The Second National Inventory of greenhouse gases was developed within the framework of preparations for SNC on climate change (2007-2010). According to the *Guidelines (17/CP8) for Preparation of National Inventories*, 2000 was taken as the baseline year. For the purpose of filling in the 1990-2006 period, GHG inventories were developed and revised, as well as for other years for which respective input data was available. The inventory report was based on IPCC's 1996 *Revised Guidelines and Good Practice Guidance*. TNC and the most recent GHG inventory were developed in 2012-2014. For the 3rd GHG inventory, 2010 was taken as the baseline year. The inventory of GHG emissions was prepared according to IPCC 2006 guidelines and by using the respective software. In terms of capacity building, a number of experts participated in online training held by the Convention Secretariat in Sri Lanka in January 2012.

In order to enhance the capacity of the national inventory group, two experts participated in online training (Inventories Review Experts of Annex-1 countries) held in September-October 2013 and a seminar in Hanoi.
In compliance with IPCC 2006 *Guidelines for National Inventories,* the third inventory of Armenia covered following sectors:

- Energy
- Industrial process and product use (IPPU)
- Agriculture, forestry and other land use (AFOLU)
- Waste

The national GHG inventory was estimated for years and by sectors, as described in table 2-1.

Table 2-1. Developed and revised inventories of greenhouse gases by year and sector

Sector	Years	
	Inventory years	Revised
Energy	2001-2010	2000
Industrial processes and product use	1995- 2010	2000
Agriculture	2000- 2010	2000
Forestry	2000- 2010	2000
Other land use	2000- 2010	2000
Waste	1995 - 2010	1990-2010

The Republic of Armenia, being a non-Annex I Party, is not obliged to prepare a GHG inventory on annual basis. It submits its inventory report within the framework of national communication preparation. Armenia has not yet established a permanent institutional mechanism and, therefore, the inventory developed by the working group is put together ad hoc on a competitive selection basis.

The organization chart for the preparation of the *Third GHG Inventory Report of Armenia* is described in Figure 2-1.

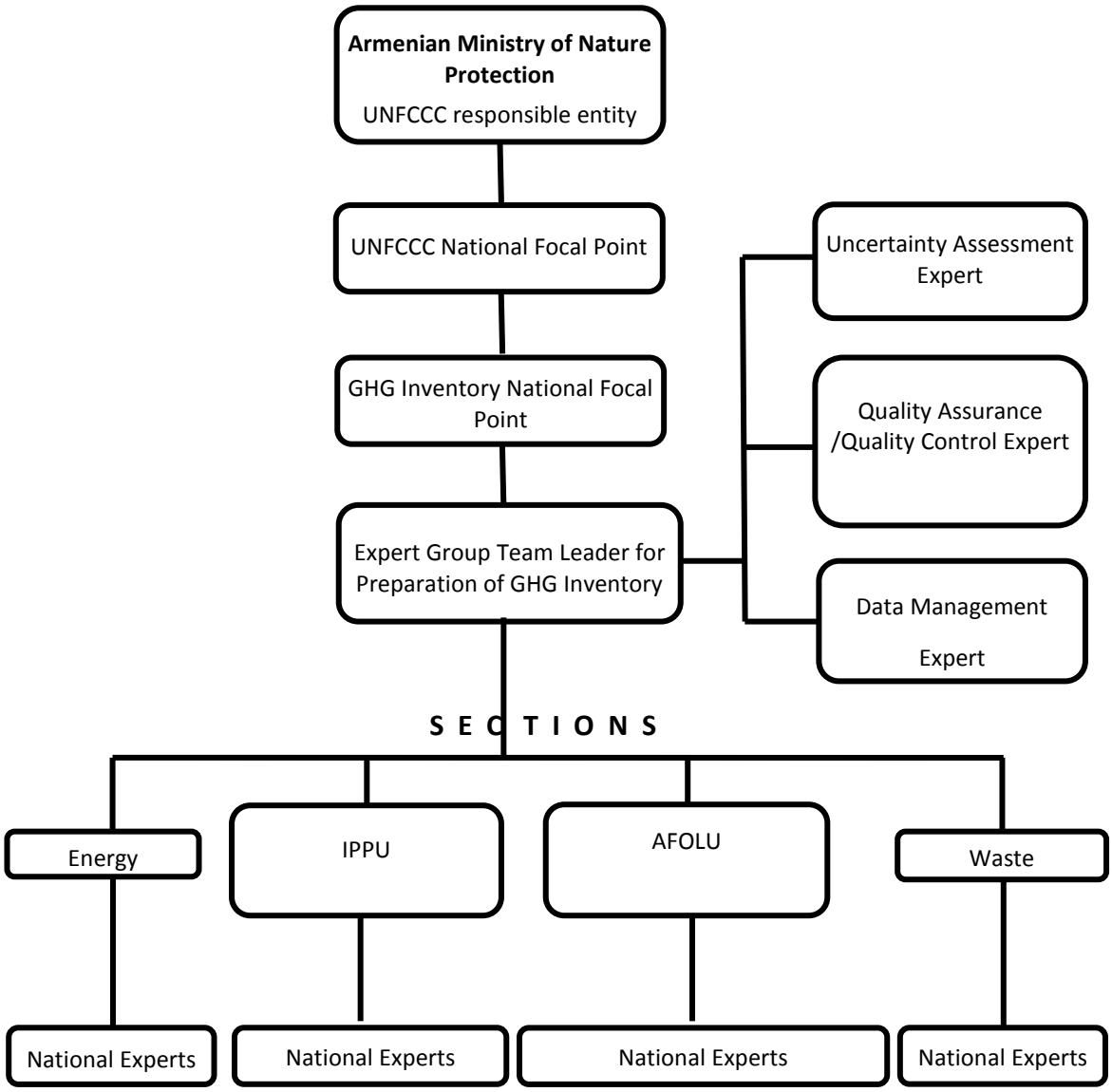

Figure 2-1. Organizational chart for preparation of the Third GHG National Inventory Report of Armenia

2.2 Methodology and Data Sources

GHG National Inventory Report is prepared pursuant to the requirements of the IPCC 2006 *Guidelines for Preparation of National GHG Inventories* and IPCC 1996 *Revised Guidelines for Preparation of National GHG Inventories*; IPCC 2000 *Good Practice Guidance* and IPCC 2003 *Good Practice Guidance for Land Use*, *Land Use Change and Forestry*; emissions calculation *CORINAIR-99 Manual of Joint Project on Observation and Assessment of the Spread of Air Pollutants in Long Range Distances in Europe (EMEP)*.

Given that IPCC 2006 *Guidelines for Preparation of National GHG Inventories* is not yet officially mandatory (they are discretionary), the IPCC 1996 *Revised Guidelines for Preparation of National GHG Inventories* also was used to estimate the total GHG emissions table, using the following principles:

- Clear observation of the logic and structure of IPCC methodology;
- Priority given to the use of national data and factors;
- Utilization of all possible activity data;
- Maximum use of national information source opportunities.

During the preparation of the third national inventory of Armenia, the highest priority was given to the estimation of gas emissions with direct greenhouse effects, i.e. CO_2, CH_4 and NO_2. Gas emissions with indirect greenhouse effects, i.e. CO, NO_x, NMVOCs and SO_2 were also estimated. Unlike previous inventories, the third inventory accounted for emissions of

F-gases (HFCs), as well as SO_2 emissions from copper and ferromolybdenum production.

The National Statistical Service served as main activity data source. Information was also provided by the Armenian Ministry of Agriculture, Ministry of Energy and Natural Resources, State Revenues Committee, Ministry of Economy, State Committee of Real Estate Cadastre, the municipalities of Yerevan, Gyumri, Vanadzor and other cities, Institute of Energy CJSC, ArmRosGasProm CJSC, Armforest SNCO, Public Services Regulatory Commission, and others.

The main phases for developing the inventory included: identification of key data sources; collection and data input of activities and emissions factors; estimation of emissions; analysis of key categories; uncertainty assessment; drafting of the national inventory report; expert assessment; preparation of the final version and design of the inventory; printing and publishing.

2.3 Greenhouse Gas Emissions, 2010

In 2010, GHG emissions in Armenia totalled 7463.6 Gg $CO_{2\ eq}$ (see table 2-2). GHG emissions fell by 70% compared to 1990, yet increased by 26% compared to 2000.

Table 2-2. Greenhouse gas emissions by sector for 2010, Gg*

Sector	CO_2	CH_4	N_2O	HFC	$CO_{2\ eq}$
Energy	4,231.0	35.64	0.094	0	5,008.6
Industrial processes and product use	225.9	0	0	0.133	481.1
Agriculture	0	44.26	1.26	0	1,320.5
Waste	7.64	27.77	0.202	0	653.4
Total	**4,464.6**	**107.67**	**1.557**	**0.133**	**7,463.6**

* *Without forestry and land use*

Total GHGs include: carbon dioxide – 59.8%, methane – 30.3%, nitrous oxide – 6.5%, and F-gases – 3.4% (see figure 2-3). Emissions by sector were: energy – 67%, IPPU – 6.4%, AFOLU – 17.9%, and waste – 8.7% (see figure 2-2).

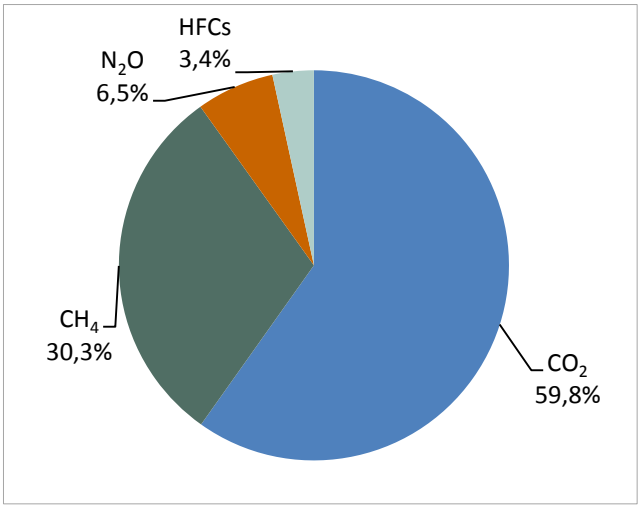

Figure 2-2. Distribution of greenhouse gas emissions by gases, 2010

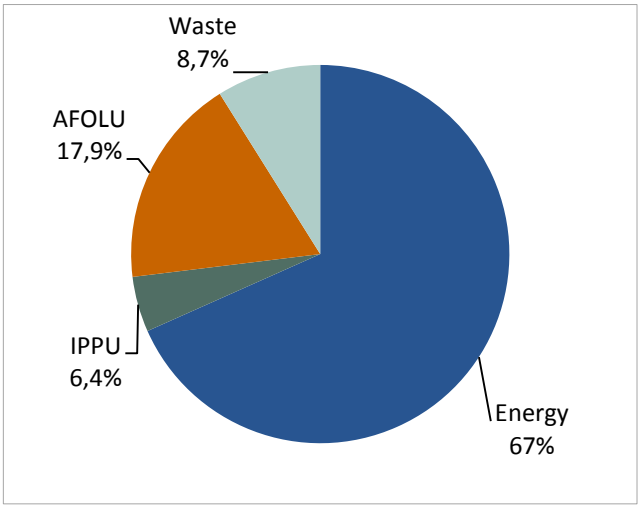

Figure 2-3. Distribution of greenhouse gas emissions by sector, 2010

Most CO_2 emissions are generated by the Energy sector (84%), while CH_4 and N_2O are mostly generated by AFOLU (41% and 81% respectively) (see figure 2-4). Aggregate emissions of gases with indirect greenhouse effects are described in table 2-3**.**

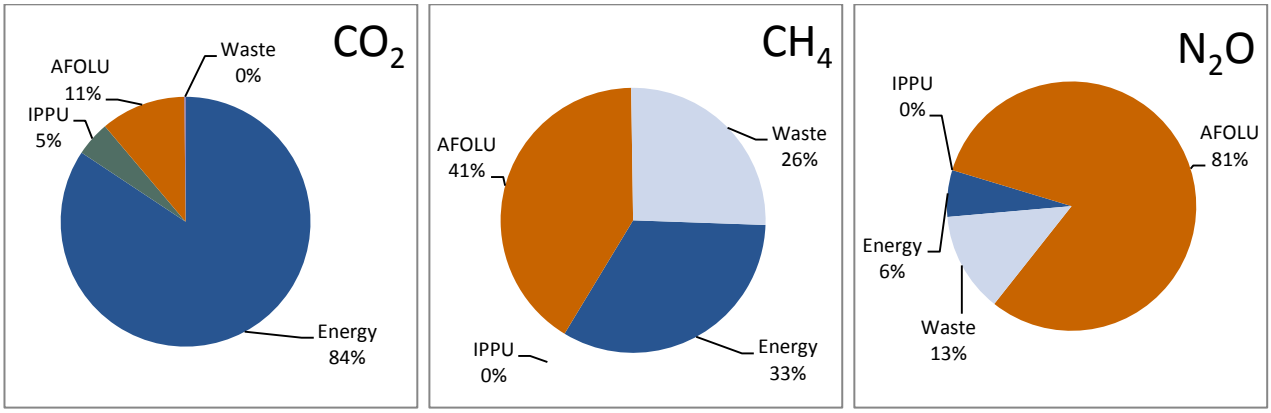

Figure 2-4. Distribution of greenhouse gas emissions in sectors by gases, 2010

Table 2-3. Emissions of gases with indirect greenhouse effects, and SO_2 for 2010, Gg

CO	NO_X	NMVOC	SO_2
66.8	**17.2**	**22.9**	**31.1**

2.4 Trends in Greenhouse Gas Emissions, 2000-2010

2000-2010 GHG emission trends by gas type are described in table 2-4 and figure 2-5, and by sector in table 2-5 and figure 2-6.

In general, there was an increase in GHG emissions in 2000-2008, due to high rates of economy development; emissions reduction occurred mainly in the Energy and IPPU sectors in 2009-2010, caused by the global economic crisis.

The increase in emissions of substances substituting ozone-layer-depleting substances (HFCs) is mainly due to the development of refrigeration and air-conditioning systems.

Table 2-4. CO_2, CH_4, N_2O and HFCs emissions for 2000-2010, Gg $CO_{2\,eq}$

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO_2	3,207.0	3,405.0	2,821.2	3,181.9	3,566.8	4,077.7	4,181.5	4,997.6	5,109.1	4,357.8	4,464.6
CH_4	1,844.6	1,883.6	1,800.6	1,869.1	1,966.3	2,097.5	2,163.8	2,414.5	2,458.0	2,272.6	2,261.0
N_2O	479.8	544.2	616.0	569.4	640.5	632.1	681.4	513.2	483.9	502.7	482.8
HFCs	3.7	8.1	11.3	17.8	27.8	45.0	73.2	110.5	173.0	204.5	255.2
Total	**5,535.2**	**5,840.9**	**5,249.1**	**5,638.2**	**6,201.3**	**6,852.3**	**7,099.9**	**8,036.8**	**8,222.0**	**7,335.0**	**7,463.6**

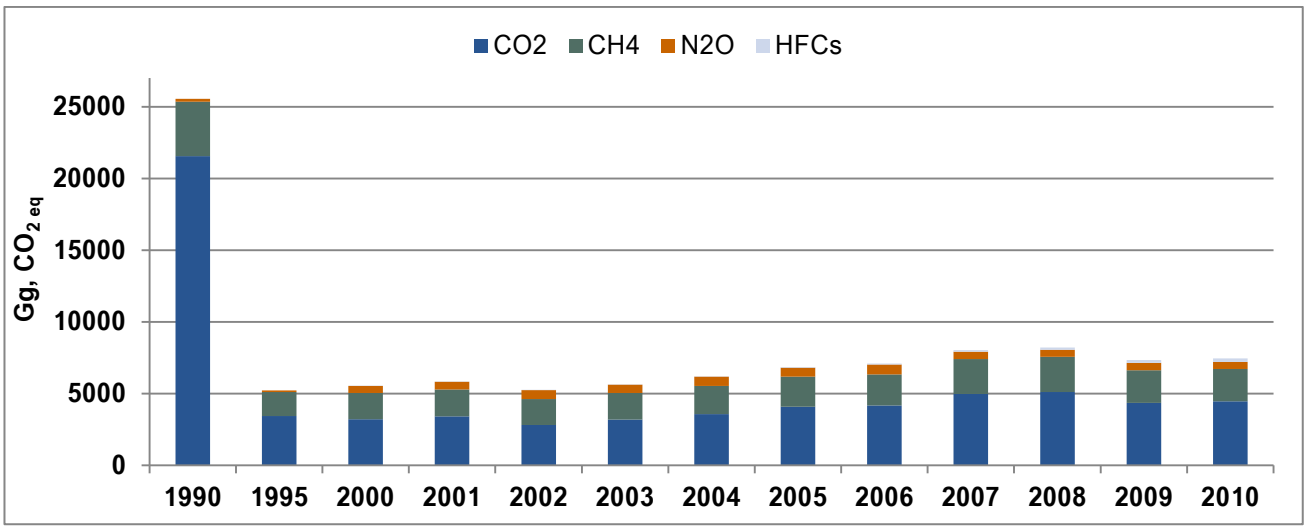

Figure 2-5. Total greenhouse gas emissions by gas types, 1990-2010

Table 2-5. Emissions of greenhouse gases by sector, 2000-2010, Gg CO_{2eq}

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy	3,601.4	3,798.0	3,050.7	3,417.8	3,795.1	4,367.6	4,493.8	5,480.0	5,671.6	4,932.6	5,008.6
IPPU	123.4	132.8	176.6	209.2	296.5	362.7	397.0	477.2	542.8	413.5	481.1
AFOLU	1,195.0	1,282.2	1,385.4	1,372.6	1,467.9	1,478.1	1,562.9	1,430.4	1,356.7	1,338.4	1,320.5
Waste	615.4	627.9	636.4	638.5	641.8	643.9	646.2	648.2	652.9	652.8	653.4
Total	**5,535.2**	**5,840.9**	**5,249.1**	**5,638.1**	**6,201.3**	**6,852.3**	**7,099.9**	**8,035.8**	**8,224.0**	**7,337.3**	**7,463.6**

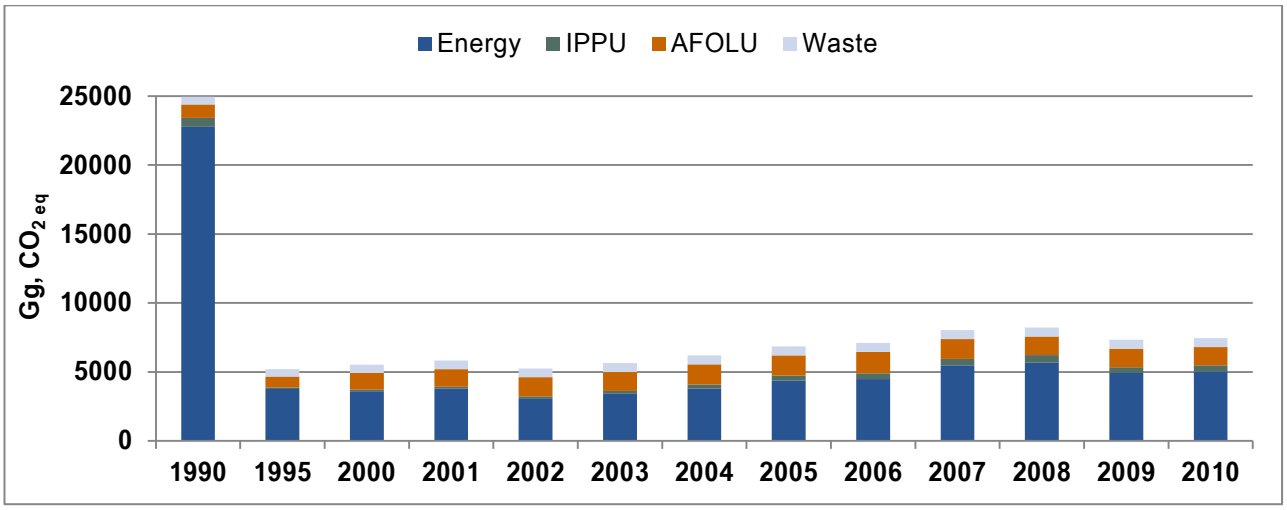

Figure 2-6. Total greenhouse gas emissions by sector, 1990-2010

2.5. Emissions of Greenhouse Gases by Sectors

2.5.1. Energy

The Energy sector accounts for the major part of GHG emissions: 56% of total emissions in 2000, and 67% in 2010.

Combustion of carbon fuels is the key category of GHG emissions. The main fuel used in Armenia is natural gas (73% of total fuel used). The share of oil products (gasoline, diesel oil) is 19%, and biomass is 8% (2010). The additional source of energy emissions is fugitive emissions of methane from the natural gas transmission and distribution system.

Using current information databases in Armenia, 'bottom-up' methodology was used as much as possible for key categories, in addition to the mandatory 'top-down' approach to estimating GHG emissions from fuel combustion.

The IPCC average value range for CH_4 emissions factor recommended for former USSR republics (527,900 kg/PJ) to calculate CH_4 fugitive emissions from the natural gas transmission and distribution system was used.

2010 GHG emissions in the Energy sector broken down by sub-sectors were: power generation – 16.5%; manufacturing and construction – 10.6%; transport – 24.9%; other sub-sectors (residential, public, commercial) – 34.5%; fugitive emissions from the gas transmission and distribution system – 13.5%.

2000-2010 GHG emissions by sub-sector are described in table 2-6 and in figure 2-7. Emissions by gas types are described in table 2-7.

GHG emission trends in the Energy sector are characterized by a reduction in emissions from: power generation – from 46% to 16.5% (caused by reductions in thermal energy generation by TPPs, and collapses in district heating systems); manufacturing and construction – from 12.4 to almost 10.6%. Increases in emissions came from: transport – from 18.3% to 24.9%; from other sub-sectors (residential, public, commercial) – from 9.6% to 34%. There has been almost no change in methane emissions from the natural gas transmission and distribution system (see table 2-6).

Table 2-6. Emissions of greenhouse gases in the Energy sector for 2000-2010, Gg $CO_{2\,eq}$

Year	Fuel combustion					Fugitive emissions in gas supply system	Total
	Power generation	Manufacturing / construction	Transport	Other sectors	Sub-total		
2000	1,675.2	447.2	658.3	346.9	3,127.6	473.8	**3,601.4**
2001	1,698.4	366.9	606.8	648.4	3,320.5	477.5	**3,798.0**
2002	986.1	388.2	694.9	627.4	2,696.6	354.1	**3,050.7**
2003	979.2	417.7	783.3	853.4	3,033.6	384.2	**3,417.8**
2004	1,019.6	547.5	838.4	936.0	3,341.5	453.6	**3,795.1**
2005	1,164.2	689.5	871.6	1,080.3	3,805.6	562	**4,367.6**
2006	961.0	683.3	970.6	1,289.8	3,904.7	589.1	**4,493.8**
2007	956.25	1,087.92	1,101.82	1,561.33	4,707.32	772.7	**5,480.0**
2008	1,142.9	693.2	1,297.7	1,702.0	4,835.8	835.8	**5,671.6**
2009	927.9	506.3	1,197.1	1,605.9	4,237.2	695.4	**4,932.6**
2010	828.1	532.0	1,247.7	1,723.5	4,331.4	677.2	**5,008.6**

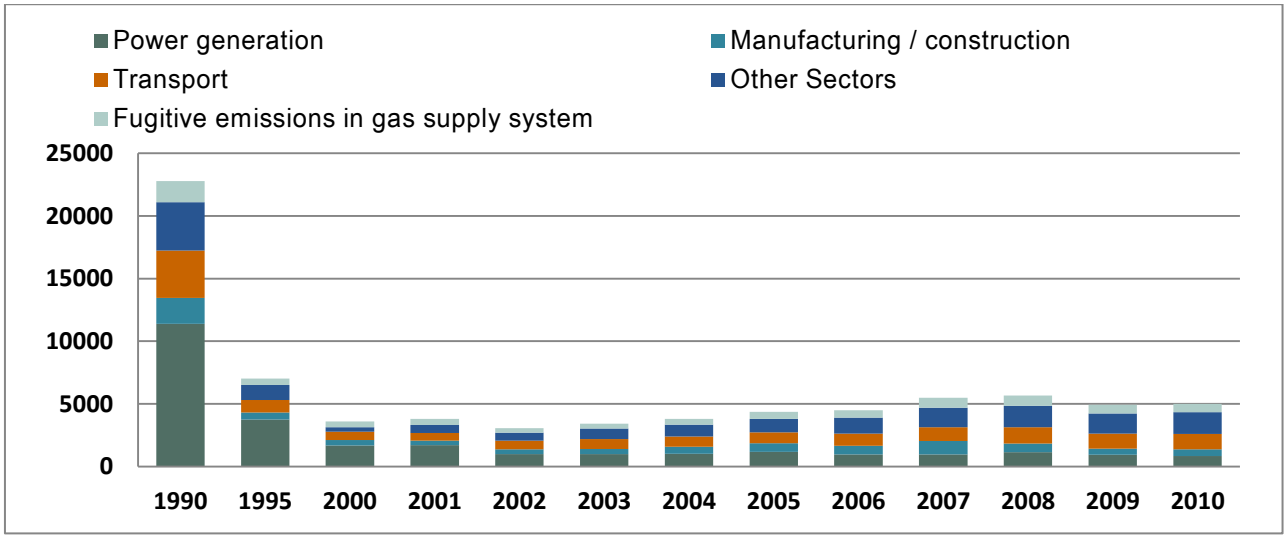

Figure 2-7. Emissions of greenhouse gases in the Energy sector, 1990-2010

Carbon dioxide accounts for a major share of GHG emissions in this sector (84-86% in 2000-2010). Methane makes up 13-14% of emissions, and nitrous oxide – 0.4-0.6% (see table 2-7).

Table 2-7. Emissions of greenhouse gases in the Energy sector by gas types for 2000-2010, Gg $CO_{2\,eq}$

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO_2	3,079.9	3,272.8	2,648.3	2,982.9	3,290.5	3,752.4	3,850.0	4,609.7	4,729.7	4,138.9	4,231.0
CH_4	505.7	509.8	386.8	417.5	486.7	596.8	624.3	842.6	911.4	765.3	748.4
N_2O	15.8	15.4	15.5	17.3	17.8	18.4	19.4	27.7	30.5	28.4	29.2
Total	**3,601.4**	**3,798.0**	**3,050.6**	**3,417.8**	**3,795.0**	**4,367.6**	**4,493.7**	**5,480.0**	**5,671.6**	**4,932.6**	**5,008.6**

2.5.2. Industrial Processes and Product Use

Sources of GHG emissions in the industrial processes and product use (IPPU) sector in Armenia include:

- Cement production (CO_2);
- Hydrofluorocarbons (HFCs) used in refrigeration and air-conditioning processes, fire protection and aerosols.

GHG equivalent emissions in 2010 accounted for 6.4%, including: 3% from cement production and 3.4% from F-gas (HFC_s) use.

Sources of emissions of gases with indirect greenhouse effects include:

- Food and beverage industries, asphalt production and use, and paint and solvent use (NMVOCs);
- Unpurified copper and ferromolybdenum production (SO_2).

National emissions factors and estimations for SO_2 were defined for the first time for non-purified copper and ferromolybdenum production. The calculation of CO_2, HFCs and NMVOCs is based on the Tier 1 (reference) approach.

2000-2010 trends for GHG emissions in IPPU are described in table 2-8 and in figure 2-8.

There was continuous growth in CO_2 emissions from cement production in 2000-2010, while in 2009-2010 there was a reduction caused by a dramatic decline in construction.

The emissions of F-gases (HFC_s) grew as a result of the development of refrigeration and air-conditioning systems.

2010 emissions of gases with indirect greenhouse effects included: SO_2 – 29.2 Gg; NMVOCs – 11.4 Gg.

Table 2-8. Emissions of greenhouse gases in IPPU sector, by gas types, for 2000 -2010, Gg $CO_{2\ eq}$

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cement production (CO_2)	119.7	124.7	165.3	191.4	268.8	317.7	323.8	366.7	369.8	208.9	226.0
Product use (HFC_s)	3.7	8.1	11.3	17.8	27.8	45.0	73.2	110.5	173.0	204.5	255.1
Total	**123.4**	**132.8**	**176.6**	**209.2**	**296.5**	**362.7**	**397.0**	**477.2**	**542.8**	**413.5**	**481.1**

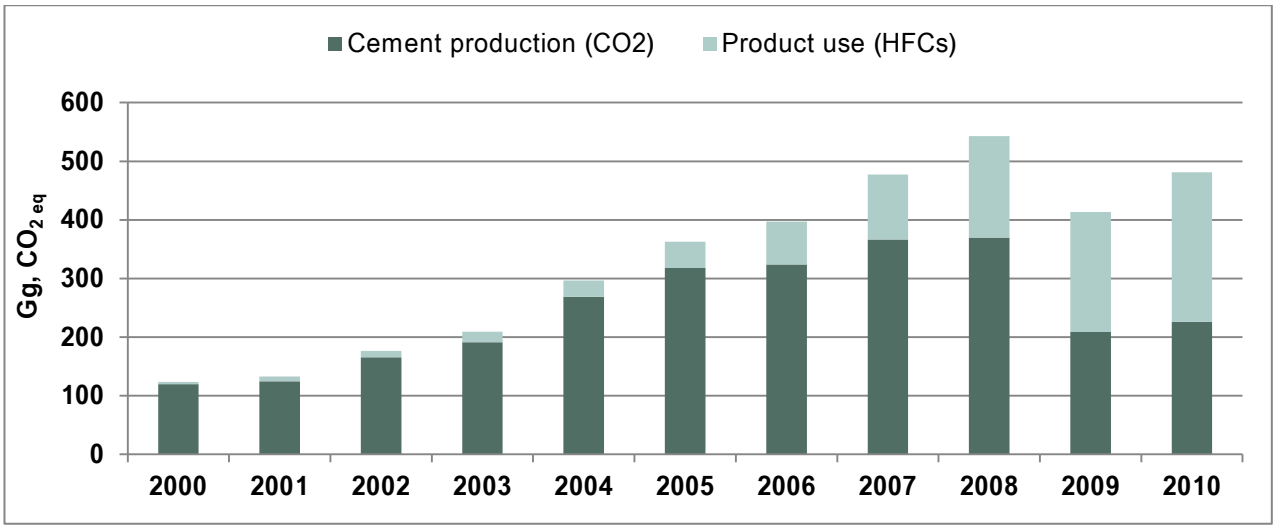

Figure 2-8. Emissions of greenhouse gases in IPPU sector, 2000-2010

2.5.3 Agriculture, Forestry and Other Land Use

GHG emissions sources/removals in the agriculture, forestry and other land use (AFOLU) sector in Armenia include:

- Enteric fermentation (CH_4);
- Manure management (CH_4, N_2O);
- Forest lands (CO_2);
- Agricultural soils (CO_2);
- Crop residue burning in fields (CH_4);
- Aggregated sources of emissions from soil and non-CO_2 emissions (N_2O).

Estimation of CH_4 emissions from enteric fermentation was based on changes in cattle population during the year; CH_4 emission factors were calculated by using detailed livestock-production data. In the forestry subsector the baseline density factor for harvested wood and annual average growth-rate values was corrected and revised.

Aggregate 2010 emissions in AFOLU totalled 1,320.5 Gg $CO_{2\ eq}$ with 75.3% from livestock production (69.1% from enteric fermentation and 10.2% from manure management) and 24.7% from managed lands (both direct and indirect).

AFOLU covers both GHG emissions (livestock production and land use) and removals (forestry, land use).

There was no clear regularity in 2000-2010 GHG emissions and removals in AFOLU (see table 2-9, table 2-10, and figure 2-9).

Table 2-9. Emissions and removals of greenhouse gases in AFOLU sector by categories for 2000- 2010, Gg $CO_{2\ eq}$

Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture											
Enteric fermentation CH_4	723.55	746.3	775	808.8	834.73	853.46	886.18	916.06	892.9	857	859.26
Manure management CH_4	59.21	64.3	67.9	71.4	71.14	72.13	76.92	77.41	72.91	69.66	69.38
Manure managementN_2O	48.67	60.7	63.8	66.8	67.27	68.2	71.61	72.54	69.13	65.4	66.03
N_2O direct emissions from managed lands	257.7	256.4	303.3	258.9	310.6	302.25	331.08	203.05	185.07	207.7	191.27
N_2O indirect emissions from managed lands	63.31	111.7	129.3	117	134.5	131.75	143.22	94.86	86.8	90.21	84.63
N_2O indirect emissions from manure management	42.47	42.8	46.1	49.7	49.6	50.22	53.94	52.7	50.22	48.36	49.29
Emissions from biomass burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.9
Forestry and land use											
Forest land remaining forest land	-470.8	-451.45	-462.46	-453.98	-497.05	-526.8	-527.11	-569.63	-564.02	-553.27	-552.93
Arable land remaining arable land	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157	-4.157
Cropland remaining cropland	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.7	0.7	0.67	0.67
Pasture remaining pasture	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46	13.46
Harvested wood	-10.65	-10.57	-10.575	-10.58	-10.575	-10.587	-10.594	-10.6	-10.6	-10.67	-10.71

Table 2-10. Greenhouse gas emissions, removals and net flows in AFOLU sector for 20002010, Gg $CO_{2\ eq}$

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Emissions	1,195.0	1,282.2	1,385.4	1,372.6	1,467.9	1,478.1	1,562.9	1,430.4	1,356.7	1,338.4	1,320.5
Removals	-469.3	-447.9	-458.9	-450.4	-493.5	-523.3	-523.2	-480.2	564.7	-543.4	-552.7
Net flows	725.7	834.3	926.5	922.5	974.4	954.8	1,039.7	860.2	792.0	785.0	767.7

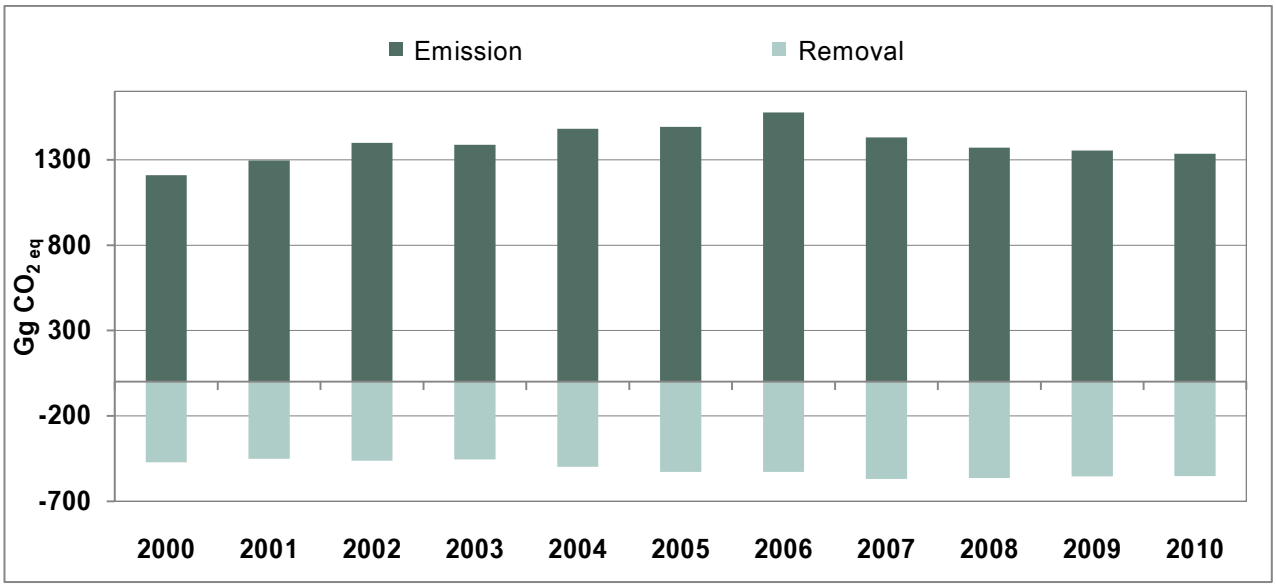

Figure 2-9. Emissions and removals of greenhouse gases in AFOLU sector, 2000-2010

2.5.4 Waste

Sources of GHG emissions in the waste Sector in Armenia include:

- MSW disposal sites (CO_2);
- Open burning of MSW (CO_2, CH_4, N_2O);
- Wastewater (CH_4, N_2O).

The share of this Sector in GHG equivalent emissions in 2010 accounted for 8.7%: CH_4 - 26%, N_2O - 13%.
2000-2010 GHG emission trends in this sector showed insignificant changes (see table 2-11 and figure 2-10).

For the calculation of methane emissions from MSW the 'first order declining' and 'mass balances' approaches used in previous inventories was applied. For all other subcategories the reference approach was used.

Table 2-11. Greenhouse gas emissions in the Waste sector for 2000-2010, Gg $CO_{2\ eq}$

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MSW landfills	449.5	458.0	463.8	464.7	465.6	466.4	467.2	468.0	468.8	469.6	470.3
MSW open burning	35.7	36.2	36.2	36.2	36.3	36.4	36.5	36.5	36.6	36.8	36.9
Wastewater	130.2	133.7	136.5	137.5	139.9	141.1	142.5	143.6	145.5	144.4	146.2
Total	**615.4**	**627.9**	**636.4**	**638.5**	**641.8**	**643.9**	**646.2**	**648.2**	**650.9**	**650.7**	**653.4**

Key emission sources: CH_4 emissions from MSW (72% of total emissions); CH_4 emissions from residential and commercial wastewater (14%); N_2O emissions from wastewater (8.6%); CH_4 emissions from MSW open burning (3.4%). The first two of these sources are also included in the key categories of the general inventory.

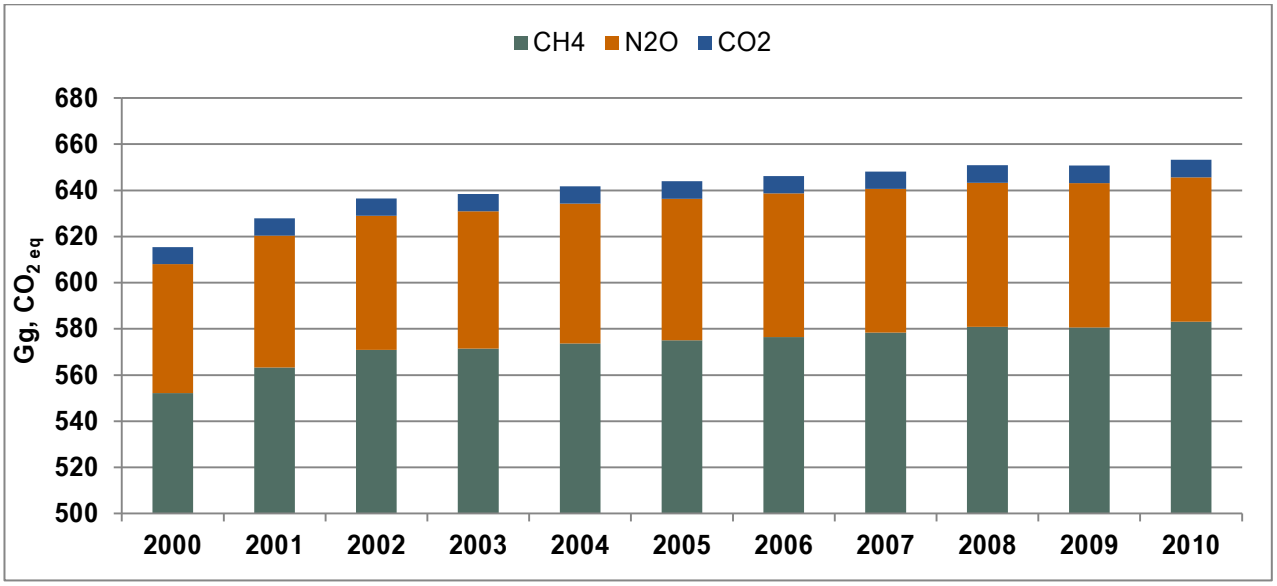

Figure 2-10. Greenhouse gas emissions in the Waste sector by gas types, 2000-2010

2.6 Analysis of Key Categories

Analysis of key categories (AKC) allows us to identify the share of GHG emissions from various sources in the total national GHG emissions. AKC also points out the most essential areas for which GHG emission-mitigation strategies should be developed and identifies priorities necessary for the improvement of inventory data and GHG emissions calculation. According to IPCC, key categories (using the classified list for emission volumes) include sources that account for at least 95% of aggregate national emissions.

Within the scope of this work, AKC for tier, as well as trend, assessment was carried out for 2000-2010, as those were the only years to which the 'bottom-up' sectorial methodology for estimating emissions in the Energy sector – a necessary provision for AKC could be applied.

Table 2-12 describes AKC tier assessment results for 2010.

Table 2-12. Analysis of key categories of greenhouse gas emissions (tier approach), 2010

A	B	C	D	E	F
IPCC category code	IPCC category	Greenhouse gas	Emissions (Gg $CO_{2\ eq}$)	Emissions from the category (Gg $CO_{2\ eq}$)	Cumulative total of column E
1.A.4	Other sectors – Gaseous Fuels	CO_2	1,226.65	0.152	0.15
1.A.3.b	Road transportation	CO_2	1,202.62	0.149	0.30
3.A.1	Enteric fermentation	CH_4	859.27	0.106	0.41
1.A.1	Energy – Gaseous fuels	CO_2	827.52	0.103	0.51
3.B.1.a	Forest land remaining forest land	CO_2	-552.93	0.088	0.60
1.B.2.b	Natural gas	CH_4	677.43	0.084	0.68
1.A.2	Manufacturing and construction – Gaseous fuels	CO_2	529.55	0.066	0.75
4.A	Solid waste disposal	CH_4	470.35	0.058	0.81
1.A.4	Other sectors – Liquid fuel	CO_2	441.80	0.055	0.86
2.A.1	Cement production	CO_2	225.96	0.028	0.89
3.C.4	Direct N_2O emissions from managed soil	N_2O	191.23	0.024	0.91
2.F.1	Refrigeration and air conditioning	HFCs	255.20	0.014	0.93
4.D	Wastewater treatment and discharge	CH_4	89.67	0.011	0.94

A	B	C	D	E	F
IPCC category code	IPCC category	Greenhouse gas	Emissions (Gg $CO_{2\ eq}$)	Emissions from the category (Gg $CO_{2\ eq}$)	Cumulative total of column E
3.C.5	Indirect N_2O emissions from managed soil	N_2O	84.65	0.01	0.95
3.A.2	Manure management	CH_4	69.38	0.009	0.96

There are 14 key categories for 2010 (reflecting changes and additions compared to 2000). For example, in energy there was a reduction in emissions which, on the one hand, could be due to economic decline or, on the other, less use of liquid and solid and increased use of natural gas. In 2010, key categories also include emissions of F-gases (that were not accounted for in previous inventories) and nitrous oxide. Methane emissions from manure have reached the limit of key categories.

Table 2-13 describes AKC trend assessment results for 2010.

Table 2-13. Analysis of key categories of greenhouse gas emissions (trend assessment), 2010

A	B	C	D	E	F	G	H
IPCC category code	IPCC category	Greenhouse gas	2000 emissions (Gg $CO_{2\ eq}$)	2010 emissions (Gg $CO_{2\ eq}$)	Assessment of trends	Contribution in trends, %	Total of column G
1.A.1	Energy – Gaseous fuels	CO_2	1,667.06	827.52	0.22	0.32	0.32
1.A.4	Other sectors – Gaseous fuels	CO_2	201.96	1,226.65	0.15	0.22	0.55
1.A.3.b	Road transportation	CO_2	642.06	1,202.62	0.05	0.08	0.63
3.B.1.a	Forest land remaining forest land	CO_2	-470.82	-552.93	0.05	0.08	0.70
1.A.4	Other sectors – Liquid fuel	CO_2	115.51	441.80	0.05	0.07	0.77
3.C.4	Direct N_2O emissions from managed soil	N_2O	257.67	191.23	0.02	0.04	0.80
1.A.2	Manufacturing and construction – Liquid fuels	CO_2	107.11	0.00	0.02	0.03	0.84
4.A	Solid waste disposal	CH_4	449.53	470.35	0.02	0.03	0.87
2.F.1	Refrigeration and air conditioning	HFCs	3.7	255.2	0.02	0.03	0.89
3.A.1	Enteric fermentation	CH_4	723.56	859.27	0.02	0.03	0.92
1.A.2	Manufacturing and construction – Gaseous fuels	CO_2	339.54	529.55	0.01	0.02	0.94
2.A.1	Cement production	CO_2	119.68	225.96	0.01	0.02	0.95

2.7 Uncertainty Assessment

The uncertainty assessment was based on IPCC 2006 and 2000 *Good Practice Guidance* (GPG), and IPCC 2003 *GPG LULUCF Guidelines*.

It was carried out using a Tier 1 approach.

For Armenia, like other transition economies, there were difficulties with regard to assessing uncertainties in 1990-2010 data; this was due to major circumstances:

- Dramatic economic decline in 1991-1994, then slow recovery, and a 2009 decline due to the global financial crisis;
- Information sources for activities (ministries or NSS, etc.) changed, and data-collection methodology frequently changed during that time period;

- Difficulties in data accounting caused by the shadow economy.

The results of the analysis of generic uncertainties are presented in tables 2-13 and 2-14.

Table 2-14. Emission uncertainties from key sources (without forestry data), 2010

Code	Category	Gas	Uncertainty, %
1.A.1	Energy – Gaseous fuels	CO_2	8.6
1.A.2	Manufacturing and construction – Gaseous fuels	CO_2	7.07
1.A.3.b	Road transportation	CO_2	8.6
1.A.4	Other sectors – Gaseous fuels	CO_2	8.6
1.A.4	Other sectors – Liquid fuel	CO_2	7.07
2.A.1	Cement production	CO_2	12.2
CO_2 generic uncertainty			**3.6**
1.B.2.b	Natural gas	CH_4	7.8
3.A.1	Enteric fermentation	CH_4	75.7
3.A.2	Manure management	CH_4	72.9
4.A	Solid waste disposal	CH_4	29.1
4.D	Wastewater treatment and discharge	CH_4	55.2
CH_4 generic uncertainty			**24.4**
3.C.4	N_2O direct emissions from managed soil	N_2O	25
3.C.5	N_2O indirect emissions from managed soil	N_2O	36
N_2O generic uncertainty			**21.9**
2.F.1	Refrigeration and air conditioning	HFCs	6.6
HFC generic uncertainty			**6.6**

Data-collection difficulties for forestry increased uncertainties. Therefore, CO_2 generic uncertainties described in table 2-15 include forestry. Generic uncertainty doubled when including uncertainties in forestry.

Table 2-15. CO_2 emission uncertainties from key sources (with forestry data), 2010

Code	Category	Gas	Uncertainty, %
1.A.1	Energy – Gaseous fuels	CO_2	8.6
1.A.2	Manufacturing and construction – Gaseous fuels	CO_2	7.07
1.A.3.b	Road transportation	CO_2	8.6
1.A.4	Other sectors – Gaseous fuels	CO_2	8.6
1.A.4	Other sectors – Liquid fuel	CO_2	7.07
2.A.1	Cement production	CO_2	12.2
3.B.1	Forest lands	CO_2	50.0
CO_2 generic uncertainty			**7.8**

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3

POLICIES AND MEASURES PROMOTING GREENHOUSE GAS EMISSIONS REDUCTION

As a Non-Annex I Party to UNFCCC, Armenia does not have quantitative commitments for reducing GHG emissions. However, as a party to the Convention and supporting its objectives, as well as taking into account that emissions reduction is in line with the economic, energy and environmental objectives of the country, Armenia, as part of its development perspectives, is currently implementing and planning the implementation of future actions for climate change mitigation.

In recent years, Armenia has adopted a number of laws and regulations, and has developed and is implementing national and sectorial development programmes based on sustainable and low-carbon development principles. Regardless of the fact that these documents are not always directly focused on climate change mitigation measures, implementation of these laws and programmes still contributes to the reduction of GHG emissions, as well as to the development of NAMAs. According to the Decree No. 1594-N, dated 10 November 2011, NAMA Action Plan must be submitted to the government for approval in 2015.

Armenia presented its assessment report and joined the Sustainable Energy for All Initiative in 2012.

The position of the Republic of Armenia to meet Convention objectives include:

- With regard to low-carbon development the Republic of Armenia recognizes a fair, 'common but differentiated approach' which takes into account the historically differing levels of countries' responsibility for increasing GHG concentration in the atmosphere and for contributing to climate change.
- Regarding adequate financial and technical support, as a Non-Annex I Party to the UNFCCC and a developing country, the Republic of Armenia, under the "Green Economy" principles, is ready to undertake commitments to certain quantitative limitations in GHG emissions by consistently reducing the energy intensity of its GDP.
- With regard to long-term cooperative actions, the Republic of Armenia recognizes that they should be based on an ecosystem approach (Annex III). This is also due to the fact that climate change is caused not only by accumulation of GHGs in the atmosphere but also by the disturbance of ecosystems, which can result in radiation and thermal balance changes.

The position of the Republic of Armenia stated at the 18th meeting of the Conference of the Parties was that efforts should be made to limit global warming by 1.5 degrees Celsius.

3.1 Legislation

The Law of the Republic of Armenia on Atmospheric Air Protection (1994). The primary objective of the law is to ensure clean atmospheric air, and reduce and prevent chemical, physical, biological and other hazardous impacts on atmospheric air. The law defines safe levels of hazardous substances' emissions (GHGs and gases with indirect greenhouse effects (NO_x, CO) and SO_2). Amendments to the law made in 2008 restrict open burning of crop stubble, as well as in areas covered by crop residues and dry plants, plants in pastures and grasslands neighbouring agricultural and forest lands, and SPANs. This provision is intended to preserve and accumulate organic carbon in soil and aboveground plants, and protect soil from exhaustion, erosion and desertification.

The Law of the Republic of Armenia on Energy (2001) and the Law of the Republic of Armenia on Energy Saving and Renewable Energy (2004). These laws define the main principles of state policy in the energy sector, including:

- Effective use of local energy resources and alternative sources of energy, and the application of economic and legal mechanisms for that purpose;
- Energy independence and energy security of Armenia;
- Creation of new industries, organization of new services, implementation of national target programmes, and the use new technologies to promote the development of RE and energy saving;
- Introduction of energy-efficient and energy-saving technologies, reducing environmental impact.

The Law of the Republic of Armenia on Waste (2004). This law regulates waste collection, transportation, handling, processing, utilization, disposal, quantitative reduction and other relevant issues, as well as the legal and eco-

nomic basis for the prevention of impact on human health and environment.

The Forest Code of the Republic of Armenia (2005). This code regulates the sustainable management of forests and forest lands and the relationships governing maintenance, protection, restoration, forestation and effective use, as well as inventory, monitoring, and supervision of forests and forestlands. Implementation of the provisions of the code will contribute to the improved capacities of forests as sinks for carbon dioxide removal.

Armenian Government Decrees

- On Approval of Maximum Permissible Concentration of Air Polluting Substances in Settlements and Maximum Permissible Norms of Hazardous Substances in Emissions from Vehicles Operated in the Republic of Armenia (Decree No. 160-N dated 2 February 2006);
- On Implementation of Projects within the Framework of the Clean Development Mechanism of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (Decree No. 974-N dated 13 July 2006,);
- On Approval of the Procedure on Examination of Design of Maximum Permissible Emission Norms for Organization with Stationary Sources of Atmospheric Air Pollution and on Granting Emissions Permits (Decree No. 953 –N dated 21 August 2008);
- On Approval of Order on Projection, Notification of, and Response to Dangerous Hydrometeorological Events Affecting Extra-normative Pollution of Atmospheric Air, Climate Change, and Ozone Layer Conditions (Decree No. 1186-N dated 16 October 2008);
- On Approval of Action Plan to be Implemented by the Republic of Armenia Under Commitments of a Number Environmental Conventions (Decree No. 1594-N dated 11 October 2011).

3.2 National programmes

Republic of Armenia Perspective Development Strategic Programme for 2012-2025 (2014). This provides a major set of social and economic development priorities of the country, its objectives, main obstacles and limitations to development, key reforms, and policy mechanisms for the realization of priority goals. The programme makes macroeconomic projections, and describes projected indicators for the economy and infrastructure. The economic growth projection for 2012-2014 is 6.5% on average, while it is 6.4% for 2015-2025. The programme is based on the following priorities: expansion of employment, improvement in the social-protection system, and institutional enhancement of governance systems. Environmental protection and sustainable management of natural resources will be addressed in parallel with the implementation of the priorities listed above. This programme was developed to replace the *Sustainable Development Programme (2008)*, taking into consideration recent developments and new realities as a result of the global financial crisis.

3.3 Sectorial Programmes

Energy

Strategy for Development of the Energy Sector within the Context of Economic Development of Armenia (2005). This strategy covers the period until 2025 and has the following objectives: facilitation of sustainable economic development and energy security of Armenia, including diversification of imported and local energy resources; maximum utilization of renewable and alternative sources of energy; promotion of energy saving; environmentally friendly energy supply in line with the international commitments of Armenia. It describes projected indicators for energy consumption for sectors of economy divided by implementation periods, and provides a list of projects for the development of electric-energy, gas, and heat supplies.

Action Plan of the Ministry of Energy of Armenia provided for in the provisions of the National Security Strategy (2007). This envisages the construction of generating facilities and measures to be taken by 2025, including: construction of new 540 MW HPPs (including 260 MW small HPPs); construction of 200 MW wind turbines; upgrading of the currently operational two TPPs using gas-turbine installations with a total capacity of 648 MW; construction of a new 1,000 MW power unit in ANPP; modernization of electricity transmission and distribution networks to reduce losses; construction of Iran-Armenia gas pipeline; restoration of 150 million m^3 capacity of un-

derground gas storage; restoration of heat supplies with the maximum use of geothermal, biogas, solar and other RE sources; organization of large-scale introduction of sustainable measures to ensuring energy saving. The work plan includes timeframes and financing sources for the implementation of measures.

The following planned activities have been accomplished as of 2012: the Iran-Armenia gas pipeline; high-performance power units in Yerevan and Hrazdan TPPs (with total generating capacity of 648 MW); 130 small HPPs (with total generating capacity of 204 MW); 2 co-generation systems for centralized heat supply; 458 high-performance autonomous heating systems for public buildings; a number of small generation plants using RE (with total generating capacity of 1.3 MW).

National Programme for Energy Saving and Renewable Energy (2007). This provides for the assessment of energy-saving potential in the power sector, heat- and gas-supply systems, industrial production, transport, and housing, as well as RE potential and measures for the cost-effective utilization of energy-saving potential.

Action Plan of the Government for Implementation of the National Programme for Energy Saving and Renewable Energy (2010). The main objectives are the facilitation of further formulation of energy-saving policies in Armenia and the finalization of specific steps for their implementation. It provides for specific activities to be implemented by sector (residential buildings, services, manufacturing, transport, water), as well as horizontal and inter-sectorial activities aligned to quantitative targets (% compared to the baseline) that can be gradually achieved by 2020.

Small Hydropower Plants Development Scheme (2010). This is designed to promote the construction of small HPPs and includes hydro energy indicators for more than 100 HPPs.

Main Issues, Status, Development Barriers, and Future Development of Small Hydro Power (2010). This focuses on assisting the energy sector of Armenia to improve potential for supply independence and security. It presents 115 possible resource sites with a capacity of 147 MW, and with annual generation capacity of 540 GWh. It provides detailed indicators of 65 licensed (yet not constructed) small HHPs with potential capacity of 158 MW and with annual generation of 500 GWh. It also presents data for various financial indicators and possible financing schemes.

Renewable Energy Development Guideline of Armenia (2011). This presents technically accessible, economically and financially sound RE potential for Armenia. It also assesses the short-term (by 2013), mid-term (by 2015), and long-term (by 2020) potential of RE for the generation of electrical and thermal energy and its use in transport. It also describes the required investments for and costs of RE types and areas of use. The estimated share of RE in total energy generation in the long term is 16.3%.

Power Transmission Rehabilitation Project (2012). This project, financed by The Asian Development Bank, is intended to improve the efficiency and power-supply reliability of power systems in Armenia. The project includes two major components: extension of dispatching-control and data-collection systems (SCADA); rehabilitation of eight existing 220 kV substations with respective replacement of aged transformers, circuit breakers and other equipment.

The Concept for Ensuring Energy Security (2013). Tasks include: (1) establishment of preconditions for sustainable economic development; (2) self-sufficiency and export potential of Armenia's energy system in the region; (3) creation of an attractive environment for investment for renewable, alternative and nuclear energy; (4) energy efficiency and energy conservation; (5) reduction of GHGs; (6) development of fundamentals to ensuring the target level of energy security for Armenia. The concept defines domestic and external challenges and threats for energy security that may undermine the implementation of measures for meeting the energy demands of the country, as well as tasks for energy-security management systems. It sets forth the following measures for ensuring energy security: (1) enhancement of energy-security insurance systems; (2) effective use of renewable energy resources and energy conservation; (3) development of nuclear energy; (4) diversification of energy-resource supplies and the regional integration of energy systems; (5) energy sector financing and established levels of economic effect; (6) energy security in emergency situations and in wartime. It also sets forth the following actions: (1) to reach the 20% target of primary RE in total

energy consumption; (2) to construct a new 1,000 MW power unit in ANPP, in parallel ensuring safe operation of the existing nuclear unit until its decommissioning; (3) to promote energy saving in buildings, to upgrade thermal-energy facilities by introducing gas and combined-cycle thermal- and electric-energy generation (co-generation) systems, and to reduce energy losses in networks/the grid; (4) to establish petroleum product strategic reserves, to construct a gas pipeline from the Islamic Republic of Iran to Armenia, and to start bio-ethanol (bio-butanol) production; (5) to strengthen Armenia-Iran and Armenia-Georgia overheat transmission lines by constructing new 400/500 kV lines, to rehabilitate the existing 220 kV line to Kars, to organize a regional market for electricity and capacity, and to integrate with energy markets in CIS countries; (6) to develop and use ecologically clean technologies for vehicles alongside the parallel development of electric transport infrastructure.

*Sevan-Hrazdan Cascade Hydropower System Rehabilitation Project (2013).*Under this project, financed by the Asian Development Bank, the rehabilitation and upgrade of four out of seven HPPs in the Sevan-Hrazdan Cascade Hydropower System is planned, as well as the rehabilitation of water-outflow canals in three plants and the replacement of electrical equipment in the four HPPs.

Rehabilitation, modernization and expansion of the gas supply system in Armenia. Measures periodically implemented by ArmRosGasProm CJSC allow for significant reduction in current and future fugitive emissions of natural gas (methane).

Financing Facilities for the Development of Renewable Energy and Energy Saving

Tariff policy. Armenia has put in place a stimulating tariff policy to create favourable conditions to promote the development of RE and attract investment. Preferential tariffs are set for power generated by small HPPs, wind turbines and biogas units. Preferential tariffs are also set for power generated by small-scale co-generation units.

Renewable Energy and Energy Saving Fund of Armenia. Pursuant to the RE and energy-efficiency strategic priorities adopted by the Government of Armenia, the fund is implementing loan and grant programmes for the development of this sector. The fund's operation is financed by the World Bank and GEF. The objective of the fund is to promote the development of RE and energy-saving markets, the use of clean, efficient and affordable heating technologies, and upgrades to increase energy efficiency in public buildings. The fund has renovated central-heating systems in schools and has provided loans to small HPPs.

Lending to renewable energy and energy saving. To promote sustainable energy development international financial institutions have financed the establishment of lending organizations in Armenia that provide credits to private businesses and entrepreneurs under favourable conditions. International financial institutions are supporting the implementation of many projects, including:

- EBRD – USD 20 million loan for private companies to invest in RE technologies or in energy saving (through Anelik Bank and Ameria Bank);
- FMO – USD 10 million for lending to small hydro power and wind plants;
- IFC – USD 15 million loan for small HPP financing. It will also provide advisory services with regard to environmental and financial aspects of the loan;
- KfW – EUR 18 million loan intended for financing up to 20 small HHPs (up to 10 MW) with a total generating capacity of 45 MW. For the next phase EUR 40 million in financing is planned to cover wind-energy projects;
- WB – USD 5 million for lending to small HPP projects, and USD 1.5 million to finance field exploration of two potential geothermal sites in Armenia;
- OeEB – USD 5 million to lend to RE and energy-saving projects.

Significant technical assistance is provided by WB, EBRD, ADB, USAID, and UNDP to improve legal and regulatory frameworks, identify potential resources, and raise awareness.

Due to the policy adopted by the country on the development of RE and energy conservation, Armenia has demonstrated significant success. In 2006-2010, as a result of international organization- and private sector-supported programmes, Armenia has implemented a number of activities to mitigation against climate change that were not ac-

counted for in projections under SNC. These activities included:

- Construction of 60 new small HPPs with total generating capacity of 94 MW;
- Solar water heaters with total capacity of 250 kW, 250 kW heat pumps, and 20 kW photovoltaic systems;
- Construction of biogas plant with capacity of 0.8 MW;
- Construction of 2 centralized heat-supply systems with combined heat and power energy units with total installed capacity 6.0MW and thermal capacity of 6.54 MW;
- Installation of 458 energy-efficient autonomous heating systems in public buildings.

Cumulative reduction of GHG emissions as a result of these activities totalled approximately 257 Gg of $CO_{2\,eq}$ per year.

Transport

Action Plan for Reducing Emissions of Hazardous Substances from Vehicles (2005). This provides for measures designed to conduct environmental monitoring and inventories of hazardous emissions, improve road transport and transportation flows, develop public transport (including electric transport), and promote the use of clean-engine fuels.

Yerevan Master Plan for 2006-2020. According the plan, emissions from vehicles will be reduced by 20% by 2020 due to developments in electric public transport and increased passenger load in the metro (from 5.2% to 11.9%) in trolleybuses (from 2.7% to 24.1%), big and small buses (from 8.3% to 45%), and reductions in passenger load in minivans (from 83.8% to 19%). It also envisions a new transport scheme for the city and the application of neutralizers for vehicle emissions.

The increase in the share of natural gas as engine fuel and the use of biogas after 2020, as well as programmes designed to improve roads will contribute to the reduction of GHG emissions from road transport.

Agriculture

Strategy for Sustainable Rural and Agricultural Development for the period of 2010-2020 (2010). This specifies the key directions for agrarian policy, and defines: sectorial priorities; preferable specializations; efficient spatial distribution; expected sustainability; social and economic indicators for agrarian development. Indicators include: volume of agricultural production in 2020 will exceed 2007-2009 average level by 64%; marketability level of agriculture will reach up to 75%; total area of cropland will increase by 39%, areas under fodder crops by 58%, and perennial plantings by 38%; an increase in livestock population (large animals by 10.4%, sheep and goats by 62%, pigs by 45%, and poultry by 46%); increase in livestock productivity by improving pedigree stock breeding, feeding and farming practices. The strategy also envisages the consolidation of farms and development of agrarian cooperatives, the improvement of credit, risk mitigation, the development of organic agriculture, vulnerability reduction to climate change, and the development of social infrastructure in rural communities.

The Procedure for Land Monitoring (approved by Decree No. 276-N of the Government of Armenia adopted on 19 February 2009). This defines state monitoring requirements intended to protect land and soil by using 15 important indicators, including, *inter alia*, the quantity and change of organic carbon in soil.

Forestry

Forest Policy and Strategy of RA (2004) and National Forest Programme of RA (2005). The main objectives of these are to ensure the rehabilitation of degraded forest ecosystems, and develop the sustainable use of forests and their useful features.

The plan for 2009-2020 is to restore an area of 2-2.5 thousand ha of degraded forest ecosystems; reforest 5-5.5 thousand ha of forest lands; establish 0.6-0.65 thousand ha of forest zones for field protection.

Waste

Armenia, in cooperation with international organizations, is implementing a number of projects designed to improve SMW systems and build new regional sanitary landfills that will create the pre-conditions for landfill gas capture.

Waste Management – Waste Governance-ENPI East regional project (2009-2013). The main objective of the project is, through regional cooperation, to assist participating countries (including Armenia) to reduce the risks caused by improper waste management,

as it creates environmental pollution risks to communities and natural resources. The piloting phase of the project covers Lori marz, where an inventory of all large and medium sources of MSW was made and 15-year waste management strategy developed (with the EU).

Integrated Solid Waste Management System for the City of Vanadzor, Armenia (2011-2014). The main objective of this programme is to develop an integrated solid waste-management strategy for the city of Vanadzor and neighboring communities. The strategy will include the decommissioning of the existing Vanadzor solid waste landfill, and a feasibility study for introducing the proposed new waste-management system (with KfW Bank).

Armenia Solid Waste Management Improvement Project (2012-2013). The main objective of this project is the development of a national waste-management strategy that defines technical, institutional, and financial conditions for implementation (involving the private sector). This project plans to shut down 48 existing MSW disposal sites and open 5 new regional MSW disposal sites with 10 reloading points for waste sorting. There will be landfill gas capturing and flaring in closed large (Yerevan, Gyumri and Vanadzor) SW disposal sites (with the Asian Development Bank).

3.4 Implementation of the Clean Development Mechanism of the Kyoto Protocol

As of 2014, the CDM international executive board has approved 6 projects in Armenia (see table 3-1).

- To assess GHG emission reduction in CDM projects, calculations of the baseline for GHG emissions from energy in Armenia were made in 2009, 2010, 2011 and 2012.

Table 3-1. Projects registered by the CDM international executive board

Project name	Annual reduction in GHG emissions, *t CO_2 eq*	Total investments, *USD million*	Installed capacities, *MW*	Annual energy generation, *million kWh*
Nubarashen landfill project	130,000	5.3	1.2(e)	10
Lusakert biogas plant	62,832	4.5	0.85(e)	7
Yeghegis small HPP	3,166	1.8	3.16	7.3
Argichi small HPP	13,331	4.6	8.56	30.5
Jradzor small HHP	8,734	2.5	5.93	20.0
Reduction of methane emissions from gas-distribution system	222,656	-	-	-

Armenia's SNC on climate change has provided projections of GHG emissions by 2020 using two scenarios: 'business as usual' and 'Mitigation' (i.e. with measures). Subsequently, the results of the 2010 GHG inventory report, taken as a baseline for SNC, identified that actual emissions were lower than the projected indicators; this is mainly due to an economic decline of 14.1% in 2009 caused by the global economic crisis. Additionally, a number of activities implemented in 2007-2010 were not accounted for in SNC, as well as emerging new national and sectorial programs. It is due to these factors that the 2010-2020 baseline is lower than the previous one. Deviations in mitigation scenarios have mainly been caused by shifts in the timeframes for the implementation of activities in the energy sector, i.e. wind power plants, medium-capacity HPPs, the extension of ANPP operation lifetime until 2026, etc.

4

PROJECTIONS AND IMPACT ASSESSMENT OF CLIMATE CHANGE MITIGATION POLICIES AND MEASURES

4.1 Methodology

The GHG emission projections for 2010-2030 are based on the expected volumes of operation in different sectors of the economy, taking into account average economic growth for 2010-2015 (6.1%) and for 2015-2025 (6.4%).

Two scenarios for GHG emissions were considered for all categories of GHG emission sources:

'Business as usual', which assumes the continuation of overall practices and relationships on the national level.

'Mitigation', which includes certain measures envisaged by sectorial development programmes, contributing to the reduction of GHG emissions.

Assumptions for future volumes of operations and measures for reducing emissions are based on the sectorial development plans presented in Chapter 3.

In cases, where sectorial plans were limited by the timeframe emission volumes for the projections, are calculated by expert judgments. Considering that target indicators are defined by development plans for the main sectors of the economy, projections for GHG emissions for each projected period are calculated based on the software package of the IPCC 2006 *Guidelines for GHG National Inventory*.

4.2 Projections of Total Greenhouse Gas Emissions

Projections of total GHG emissions for the two mitigation scenarios are presented in tables 4-1 and 4-2, and figure 4-1.

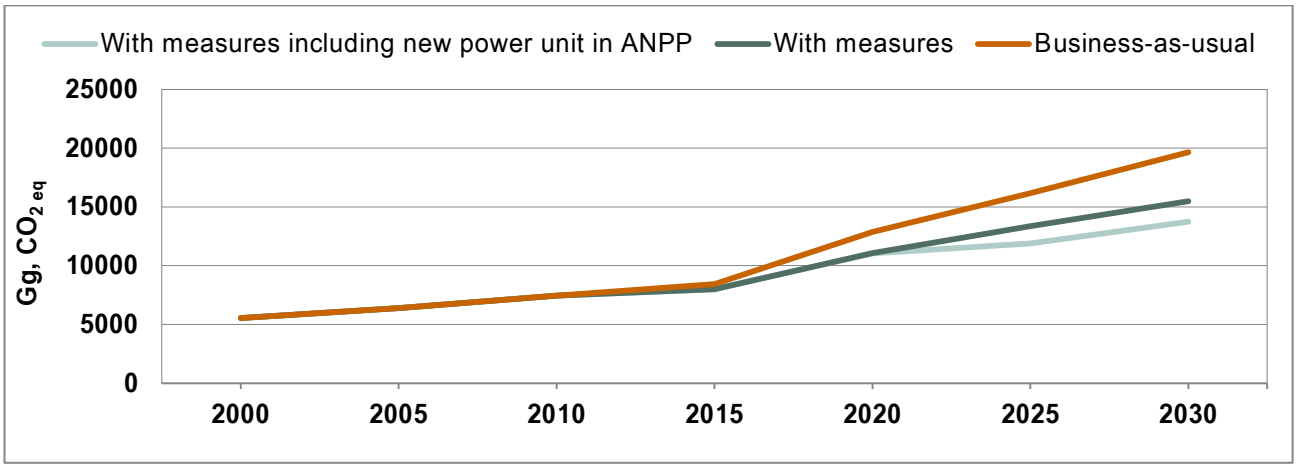

Figure 4-1. Total greenhouse gas emissions for 2000-2010, and projections for 2030

Table 4-1. Greenhouse gas emissions by gases for 2010, and projections by 2030, Gg

Scenario/gases	2010	2015	2020	2025**	2030**
Business as usual *					
CO_2	4,464.6	5,421.4	8,947	11,567.1	14,299.3
CH_4	107.7	123.7	150.7	189.0	216.5
N_2O	1.56	2.0	2.263	2.34	2.514
HFC_s	0.133	N/E	N/E	N/E	N/E
With measures *					
CO_2	4,464.6	4,933.8	7,454.4	9,056.2 7,8412	10,597.4 9,164.4
CH_4	107.7	106.7	128.5	156.1 146.5	180.7 169.3
N_2O	1.56	0.53	0.436	0.473 0.457	0.534 0.516
HFC_s		N/E	N/E	N/E	N/E

** Without forestry and other land use.*
*** Denominators describe emissions in mitigation scenario with new unit in ANPP.*

In the mitigation scenario, the share of CO_2 in the future (2030) composition of GHG emissions will amount to 72.2% (including 67.2% from the Energy sector), CH_4 – 27.4%, and N_2O – 0.4%.

Table 4-2 Total greenhouse gas emissions for 2000-2010, and projections by 2030, Gg $CO_{2\ eq}$*

Scenario/Sector	1990	2000	2005	2010	2015	2020	2025**	2030**
Business as usual								
Energy	22,777	3,601.4	4,367.6	5,008.6	5,939.2	10,103.7	13,109.1	16,219.7
Industrial processes and product use	630.3	123.4	362.7	481.1	231.2	289.1	356.8	453.1
Agriculture	982.6	1,195.0	1,009.4	1,320.5	1,599.3	1,784.1	2,024.5	2,260.9
Waste	564.9	615.4	643.9	653.4	663.5	690.4	707.5	724.6
Total	**24,954.8**	**5,535.2**	**6,383.6**	**7,463.6**	**8,433.2**	**12,867.5**	**16,197.4**	**19,658.7**
With measures								
Energy	22,777	3,601.0	4,367.0	5,008.6	5,504.5	8,653.0	10,531 9,072	12,304 10,579
Industrial processes and product use	630.3	123.4	362.7	481.1	222.0	228.0	291.8	377.5
Agriculture	982.6	1,195.0	1,009.4	1,320.5	1,599.3	1,700.3	1,924	2,146
Waste	564.9	615.4	643.9	653.4	663.5	493.9	614.0	668.8
Total	**24,954.8**	**5,535.2**	**6,383.6**	**7,463.6**	**7,989.4**	**11,075.6**	**13,361.1 11,878.6**	**15,496.8 13,771.5**

***** *Without forestry and other land use.*
*** Denominators in energy and total rows describe emissions in mitigation scenario with new unit in ANPP.*
In the mitigation scenario, GHG emissions in 2030 will amount to 68% - 55% (business-as-usual scenario – 79%) of the 1990 level.

Table 4-3. Greenhouse gas emissions reduction potential by sector, Gg $CO_{2\ eq}$

Sector	2015	2020	2025	2030
Energy	384.2	1,265.0	4,119.6	5,436.0
Industrial processes and product use	9.2	61.1	65.0	75.6
Agriculture	0	83.8	100.7	114.6
Waste	0	196.5	93.5	55.8
Total	**393.4**	**1,606.4**	**4,378.8**	**5,682.0**

The results of the assessment of the potential for reducing GHG emissions are described in table 4-3. The dominant part of the potential (79-97%) comprise measures implemented in the Energy sector.

The projected proportional values of GHG emissions are described in table 4-4.

Table 4-4. Proportional values of greenhouse gas emissions for 2000, 2005, 2010 and projections for 2030

	2000	2005	2010	2015	2020	2025*	2030*
GDP, million USD	1,912	4,900	9,371	11,984	20,380	30,651	38,696
Population, million people	3.21	3.02	3.03				N/A
Business as usual							
Emissions per GDP unit, ton $CO_{2\ eq}$/ thousand USD	0.37	0.76	0.79	0.7	0.63	0.53	0.51

	2000	2005	2010	2015	2020	2025*	2030*
Emissions per capita, tonne $CO_{2\ eq}$/ person	1.72	2.11	2.46	-	-	-	-
With measures							
Emissions per GDP unit, tonne $CO_{2\ eq}$/ thousand USD	0.37	0.76	0.79	0.7	0.54	0.43 0.39	0.4 0.35
Emissions per capita, tonne $CO_{2\ eq}$/ person	1.61	2.11	2.46	-	-	-	-

** Denominators describe emissions in mitigation scenario with new unit in ANPP*

4.3 Projections of GHG Emissions by Sector

4.3.1 Energy

Energy is the main source of GHG emissions in Armenia, accounting for 70% of all national emissions. At the same time, the Energy sector has the greatest potential for reducing GHG emissions. The realization of this potential is a major contribution to climate change mitigation processes on the national level. For 2010-2030, projections of GHG emissions are calculated based on the future operations of energy sub-sectors envisaged by the Energy Development Strategy of Armenia, and long-term energy (fuel) demand. Two scenarios are considered.

Business as usual. This envisions economic development trends with increasing use of fuel and energy resources, insufficient use of energy efficiency and alternative sources of energy, and a number of measures implemented after the submission of Armenia's SNC on climate change (2006-2012). In particular, this foresees the commissioning of modern power units in Yerevan and Hrazdan TPPs, the construction of two co-generation systems for heat supply, the installation of autonomous energy-efficient heating systems in public buildings, and the introduction of new RE sources, including small HPPs, solar panels, heat pumps, and a biogas plant.

Mitigation. This considers the implementation of energy-saving policies and extended use of alternative sources of energy pursuant to measures envisaged in strategy documents adopted by the Government of the Republic of Armenia, as well as activities facilitating GHG emission reduction specified in a number of analytical reports.

One of the main directions for the development of the Energy sector in Armenia is the establishment of an export-orientated energy system (see table 4-5)

Table 4-5. Power generation in 2010 and projections for 2030, GWh

Indicators	2010	2015	2020	2025	2030
Electricity generation	6,491	7,158	11,606	13,220	14,008
Domestic consumption	4,507	5,158	5,672	6,320	7,108
Export	1,225	2,000	5,933	6,900	6,900

Renewable energy development roadmap, a small hydropower development programme, and a wind-energy development study are envisioned to significantly increase the share of RE sources in Armenia. Table 4-6 below describes summarized indicators for the use of RE sources.

The national energy-efficiency action plan (NEEAP) provides for the realization of existing potential in various sectors of the economy, including the application of energy-efficient technologies and measures aimed at reducing losses in energy transmission and distribution, thermally protecting buildings, and promoting widespread use of energy-efficient lighting and home appliances.

In the transport sector the action plan envisions increasing levels of fuel-gas use, the use of biofuel, the gradual replacement of old vehicles with new ones, the development of public transportation in general and, in particular, electric transportation in Yerevan and the improvement of roads.

Nuclear energy is a development priority for Armenia. According to the number of documents approved by the Government of Armenia, the currently operating nuclear unit in

ANPP is planned to be replaced by a new 1,000 MW unit which will enhance the country's energy independence and safety, as well as contribute to GHG emissions reduction.

Table 4-6. Projected power generation by renewable energy sources, GWh

Energy sources	2010	2015	2020	2025	2030
HPPs	2,142.5	2,142.5	2,342.5	2,642.5	3,442.5
Small HPPs	408.5	600.0	799.3	998.7	1,198.0
Wind PPs	3.8	53.8	253.8	503.8	628.8
Geothermal plants	0.0	0.0	192.0	192.0	192.0
Solar-photovoltaic plants	0.1	0.1	20.6	102.6	205.1
Biogas stations	3.0	9.3	14.3	19.2	24.2
Heat pumps	0.5	0.9	1.8	3.6	7.2
Solar heaters	0.5	0.9	1.5	1.8	2.3
Total	**2,5598.9**	**2,8087.8**	**3,625.8**	**4,464.2**	**5,700.1**

Tables 4-7 and 4-8 describe projections of GHG emissions. Assessments of the potential of measures to reduce GHG emissions and promote fuel-saving measures are presented in tables 4-9 and 4-10.

Table 4-7. Projections of GHG emissions in the Energy sector, Gg $CO_{2\ eq}$

Scenarios/Sub-sectors	2000	2005	2010	2015	2020	2025	2030
Business as usual							
Electricity generation	1,675.2	1,164.3	828.1	522.8	2,747.5	3,689.9	4,172.4
Industry and construction	447.2	689.5	532.0	860.5	1,253.3	1,811.9	2,619.4
Transport	658.3	871.6	1,247.7	1,684.1	2,374.0	2,708.1	3,042.1
Housing (public, commercial)	235.0	786.2	1,054.9	1,266.3	1,654.0	2,233.4	3,097.7
Fugitive emissions from gas-delivery systems	473.8	562.0	677.2	686.0	1,348.5	1,793.0	2,251.4
Other	111.9	274.0	668.7	919.5	726.5	872.9	1,036.8
Total	**3,601.4**	**4,367.6**	**5,008.6**	**5,939.2**	**10,103.7**	**13,109.1**	**16,219.7**
With measures							
Electricity generation	1,675.2	1,164.3	828.1	259.6	2,157.0	2,764.0	2,752.1
Industry and construction	447.2	689.5	532.0	856.9	1,199.2	1,673.3	2,396.4
Transport	658.3	871.6	1,247.7	1,649.2	2,229.6	2,444.0	2,649.5
Housing (public, commercial)	235.0	786.2	1,054.9	1,183.8	1,395.7	1,824.9	2,595.2
Fugitive emissions from gas delivery systems	473.8	562.0	677.2	686.0	946.4	954.0	876.5
Other	111.9	274.0	668.7	919.4	725.6	871.3	1,034.5
Total	**3,601.4**	**4,367.6**	**5,008.6**	**5,504.9**	**8,653.4**	**10,531.5**	**12,304.2**
With measures, including new power unit in ANPP							
Electricity generation	1,675.2	1,164.3	828.1	259.6	2,157.0	1,567.0	1,214.2
Industry and construction	447.2	689.5	532.0	856.9	1,199.2	1,673.3	2,396.4
Transport	658.3	871.6	1,247.7	1,649.2	2,229.6	2,444.0	2,649.5
Housing (public, commercial)	235.0	786.2	1,054.9	1,183.8	1,395.7	1,824.9	2,595.2
Fugitive emissions from gas-delivery systems	473.8	562.0	677.2	686.0	946.4	691.0	689.1

Scenarios/Sub-sectors	2000	2005	2010	2015	2020	2025	2030
Other	111.9	274.0	668.7	919.4	725.6	871.3	1,034.5
Total	**3,601.4**	**4,367.6**	**5,008.6**	**5,504.9**	**8,653.4**	**9,071.6**	**10,578.9**

Table 4-8. Emissions of CO_2, CH_4, N_2O in the Energy sector for 2000-2010, and projections for 2030, Gg

Scenario/GHGs	2000	2005	2010	2015	2020	2025	2030
Business as usual							
CO_2	3,067.6	4,151.3	4,231.0	5,182.7	8,657.5	11,202.7	13,838.6
CH_4	23.1	27.8	35.7	34.6	66.9	88.5	110.8
N_2O	0.010	0.015	0.094	0.094	0.131	0.152	0.174
With measures							
CO_2	3,067.6	4,151.3	4,231.0	4,695.0	7,224.4	8,764.4	10,219.9
CH_4	23.1	27.8	35.7	31.4	55.9	69.3	81.8
N_2O	0.010	0.015	0.094	0.085	0.109	0.119	0.128
With measures, including new power unit in ANPP							
CO_2	3,067.6	4,151.3	4,231.0	4,695.0	7,224.4	7,549.4	8,786.9
CH_4	23.1	27.8	35.7	31.4	55.9	59.7	70.4
N_2O	0.010	0.015	0.094	0.085	0.109	0.103	0.110

Table 4-9. Potential for greenhouse gas emissions reduction in the Energy sector, Gg $CO_{2\,eq}$

Emission-reduction measures	2015	2020	2025	2030
Small HPPs	240.0	319.7	399.5	479.2
HPPs	0.0	80.0	200.0	520.0
Wind PPs	20.0	100.0	200.0	250.0
Geothermal plants	0.0	76.8	76.8	76.8
Solar-photovoltaic plants	0.0	8.2	41.0	82.0
Biogas stations	2.5	4.5	6.5	8.5
Heat pumps	0.4	0.7	1.4	2.9
Solar heaters	0.2	0.3	0.4	0.5
New 1,000 MW power unit in ANPP	0.0	0.0	1,802.0	1,802.0
Biofuel use in vehicles	0.0	0.0	2.2	6.8
Modernization of fleet, expansion of electric transport in cities	33.7	92.9	156.0	230.4
Energy saving	87.5	364.8	656.7	890.0
Modernization of gas-transportation system, reduction in fugitive emissions	0.0	217.0	577.2	1,087.1
Total	**384.2**	**1,265.0**	**4,119.6**	**5,436.0**

Table 4-10. Fossil-fuel saving potential, thousand tonne

Fuel-saving measures	2015	2020	2025	2030
Small HPPs	102.2	136.1	170.1	204.0
HPPs	364.8	398.9	450.0	586.2

Fuel-saving measures	2015	2020	2025	2030
Wind PPs	9.2	43.2	85.8	107.1
Geothermal plants	0.0	32.7	32.7	32.7
Solar-photovoltaic plants	0.0	3.5	17.5	34.9
Biogas stations	1.6	2.4	3.3	4.1
Heat pumps	0.15	0.31	0.61	1.23
Solar heaters	0.08	0.12	0.15	0.19
New 1000 MW power unit in ANPP	0.0	0.0	767.1	767.1
Biofuel use in vehicles	0.0	0.0	31.1	95.3
Energy saving	29.2	139.8	253.4	336.6
Total	**507.2**	**757.0**	**1,811.7**	**2,169.4**

Figure 4.2 below estimates GHG emission trends in Energy sector for 2000-2030. A significant reduction of emissions in 2025-2030 is projected under the mitigation scenario as a result of the commissioning of a new power unit in ANPP. Table 4-11 describes long-term specific values for energy consumption and GHG emissions.

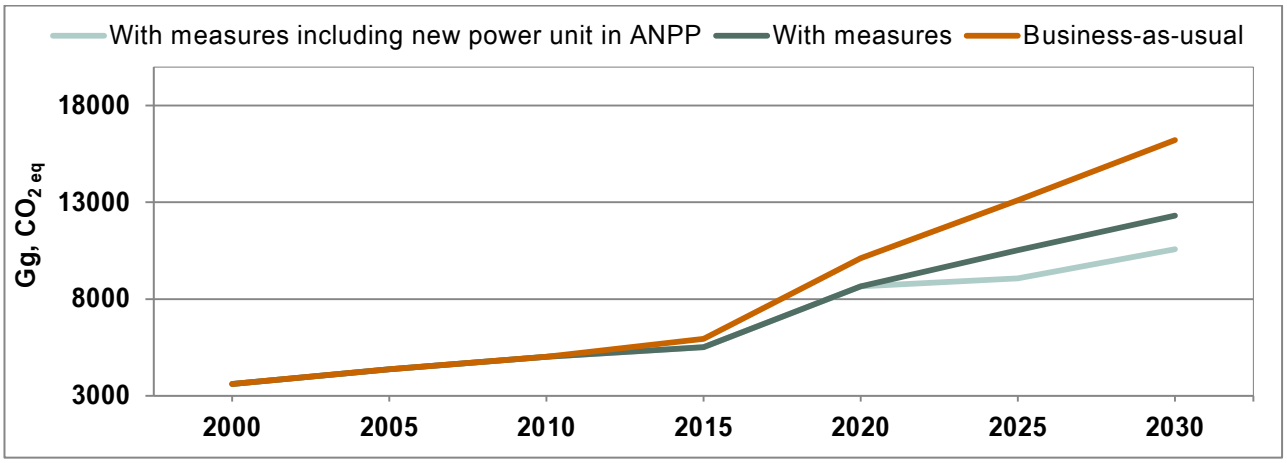

Figure 4-2. GHG emissions in the Energy sector in 2000-2010, and projections for 2030

Table 4-11. Indicators of energy consumption and greenhouse gas emissions in 2000-2010, and projections for 2030

Indicators	2000	2005	2010	2015	2020	2025	2030
GDP, million USD	1,912	4,900	9,371	1,1984	20,380	30,651	38,696
Population, million people	3.21	3.02	3.03	3.29	3.32	3.35	3.38
Business as usual							
GDP energy intensity, toe /thousand USD	1.13	0.55	0.26	0.2	0.22	0.18	0.17
Primary energy consumption, thousand toe	2,152.9	2,679.0	2,474.8	2,931.6	4,507.9	5564.1	6,657.1
GHG emissions, thousand tonne	3,601.4	4,367.4	5,008.6	5,939.2	10,103.7	13,109.1	16,219.7
Energy consumption per capita, toe/person*	0.67	0.88	0.81	0.89	1.35	1.66	1.97

Indicators	2000	2005	2010	2015	2020	2025	2030
Emissions per unit of energy, tonne $CO_{2\ eq}$/toe	1.65	1.63	2.02	2.03	2.24	2.36	2.44
With measures							
GDP energy intensity, toe /thousand USD				0.23	0.2	0.16	0.15
Primary energy consumption, thousand toe				2,836.2	4,091.5	4,857.0	5,691.5
GHG emissions, thousand tonne				5,504.9	8,653.4	10,531.5	12,304.2
Energy consumption per capita, toe/person*				0.86	1.23	1.45	1.68
Emissions per unit of energy, ton $CO_{2\ eq}$ /toe				1.94	2.11	2.17	2.16
With measures, including new power unit in ANPP							
GDP energy intensity, toe/thousand USD				0.23	0.24	0.22	0.19
Primary energy consumption, thousand toe				2,836.2	4,091.5	5,195.7	6,084.8
GHG emissions, thousand tonne				5,504.9	8,653.4	9,071.6	10,578.9
Energy consumption per capita, toe/person*				0.86	1.23	1.55	1.8
Emissions per unit of energy, ton $CO_{2\ eq}$/toe				1.94	2.11	1.75	1.74

** Relative to domestic energy consumption (without power export).*

In the mitigation scenario, in case energy consumption increase by 2.3-2.7 times in 2010 - 2030, GHG emissions per unit of consumed energy (carbon intensity of energy consumption) will increase by 6.5% without the installation of a new power unit in ANPP. With the new unit there will be 13.8% reduction, evidence of a low-emission development opportunity for the Armenian energy sector.

4.3.2 Industrial Processes and Product Use

GHG emission sources in IPPU in Armenia include:

- Cement production (CO_2);
- Refrigeration and air conditioning, fire protection and aerosols with hydrofluorocarbons (HFCs);
- Production of food and non-alcoholic beverages, asphalt production and paving, and use of paints and solvents (NMVOC).

After banning imports of ozone-layer-depleting substances in 2000-2010, the use of F-gases (HFCs) in Armenia has increased from 3.7-133 tonnes (225 Gg $CO_{2\ eq}$). Increasing use of F-gases will continue while F-gas substitutes command high market prices (they are not widely used in Armenia). There are no laws restricting imports of F-gases into Armenia. In order to promote a reduction in F-gas use the country will need to ensure availability of affordable substitute substances in the market, regulations restricting imports of F-gases, financial policies promoting use of substitute substances, and the training of relevant human resources. Due to these factors and great uncertainty, no prediction for F-gases emissions has been made.

Taking into account the insignificant volume of NMVOC emissions from processes and products (11.4 Gg), as well as the fact that NMVOCs are gases with indirect greenhouse effect, these gases have not been considered in mitigation projections.

The major source of GHG emissions in IPPU is cement production.

In Armenia, cement is produced at the Hrazdan (Mika-Cement) and Ararat (Araratcement) plants. As a result of the deep economic and energy crisis in 1990-1995 there was a dramatic reduction in cement production (and consequently a reduction in CO_2 emissions. In

1995, cement production and CO_2 emissions were only 18% of the 1990 level, while in 2000 it reached 37%. After 2000 there was a substantial increase in cement production caused by an increase in construction activities and exports. However, in 2010, as a result of a sharp reduction in construction, cement production went down again by 39% compared to the 2008 production level.

GHG projections from the cement industry have been made based on long-term growth in construction envisaged in the *RA Strategic Development Plan, 2012-2025 (2012)*.

Two projection scenarios for CO_2 emissions from cement production have been considered: business as usual scenario (present technologies will remain unchanged) and mitigation (implementation of technological measures contributing to GHG emissions reduction).

By 2015, the Mika-Cement plant will have developed plans to rehabilitate two cement mills, and refurbish/replace grinding-load and separator equipment, which will result in a reduction in CO_2 emissions. These measures will enable a drop in CO_2 emissions from 0.507-0.397 tonnes per tonne of cement produced. It is envisaged that these measures will be introduced in both cement plants in 2020-2030. The forecast for 2015-2030 has been made for CO_2 emissions from cement production process only (see figure 4-3).

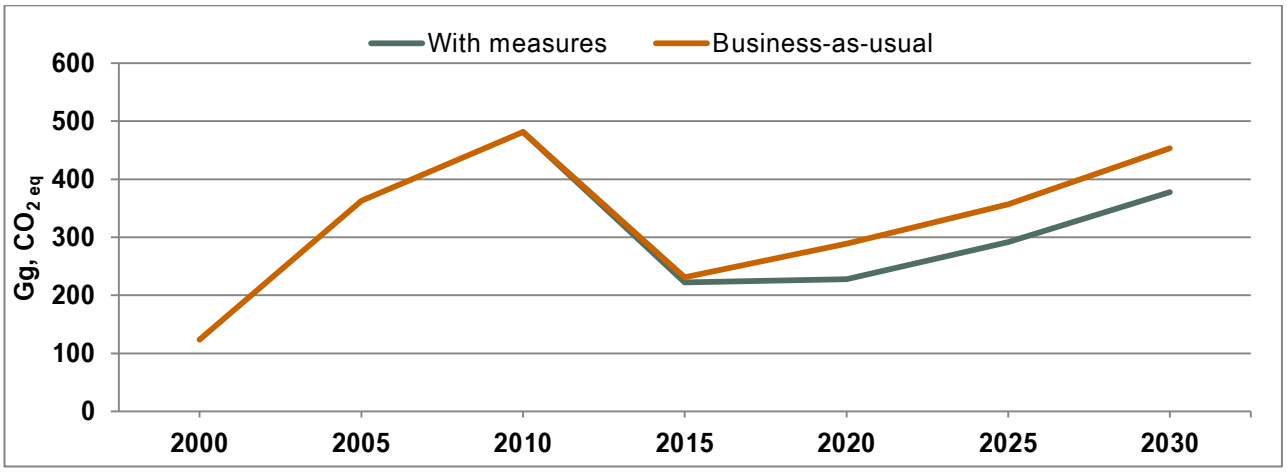

Figure 4-3. CO_2 emissions in 2000-2010, and projections for 2030 in IPPU

4.3.3 Agriculture, Forestry and Other Land Use

This section explores GHG emissions/removal in agriculture and forestry. No projections are made for 'other land use' because of great uncertainty in changes in land use.

Agriculture

The key sources of GHG emissions from agriculture in Armenia are the following: CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management, and N_2O emissions from agricultural soil. Enteric fermentation accounts for 75% of all emissions of the sector.

The assessment of emissions is based on the population and structure of livestock as projected in the *Sustainable Rural and Agriculture Development Strategy of Armenia*, as well as on forecasts for mineral-fertilizer use. Emissions reduction in agriculture can be achieved by using animal (livestock and poultry) waste for further biogas production. However, there is a limited potential for biogas production as there are no large livestock farms in Armenia.

Table 4-12 describes CH_4 emission projections from livestock production, and figure 4-4 shows total emissions in agriculture. Utilization of methane from manure will enable reduction of GHG emissions by 14% in 2010-2030.

Table 4-12. CH_4 and N_2O emissions in 2005, 2010 in agriculture, and forecast for 2030, Gg

	2005	2010	2015	2020	2025	2030
Business as usual						
CH_4	44.1	44.2	48.6	55.1	64.0	73.8
N_2O	0.22	0.213	0.234	0.277	0.339	0.417
With measures						
CH_4	44.1	44.2	48.6	53.1	61.6	71.2
N_2O	0.22	0.213	0.234	0.142	0.167	0.217

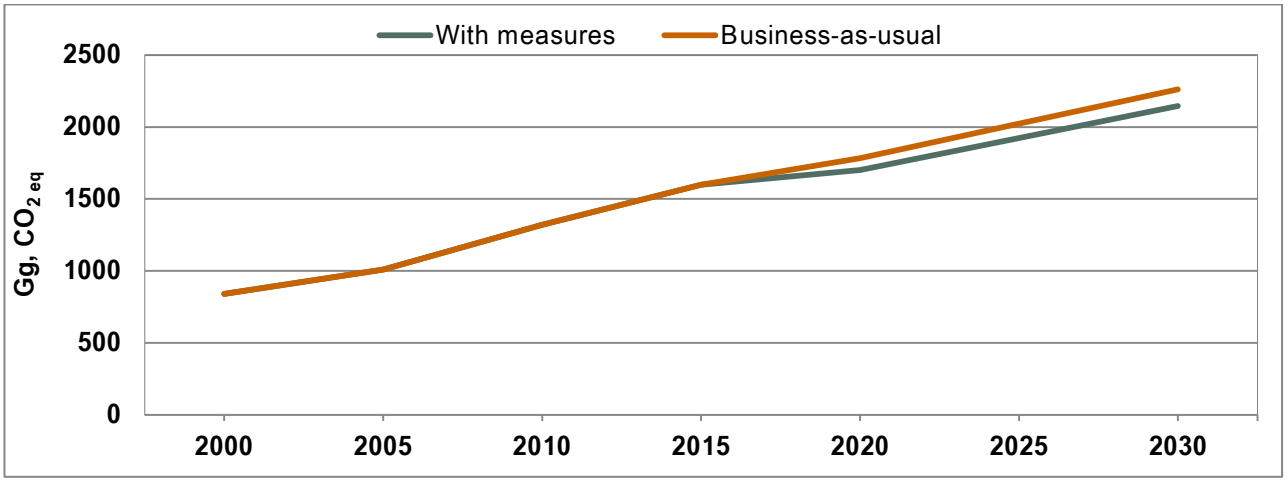

Figure 4-4. Greenhouse gas emissions in the agriculture sector in 2005-2010, and forecast for 2030

Forestry

Forests cover 11.8% of the total area of Armenia. Forests are essential players in climate change mitigation. In recent years, average CO_2 removal through forests have totalled as high as 14% of CO_2 emissions. The economy and energy crisis in Armenia in the 1990s had an extremely negative impact on forests. There was large-scale illegal logging in forests for fuel, which experts estimate to have been about 0.8-1.0 million m^3 annually. This value was much greater than the forest annual growth rate. The legacy of this large-scale logging has essentially reduced the CO_2-removal potential of forests. CO_2 removals in 1990 totalled 905 Gg, while emissions were 86 Gg. In 2000, according to the official data CO_2 removals dropped to almost 601 Gg, and emissions totalled 118 Gg, as per expert judgements correspondingly 558 Gg and 784Gg.

After 2000 there were some positive trends in the Armenian forest sector. A number of programme documents, secondary legislation and normative acts were developed targeted at the sustainable development of forests (see Chapter 3). There was a sharp reduction in illegal logging and an increase in forestation and reforestation activities (2,754.2 ha) in 2006-2012. These measures were focused on both increasing forested lands and enhancing the productivity of forests. This, in turn, contributed to an increase in CO_2 removals to 630 Gg (2010) (69% of the 1990 level).

The forecast for GHG removals/emissions was conducted using two scenarios: business as usual (maintaining current trends in forest use in the future) and mitigation (implementation of measures). For 2010-2030 the following mitigation measures are envisaged:

- Rehabilitation of degraded forest ecosystems and forestation of forest lands (1,983 ha in 2015, 947 ha in 2020, and 3,750 ha in 2030). This forecast was made according to 10-year forest management plans for forestation and forest rehabilitation (sowing, planting). These plans specify the period from planting to forest-land conversion. The new areas have been added to total forest lands.
- Implementation of forest-protection measures: annual integrated pest control by aviation to prevent the mass propagation of leaf-eating pests on an area of 15.0 thousand ha.
- Fire protection for forests: in 2001-2010 wildfires destroyed nearly 1,200 ha of for-

est lands. Wildfires destroy an average of 60-65 ha of forestlands annually. Reduction of wildfire risks through preventive measures will allow for the prevention of fires on an area of 30-35 ha annually.

- Prevention of illegal logging in forests to ensure approved annual plans for logging volumes.

The calculation of CO_2 removals/emissions for the forecast period was made using the software in the 2006 IPCC guidelines by entering respective indicators for each scenario.

Figure 4-5 presents the forecast of CO_2 removals/emissions in the forestry sub-sector for both scenarios. Table 4-13 describes net CO_2 flows.

Table 4-13. Net CO_2 flows in 2000-2010, and forecast for 2030, Gg

	2000	2005	2010	2015	2020	2025	2030
Based on official data							
Business as usual	-483	-540	- 558	-534	- 490	- 472	- 457
With measures	-483	- 540	- 558	- 581	- 590	- 594	- 602
Based on expert assessment							
Business as usual	+226	+116	-15	-27	-138	-224	-398
With measures	+226	+116	-15	- 526	- 550	- 570	-593

For both scenarios, the projected values of CO_2 removals/emissions in 2000-2010 were considered using official data on the condition of forestry, and data obtained through similar studies based on expert calculation for quantities of wood use.

If the intended measures are implemented, it is forecast that, in 2030, CO_2 removal from forests will reach 641-650 Gg (the 71-72% of 1990 level).

Forecast values of CO_2 removals/emissions are slightly different from those presented in SNC. This difference is due to corrected data for forest lands, use of long-term projection methods, the introduction of the new national factor for wood density, annual average growth rates, the implementation of measures preventing illegal logging, etc.

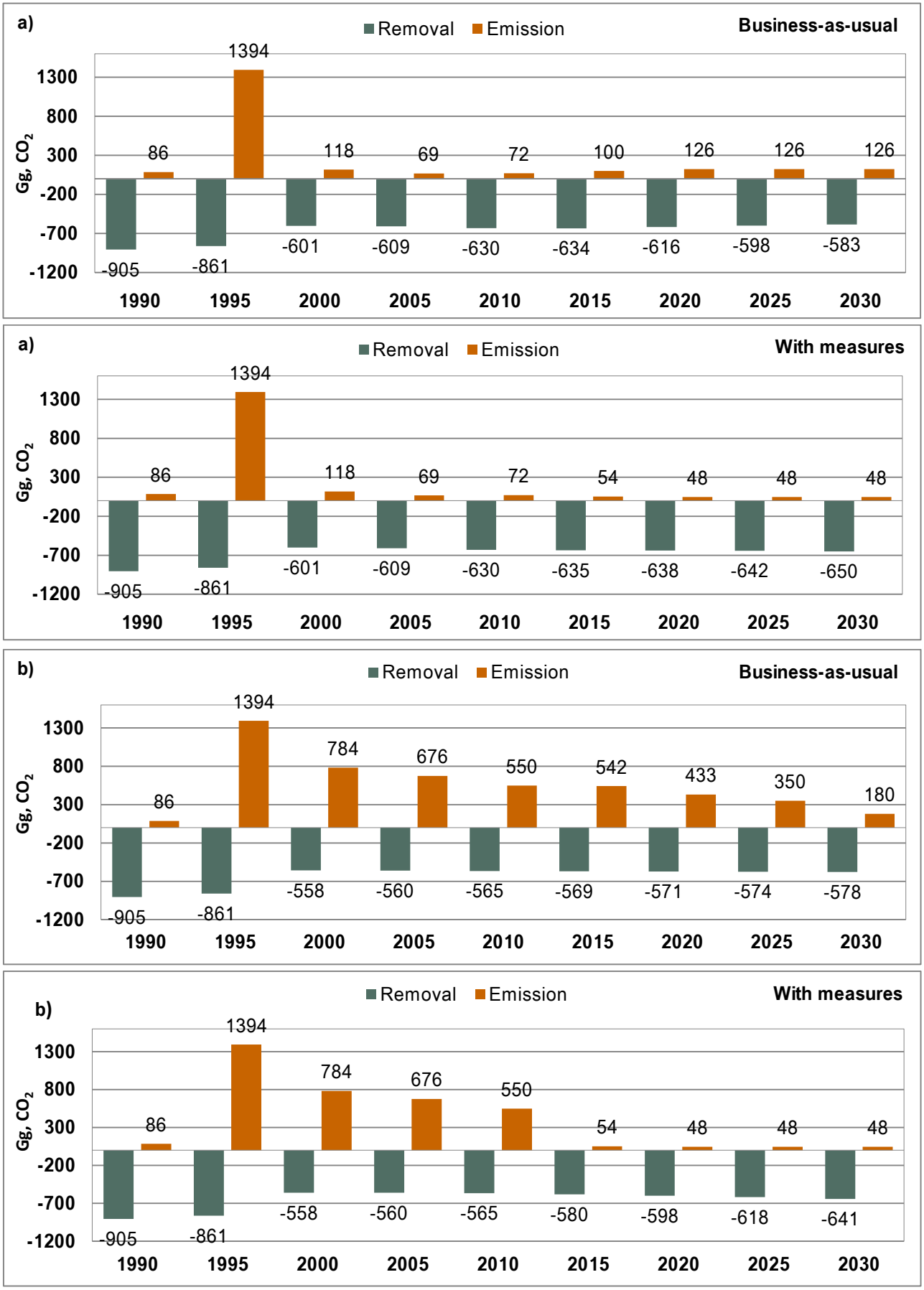

Figure 4-5. CO_2 removals/emissions from the forest sub-sector in 1990-2010, and projections for 2030; (a) 2000-2010 based on official data; (b) based on expert assessment

4.3.4 Waste

84% of all emissions of the Waste sector are generated by SW, and 16% by wastewaters. The sector accounts for 8.7% of total GHG emissions (11% of CH_4 emissions, and 13% of N_2O emissions).

Projections of SW and municipal wastewater volumes are based on predicted population growth, while industrial wastewater volumes were calculated according to the growth projections of respective industries.

GHG emission projections were made using two scenarios: 'business as usual' (maintaining existing practices in the future) and 'mitigation' (with measures).

Given the fact that, in Armenia, there are currently no programmes for the rehabilitation and modernization of wastewater treatment stations, the forecast in the mitigation scenario is made for SW only. The mitigation scenario is based on the SW management programme supported by the Asian Development Bank. According to the programme is envisaged to shut down the existing 48 SW disposal sites and open 5 new regional SW disposal sites with 10 reloading points for waste sorting in 2017. There will be landfill gas capturing and incineration in closed large (Yerevan, Gyumri and Vanadzor) SW disposal sites and the SW open-burning practices will be terminated.

Table 4-14 describes forecasts for CH_4 and N_2O emissions from SW disposal sites and wastewaters. Figure 4-6 presents sector-specific emissions forecasts with regard to uncontrolled SW open-burning practices in the baseline scenario (36.9 Gg $CO_{2\ eq}$).

Table 4-14. The forecast of greenhouse gas emissions in the Waste sector, Gg

	2010		2015		2020		2025		2030	
	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Business as usual										
SW disposal sites	22.4	0	22.8	0	23.6	0	24.1	0	24.6	0
Wastewater	4.27	0.182	4.52	0.184	4.79	0.185	5.08	0.187	5.38	0.189
Total	26.67	0.182	27.32	0.184	28.39	0.185	2.18	0.187	29.98	0.189
With measures*										
SW disposal sites			22.5	0	14.6	0	20.0	0	22.3	0
Wastewater			4.52	0.184	4.79	0.185	5.08	0.187	5.7	0.189
Total			**27.02**	**0.184**	**19.39**	**0.185**	**25.08**	**0.187**	**28.0**	**0.189**

* Mitigation scenario is made for SW only

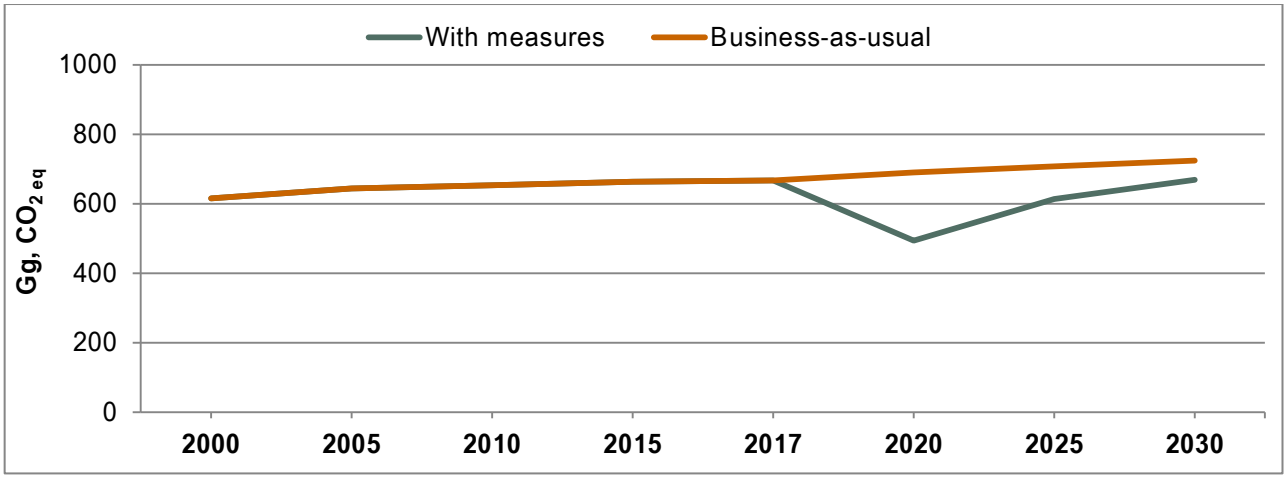

Figure 4-6. Greenhouse gas emissions in 2000-2010, and forecast for 2030 in the Waste sector

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5

CLIMATE CHANGE IMPACTS: VULNERABILITY ASSESSMENT AND ADAPTATION

Armenia is a mountainous country with arid climatic conditions; as such, it is vulnerable to global climate change. According to the World Bank, Armenia is among the most sensitive countries in Europe and Central Asia with regard to climate change. Temperature increases and reduced precipitation will accelerate desertification processes, result in reduced ecosystem services, and have a negative impact on both public health and climate-dependent sectors of the economy. Declining water resources will have a direct impact on agriculture (reduced capacities for irrigation, worsened conditions for rain-fed agriculture, drop in crop yields), will reduce electricity generation by HPPs, and cause technical water shortages. The forecast higher frequency of extreme climatic phenomena as a result of climate change will have a negative impact on human health, property, agriculture and infrastructure. Climate change will bring about changes to natural ecosystems, which will also reflect on biodiversity, forest land, alpine land, sub-alpine land, and wetland ecosystems in the country.

In the years after the preparation of Armenia's SNC on climate change, there have been significant changes with regard to both legislation and the institutional structure of governance. The country has developed new scenarios for climate change that make corrections to not only to seasonal changes, but also by regions. Based on this information, the vulnerability of different sectors has been reassessed and the forecasts made in SNC was verified.

Some findings made by the study conducted in Armenia under the regional programme of UNDP Bureau for Crisis Prevention and Recovery have been used to prepare TNC.

Vulnerability assessments to climate change have been made and adaptation measures for Vayots Dzor Marz (province) proposed, which was selected as a pilot region. This marz, among other regions of the country has great diversity of climatic conditions and relatively diversified economic activities, as well as relatively weaker influence of anthropogenic factors on nature. More detailed results are described in Annex IV.

5.1 Climate Change Observed in Armenia

Trends in ambient air temperature and precipitation changes

Changes in annual ambient temperature and precipitation in Armenia have been assessed for various time periods; the results were used in preparations for FNC and SNC. These results show that, in recent decades, there has been a significant temperature increase (see table 5-1 and figure 5-1). In the period of 1929-1996, the annual mean temperature increased by 0.4^0C; in 1929-2007 by 0.85^0C; in 1929-2012 by 1.03^0C.

Table 5-1. Annual mean temperature and precipitation changes in 1929-2012 changes relative to the 1961-1990 average

Time period	Air temperature, ^{0}C	Time 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)

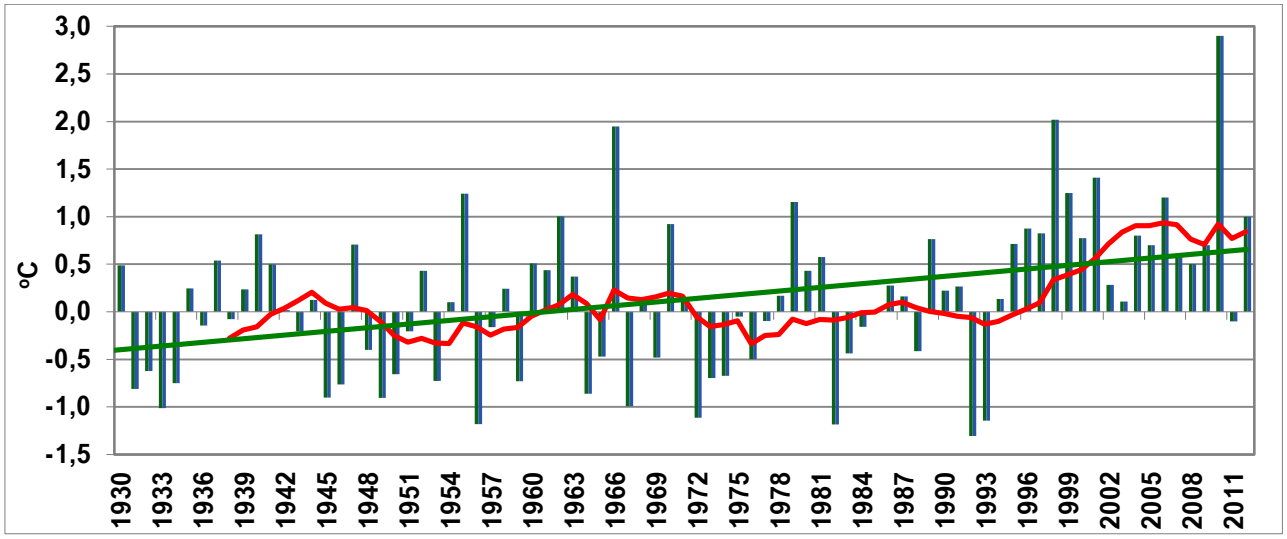


Figure 5-1. Deviations of average annual air temperature in the territory of Armenia from the average values for 1961-1990

On 31July 2011 the absolute maximum temperature 43.7^{0}C for the whole period of observations in Armenia was recorded in Meghri region, which exceeded the previous record by 0.7^{0}C. Over various seasons of the yearambient air temperature changes exhibit different trends. In 1935-2011 the summer average temperature increased by about 1.1^{0}C, and extremely hot summers have been observed over the last 17 years (1998, 2000, 2006, 2010) (see figure 5-2a). Winter temperature changes look different: seasonal mean temperature increases are insignificant at 0.4^{0}C (see figure 5-2b).

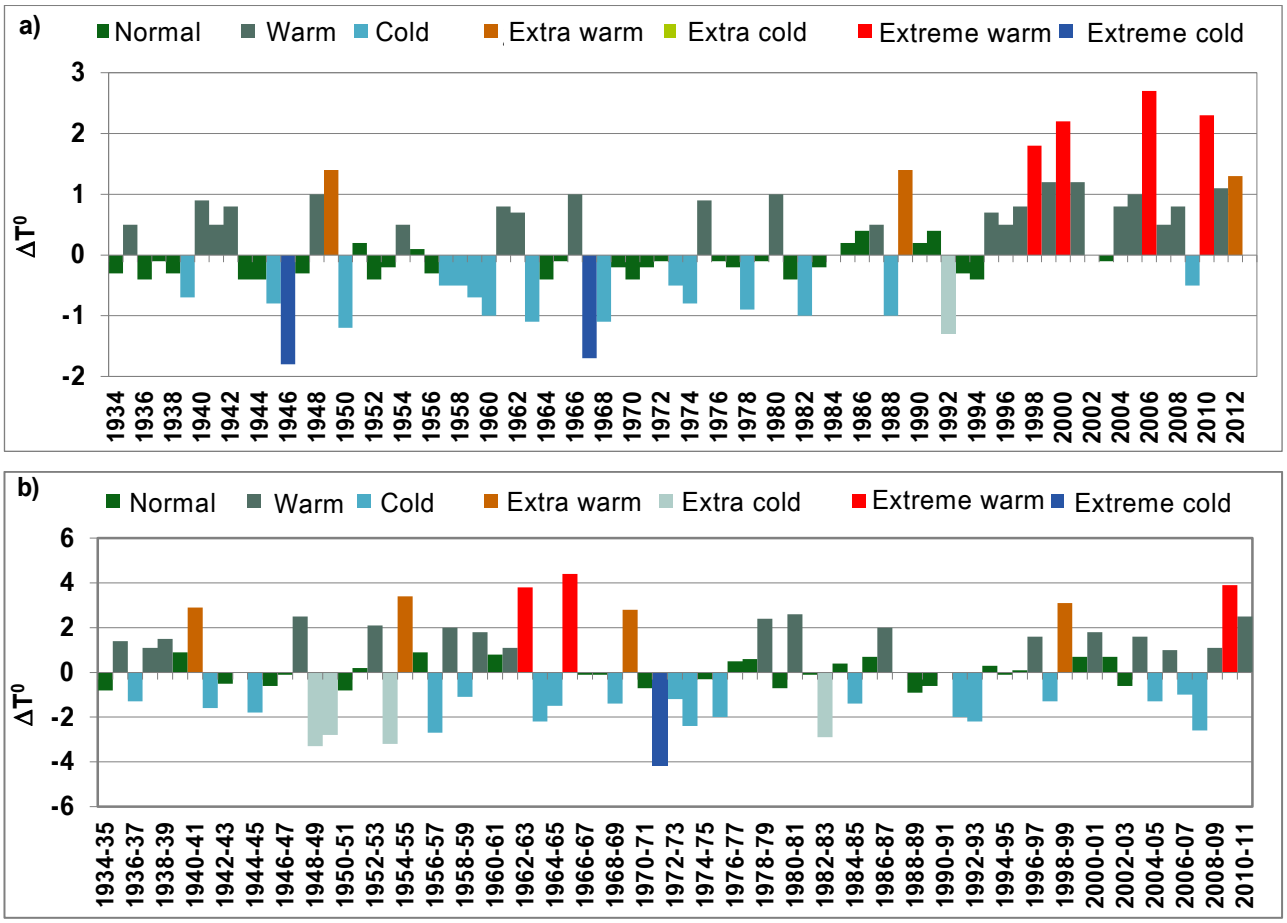


Figure 5-2. Deviation of summer (a) and winter (b) temperatures in the territory of Armenia in 1935-2012 from the average values for 1961-1990

The comparison of changes in the assessment of precipitation amounts for different periods demonstrates that precipitation continues to decline. Observations showed that, in 1935-1996, there was a 6% decrease in annual precipitation, while in 1935-2012 it was close to a 10% decline (see figure 5-3).

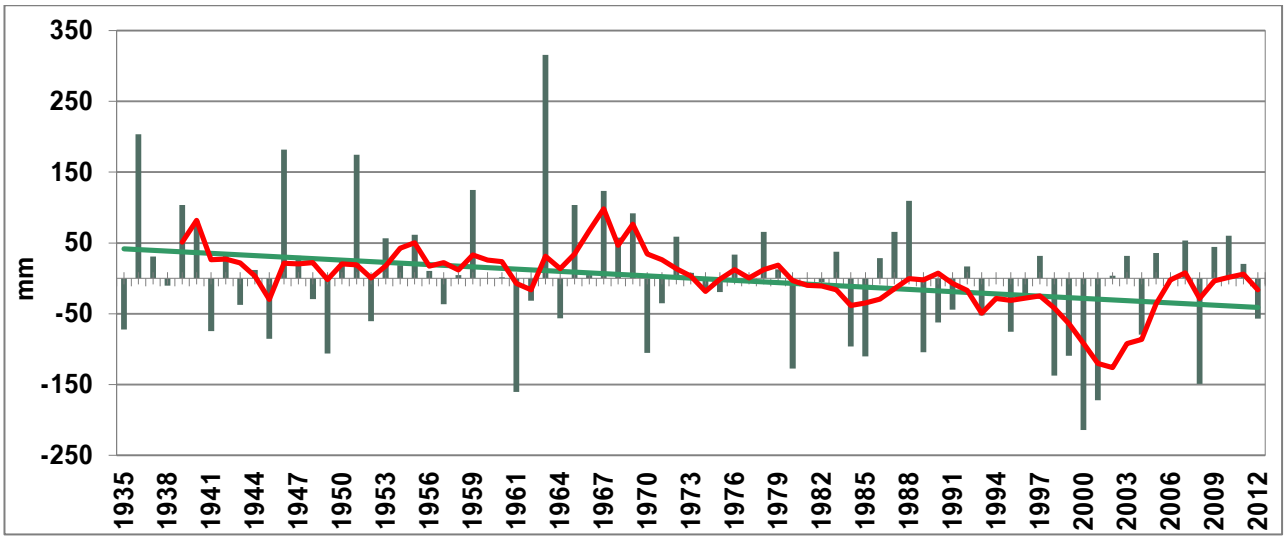


Figure 5-3. Deviation of annual average precipitation in the territory of Armenia from the average of 1961 -1990

The spatial distribution of changes in precipitation amounts is fairly irregular. Over the last 80 years, the climate in the northeastern and central (Ararat Valley) regions of the country has turned arid, while precipitation has increased in the southern and northwestern regions, as well as in the western part of the Lake Sevan basin.

Trends in atmospheric circulation changes

Atmospheric circulation is a key factor for climate formation which, in the territory of Armenia, is expressed as an influence of Western air streams peculiar to sub-tropical zones. There have been changes of general circulation processes in the atmosphere as a result of the global climate change. Climate risks and the frequency of hazardous hydrometeorological phenomena have increased over the last decade as a result of changes in global atmospheric circulation. For this purpose, a study was conducted on the regional daily, monthly and annual thermobaric fields for 1948-2008; 14 types of processes determining the climate of Armenia have been identified.

Cyclones penetrating into the territory of Armenia mostly come from the Mediterranean Sea, Asia Minor regions (from Syria and northern Iraq), and sometimes from northeastern Africa. Cyclones transiting the country create more clouds and more intensive winds at velocities up to 25-30 m/sec.

The entrance of southern cyclones into the territory of Armenia is accompanied by thunderstorms, heavy precipitation and more intensive south winds. The average amount of penetration of southern cyclones has increased by 24%, which has increased the number of days with intensive rainfall in the entire territory of the country. The number of events with heat depression has increased by 107%, therefore increasing recurrence of summers with high thermal background and scarce rainfall.

Late spring and early autumn frosts, strong winter frosts, and strong winds are mainly due to Scandinavian anticyclones, the frequency of which has increased by 71%. This shows that the recurrence of hazardous atmospheric phenomena in the territory of Armenia caused by these anticyclones is expected to grow. The occurrence of formation of Iranian anticyclones in the territory of Armenia has increased by over 63%, resulting in the increased recurrence of heat waves. The occurrence of weakly expressed steady pressure fields not leading to any hazardous meteorological phenomena has decreased by 26% in Armenia.

Hazardous hydrometeorological phenomena

In recent decades, climate change has significantly increased the frequency and intensity of natural disasters both in Armenia and globally.

The marginal values so far recognized characterizing these phenomena have also changed. Damage caused by hazardous hydrometeorological phenomena to the economy and to human life has increased. Extreme events (hail, frost, strong winds, heavy rainfall, floods, droughts, heat waves) may be contributing to the generation of natural calamities (or their escalation), such as landslides, avalanches, mudflows, forest wildfires, rock-falls, outbreaks of infectious diseases, etc.

To reveal trends in extreme hydrometereological events the dynamics of phenomena most frequently observed in Armenia from 1980-2012 were analyzed, including: frost, hail, strong winds, and heavy precipitation. The maximum aggregate number of 245 hazardous events was observed in 2004; the minimum number of 106 events in 2006. The amount of hail was greatest in Shirak valley; heavy precipitation was most common in Tashir and Ijevan regions; more frost events were observed in Ararat Valley and premountainous regions.

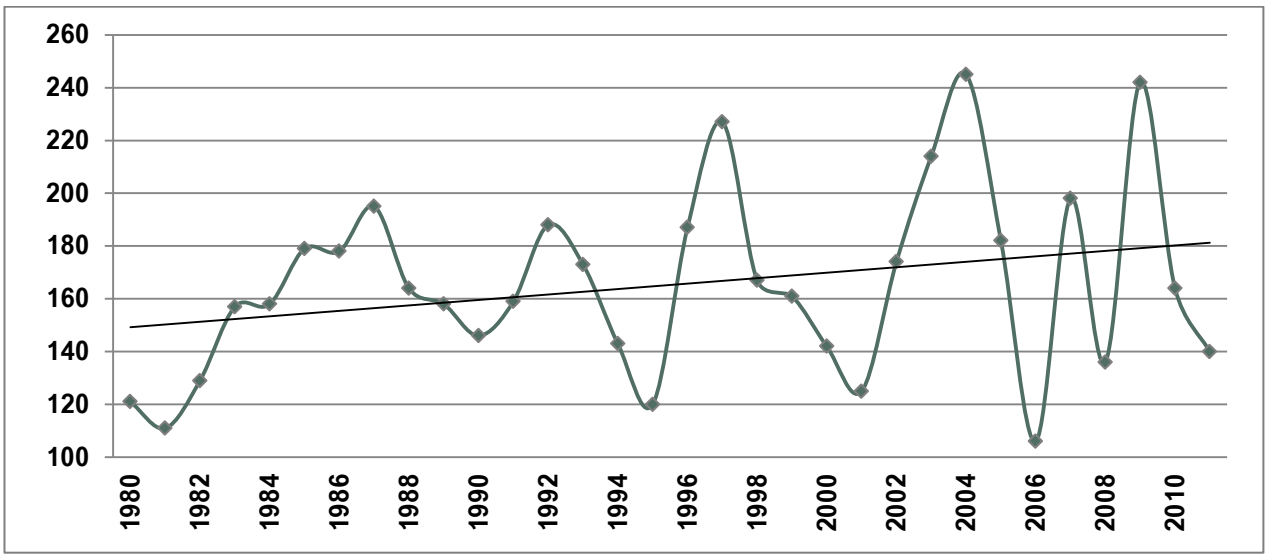


Figure 5-4. Number of extreme hydrometereological events (frost, hail, heavy rainfall and strong winds) observed in the territory of Armenia in 1980-2012

The analysis showed that:

- The number of frost events has increased significantly, which may have the following explanation: the annual mean temperature increase in Ararat Valley mostly occurs in March, which triggers the earlier start of vegetation; the sharp temperature fall in April consequently increases the frequency of frost events;
- The number of days with heavy precipitation and hail has increased. This is due to the higher frequency of penetration of high cyclones generating heavy rain and hail clouds.

Extreme Climate Indexes

The increase in the frequency of extreme climatic phenomena is one of the main indicators of climate change. 30 indexes recommended by the WMO for the entire territory of Armenia for 1935-2012 have been assessed. These indexes can be applied to several sectors such as: public health, agriculture, water resources, etc.

The number of summer days (Tmax > 25^0C) has significantly increased, particularly in arid semi-desert and steppe zones (3.9-4.9 days/10 years); the number of tropical nights (4.6 days/10 years) has increased in the dry desert zone. For the same period, the number of cold days (1.1-3.5 days/10 year) has decreased, while there has been a reduction in the number of frosty days (0.4-3.1 day/10 year). The duration of heat waves has increased from 1.6-5.4 days/10 year, while the duration of cold waves has fallen to 0.3-2 days/10 years.

The average number of consecutive dry days is particularly high in Meghri and Ararat (61 and 58 days respectively). The average number of dry days in Yerevan is 42; the maximum of 63 days was recorded in 2010.

In 1935-2012 the number of dry days increased in almost all zones: the maximum of 3 days/10 years was recorded in the dry subtropical zone.

Given the particular importance of the effect of hot and cold waves on public health and agricultural crops, a deviation of $\pm 3^0$C from the norm of the daily maximum ambient air temperature for the maximum (minimum) daily average of five and more consecutive days was estimated in 1961-1990.

The average value of heat waves in the different climatic zones of Armenia varies between 12-26 days, while the maximum value is 34-70 days. The average value of cold waves ranged from 10-20 days, and the maximum value is 31-70 days.

It should be noted that the maximum number of cold waves in Armenia was recorded in 1982; the maximum number of heat waves were in 1998, 2000 and 2010. An analysis of annual change trends in the aggregate quantity of hot days in several settlements proves that the duration of heat waves has significantly increased over the last 30 years. For instance, in Yerevan in 1981-2013 the heat-wave average has increased by about 40 days, while the duration of cold waves has decreased by 1.4 days for the same period.

5.2 Climate Change Projections

Climate change in Armenia is assessed using the CCSM4 model in accordance with the IPCC recommended RCP8.5 and RCP6.0 scenarios for CO_2 emissions. Therefore, as per the RCP6.0 scenario (equivalent to the SRES B2 scenario) CO_2 concentration will be 670ppm by 2100 and it will be 936ppm according to the RCP8.5 scenario (equivalent to the SRES A2 scenario). Future change forecasts for ambient air temperature and rainfall have been developed up until 2100. The results indicate that the temperature will continue to increase in all seasons of the year (see table 5-2). However, according to the RCP8.5 scenario, starting from the mid-21th century (2041-2100) the temperature will rise at a more rapid rate. According to the RCP8.5 scenario, it is very likely that, by 2100, the average annual temperature in Armenia will be 10.2^0C, which exceeds the baseline (1961-1990) by 4.7 ^{0}C.

Table 5-2. Projected changes in annual and seasonal average temperatures in the territory of Armenia compared to the average for 1961-1990, ^{0}C

Seasons	1961-1990 average	Scenarios	2011-2040	2041-2070	2071-2100
Winter	-5.3	RCP, 6.0	1.4	2.6	3.6
		RCP, 8.5	1.7	2.8	4.4
Spring	4.3	RCP, 6.0	1.3	2.4	2.7
		RCP, 8.5	1.4	2.7	3.9
Summer	15.7	RCP, 6.0	1.9	3.0	3.8
		RCP, 8.5	2.1	4.0	6.0
Autumn	7.2	RCP, 6.0	0.8	2.3	3.0
		RCP, 8.5	1.4	3.2	4.4
Year	5.5	RCP, 6.0	1.3	2.6	3.3
		RCP, 8.5	1.7	3.2	4.7

Figure 5-5 presents spatial distribution maps for annual mean temperature for the 1961-1990 baseline, and projections for 2071-2100. It is expected that, by 2100, temperatures will increase in most regions of Armenia. Increased temperature in mountainous regions demonstrates an apparent retreat in negative temperatures (blue-coloured areas, see figure 5-5b). For instance, 2100 annual mean negative temperatures will be maintained only in the highlands of Aragats, Geghama, and the Zangezur mountains. In general, seasonal and annual temperature and precipitation change trends are similar. It should be noted that maximum temperature growth is observed during the summer.

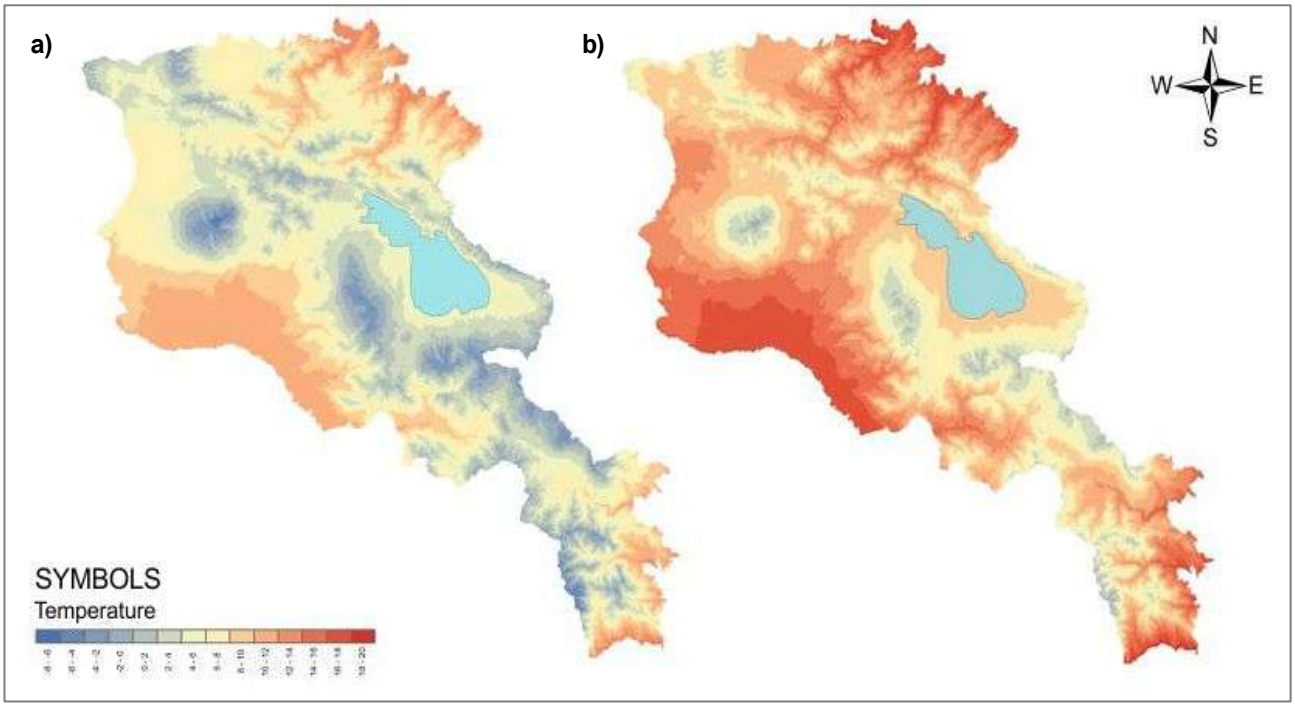


Figure 5-5. Distribution of annual average temperature in Armenia in (a) 1961-1990 and (b) projections for 2071-2100, RCP 8.5 scenario

Evaluation results for precipitation change show that, according to the RCP8.5 scenario, there might be 16.3% increase in annual precipitation in Armenia by the mid-21st century. There will be no changes in precipitation according to the RCP6.0 scenario. However, according to both scenarios for the summer months there is an expected significant decrease in precipitation in all 3 periods: in 2011-2040 summer precipitation is expected to decrease by about 23% compared to the baseline (1961-1990) period.

Table 5-3. Changes in annual and seasonal precipitation in the territory of Armenia compared to the average of 1961-1990, mm

Season	1961-1990 average	Scenarios	2011-2040	2041-2070	2071-2100
Winter	114	RCP, 6.0	5.3	5.8	6.2
		RCP, 8.5	-5.7	16.3	2.9
Spring	211	RCP, 6.0	1.2	4.2	2.6
		RCP, 8.5	4.2	-8.0	2.4
Summer	148	RCP, 6.0	-10.1	-10.8	12.8
		RCP, 8.5	-23.0	-3.4	-13.0
Autumn	119	RCP, 6.0	5.0	3.2	1.2
		RCP, 8.5	2.5	8.6	13.6
Year	592	RCP, 6.0	5.3	5.8	6.2
		RCP, 8.5	-5.7	16.3	2.9

The distribution of annual precipitation amount seen Armenia will not undergo significant change; however, in pre-mountainous and mountainous regions there will be a slight increase by the mid- 21st century.

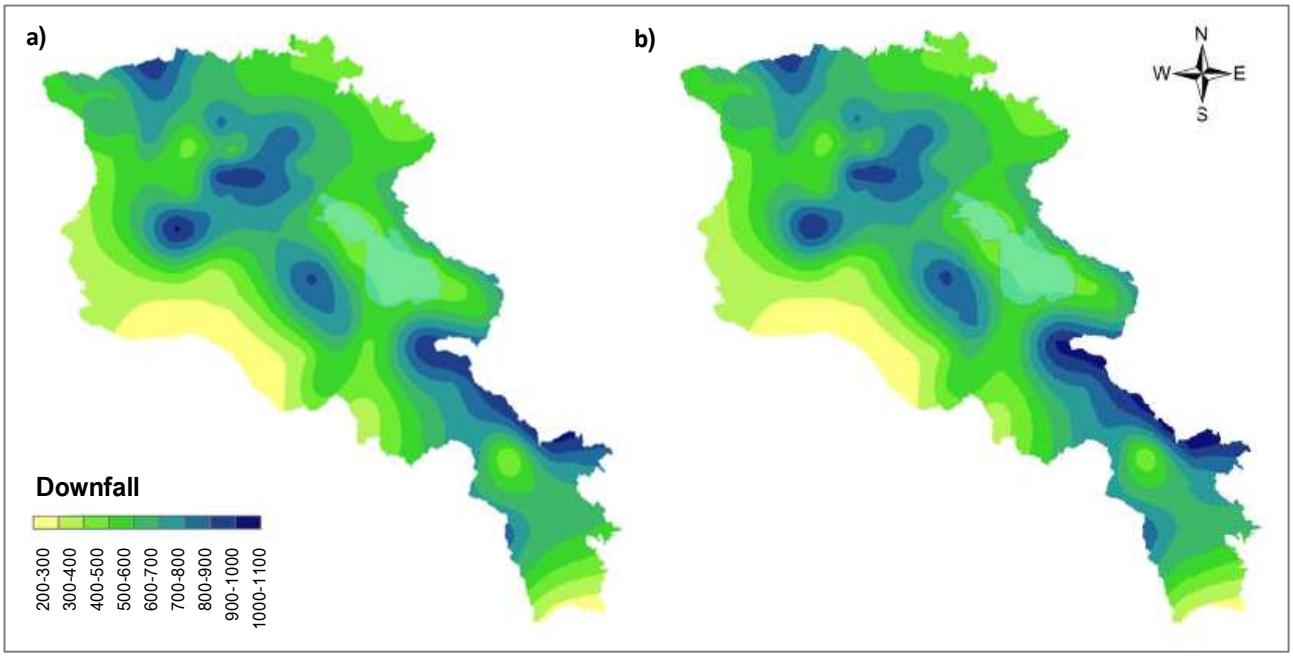


Figure 5-6. Distribution of annual average precipitation (mm) in Armenia in (a) 1961-1990 and (b) projections for 2071-2100, RCP 8.5 scenario

Summers in most of the regions of the country are usually characterized by hot and dry weather conditions. According to the model projections, these conditions will worsen, leading to a variety of problems in water resources, agriculture, energy, healthcare and other sectors.

Although the results of the CCSM4 model reproduce changes in temperature fairly well, there are large uncertainties in terms of precipitation. Additionally, the resolution of the model for the mountainous terrain of Armenia is insufficient.

5.3 Water Resources

Proper management of water resources plays a significant role in the social and economic development of Armenia. Water resources are important for development of Armenia, particularly for agriculture (about 80% of agricultural crops are irrigated) and hydro energy (1,032 MW installed capacity, or around 30-40% of annual power generation). Ground waters account for about 96% of drinking water, and 39% of total water intake (2013).

In 2013, the total intake from water sources amounted to 2,955 million m^3, of which 2,081 million m^3 was actually used. The distribution of water use by sector was: 88% for irrigation, pisciculture and forestry; 8% for manufacturing; 4% for drinking and domestic needs.

There are no major rivers in Armenia apart from the Aras. However, the river network of the country is fairly dense (215 rivers longer than 10 km), with a total length of 13 thousand km. The majority of these rivers do not have a permanent flow and dry in summertime.

The spatial and seasonal distribution of water resources in Armenia is extremely uneven. In particular, water is scarce in the densely populated watershed basin of the River Hrazdan located in central Armenia. About 50% of the total flow of the river is subject to significant annual fluctuations. During dry seasons, the flow is less than 65% of the annual average. In addition to annual fluctuations, the Hrazdan river flow also undergoes significant seasonal fluctuations. In a normal year, about 55% of the total river flow is fed by melting snow in spring and rainfall; the maximum and minimum flow ratio can be in the range of 10: 1.

5.3.1 Vulnerability Assessment

Detailed analysis on the vulnerability of the country's water resources from climate change was described in SNC. Below is present the amended assessment of the vulnerability of the water resources of Armenia as a result of climate change.

After SNC submission (2010), there have been a number of developments in Armenia's water resources management. The government has adopted a number of decisions on water resources, including:

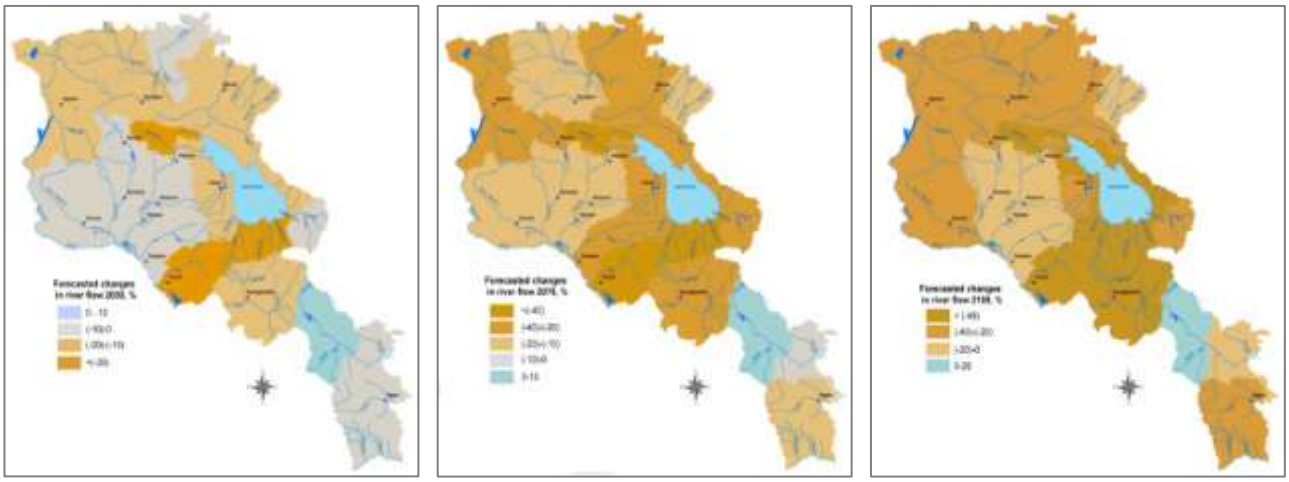
- On “Approval of the content of the model plan for water basin management” (2009) – for water-resource management;
- On “Compliance with water quality standards for each water basin management area dependent on the specific peculiarities of terrains” (2011) – for water-quality assessment;
- On “Defining assessment of water demand for drinking-households, agricultural, as well as environmental flows” (2011) – for determining environmental flows

In addition, a number of programmes have been implemented, including assessments of vulnerability and the adaptation of water resources:

- “Vulnerability assessment of water resources in transboundary river basins (Khrami-Debed and Aghstev) and recommendations for appropriate adaptation measures under climate change”, UNDP (2010-2011);
- “Armenia: the water sector vulnerability under climate change”, UNDP (2012);
- “Assessment of water resources of Vorotan, Voghji, Meghriget river basins under climate change”, USAID (2013);
- “Study for introduction of Integrated Water Resources Management principles in 6 water basin management areas”, Sher (2013);
- “Promoting reforms in economic mechanisms of water management”, OECD (2013);
- “Toward Integrated Water Resources Management in Armenia Analysis”, World Bank (2013-2014);
- “Defining target areas and identification of appropriate targets for Armenia”, UNECE Water and Health Protocol (2013-2014).

The vulnerability assessment of the water resources of model water objects - Arpa, Debed, Voratan, Voghji, Meghriget river basins, Arpi and Aparan reservoirs – was conducted using the WEAP model. The vulnerability of Lake Sevan water resources, for which no assessment was made during the preparation of SNC, was also analyzed.

The water resources vulnerability map of Armenia as a result of climate change (see figure 5-7) is updated.



2030 2070 2100

Figure 5-7. Projected changes in river flows in Armenia for 2030, 2070 and 2100

Under the A2 scenario, the projected change in the aggregate volume of studied river flows in the territory of Armenia will decrease approximately by 11.9% by 2030, 24% by 2070, and 37.8% by 2100 (see table 5-4).

Table 5-4. Projected changes in aggregate river flows

Year	Flow, million m^3	Flow change	
		million m^3	%
1961-1990	5,797.0	0	0
2030	5,141.6	-655.3	-11.6
2070	4,405.6	-1,391.5	-24.9
2100	3,602.2	-2,195.0	-39.8

Vulnerability of Water Resources in the Arpa River Basin

Using WEAP software, the monthly, seasonal, and annual value of the Arpa river flow was modelled using the A2 and B2 scenarios for 2030, 2070, and 2100. The annual average flow of the Arpa will significantly decrease compared to the baseline (1961-1990) period (see table 5-5).

Table 5-5. Projected change in the Arpa River flow

River – observation point	Scenario	Flow change							
		1961-1990		2030		2070		2100	
		million m^3	%	million m^3	%	million m^3	%	million m^3	%
Arpa-Areni river	**A2**	728.8	0	578.9	-21	532.8	-27	489.1	-33
	B2	728.8	0	604.0	-17	573.5	21	513.7	-30

The estimated river flow of the Arpa will increase only in winter: A2 scenario by 12%; B2 scenario by 17.9%. In parallel with ambient air temperature increases, there will be an increase in rainfall, while snowfall will decrease. The river flow will become more vulnerable as a result of reduced snow stored in winter.

Debed and Aghstev River Basins

In 2009-2011 the UNDP "Climate change in the South Caucasus" project analyzed and assessed the vulnerability of the river flows of the trans-border river basins of Debed and Aghstev, according to the ECHAM5, GFDL CM2.X, GISS-ER and HadCM3 regional atmospheric-circulation models. By testing historical data, these models have been adopted by South Caucasus countries to generate the most reliable results. Thus, the results for average values derived by the aforementioned four models show that, in the A2 scenario, the flow of the Debed river will fall by 10-11% by 2040; by 29-37% in 2041-2070; by 55-62% in 2100. By 2040 the Aghstev river flow will decrease by 11-14%; by 2070 – 31-37%; by 2100 – 62-72% (see table 5-6 and figure 5-8).

Table 5-6. Projected change in flow of the Aghstev and Debed rivers, A2 scenario

River – observation point	Flow change							
	1961-1990		2030		2070		2100	
	million m^3	%	million m^3	%	million m^3	%	million m^3	%
Debed-Ayrum river	1054	0	937	-11	669	-37	402	-62
Dzoraget-Gargar river	480	0	427	-10	343	-29	215	-55
Pambak-Tamanyan river	336	0	300	-11	240	-29	160	-53
Aghstev-Ijevan river	286	0	255	-11	196	-31	108	-62
Voskepar (with its tributary Kirants)-Voskepar	67	0	58	-14	42	-37	19	-72

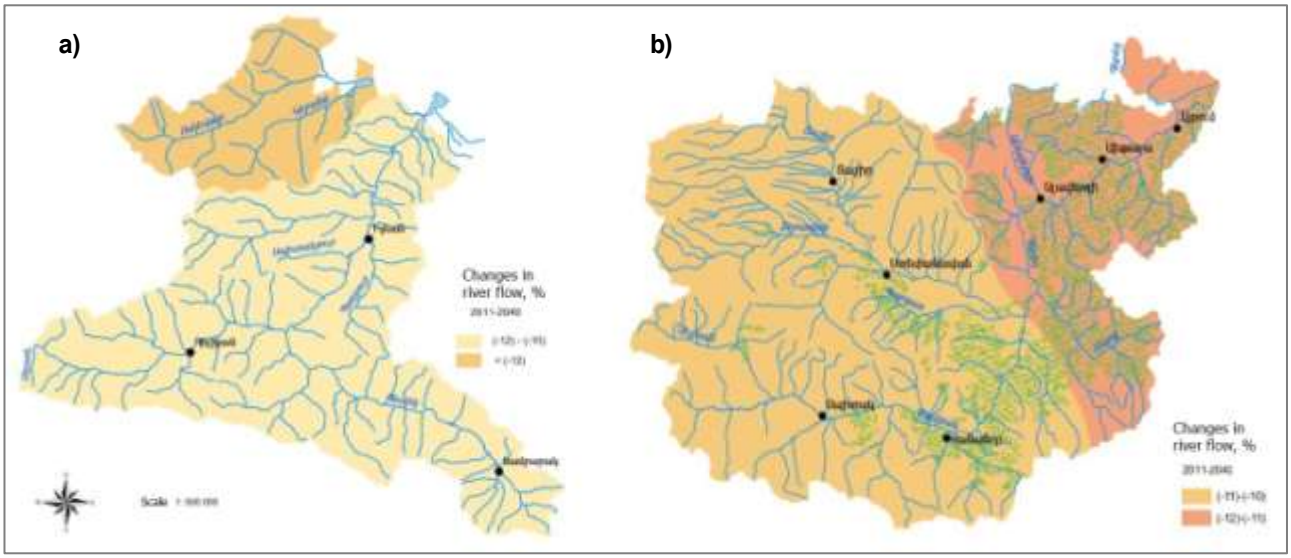


Figure 5-8. Projected changes in flows in river basins of the (a) Aghstev river and (b) the Debed river, 2040

Vorotan River Basin

The vulnerability of water resources as a result of climate change in the Vorotan river basin was assessed within the framework of the USAID "Clean Energy and Water" programme during the development of the Vorotan river-basin-management plan. According to the assessment, according to the A2 scenario, snowfall will also increase by 2100 in parallel with the projected increase in the total annual average precipitation amount in the river basin: in Voratan mountain pass by about 24 mm (16%); in Goris by about 15 mm (16%); in Sisian by about 8 mm (17%).

At the observation points of Vorotan-Vorotan, Voratan-Tatev HPP, Gorisget-Goris and Loradzor-Lchen river basins, the projected decrease in natural river flow by 2100 is 4%, 9%, 8% and 25% respectively. At the observation points in Tsghuk-Tsghuk, Sisian-Arevis and Vorotan-Gorhayk, the projected flow will grow by 11-15%. This means that the mid- and upstream river flow will increase, while it will decrease downstream (see table 5-7 and figure 5-9). This is due to intensive evaporation driven by the projected high temperature in the downstream part of the Vorotan river.

Table 5-7. Projected changes in the Voratan River flow

River – observation point	Scenario	Flow change							
		1961-1990		2040		2070		2100	
		million m^3	%	million m^3	%	million m^3	%	million m^3	%
Vorotan - Gorhayk river	**A2**	131.9	0	137.9	5	145.0	10	152.8	16
	B1	131.9	0	136.7	4	141.4	7	148.3	12

According to natural flow projections in various observation points of the river basin, it is expected that the annual natural river flow will increase by about 3%. In terms of seasonality, it is predicted that, by 2100, the Vorotan-Gorhayk flow will increase by approximately 21.4 million m^3 (16%) (A2 scenario); 16.8 m^3 (13%) (B1 scenario).

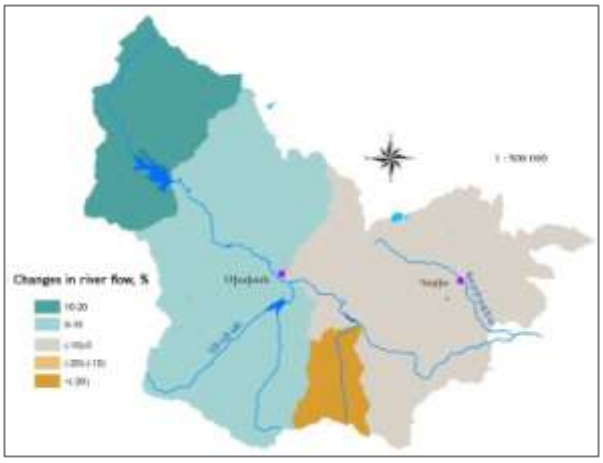


Figure 5-9. Projected change in the Vorotan river basin, 2100

Araks-Akhurian River Basin

The vulnerability of the Araks and Akhurian river annual flows for 2040, 2070, and 2100 has been projected using CCSM4 model data-emissions scenarios (RCP8.5 (A2) and RCP6.0 (B2)). According to the assessments, there will be no significant change in flows for both river basins by 2040. In 2071-2100 it is expected that the flow in the Haykadzor sector of the Akhurian river will fall by 2.1% (A2)/ 4.4% (B2); in 2071-2100 the flows will reduce by 10.5% (A2)/5.7% (B2).

For both scenarios there will be some increase in the Araks river flow: 3-4% in 2041-2070, and 1-2% in 2071-2100.

Hrazdan, Azat, Vedi River Basins

Climate change impacts on river flows vary for different river basins. For instance, it is projected that, by 2040, there will be a 2-3% increase in annual river flow in the Azat and Vedi River basins, while in upper streams of the Hrazdan river there will be a reduction of 2-3% (A2). In 2041-2070 there is a projected decrease in river flows for all three river basins: 3-4% in 2070 in the Azat and Vedi river basins, and 6-7% in the Hrazdan river basin; in 2100 the projected decrease will reach to 12-14% and 15-20% respectively.

The Vulnerability of Maximum Water Levels in Reservoirs

The vulnerability of maximum water levels as a result of global climate change in the Akhurian, Aparan and Azat reservoirs – incredibly important for Ararat Valley and its pre-mountainous zone – was assessed by using the physical-statistical (regressive) method.

By using maximum annual water levels for these reservoirs and many years' observation data for precipitation and air temperature in these reservoir watersheds collected by hydrometeorological stations, multifactorial correlative links have been established between these elements, by which (based on the RCP8.5 (A2) and RCP6.0 (B2) emission scenarios) the vulnerability of maximum water levels in these reservoirs is projected for 2040, 2070 and 2100. The results show that Aparan reservoir is expected to be the most vulnerable: reduction of 11 metres by 2100 (A2). In terms of volume, it means that, in 2100 the maximum quantity of water in the Aparan reservoir will be 25-36 million m^3 (the capacity of the reservoir is 90 million m^3). This indicator for the Akhurian reservoir will be 405 million m^3 (the capacity of the reservoir is 525 million m^3), and for the Azat reservoir it will be 45 million m^3 (the capacity of the reservoir is 70 million m^3).

Lake Arpi Reservoir

Lake Arpi reservoir is located in the upstream area of the Akhurian river. Initially, the natural water volume in the lake was about 5 million m^3. After the construction of a 10-metre high dam in 1951 it was turned into a lake-reservoir. At present, the reservoir depth is approximately 8.0 m, its volume is 105 million m^3, and the surface area is 22.5 km^2. Under the A2 scenario, the water temperature in the reservoir will increase by 6.6^0 C against the baseline (12.4^0C) by 2100; for B2 – by 6^0C. The maximum reservoir inflow will fall by about 4 million m^3 against the 2030 baseline (60.15 million m^3); in 2070 by about 9 million m^3; in 2100 by about 15 million m^3 (see table 5-8).

Lake Sevan

Water temperature changes were projected under the A2 and B2 scenarios for 2030, 2070 and 2100 using ambient air and water temperatures interconnection formulae.

The results indicate that Lake Sevan's water temperature, according to the A2 scenario, will increase by 4^0C against the baseline (9.4^0C) by 2100; for B2 – by 3.6^0C. Therefore, it is projected that, in 2030, Lake Sevan inflow will decrease by more than 50 million m^3 against the baseline (787 million m^3); in 2070 – by about 110 million m^3; in 2100 – by about 190 million m^3. This means that the water level will start going down by about 16 cm per year (see table 5-8).

Table 5-8. Projection of inflows in Arpi reservoir and Lake Sevan, A2 scenario, million m^3

Reservoir	1961-1990	2030	2070	2100
Lake Arpi Reservoir	60.15	56.12	51.43	45.47
Lake Sevan	787.00	734.00	673.00	595.00

5.3.2. Adaptation Measures

Objectives: rational and sustainable water use

Type	Measures	Implemented (underway) actions
Administration and planning	In developing plans for the management of all major river basins of Armenia consideration should be given to climate change factors (taking into account the EU Water Framework Directive Common Implementation Strategy Guidance Document No. 24)	Protocol decision of the Government of Armenia No. 4 adopted on 3 February 2011 "On approval of the content of the model plan for water basin management" envisages requirements for climate change factor consideration. With international assistance programmes were developed: • Debed and Aghstev river-basin-management draft plans (EU), • Arpa river basin management draft plan (UNDP/GEF) • "Southern Basin Management Plan" development is in progress. It covers the Vorotan, Voghji and Meghriget river basins and include quantitative and qualitative assessments of climate change impact on water resources and appropriate adaptation measures. The draft of the "Southern Basin Management Plan" will be submitted to the Armenian government in August 2015 (USAID "Clean Energy and Water" programme).
	Optimization of the hydrological observation network and upgrading of equipment in compliance with Armenian water legislation and EU Water Framework Directive requirements	In 2013 the Belgian "Sher" organization, has conducted a feasibility study and a developed proposal for the optimization and upgrading of equipment.
	Provision of water-use permits with due consideration to climate change risks. Development of regulations for long-term water-resources planning, and creation of decision-making tools	Currently, the creation of a decision-making support system is underway, testing the findings for the southern basin-management area. It will enable relevant hydrological, climatic and economic analysis in decision-making processes for Armenian water-resources management (USAID "Clean Energy and Water" programme).
	Creation of hydrological reserves and development of institutional status for all river-basin watershed areas	The Armenian government has reaffirmed the Hankavan and Jermuk hydrological reserves' status (Decision No. 1063-N, adopted on 17 September 2009).
Research and information	Assessment of ground water resources	The USAID "Clean Energy and Water" programme implemented study of the impacts of current and future water use on the balance, depletion and recharge rates of ground water resources in the Ararat Valley, using different development scenarios. The findings and recommendations of the assessment were presented to the Armenian government and national/international stakeholders in 2014. The Armenian government adopted two decisions aimed

Type	Measures	Implemented (underway) actions
		at the sustainable management of ground water resources in the Ararat Valley. Decision No. 340-N (adopted on 3 April 2014) on "Approval of the procedure for issuing water use permits for illegally-operated and also non-operated wells, as well as on the procedure for liquidation and conservation of such wells". Protocol Decision (adopted on 26 June 2014) on "Approval of the terms of reference for introducing centralized, automated management system for water use in the Ararat Valley".
	Revising the methodology for determining environmental flow	The annual environmental multiyear flow assessment methodology was approved by the Armenian government's Decision No. 927-N (2011). Experts on the USAID "Clean Energy and Water" programme have developed a methodology for determining monthly/seasonal environmental flows, which will be proposed to the Armenian government in 2015.
Economic and technical measures	Construction of new small water reservoirs and rehabilitation of non-operating ones	Negotiations on construction efforts in Kapsi, Eghvard, Vedi and Mastara reservoirs are underway: • A feasibility study project to rehabilitate the water-engineering system of Kapsi reservoir is being implemented with the financial assistance of KfW under a government initiative. • A detailed programme for a feasibility study of Vedi reservoir and its irrigated areas is being prepared, and design work for Vedi reservoir construction is in implementation phase managed by the French Assistance Agency (AFD – Agence Française de Développement). • Preparation of the initial version of a feasibility study for the construction of Eghvard reservoir is currently underway, with financial support from the Japanese International Cooperation Agency. • Negotiations with Kuwait Fund for the construction of Mastara reservoir are in progress.
	Ground water monitoring	Monitoring in a limited number of observation points (undertaken by the Hydrogeological Monitoring Centre SNCO of the Ministry of Nature Protection) resumed in 2009.
	Reduction of leakage from drinking-water supply and irrigation systems. Development and implementation of economic mechanisms for leakage reduction	Implementation with international assistance and state co-financing, including: • Construction of 49 km of pipes, and repairs to 50 km gravity canals (Millennium Challenge Account Programme, USA); • Restoration of water-supply systems and construction of new ones in 5 communities (USAID); • The IBDA/IDA "Irrigation System Enhancement Project" has reduced the amount of energy used and improved irrigation conveyance efficiency in targeted irrigation schemes, as well as improved the availability and reliability of important sector data and information for decision makers and other stakeholders.

Type	Measures	Implemented (underway) actions
	Development and introduction of economic mechanisms for promoting the application of advanced water-saving irrigation methods in agriculture	There are a several small pilot drip-irrigation initiatives.

5.4 Agriculture

Agriculture accounts for about 20% of the country's total GDP. The strategic objective of agriculture sector is to increase the country's food security by providing 75-80% of self-produced basic foods. Agriculture is one of the most climate-dependent sectors in the economy; the negative impact of projected climate change will further increase risks to food security. Almost every year, Armenia is affected by adverse weather phenomena such as: drought, hail, early frost, spring floods, and landslides. Agriculture and the national economy are highly sensitive to climate change. 2009-2013 estimates show that the damage from extreme weather events amounted to AMD 72.71 billion (about USD 177 million). Therefore, the strategy for this sector should be aimed at enhancing competitiveness and sustainable development, and at implementing preventive adaptation measures.

The existing regulatory framework undergoes regular transformation and updates, focused on the development and regulation of agriculture. After submission of SNC on climate change the Armenian government has adopted the following decisions: "Procedures for land monitoring" (2009), "2010-2020 RA agriculture and rural sustainable development strategy and action plans for its implementation" (2010), "RA concept for ensuring food security" (2011), and the "RA Strategic Development Plan, 2012-2025" (2014) - this Includes a prediction of macroeconomic indicators for agriculture.

These documents, however, do not properly assess the impact of climate change on sector development. However Decision No. 1594 (November 2011) on "Approval of Action Plan of RA Obligations Emanating from a Number of International Environmental Conventions" envisages the development of national action plans for each sector sensitive to climate change by 2015.

5.4.1 Vulnerability Assessment

Crop Production

The geographical position of Armenia and its expressed vertical zonation, abrupt mountain relief, active exogenic processes, land shortage, and insufficient moisture supply in soil poses significant risks to crop production. Agricultural risks are increased due to the shortage of land (per capita 0.14 ha of arable land). Almost 80% of land shows notable desertification features and has suffered various levels of degradation as a result of the irrational use of land resources. Projected climate change will further worsen the situation.

Major negative consequences forecast for agriculture of Armenia as a result of climate change include:

- Shift in agro-climatic zones 100 m upward by mountain slopes by 2030, and 200-400m by 2100;
- Reduced crop yield as a result of temperature increases, reduced rainfall, and increasing evaporation from soil surface;
- Reduction of fertility and deterioration of agricultural land;
- Increased negative impact of extreme weather events due to expected increases in their frequency and intensity;
- Expansion of irrigated lands and the need for additional irrigation water;
- More intensive degradation of land, including natural grazing land.

It is also necessary to consider and evaluate the negative impact of climate change on land resources. It is expected that, as a result of projected temperature increases and reduced rainfall, there will be more evaporation from the soil, increases in secondary salinization (alkalization of soils), intensification of water erosion in certain seasons of the year caused by heavy rains and floods, wind erosion, a 10-30% decline in natural soil moisture, reduction in rain fed agricultural lands, and activation of landslide processes. Almost all land types in

Armenia, especially cultivated soil types, have become more vulnerable to erosion processes as a result of climate change. Erosion processes are growing, which, in addition to natural factors, are also a result of anthropogenic factors (no systematic cultivation; absence of crop rotation; logging of forests and field-protection forest belts; road erosion; negligence of flood- and erosion-control measures; etc.). There are also cases of soil waterlogging – first-degree terraces have flooded near reservoirs, raising ground water near fish farms.

Climate change and anthropogenic factors have especially affected organic carbon (humus) resources in soil. Organic carbon stock is declining in all soils except than mountain grasslands where climate change, desertification and anthropogenic factors are insignificant (see figure 5-10).

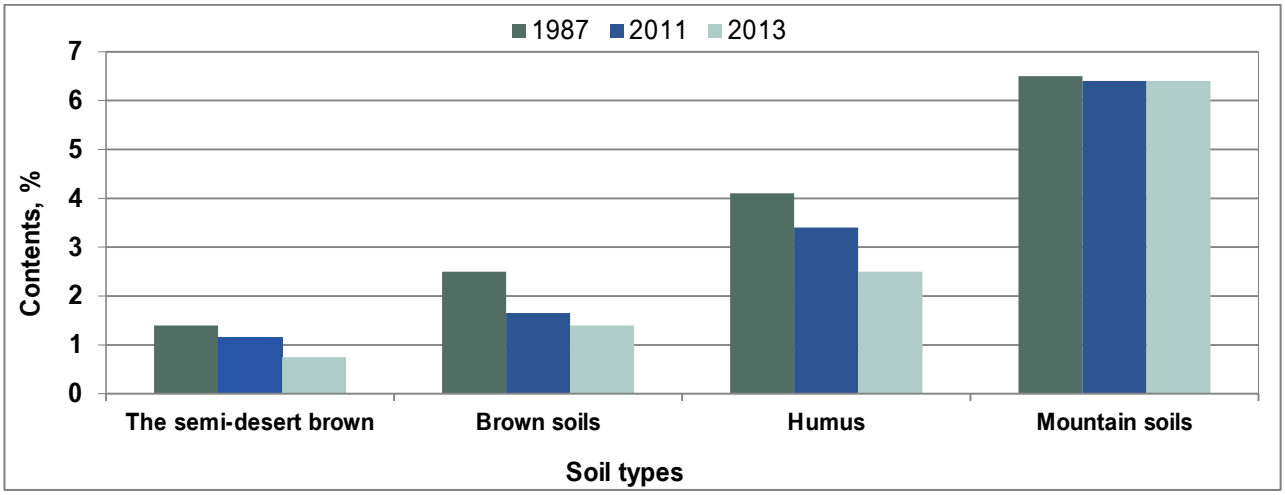


Figure 5-10. Organic carbon content in 0-25 cm soil layer

Redistribution of agro-climatic zones caused by climate change will bring forth changes in the proportion of irrigated and non-irrigated areas. This is a serious problem, especially with regard to the vulnerability of available water resources.

The total area of irrigated land in Armenia's land stock is 207.8 thousand ha. As a result of the forecast temperature rise and intensification of evaporation of moisture from the soil surface, additional demand of irrigation water for agricultural land will total about 202.08 million m^3 (see table 5-9).

Table 5-9. Additional water demand for crop production by irrigation zone

Irrigation zones	Altitude from sea level, m	Additional water demand, million m^3
Ararat valley	900-1800	172,0
Shirak	1400-2200	13.2
Lake Sevan basin	1900-2200	2.04
Northeastern	400-1400	4.2
Lori-Pambak	900-1700	6.6
Vayots Dzor-Syunik	700-2200	4.04
Total		**202.08**

In the case of 5-25% atmospheric precipitation sufficiency, water-supply vulnerability in Aparan, Amasya, Sevan, Lori, Tavush, and Ijevan non-irrigated agricultural zones will increase by 50-100%. These areas will end up in an insufficient humidification zone; high crop production will not be possible without irrigation. Water supply vulnerability of highland zones in these areas will increase by 30-40%.

Crop yields are the most sensitive indicator of climate change impacts on crop production. For Armenia, the circumstances for projected deviations in crop yields for 7 important crops in lower-, middle- and upper-mountain zones with irrigated and non-irrigated conditions have been calculated using the FAO's "Aqua Crop" model for 2040-2050 (see table 5-10).

Table 5-10. Projected impact of climate change on crop yield in 2040-2050

Crop	Cultivation zones		
	Lower	Middle	Upper
Irrigated lands			
Alfalfa	-5%	-7%	-2%
Apricot	-5%	-5%	-5%
Grapes	-7%	-5%	-5%
Potatoes	-12%	-9%	-5%
Tomatoes	-16%	6%	50%
Watermelon	-12%	10%	Not cultivated
Wheat	-6%	1%	38%
Non-irrigated lands			
Alfalfa	-3%	-8%	-1%
Apricot	-28%	-7%	-5%
Grapes	-24%	-12%	-1%
Potatoes	-14%	-14%	-8%
Tomatoes	-19%	-8%	34%
Watermelon	-18%	0%	Not cultivated
Wheat	- 8%	1%	38%

Source: Reducing vulnerability of the agricultural systems of Armenia under climate change. Impact assessment and adaptation options: WB, Yerevan, 2013.

In recent decades, extreme weather events (drought, hot dry winds, hail, spring frosts) have been becoming more frequent and lasting longer, inflicting great damage on agriculture. The vulnerability of the marzes of Armenia to climate risks is described in figure 5-11. Hazardous hydrometereological phenomena listed in figure 5-11 are coloured with respect to levels of frequency. Vulnerability to extreme weather events is presented in a three-level scale: up to 1.5; 1.5-3; more than 3 events per 1 km^2.

The assessment of extreme weather event damage to agriculture of Armenia in 1995-2013 is described in table 5-11.

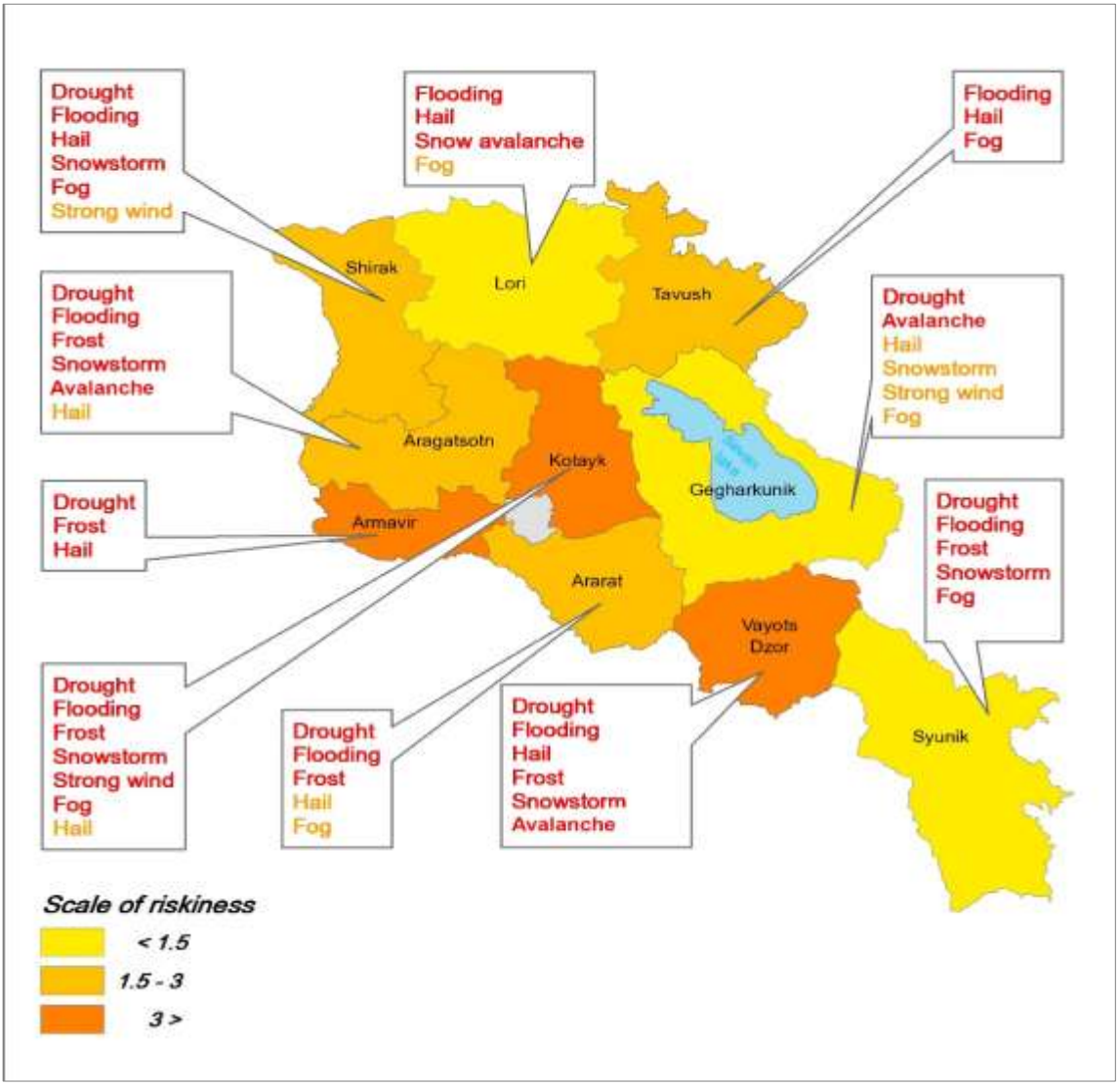


Figure 5-11. Vulnerability of Armenian marzes to hazardous hydrometereological phenomena
Source: Hydromet Service

Table 5-11. Damaged croplands and financial losses in Armenian agriculture, 1995-2013

Year	Damaged land area (1000 ha)	Losses (AMD million)
1995	86.96	17.00
1996	36.65	12.59
1997	129.82	26.53
1998	63.41	14.95
1999	430.03	11.33
2000		59.78
2001	83.50	23.94
2002	74.55	15.14
2003	48.67	82.63
2009	35.37	11.89
2010	17.47	35.50
2011	4.06	0.91
2012	2.22	0.49
2013	11.10	23.92

An agro-economic analysis (including a vulnerability assessment of crops to a number of climatic and economic factors) was conducted, given that in, Armenia, the price risk is lower (0.18) than crop-yield risk (0.22). The AMBAV/AMBETI model was used to assess

the impact of climatic factors on yields. The assessment findings showed that the vegetative season now begins in March instead of April (1960-1970s) and has fallen by 0.3 days per year. Wheat flour and bread demand by price and population income were modelled according to climate change impact.

Demand of wheat flour and bread was modeled to be dependent on price and income of population, whereas supply was taken to be determined not only by market price, but by climate conditions (drought indices). Year 2006, had a minimum standardized precipitation index value of 1.02, was taken as a representative drought episode. It was estimated that during this year, deadweight market loss were 7 million US$. It was assessed that the tax revenue generated during the "worst case scenario" (i.e., drought episodes) can approach 0.11 million US$, which could be allocated to subsidies as compensation. Using the same demand and supply model for the other main crops for Armenian agriculture, nearly 90% of the whole agricultural loss can be estimated. The study also estimated insurance benefits and noted that, in the worst case scenario, effective insurance would be 229 million US$, which represents approximately 30% of the GDP in the planting sector.

Currently there is no insurance system for agricultural activities in Armenia. Therefore, subsidization programmes will be important to mitigate against the vulnerability of agricultural income to climate risks and to improve the capacity to reinvest in agriculture.

Livestock production

Climate change can impact livestock production directly (impact of temperature increases on animals), and indirectly (effect on the spread of diseases, pests, parasites, and pasture productivity decline).

Climate change affects natural pastures and grasslands. During the grazing season, family farms get about 70% of the annual production of milk, more than 50% of meat, and 100% of the wool as a result of activities on natural grazing lands. The importance of natural pasture is emphasized by the fact that the major breeds of cattle, sheep and goats in Armenia are fully adapted to the mountainous and high-mountainous pastures of the country.

The majority of grazing lands in Armenia have deteriorated over the last two decades as a result of irregular grazing, and a lack of control and improvement measures. Pastures around settlements were subjected to intense overgrazing, the while productivity of remote pastures decreased as a result of underuse. The forecast climate change will have a further adverse impact on natural grasslands and grazing land.

As a result of shifts in natural zones, the areas of more valuable alpine and sub-alpine grazing land will be reduced by 19 and 22% respectively, while semi-desert and meadow-steppe areas will increase by 17%, and grazing land with relatively low productivity by 23%, unless the negative impacts of climate change are not mitigated against. Based on official statistical data and analytical reports, the impact of climate change on main livestock products has been projected (see table 5-12). As a result of structural changes in natural zones, milk production will fall by 52.4 thousand tonnes, meat production by 15.1 thousand tonnes, and wool production by 116.4 tonnes.

Table 5-12. Projection for changes in pasture areas and milk production due to climate change

Natural zones	% by zones	Actual, in 2012		Projected, in 2030	
		Pastures, thousand ha	Milk production, thousand tonne	Pastures, thousand ha	Milk production, thousand tonne
Semi-desert	8.5	89.8	23.0	111.8	28.6
Steppe	20.7	218.6	111.9	218.6	111.9
Meadow-steppe	15.5	163.7	92.1	214.5	120.7
After forest	12.4	131.0	72.5	131.0	72.5
Sub-alpine	28.3	299.0	210.5	210.6	148.3
Alpine	13.7	144.7	144.8	120.1	120.2
Off-zone	0.9	9.5	3.3	10.0	3.5
Total	**100**	**1,056.3**	**658.1**	**960**	**605.7**

Climate change-related changes to natural pasture could lead to serious fluctuations in the volume of livestock products. Given that pastures in Armenia are under disproportional use, it will be possible to offset expected losses through increased livestock populations and fodder-crop production by implementing of activities designed to improving balanced use of pasture.

Aquaculture

Armenia has been intensively developing aquaculture in recent decade. Climate change vulnerability in this sector is directly due to the vulnerability of water resources.

Pisciculture in Armenia is based on breeding species including: Sevan trout (*Salmo ischchan*), rainbow trout (*Salmo gairdneri irideus*), carps (*Hypophthalmichthys molitrix*), *Cyprinus Carpio, Ctenopharingodon idella*, and sturgeon (*Acipenseridae Huso*). Basins constructed for trout and sturgeon breeding generally use artesian water. The required water temperature for each fish species is maintained by regulating water flow. Carp species are grown in ponds. Effluent waters from trout and sturgeon farms are also used for the breeding of small quantities of carp (*Carassius*) species.

Temperature increases will trigger eutrophication and/or stratification of static waters – ponds used for breeding carp species. Eutrophication could greatly affect water quality. Stratification caused by temperature and limited content of dissolved oxygen may restrict cold-water fish migration to narrow areas in the water column. Temperature increases may also significantly affect pisciculture, leading to diseases and slow growth. The vulnerability of pond-based pisciculture to climate change is higher than that of basin-based farms, where water flows in basin system keep the water fresh, ensuring lower water temperature and purity.

While temperature increases might not immediately affect basin-based pisciculture, decreases in precipitation will inevitably lead to the depletion of underground water resources. Therefore, the expected impact on basin-based farms fed from underground springs could be direct and severe. Explicit regulatory instruments for underground water flow shall be required to offset climate change impacts on the farms (trout and sturgeon) fed by deep wells. The gradual depletion of ground waters may lead to their restricted use, which may affect the scope of the pisciculture industry. Changed hydrological regimes of rivers, caused by reduced precipitation, might also lead to reduced access to river waters used for pond-based pisciculture.

5.4.2 Adaptation Measures

Objective: To reduce the potential negative effects of changes in climatic conditions on Armenian agriculture.

Type	Measures	Implemented (underway) actions
Administration and planning	Creation of risk-preventing infrastructure for agricultural producers, and reduction of agricultural dependence on climate conditions	Armenian government decisions: • On "Adoption of the procedure for monitoring of lands" (19 February 2009, No. 276-N); • On "2010-2020 agriculture and rural sustainable development strategy of the Republic of Armenia" (2010); • On "RA concept for ensuring food security in the Republic of Armenia" (2011); • On "Approval of the concept for natural disasters prediction and prevention system" (27 May 2010); • On "Approval of national strategy for natural disaster risks reduction, and action plan for implementation of national strategy for natural disaster risks reduction", (7 March 2012, No. 281-N).

Type	Measures	Implemented (underway) actions
Economic and technical measures	Inventory-making and improvement of grassland and pasturelands	Inventory-making and improvement of grassland and pasture is supported under GIZ, WB, and EU programmes: • WB 1st loan programme (USD 16 million) is intended to improve the productivity and sustainability of pasture-based livestock production farms in 55 mountain communities (2011-2012). • WB 2nd loan programme (USD 32.67 million) is intended to facilitate community agricultural resources management, and develop competitiveness (2014).
	Prevention of crop and animal diseases, and pest control	The plant-protection action plan includes activities for forest pest and disease control by aviation, as well rodent-, locust-, and insect-control measures. A livestock vaccination programme includes 9 preventive and 2 diagnostic measures for more dangerous diseases. In total, about 7 million conventional heads of animals shall be vaccinated. The programme for the provision of veterinary-sanitary, food security and phyto-sanitary services includes the following measures: (i) quarantine and correction of the habitat of the infected by more harmful organisms; (ii) monitoring of agricultural soils; (iii) provision of stable epidemiological conditions for animals with regard to animal infectious diseases; (iv) protection of population in 915 communities of the country from communicable diseases common to the human and animal populations.
Research and information	Selection and cultivation of more drought-resistant hybrids adapted to local conditions, including maintenance and dissemination of traditional crop varieties	The Scientific Centre for Vegetable and Industrial Crops tests and disseminates new and traditional varieties (vegetable soy, winter cherry (Physalis), custard marrow (Cymbling), haricot, etc.) and introduces modern technologies.
	Development of an advisory and information system in the agriculture sector	Provision of agricultural advisory services to farmers and SMEs: feasibility studies on application of new technologies; organization of training seminars for farmers and specialists in marzes under the rural advisory services programme. The Armenian Ministry of Agriculture has developed a new draft concept for reforming the agricultural advisory system adopted by the Armenian government.
	Institutional and professional capacity building for the application of climate change models	An assistance request has been developed through the EU ClimaEast programme. Training courses have been organized under a programme implemented by FAO.

5.5 Natural ecosystems and biodiversity

5.5.1 Vulnerability Assessment

Terrestrial ecosystems

In recent years, special studies have been conducted to assess the impact of climate change on natural ecosystems. Individual components of these studies include:

- Study on alpine plants by the “Gloria” international network.
- Study on impact assessment and predictions for individual ecosystems and areas, rare and endangered species of plants, and invertebrates of special environmental interest by the “Emerald” network in Armenia.
- *Ecological factors impact assessment and protection measures for plants included in the Red Data Book of Armenia* (2011-2013), a study by the Institute of Botany of the Armenian National Academy of Sciences (RA NAS). The findings of this study have been used for projections and

assessment of the probable risks of climate change for rare flora populations in Armenia. In 2011-2013, the Zoology and Hydro-Ecology Research Centre of RA NAS has conducted a joint Armenian-Belarusian joint study: *Genetic heterogeneity and taxonomic state of hardly identifiable groups of invasive phytophagous insects under current climate change (synthesis of molecular biological, cytogenetic and morphometric approaches)*. Different populations of beetles were studied to assess their adaptation capabilities to changing climatic conditions.

- The EU-funded Caucasus Regional Environmental Centre is making vulnerability assessments of ecosystems and agro-biodiversity in Vayots Dzor and Ararat marzes, and developing activities for their conservation and sustainable use.
- The Institute of Botany of RA NAS is using "Holdridge Life Zones" system-based ecosystem change models. Respective predictions of 'bio-climate' changes and major ecosystem changes have been made based on climate change projections (see table 5-13).

Forest ecosystems

The total area of forest land covers nearly 350 thousand ha in Armenia. Forest spatial distribution is uneven and dependent on areas' climatic conditions and anthropogenic impact. Forests in Armenia are diverse in their structure and composition.

Beech forests are located only in the north of Armenia, from 800-2,000 m above sea level. They grow mainly on northern slopes.

Oak forests have a complex and diverse structure. They grow in the northern, southern and central regions of Armenia, and are concentrated at the altitudes of 600-2,200 m above sea level.

There are also pine forests in the forest ecosystem of Armenia. Pines grow alongside hornbeam and Caucasian oak, and sometimes with beech.

Sub-alpine forests grow at the altitudes of 1,900-2,300 m above sea level. There are Litvinov birch, high-mountain maple, and ash trees, which form low stand density.

The studies summarized in SNC showed that, depending on climate change conditions, the main risks for forest ecosystems would be the shift in their vertical zonal boundaries, associated with the development and spread of other ecosystems, forest wildfires, diseases and pest outbreaks. Therefore, without adaptation measures by 2030, 14-17.5 thousand ha of forest would be lost. The first UNDP-GEF "Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia" adaptation-orientated programme was implemented in 2009-2013 to assess the damage level caused by various factors to forests in Armenia.

Armenia is already implementing certain measures to prevent forest wildfires, given that forest ecosystems in Armenia are more endangered by forest wildfires, the frequency of which might increase as a result of climate change.

According to recent studies, wet forests in mid-mountainous zones will most probably undergo some xerophytization processes, and there will be an invasion of plants typical to steppe, arid open forest and shibliak. Certain levels of xerophytization will result in converting wet forests to humid forests. Over a period of time, forests in sub-alpine zones will be replaced by wet forests: the shift in sub-alpine elfin woodland and parkland forests will raise the upper boundaries of forest vegetation.

With regard to climate change predictions, mainly south-orientated slopes with xerophilous vegetation will become more vulnerable, Lower boundaries of forest stands in almost all forest areas with low relative humidity and little precipitation will also become more vulnerable. Under such conditions, xerophilous plants will actively invade forest land, causing undesirable shifts in plant species. As a result, natural reforestation processes will deteriorate, and the average annual tree growth rate will decline. This will lead to the gradual conversion of forest land to open arid forests, which will then turn into to semi-desert and steppe with xerophilous plants.

Projected climate change may have a negative impact on forest ecosystems by causing deterioration of sanitary conditions, mass generation of pests and diseases, and increased fire hazards.

Important Ecosystems Included in Specially Protected Areas of Nature

SPANs play a crucial role in preserving ecosystems and biodiversity. SPANs in Armenia

include 3 state reserves, 4 national parks, and 26 reservations.

In recent years it has become apparent that preserving as many diverse natural ecosystems as possible in SPANs under sufficient conditions should be the most important measure for the adaptation of certain plant and animal species and natural ecosystems. The vulnerability assessment for the most important ecosystems in Armenian SPANs is described in table 5-14.

Climate Change Risks for Rare Species of Plants and Animals

Climate change will first endanger rare plants and those with narrow ecological amplitude. These may go extinct as it may be impossible to find new areas for their habitat. The *Plant Red Data Book of Armenia* (2010) includes 452 higher-class species. Probable ecosystem changes expected as a result of climate change will have a significant impact on 238 plant species, while climate change will significantly improve conditions for another 140 (these are thermophilic species; current temperatures are insufficient for them to grow more widely). Projected climate change and expected changes in ecosystems will have a negative impact on the population conditions for 74 plant species; this could lead to a sharp reduction of their habitat or even put their existence in the territory of Armenia in danger.

A vulnerability assessment based on ecosystem change predictions was conducted for 35 of 150 species of vertebrate animals included in the *Animal Red Data Book of Armenia* (2010). The findings showed that, for some of these species, projected climate change might be favourable and improve their suitable biotope, feeding and breeding conditions, and also expand the area of their habitat (e.g. Asia Minor ground squirrel, grey pochard, corncrake, otter, water shrew, etc.). Climate change would be highly unfavourable for other species as it would reduce their habitat and population (e.g. Caucasian black grouse, porcupine, bezoar goat, Armenian mouflon, etc.).

Ecosystems of Lake Sevan

Lake Sevan is the most important water ecosystem in Armenia. As a result of anthropogenic impact spanning many years, the water level of the lake has dropped by 20.2 m from natural level (as of 2002), while the volume has been reduced by more than 42%, leading to significant changes in the thermal regime and ecosystem of the lake. Since 2003 the water level of the lake has risen by 3 m, again leading to a number of changes in the lake ecosystem.

The latest rise of water level has been characterized by a decline of phytoplankton diversity, growth of blue-green algae, and unpredictable changes in species (zooplankton and zoobenthos have undergone qualitative and quantitative changes). Based on the results of long-term studies it can be expected that the impact of climatic factors will also increase the vulnerability of macrophytes.

As a result of climate change, the forecast increase of the lake water temperature by 3.6-4^{O}C by 2100 will lead to shifts in seasonal migration, and in spawning and feeding areas for cold-water fish, particularly whitefish (*Coregonus lavaretus*), the main fish in the lake. It is likely that whitefish may lose traditional feeding areas, and that high temperatures may change physiological processes in the fish. The absence of an appropriate environment in summer habitat under thermal stratification may cause serious damage to the fish population.

As a result of the projected warming of the thermal regime, cold-water fish species will be gradually replaced by thermophilic species, despite the fact that, in general, there may be an increase in fish production and quantities. It is unlikely that the fragmented populations of cold-water species will completely disappear under the conditions of projected temperature increases. Due to their small quantities they will most probably find the most suitable environments for their propagation. However, their feeding areas may temporarily shrink, deteriorating some of their biological and population indicators.

Climate warming will have a positive impact on the population of omnivorous and thermophilic carp species; however, their rapid growth may significantly affect other native species by reducing the availability of feed for other species.

Ongoing anthropogenic impact on Lake Sevan ecosystems (primarily water-level changes despite the existence of laws and decisions) does not allow for making more accurate predictions for changes in lake ecosystems and biodiversity. It is necessary to keep raising the lake up to the designed water level or implement certain measures to stabilize the current level.

Table 5-13. Ecosystem change projections

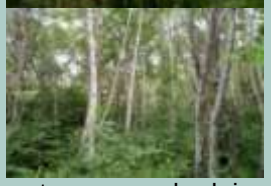
Current ecosystem	Expected changes	Projected ecosystem
Alpine meadows	Expected complete shift of conditions towards expansion of sub-alpine tall grasses and wetlands	Subalpine tall grasses
Sub-alpine meadows	Projected conversion to meadow-steppe and a probable expansion of forest ecosystems	 Meadow-steppe or sub-alpine forest
Meadow-steppe	Expected general conversion to steppe ecosystem	Steppe
Steppe	Phryganoids (mountain xerophilous plants) will be converted to steppe, tragacanth steppe areas will be expanded. Steppe mesophilous ecosystems will be replaced by more arid species	Phryganoids
Semi-desert	It is assumed that semi-desert plants – phryganoids (mountainous xerophilous plants) – will survive while their zone will expand. It is also expected that desert ecosystems – alkaline lands and saline deserts – will expand	Desert
Shibliak and arid open forests	In general terms, these ecosystem conditions will remain unchanged and even expand a little. However, the natural reproduction of trees and shrubs may deteriorate and, over the course of time, these ecosystems may be converted to phryganoids.	Phryganoids

Table 5-14. Vulnerability of SPAN ecosystems

Ecosystems	Specially protected areas of nature						
	Khosrov Forest State Reserve	Shikahogh State Reserve	Erebuni State Reserve	Arpi Lake National Park	Sevan Ntional Park	Dilijan National Park	Arevik National Park
Forests	Deterioration of forest growth conditions	Quercus macranthera replaced by Georgian oak variety	-	-	No large expansion	Conversion of humid forests to wet forests	Quercus macranthera replaced by Georgian oak variety
	Conversion to open forests in lower zone	Conversion to open forests in lower zone	-	-	-	Expansion of beech and Quercus macranthera forests	Conversion to open forests in lower zone
	Upper boundary rise	Upper boundary rise	-	-	-	Upper boundary rise	Upper boundary rise
Steppe	Conversion to phryganoids	-	Will remain unchanged	Will remain unchanged	Significant spread of tragacanth steppe and trangacanths	-	-
	Significant spread of tragacanth steppe and trangacanths	-	-	-	-	-	-
Open forests and shibliak	Spread of forest lower boundary	Spread of forest lower boundary	-	-	Deterioration of natural regrowth	Spread of forest lower boundary	Spread of forest lower boundary
Sub-alpine meadows	-	-	-	Conversion to meadow-steppe and steppe	Conversion to meadow-steppe	Conversion to meadow-steppe	Conversion to meadow-steppe
Sub-alpine high grasslands	-	-	-	-	Conversion to forests	Conversion to meadow-steppe	-
Meadow-steppe	-	-	-	Conversion to steppe	Conversion to steppe	-	-

(-) This ecosystem does not currently exist in this SPAN.

5.5.2 Adaptation Measures

Objective: Biodiversity protection

Type	Measures	Implemented (underway) actions
Administration and planning	Reduction of anthropogenic impacts on natural ecosystems	Decisions adopted by the Armenian government: • "On approval of Arpi Lake National Park 2011-2015 management plan" (No. 1854-A from 22 December 2011); • "On establishment of Zangezur Reserve" (No. 1209-N from 15 October 2009); • "On establishment of Arevik National Park" (No. 1187-N from 15 October 2009); • "On merger of Shikahogh and Arevik National Park SNCOs, creation of Zangezur Biosphere Complex SNCO, as well as on approval of the statute of Khustuf State Sanctuary, and on amendments in a number of RA Government decisions" (No. 1465-N from 19 December 2013).
	Implementation of forest-conservation activities (integrated control of leaf cutting beetles, fire protection of forests, combatting illegal logging through aviation)	There were certain important developments in forest sector regulations: • 2004 National forest policy and strategy; • 2005 National forest programme of the Republic of Armenia; • 2004 Action plan for supporting measures addressing illegal logging issues; • Government decision on "Approval of national target programmes for improving fire safety in forests and other plant covered areas, and on approval of the list of comprehensive activities intended for improving fire safety in forests and other plant covered areas" (No. 563-A from 29 May 2013)
	Assessment, development and monitoring of ecosystems and biodiversity in existing SPANs	Research programmes in Sevan National Park and Khosrov State Reserve are underway. Government decision on "Amendments in a number of RA Laws", envisioning improvement of environmental monitoring systems and quality, including biodiversity and ecosystem monitoring (draft).
	Conservation of existing rare habitats and development of SPAN systems	The Ministry of Nature Protection is developing a decision on "The strategy for development of a SPAN network in Armenia",
Research and information	Assessment of population status for rare plant and animal species	Animal and plant *Red Data Books* of Armenia were made and approved by the Government (2010). Institutes under RA NAS are conducting limited scoping studies.
	Development of pasture sustainable-management mechanisms, ensuring biodiversity protection	The "Sustainable management of pastures and forests in Armenia to demonstrate climate change mitigation and adaptation benefits and opportunities for local communities" EU-UNDP ClmaEast pilot project was launched in 2013.
	Studies on climate change impact on ecosystems, individual species of flora and fauna	Research is being conducted through thematic funding from state budget in the institutes of RA NAS and the framework of "Gloria" international network.

Type	Measures	Implemented (underway) actions
	Study and monitoring on the spread of invasive species of plants and animals	Studies on invasive plant species (Institute of Botany of RA NAS).
Economic and technical measures	Ex-situ conservation of rare species of plants and animals	• Seed gene bank (Institute of Botany of RA NAS); • Gene bank of crops and their wild relatives (Scientific Centre for Agriculture and Plant Conservation); • Land plots for cultivation of rare flora (Botanical Garden of RA NAS).
	Restoration of degraded forest ecosystems, reforestation of forest land	Ten-year forest-management plans are being developed and adopted. Activities for recovering forest ecosystems in southern Armenia (Syunik marz) which have suffered from fires and human activities have been implemented within the framework of the first UNDP-GEF "Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia" (2009-2013) adaptation project. Forestation and reforestation of 57 ha of indigenous trees and shrubs was carried out. A guidebook was developed for forest pest control. Biological pest-control methods were applied on a 500 ha area (in Arevik National Park) for the first time in recent years. WWF is implementing pilot projects addressing issues of adaptation of forest ecosystems to climate change: • "Increasing the resilience of forest ecosystems against climate change in South Caucasus countries through forest transformation", • "Restoration of forest landscapes in northern Armenia". Armenia is participating in the implementation of the regional "Streams suppress fires" programme, intended to set up cooperation frameworks in forest-fire risk assessment and the development of actions for fire prevention in various types of forests in the BSEC region, funded by the Council of Europe (2013-2015).

5.6 Settlements and Infrastructure

5.6.1 Vulnerability Assessment

Most hazardous natural phenomena, including landslides, floods, rock falls, and flash floods, are directly or indirectly associated with specific climatic conditions. Climate change may have an impact on their frequency and coverage in the territory of Armenia.

The high degree of settlement and infrastructure vulnerability in Armenia is due to abrupt relief, critically steep slopes, and unfavourable ground conditions. There are high-risk zones in the country, as some settlements, including major cities and the most important communication routes in Armenia, are located in deep canyons, river valleys and unstable parts of steep hillsides. The specific climatic, geological and hydrogeological conditions must beconsidered. In particular, a significant number of settlements, roads, reservoirs and other infrastructure in Armenia are located in landslide-prone zones (see figure 5-13).

Settlements and infrastructure in Armenia areexposed to hazardous natural phenomena, including landslides, rock falls, flash floods, mudflows, floods, and avalanches. Extraordinary weather events are growing in scope and intensity, resulting in increased frequency of high-risk situations. Therefore, the Government of Armenia have adopted a number of decisions in recent years that have served as basis for the development of programmes and projects aimed at risk assessment, the development of forecasting and prevention methods, and the implementation of protective engineering measures in the territory of Armenia.

Landslides in recent years have been active over a significant area of the country, associated with the pressure of changing external factors, including meteorological factors. A

comprehensive study on landslides has identified more than 2,500 landslide-prone areas of the country, covering a total surface area of 1,221 km² (4.1% of the total territory of the country). According to the study:

- 233 of the total 960 communities in Armenia have suffered damage caused by landslides. In more than 100 of them there has been significant landslide activity causing damage to hundreds of houses, communication routes and other utility infrastructure;
- 3.2% of the motorway network and 0.5% of the railway network have suffered damage.

The spatial distribution of settlements and infrastructure in Armenia in landslide-prone zones is described in figure 5-12.

Landslide areas in the marzes of Armenia are described in table 5-15.

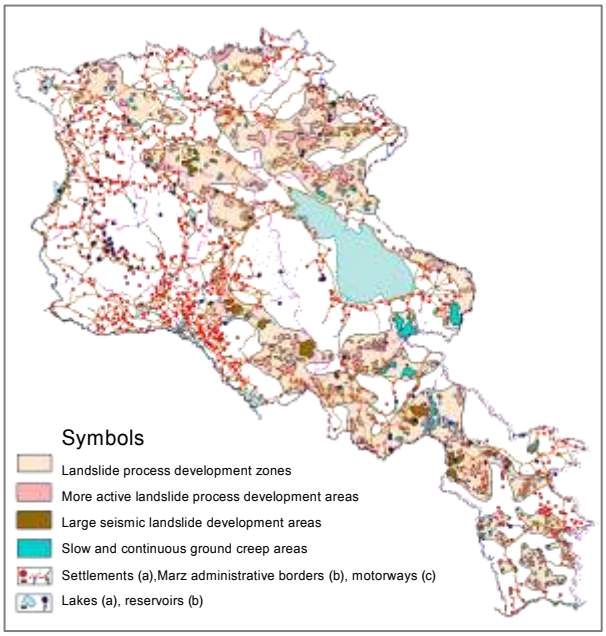


Figure 5-12. Spatial distribution of settlements and infrastructure of Armenia in landslide-prone zones

Table 5-15. Landslide-prone areas by marz

Marz	Surface area, km²	Number of landslides	Total landslide surface area , km²	Landslide relative surface area , %
Aragatsotn	2,763.4	19	75.5	3%
Armavir	1,191.6	0	0.0	0%
Yerevan	222.3	152	13.0	6%
Kotayk	2,034.0	110	77.8	4%
Tavush	2,740.7	151	210.6	8%
Shirak	2,682.6	23	20.6	1%
Ararat	2,090.2	142	143.9	7%
Gegarkunik	5,369.6	126	202.8	4%
Lori	3,852.0	217	234.8	6%
Syunik	4,492.2	289	246.7	5%
Vayots Dzor	2,287.9	184	242.4	11%

The reactivation of landslides is associated with changes in water balance circulating in the ground massive. Flows are mainly developed in the Yeghegis, Azat and Vedi river valleys, on the northeastern shore of Lake Sevan, around Ijevan, and other areas of the country. The landslide in the administrative area of Urtsadzor in 2007 was triggered by extremely heavy spring rainfall that oversaturated the unstable ground masses – ground water brought about a major landslide. It rapidly travelled 8 km down the slope, creating a 10-metre high mud and rock dam.

Landslides are occurring more frequently over larger areas. This is associated with the pressure of changing external factors, including meteorological factors. One vivid examples is the landslide on the M-6 motorway near Ayrum that also claimed human lives. This catastrophic landslide was preceded by heavy rainfall that raised the level of ground waters. A similar situation could arise in the segment of the Jajur railroad tunnel, as it crosses a landslide-prone zone.

Mudflow activation is due to the presence of denuded and weathered matter on steep slopes, and abundant precipitation. Yerevan, Vanadzor, Gyumri, Kapan, Goris, Alaverdi and a number of other settlements, rural communities, motorways and railways periodically suffer from mudflows. There is a need urgently to address these vulnerability and adaptation issues. Figure 5-13 describes the distribution of mudflow zones in Armenia,

and distribution mudflow regions are presented by marz in table 5-16.

High river water and flooding cause significant damage to almost all marzes, particularly the economy of the northern marzes in particular. River Aghstev flooded in 2006, overflowing and destroying the frontal part of a landslide near the village of Haghartsin. This in turn blocked the river, changed its flow, destroyed segments of the M-4 motorway, and rushed into low riverside zones in the village, causing serious damage to houses and gardens (see figure 5-14).

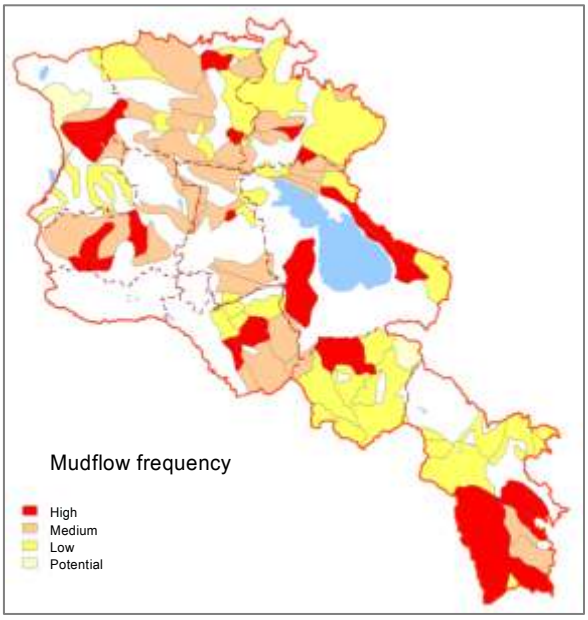


Figure 5-13. Mudflow zones of Armenia by frequency of events

Table 5-16. Mudflow regions by marz

Marz	Surface area, km^2	Number of mudflow regions	Space area of mudflows, km	Mudflow specific surface area, %
Aragatsotn	2,763.37	8	1,441.3	52
Armavir	1,191.6	0	0.0	0
Yerevan	222.3	0	0.0	0
Kotayk	2,034.0	7	867.3	43
Tavush	2,740.7	8	2,147.0	78
Shirak	2,682.6	8	1,102.3	41
Ararat	2,090.2	6	1,033.6	49
Gegharkunik	5,369.6	10	1,551.4	29
Lori	3,852.0	17	2,494.6	65
Syunik	4,492.2	13	3,153.9	70
Vayots Dzor	2,287.9	10	2,277.3	100

Figure 5-14. Aghstev river flood, spring 2006

Flooding is directly associated with high levels of ground waters and their hydrodynamic features formed under the influence of atmospheric precipitation. Flooding largely occurs in the Ararat and Shirak valleys. It also occurs in some areas of Tavush, Vayots Dzor and Syunik marzes. The majority of flooding-prone areas are located in Ararat valley, where the level of ground waters varies in the range of 0-2 m.

Rock fall. According to data provided by the Armenian Ministry of Urban Development, as of 2010, the number of rock fall-prone towns has reached 45. Vulnerable targets include Vanadzor, Alaverdi, Akhtala, Gavar, Kapan, Meghri, and Agarak. In general, the risk zone covers 703 single-family houses and 6 multi-storied buildings in towns and rural communities. Rock falls also occur in the administrative district of Yerevan, particularly in the Hrazdan river gorge.

Avalanches. Although limited in the territory of Armenia, avalanches endanger settlements

and communication routes. The most avalanche-prone areas are the highlands of Zangezur, Vardenis, Bazum, and Aragats, which are characterized by 5 avalanches/km^2 area, 1 case per year, and maximum volume of 100 thousand m^3. This phenomenon also affects the Yeghegis river basin, the areas around Yeghegis, and Arates, Sers and Shishkert.

Thus, a considerable number of settlements and infrastructure in Armenia can be classified as vulnerable areas, as their spatial location (in terms of natural hazards) is considered unfavourable due to their specific geography.

Projected climate change, including the increasing frequency of hazardous hydrometereological phenomena, will lead to increased vulnerability of settlements and infrastructure due to natural hazards.

Over the last 5 years, recovery activities carried out in the country against hazardous phenomena have been exclusively based on the 'de-facto' principle. A few examples include: recovery activities in the segment of Vanadzor-Alaverdi interstate highway which suffered from the Ayrum landslide; Hrazdan gorge rock fall preventive activities in the administrative district of Yerevan; Araks riverbank protection against spring flooding in Ararat valley, etc. However, it should be noted that no coordinated, comprehensive and consistent measures have been implemented in recent years in the context of any settlement- and infrastructure-protection programme adopted by the government.

5.6.2 Adaptation Measures

Objective: Identification and prevention of hazardous phenomena

Type	Measures	Implemented (underway) actions
Administration and planning	Identification and prevention of hazardous natural phenomena	Armenian government decisions: • "Approval of the activities schedule for rock-fall prevention on railway transportation facilities and interstate and republican motorways under the RA Ministry of Transport and Communication" (2009, No. 1496-N); • "Adoption of the inventory programme for rock-fall sites threatening the buildings stock in the Republic of Armenia" (2010, No. 957-N); • "Armenia's landslide disaster management concept" (2013, No. 27).
Research and information	Prediction of spring floods for major rivers in Armenia	Analysis made by Hydromet Service (2012).
	Analysis of the probability of flooding risks for settlements and communication routes located in river valleys in the northern marzes of Armenia, and development of protective measures	Scientific research: *Identification and mapping of danger and risk zones for the river valleys located in the northern marzes of RA* (2013, State Committee of Science of RA NAS; Yerevan State University Department of Geography and Geology).
Economic and technical measures	Designing and construction of engineering facilities for settlement and infrastructure protection against landslides. Implementation of anti-landslide measures	Recovery activities on the destroyed segments of interstate motorways M-6 (Lori marz, Ayrum landslide), M-4 (Tavush marz, Hovk landslide) and M-2 (Syunik marz, Karahundj landslide), implemented in 2011-2012 by the Armenian Ministry of Transport and Communications. In 2013-2014, Arpa-Sevan CJSC restored a 1.5 km long drainage tunnel in Dilijan. In 2014-2015, landslide-protective measures are planned in Arapi (Shirak marz), and Getahovit (Tavush marz), within the framework of a JICA pilot project.

Type	Measures	Implemented (underway) actions
	Installation of bank-protection hydraulic-engineering facilities in riverbeds, application of phyto-melioration measures in flood-prone river basins, construction of flood protective dams for preventing heavy rains, flooding and spring floods	In 2007, the Armenian Ministry of Urban Development developed a detailed plan for the riverside areas of Haghartsin, Tavush marz, In 2014-2015 river-protecting dams and drainage systems in the river body of the Aghstev river will be constructed. In 2010-2011, the Armenian Ministry of Agriculture implemented riverbank-protection measures in Armavir and Ararat marzes to prevent spring floods of the Araks river.

5.7 Human Health

5.7.1 Vulnerability Assessment

Human health will be affected by climate change and, above all, by the rise in temperature, changes in frequency of precipitation, and increased frequency and intensity of extreme weather events.

Specific provisions for climate change have been included in several legal strategy documents for public health of Armenia during the preparation of SNC on climate change.

Climate change may have both direct and indirect impacts on human health. Direct impacts are primarily associated with an increase in accidents caused by extreme weather events. On the one hand, indirect impacts are indirectly due to temperature and precipitation frequency changes and the associated human morbidity rate; on the other hand, climate change indirectly affects public health by increasing populations of infectious-disease carriers and transmitters.

Climate change is believed to be a high risk factor with regard to its impact on human health. Adverse effects of climate change on human health may occur due to more days with extreme high and low temperatures, and volatility of atmospheric pressure. These are risk factors for various diseases, particularly cardiovascular diseases, and ecological and socio-economic factors (reduced availability of quality drinking water supplies and reduced agricultural production). The adverse effect of climate change in cities will be greater, combined with high air pollution.

The morbidity and mortality of cardiovascular-system diseases is the highest in the winter and spring months. The possible impact of heat waves on hot summer days on morbidity- and mortality-rate indicators on the population was also studied. Global climate warming could significantly change seasonal shifts in transmitters of communicable diseases and enlarge their habitat, which could lead to increases in communicable diseases and the incidence of new diseases in areas not previously recorded.

A number of causative agents, carriers and transmitter species, and natural foci of extremely dangerous infections have been recorded in the territory of Armenia. These include: plague, tularemia, anthrax, western tick-borne encephalitis, hemorrhagic fever with renal syndrome, Crimean-Congo hemorrhagic fever, West Nile fever, brucellosis, Q-Fever, as well as other dangerous infections such as cholera, malaria, tick typhus, leishmaniasis, leptospirosis, etc. In recent years, studies have been conducted to project climate change impacts on the spread of certain diseases in Armenia.

Plague and Tularemia

Special attention was paid to studying the possible impact of climate change factors on plague and tularemia. Ecological peculiarities of the ordinary field mouse (*Microtus arvalis)* - the major transmitters of plague and tularemia – were studied by analyzing data from 1981-2012 outbreaks in Armenia. It was proven that 83% of outbreaks were observed between June to September. Based on meteorological data, experts determined the optimal climatic data, including monthly average temperature and precipitation, for the development of outbreaks. By using climate change projections for Armenia, maps showing the change of optimal parameters for living conditions of the population of ordinary field mice – the main player for spreading infections – were developed. These showed that, by 2050, the condition of 52% of the current population habitat of field mice will become extraordinary by June. It is likely that in dry steppe zones these populations may adapt to some extent to the new environment; they will also be able to migrate

to colder and humid areas (e.g. north-orientated slopes).

Given that field mice are not used to long-distance migration, a reduction in the population is expected. More-or-less favourable survival conditions are expected to be sustained at altitudes of 2,200-2,300m above sea level (small populations may possibly survive at lower altitudes, but only near reservoirs and rivers). As a result, epidemiological risk reduction in the territory of Armenia can be expected, especially in light of very low field mouse population density at these altitudes.

Anthrax

Armenia is one of the most active regions for animal and human anthrax, as the country is characterized by a number of permanent unfavourable anthrax foci. Sustainability of anthrax foci is probably due to climatic factors and various features of the landscape, soil, and plant cover patterns, as well as the intensity of livestock production. Incidence of anthrax in humans, in the vast majority of cases, is caused by communication with infected animals during slaughtering and meat handling. However, anthrax as a natural infection foci is found in many species of wild mammals, most often in ungulates, and in some rodents and predators. Infections in wild animals are spread by hornets, blackflies, mosquitoes and flies. Numerous observations and experiments prove the primary significance of flying blood-suckers as key transmission mechanisms for anthrax infestants. Moreover, anthrax infestants can be discovered in healthy rodents in Armenia and in number of other countries. Based on some of these studies, it can be assumed that it is very likely that climate change will affect the epidemiological situation of anthrax (changes in habitat, parasitic arthropods, new anthrax infections in 'clean' areas). Another option is that the activation of landslides and floods through climate change may destroy animal burials leading to the infection of soil and water with anthrax. Relevant studies and analysis will be required to assess the probability of such scenarios and for relevant preventative measures.

Malaria

The increase in malaria transmitters and its geographical spread was projected in FNC. Malaria had been recorded in 1990s. Fortunately, thanks to diagnosing and treating patients and implementing preventive actions under the UN's "Roll Back Malaria" programme, Armenian specialists successfully localized and abolished the secondary natural foci of malaria, thus preventing the larger spread of the disease. Further efforts to control malaria incidence have meant that, since 2005, no locally infected case has been recorded in Armenia. In 2011, the WHO granted malaria-free area status to Armenia. However, given the existence of malaria mosquitoes in the territory of Armenia and recorded cases of imported malaria, care should be taken to continue measures to identify malaria early in order to prevent the repeated spread and ecesis of the disease.

Other Infectious Diseases

The annual shift in infectious morbidity rates prove the projection that climate change will have a significant impact on the incidence of acute gastrointestinal diseases and upper respiratory infections, leading to growth in the morbidity rate (see table 5-17). In the last 5 years, the number of patients with acute intestinal infections almost doubled (from 18,630 incidents to 32,876) against the 2000-2004 period. Under these circumstances, there will be a need to conduct serious studies on this issue in all regions of the country in order to implement preventive and adaption measures.

Table 5-17. Intestinal and other infections' morbidity rate for 2007-2012

Disease	Number of recorded incidences					
	2007	2008	2009	2010	2011	2012
Typhoid	15	11	1	-	-	-
Paratyphoid	6	1	1	-	-	-
Salmonellosis infections	283	366	433	368	341	449
Acute intestinal diseases	5,110	5,438	5,258	6,994	7,325	7,861
Including bacterial dysentery	886	807	820	1158	980	681
Yersiniosis	4	2	7	9	12	3

Disease	Number of recorded incidences					
	2007	2008	2009	2010	2011	2012
Enteritis, colitis, food toxicoinfection and other gastric infections infested by fixed agents	1,089	1,501	1,705	2,303	2671	3026
Acute intestinal infections with unknown agents	3,131	3,128	2,726	3,524	3,662	4,152
Tularemia	43	-	1	5	6	1
Anthrax	1	2	-	-	-	11
Primary brucellosis diagnosed	239	280	331	276	248	219
Meningococcal infection	10	13	15	12	4	7
Primary malaria diagnosed	1	1	-	1	-	4
Leptospirosis	-	3	3	5	-	-
Leishmaniasis	4	8	12	7	6	4
Rabies	-	2	1	-	-	-
Upper respiratory infections	74,081	81,317	146,183	94,483	101,121	102,874

Leishmaniasis

It was reported in SNC that the mosquito population – Leishmaniasis transmitters – started to gradually recover, assisted by the reduction in large-scale pest control measures in forest land. In the early 2000s, this led to periodical (once in 1-2 years) incidence of this disease in men (see table 5-17). The growing morbidity rate proves increased risk of Leishmaniasis, predicted using risk probability analysis for climate change.

Protocol Decision of the Armenian government (adopted on 29 May 2014 , No. 22) on "Approving the programme for fighting against infectious disease transmitters in the Republic of Armenia, and 2014-2018 schedule for implementation of measures under said programme" is intended to reduce infectious morbidity risks.

Crimean-Congo hemorrhagic fever and Western tick-borne encephalitis

There are number of diseases that experts believe will emerge or grow as a result of climate change in Armenia: Crimean-Congo hemorrhagic fever, Western tick-borne encephalitis, and several other arboviral fevers, which are mostly transmitted by ixodidae ticks and mosquitoes. Crimean-Congo hemorrhagic fever is considered to be especially dangerous, with a 30+% of lethality rate in patients. Fortunately, no cases have been diagnosed in the territory of Armenia; however, they have been recorded in Georgia and Azerbaijan in the last 2-3 years. This means that, although there is an absence of favourable climatic conditions in Armenia so far, it is likely that, in parallel with global warming, the probability of its spread in Armenia will increase. Western tick-borne encephalitis is also transmitted by ticks, and climate change may also trigger the wider spread of the disease.

Population vulnerable groups

It has been proven by numerous studies that-patients in Armenia and other regions with cardiovascular and central nervous system diseases are more vulnerable to climate change. Some studies focus on the correlation between temperature increases and incidences of miscarriage in expectant mothers and post-natal mortality in babies.

Patients with asthmatic and allergic diseases are also considered vulnerable to increases in dry and related air-contamination conditions. Natural foci and dangerous infection risk groups include the rural population (livestock producers, farmers, agricultural workers) and people who due to their character of work or other reasons are directly related to natural landscapes or natural products, e.g. butchers, hunters, fishers, tourists, etc.

5.7.2 Adaptation Measures

Objectives: Protection of public health against climate change

Type	Measures	Implemented (underway) actions
Administration and planning	Assessment of spread of infectious diseases, and risk management	Armenian government decisions: • On "Approval of 2012-2016 strategy programme for preventing and fighting against infectious diseases, and the list of measures to be implemented under the strategy programme" (No. 1913-N from 29 December 2011); • On "Approval of 2011-2015 state programme for prevention of malaria invasion and ecesis in the Republic of Armenia, and the list of 2011-2015 measures for prevention of malaria invasion and ecesis" (No. 23 from 17 June 2012); • On "Approval of the programme for fighting against infectious disease transmitters in Armenia, and 2014-2018 schedule for implementation of measures under said programme" (No.22 from 29 May 2014); • A new institution has established in the Armenian Ministry of Health, the National Centre for Disease Prevention and Control SNCO, in order to implement more coordinated and effective measures for ensuring the sanitary-epidemiological security of the Armenian population and for the provision of respective services in accordance with international standards (No. 1134-N from 17 October 2013); • Normative acts, state programmes for laboratory risk assessment and management, standard criteria procedures, as well as field and laboratory work guidebooks and recommendations are developed.
	Early notification of population on probable unfavourable weather conditions	Hydromet Service notifies the population on certain unfavourable weather conditions (primarily for agrarian sector).
	Rapid response to disaster and epidemiological situations	There are structures and services responding to natural disasters and epidemics under the Armenian Ministry of Emergency Situations and Ministry of Agriculture.
	Infection control of disease carriers and transmitters	Implementation of state programmes for fighting against malaria and other transmitters, including especially dangerous infections; Development of sanitary norms and regulation for rodent control in the field and urban environment; In the event of a threat of an infection and/or natural foci-related diseases spreading, insect- and rodent-control measures will be taken.
Research and information	Studies on climate change impact on particularly dangerous diseases and development of country projections	Studies implemented within the framework of international programmes on the direct impact of climate change on plague and tularemia carriers' and transmitters' ecology, as well as the link between possible changes in the spatial distribution of morbidity as an indirect impact of climate change.
	Preparedness of population for possible natural disasters and epidemiological situations	Seminars and training; discussions with rural populations on natural foci; distribution of thematic printed materials (leaflets and flyers) on personal hygiene, and the mitigation of various natural disaster impacts. These measures, however, are irregular and clearly insufficient.
	Studies on climate change impact on various areas and population groups	The impact of heat waves on cardiovascular diseases and mortality in some regions of Armenia has been assessed and the results have been published.

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6

OTHER INFORMATION FOR ACHIEVING CONVENTION GOALS

6.1 Research and Systematic Climate Observation

The Hydromet Service is the state-authorized entity in charge of hydrometeorological observations in Armenia. Hydromet Service carries out regular atmospheric, surface-water, soil, agricultural crops, background-radiation, heliogeophysical-phenomena (UV radiation, ozone layer), actinometric, and aerological observations. It provides state bodies, the general population, and various sectors of economy with current hydrometeorological data, including information on weather forecasts, extreme events, climate, and climate change.

Hydrometeorological and Hydrological Observations Network

Hydrometeorological observations

At present, Hydromet Service is carrying out standard full-scale hydrometeorological observations at 47 observation stations. Stations operating a full programme observe: horizontal visibility, cloudiness, atmospheric phenomena, soil temperature on surfaces and in different depths, ambient air temperature and humidity, atmospheric pressure, wind direction and velocity, precipitation, and sunshine duration. Data from 3 stations of the network (located in Yerevan, Sevan, and Gyumri) are shared with global and regional data centres.

The station network is spatially distributed by climatic zones and economic significance. Figure 6-1 shows the percentage distribution of the territory of Armenia by (a) elevation and (b) distribution of stations at the same altitudes. In general, there are a sufficient number of stations located in all vertical zones. However, there are no stations in the 2,500-3,000 m altitude zone, which has an adverse impact on the results of climatic studies. It is therefore important to fill this gap by restoring the stations operating at this altitude zone.

Figure 6-2 describes the network of hydrometeorological observation stations (both under operation and closed) in Armenia. Data from these stations are used to develop climatic information, provide climatic services, and conduct scientific research. Observation data undergo preliminary quality control and are stored in a database.

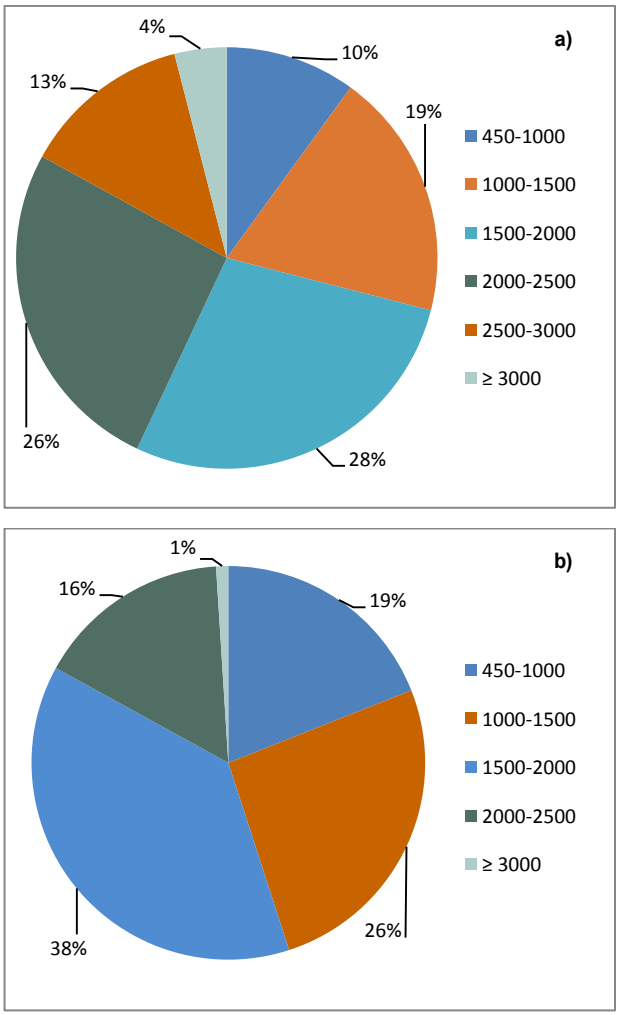

Figure 6-1. Elevation zones of (a) the territory of Armenia and (b) distribution of stations at the same altitudes

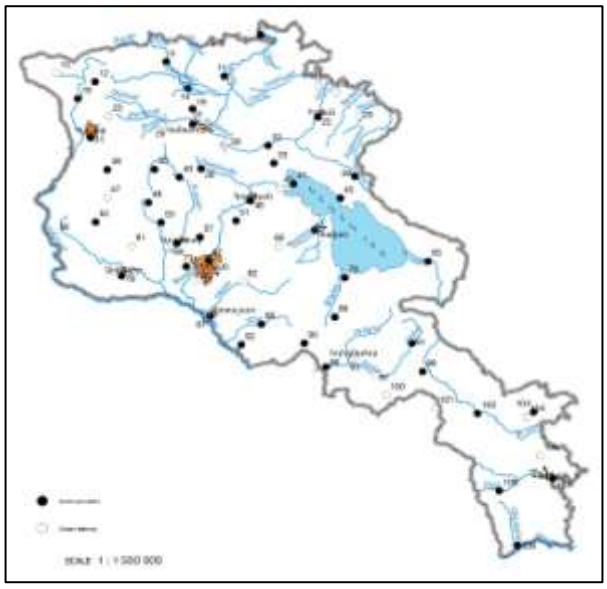

Figure 6-2. The network for hydrometeorological observation in Armenia

Agro-meteorological observations are carried out by 40 stations and 2 observation points to assess the growth and development of the agro-meteorological conditions for about 30 agricultural crops, as well as for grasslands and pasture. In 2011-2012, automatic soil-humidity meters were installed in 10 stations.

Total ozone content (TOC) is monitored by the Amberd high-mountain, and Yerevan Arabkir meteorological stations. In 2000, the Amberd meteorological station was included in the WMO Global Ozone Observation Network. TOC measurements are carried out by a D-044 Dobson spectrophotometer. TOC observed at this station monitors the ozone-layer condition across the entire South Caucasus region. These data are processed and communicated to the World Ozone and Ultraviolet Radiation Data Centre (WOUDC). TOC observations in the Arabkir station are conducted using a M-124 filter ozonometer. These data, along with data from Amberd station, are used to assess seasonal change in near-ground ozone content. According to WMO-approved methodology, the Hydromet Service forecasts UV-radiation density on the territory of Armenia once every two days in the form of indexes which then are estimated by altitude and cloudiness data.

Information received from the Russian Institute of Applied Geophysics on solar activity and geomagnetic fields is processed and archived by Hydromet Service. These data are the key indicators of climate change and the results of their study can be used for developing regional climate scenarios.

Actinometric measurements of solar radiation balance, direct solar radiation, and diffused and reflected solar radiation are taken by the Tashir, Gyumri, Sevan, Martuni, Yerevan-agro, and Amberd meteorological stations. They also calculate total radiation and earth-surface albedo values.

Aerological observations[2] are made once a day by the Davtashen aerological station (1134 m o.s.l.) in Yerevan. This station is included in the GCOS Global Upper Air Network (GUAN). Aerologic data obtained by this station are shared with global and regional data centres. These data are used to study the upper layers of the atmosphere, for weather forecasting in the territory of the country, and aero-navigation services. Climate change studies stress the need for research on thermal regime change, not only for near-ground, but also for higher layers of atmosphere, using data from aerological observations.

Radiological observations are used to assess the radioactive levels of the atmosphere, soil, and water in the territory of Armenia. Soil and water samples from 34 meteorological stations are used.

Monitoring of the quantity of surface waters and other hydrological observations in Armenia is carried out at 94 observation points including: 86 rivers, 4 reservoirs (Lake Arpi, Akhurian, Aparan, Azati), and 4 lake points (Lake Sevan), located in seven water-body hydrological stations (see figure 6-3).

Figure 6-3. Distribution of river-basin hydrological stations and observation points in the territory of Armenia

Building Up an Observation Network

In recent years, the Hydromet Service has modernized its equipment and updated its methodologies. Within the framework of international cooperation it has purchased and installed numerous professional devices and pieces of equipment (see table 6-1).

Under the European Commission-funded "Programme on Information System to Improve Food Security Decision Making" in Armenia, Hydromet Service has purchased 3

[2] Meteorological elements of the upper layers of the atmosphere (up to 30 km) are measured by aerological observations. For such observations, the station launches a hydrogen balloon carrying a radiosonde, which periodically transmits data on the vertical distribution of air temperature, humidity, atmospheric pressure, and wind.

automatic agro-meteorological stations and 7 soil-moisture measuring systems. These systems are placed in areas vulnerable to agro-meteorological phenomena (Merdzavan, Gyumri, Ararat, Aparan, Areni, Meghri, Fantan, Martuni, Ijevan, and Armavir meteorological stations), which enables complete data on agro-meteorological conditions in these areas (wind speed and direction, atmospheric pressure, ambient air temperature, relative humidity, soil temperature, precipitation, and soil humidity at different depths -0,1; 0,25; 0,50; 0,75; 1 m). A new methodology for yield-productivity predictions was introduced into the agro-meteorological forecasting system of the Hydromet Service. This involves the use of satellite data, in parallel with meteorological, phonological, and statistical data.

A new agro-meteorological bulletin is being published, which provides detailed analysis on crop wintering, growth progress, data on meteorological conditions, graphs, tables, and figures to make the materials more explicit.

Hydromet Service has further developed its agro-meteorological internet page in order to provide comprehensive agro-meteorological information on the agrarian sector.

Table 6-1. Upgrading of Hydromet Service observation stations as part of international co-operation programmes, 2007-2012

Assistance	Date	Financing
SP 10 radiozonding system, M10 radiozondes	2012	France
4 sets of hydrometeorological equipment with psychometrical cabin	2012	WMO/ Germany
IMETOS 3 automatic weather stations, and 7 automatic soil humidity and temperature stations	2011	European Commission and FAO/ Austria
Automatic meteorological station	2010	WMO/ Russian Federation
«DAWBEE» Weather-mapping and -analysis system	2010	EUMETSAT/ Germany
Automatic snow-measurement station	2007	Norway
4 automatic hydrological systems	2007	USA

Research Activities

Research for Hydromet Service is conducted by the Hydrometeorological and Environmental Research Centre which includes departments for applied climate observation, climate studies, and hydrometeorological modelling and testing. Fields of study include: climate observation, digital modelling of hydrometeorological processes, climate monitoring, climate change assessment, and national lever forecasts by using global and regional climate change model outcomes.

The Department of Applied Climate Observations prepares and updates weather bulletins based on historical and current data for beneficiary use.

The Department of Climate Studies carries out various activities on climate monitoring, climate indices, and vulnerability assessments of climate change impacts on ecosystems.

The Department of Hydrometeorological Modelling and Testing carries out activities including: global and regional climate models and weather analysis, and localization and assessment of ongoing observations. They use state-of-the-art software and software languages, and map the outcomes.

With the active involvement of young specialists, the Hydrometeorological and Environmental Research Centre, within the framework of activities on climate change funded by a UNDP-GEF project, published a number of manuals in 2011-2013 and disseminated them among ministries, local governments, educational systems, and libraries:

- *Air and Soil Temperature* (I vol.);

- *Air Humidity, Atmospheric Precipitation and Snow Cover* (II volumes);
- *Atmospheric Pressure and the Wind* (III volumes);
- *Agro-Climatic Resources of Armenia*;
- *Solar Radiation in the Territory the Republic of Armenia, 1980-2004 reference book*;
- *Theory of Hydrometeorological Service Operations*;
- *Construction Climatology Requirements of the Republic of Armenia*;
- *Current State and Prospects of Climate Services Development in Armenia* (in Armenian and English);
- *Climate Change Regional Impact Assessment in South Caucasus Region* (in Russian);
- *Climate Risk Management in Armenia* (in Armenian and English).

6.2 Studies and Programmes Contributing to Addressing Climate Change Issues

In 2000, the Armenian National Assembly adopted the law on "Scientific and Technological Activities". According to this law, one of the types of budget financing for scientific and technological activities would be allocated to public research organizations to carry out applied research activities. According to the law, one of the goals of state policy in science and technology is to improve the environmental situation.

On 11 July 2007 the Armenian government adopted the *Concept for Reforms in Science Sector*. The *Science Sector Development Strategy*, adopted in 2010, assigned state policy for future development in the science sector for 2011-2020.

The Decree of the Armenian president passed in October 2007 established the State Science Commission under the administrative structure of the Ministry of Education and Science. This commission is tasked with the further implementation of scientific reforms. Allocations from the 2006-2010 state budget for science financing are about 0.9% of total state budget expenditure. However, in the last three years there has been an increase in budget allocations for science: from AMD 8,353 million in 2010 to AMD 11,430 million in 2013.

The government decision on establishing "2010-2014 Priorities for Science and Technology Development in the Republic of Armenia" (2010) recognized RE as one of the priorities for scientific and technological development.

State budget allocations (2009) for 18 climate change-related research activities amounted to about 22% of total funding for research activities. Since 2009, the Armenian state budget has financed 58 scientific research themes on nature-protection issues. Some of these themes were associated to biodiversity and desertification, therefore covering climate change.

2011-2012 grants allocated on a competitive basis for scientific and technological activities include research on climate change:

- Identification and mapping of dangerous and risk zones for river valleys located in the northern marzes;
- Global climate change impact on desertification processes in hillside agrocenosis and development of effective countermeasures;
- The proportion of efficient use of ground water in Ararat valley, and mathematical modelling of salty-water balance for prevention of secondary salinization;
- Ecological and hydro-geochemical research for drinking water in Lori, Kotayk, and Armavir marzes; and creation of a database;
- Assessment of the impact of ecological factors on plant species included in the *Red Data Book of Armenia*, and development of measures for their protection;
- Development of new technologies for improving ameliorative-ecological conditions of soils in Ararat valley.

Programmes implemented in 2010-2014:

Vulnerability and Adaptation:

- Assessment report on Vayots Dzor Marz vulnerability to climate change, and action plan for adaptation measures (UNDP, 2014);
- Climate change adaptation trans-border programme, (Research and Assessment Development Centre, 2014);

- Reducing climate change vulnerability of the agricultural systems of Armenia. Impact assessment and adaptation options (World Bank, 2013);
- Climate change assessment of water resources of the Vorotan river basin (USAID, 2013);
- Study for introduction of IWRM principles into 6 water-basin-management areas (Sher, 2013);
- Development of the report on promoting reforms in economic mechanisms for water management (OECD, 2013);
- Country water sector vulnerability to climate change (UNDP, 2012);
- Vulnerability assessment of water resources in the trans-border river basins (Khrami-Debed and Aghstev) and recommendations for appropriate adaptation measures to climate change (UNDP, 2010-2011).

Energy:

- Preparation of investment plan for renewable energy enhancement in Armenia, (DHInfrastructure, 2013);
- Development of emissions-reduction policy (Kapodistry National University of Athens, 2013);
- Estimation of CO_2 emission factors (baseline) for electric power systems in Armenia for 2009-2013 (UNDP, 2013);
- Sustainable energy for all: an assessment of energy sector current state and needs (UNDP, 2012);
- Drafting a renewable energy development roadmap for Armenia (Danish Energy Management A/S, 2011);
- Technical assistance for the development of a national energy balance and greenhouse-gas inventory system (USAID /TetraTech, 2010-2014).

6.3 Education, Training, and Public Awareness

6.3.1 Education and Training

The Armenian education system is regulated by laws, secondary legislation and programmes, including:

- Law “On education” (1999) defines principles for educational strategy in Armenia;
- Law “On population environmental education and upbringing” (2001) provides for the implementation of lifelong environmental education and regulates principles of state policy, legal, organizational and financial bases for lifelong environmental education of the population;
- Law “On environmental education strategic plan” (2007), which replaced the 2001 programme;
- Concept “For establishing a comprehensive and unified national system for environmental education, upbringing and awareness” (Decree No. 1551-N from 25 November 2010).

The 2011-2015 Action Plan under this Concept includes institutional and legislative improvements for environmental education, upbringing and awareness, and capacity building.

In 2005 the Republic of Armenia joined the UN Decade on Education for Sustainable Development and is engaged in activities under the “Education for Sustainable Development Strategy”.

The national authorized bodies for the implementation of environmental education in Armenia are the Ministry of Education and Science and the Ministry of Nature Protection. Their major task is to develop a common policy for this sector; to establish scientific-educational and methodological bases for its implementation; to provide information, personnel and financial support; to organize awareness raising, training and environmental education at all levels of public education; to regulate the legal framework.

Environmental education in the country is implemented using both formal and non-formal education systems. Formal education is provided by educational institutions in compliance with mandatory documents (state educational standards and programmes) approved by the Ministry of Education and Science.

Non-formal (informal) education is provided outside of the formal educational system and vocational training, although sometimes in parallel. As a general rule, no official diplomas are granted after ‘graduation’. Non-formal education can be carried out in the workplace, by civil or non-governmental organizations, or

by institutions that have been established alongside state-formal systems.

At present, all levels of the educational system of Armenia are involved in ecological education, including: preschool education, general education, vocational training, university education, and postgraduate education.

The education sector in Armenia includes two types of educational institutions:

- general education (preschool institutions and schools);
- professional education (i.e. primary professional educational institutions: technical schools, secondary professional educational institutions (colleges), and higher education institutions (HEIs) (universities, institutes, academies).

General Education

Preschool: To guide environmental education at this level, manuals that reflect climate change-related issues have been compiled within the framework of local and international projects. Current local educational programmes, such as "Environmental Education at Preschool Age", "Educational Programme for 5-6 year old children", "Little Lover of Nature", "Behaviour", and other UNICEF-implemented environmental programmes promote preschool environmental education in Armenia.

Elementary school: New disciplinary standards and programmes elaborated in 2010 include climate change-related topics in nature protection. Depending on the ages of students, mandatory disciplines included in curricula for grades 2-12 partly cover climate change issues. At the general-education level, climate change issues are taught to some extent in the environmental aspects of the "Us and the World", "Natural Science", "Physics", "Chemistry", "Biology", "Geography", and "Social Science".

Secondary school: New disciplinary standards and programmes have been submitted for approval and will be applied starting from the 2013-2014 academic year. Curricula for geography, biology, and social science classes include methodological guidelines on climate change issues. Schools' mandatory curricula for each respective grade (except 1st and 10th grades) also include extra classes guaranteed by the Minister of Education and Science, including ecology.

Professional education: This includes 72 state and non-state vocational schools (colleges) and 25 primary professional/trade/vocational institutions. Students in all secondary vocational education institutions attend the "Basics of Ecology" courses, the curriculum and textbooks of which partly cover climate change-related issues.

Higher Education

There are 26 state and 41 private HEIs in Armenia. All HEIs, regardless of professional orientation, teach "Ecology and Nature Protection" courses. These courses partly deal with climate change-related issues.

There are also optional, alternative, and special classes for each professional course, in which climate change-related issues are included in curricula.

Armenia has successful educational practices for the teaching of ecology, economics of natural resource use, environmental risk and safety, environmental engineering, medical ecology, ecology audit, environmental assessment, environmental management, agro-ecology, informative ecology, etc.). Since 2008, state HEIs also provide climate change courses. The proliferation of HEI training on climate change shows that great progress has been made on the previous period.

The Department of Geography and Chemistry at Yerevan State University (YSU) puts on a "Climate Change Basics" special course for students. It trains 7 specialists per year majoring in "Hydrometeorology", which includes "Climatology" and "Climate Change" in the programme. It also teaches "Geo-ecology in the Sustainable Development Context" and "Sustainable Social Development Theory (Global Sustainable Development Programme)" disciplines, including global climate change issues and developments under UNFCCC.

Since 2007, the State Engineering University of Armenia (SEUA) has offered courses on "Use of the Clean Development Mechanism in Energy Projects" to graduate students.

In 2013, the Armenian National University of Architecture and Construction Foundation established an energy-efficiency laboratory, supported by UNDP. University curricula also include "Green Architecture" courses, which cover energy efficiency and RE sources in building design and construction processes.

Postgraduate Education

Postgraduate education is offered by both HEIs and scientific research institutes of RA NAS. Therefore, a great number of specialists deal with climate change-related issues. In recent years, several candidate and doctorate dissertations have been defended on climate change.

6.3.2 Public Awareness

Public awareness campaigns on climate change cover the following activities:

- Organization of seminars and conferences;
- Publication and distribution of thematic materials;
- Coverage through mass media;
- Presentations and discussions with the participation of representatives from public and non-governmental organizations on the findings of studies conducted on climate change-related issues in Armenia.

Topics of awareness-raising training and seminars on climate change-related issues organized in 2010-2013 included: "Forest Protection", "Increased Incidence of Droughts", "Biodiversity Degradation", "Health Vulnerability", "Safe Life Activity", "Increase in Dangerous Phenomena Incidence", "Greenhouse Gas Emissions", etc. Materials from these events have been distributed to professionals, teachers, civil servants and the public.

Activities implemented by the UNDP-GEF climate change programme (jointly with other stakeholders) include:

- Seminar on "Global Climate Change Issues and Armenia", organized for students of journalism at Armenian universities (2008);
- International Conference on "Ecology and the Importance of Nature Protection from a Sustainable Development Perspective", where a special session was devoted to local and global climate change issues (2008);
- Seminar on "Global Climate Change and its Impact for Armenia", organized for students of the State Pedagogical University of Armenia (2009);
- "Solar Architecture" training course on active and passive solar solutions in building design for practicing architects and professionals (2012);
- "Sustainable development" workshop on energy-efficiency and renewable-energy issues (2012);
- Contest for journalists covering climate change related-issues (2012);
- "Forest and Climate Change" art exhibition, essay contest, and open-door training series (2014).

In all, almost 300 students from 16 schools, as well as representatives from professional institutions and eco-clubs, participated in these events (2013).

Articles covering climate change issues published by Armenian experts in thematic, regional, and international scientific articles are contributing to raising awareness.

In 2009-2013 UNDP-GEF supported the publication of a number of books, manuals, tutorials and reference materials on climate change in national language. These materials are designed for professionals, university professors, and decision makers, as well for the promotion of public awareness.

It is worth noting some specific publications, including:

- *Use of renewable energy in the world and in Armenia: With innovation – towards clean technologies* (2009);
- *Materials of national, regional and international conferences on renewable energy, energy efficiency and climate change mitigation* (2009, 2014);
- *Flora Goddess Ball* (2011);
- *Renewable energy sources and technologies tutorial* (2012);
- *Main forest pests in Armenia and pest control* (2012);
- *Building Climatology: Construction Norms* (2012);
- *Current state and prospects of the development of climate services* (2013);
- *ABC: Climate Change Tutorial* (2013);
- *Regional Climate Change Impact Study for the South Caucasus Region* (2013);
- *Climate Risk Management in Armenia* (2013);
- *Hydrology, Meteorology and Climate Contemporary Issues in Armenia* (2014).

Posters covering RE and vulnerability topics, as well as calendars reflecting climate change impact in Armenia, have been published. These materials are distributed to professionals, teachers, and civil servants.

The website of the Climate Change Information Centre of Armenia launched yet in 1997 is periodically updated and is intended to make information on climate change impacts in Armenia and appropriate activities available to all stakeholders, including the Armenian public.

The publication of the *Climate Change Newsletter – Armenia* electronic journal was launched in 2009. The newsletter is distributed through electronic networks and is published on the website of the Climate Change Information Centre of Armenia.

Climate change-related issues are periodically covered by mass media. The weekly broadcast of the "Ecologic" TV programme often covers climate change-related topics.

Videos and radio programmes on energy saving and energy efficiency have been made and broadcast. A number of printed materials and articles have also been published.

Environmental NGOs are actively involved in promoting environmental education and public awareness in the country. NGOs have supported the publication of manuals on environmental education in secondary schools. Schools received awareness posters for students and teachers, as well as methodological guidelines, including: "Energy", "Renewable Energy", "Climate Change and its Implications", and "Save Energy at Home and at School". Publications: *Safe Life Activity*, *Education Guidelines for Sustainable Development*, *Water Pollution and Protection Issues*, *School Programme on Energy and Resource Use*, and *Practical Workshops*.

School and higher education libraries have all of this literature in stock. NGOs organize training seminars for teachers and students, as well as training for tutors and professors from HEIs and secondary educational institutions. In particular: Caucasus Environmental NGO Network (CENN) and Mercy Corps within the framework of the "Local Capacities and Regional Cooperation Development Needs for South Caucasus Climate Change Mitigation" (2013, EU) programme has organized a workshop series for students in a number of communities in Tavush and Lori marzes and published the *Global Climate Change and the South Caucasus* guidebook for school students.

Since 2002, 14 Public Ecological Information (Aarhus) Centres have been operating in all marzes of Armenia. They are actively involved in promoting public participation in public awareness and decision-making processes on nature protection.

Climate change observation findings in Armenia are periodically published in the *Environment and Natural Resources in the Republic of Armenia* statistical yearbook.

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7

GAPS, CONSTRAINTS, AND CAPACITY NEEDS FOR CONVENTION IMPLEMENTATION

At present, policy and certain measures aimed at implementation of the Convention in the Republic of Armenia are defined by the government statement on association with the Copenhagen Accords; the statement of the Head of the Armenian Delegation at the 18th Conference of the Parties to the Convention; and the Decree No.1594 on "Approval of the Action Plan of RA Obligations Emanating from a Number of International Environmental Conventions", adopted on 10 November 2011.

During the preparation of TNC, a number of national capacity-building constraints and gaps with regard to implementation of the Convention were identified on the institutional, organizational, technical, informational, financial, and professional level. Taking into account the new phase of international efforts and Convention initiatives new emerging need were identified (see table 7-1).

Practically, there is observed lack of necessary professional and knowledge capacity and financial resources in all required fields for addressing climate change challenges.

Table 7-1. Needs to overcome gaps, barriers, and constraints for addressing climate change-related issues

Gaps, constraints	Comments	Needs
Greenhouse gas inventory		
Absence of institutional mechanism for periodical updating of GHG inventory.	GHG inventories are made by an ad hoc group of experts established under GEF-funded programmes. However, given the requirements for the development and official submission of national biennial reports there is a need for a relevant legal act to regulate GHG inventory-making procedures.	Define by a Decree of RA Government or by any other legal act the procedure for preparation and developing (managing) GHG Inventories, which will also set the powers and functions of central and local governments. Establish a sustainable inter-institutional mechanism for making and updating the GHG inventory.
Inadequacy of the system: for inputting data collection; quality assurance and quality control; and for ensuring accessibility to this data. Absence of officially approved energy balance of the country.	No procedures have been established in line with current requirements for environmental statistics and current economic activities. It has been proven that methods for promoting existing administrative data collection and voluntary data provision systems should be combined. The absence of an energy balance creates difficulties for making a GHG inventory in the energy Sector and increases the level of uncertainty. Official data for the consumption of fuel and energy resources are necessary for mitigation projects.	Based on IPCC guidelines on preparing national GHG inventories there is a need to adapt agency guidelines on the collection of data necessary for preparing GHG inventories. In addition, there will be a need for identifying special studies the promotional measures of which (including financial measures) would raise real 'bottom-up' interests for the provision and collection of reliable input data. There is a need to establish respective procedures based on these measures. Introduce a system for collecting statistical data on the consumption of fuel and energy resources as a basis for creating the energy balance, and an official-publication procedure of energy balance.
Different formats required for the preparation of inventories of substances emitted into the atmosphere pursuant to various conventions and national legislation creates data-collection and compatibility problems.	GHG inventories also include data on substances emitted into the atmosphere that are regulated by the "Montreal Protocol on Ozone Depleting Substances", the "Convention on Long-range Transboundary Air Pollution" as well as by the national legislation for the management of emissions of dangerous substances into the	Develop inventories of emissions pursuant to the aforementioned documents and manage respective inventories in a single system. Update software for inventory management, ensuring data accessibility and sharing. Establish cooperation between stakeholders from different sectors to meet goals.

Gaps, constraints	Comments	Needs
	atmosphere.	
Unavailability of actual data on emissions, removals, and storage in AFOLU results in imperfections in and uncertainty over GHG balance in this sector.	Armenian government Decree No. 276-N on "Approval of the procedures for land monitoring" provides for a number of indices for defining land use and land use change, including criteria for organic carbon deposited in soil; however, no monitoring has been conducted yet.	There is a need for targeted studies, including field studies, the findings of which could be used to develop procedures and guidelines for the regular monitoring and inventory of organic carbon deposits in soil. Comparison with IPCC guidelines will enable the development of national factors for carbon emissions, removals and storage, and consistently improvement. Create, though training and awareness raising, and economic mechanisms for promoting implementation of soil monitoring (in particular, for organic carbon content (humus) in soil) by land users.
High uncertainties in assessing fugitive emissions (methane) from natural-gas transmission and distribution systems.	Official data for fugitive emissions (methane) from natural-gas transmission and distribution systems are based on tariff contracts between gas-utility company and Public Services Regulatory Commission. The format of these contracts, however, does not allow for separating fugitive emissions of methane from total commercial losses. The existing tariff-setting system for gas-utility companies does not create incentives for reduction of fugitive emissions.	Carry out studies to identify fugitive emissions based on direct measurements in all segments of gas-supply systems. With the participation of concerned consumers improve tariff-setting principles, ensuring the inclusion of a provision stipulating gradual reduction of leakages in the conditions of the contracts. Impose environmental fees for methane emissions and use proceeds for supporting civic investment funds (as tasked by the government for establishment of such funds).
GHG emissions reduction/abatement policy and measures		
Insufficient capacities of projections for reduction/abatement of GHG emissions.	Peculiarities of national development planning are characterized by significant uncertainties, which prevent the realization of emissions as projected in FNC and SNC.	Analyze the applicability potential of recommended models and, at the same time, organize training on abatement projections for appropriate entities involving international experts.
Lack of clear policies with regard to GHG emissions/removals in IPPU and AFOLU sectors, which prevents assessment of mitigation projections with regard to the development of those sectors.	The projection of GHG emissions abatement is implemented by expert assessments not based on existing policies.	With international technical assistance support to study and locally adapt GHG emission-reduction policies in the IPPU and AFOLU sectors applied in CIS countries and the EU.
Lack of approved concept for the reduction and abatement of GHG emissions.	The existence of a special concept would enable discussion and the development of indicators for GHG emission reduction, that should be formulated as intended nationally determined contributions (INDC), including the required investments for implementation.	Develop a GHG emission-reduction concept based on no more than a 2.0^{0}C increase in the global temperature. This concept should include: • Financial and economic mechanisms, including the exchange of emission credits with domestic and foreign market mechanisms; • Establishment of favourable conditions for technology development, transfer, introduction, and cooperation with the Climate Technology Centre

Gaps, constraints	Comments	Needs
		and Network; • National capacity building and development, and personnel training; • Expansion of international cooperation frameworks; • Civil society and private sector participation.
General Provisions for Vulnerability and Adaptation		
Lack of climate change adaptation concept with ecosystem approach and, as a result, absence of state action plan.	There is no comprehensive assessment of current and future vulnerability indicators for all sectors. Armenian government Decree No. 1594-N, on 10 November 2011 envisaged the elaboration of an adaptation to climate change concept using an ecosystem approach until 2015 and submission for approval.	Elaborate a climate change adaptation concept using an ecosystem approach, which will include: • Financial and economic mechanisms; • Technology transfer; • Capacity building; • International, including regional cooperation, frameworks; • Private sector participation; • Use of traditional community practices, etc. Combine adaptation and mitigation actions to the greatest extent possible and develop a combined adaptation and mitigation ideology for that purpose.
Climate change-related risk management is not sufficiently integrated into national strategy and policy for disaster risk reduction, and into territorial development-planning process.	Damage caused by climate risks is not adequately estimated and accounted for; it is not submitted to decision makers with proper evidence. This gap impedes risk-mitigation/prevention policy planning and ensuring financial allocations.	Develop recommendations for climate change-related risk mitigation and ensure their integration into the national security strategy, as well as include them in regional community development plans. Elaborate guidelines and conduct professional training to facilitate adequate integration of climate risks.
Insufficient input data for application of IPCC-recommended models for vulnerability assessment.	Quantitative assessment of vulnerability is necessary for the substantiation of adaptation (including financial) programmes.	Elaborate proposals for targeted financing of research studies, and promote establishment of international research cooperation.
Lack of methods and approaches for inter-sectorial coordination and harmonization of climate change vulnerability and adaptation.	As of today, vulnerability and adaptation for each sector of the economy and industry is considered separately. Interrelation and interconnection between sectors and industries are not considered deeply enough, which often leads to discrepancies.	Elaborate complex approaches for vulnerability assessment and develop comprehensive adaptation measures between industries.
Lack of clear mechanisms for international support for adaptation funding.	While there are mechanisms for funding mitigation actions (GEF, Kyoto Protocol), the resources and opportunities for adaptation measures are limited.	Develop adaptation programmes to submit to multilateral funds. Establish a national system for adaptation funding pursuant to Armenian government Protocol Decision No. 47, adopted on 14 November 2013.
Insufficient level of regional cooperation in climate	Active and concerned regional cooperation is important in the	Develop, with the participation of civil society and the international scientific

Gaps, constraints	Comments	Needs
change adaptation activities.	context of applying ecosystem approaches to adaptation – ecosystem vulnerability is not limited by state boundaries.	community, a concept and action plan for regional studies, systematic observations, vulnerability assessment, and adaptation. Possible areas for cooperation include: • Selection of scenarios for systematic observations and climate change; • Forecasting, warning and response to hazardous meteorological conditions; • Studies on ecosystem vulnerability, including water basins, and the implementation of adaptation programmes; • Prevention of forest wild fires and spread of forest leaf-cutting pests; • Organization of joint control over the spread of parasitic diseases.
Water Resources		
Lack of applicable models for the vulnerability assessment of water resources.	Existing models require sufficiently detailed and accurate data on water-resource balance by components, land use and soil, vegetation cover and climate change projections at the water-basin level.	Upgrade applicability of climate change projection scenarios and models, simultaneously conducting studies at the water-basin level.
Large losses from water-distribution and water-use systems.	Tariff-setting principles for using water resources do not promote water saving and loss reduction.	Develop economic-promotion mechanisms for water-resource loss reduction and water recycling.
Insufficient database at the State Water Cadastre on water resources and on the sector in general.	Data on water resources, water use, quality and quantity available at the State Water Cadastre is incomplete and, as a result, it is impossible to fully compare and assess climate change impact on water resources.	Restore water-resources quantity- and quality-monitoring data series using available and accessible software methods.
The principle and order for setting ecological flows in the water-use quota system does not take into account climate change impact.	The existing principle and order of the quota system for major seasonal flow change in mountain rivers is defective as it does not guarantee sufficient quantity of water for ecosystems, and would further reduce ecological flows as a result of climate change.	Develop new quota-setting principles for water intake based on ecosystem-adaptation approaches to climate change. Ecological flow and its regime must also comply with the requirements and provisions set forth by global and regional environmental conventions and other international agreements signed by the Republic of Armenia.
Reduction in flows of the border rivers (Akhurian and Hrazdan) as a result of uncoordinated water use and climate change, leading to potential vulnerability of agriculture and energy sectors, as well as aquatic and shore ecosystems.	Reservoirs constructed and under construction to irrigate other tributaries feeding the Akhurian and Araks rivers are dramatically dropping and will continue to do so. A drop in the Akhurian reservoir will reduce the flow of the Araks river. On top of that, there will also be a reduction in the usable quantity (resource) of water. The unilateral approach for the solution of this problem is ineffective, especially in terms of protecting aquatic and shore ecosys-	Given that the borders of natural ecosystems do not coincide with the state borders, initiate joint research activities on the vulnerability of aquatic ecosystems and water resources to cover the watersheds of the Araks and Akhurian rivers, and recommend that concerned bordering countries develop a joint regional adaptation programme using ecosystem approaches. Include these programmes in the regional cooperation component of the national adaptation programme.

Gaps, constraints	Comments	Needs
	tems and their adaptation to climate change.	
Agriculture		
Insufficient methodology, information, and personnel capacity to apply modern climate change impact-assessment models.	The data-collection (indicators) system for climate change impact on yields of main agricultural crops and livestock production is defective and insufficient for making complete analysis.	Establish a reliable system for collecting detailed data based on the real needs of all stakeholders. Apply crop-yield assessment models, with regard to climate change impact. Enhance methods for agro-climatic modelling. Substantiate necessity of continuous financing for agro-climatic studies.
Lack of data and research activities on possible changes in agro-climatic zonal distribution (with regard to climate change).	Climate change leads to shifts in agro-climatic zonal borders. However, there are some uncertainties with regard to the direction of shifts – this does not allow for making accurate and reliable projections.	Develop recommendations for spatial distribution of cultivated crops, taking into account climate change factors and uncertainties. Compile maps by using Geographical Information System (GIS) technologies.
Lack of data on productivity of natural grasslands and pasture.	Lack of accurate information on natural grasslands and pasture hinders assessment of the effects of climate change on productivity.	Organize studies on productivity of natural grasslands and pasture. Establish a procedure for periodic monitoring.
The food security strategy does not reflect climate change impacts on food security.	Climate change will have a significant impact on agriculture and, consequently, food security.	Reduce food-production dependence on weather conditions by introducing appropriate diversification and complex technological solutions, including 'closed' self-sufficient systems and modern agro-melioration methods.
Absence of insurance system for agricultural activity risks caused by climate change.	The absence of an insurance system against hazardous hydro-meteorological phenomena makes crop production extremely vulnerable.	Create preconditions for the establishment of an insurance system. Carry out comprehensive scientific, statistical, socio-economic studies and analysis.
Biological diversity and natural ecosystems		
Insufficient data on natural ecosystems.	There is no monitoring of natural ecosystems for changes brought about by climate change. There are no or insufficient data on assessment indicators for the state of ecosystems.	Develop assessment indicators for the state of ecosystems (terrestrial, water, plant and animal). Carry out studies for setting up a monitoring system on changes in natural ecosystems.
The national forest strategy does not sufficiently include optimal forest coverage concept, responsability for implementation and regime for afforestation.	Regardless of the fact that the clause on "Reforestation and afforestation" in Armenian government Decree No.1232 adopted on 21 July 2005 indicates 20.1% as the optimal forest coverage for the country; however, the afforestation regime has not yet been clarified.	Clearly indicate in the national forest strategy the optimal (20.1% forest coverage of the territory of Armenia by 2050)afforestation regime, and implement activities that would consolidated in the forest management and will be targeted at the: • Correction and substantiation of quantitative indicators for carbon emissions, removals and storage by years; • Finalization of areas subject to reforestation and afforestation; • Conservation of forest biodiversity and the natural environment; • Assessment of technical and financial resources needed for afforestation

Gaps, constraints	Comments	Needs
		and reforestation.
Lack of environmentally friendly pest-control measures for forest ecosystems.	Currently the country uses chemical pest-control methods in forest ecosystems. Positive experiences of forest-pest biological control implemented in the UNDP-GEF programme have not been replicated.	Develop and introduce biological methods for pest control in forest ecosystems. Enforce such approaches and methods with a respective legal act.
Inadequate legislation for protecting lands, particularly natural soils, and a lack of programmes for soil protection.	Effective legislation (Armenian Land Code and other legal acts) mainly regulates land relations. Although there is a reference to land protection in the Armenian Land Code, however it is not sufficient to ensure soil protection in ecosystems.	Develop a concept for land (soil) protection and rehabilitation, and make respective improvements in legislation.
Ex-situ methods are insufficient to protect the biodiversity of rare species and individual elements of ecosystems and ensure conditions allowing them to adapt to climate change.	Currently there is one state botanic garden with two branches, 4 arboretums, and one state zoological garden in Armenia; however, the protection of Armenia's biodiversity is not considered as a priority in these institutions.	There is a need to establish new arboretums to protect local rare and useful plant species. There is also a need to expand the activities of existing arboretums and botanic gardens by providing them with additional financing.
Human health		
Insufficient inclusion of climate change factors in healthcare programmes and statistics.	Current statistical information includes data on diseases and morbidity; however, there is no analysis and regular study on their relation with weather and climate conditions. Certain studies are needed to prove the necessity of sustainable and consistent studies.	Envisage development of a concept and programme for human health vulnerability and adaptation to climate change and include them in the Armenian National Adaptation Programme as a separate chapter.
Research and systematic observations		
Low level of climate change forecast reliability.	There are a number of objective reasons behind this: the complexity of climate change phenomenon; science is not adequately advanced in this field; limited applicability of the recommended models for small territories and mountainous conditions; lack of specialized personnel; low level of input data reliability, etc.	Ensure constant cooperation with neighbouring countries (Turkey, Georgia, Azerbaijan, Russia, and Iran) in order to develop and continuously update regional scenarios for climate change. Involve scientific institutions from countries in this field.
The existing system for forecasting and monitoring hazardous hydrometeorological phenomena resulting from climate change does not meet the requirements of the economy.	90% of existing hydrometeorological stations are in need of modernization: this hinders the organization of an effective early warning system.	Develop a system-modernization programme to attract relevant financing. Improve hazardous hydrometeorological phenomena forecasting and monitoring systems. Establish a regional data-sharing network.

Technology development and transfer

Lack of system for development, transfer and introduction of technologies to addressing climate change issues.	The absence of operational systems for the development and transfer of technologies hinders the organization and regular implementation of mitigation and adaptation projects, as well as cooperation with the Technology Centre and Network established under the Convention.	Identify and assess technological needs and define ways to meet these needs. Based on the arrangement, operation principles and functions of the Technology Centre and Network, create a country-level "Technology Mechanism" as a framework for cooperation between legal and physical entities participating in this process.

Science, education, personnel training and public awareness

Poor involvement of the scientific community in studies on climate change.	The scientific community does not pay proper attention to climate change mitigation and adaptation issues, or the development of technology to either address or commercialize them.	Involve representatives from both the scientific community and businesses in the climate technology mechanism. Provide targeted financing mechanisms for the implementation of scientific and research activities in sectors more vulnerable to climate change.
Lack of specialists in hydrometeorology and climatology.	The only hydrometeorology professional course in the country (at the Department of Geography of Yerevan State University) was closed in 2013.	Act more actively to develop programmes, including climate change issues, in science, education, personnel training, and public awareness. Include hydrometeorology and climatology expert training into professional training and exchange programmes for CIS countries.
Poor public awareness and absence of involvement in climate change.	Awareness is an important instrument for civil society involvement. However, current passive information sharing and training without practical work is ineffective. Real actions are needed on top of knowledge and material support (including development of new economic instruments and financing).	Build and develop capacities (including financial capacities) in rural communities for participation in climate change adaptation and mitigation activities. Use the revolving investment funds supported through environmental fees to be established pursuant to the Armenian government Protocol Decision No.47, adopted on 14 November 2013.

Synergies between the global environmental conventions

Measures implemented for climate change impact mitigation do not take into account cross-cutting issues between global/regional environmental conventions.	Consideration of goals and cross-cutting issues between global environmental conventions will contribute to the optimization of implemented measures and targeted use and saving of financial resources. It will also ensure the feasibility of measures from a long-term perspective.	Address cross-cutting issues and develop a concept for coordination and cooperation on the implementation of Armenia's obligations to global and regional environmental conventions.

Lack of adequate linkages between climate change-related processes and relevant regional and international processes, which often lead to non-agreed and divergent positions.	This refers to the UN Convention on Long-range Trans-boundary Air Pollutants; the Convention on Biodiversity; Convention to Combat Desertification, the provisions and practices under the Ramsar, Bonn, and Bern Conventions. All of these comply with the ecosystem approach adapted by the Convention on Climate Change. Cross-cutting issues from the convention on protection of the ozone layer also need to be addressed.	Study and identify cross-cutting issues (synergies) under the UNFCCC and aforementioned conventions and develop a concept, programmes and harmonized activities in the fields of: • Collect joint data and prepare inventories for emissions (including cadastres); • Adapt to climate change by using ecosystem approaches, reduce emissions of hazardous substances and GHGs, and develop removal sinks; • Reduce adverse impacts of emissions on ecosystems; • Mobilize funding and financial resources.

Financing

Lack of clear financing mechanisms for the implementation of provisions of the Convention and future national mitigation and adaptation investment programmes.	Currently available financing mechanisms include: GEF as a temporary financial mechanism for mitigation; CDM of the Kyoto Protocol with its Adaptation Fund. However, these and other resources are insufficient to ensure implementation of Armenia's future obligations.	Attract foreign financing to accelerate discussions and agreements on priority-and-needs-based projects of the Inter-agency Council on Climate Change. Pursuant to Armenian government Protocol Decision No.47, adopted on 14 November 2013, create a sustainable and consistently developing system to finance climate change mitigation and adaptation measures.

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 years 2000, 2006 and 2010

2000

GHG source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and removals	**3,213.704**	**-470.820**	**87.840**	**1.548**	**12.126**	**63.604**	**14.539**	**0.636**
1. Energy	**3,079.899**		**24.077**	**0.051**	**11.967**	**59.277**	**11.081**	**0.561**
A. Fuel combustion (sectorial approach)	3,079.837		1.537	0.051	11.967	59.277	11.081	0.561
1. Energy	1,673.627		0.030	0.003	4.474	0.596	0.149	0.170
2. Manufacturing and construction	446.643		0.011	0.001	1.207	0.197	0.038	0.250
3. Transport	642.060		0.331	0.030	5.938	58.270	10.867	0.128
4. Other sectors	317.506		1.165	0.016	0.348	0.214	0.027	0.013
5. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	0.061		22.540		NO	NO	NO	NO
1. Solid fuels			NO		NO	NO	NO	NO
2. Oil and natural gas			22.540		NO	NO	NO	NO
2. Industrial processes	**119.676**				**NO**	**NO**	**2.538**	**0.075**
A. Mineral products	119.676				NO	NO	NO	0.075
B. Chemical industry	NO		NO	NO	NO	NO	NO	NO
C. Metal production	NO		NO	NO	NO	NO	NO	NO
D. Other production	NO		NO	NO	NO	NO	2.538	NO
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
3. Solvent and other product use	**NO**			**NO**			**0.920**	
4. Agriculture			**37.471**	**1.316**	**0.159**	**4.327**	**NO**	
A. Enteric fermentation			34.455					
B. Manure management			3.015	0.191			NO	
C. Rice cultivation			NE				NO	
D. Agricultural soils				1.125			NO	
E. Prescribed burning of savannahs			NO	NO	NO	NO	NO	
F. Field burning of agricultural residues			0.042	0.005	0.159	4.327	NO	
G. Other (please specify)			NO	NO	NO	NO	NO	
5. Land use change and forestry	**14.130**	**-470.820**	**NE, NO**	**NO**	**NO**	**NO**		
A. Changes in forest and other woody biomass stocks	NE	NE						
B. Forest and grassland conversion	14.130	NE	NO	NO	NO	NO		
C. Abandonment of managed lands		NA						
D. CO_2 emissions and removals from soil	NE	-470.820						
E. Other (please specify)	NE	NE	NE	NO	NO	NO		
6. Waste			**26.293**	**0.180**	**NO, NE**	**NO**	**NO, NE**	**NO**
A. Solid waste disposal on land			21.406		NE		NE	
B. Wastewater handling			3.822	0.161	NO	NO	NO	
C. Waste incineration					NO	NO	NO	NO
D. Other (please specify)			1.065	0.019	NO	NO	NO	NO
7. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International bunkers	**90.527**		**0.001**	**0.003**	**0.540**	**0.653**	**0.410**	**0.037**
Aviation	90.527		0.001	0.003	0.540	0.653	0.410	0.037
Marine	NO		NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**362.079**							

2006

GHG source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and removals	**4,188.076**	**-523.197**	**103.042**	**2.198**	**15.069**	**62.525**	**18.138**	**27.262**
1. Energy	**3,850.163**		**29.727**	**0.063**	**14.892**	**57.882**	**10.298**	**0.160**
A. Fuel combustion (sectorial approach)	3,850.075		1.685	0.063	14.892	57.882	10.298	0.160
1. Energy	960.026		0.017	0.002	2.567	0.342	0.086	0.003
2. Manufacturing and construction	682.687		0.013	0.001	1.827	0.351	0.060	0.003
3. Transport	937.461		0.898	0.046	9.162	56.273	10.043	0.062
4. Other sectors	1,269.901		0.757	0.013	1.336	0.916	0.109	0.003
5. Other (please specify)	NO		NO	NO	NO	NO	NO	0.089
B. Fugitive emissions from fuels	0.088		28.042		NO	NO	NO	NO
1. Solid fuels			NO		NO	NO	NO	NO
2. Oil and natural gas			28.042		NO	NO	NO	NO
2. Industrial processes	**323.783**				**NO**	**NO**	**0.363**	**27.102**
A. Mineral products	323.783				NO	NO	NO	0.202
B. Chemical industry	NO		NO	NO	NO	NO	NO	NO
C. Metal production	NO		NO	NO	NO	NO	NO	26.900
D. Other production	NO		NO	NO	NO	NO	0.363	NO
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
3. Solvent and other product use	NO			NO			**7.477**	
4. Agriculture			**45.862**	**1.935**	**0.177**	**4.643**	**NO**	
A. Enteric fermentation			42.199					
B. Manure management			3.663	0.231			NO	
C. Rice cultivation			NO				NO	
D. Agricultural soils			NO	1.704			NO	
E. Prescribed burning of savannahs			NO	NO	NO	NO	NO	
F. Field burning of agricultural residues			0.042	0.005	0.177	4.643	NO	
G. Other (please specify)			NO	NO	NO	NO	NO	
5. Land use change and forestry	**14.130**	**-523.197**	NO	NO	NO	NO		
A. Changes in forest and other woody biomass stocks	NE	NE						
B. Forest and grassland conversion	14.130	NE	NO	NO	NO	NO		
C. Abandonment of managed lands		NE						
D. CO_2 emissions and removals from soil	NE	-523.197						
E. Other (please specify)	NE	NE	NE	NO	NO	NO		
6. Waste			**27.453**	**0.201**	NO,**NE**	NO	NO,**NE**	NO
A. Solid waste disposal on land			22.250		NE		NE	
B. Wastewater handling			4.114	0.181	NO	NO	NO	
C. Waste incineration					NO	NO	NO	NO
D. Other (please specify)			1.089	0.020	NO	NO	NO	NO
7. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
Memo items								
International bunkers	**115.784**		**0.001**	**0.003**	**0.512**	**0.548**	**0.330**	**0.039**
Aviation	115.784		0.001	0.003	0.512	0.548	0.330	0.039
Marine	NO		NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**179.691**							

2010

GHG source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and removals	**4,471.119**	**-552.704**	**107.630**	**1.463**	**17.213**	**66.784**	**22.890**	**29.439**
1. Energy	**4,231.025**		**35.640**	**0.094**	**17.213**	**66.784**	**11.514**	**0.189**
A. Fuel combustion (sectorial approach)	4,230.937		3.382	0.094	17.213	66.784	11.514	0.189
1. Energy	827.518		0.015	0.001	2.213	0.295	0.074	NO
2. Manufacturing and construction	531.522		0.010	0.001	1.416	0.283	0.047	0.012
3. Transport	1,202.622		1.263	0.060	11.831	62.476	10.952	0.057
4. Other sectors	1,669.275		2.095	0.031	1.753	3.730	0.441	0.120
5. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	0.088		32.258		NO	NO	NO	NO
1. Solid fuels			NO		NO	NO	NO	NO
2. Oil and natural gas			32.258		NO	NO	NO	NO
2. Industrial processes	**225.964**				NO	NO	**0.486**	**29.250**
A. Mineral products	225.964				NO	NO	NO	NE
B. Chemical industry	NO		NO	NO	NO	NO	NO	NO
C. Metal production	NO		NO	NO	NO	NO	NO	29.250
D. Other production	NO		NO	NO	NO	NO	0.486	NO
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
3. Solvent and other product use	NO			NO			**10.890**	
4. Agriculture			**44.221**	**1.261**	**0.000**	**0.000**	NO	
A. Enteric fermentation			40.917					
B. Manure management			3.304	0.213			NO	
C. Rice cultivation			NO				NO	
D. Agricultural soils				1.0485			NO	
E. Prescribed burning of savannahs			NO	NO	NO	NO	NO	
F. Field burning of agricultural residues			0.042	0.005	0.000	0.000	NO	
G. Other (please specify)			NO	NO	NO	NO	NO	
5. Land use change and forestry	**14.130**	**-552.704**	**0.000**	**0.000**	**0.000**	**0.000**		
A. Changes in forest and other woody biomass stocks	NE	NE						
B. Forest and grassland conversion	14.130	NE	NO	NO	NO	NO		
C. Abandonment of managed lands		NE						
D. CO_2 emissions and removals from soil	NE	-552.704						
E. Other (please specify)	NE	NE	NE	NO	NO	NO		
6. Waste			**27.768**	**0.202**	**NE,**NO	NO	**NE,** NO	NO
A. Solid waste disposal on land			22.398		NE		NE	
B. Wastewater handling			4.270	0.182	NO	NO	NO	
C. Waste incineration					NO	NO	NO	NO
D. Other (please specify)			1.100	0.020	NO	NO	NO	NO
7. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
Memo items								
International bunkers	**136.172**		**0.001**	**0.004**	**0.539**	**0.485**	**0.325**	**0.043**
Aviation	136.172		0.001	0.004	0.539	0.485	0.325	0.043
Marine	NO		NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	**647.827**							

Annex II

PRIME MINISTER OF THE REPUBLIC OF ARMENIA

DECREE № 955 – A, 2 October 2012

ON APPROVING THE COMPOSITION AND RULES OF PROCEDURE OF THE INTER-AGENCY COORDINATING COUNCIL ON IMPLEMENTATION OF REQUIREMENTS AND PROVISIONS OF THE *UN FRAMEWORK CONVENTION ON CLIMATE CHANGE*

In line with paragraph 121 sub-paragraph 2 of the Procedure approved by paragraph 1 of the 18 July 2007 President of the Republic of Armenia' Order № NH-174-N, with a view to ensuring the implementation of a number of activities outlined in the Annex to the 10 November 2011 Government of the Republic of Armenia's Decree 1594-N and taking into consideration an interdisciplinary nature of the climate change problem and of the *UN Framework Convention on Climate Change* that aims to solve that problem, the emerging innovative approaches and mechanisms in the struggle against climate change and the necessity of close cooperation with inter-governmental and international organizations for effective involvement of the Republic of Armenia in those mechanisms, promising prospects of regional cooperation, active participation of communities, civil society and research community and importance of training the professional cadre and the necessity of effective inter-agency cooperation and coordination to that end:

1.To establish an Inter-Agency Coordinating Council on implementation of requirements and provisions of the UN Framework Convention on Climate Change and to approve the composition and rules of procedure of the Inter-Agency Coordinating Council as per Appendix 1 and 2.

2. To the Council Chairperson: With a view to ensuring professional and expert activities of the Council - To establish within a 6-month period an Inter-Agency Working Group and to approve its composition and the rules of procedure as well as the procedure for the Working Group cooperation with inter-governmental and international organizations, for regional, community and inter-community cooperation and for research community and civil society participation in the Working Group.

3. To Heads of State bodies included in the Inter-Agency Coordinating Council, approved by paragraph 1 of this Decree, on implementation of requirements and provisions of the UN Framework Convention on Climate Change To inform the Republic of Armenia Minister of Nature Protection, within one month after this Decree will have entered into force, about their designated representatives in the Council.

PRIME MINISTER
OF THE REPUBLIC OF ARMENIA T. SARGSYAN
2 October 2012
Yerevan

Appendix 1
To RA Prime Minister's
Decree № 955 – A
2 October 2012

COMPOSITION
OF THE INTER-AGENCY COORDINATING COUNCIL
ON IMPLEMENTATION OF REQUIREMENTS AND PROVISIONS
OF THE *UN FRAMEWORK CONVENTION ON CLIMATE CHANGE*

RA Minister of Nature Protection (Council Chairperson)
RA First Deputy Minister of Nature Protection (Deputy Council Chairperson)
RA Ministry of Foreign Affairs
RA Ministry of Economy
RA Ministry of Finance
RA Ministry of Emergency Situations
RA Ministry of Energy and Natural Resources
RA Ministry of Agriculture
RA Ministry of Education and Science
RA Ministry of Urban Development
RA Ministry of Territorial Administration
RA Ministry of Labor and Social Affairs
RA Ministry of Healthcare
RA Ministry of Justice
RA Ministry of Transport and Communication
State Committee of the Real Estate Cadastre adjunct to the RA Government
General Department of the Civil Aviation adjunct to the RA Government
RA National Statistical Service (by consent)
RA Public Services Regulatory Commission (by consent)
RA National Academy of Sciences (by consent)
National Coordinator of the UN Framework Convention on Climate Change (by consent)

CHIEF OF STAFF
RA GOVERNMENT STAFF D. SARGSYAN

Appendix 2

Prime Minister of the Republic of Armenia

Decree № 955 - A, 2 October 2012

RULES OF PROCEDURE OF THE INTER-AGENCY COORDINATING COUNCIL ON IMPLEMENTATION OF REQUIREMENTS AND PROVISIONS OF THE *UN FRAMEWORK CONVENTION ON CLIMATE CHANGE*

I. GENERAL PROVISIONS

1. The Inter-agency Coordinating Council on the implementation of requirements and provisions of the *UN Framework Convention on Climate Change* (hereinafter, the Council) is set up with a view to coordinate short-term, medium-term and long-term activities and measures related to the implementation of the obligations assumed by the Republic of Armenia under the *UN Framework Convention on Climate Change* (hereinafter, the Convention) and of the provisions of said Convention.

II. COUNCIL'S OBJECTIVES

2. The Council's objectives are:

1) coordination of the implementation of the obligations assumed by RA under the Convention;

2) periodic review of the reports by the National Coordinator of the Convention;

3) submission of recommendations and provision of advice with regard to activities to be undertaken for the implementation of the provisions of and obligations under the Convention;

4) evaluation of the process of the implementation of the obligations assumed by the Republic of Armenia under the Convention and of the provisions of said Convention;

5) submission of recommendations to competent State and local self-government bodies regarding the implementation of the obligations assumed under the Convention.

III. ORGANIZATION OF COUNCIL'S OPERATION

3. The Minister of Nature Protection of the Republic of Armenia shall serve as a Council Chairperson.

4. The Council shall operate through sessions, which will be convened at least once every six months. When necessary, a special session can be convened on the initiative of the Council Chairperson. A Council member can approach the Council Chairperson with a suggestion to convene a special session.

5. The Council session will be competent, if at least over a half of the Council members are present. In the absence of the quorum, a new session shall be convened within a week.

6. The Council's decisions shall be adopted by a simple majority vote of the Council members present at the session.

7. Each Council member shall have one vote. In the case of a tied vote, the Council Chairperson's vote shall be decisive.

8. The Council sessions shall be chaired by the Council Chairperson or, when the Council Chairperson is absent, by the Deputy Council Chairperson.

9. Experts from state bodies dealing with the issues on the agenda of the Council session, Inter-agency Working Group experts, and representatives from research, educational, and non-governmental organizations, mass media and civil society can be invited to Council sessions.

IV. PROCEDURE FOR HOLDING SESSIONS

10. The Council sessions shall be held according to the agenda approved by the Council. The Council Chairperson shall make a decision as to the venue, date and time of the Council session.

11. The agenda of the Council session shall specify:
1) the venue, date and time of the Council session;
2) issues for discussion;
3) the first and last name of a presenter for each issue on the agenda.
12. The draft agenda and other necessary documents related to the issue set for discussion at the Council session shall be delivered to Council members at least 5 working days prior to the session.
13. The Council session agenda issues can be presented by Council members, as well as by public administration and local self-government bodies and the Inter-agency Working Group.
14. Logistical support to Council activities shall be provided by staff of the Republic of Armenia Ministry of Nature Protection, while professional and expert support shall be provided by the Inter-agency Working Group.

V. THE PROCEDURE FOR TAKING MINUTES AND FOR PAPERWORK OF THE SESSION

15. The minutes of the Council session shall be taken by the staff of the Republic of Armenia Ministry of Nature Protection.
16. The session minutes shall state:
1) the session month, day, year and venue and the time the session began and was adjourned;
2) the session agenda;
3) names of the persons taking part in the session, including invitees and representatives of the Inter-agency Working Group and other organizations;
4) main points in discussions, presentations and speeches;
5) vote results and a Council member's differing view (if any), which shall be attached to the minutes;
6) adopted decisions and ways for their dissemination and publication.
17. When necessary, materials related to the issues under discussion, including draft legal and other documents (concept papers, strategies, reports, etc.), texts of written reports and speeches, and recommendations and opinions shall be attached to the session minutes.
18. The Council session minutes shall be signed by the Council Chairperson within 3 working days following the session.
19. The Council session minutes shall be kept in the office of the staff of the Republic of Armenia Ministry of Nature Protection.

VI. POWERS OF THE COUNCIL CHAIRPERSON AND OF THE COUNCIL MEMBERS

20. The Council Chairperson shall:
1) chair the Council sessions;
2) approve the Council session agenda and sign the Council session minutes;
3) hear progress reports on implementation of the decisions adopted by the Council and give instructions and recommendations;
4) make a decision as to whom shall be invited to the session;
5) perform other powers outlines in these Rules of Procedure.
21. In the absence of the Council Chairperson, the latter's duties shall be performed by the Deputy Council Chairperson.
22. Council members shall have the right:
1) to present issues for inclusion in the Council session agenda;
2) to present his or her opinion about the issues under discussion at the session orally or in writing.
23. It shall be incumbent on Council members:
1) to attend sessions;
2) to take part in voting when decisions are adopted;
3) to explore and present an issue when assigned (asked) to do so by the Council Chairperson;

4) to inform the Agency that he or she represents the issues discussed by the Council and to submit a report about the activities undertaken by the Agency that he or she represents.

VII. DISSEMINATION AND PUBLICATION OF INFORMATION ABOUT THE ISSUES DISCUSSED BY THE COUNCIL

24. The staff of the Republic of Armenia Ministry of Nature Protection shall submit Council session minutes or excerpts from minutes to all Council members within 5 working days following the session.

25. The decisions adopted by the Council shall be posted on the website of the Republic of Armenia Ministry of Nature Protection.

CHIEF OF STAFF
RA GOVERNMENT STAFF D. SARGSYAN

Annex III

Statement

of the delegation of the Republic of Armenia at the 18th session of the Conference of the Parties of the UN Framework Convention on Climate Change and the 8th Conference of the Parties serving as the Conference of the Parties to the Kyoto Protocol

Doha, Qatar, 5-7 December 2012

Since the date of adoption of the UN Framework Convention on Climate Change, the accumulation of greenhouse gases in the atmosphere and the global temperature in lower layers of the atmosphere continue to grow; therefore, it is obvious that we should take expeditious and stronger measures to reduce and limit greenhouse gas emissions.

Adaptation to climate change is a priority for Armenia because of the high vulnerability of its mountain ecosystems to climate change, and its geographic location in the arid zone with no access to the sea. Therefore, Armenia is involved in the informal negotiating group of 'landlocked mountainous countries'. The most vulnerable sectors are agriculture, water resources and natural ecosystems.

With respect to adaptation, Armenia has defined and continued to support 'ecosystem approaches'. These approaches, among other things, allow us to overcome uncertainties in predicting climate change, and provide synergies with other global and regional environmental conventions.

However, there are still concerns about the availability of relevant funding for adaptation. Price reductions in the carbon market make us look for alternative sources to the Adaptation Fund, which will have to enable the access of 'other developing countries' to adaptation funds (given their specific vulnerability to climate change)..

Regarding low-carbon development, Armenia considers the "common, but at the same time, differential approach" as fair given the different levels of countries' historical responsibility for the increase in greenhouse gases in the atmosphere and their negative impact on the economy and natural ecosystems as a result of climate change.

With adequate financial and technical support from developed countries and following axiomatic and principles of the "green economy", Armenia, as a developing country not included in Annex I of the Convention, is ready to take certain quantitative commitments not only for the reduction, but also for the limitation of the growth of greenhouse gas emissions (relative to current emissions) by gradually reducing the energy intensity of GDP. After the collapse of the USSR, the transition period was marked by a sharp economic downfall, which brought a reduction in greenhouse gas emissions (by 70% against 1990) – this level is almost unchanged. However, it is clear that this level cannot remain unchanged in the future, as the development of the economy may generate more emissions. That said, it can occur at a slower rate than economic growth due to the projected mitigation measures.

Mitigation measures per sector are communicated through the statement of Armenia in association with the Copenhagen Accords. The aforementioned is the firm position of Armenia in negotiations on the Durban Platform.

The Armenian government intends to develop and adopt the National Adaptation Plan, as well as National Appropriate Mitigation Actions by 2015.

Relevant to the consensus on the development of a new Protocol to the Convention on Climate Change, the role of the Kyoto Protocol is, and continues to be, diminished. Nevertheless, we keep to the position that, at present, the Kyoto Protocol should endure; its future should be determined by the content of the new Protocol.

In connection with the possibility of taking quantitative commitments in the future, we should consider the feasibility of CDM, particularly given current carbon-market prices.

However, we believe that: the CDM should be maintained; improvements to the mechanism must enforce control over the principle of additionality; clear rules are needed to avoid double accounting and leakage; strong compliance is necessary according to criteria for sustainable development of the host party; civil society should be involved, also in appeal procedures. We also consider the necessity to revise the methodological approaches of CDM projects to ensure synergy with other environmental agreements, as well as evaluations of full-cycle impact.

According to the Long-term Cooperative Action under the Convention, Armenia believes that these actions should be based on an ecosystem-based approach. This is also stipulated by the fact that climate change is caused not only by increases in greenhouse gases in the atmosphere, but also by disturbance to natural ecosystems. This, among other things, leads to changes in the radiation and thermal balances of the Earth. We consider that the target should be to limit the increase in global temperature to a maximum of 1.5 degrees Celsius.

The ecosystem approach, in combination with axiomatic and principles of the green economy, allows for many sectors to combine mitigation and adaptation actions. This will significantly increase the effectiveness of actions to address climate change; therefore, this approach deserves special attention and priority.

In conclusion, let me express my gratitude to the government and people of Qatar for their hospitality and excellent organization of the conference. We hope that the efforts of the countries gathered in Doha to prevent further climate change will not be made in vain.

Annex IV

Vulnerability to climate change and the adaptation action plan for Vayots Dzor marz of the Republic of Armenia

Within the framework of preparations for TNC on climate change the vulnerability assessment to climate change was done and were proposed adaptation measures for Vayots Dzor Marz (province) of Armenia, as a pilot region. The selection of this marz was based on the fact that it is quite specific for both its great diversity of natural conditions and diversified economic activities, as well as the relatively weaker influence of anthropogenic factors on its environment.

The work was carried out by Avenue Consulting Group LLC and Apricot Plus LLC. The description of the marz vulnerability features is based on various reports, analysis, and evaluations derived from discussions with stakeholders and experts.

The climate change impact adaptation policy framework and action plan is based on climate change vulnerability assessment for Vayots Dzor Marz and aims to support the development of resilience capacities of the marz to expected negative phenomena and climate change impacts. The special objective of this adaptation action plan is to finalize climate change adaptation measures from short-term, mid-term and long-term perspectives; to define principles for cooperation between state agencies, the private sector, public and non-governmental organizations, educational institutions, and other stakeholders. The implementation of these measures will contribute to mitigation and management of the climate change risks to the marz.

Background

Vayots Dzor Marz is located in the southeast of the Republic of Armenia: its territory is in the medium position (2,308 km^2) among other marzes, and has the smallest population. There are high mountains and deep gorges cutting through the terrain of the marz. The lowest point of the marz is 920 m (in Arpa Valley), and the highest point is 3,520 m (Vardenis mountain peak). Vayots Dzor covers the upper and middle streams of the Arpa river basins.

The territory of the Marz has vertical landscape zonality, where the landscapes are located in zones, including: lower mountain zone (1,400 m) with semi-desert and phryganoid landscapes; middle mountain zone (1,400-2,300 m) with steppe and forests; upper mountain zone (2,300 m) with subalpine and alpine meadows. The physical map of Vayots Dzor with the location of its meteorological stations is presented in Figure A-1 below.

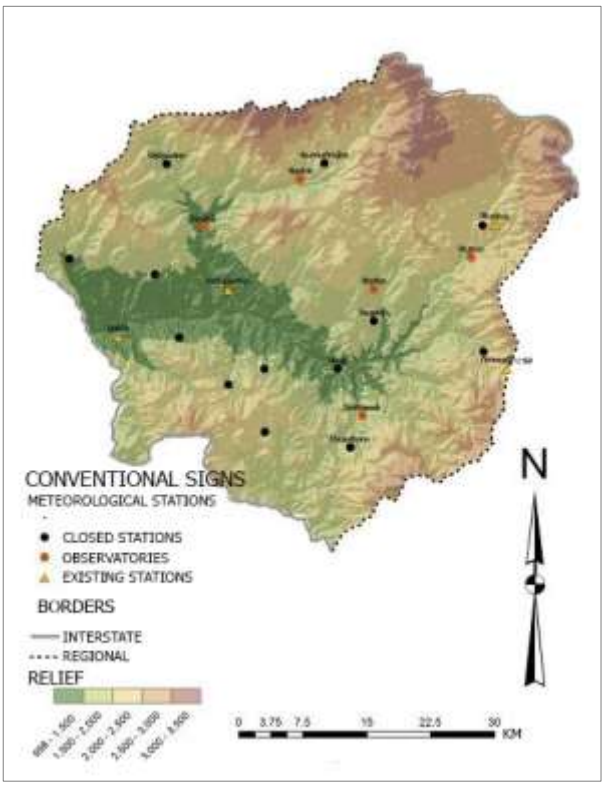

Figure A-1. The network of metereological stations in Vayots Dzor Marz

In the period of observations significant changes in climate change indicators in Vayots Dzor were observed, as well as in the entire territory of Armenia. Some of the climatic indicators and their changes are described below:

- Annual average air temperature in Jermuk is 4.8^{0}C; in Yeghegnadzor 10.8^{0}C; in Areni 12.3^{0}C. Monthly average maximum temperature is 26.1^{0}C (Areni), while the minimum temperature is -8.6^{0}C (Vorotan pass). Annual absolute minimum air temperature is -30.1^{0}C (Yeghegnadzor), while the maximum is 41.6^{0}C (Areni). Annual average air temperature of the marz com-

pared to the 1961-1990 average has increased by 0.8-1.7^{0}C.

- Annual maximum precipitation is 779 mm (Jermuk), while the minimum is 385 mm (Areni). Maximum monthly precipitation was recorded in April (103 mm) in Jermuk, while the minimum was in Areni (9 mm). Annual precipitation in the marz compared to 1961-1990 average has decreased by 4-6%.

Over the past 10 years, the Armenian Ministry of Emergency Situations has recorded cases of the following in the marz: severe hailstorms – 49, strong winds – 29, flooding – 26, abundant precipitation – 14, frost – 2, and drought - 3.

The PRECIS regional climate model was used for a quantitative assessment of climate change.

Table A-1. Annual (for 2030, 2070 and 2100) temperature and precipitation changes in Vayots Dzor Marz over the respective averages of the PRECIS model

Meteoro-logical stations	Temperature				Precipitation			
	Norm	2030	2070	2100	Norm	2030	2070	2100
Jermuk	4,8	6,2	8	10,8	779	719,0	657,5	613,1
Areni	12,3	13,7	15,5	18,3	385	355,4	324,9	303,0
Yeghegnadzor	10,8	12,2	14	16,8	417	384,9	351,9	328,2
Martiros	6,9	8,3	10,1	12,9	618	570,4	521,6	486,4
Vorotan pass	2,7	4,1	5,9	8,7	667	615,6	562,9	524,9
Vayk	10,4	11,8	13,6	16,4	411	379,4	346,9	323,5

Based on study's findings and subsequent analysis, it is expected that the temperature in the marz will continue to grow; by 2100 it will have increased by around 5-6^{0}C. The annual average temperature in the Arpa river basin will reach 16-20^0 C, while in highlands it will reach 8-10^{0}C (see Table A-1).

Agriculture

Agriculture is the leading sector in the economy of the marz; livestock production accounts for the principal share. The sub-sectors of livestock production include: cattle breeding, wool, goat breeding, apiculture, and aviculture. Horticulture and viticulture are the most popular sectors in terms of crop production.

Climate change poses serious threats to agriculture. It is expected that, by 2030, there will be an increase in temperature and decrease in precipitation: increased evaporation from soil will result in secondary salinization; heavy rains and floods will increase water erosion; droughts and hot, dry winds will accelerate soil erosion. The shortage of forage for animals in winter would trigger earlier starts and later endings of the grazing season - this would increase the depletion of pasture. It is expected that soil moisture will decrease by 10-30%. Availability of moisture for various agricultural crops will drop by 7-13%, while the water deficit in soil will increase by 25-30%. It is expected that climate change would lead to a decline in crop yields. According to projections for 2030 the main agricultural crop yields will fall by 8-14% (cereals by 9-13%; vegetables by 7-14%; potatoes by 8-10%; fruit by 5-8%). It is estimated that the area and productivity of pasture will drop by 4-10%. There might be a decrease in grasslands yield by 7-10%. The impact on livestock production will partly be due to the impact on pastures used for grazing animals.

The temperature rise, along with lower precipitation, will definitely lead to increased frequency of droughts, which will result in declined crop yields and the depletion of pasture. This in turn will lead to a reduction in livestock milk and meat yields. There will also be a drop in apiculture products.

In general terms, the key challenges faced by agricultural sector with regard to climate change include:

- Decrease in crop yields and losses associated with the increased frequency of extreme hydrometeorological phenomena;
- Decreased productivity of grasslands and pasture;
- Agricultural land degradation, poor fertility;

- Drop in apiculture products;
- Increased morbidity rate in agricultural animals, drop in animal milk and meat yields.

Thus, vulnerability-assessment findings show that the leading sector of the marz economy – agriculture and all its sub-sectors – is highly vulnerable to climate change in the medium and long term.

Water resources

The territory of Vayots Dzor is characterized by numerous rivers, rivulets and valleys, making its environment unique and diverse. The Arpa river is the main water artery of the marz, flowing 92 km though its territory, and with a catchment covering 2,080 km^2 (see figure A-2). It starts in the northwest of the Artsakh plateau – from a height of 3,200 m – and flows into the Araks river on the Turkish and Nakhichevan borders. The Arpa River has 20 tributaries, of which the largest is the Yeghegis. As of 1 January 2014 there are 24 small hydropower plants (SHPPs) operating in Vayots Dzor. Most of these SHPPs have been constructed on natural water flows.

Figure A-2. The Arpa River basin in Vayots Dzor marz

It is projected that, compared to the 1961-1990 baseline, river flow in the marz will drop by up to 6.7% (0.6 billion m^3) in 2030; by up to 14.5% (1.2 billion m^3) in 2070; by 24.4% or (1.8 billion m^3) in 2100. The biggest changes are expected to occur at altitudes of 1,700-1,800 m and higher, where the main river flow starts.

According to the projections, expected climate change will lead to decreases in precipitation and a rise in temperature, which in turn will cause reductions in the level and flow of waters, and changes in demand. Therefore, there will be a shortage of irrigation and drinking water. If we add up the predicted risks on natural flow change due to the operation of hydropower plants then risks of reduced water-resource availability will worsen.

The major challenge for water resources in the marz is creation of an efficient system for water use. This will not only address water-use problems in the marz, but will also reduce the risks associated with climate change.

In general terms, key challenges for water resources as a result of climate change include:

- Reduction in water resources (irrigation and drinking water);
- Irrigation systems in poor condition;
- Destruction of river beds, and flooding;
- HPP operation failure.

Natural ecosystems and biodiversity

Vayots Dzor Marz stands out in terms of comprehensiveness, diversity and complexity of its natural systems. A large range of elevations, the diversity of geological history, and broken terrain have formed a great variety of ecosystems in the area. The most important and widespread ecosystems include: alpine and sub-alpine meadows, sub-alpine tall grasses, forest vegetation, meadow-steppe, steppe, broad-leaf and juniper arid open forests, and phryganoids, as well as wetlands, solid rocks, scree, and rock streams. It should be noted that most of the natural ecosystems are in good condition and have undergone little change as a result of anthropogenic influence.

Projected climate change will have a serious impact on natural ecosystems and biodiversity, resulting in the extinction of hydrophilous vegetation, the intensification of desertification processes, and wind erosion of soil which, in turn, will increase xerophilous plant varieties in forests. In general, there will be serious changes in vertical distribution of ecosystem zones. Alpine meadows will shrink and phryganoid vegetation will cover larger areas. The vertical distribution of steppe and sub-alpine vegetation will change and there will also be some expansion of arid open forests.

Findings of comprehensive studies for vulnerability assessments emphasize that climate change will have a stronger impact on the vulnerability of natural ecosystems and biodiver-

sity; this vulnerability is expressed predominantly from a long-term perspective.

Key challenges for natural ecosystems and biodiversity of the marz include: creation of a system in the marz for conservation as well as the efficient use of resources. Such a system will contribute to improving social and economic conditions in the marz.

In general, the key challenges for natural ecosystems and biodiversity resulting from climate change include:

- Degradation of forests;
- Wind erosion of soil;
- Lack of conditions for plant and animal species' migration to higher and more favourable zones;
- Small territories for SPANS, and poor control;
- Exploitation of natural resources by individuals and businesses pursuing their economic interests.

Human health

Primary medical assistance continues to remain a priority issue for public health in Vayots Dzor Marz. Since 2006, the entire population of the marz has been included in free outpatient medical-assistance programmes. Due to expected increases in average temperature, the population (especially children and the elderly) may be exposed to higher health risks.

Vayots Dzor is the most endangered marz of Armenia with regard to temperature variation. Climate change directly or indirectly affects the health of the population. Direct consequences of heatwaves include: exacerbation of cardiovascular and chronic diseases, and injuries and death caused by dangerous weather phenomena. Indirect effects are expressed as increased morbidity rates and the spread of infectious and seasonal diseases caused by changes in habitat of causative agents, as well as inadequate provision of clean water and food security issues.

In general, health-related challenges arising from climate change include:

- Escalation of thermal diseases (thermal stress and discomfort);
- Exacerbation of cardiovascular diseases;
- Favourable conditions for the spread of infectious diseases;
- Water- and food-borne diseases;
- Increased injury and mortality incidence caused by dangerous climatic phenomena.

Infrastructures

In general, there is a sufficient road network in Vayots Dzor Marz. However, both municipal and community road infrastructure is in need of radical reconstruction and development. The Yerevan-Meghri-Iran interstate motorway runs across the centre of the marz. There are rock-fall, landslide, and rock-slide zones on 57 km section of intercity roads; there are similar problems on 33 km of community-to-motorway roads. 53.7% of community-to-motorway roads and 43.9% of intercommunity roads are asphalt or concrete paved. The general condition of roads inside communities is poor.

The region stands out for its landslide-prone sectors per unit of area. Despite the fact that incidences of recorded rock-fall events in 1994-2007 were not that high in the country as a whole, the highest incidence of rock-fall events was recorded in Shatin and Artabunk in Vayots Dzor along the motorway connecting the northeastern and southern regions of Armenia. Furthermore, mudflow-prone zones cover the entire territory of the marz; damage in 1994-2007 caused by recorded mudflows amounted to AMD 335 million.

Climate change impact on the marz infrastructure will be vividly expressed as a deterioration of road infrastructure caused by rock falls, mudflows and landslides. In addition to roads, communication infrastructure, residential housing, orchards and other vital facilities will be exposed to danger.

In 2010, the community and neighbourhood drinking-water supply network in Vayots Dzor Marz was extended by 15%.

When studying infrastructure, consideration should also be given to power generation. As already noted, there are 24 small hydropower plants in the marz. Reduction in river flows as a result of climate change will result in reduced power generation by hydropower plants.

In general, key challenges for infrastructure and settlements resulting from climate change include:

- Damage to motorways and community roads;
- Damage to agricultural land;
- Damage to vitally important facilities and residential housing stock;
- Damage to power-supply, water-supply and communication infrastructure.

Tourism

Tourism in is one of the leading and rapidly growing sectors of the economy in Vayots Dzor Marz. According to data provided by the local government in 2013, the number of tourists in the marz totalled 16,000. 69% of tourists visit the region from summer to autumn. It should be noted that most tourists visit Jermuk in summer and winter, while in autumn Yeghegnadzor is the most attractive site for its abundant viniculture and agricultural products.

The impact of climate change on the region's tourist industry will affect small catering and overnight hospitality businesses such as small hotels, guest houses and eateries.

Ambient air-temperature variation would significantly increase energy costs for ventilation, air conditioning and heating, thus increasing the cost of services. According to the assessment, climate change will increase the incidence of rock falls, mudflows, and flooding, which would hinder tourists from making visits and excursions.

In general, the key challenges for the tourist industry resulting from climate change include:

- Increased service costs due to increased costs for ventilation/heating;
- Poor road conditions;
- Security for tourists;
- Damage to environmental and historical/cultural monuments.

Table A-2. Adaptation Action Plan for Vayots Dzor Marz

	Action	Goal	Implementing entities	Subsectors	Monitoring and assessment indicators	Time frame	Costs
1.	Introduction of early-warning and -response systems for hazardous hydrometeorological phenomena	Hazardous hydrometeorological phenomena impact mitigation	RA Ministry of Emergency Situations, RA Ministry of Agriculture, Regional centres for agricultural support	All subsectors	Number of early-warning systems	Medium term	High
2.	Establishment of legal framework to promote introduction of mechanisms for development of insurance systems against damage caused by natural disasters to public and private property, and for damage evaluation and indemnity	Mitigation of damage caused by natural disasters	RA Ministry of Finance, Insurance companies	Infrastructure	Number of legal acts for the sector	Long term	Medium
3.	Agriculture risk assessment for climate change, and introduction of insurance system	Mitigation of climate change impact and adaptation enhancement	RA Ministry of Agriculture, RA Ministry of Finance, Insurance companies	Agriculture	Number of laws and regulations promoting introduction of risk-assessment and insurance systems	Long term	High
4.	Provision of state financing for landslide, mudflow, flooding, and rock-fall studies	Mitigation of impact of said events	RA Ministry of Emergency Situations, RA Ministry of Urban Development, RA Ministry of Finance	All subsectors	Maps for landslide, mudflow, flooding, and rock-fall areas	Medium/Long term	High
5.	Integration of hazardous climatic phenomena risks into planning of investment programmes and land-development projects, as well as ensuring strict control over land development activities	Climate risk assessment in planning of investment programmes and land-development projects	RA Ministry of Urban Development, Local governments	All subsectors	Mandatory control over availability of integration of risk factors into work programmes	Medium term	Medium
6.	Improvement of terms and conditions of state-subsidized lending for loan types targeted at the introduction of new mitigation technologies	Climate risk mitigation, promotion of new technologies	RA Ministry of Agriculture, RA Ministry of Finance, Local governments	All subsectors	Number of subsidy programmes, loans provided	Medium term	High

	Action	Goal	Implementing entities	Subsectors	Monitoring and assessment indicators	Time frame	Costs
7.	Construction of local-use reservoirs	Water-resource conservation and safe supply	RA Ministry of Territorial Administration, Local governments	Agriculture, water resources	Number of local reservoirs	Medium term	High
8.	Selection and cultivation of more drought-resistant and xerophilous hybrids adapted to local conditions, including maintenance and dissemination of traditional crop varieties with these properties	Crop-loss reduction	Agriculture scientific-research institutions, Regional centres for agricultural support, Farmers	Agriculture	Yield volumes; yield volume from local, traditional varieties	Short term	Medium
9.	Installation/upgrading of drip and/or sprinkle irrigation systems	Efficient use of water resources	Farmers, NGOs, Experts	Agriculture, water resources	Number of new irrigation systems	Short term	Medium/ High
10.	Introduction and development of anti-hail systems	Crop-loss reduction	RA Ministry of Emergency Situations, RA Ministry of Agriculture, Farmers	Agriculture	Volume of lost crops	Short/Medium term	Medium
11.	Planting of slopes, and establishment of terraces	Soil-erosion prevention	Local governments, Armforest SNCO, RA Ministry of Nature Protection	Natural ecosystems and biodiversity	Area of mountain slopes covered with vegetation, number of slopes with new terraces	Medium term	Medium
12.	Forest-planting, forest-density improvement, as well as organization of comprehensive measures for forest-wildfire prevention	Forest protection, reduction of landslides and mudflows	Armforest SNCO, RA Ministry of Emergency Situations, RA Ministry of Nature Protection, Local governments	Natural ecosystems and biodiversity	Number of forest wildfires, amount of damage caused by forest wildfires, amount of damage caused by forest landslides	Medium/Long term	Medium
13.	Pasture load-pressure planning	Prevention of pasture degradation, prevention of overuse	Local governments, RA Ministry of Agriculture, Farmers	Agriculture, natural ecosystems and biodiversity	Pasture productivity	Medium term	Medium
14.	Strengthening of preventive veterinary systems	Prevention of animal diseases	RA Ministry of Agriculture, RA Ministry of Health, Local governments	Agriculture	Number of infected animals	Medium term	Medium

	Action	Goal	Implementing entities	Subsectors	Monitoring and assessment indicators	Time frame	Costs
15.	Change irrigation and fertilization norms taking into account climate change	Mitigation of climate change's adverse impact, increased fertility level	RA Ministry of Agriculture, Agricultural research institutions	Agriculture	Fertility indicators for various crops	Medium term	Low
16.	Complete renovation of water-supply network, which will include introduction of efficient and advances irrigation systems	Saving water resources, preventing leakage	ArmWaterSewerage Co., State Water Administration under RA Ministry of Territorial Administration, RA Ministry of Agriculture	Water resources, infrastructure, agriculture	Quantity of leakage, areas irrigated by advanced technology use, number of respective draft laws	Medium term	High
17.	Regulation of river flows, as well as resuming monitoring of ground water, refurbishment of hydrological observation points and optimization of the network	Assessment of water resources, improvement of hydrological observation quality	RA Ministry of Territorial Administration, RA Ministry of Emergency Situations	Water resources	Surface- and ground-water monitoring reports, number of refurbished hydrological observation points	Medium term	Medium/ high
18.	Preparation of water-resource newsletters, and development of new regulations for long-term planning for water-resource use	Assessment of water resources	Research institutions, RA Ministry of Nature Protection	Water resources	Newsletters, long-term planning regulations	Medium term	Medium
19.	Construction of river-bank protection engineering facilities in flooding-prone sectors, periodic cleaning of riverbeds, bank enlargement or raising, installation of observation points for studying mudflows	Flooding impact mitigation, mudflow impact mitigation	RA Ministry of Emergency Situations, Local governments	Water resources, infrastructure and settlements	Number of shore-protection facilities, number of mudflow observation points	Medium term	High
20.	Reconstruction of water-supply system, ensuring round-the-clock water supply	Ensuring round-the-clock water supply, prevention of infectious diseases	Water utilities	Water resources, human health, infrastructure	Water-supply hours, periodic water-quality monitoring, number of water-borne diseases	Medium term	High
21.	Renovation and/or construction of sewer, collector and drainage infrastructure	Improvement of sanitary/hygiene conditions	RA Ministry of Territorial Administration, water-utility companies	Infrastructure, water resources	Number of water-borne diseases	Medium term	High
22.	Expansion of borders of SPANs, as well as the creation of conditions for ex-situ conservation of	Conservation of marz-specific flora and fauna	RA Ministry of Nature Protection	Natural ecosystems and biodiversity	The territory under SPANs, ex-situ number of high-mountain rare species	Medium term	Medium

	Action	Goal	Implementing entities	Subsectors	Monitoring and assessment indicators	Time frame	Costs
	high-mountain rare species, e.g. in Jermuk						
23.	Organization of training on the importance of ecosystem conservation for representatives of the general public and businesses, including travel companies	Increasing awareness among general public and businesses	RA Ministry of Nature Protection, Non-governmental organizations	Natural ecosystems and biodiversity	Number of organized training courses, number of participants in training	Medium term	Medium
24.	Implementation of research and monitoring for sanitary/hygiene and for infectious-disease carriers and transmitters	Preventing the spread of diseases	RA Ministry of Health	Human health	Number of violations of sanitary/hygiene norms, number of infectious-disease carriers and transmitters	Medium term	Medium
25.	Provision of proper conditions for medical assistance and training for medical staff in all communities	Preventing the spread of diseases	RA Ministry of Health	Human health	Number of renovated primary medical-assistance institutions, number of staff trained	Medium term	Medium/ High
26.	Upgrading of guesthouse ventilation, heating, sanitation systems, and improvement of roofs and windows	Increased service level offered by guest houses	Entrepreneurs doing business in the tourist industry	Tourism	Number of restored structures, specific weight of energy costs in one customer-service expenditure	Medium term	Medium/ High
27.	Reinforcement of summer pavilions, seasonal structures for leisure and recreation	Increase safety level of summer pavilions, seasonal structures for leisure and recreation	Entrepreneurs doing business in the tourist industry	Tourism	Number of restored structures	Short term	Low
28.	Periodic inspection of the state of natural and historical/cultural monuments, and investment planning for restoration works	Protection of natural and historical/cultural monuments	RA Ministry of Culture, RA Ministry of Nature Protection	Tourism	Annual reporting on the state of monuments	Medium term	Low

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