REPUBLIC OF ARMENIA

SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE

A REPORT UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

REPUBLIC OF ARMENIA
MINISTRY OF NATURE PROTECTION

SECOND NATIONAL COMMUNICATION

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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FOREWORD

Global climate change is one of the serious contemporary challenges faced by the mankind. The impacts of climate change are already felt across the globe. The Republic of Armenia, as a mountainous land-locked country, is characterized by vulnerable ecosystems, arid climate, active exogene and desertification processes and frequent natural disasters, which make the country more sensible to the impacts of climate change.

The Republic of Armenia ratified the UN Framework Convention on Climate Change in May 1993, and the Kyoto Protocol - in December 2002. According to Articles 4.1 and 12.1 of the UNFCCC, Armenia regularly carries out its commitments, defined for the non-Annex I Parties to the Convention, as well as participates in international cooperation and regional programs related to climate change.

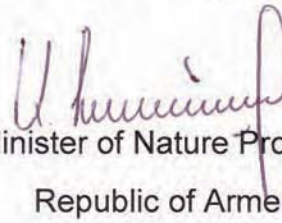
The First National Communication of the Republic of Armenia was prepared and submitted to the Fourth Conference of Parties to the Convention in November 1998.

The greenhouse gas emissions of the Republic of Armenia are rather small - currently accounts for approximately 0.02% of the global emissions. As a non-Annex I Party to the UNFCCC, Armenia does not have quantitative commitments to reduce greenhouse gas emissions, however, realizing the importance of supporting global efforts of greenhouse gas emissions reduction, the Republic of Armenia is voluntarily taking measures and implementing projects targeted at emissions reduction and climate change mitigation, in general. The country is also consistently mainstreaming climate change issues into national development programs and documents.

The Republic of Armenia continues implementing wide-scale awareness raising activities on climate change to contribute to the reduction of climate change risks and building resilience to the projected impacts of climate change in the country.

On behalf of the Government of the Republic of Armenia I extend my sincere appreciations to the Global Environment Facility for the financial support, the UN Development Program for supporting the preparation of Armenia's Second National Communication to the UNFCCC, as well as to all national experts and specialized institutions for their contribution to the preparation of the Communication.

Aram Harutyunyan



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ABBREVIATIONS

ACDP	Asian Center for Disaster Preparedness
AMD	Armenian dram
AMSL	Above mean sea level
Armstatehydromet	State Hydro-meteorological and Monitoring Service of the Republic of Armenia
ATP	Armenia Tree Project
BUFR	Binary Universal Form for the Representation
CCHF	Crimean-Congo Haemorrhagic fever
CDM	Clean Development Mechanism
CIS	Commonwealth of Independent States
CJSC	Closed joint-stock company
DNA	Designated National Authority for Clean Development Mechanism
DOC	Degradable organic carbon
DWD	German Meteorological Service
EBRD	European Bank for Reconstruction and Development
ECA&D	European Climate Assessment and Dataset
GCM	Global Circulation Model
GCOS	Global Climate Observing System
GCS	Global Communication System
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographical Information System
GSN	Global Surface Network
GUAN	Global Upper Air Network
HPP	Hydropower plants
IPCC	Intergovernmental Panel on Climate Change
IPCC GPG	IPCC Good Practice Guidance
KFW	German Bank for Reconstruction and Development
KSA	Key source analysis
LRTAP	Long Range Transboundary Air Pollution
LULUCF	Land use, land use change and forestry
MCF	Methane correction factor
MSW	Municipal solid waste
MSWD	Municipal solid waste disposal
n/a	Not available
n/e	Not estimated
NGHGI	National Greenhouse Gas Inventory
NGO	Non-governmental organization
n/o	Not occurring
RA	Republic of Armenia
REC	Regional Environment Centre
PPP	Purchasing power parity
SNC	Second National Communication
SNCO	State non-commercial organization
SPANs	Specially protected areas of nature
TPP	Thermal power plant
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States dollar
WB	World Bank
WM	With measures (scenario)
WMO	World Meteorological Organization
WTO	World Trade Organization

Units of Measurement

mm	millimeter
m	meter
m^3	cubic meter
km	kilometer
km^2	square kilometer
km^3	cubic kilometer
Gg	gigagram (10^9 g)
t	ton
toe	tonne oil equivalent
PJ	petajoule (10^{15} J)
GWh	gigawatt hour (10^6 kWh)
MW	megawatt
m/s	meters per second
^oC	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 GW h=23.88 * 10^3 toe

Global Warming Potential of Gases

CO_2 = 1
CH_4 = 21
N_2O = 310

Executive Summary

The Second National Communication (SNC) of the Republic of Armenia (Armenia) is prepared 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 data included in the SNC refer to the period from 1998 (submission year of the First National Communication on Climate Change) to 2006.

The First National Communication of the Republic of Armenia on climate change includes the 1990 greenhouse gas (GHG) inventory, the 1994-1996 GHG emissions trends, mitigation measures, projection of emissions until 2010, assessment of Armenia's vulnerability to climate change and the general characteristics of adaptation measures.

In Armenia's SNC, studies and assessments related to climate change issues are enhanced, considering the new developments within the country and under the UNFCCC after the submission of the First National Communication. Activities conducted in the country under the SNC allowed to:

- Improve and expand the database of the national GHG inventory and analyze the emission trends for 1990-2006;
- Assess the potential for reducing GHG emissions in various sectors of the economy;
- Develop climate change scenarios for Armenia;
- Assess the vulnerability of ecosystems and climate-dependent sectors of the economy and define priority adaptation actions for mitigating the consequences of climate change;
- Assess the impact of the projected intensification of dangerous hydro-meteorological phenomena and the related early warning needs;
- Asses improvement needs of the national system for systematic observation and climate monitoring;
- Enhance knowledge and public awareness on climate change issues and promote to improvement of the qualifications of climate change specialists.

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 a social state governed by the rule of law. In the Republic of Armenia, the state power is exercised 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 the 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.

The Government is comprised of the Prime Minister, Deputy Prime Minister and Ministers. Currently, the Government has 18 ministries and seven agencies - services, departments, committees.

The Republic of Armenia has a three-tier governance system - central state governance, regional state governance and local self-governance.

The administrative-territorial units of the Republic of Armenia are marzes and communities. The Republic of Armenia is divided into 11 marzes, including Yerevan, and 931 communities - 60 urban and 871 rural. The largest cities are Yerevan (1,104.9 thousand residents), Gyumri (147.71 thousand residents) and Vanadzor (105.2 thousand residents).

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, Council of Europe - since 25 January 2001, and World Trade Organization (WTO) - since 5 February 2003.

As of 2008, the Republic of Armenia has established and maintains diplomatic relationships with 153 states.

Geographical location and natural resources

The Republic of Armenia is located in the north-east of the Armenian Highlands, at the border of Caucasus and Western Asia.

Armenia borders Georgia from the north, Azerbaijan from the east, Turkey from the west and southwest, Iran from the south.

The territory of the Republic of Armenia is 29,743 square kilometers.

Armenia is a mountainous country: 76.5% of the territory has altitudes of 1000-2500 meters above sea level.

According to the Land Balance for 2006, agricultural lands account for 71.6%, forest lands - 12.5%, protected natural areas - 7.4%, water areas - 0.9%, settlements, industries, communications, transport and utility infrastructures - 5.4% and other types of lands - 2.2% of the territory of Armenia.

Armenia is characterized by rich biodiversity - more than 100 species per square kilometer.

The forest covered area in Armenia is rather small - only 10.4% of its territory is covered with forests. Forests are distributed unevenly. About 270 species of trees and bushes grow in forests, of which the main forest building species are oak, beech, hornbeam and pine.

Rivers of Armenia are influents of the largest rivers of Caucasus - Araks and Kura Rivers. About 9500 small and medium size rivers flow in Armenia, the total length of which amounts to 25,000 kilometers. The longest rivers are Araks (1072km), Vorotan (179km), Debed (178km) and Hrazdan (146km). There is a wide range of river network density in the country, varying within the limits of 0-2.5 km/km^2.

The average annual flow of surface waters amounts to 6.8 billion cubic meters, the volume of underground water resources is about 4.0 billion cubic meters.

The largest lake in Armenia is Lake Sevan - one of the highest mountainous freshwater lakes in the world. The current (2006) level of the Lake is 1,898 meters, the mirror surface amounts to 1,257km^2, and the volume is 33.4 km^3. Armenia has one hundred small mountainous lakes with a total volume of 0.8 km^3.

Climate

Armenia is a country of climate contradictions; even on small distances, one can see substantial changes of climate because of the complex terrain. The country has almost all types of climate - from arid subtropical to cold high mountainous.

The average annual temperature of the air is 5.5°C. The highest annual average temperature is 12-14°C. At altitudes above 2500 m, the average annual temperatures are below zero.

The summer is temperate, at the end of July the temperature is 16.7°C, and in Ararat valley it varies between 24-26°C. The highest absolute temperature ever recorded is 43°C.

Winters are cold. January is the coldest winter month, with an average temperature of -6.7°C. The absolute lowest temperature ever recorded is -42°C. Winters in north-eastern and south-eastern 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. The annual precipitation here is around 200-250 mm. Maximum precipitation is recorded in high mountainous areas at around 1000 mm per year. In Ararat valley, the average precipitation in summer months does not exceed 32-36 mm.

The average annual wind velocity in Armenia is distributed unevenly in the range of 1.0-8.0 meters per second. In some regions, particularly in Ararat valley, mountain valley winds are quite common. In summer, their velocity reaches 20 m/s and over.

Population

The population of the Republic of Armenia at the end of 2006 was 3,222.9 thousand and the average population density was 108 person/km$^{2.}$

The distribution of the population is very uneven, which is due to the mountainous terrain of the country and the level of economic development in various areas. The maximum density of population, 686 person/km^2, is recorded in altitudes up to 1000 m, while the minimum - 22 person/km^2, is noted in altitudes of 2000-2500 m.

Men constitute 48.3% of the population, women-51.7% (2006). The average life expectancy is 73.3 years - 70 years for men and 76.4 years for women (2006).

As of 1 January 2007, the number of the economically active population is 1,181.3 thousand. In 2000-2006, 64% of the population was urban, and the remaining 36% - rural.

The natural growth of population per thousand people has declined from 15.6 (1990) to 3.2 (2006).

Economy

After the sharp economic decline of 1991-1994, overcoming the difficulties of the transition period, Armenia was able to ensure economic stability and growth. Economic growth in 1995-2000 amounted to an annual average of 5.4%, and in 2001-2006 the average growth rate was 12.4%.

In 2006, Armenia's gross domestic product (GDP) amounted to 2,657.1 billion drams (USD 6,386.7 million); the per capita GDP was USD 1,982.8 (with a PPP equivalent of USD 4,995). Structural changes of the economy resulted in changes to the composition of GDP - with a decrease in the share of industrial production and an increase in the share of construction and services. In 2006, the GDP had the following composition - industrial production - 17.9%, agriculture - 18.1%, construction - 24.5%, services - 32.3%, and net taxes -7.2%.

Priority issues for economic development of the country are addressed in the frames of the 2008-2012 Socio-Economic Development Program of the RA Government, the Sustainable Development Program, and the Millennium Development Goals.

Energy

Armenia does not have its own fuel resources and the fuel demand is met through imports. Armenia produces around 31% of its energy by its own primary energy sources (hydro-energy and nuclear energy).

The main fuel type is natural gas. In 2000-2006, the share of natural gas in the total fuel consumption amounted to 70-79%. The composition of energy consumption is characterized by the large share of natural gas (53.6%) and nuclear energy (25.1%).

In 2006, the total energy consumption in Armenia amounted to 114.2 PJ (34% of the 1990 level). The main areas of fuel consumption are transportation (26.6%), power production (23%) and the housing sector (22%).

Power is produced by thermal power plants (TPP), the nuclear power plant (NPP) and hydropower plants (HPP). In 2006, power production amounted to 5,941 GWh, where the share of TPPs was 25%, NPP produced 43% and HPPs accounted for 32% of the production.

Heat energy is produced in thermal power plants and boiler houses in the housing and public/private sectors. In 1992-1994, the economic and energy crisis and removal of subsidies resulted in the collapse of the district heating system. In 2006, the total heat energy production for industrial and municipal needs amounted to only 6% of its volume in 1990. In the housing sector, heating and hot water are supplied mainly by individual gas fired and electrical appliances. In 2005, programs for phased rehabilitation of district heating systems using energy efficient technologies were implemented. Centralized heating of public/private sectors is being restored at fast rates. In 2000-2006, heat energy production increased by 1.5 times.

The fast rates of gasification are an important factor in ensuring stable energy supply. In 2007,

the level of gasification was 85%.

The basis for long-term energy policy in Armenia is the Strategy for Development of the Energy Sector within the Context of the Economic Development of the Republic of Armenia, which defines the ways for creating a safe, efficient and sustainable energy sector in Armenia. In particular, the strategy envisages an increase in the share of renewable energy, by constructing new HPPs and wind turbines, as well as modernization of TPPs and construction of a new energy block in the NPP.

Industry

In 2006, the industrial output volume in Armenia amounted to 78% of the 1990 level.

Industrial output of Armenia has the following composition by types of economic activity - electricity, gas and water production and distribution - 17.4%, processing industries - 65%, mining industry - 17.6% (2006).

The processing industry includes food production (48.6%), metallurgy (26.1%), construction materials (7.5%), chemical production (4.4%), machinery production (4.2%), jewelry production (1.5%), light industries (1.2%) and other sectors (6.5%).

The share of industrial production in the total fuel consumption is 16.2%.

Transport

The transport sector in Armenia includes railway, vehicle, air and pipeline transportation routes.

As a result of significant structural changes in the economy and the transportation blockade, substantial changes have occurred in the transport sector of Armenia since 1990 - the overall shipment volume reduced by four times and passenger transportation declined by 2.8 times.

In 2006, the share of pipeline routes transportation in the total volume of shipments amounted to 67.1%, rail transportation - 28.5%, vehicle transportation - 3.9%, and air transportation - 0.5%. In the overall passenger transportation volume, vehicle transportation's share was 69.2%, air transportation - 25.8%, and rail transportation - 0.5%. The fuels used for vehicle transportation for 2006 are gasoline (43.2%), diesel fuel (21.5%), compressed natural gas (35.1%) and liquid gas (0.2%).

Agriculture

Armenia's agricultural lands constitute 2,129.6 thousand hectares, including arable land - 452.9 thousand hectares (21.3%), perennial plantations - 27.3 thousand hectares (1.3%), grasslands - 127.5 thousand hectares (6%), pastures - 1,125.0 thousand hectares (52.8%), other lands - 396.9 thousand hectares (18.6%). The surface of perennial plantations in backyards and orchards of settlements amounts to 23.8 thousand hectares.

Farming in Armenia needs irrigation, and more than half of the agricultural lands is irrigated. The main agricultural crops are cereals, potato, fruits, grape and vegetables. The main livestock are cattle and ruminants.

As a result of the agrarian reform and land privatization, large agricultural farms were broken down into 338 thousand small farms. The areas and composition of agricultural lands changed - arable lands shrunk by around 30% and perennial plantations - by around 50%. The number of livestock also shrunk. The area of irrigated lands reduced by two times and the use of fertilizers declined by three times.

In 2000-2006, the average annual growth in agriculture production amounted to 7.7%. In the same period, the share of crops production in the gross agricultural production was 57% on average, while the share of livestock production amounted to 43%.

Within the GDP, the share of agriculture in 2000-2006 was 21.7% on average. Around 502 thousand people, or 43% of the economically active population, are employed in farms.

The Strategy for Sustainable Agricultural Development of Armenia (2006) aims to increase the level of agricultural production.

Forestry

Armenia's forest land is 373.0 thousand ha, and the forest covered area is 308.5 thousand hectares (10.4% of the country's territory). Forests are mainly in altitudes of 550-2400 meters above sea level, on steep slopes and very fragmented mountainsides. Forest covered areas are distributed unevenly - 62.5% of forests are in the north-eastern part of Armenia, 21.6% in the south-eastern, 13.5% - in the central part and 2.4% - in the south.

According to the Forest Code (2005), Armenia's forests are categorized as forests with protective, special and production significance.

Mass logging of forests as a result of the energy crises in 1990s, had serious negative impacts on forests and forestry.

The National Forest Policy and Strategy of Armenia and the National Forest Program of Armenia (2005) aim to ensure the protection, restoration, natural regeneration and sustainable use of forests.

Waste

In 2000-2007, the average annual volume of municipal solid waste (MSW) generated in the country was 595 thousand tons, or 289 kilograms per city resident. MSW is collected, transported and stored in 48 managed landfills.

In all landfills, waste is accumulated without preliminary sorting and separation, and they are partially decontaminated by covering with a layer of gravel. In 2006, the organic carbon decomposed in MSW amounted to 68.5%. Storing large quantities of MSW in landfills, results in anaerobic fermentation and methane emissions.

Municipal wastewaters include household, commercial and, partially, industrial waste waters. In 2006, the volume of wastewater discharge in Armenia amounted to 174 million cubic meters, from which 59.8 million cubic meters from treatment facilities. The 20 waste water treatment facilities built before 1970s are in extremely poor technical conditions; they are non-operational and waste waters are discharged into surface waters without treatment. The sediment waste accumulated in the bulky equipment of the treatment plants are not decontaminated and part of the generated methane is emitted into the atmosphere.

Since 2008, the restoration and modernization of wastewater treatment plants and sewage networks have started in Armenia with international financial support.

Legal and institutional bases for implementation of UNFCCC

The Republic of Armenia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and the Kyoto Protocol in 2002. By a Decree of the Government of Armenia, the Ministry of Nature Protection has been appointed as the Designated National Authority (DNA) for the Clean Development Mechanism (CDM) of the Kyoto Protocol, one of the main functions of which is to approve the compliance of CDM projects with the requirements of the Kyoto Protocol, as well as to ensure effective participation of Armenia in international CDM processes. 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.

2. National greenhouse gas inventory

The GHG inventory includes the assessments of GHG emissions and sequestration of GHG not controlled by the Montreal Protocol in the period of 1990-2006.

The main GHG is carbon dioxide. In 2000, in the total GHG emissions, without “Land use, land use change and forestry (LULUCF)” sector, the share of carbon dioxide amounted to 62.8%, methane - 34.2% and nitrous oxide - 3%.

Carbon dioxide emissions in 2006 declined by 81% compared to the 1990 level, methane - by 38% and nitrous oxide - by 42% (Table ES-1).

In 2000, the total GHG emissions reduced by 80% compared to the baseline (1990). The sharp decline in emissions is due to the energy and

Table ES-1 Greenhouse gas emissions in Armenia (Gg CO_2 eq)

Gas	1990	1994	2000	2006
CO_2	**21558.5**	2994.8	**3187.2**	4157.0
CH_4	**3200.5**	1557.3	**1733.3**	1986.5
N_20	**195.9**	106.9	**151.8**	279.3
Total emissions, without LULUCF	**24954.9**	4679.0	**5071.3**	6422.8
Total emissions, with LULUCF	**24218.9**	n/e	**6634.9**	n/e

economic crisis of 1992-1995, and the following significant changes in the economy - decline in the share of industrial production and increase in the share of non-production sectors, as well as prevalence of natural gas consumption.

increased from 4% to 17.9% (16.5% in 2000), the "Waste" sector share grew from 2.3% to 7.9% accordingly (in 2000 - 11%) and "Industrial processes" sector - from 2.5% to 5% (in 2000 - 2.4%). Rapid

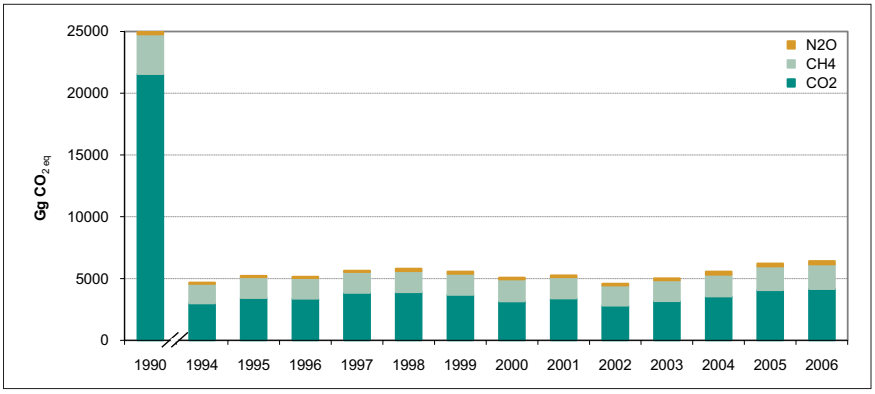


Figure ES-1 Greenhouse gas emissions by gases, 1990-2006 (without LULUCF)

Table ES-2 Greenhouse gas emissions/removals by sectors (Gg CO_2 eq)

Sector	1990	1994	2000	2006
Energy	22777.0	3268.6	3550.6	4441.4
Industrial processes	630.3	53.0	119.7	323.8
Agriculture	982.6	812.6	840.7	1149.5
Waste	564.9	544.9	560.3	508.0
LULUCF	-736.0	n/e	1563.62	n/e

The "Energy" sector accounts for the major part of the total GHG emissions in 1990-2006 (Table ES-2). However, the share of the "Energy" sector emissions reduced in the mentioned period - from 91% in 1990 to 64.7% in 2006 (70% in 2000). In the same period, the "Agriculture" sector share

changes in emission/removals balance have taken place in the "LULUCF" sector: from -736 Gg in 1990 to +1563.6 Gg in 2000, which is mainly due to an increase in the volume of forest logging and loss of quality of arable lands and meadows.

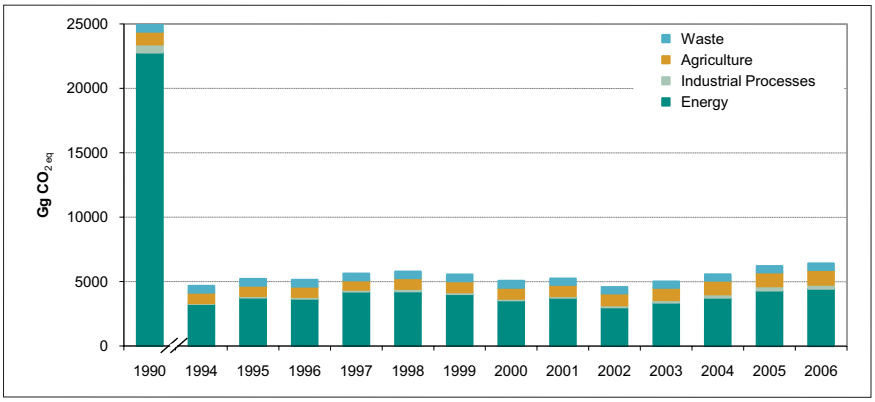


Figure ES-2 Greenhouse gas emissions by sectors, 1990-2006 (without LULUCF)

The total emissions of indirect GHG (NO_X, CO, NMVOC) and SO_2 shrunk by 76% in 1990-2006 (from 406 Gg to 95 Gg). This reduction in emissions is also a result of the above-mentioned circumstances.

GHG emissions per capita (CO_2 eq) have dropped from 6.9 tons in 1990 to 1.6 tons in 2000 with slight growth to 2.0 tons in 2006.

3. Policy and measures to mitigate climate change

Armenia's climate change policy is formulated within the framework of the status of the country under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. As a non-Annex I Party to the UNFCCC, Armenia does not have quantitative commitments for reducing GHG emissions.

However, acknowledging and supporting the objective of the Convention, as well as taking into account that reduction in GHG emissions is in line with the economic, energy and environmental objectives of the country, Armenia has passed a number of laws and is implementing national and sectoral development programs, which contribute to the reduction of GHG emissions. At the same time, due to mitigation projects implemented through the Clean Development Mechanism of the Kyoto Protocol, Armenia has a certain potential for emissions reduction transfer.

Legislation

Armenia has passed several laws and Government decrees, which define policies in areas relevant to climate change mitigation. Some of the key ones include:

Laws

- Law on atmospheric air protection (1994)
- Law on energy (2001)
- Law on energy saving and renewable energy (2004)
- Forest Code (2005)

Government decrees

- On approval of the order on examination of norms of maximum permissible emissions design documents of organizations with stationary sources of atmospheric air polluting emissions and on granting emission permits (2008).
- On approval of maximum permissible concentration of air polluting substances in settlements and maximum permissible norms of hazardous substances in emissions from vehicles used in the Republic of Armenia (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 (2006).
- On approval of the action plan to meet the commitments of the Republic of Armenia under a number of environmental conventions (2004).
- On norms and permits of maximum permissible emissions of atmospheric air polluting substances and maximum permissible level of harmful physical impact (1999).

National programs

- Sustainable Development Program (2008)
- Second National Environmental Action Plan (2008)

Sectoral programs

Measures contributing to GHG reduction by sectors are planned in the following programs:

Energy

Energy Sector Development Strategy in the Context of Economic Development of Armenia (2005). The strategy covers the period until 2025 and aims at addressing the following issues: contribute to sustainable economic development of Armenia and ensure energy security, including the classification of imported and local energy reserves; maximum utilization of renewable and nontraditional sources of energy; promotion to energy saving; and environmentally friendly energy supply in line with the international commitments of Armenia. The strategy includes projected energy consumption indicators in the sectors of economy and the list of projects for development of electrical energy, gas supply and heat supply sectors by implementation periods.
Program of Actions of the Ministry of Energy

based on the Provisions of the National Security Strategy (2007). The program is based on the provisions of the energy strategy and plans the following energy capacity exploitations and measures by 2025: construction of new HPPs with 540 MW capacity (including 260 MW from small HPPs); construction of wind turbines with 200 MW capacity; modernization of the currently operational two TPPs by gas turbine installations with a total capacity of 648 MW; construction of 1000 MW new energy block in the Armenian nuclear power plant (NPP); modernization of power transmission and distribution networks in order to reduce losses; construction of Iran-Armenia gas pipeline; restoration of underground storage facilities for natural gas with the volume of 150 million cubic meters; restoration of heat supply with maximum use of geothermal, biogas, solar and other renewable energy sources; and wide scale introduction of sustainable measures ensuring energy saving.

National Program for Energy Saving and Renewable Energy (2007). The program provides assessment of the energy saving potential in power supply, heat supply and gas supply systems in the industrial production, transportation, housing and public sectors, as well as assessment of the potential for renewable energy and measures for effective exploitation of the energy saving potential.

Restoration, modernization and expansion of Armenia's gas supply system. The measures implemented contribute to significant reduction of natural gas (methane) leakages at present and in the future. One of the projects of "ArmRosgasprom" CJSC to reduce methane leakages in gas distribution system is developed under the CDM.

Tariff policy. Armenia carries out an energy tariff policy which contributes to the development of renewable energy and creation of favorable conditions for attracting investments in the sector. Privileged tariffs and purchase guarantee are defined for electricity produced by small HPPs, wind turbines and biogas facilities and for electricity produced in combined production systems based on useful heat demand.

Transport

The Action Plan for Reducing Emissions of Hazardous Substances from Vehicles (2005). The 26 measures of the program aim to record emissions, improve transport traffic and transportation flows, develop public transportation (including electrical means of transportation), and promote the use of clean engine fuels. The measures are planned for the period of 2005-2013.

Yerevan Master Plan (2006-2020). The master plan aims to reduce emissions from vehicles by 20% until 2020 through development of electrical transportation, implementation of the new transportation scheme for the city and application of neutralizers.

The increase in the share of natural gas, as engine fuel, by up to 45% and the use of biogas after 2015, as well as improvement of roads will contribute to the reduction of GHG emissions from vehicles.

Waste

Since 2008, projects are implemented for extraction of biogas from large landfills of municipal solid waste, as well as reconstruction and modernization of wastewater treatment plants in Yerevan and cities near Lake Sevan. At the same time, the WB Armenia office conducts a consultative study on municipal solid waste management in Yerevan through public private partnership.

Forestry

National Forest Policy and Strategy (2004) and National Forest Program (2005). The main objectives of the Programs are to restore the degraded forest ecosystems, their sustainable use and to ensure the development of useful characteristics of forests.

For 2009-2020, the following are planned: restoration of degraded forest ecosystems on 2-2.5 thousand hectares, forest plantation/ afforestation on 5-5.5 thousand hectares, creation of protective forest zones on 0.6-0.65 thousand hectares.

Implementation of the CDM under the Kyoto Protocol

As of 2008, the CDM Designated National Authority of Armenia has approved seven CDM projects, four of which are registered by the CDM Executive Board.

4. Projections of greenhouse gas emissions

Projections of GHG emissions in Armenia for 2005-2020 are based on the 6.0% average annual economic growth scenario and expected range of activities in various sectors of the economy.

Two scenarios of GHG emissions are considered - "business-as-usual", which assumes the continuation of existing practices and relative shares of sectors at national level, but also includes certain modernization processes corresponding to international trends, and "with measures" (WM), which includes measures contributing to the reduction of GHG emissions planned by national and sectoral development programs.

As a result of the planned measures by 2020, GHG emissions will amount to 61% of their level in 1990 (92% in the case of "business-as-usual" scenario) with the largest share of emissions (73%) continuing to be in the "Energy" sector.

Table ES-3 Projections of greenhouse gas emissions by gases (Gg)

Gas	2005	2010	2015	2020
Business-as-usual				
CO_2	4633.20	9553.30	16222.20	19435.30
CH_4	71.78	94.88	128.38	173.51
N_2O	0.15	0.15	0.15	0.15
With measures				
CO_2	4633.20	8197.20	12932.70	11862.80
CH_4	71.78	83.47	114.52	157.50
N_2O	0.15	0.15	0.15	0.15

Table ES-4 Greenhouse gas emissions by sectors in 2005 and projections by 2020 (Gg CO_2 eq)*

Sector	2005	2010	2015	2020
Business-as-usual	**6226.0**	**11591.3**	**18964.8**	**23125.3**
Energy	4315.5	9048.3	15461.2	18471.8
Industrial processes	317.7	505.0	761.0	963.5
Agriculture	1080.3	1430.1	2077.6	2954.8
Waste	509.5	607.9	665.0	735.2
With measures	**6226.0**	**9995.6**	**15383.4**	**15216.6**
Energy	4315.5	7802.2	12336.7	11108.3
Industrial processes	317.7	395.0	596.0	754.5
Agriculture	1080.3	1402.8	2030.6	2901.6
Waste	509.5	395.6	420.1	452.2

** Without LULUCF*

Table ES-5 Greenhouse gas reduction potential by sectors by 2020 (Gg CO_2 eq)

Sector	2010	2015	2020
Energy	1246.1	3124.5	7363.5
Industrial processes	110.0	165.0	209.0
Agriculture	27.2	47.0	53.2
Waste	212.3	244.9	283.0
Total	**1595.7**	**3581.4**	**7908.7**

In the case of WM scenario, the projected share of CO_2 in the composition of GHG emissions will amount to 72.2% (in 2020) (including 67.2% from the "Energy" sector), the share of CH_4 - 27,4%, N_2O - 0,4%.

The total emission reduction potential for the period of 2005-2020 will amount to 45,657 Gg CO_2 eq

with the major share of the potential (78-93%) belonging to the measures implemented in the "Energy" sector.

5. Climate change impacts, vulnerability assessment and adaptation

Climate change observed in Armenia

According to the analysis of recorded hydro-meteorological data, the average annual temperature increased in the last 80 years by 0.85°C, and the annual precipitations, reduced by 6% compared to the average of the 1961-1990 baseline period. Since 1994, the changes of annual air temperatures were only positive. The geographical distribution of changes to annual precipitation in Armenia is very uneven - the north-eastern and central (Ararat valley) regions have become more arid, while the southern and north-western areas and Lake Sevan basin have had a significant increase in precipitation during the last 70 years.

In the last decades (1975-2005), also an increase in the severity and frequency of dangerous hydro-meteorological phenomena is recorded in Armenia. In the last 30 years, the total number of dangerous hydro-meteorological phenomena has increased by 1.2 cases and in the last 20 years - by 1.8 cases annually.

Climate change scenarios for Armenia

Climate change scenarios have been developed for Armenia through application of the PRECIS model. According to the model, an increase in annual temperatures by 1°C by 2030, 2°C by 2070, 4°C by 2100, and a decrease in atmospheric precipitations - correspondingly by 3%, 6% and 9% are forecasted for Armenia.

The forecasted changes to temperatures and precipitation will have both positive, and negative deviations by seasons and in comparison to the norms for Armenia's regions.

Table ES-6 Forecasted changes in river flow

Year	Flow, million m^3	Changes in the flow	
		million m^3	%
1961-1990	4994.4	0.0	0.0
2030	4660.9	-333.5	-6.7
2070	4269.9	-724.5	-14.5
2100	3777.6	-1216.8	-24.4

Water resources

River flow. In the case of the forecasted climate change, river flow in Armenia will reduce by 6.7% by 2030, 14.5% by 2070 and 24.4% by 2100 compared to the baseline period of 1961-1990.

Snow cover. The forecasted volume of precipitations in the form of snow in the major part of Armenia will reduce by 7-11% by 2030, 16-20% by 2070 and 20-40% by 2100 compared to the norm for 1961-1990. The biggest changes will be recorded in altitudes of 1700-1800 meters and higher, which are the main areas of river flow formation.

Lake Sevan. The forecasted climate change will result in significant changes to the water balance of Lake Sevan, which will have severe negative consequences for the Lake.

As a result of the projected changes to the water balance elements in Armenia, river flow will reduce by 0.6 billion cubic meters by 2030, 1.2 billion cubic meters by 2070 and 1.8 billion cubic meters by 2100.

Table ES-7 Forecasted changes in the main elements of Lake Sevan water balance

Year	Precipitation		Evaporation		Surface flow	
	million m^3	Deviation, %	million m^3	Deviation, %	million m^3	Deviation, %
1961-1990	457	-	1076	-	758	-
2030	449	-1.7	1158	+7.6	665	-12.2
2070	445	-2.6	1192	+9.7	559	-26.3
2100	436	-4.6	1268	+17.8	449	-40.7

In order to mitigate the consequences of climate change on water resources and adapt the economy

Table ES-8 Assessment of water resources balance elements in the case of projected climate change

Year	Precipitation	Evaporation	River flow
	billion m^3	billion m^3	billion m^3
1991-2006	17.6	10.5	7.1
2030	17.1	10.6	6.5
2070	16.6	10.7	5.9
2100	16.1	10.8	5.3

to the new natural conditions, it is proposed to implement measures for accurate assessment of water reserves, as well as apply certain technological and legal-organizational measures.

Accurate assessment of water reserves. (1) refurbishing hydrological observation stations with modern equipment and streamlining the network of hydrological observation stations; (2) restarting the measurements and monitoring of floods, the water layer in the snow and other characteristics of snow cover; (3) restarting the monitoring of underground waters; (4) preparing new data book on water resources; (5) developing water and water system balances for individual river basins; (6) developing modern technologies for transforming the actual flow to natural flow.

Technological. (1) regulation of river flow by increasing the volumes of the existing water reservoirs or constructing new water reservoirs; (2) reduction of losses in the irrigation and drinking-household water supply system through repairs of the systems and pipelines; (3) accumulation of moisture (water) in irrigated fields through storage of snow or snow melt water; (4) replenishment of moisture through early spring sowing of crops in rows, deepening irrigation ditches and using polyethylene covers; (5) use of advanced agro-technical measures and irrigation methods (drip-subsurface irrigation, pivot and sprinkler irrigation, subsurface drip-pipe and mole irrigation).

Legal-organizational measures. (1) development of procedures for taking into account the climate change factors during the assessment of water demand; (2) introduction of legal, economic and administrative incentives for reducing leakages from drinking water and irrigation water systems; (3) introduction of water saving technologies and initiation of legislative changes to promote water saving; (4) development of procedures for defining the priorities of water use by priority sectors considering the climate change impacts in river basin management plans.

Agriculture

Armenia is one of the very high risk countries for farming due to the fragmented mountainous terrain, active exogene processes, limited land resources (0.14 hectares arable land per capita) and inadequate level of moisture. In addition, as a result of the non-rational use of land resources, around 80% of land plots are characterized by desertification processes and various levels of land degradation. Agriculture suffers from huge losses due to dangerous climatic phenomena, the frequency and duration of which have increased during the last decades.

According to the assessments conducted, climate change in Armenia will further aggravate the situation by 2030: due to higher temperature and reduced precipitation the areas needing irrigation will expand, increased evaporation from the soil will result in the secondary salination of land plots, heavy rains and floods will further worsen water induced erosion, and droughts and hot dry winds will further aggravate wind erosion of lands.

As a result of climate change, soil humidity in Armenia will reduce by 10-30%, moisture availability for various crops will decline by 7-13%, and the water deficit of land will increase by 25-30%. As a result, the rain-fed farming in pre-mountainous and lower mountainous areas of Armenia will become more vulnerable.

According to climate change scenarios by 2030, a decline of 8-14% in the yields of the main agriculture crops is forecasted (9-13% for cereals, 7-14% for vegetables, 8-10% for potato and 5-8% for fruits). A decrease of 4-10% is forecasted for the total pasture area and its yields, including 19-22% in the most valuable pastures of the sub-alpine and alpine zones. A 7-10% decrease in the yields of grasslands is possible, which, in its turn, will result in lower levels of fodder production.

In order to mitigate the consequences of climate change, it is necessary to implement the following adaptation measures: (1) select and introduce more drought- and heat-resistant species and hybrids, including protect and spread traditional local species with those characteristics; (2) expand the use of high mountainous pastures and reduce their relative loads; (3) change the norms of fertilizer application; (4) shift the farming zone to areas with more moisture; (5) apply water saving irrigation technologies; (6) introduce crop species resistant to diseases and pests; (7) implement hail and flood protection measures; (8) ensure early warning on extreme hydro-meteorological events; (9) revise the vaccination practice of livestock.

Biological diversity and natural ecosystems

Climate change will result in the expansion of desert, semi desert and arid sparse forest areas, at the expense of the vertical shift of their upper limits. Further, upward shift of steppe ecosystems by 250-300 m will occur and the areas of meadow ecosystems will shrink. As a result, significant changes in composition and structure of ecosystems will take place.

More than 17,000 hectares of forest (5-5.5%) may disappear due to unfavorable conditions for forest growth. Worsening sanitary conditions, mass outbreaks of diseases and pests and larger risk of forest fires will have a negative impact on forest ecosystems.

In order to mitigate the consequences of climate change on natural ecosystems, it is necessary to implement the following measures: (1) ensure grazing norms and rules in grass systems used as pastures and grasslands; (2) properly zone the new specially protected areas of nature by expanding the zone upwards by 200-250 m; (3) restore the degraded forest ecosystems - reforest 5000 hectares of degraded forest areas and create 600 hectares of agricultural forest protection zone during the period of 2009-2020; (4) in order to control the mass development of forest pests and diseases, organize regular forest phytosanitary control studies and implement integrated measures, such as treating forests from the air.

Settlements and infrastructures

Exogene and various weather extreme events are characteristic to Armenia. Those phenomena cause huge damages to Armenia's population, economy and infrastructures.

More than 2500 landslide-prone areas have been identified in the country with a total surface of 1221 km² (4.1% of that total territory of the country). Besides, 233 out of the total 931 communities in Armenia have suffered damages from landslides; in more than 100 of the damaged communities landslides are especially active and have caused damages to hundreds of residential houses, communication lines and vital objects, about 3.2% of the motorways network, and around 0.5% of the railway network have suffered damages as well.

Areas prone to mudflows in Armenia are quite numerous. The damage caused by mudflows in the country in 1994-2007 amounts to more than 5.6 billion drams (around USD 17.5 million), and by floodings - more than 13 billion drams (around USD 41 million).

The following preventive measures are proposed to be taken to reduce the risks of the mentioned phenomena:

- *Landslides*: (1) Design and construct dams and reservoirs protecting settlements and infrastructures; (2) regularly clean the river beds, widen or heighten the banks and their reinforcement; (3) create water collection and water drainage constructions or improve the existing ones; (4) plant forest and vegetation on the slopes, as well as terrace, fence or net; (5) strictly control and regulate irregular irrigation and site development licenses.

- *Mudflows, flood and spring inundations*: (1) Conduct phyto-melioration in river basins of rivers causing mudflows and floods, and construct anti-mudflow and anti-flood barriers; (2) Install automatic warning observation points and mudflow observation points on rivers; (3) develop modern methods of short-term and long-term forecasting of floods, mudflows and spring inundations; (4) revitalize snow packs

measurement activities using contemporary methods development.

Human health

Climatic conditions in the most densely populated areas of Armenia are very tense in July-August, the population suffers from the heat stress discomfort. Climate warming will further increase the risk of heat and sun strokes. More frequent heat waves are also expected, which could further aggravate the stress situation related to heat discomfort.

As a result of climate change, it is expected to have higher risks of vector-born diseases: cholera, plague, tularemia, malaria, acute intestinal infections and a number of other diseases. Parallel to climate change, the risks of Crimean-Congo fever, West Nile fever, Sindis fever and Tyagin fever will emerge. Those diseases are recorded in neighboring countries and depending on the expansion of the aerials and infiltration of pathogene and their main carriers into Armenia, emergence of those diseases can be expected as well.

In order to prevent and mitigate the consequences of climate change for population's health, comprehensive social, behavioral, sanitary, preventive and administrative measures are proposed.

6. Other information

Systematic observation and research

Systematic observation of the climate

The state authorized body in charge of hydrometeorological observations is the "State hydrometeorological and monitoring service of the Republic of Armenia" ("Armstatehydromet") SNCO. The network of hydro-meteorological observations in Armenia currently includes 42 meteorological and three specialized stations, 79 hydro-meteorological observation points (for measuring precipitation), and seven hydrological stations with 92 water gauging observation points. Three meteorological (Yerevan, Sevan, Amasya) and one aerological (Yerevan) station of the Service are included in the global communication system (GCS), and 20 more are included in the CIS intergovernmental hydro-meteorological network of the GCS.

Since 2003, the Yerevan aerological station of "Armstatehydromet" is included in the Global Climate Observation System (GCOS) Upper Air Network (GUAN). "Amberd" high mountainous station is included in the WMO Global Ozone Observation System (GAW/GO3OS). In 2007 "Aragatz" high mountainous station (3226 m), the only station in the region operating above 3000 m of altitude, was included in the GCOS Surface Network (GSN). The station is operational since 1929 and is extremely significant for climate change studies in the region.

Being included in the European Climate Assessment and Dataset (ECA&D) program in 2003, the "Armstatehydromet" regularly provides observation data, which are used for calculation of the indices developed by IPCC for climate change assessment. In 2007, the computer software developed for calculating those indices was introduced in "Armstatehydromet".

"Armstatehydromet", jointly with the German meteorological organization (DWD), is implementing the program "The use of CM-SAF satellite products for monitoring climate on Armenia's territory". In 2009, "Armstatehydromet" participated in the "Technical support to climate risks management" Project, implemented by the Asian Center for Disaster Preparedness (ACDP) and the UNDP.

Research

Research activities are conducted in "Armstatehydromet" by the Climate Study Center, which includes divisions for climatology, digital modeling of hydrometeorological processes, global and regional climate change studies, applied climatology and atmosphere pollution studies. The Climatology Division processes data from 280 stations and observation points operating at various periods on the territory of Armenia, prepares climate yearbooks where the climate resources of the territory are presented in detail.

The Global and Regional Climate Change Studies Division develops models, with the help of which

climate change scenarios for the territory of Armenia are calculated taking into account the changes to the global climate. Long-term forecasting methods (monthly, seasonal, annual) are developed and used to interpret and solve various problems.

Programs and studies contributing to climate change mitigation measures

In 2009, the state budget of Armenia financed over 70 scientific themes relating to environmental problems, the majority of which refer to biodiversity and desertification problems, which are, at the same time, relevant to climate change related issues.

Studies and programs on climate change issues in Armenia are basically devoted to vulnerability, assessment of climate change consequences and development of adaptation measures. Since 2008, the state budget is financing the implementation of seven scientific studies on the assessment of losses as a result of climate change impact on ecosystems and agricultural crops, development of methodologies for forecasting the yields in the regions of Armenia during drought periods, as well as assessment of changes to water resources in large river basins.

In 2008-2009, with the financial support of the UNDP, six pilot projects were implemented to assess climate change impacts on various sectors and develop adaptation measures.

Several other studies have been conducted in Armenia aimed at assessment of the potential and promotion of the use of renewable energy sources, thus contributing to the reduced use of fossil fuels and GHG emissions reduction.

Education, personnel training and public awareness

Education and personnel training

After the submission of the First National Communication on Climate Change (1998), Armenia has ensured notable progress in the field of environmental education: both in legislation and in practice.

Environmental education in Armenia is introduced in all levels of the educational system - from preschool to postgraduate. The policy and coordination of environmental education are vested in the Ministry of Education and Sciences and the Ministry of Nature Protection.

At preschool education level, 6 manuals reflecting climate change related issues have been developed in the frames of national and international projects to support environmental education. Ongoing national projects include "Environmental Education at Preschool Age", "Educational Program for 5-6 year old children", "Little Lover of Nature", "Behavior". UNICEF supports environmental education at preschool level as well.

At secondary education level, environmental protection issues are included in the curricula of subjects on natural sciences. Programs for senior school include the "Environmental Protection and Nature Use" subject. In senior schools, climate change issues are discussed during "Biology" and "Geography" lessons.

Vocational education in Armenia is provided through 30 crafts schools, 80 state and around 25 non-state colleges. In almost all institutions of the secondary vocational educational system, "Basics of Ecology" or "Basics of Ecological Education" subjects are taught.

At all levels of *higher educational system*, ecology and environmental protection are mandatory courses. Depending on the profile of the higher educational institution, ecology and environmental protection courses are taught in 19 universities of Armenia. Educational programs of nine universities include climate change issues. The "Hydro-meteorological" specialization in Yerevan State University trains climatology specialists and has a special course on climate change. In the State Engineering University of Armenia the "Use of Clean Development Mechanism in the Energy Projects" course is taught to the students of several professions.

Postgraduate education is provided by higher educational institutions, as well as scientific

institutes of the National Academy of Sciences, where the number of specialists working on climate change issues is gradually increasing. In recent years, candidate and doctorate dissertations on the subject have been defended.

To improve the level of teaching and knowledge on climate change in Armenia's educational system, a number of trainings were organized for teachers, university lecturers and students, as well as a number of thematic booklets, guidelines and manuals were published during 2003-2008.

Public awareness

Public awareness building on climate change is conducted through the following:

- Organization of seminars: e.g. in 2000-2009, in the frames of the UNDP/GEF projects over 40 seminars were organized.
- Publication and dissemination of thematic materials: e.g. in 1999-2006, in the frames of the UNDP/GEF projects 35 printed materials, including booklets, manuals and posters were published, three films were produced and the Climate Change Information Center website was regularly updated.
- Presentations through mass media: since 2005, the TV program "Nature protector's diary" is broadcasted, with some of its transmissions being on climate change. There is a growing coverage of environmental issues with a focus on climate change problems in the printed and electronic media outlets as well.
- Discussions on the results of climate change related studies in Armenia with participation of representatives from the state and non-governmental organizations.

Non-governmental organizations

Environmental NGOs play an active role in promoting environmental education and public awareness activities in the country. A number of manuals have been published with the support of NGOs, which have been approved as additional manuals for environmental education in secondary schools. The mentioned publications have been distributed to secondary schools. Training seminars have been organized for teachers and students, lecturers of higher educational institutions and secondary vocational educational institutions have been trained.

Since 2002, 14 public environmental information (Aarhus) centers are operating in the country, which aim to build public awareness on environmental issues and promote public participation in decision-making processes.

7. Gaps, constraints and capacity needs for Convention implementation

A number of constraints and gaps related to institutional, organizational, technical, informational, financial and personnel capacity building have emerged in relation to activities for implementation of the Convention in Armenia. The shortage of specialized personnel capacity and financial resources is observed in all areas of operation.

National inventory of greenhouse gases. The main capacity building needs include: development of national emission factors for leakages from the fuel transportation, “LULUCF” sector, and non-ferrous metals production, as well as identification of new sources of emissions.

GHG emissions reduction policy and measures. The key needs are: analysis, localization and use of models recommended for assessing the potential for reducing GHG emissions.

Vulnerability and adaptation

Water resources. Key capacity building needs include: vulnerability assessment, improvement of projected scenarios, including the regional approach, development of new methodologies for calculating flood flows and inundations, taking into account the impact of economic activity and climate change, introduction of groundwater resources monitoring system.

Agriculture. It is recommended to select and apply models to assess vulnerability of crop yields under climate change, map and identify priorities for redistribution of crops, develop the existing insurance system.

Biodiversity and natural ecosystems. Key needs in the sector are: establishment of a system to monitor the changes in natural ecosystems, conducting studies and data collection of model natural ecosystems, implementation of measures targeted at restoration of ichthyofauna in water basins through application of ecosystem approach, and introduction of the "optimal afforestation" idea in the National Forest Strategy.

Human health. The main capacity building needs in the sector include: identification of diseases and risk groups most sensitive to climate change, creation of a database and registration of diseases characteristic to hot periods, regional analysis of diseases, identification and mapping of the most vulnerable areas.

Adaptation. The key need in the sector is development of a comprehensive national strategy on climate change adaptation taking into account cross-cutting issues among sectors and the synergistic effect among global environmental conventions.

Research and systematic observations. Capacity building needs include: conducting research to increase reliability of climate change scenarios in Armenia through cooperation with neighboring countries and development of regional scenarios. For systematic observations it is necessary to restore hydro-meteorological stations and observation points in their previous scope, refurbish the observations system, modernize means of communication and telecommunication, create a radar network, resume and monitor the measurements of snow cover, water layer in the snow and characteristics of snow melt.

Technology transfer. The key needs are: creation of a database on environmentally sound technologies, establishment of an interagency advisory center for coordinating and managing technology transfer and ensuring state support through attraction of grants and foreign investments and provision of concessional loans.

Science, education, public awareness raising and staff training. Key needs include continuous capacity building, enhancing activities and development of a comprehensive program for the sector.

CHAPTER 1

National Circumstances

1.1 State structure

The Republic of Armenia (RA) 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 on the basis of 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 of office.

The 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 election rights.

The executive power of the Republic of Armenia is exercised by the Government whose responsibilities 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 7 state management bodies adjunct to the Government, which include services, administrations, committees and the Police.

The Republic of Armenia employs a three-level 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 11 marzes, including Yerevan. It has 931 communities, out of which 60 are urban and 871 - rural communities (2006). The biggest communities are: Yerevan (1104.9 thousand people), Gyumri (147.71 thousand people) and Vanadzor (105.2 thousand people).

Since 2 March 1992, the Republic of Armenia is a member to the United Nations Organization, CIS - from 21 December 1991; Council of Europe - from 25 January 2001, WTO - from 5 February 2003.

Since 2008, the Republic of Armenia has established and is maintaining diplomatic relations with 153 states of the world.

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

1.2 Geographical location and natural resources

The Republic of Armenia is located in the north-east of the Armenian Highland at the turn of Caucasus and south-western Asia.

The length of the RA state borders is 1479 km. It borders with Georgia in the north, Azerbaijan in the east, Turkey in the west and south-west and with Iran in the south.

The RA territory is 29743 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; 76.5% of its territory is 1000-2500 m above sea level.

According to the Land Balance data of 2006, 71.6% of the territory of Armenia falls under agri-

cultural lands, 12.5% - forests (10.4% - under forest covered), 7.4% - specially protected areas of nature, 0.9% - water surface, 5.4% - settlements, industry, transportation and communications territory, 1.3% - other areas.

Due to vertical alternation, 10 landscape zones have been formed in Armenia - from semi-desert to snowy highlands, including 6 climate patterns - from dry sub-tropical to frosty highlands. These natural conditions have enabled the existing biodiversity. The territory of Armenia is inhabited by 3600 plant species (which is almost half of the whole Caucasian flora), around 450 species of vertebrate animals and 17000 species of invertebrates. The significant part of biodiversity is represented by endemic and rare species. To preserve the biodiversity, specially protected areas of nature have been created, including 3 reserves, 2 national parks and 26 sanctuaries.

The rivers of Armenia are the confluents of the big rivers in Southern Caucasus - Araks and Kur. Armenia has around 9500 small and medium rivers, the total length of which is 25 thousand km. The longest rivers are: Araks (1072 km), Vorotan (179 km), Debed (178 km), Hrazdan (146 km). The density of rivers 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 km^3. The flow of ground waters is approximately 4.0 billion cubic meters.

The greatest lake of Armenia is Sevan - one of the largest high-mountain fresh-water lakes of the world. Presently (2006), the level of the Lake is 1898 m, the surface area - 1257 km^2, the volume - 33.4 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 seismicity and intensive exogenous processes, contributing to landslide occurrence and development of erosion. The frequency and magnitude of hazardous hydro-meteorological phenomena also contribute to emergence of hazards and incur significant losses for the population and 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, including 26.8% - to extremely high, 24.6% - high, 19.6% - medium, and 8.8% - low degrees. Additional concern is caused by projected intensification of the mentioned phenomena due to the forecasted 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 sub-tropical to frosty highlands.

The average annual temperature is 5.5°C. The highest average range of temperature is 12-14°C (in Alaverdi and Meghri). Negative average annual temperatures are recorded at the altitude of 2500 m and higher.

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 recorded in Artashat (43°C), whilst the absolute maximum temperature for Yerevan is 42°C.

Winter is cold. January is the coldest month of winter with an average temperature of -6.7°C. The absolute minimum temperature is recorded in Paghakn (-42°C). Winter is temperate in north-eastern and south-eastern regions of the country.

The average annual precipitation in Armenia is 592 mm. The most arid regions are Ararat valley and Meghri region. The annual precipitation here is 200-250 mm. The highest annual precipitation - up to 1000mm - is observed in high-altitude mountain 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/sec in Meghri to 8.0 m/sec in Sisian mountain pass. In some of the regions, particularly Ararat valley, mountain-valley winds are well observed. The wind speed in summer can reach 20m/sec and more.

1.4 Population

As of the end of 2006, the population of the Republic of Armenia is 3222.9 thousand people, with an average density of 108 person/km^2.

Distribution of population is extremely disproportionate, due to the country's mountainous relief and the varying level of economic development. The maximum density of population, 686 person/km^2, is characteristic of high-altitude zones of up to 1000 m height, the minimum density, 22 person/km^2, is observed in high-altitude zones of up to 2000-2500 m of height.

48.3% of total population are males, and 51.7% - females (2006). The average life duration is 73.3 years - men's estimated as 70 years and women's - 76.4 years (2006).

As of 01 January 2007, the number of employed people is 1181.3 thousand people. Figure 1-1 demonstrates data on the RA population number. In 2000-2007, the number of urban population was 64% and rural population - 36%.

1.5 Economy

Following the sharp economic recession of 1991-1994, Armenia successfully passed through transition economy hardship and reached certain economic stability and notable economic growth (Table 1-1). Average annual economic growth made up 5.4% in 1995-2000 and 12.4% in 2001-2006. Structural economic changes brought to respective changes in GDP structure, that is - decrease in industry share and increase in that of construction and services (Table 1-2).

Priority issues for economic development of the country are envisaged to be addressed in the

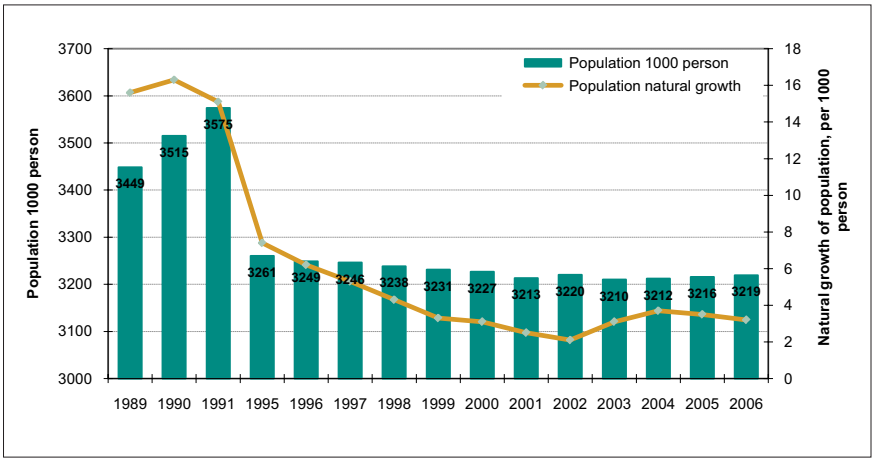


Figure 1-1 The RA population and natural growth, 1989-2007

Source: National Statistical Service of RA, 1989-2007

Table 1-1 Main macroeconomic indicators of Armenia, 1995-2006

Indicator	1995	2000	2001	2002	2003	2004	2005	2006
GDP (billion AMD)	531.1	1031.3	1175.9	1362.5	1624.6	1907.4	2242.9	2657.1
GDP (million USD)	1286.0	1915.2	2120.0	2376.3	2807.1	3576.6	4900.4	6386.7
GDP index (%)	106.2	105.9	109.6	113.2	114.0	110.5	113.9	113.3
Export (million USD)	270.9	300.5	341.9	505.1	685.6	122.9	973.9	985.1
Import (million USD)	673.9	884.7	877.4	987.1	1279.5	1350.7	1801.7	2991.6
GDP per capita (USD)	394.0	593.6	659.0	740.0	874.0	1112.8	1523.0	1982.8
GDP per capita (at PPP) (USD)	1788.0	2315.0	2596.5	2974.8	3461.0	4017.6	4693.3	4995
External state debt (million USD)	373.0	860.0	905.4	1025.0	1097.0	1183.0	1099.0	1205.0
USD exchange rate	413.0	529.0	539.0	573.0	578.0	523.0	467.0	416.0

Source: National Statistical Service of RA (1990, 1995, 2000, 2005, 2007)

Table 1-2 Structure of the GDP of Armenia, 1990-2006 (%)

Sector	1990	1995	2000	2001	2002	2003	2004	2005	2006
Industry	44.0	24.3	21.9	20.2	20.0	19.9	19.2	18.8	17.9
Agriculture	13.0	38.7	23.2	25.0	23.1	21.3	22.6	18.7	18.1
Construction	18.0	8.5	10.3	10.7	12.6	15.5	15.6	21.7	24.5
Services	25.0	24.8	35.5	34.5	34.6	34.2	34.2	32.3	32.3
Net Taxes	-	3.1	9.1	9.6	9.7	9.1	8.4	8.5	7.2

Source: National Statistical Service of RA (1990, 1995, 2000, 2005, 2007)

framework of the 2008-2012 Socio-Economic Development Programme of the Government, Sustainable Development Programme, and the Millennium Development Goals.

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 a stable growth of energy consumption (Table 1-3).

Armenia does not possess significant fuel resources and satisfies its demand for fuel through import. Own primary energy resources (hydro-, nuclear energy) cover 31% of country's total energy consumption. The main type of fuel being consumed is natural gas. In 2000-2006, the share of natural gas in the total fuel consumed reached 70-79%. In the structure of primary energy demand, the shares for natural gas and nuclear energy prevail (Figure 1-2).

Electrical energy is produced in thermal-, hydro- and nuclear power plants. The total installed capacity of electrical energy systems is 3615 MW including 1756 MW of thermal power plants, 1044 MW of hydro power plants (including small HPP), and 815 MW of the nuclear power plant. Electrical energy production dynamics is demonstrated in Figure 1-3.

Table 1-3 Energy consumption in Armenia, 1990-2006 (PJ)

Energy carriers	1990	1995	2000	2001	2002	2003	2004	2005	2006
Natural gas	151.4	43.1	47.0	47.0	38.2	42.6	47.0	58.4	61.5
Oil products	162.8	21.2	12.9	14.8	14.7	15.7	16.2	14.7	15.0
Coal	13.4	0.4	-	-	-	-	-	-	0.0
Fire-wood	0.1	3.5	3.4	3.3	3.1	2.8	2.6	2.3	1.8
Liquid gas	0.0	0.1	0.6	0.8	0.9	0.9	1.0	0.9	0.7
Hydro energy	6.7	7.1	4.5	3.5	6.0	7.1	7.3	6.4	6.6
Atomic Energy	-	2.2	21.7	21.5	24.8	21.7	26.1	29.4	28.6
Total	**334.4**	**75.8**	**90.1**	**90.9**	**87.6**	**90.9**	**100.1**	**112.1**	**114.2**

Source: RA Ministry of Energy (1990, 1995, 2001); National Statistical Service of RA (1990, 1995, 2000, 2005, 2007); "ArmRosgasprom" CJSC (2002-2006)

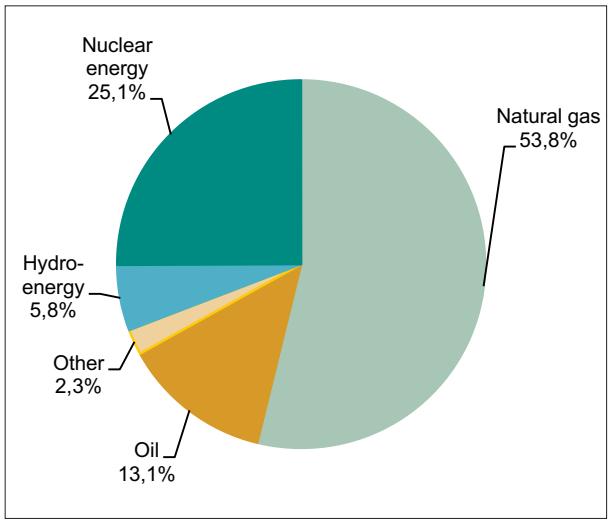


Figure 1-2 Proportion of energy sources in general energy consumption, 2006

Thermal energy is produced in thermal power plants and in boiler-houses of apartment and public/commercial sector buildings. The economic and energy crisis of 1992-1994 period, together with the destruction of the subsidization system, caused the devastation of the heat supply system. In 2006, total production of thermal energy for industrial and urban needs fell to 6%

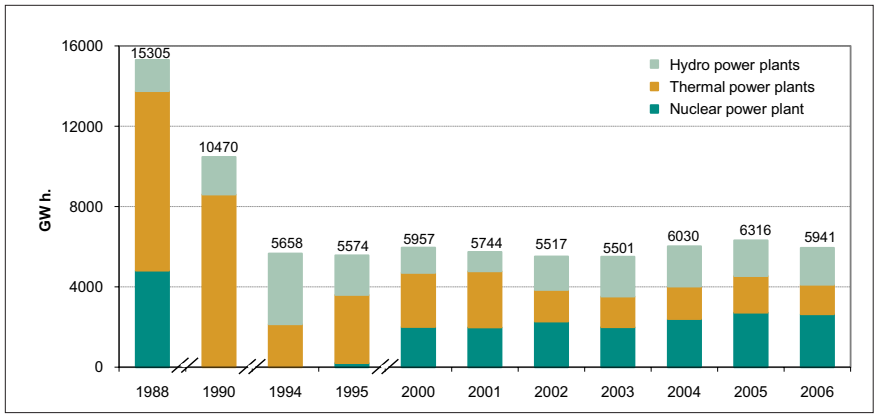


Figure 1-3 Electrical energy production, 1988-2006

Source: RA Ministry of Energy, 1988-2006

of 1990 level. In the residential sector, individual devices for gas and electricity are mainly used for space and water heating. Since 2005, projects targeted at reconstruction of municipal heat supply system are being implemented in the country through application of energy efficient technologies. Since heat supply in public/commercial sector has been recovering at a fast pace, thermal energy production has increased 1.5 times within 2000-2006.

Energy crises resulted in the collapse of the gas supply system. Since 2000, large scope of work has been done for restoration of the system. In 2007 the level of gasification reached 85%, which is an important factor for stable energy supply.

The Energy Sector Development Strategy in the context of the RA economy development has served as a basis for development of long-term energy policy in Armenia. The Strategy is envisaged for the period up to 2025. It defines the ways for establishment of conditions for safe, efficient and stable functioning of the energy sector of Armenia.

Table 1-4 Fuel consumption by sectors, 2000-2006 (PJ)

Sector	2000	2001	2002	2003	2004	2005	2006
Electrical energy	29.80	30.22	17.50	17.20	18.11	20.73	17.11
Industry/construction	7.55	6.42	6.81	7.31	9.63	12.12	12.02
Transport	10.91	13.01	15.52	15.63	17.48	17.10	19.8
Agriculture	0.66	2.08	4.33	1.67	1.61	1.73	1.70
Residential	9.06	9.14	8.56	10.20	11.28	13.69	16.28
Public/commercial	2.50	2.62	2.50	3.11	2.56	2.89	7.32
Total	60.48	63.49	52.22	55.12	60.65	68.26	74.23

Source: The RA Ministry of Energy (2000-2002), "ArmRosgasprom" CJSC (2002-2006)

1.7 Industry

Hardships of the initial transition period to market economy and the collapse of the former USSR, were among the main reasons of industrial debacle in Armenia. In 1993, industrial production fell to 43% of 1990 level. Since 1994, the situation has stabilized and slow growth of industrial production has been attained (Figure 1-4).

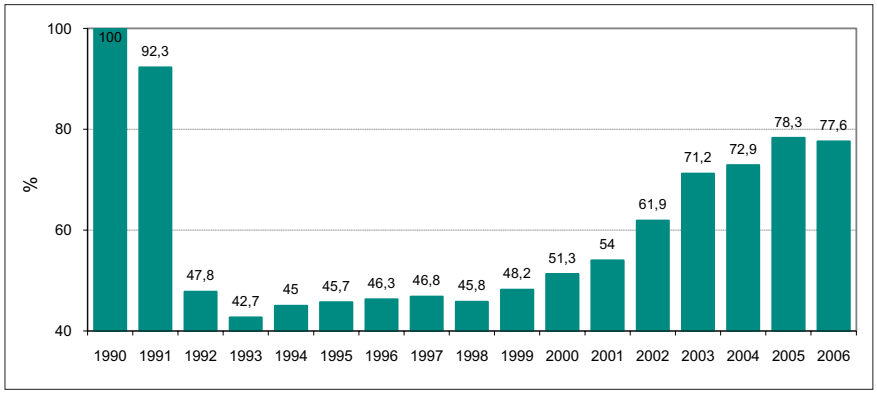


Figure 1-4 Dynamics of industrial production, 1990-2006

Source: National Statistical Service of RA, 1990-2007

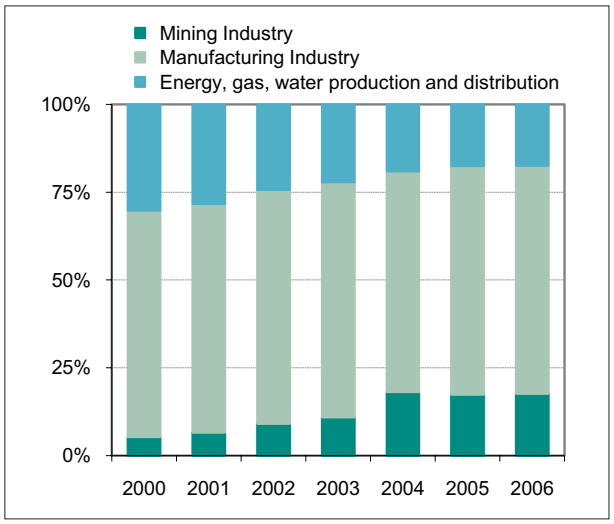


Figure 1-5 Structure of industrial output by types of economic activity, 2006
Source: National Statistical Service of RA, 2004, 2007

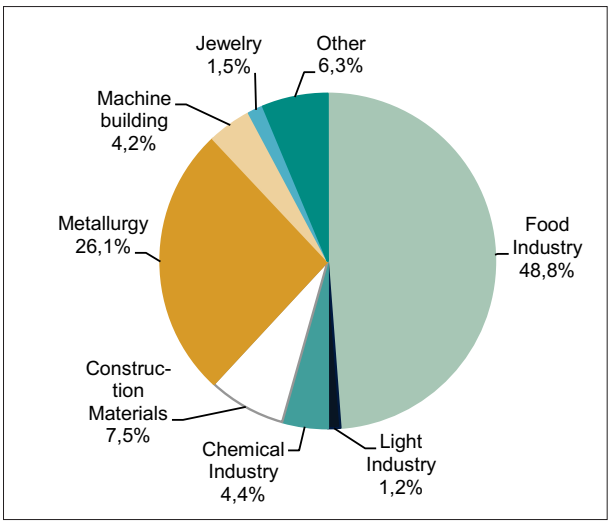


Figure 1-6 Structure of processing industry, 2006
Source: National Statistical Service of RA, 2006

Within adaptation to the new conditions, significant changes in sectoral composition of industrial production took place. Comparing to 1990, share of previously leading sectors, such as machine-building and light industry sharply declined - from 34 to 4.4 and 24.9 to 0.9% respectively, while shares of non-ferrous metallurgy and food processing grew from 8.8 to 31 and from 16.3 to 31.3% respectively.

The volume of the industrial output in 2006 was 78% of the one observed in 1990.

1.8 Transport

The transport sector in Armenia includes rail roads, highways, air routes and main pipe lines (Figure 1-7).

The length of communication routes in exploitation reaches:

- 731.9 km of railroads
- 7504 km of highways
- 1387 km of main pipe lines (as of 2006).

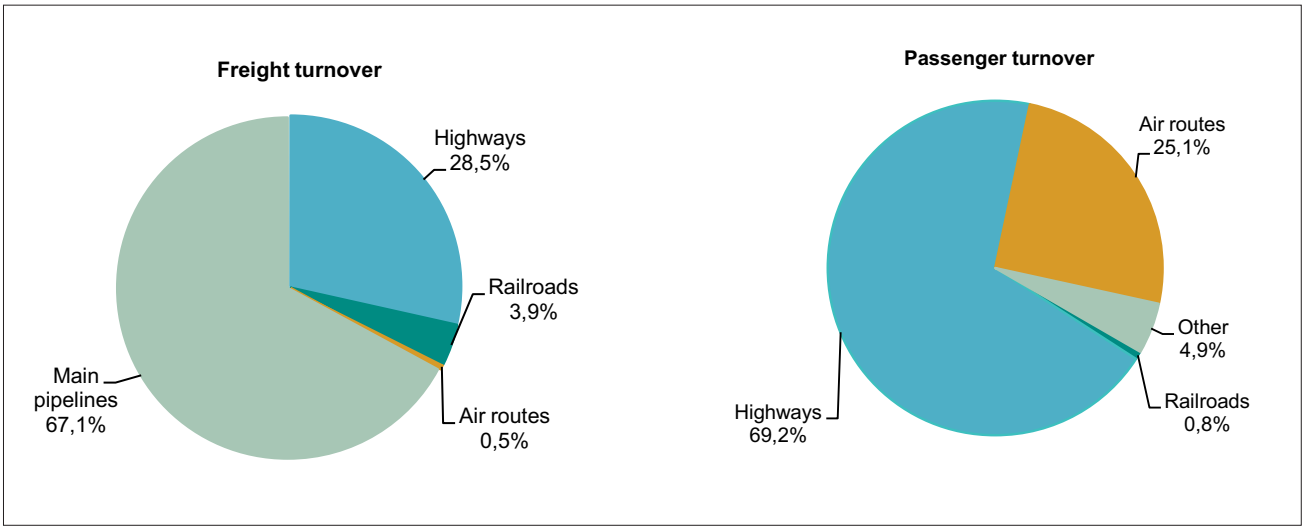


Figure 1-7 Shares of transportation means in freight and passenger turnover, 2006
Source: National Statistical Service of RA, 2006

Sectoral composition of industrial production is demonstrated in Figures 1-5 and 1-6.

After 1990, in the result of significant structural changes in economy and transportation blockade, the transport sector underwent substantial trans-

Table 1-5 Transport sector indicators, 1990-2006

Indicator	1990	2000	2001	2002	2003	2004	2005	2006
Freight turnover (million ton km)	9410.0	1705.1	1722.1	1535.6	1740.5	2007.3	2300.9	2345.5
-railroads	4884.0	353.6	343.5	451.8	529.2	678.2	654.1	668.0
-highways	4477.0	40.0	43.0	68.2	79.3	55.3	55.5	91.2
-air routes	49.0	9.6	9.1	5.5	5.5	10.0	10.7	12.4
-main pipe lines	-	1301.9	1326.5	1010.1	1126.5	1263.8	1580.6	1573.9
Passenger turnover(million passenger*km)	9511.5	2063.4	2450.4	2615.4	2719.4	3074.8	3199.4	3271.1
-railroads	316.0	46.8	48.2	48.4	41.1	30.0	26.6	27.7
-highways	3526.0	1310.0	1561.6	1706.8	1858.1	1954.3	2072.4	2264.6
-air routes	5557.0	579.2	725.1	753.9	719.2	984.0	959.5	822.2
-other types of transport	112.5	127.4	115.5	106.3	101.0	106.4	140.9	156.6

Source: National Statistical Service of RA (1991, 2000, 2005, 2006)

formation. Compared to 1990, freight turnover fell 4 times in all types of transportation in 2006: 7.3 in railways, 48.7 in highways, 4 in air routes. Total passenger turnover decreased 2.8 times with 11.4 in railways, 1.6 in highways and 6.7 in air routes (Table1-5).

1.9 Agriculture

According to the Land Balance data of 2006, agricultural lands in Armenia occupy 2129.6 thousand hectares, including plough-lands - 452.9 thousand hectares (21.3%), perennial plantings - 27.3 thousand hectares (1.3%), hayfields - 127.5 thousand hectares (6%), pastures - 1125.0 thousand ha, and other lands - 396.9 thousand hectares (18.6%). The territory of the perennial plantings of household and garden plots of the residential area covers 23.8 thousand hectares. Armenia's agriculture has also undergone the consequences of severe economic crisis of 1991-1994. In the result of the agrarian reform and land privatization, major agricultural households were transformed into 338 thousand small agricultural households, each having the land share of approximately 1.4 hectares. The land fund was divided into parts, impeding the efficiency of its householding.

Production infrastructure was also affected. The area and structure of agricultural lands changed as well; the sown area was reduced by approximately 30% (Figure 1-8). The cattle-head was reduced too (Table 1-6). The area of irrigated lands was reduced twice, whilst the use of chemical fertilizers was decreased thrice.

Prevention of further decline in agriculture, ensuring stabilization and further development required tremendous efforts and implementation of various programs. Slowly but steadily agricultural production grew (Table1-7).

Table 1-6 Number of livestock and poultry (thousand heads)

Livestock/poultry	1990	1995	2000	2001	2002	2003	2004	2005	2006
Cattle	690.0	507.5	478.7	497.3	514.2	535.8	565.8	573.3	592.1
Sheep and goats	1291.0	603.2	548.6	540.0	592.1	602.6	628.5	603.3	591.6
Pigs	329.3	79.6	70.6	68.9	97.9	111.0	85.4	137.5	152.8
Horses	-	-	11.5	11.4	12.1	12.1	12.2	11.9	12.6
Poultry	11245.0	3100.0	4255.1	3975.2	4239.0	4625.0	5023.8	4861.7	4954.1

Source: National Statistical Service of RA (1990, 1995, 2000, 2005, 2007)

Within 2000-2006, average annual growth of agricultural production was 7.7%. In the same period, average share of plant growing in aggregate agricultural production reached 57% and 43% - that of stock-breeding.

Average share of agriculture in Armenia's GDP structure was 21.7% within 2000-2006 with 18.1% in 2000. 502 thousand people are employed at farms that make up to 43% of total workforce.

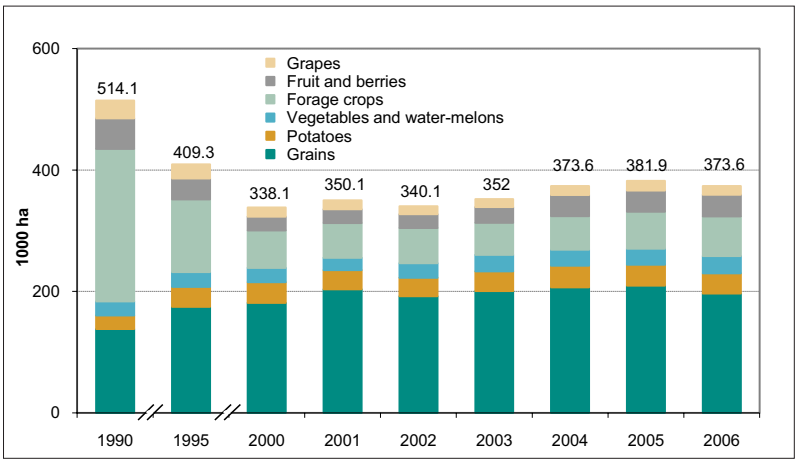


Figure 1-8 Areas of agricultural land allotment, 1990-2006

Source: National Statistical Service of RA (1990, 1995, 2000, 2005, 2007)

Table 1-7 Production of main types of agricultural output in Armenia (thousand ton)

Agricultural output	1990	1995	2000	2001	2002	2003	2004	2005	2006
Grains	271.0	262.7	224.8	367.3	415.5	310.0	456.9	396.2	212.5
Potatoes	212.5	427.7	290.3	363.8	374.3	507.5	576.4	564.2	539.5
Vegetables	389.7	450.9	375.7	456.0	466.0	569.4	600.8	663.8	780.0
Watermelons	31.4	54.0	52.8	54.8	89.7	115.4	112.9	117.8	134.9
Fruit and berries	155.5	146.1	128.5	102.4	82.6	103.1	113.7	315.6	286.0
Grape	143.6	154.9	115.8	116.5	104.0	81.6	148.9	164.4	201.4
Meat (slaughter weight)	145.0	82.4	49.3	48.3	50.2	52.6	53.4	56.0	66.8
Milks	432.0	428.3	452.1	465.3	489.5	513.7	555.2	594.6	620.0
Eggs (million pieces)	606.0	518.0	385.4	448.3	477.7	502.2	563.0	518.2	463.7

Source: National Statistical Service of RA (1990, 1995, 2000, 2005, 2007)

1.10 Forestry

Armenia is a forest-poor country. According to the Land Balance data of 2006, forest lands cover about 373.0 thousand hectares, with 308.5 thousand hectares forest-covered (10.4% of country's territory). Forests mainly grow on steep slopes in cross-country mountains at 550-2400 m above sea-level. Forest covered territories are distributed unevenly with 62.5% in the north-east, 21.6% - in the south-east; 13.5% in the central part and 2.4% in the south. About 270 tree and bush species grow in the forests; oak, beech, hornbeam and pine-tree are major natural components of the forests.

Because of the energy crisis of 1992-1995, the massive, including illegal cuttings brought about negative impacts on forest ecosystems. Degraded forest ecosystems only partially use the potential of natural growth, which in its turn, reduces carbon absorption from the atmosphere.

Intensive afforestation and reforestation efforts are required to promote forest regeneration. 21.5 thousand hectares of area underwent reforestation and afforestation activities within 1998-2006: including 16.1 thousand hectares during the period of 2004-2006.

According to the Forest Code of 2005, Armenia's forests are classified as important for protective, special and production purposes.

Armenia's forests and forest lands are the property of the State. For the purpose of increasing the forest cover, the Forest Code defines the right for community and private ownership over self-established forests.

The preservation, rehabilitation, natural reproduction and sustainable use of forests are ensured with the help of Armenia's National Forest Policy and Strategy paper, as well as Armenia's National Forest Program (2005).

1.11 Waste

Municipal solid waste (MSW) is collected, removed and stored in 48 managed slandfills. The total area of landfills covers 219 hectares: the largest ones are located in Yerevan (60 hectares), Vanadzor (13 hectares), Gyumri (10 hectares), Armavir (8 hectares), Etchmiadzin (7 hectares) and Hrazdan (6 hectares).

MSW includes domestic, commercial, building and other types of waste. In none of the landfills the waste is preliminarily classified or sorted; it is neutralized only partially - via covering it with a layer of soil. The annual average amount of MSW in 2000-2007 was 595 thousand ton, or a 289 kg per city-dweller. In MSW the decomposable organic carbon reached 47.9% in 2000 and 68.5% in 2006. Dumping MSW in landfills results in its anaerobic decomposition and methane emissions.

Urban wastewater includes domestic, commercial and partially industrial wastewater. In 2006, the amount of water discharge decreased 2.4 times compared to 1990 (740 million cubic meters) and reached 303 million cubic meters; this is due to population reduction, rational water use and industrial decline.

In 2000, the amount of discharged water reached 375 million cubic meters, with an amount of 153.2 million cubic meters wastewater discharged through sewerage system and 122.9 million cubic meters - through purification equipment. The same indicators for 2006, have correspondingly composed 303 million cubic meters, 81 million cubic meters and 57.2 million cubic meters. The 20 existing wastewater treatment stations are in extremely unfavorable technical conditions, practically non-operational, and wastewater flows into the surface water basins without any treatment. Sludge accumulated in wastewater treatment facilities is not neutralized and part of the methane emerging from wastewater is emitted into the atmosphere.

Since 2008, various projects are being implemented in Armenia aimed at biogas utilization from MSW landfills in Yerevan, as well as restoration and modernization of wastewater treatment stations in the Lake Sevan basin.

1.12 Legal and institutional bases for implementation of UNFCCC

The Republic of Armenia ratified the UNFCCC in 1993 as a non-Annex I Party. The Ministry of Nature Protection of RA is the responsible body for coordination of Convention implementation activities in the country. The Ministry is developing a long-term action plan which is approved by the Government of Armenia. The following decrees have been adopted by the Government of Armenia for implementation of the Convention: "On the approval of the action plan of the obligations of the Republic of Armenia outgoing from the series of the environmental conventions (Decree No. 1840, adopted on 2 December 2004) and "On the amendments of the Government Decree No. 1840, dated 2 December 2004 and on the approval of the action plan of the cross-cutting activities of the three global Conventions on Biodiversity, Climate Change and to Combat Desertification (Decree No. 880, dated 16 June 2005). These decrees define the activities outgoing from the UNFCCC provisions and commitments of Armenia, as well as define responsible bodies for implementation of the mentioned activities. The National Focal Point of the UNFCCC is the head of the Environmental Protection Department of the Ministry of Nature Protection of Armenia.

The Republic of Armenia ratified the Kyoto Protocol of the UNFCCC in December 2002. By the Government Decree "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, dated 13 July 2006) the Ministry of Nature Protection has been appointed as the Designated National Authority for the CDM. 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 indicators of the country.

Literature

1. Energy Saving and Renewable Energy National Programme of the Republic of Armenia. Protocol Decision of the RA Government, 18 January 2007.

2. Environment and Natural Resources in the Republic of Armenia in 2006, RA National Statistical Service, Yerevan, 2007

3. External Trade of the Republic of Armenia. RA National Statistical Service, 2001-2007.

4. National Atlas of Armenia, Volume A, State Committee of Real Estate Cadastre adjunct to the RA Government, Yerevan, "Geodesy and Cartography Center" SNCO, 2007.

5. RA Statistical Yearbook (2001-2008) / RA National Statistical Service. -2001-2008.-in Armenian, English, Russian: http:// www. armstat.am

6. Socio-economic Conditions of Armenia (1989-1995). RA Service of Statistics, State Registry and Analyses.

CHAPTER 2

National Greenhouse Gas Inventory

According to Article 4 of the UNFCCC, the Parties have primary commitment to develop, periodically update, publish and make available to the Conference of the Parties national inventories of anthropogenic emissions.

GHG inventories were elaborated and recalculated also for those years which have the necessary output data. Table 2-1 presents those years of the timeline 1990-2006, for which the GHG inventory has been prepared.

Table 2-1 Elaborated and recalculated greenhouse gas inventory years by sectors

Sector	Year	
	Inventories	Recalculation
Energy	1990, 1994-2006	1990, 1994-1996
Industrial processes	1990-2007	-
Solvent use	2000-2007	-
Agriculture	1990-2006	1990, 1994-1996
LULUCF	1990, 2000	1990
Waste	1990, 1994-2006	1990, 1994-1996

Armenia's First National GHG Inventory was prepared in 1996-1998, within the framework of preparation of the First National Communication to the UNFCCC. In the mentioned inventory, GHG emissions and sinks were evaluated for 1990 (baseline year) and 1994-1996, using the 1995 IPCC methodology.

In 2004, within the framework of the regional UNDP/GEF project for capacity building in order to improve the quality of national GHG inventories, the first inventory of GHG was improved, national experts were trained and some emission coefficients were updated. The key sources were also analyzed and the emission sources which needed an improved inventory were identified. Inventory data for methane emissions from solid waste landfills and livestock enteric fermentation were revised. Within the framework of the project, a national manual for GHG inventory was also developed, which was widely used during the preparation of the Second GHG inventory of Armenia.

According to the Guidelines (2003) for preparation of national communications of non-Annex I Parties, the year 2000 is selected as the baseline year for GHG inventory. For that year a comprehensive GHG inventory is developed, which includes all six sectors of IPCC - "Energy"; "Industrial Processes"; "Solvent Use"; "Agriculture"; "LULUCF" and "Waste". In order to complete the data series for the timeline 1990-2006, Data series were completed for the motioned period, with the exception of the "Solvent use" sector, for which data were collected only for the years 2000-2007, and the "LULUCF" sector, for which the necessary data have not been available. GHG emissions for “LULUCF” sector were calculated for the year 2000 and recalculated for 1990.

The Republic of Armenia, as a non-Annex I Party to the Convention, does not have the obligation to prepare annual GHG inventories and its national inventories are prepared within the framework of preparations of National Communications. The sustainable institutional mechanism for preparation of national GHG inventories has yet to be established in Armenia and inventories are prepared by temporary working groups. Independent experts, as well as the "Scientific Research Institute of Energy" CJSC have been involved in the preparation of the Inventory.

The organizational chart for preparation of the Second National GHG Inventory is presented in Figure 2-1.

2.1 Methodology and data sources used

With respect to the methodology, the National GHG Inventory was prepared based on the Revised 1996 IPCC Guidelines for National GHG Inventories, Good Practice Guidance and Uncertainty Management in National GHG Inventories (IPCC 2000), and Good Practice Guidance for

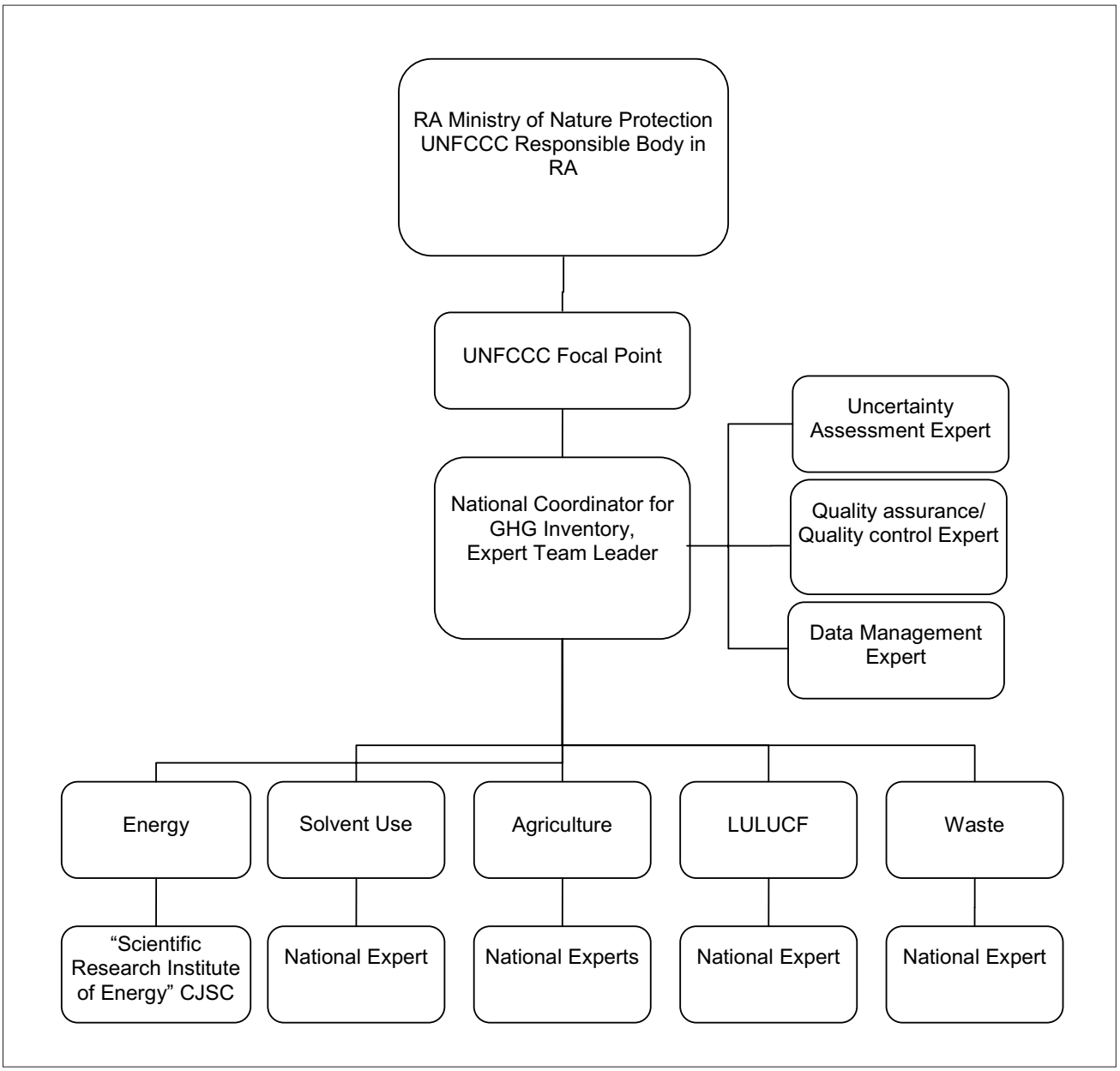


Figure 2-1 Organizational chart for preparation of the Second National Inventory of Greenhouse Gases

Land Use, Land-Use Change and Forestry (IPCC 2003). In the "Solvent Use" sector Atmospheric Emission Inventory Guidebooks (CORINAIR-99) of the Cooperative Program for Monitoring and Evaluation of the Long-Range Transboundary Air Pollution in Europe (EMEP) is used.

IPCC methodology is an open system, which can be completed, developed and updated based on country specific conditions. The work was done based on the following principles:

- strict compliance with the logic and structure of the IPCC methodology,
- prevalence of the use of national data and coefficients,
- use of all possible sources of information,
- maximum use of the possibilities of national information sources.

During the preparation of the GHG Inventory of Armenia, inventory of gases with direct greenhouse effect - CO_2, CH_4 and N_2O, from key sources were prioritized. The inventory of gases with indirect greenhouse effect - CO, NO_x, NMVOC, SO_2, was also prepared. The emissions of HFCs, PFCs, SF_6 compounds were not identified.

Input data for the sectors were provided by the Ministry of Agriculture, Ministry of Energy and Natural Resources, Ministry of Economy, the

State Revenue Committee under the RA Government, State Committee of the Real Estate Cadastre under the RA Government, National Academy of Sciences, municipalities of Yerevan, Gyumri, Vanadzor and other cities of Armenia, the "Scientific Research Institute of Energy" CJSC, "ArmRosgasprom" CJSC, "Hayenergo" CJSC, "Hayantar" SNCO, etc.

2.2 Greenhouse gas emissions for 2000

The overall GHG emissions of Armenia for the year 2000 is 6634.9 Gg CO_2 eq or 27% of the 1990 year's level (Table 2-2).

Carbon dioxide constitutes 71% of greenhouse gas emissions, 27% is methane, and 2% is nitrous oxide (Figure 2-2). The distribution of emissions by key sectors is as follows: "Energy" - 53%, "LULUCF" - 24%, "Agriculture" - 13%, "Waste" - 8% and "Industrial Processes" - 2% (Figure 2-3).

The main share of CO_2 emissions belongs to the "Energy" sector with 65% share, CH_4 and N_2O to the "Agriculture" sector with respectively 42% and 67% shares.

Compared to 1990, total GHG emissions in 2000 were four times less - from 24,219 Gg CO_2 eq to 6,635 Gg CO_2 eq. The largest declines in emissions took place in the “Energy” sector - from 22,777 Gg CO_2 eq to 3550 Gg CO_2 eq, as a result of the sharp decline in electrical and heat energy production in 1992-1994. Emissions from the “Industrial Processes” sector declined from 630 Gg CO_2 to 119 Gg CO_2, as a result of the shrinking cement production. Significant changes occurred also in the “LULUCF” sector - net flows in the sector in 1990 amounted to -736 Gg CO_2 eq, compared to1563.7 Gg CO_2 eq in 2000. The reduced GHG sequestration in the “LULUCF” sector is mainly because of the increase in the volume of forest logging and the deteriorating quality of croplands and grasslands, as a result of which the accumulated carbon was emitted into the atmosphere. Changes in emissions from other sectors were insignificant.

Table 2-2 Greenhouse gas emissions in Armenia, 2000 (Gg)

Sector	CO_2	CH_4	N_2O	CO_2 eq
Energy	3067.57	22.84	0.01	3550.62
Industrial processes	119.68			119.68
Agriculture		35.20	0.33	840.68
LULUCF	1536.30	1.30	0.00	1563.60
Waste		24.49	0.15	560.31
Total	4723.55	83.83	0.49	6634.89

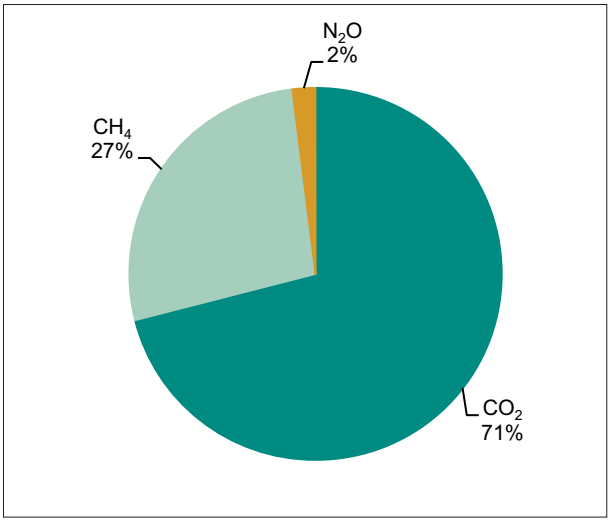


Figure 2-2 Distribution of greenhouse gas emissions by gases, 2000 (CO_2 eq)

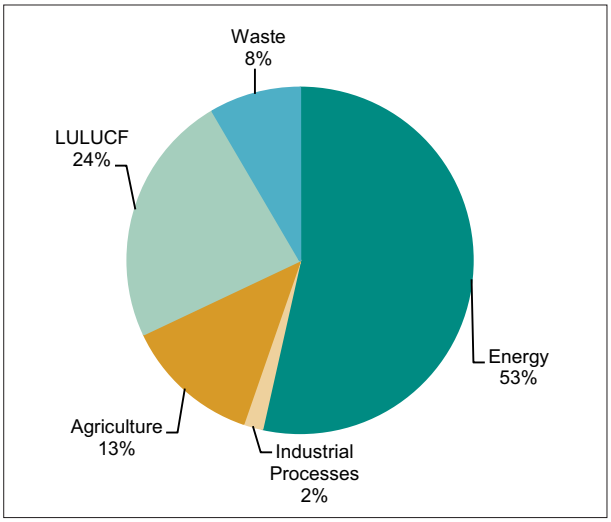


Figure 2-3 Distribution of greenhouse gas emissions by sectors, 2000 (CO_2 eq)

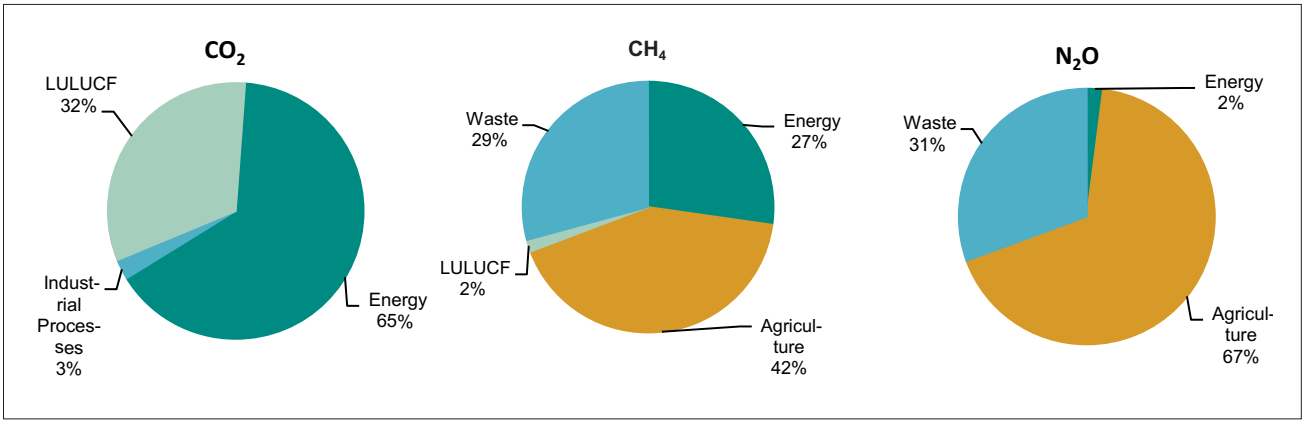


Figure 2-4 Distribution of greenhouse gas emissions in sectors by gases, 2000

Emissions of gases with indirect greenhouse effect reduced down to 80% of the levels in 1990 and amounted to 63.6 Gg of CO, 12.1 Gg of NO_X, 14.5 Gg of NMVOC and 0.6 Gg of SO_2.

More detailed data on GHG inventories, including those on gases with indirect greenhouse effect - CO, NO_X, NMVOC and SO_2, for the years 1990, 2000 and 2006 are provided in the Annex in the format suggested by the UNFCCC Guidelines for preparation of national communications.

2.3 Greenhouse gas emission trends, 1990-2006

Compared to 1990, total GHG emissions in 1990-2006 reduced by four times - from 25,000 Gg CO_2 eq to 6400 Gg CO_2 eq. The largest decline in emissions took place in 1991-1994, as a result of the economic and energy crisis in the transition period. In 1995-2006, parallel to the stable growth of GDP, GHG emissions remained at a low level and, in effect, did not change (Figure 2-5 and Table 2-3).

The mentioned pattern is explained by the drastic changes in the structure of the economy, decline in the share of the industrial sector and increase in the share of the non-industrial sector (Table 1-2), changes to the structure of the consumed energy resources - decline in the share of oil products, increase in the share of natural gas and use of nuclear energy (Table 1-3), and the decline in the production of electrical and heat energy as a result of the shrinking industrial production.

GHG emissions for 1990-2006 by sectors are presented in Figure 2-6 and Table 2-4.

The biggest reduction of GHG emissions occured in the "Energy" (80%) and "Industrial Processes" (49%) sectors. Since 2000, the emissions have increased in the "Industrial Processes" sector due to growing volumes of construction.

Significant changes were noticed in the "LULUCF" sector. In 1990 the removal and emission balance was -736 Gg CO_2 eq, in 2000 it was 1563.7 Gg CO_2 eq.

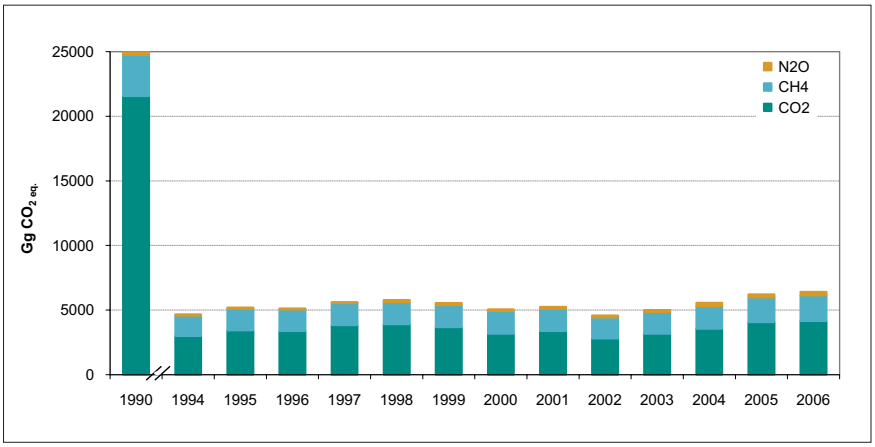


Figure 2-5 Greenhouse gas emissions by gases, 1990-2006

Table 2-3 Emissions of CO_2, CH_4 and N_2O,1990-2006 (Gg CO_2 eq)*

Year	CO_2	CH_4	N_2O	Total
1990	21558.52	3200.50	195.87	**24954.92**
1994	2994.83	1577.32	106.94	**4679.09**
1995	3427.09	1688.42	97.21	**5212.72**
1996	3376.95	1664.10	98.18	**5139.23**
1997	3835.91	1697.03	96.99	**5629.93**
1998	3897.38	1703.71	191.48	**5792.57**
1999	3679.63	1695.38	184.11	**5559.13**
2000	3159.90	1760.58	150.76	**5071.29**
2001	3384.74	1718.42	151.84	**5255.01**
2002	2803.80	1628.44	157.95	**4590.19**
2003	3162.82	1687.35	166.00	**5016.17**
2004	3546.91	1769.37	254.04	**5570.32**
2005	4053.63	1919.82	249.27	**6222.72**
2006	4157.02	1986.47	279.25	**6422.74**

** Without LULUCF*

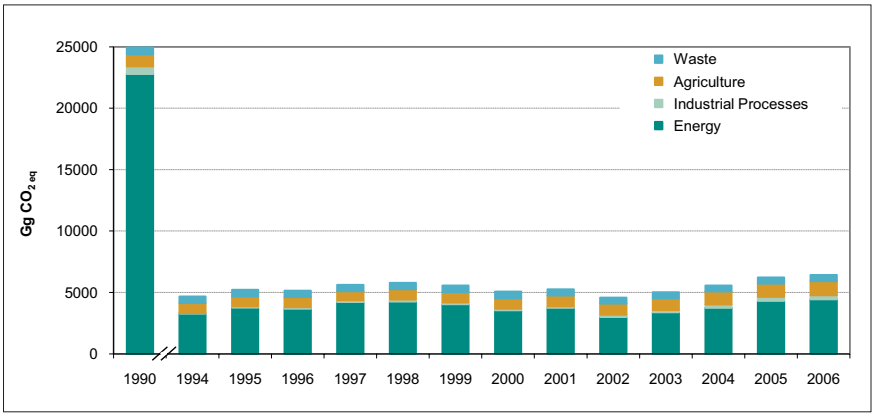


Figure 2-6 Greenhouse gas emissions by sectors, 1990-2006

Table 2-4 Greenhouse gas emissions by sectors, 1990-2006 (Gg CO_2 eq)

Year	Energy	Industrial Processes	Agriculture	LULUCF	Waste	Total
1990	22777.02	630.33	982.61	-736.02	564.96	**24218.89**
1994	3268.56	52.99	812.60	n/e	544.95	**4679.09**
1995	3757.19	120.00	804.04	n/e	531.49	**5212.72**
1996	3663.81	136.84	808.37	n/e	530.20	**5139.23**
1997	4216.37	141.02	739.69	n/e	532.84	**5629.93**
1998	4247.46	176.01	838.30	n/e	530.80	**5792.57**
1999	4031.84	144.02	846.37	n/e	536.90	**5559.13**
2000	3550.62	119.68	840.68	1563.60	560.31	**6634.88**
2001	3748.36	124.70	872.43	n/e	509.52	**5255.01**
2002	3003.68	165.31	911.49	n/e	509.71	**4590.19**
2003	3369.99	191.38	954.30	n/e	500.49	**5016.17**
2004	3746.44	268.81	1052.39	n/e	502.67	**5570.32**
2005	4315.47	317.71	1080.25	n/e	509.29	**6222.72**
2006	4441.40	323.78	1149.52	n/e	508.04	**6422.74**

Emissions from the "Agriculture" and "Waste" sectors did not change much during that period.

Total emissions of gases with indirect greenhouse effect in 1990-2006 reduced by 78%, including reduction of CO emissions by 76%, NO_x by 80% and NMVOC by 66% (Table 2-5).

lines, with the exception of heating values for natural gas and coefficients of sulfur content in various fuels, for which local values were identified and applied.

The CH_4 emissions factor for gas transportation and distribution system calculated based on the official data for natural gas leakages, exceeds the default value by 3.5 times, which is highly unlikely considering the measures implemented in the country for modernizing the gas supply system. This might be the result of the error in the balance of natural gas consumption. CH_4 leakages from natural gas transportation and distribution system were calculated using the average value of the CH_4 emissions factors proposed by the IPCC for former USSR republics (527,900 kg/PJ).

The available contradicting data on CH_4 fugitive emissions necessitate conducting investigations based on immediate measurements.

Table 2-5 Greenhouse gases emissions with indirect greenhouse effect and sulphur dioxide

Year	CO	NO_X	NMVOC	SO_2
1990	279.13	76.59	50.44	0.39
2000	64.60	12.13	14.54	0.64
2006	62.52	15.07	17.26	0.36

Detailed data on emissions of greenhouse gases and gases with indirect greenhouse effect for 1990, 2000 and 2006 are presented in the Annex.

2.4 Sectoral inventories

2.4.1 Energy

The largest decline in GHG emissions was noted in the “Energy” sector - the average emission for the period of 2000-2006 declined by 83% compared to 1990 (Figure 2-7).

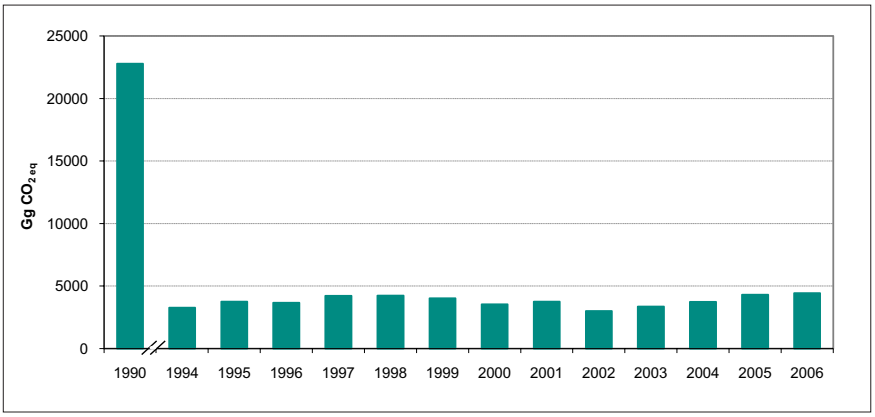


Figure 2-7 Greenhouse gas emissions in the "Energy" sector, 1990-2006

It must be noted that because of the absence of data on the distribution of fuel in the First National GHG Inventory for the period of 1994-1996, emissions from fuel combustion were calculated using the top-down approach. In the Second National GHG Inventory for 1997-2006, the bottom-up approach was applied, which allowed for distinguishing emissions from fuel combustion by subsectors. Emissions were calculated by IPCC Excel worksheets, using the emission coefficients provided by IPCC guide-

Parallel to the decline in the total GHG emissions, the share of fuel combustion in the emissions from the "Energy" sector declined from 93% in 1990 to 87-88% in 1997-2006, and the share of methane leakages increased respectively from 7% to 12-13% (Table 2-6).

GHG emissions from the “Energy” sector in the year 2000 were distributed by subsectors as follows - 47% from energy production, 18% from transport, 13% from the gas supply system, 12%

Table 2-6 Greenhouse gas emissions in the "Energy" sector, 1990, 1997-2006 (Gg CO_2 eq)

Year	Energy production	Transport	Processing industry and construction	Commercial/ institutional	Housing	Agriculture/ forestry/ fishery	Leakage emissions	Other	Total
1990	11391.46	3783.05	2058.23	1725.45	1687.70	145.79	1670.16	315.19	**22777.03**
1997	1951.54	995.76	548.41	30.36	47.18	133.88	509.24	0.00	**4216.37**
1998	1991.08	912.00	517.89	27.18	163.69	121.53	514.11	0.00	**4247.48**
1999	1550.11	937.40	505.8	106.35	311.92	137.26	483.00	0.00	**4031.84**
2000	1666.76	647.84	445.49	39.62	195.34	82.23	473.35	0.00	**3550.63**
2001	1689.85	596.93	365.39	90.20	208.05	320.29	477.64	0.00	**3748.35**
2002	980.99	682.50	387.10	84.53	198.24	316.80	353.53	0.00	**3003.69**
2003	974.92	768.38	416.02	140.77	334.82	350.97	384.12	0.00	**3369.99**
2004	1014.37	822.13	545.45	73.66	468.85	368.60	453.38	0.00	**3746.44**
2005	1158.37	853.17	687.01	35.78	634.43	384.08	562.64	0.00	**4315.48**
2006	956.12	947.94	680.78	109.08	792.18	366.43	588. 87	0.00	**4441.40**

from industry and construction, and 6% from the household sector. The share of emissions from other subsectors in the total emissions amounted to 4%.

The major share of GHG emissions from the sector is carbon dioxide, which amounted to 87-88% in 1997-2006. The share of methane amounted to 12-13%, nitrous oxide's share was less than 0.2% (Table 2-7).

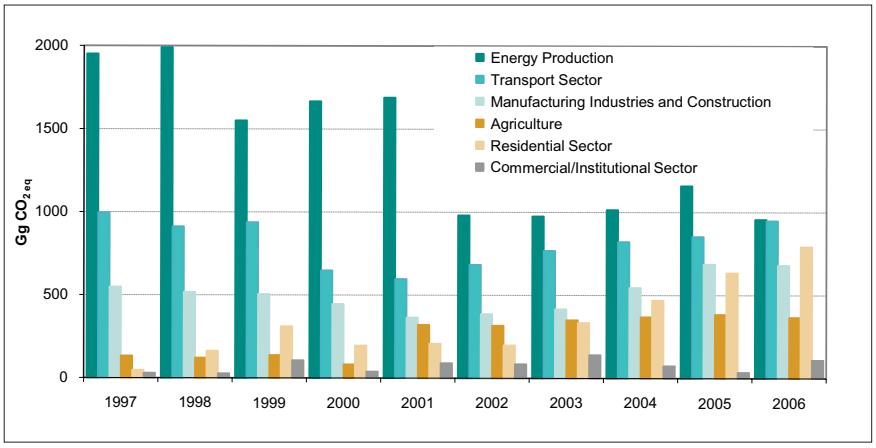


Figure 2-8 Greenhouse gas emissions from fuel combustion in the "Energy" sector, 1997-2006

The main trends of GHG emissions from the "Energy" sector in 1997-2006 are as follows: decline in the share of emissions from energy production from 47% to 21%, increase in the share of emissions from commercial/institutional and household subsectors from 2% to 20% and agricultural subsector from 3% to 13%.

Figure 2-8 presents GHG emissions from fuel combustion, 1997-2006.

2.4.2 Industrial processes

In Armenia's "Industrial Processes" sector, the main source of GHG emissions with direct greenhouse effect is cement production which emits carbon dioxide. The "Industrial Processes" sector in Armenia also includes food production, which has an insignificant amount of emissions of gases with indirect greenhouse effect (NMVOC).

Table 2-7 Emissions by gases in the "Energy" sector, 1990, 1997-2006 (Gg CO_2 eq)

Year	CO_2	CH_4	N_2O	Total
1990	20985.6	1725.0	66.4	**22777.0**
1997	3694.9	516.8	4.7	**4216.4**
1998	3721.4	521.5	4.6	**4247.5**
1999	3535.6	491.7	4.5	**4031.8**
2000	3067.6	479.6	3.4	**3550.6**
2001	3260.1	484.6	3.8	**3748.4**
2002	2638.5	361.9	3.3	**3003.7**
2003	2971.4	393.7	4.9	**3370.0**
2004	3278.1	464.3	4.1	**3746.4**
2005	3735.9	575.3	4.2	**4315.5**
2006	3833.2	604.0	4.1	**4441.4**

CO_2 emissions from cement production are presented in Figure 2-9. During the years of economic crisis, emissions reduced by five times (from 630 Gg in 1990 to 120 Gg in 1994). Since 2000, emissions increased by 37% - from 119 Gg to 324 Gg due to increased demand of cement in construction activities.

The current IPCC methodology for this sector does not offer emission calculation methods, and as a result, the atmospheric emissions guide book (CORINAIR) of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transboundary Air Pollutants in Europe (EMEP) was used. Data on the volumes of

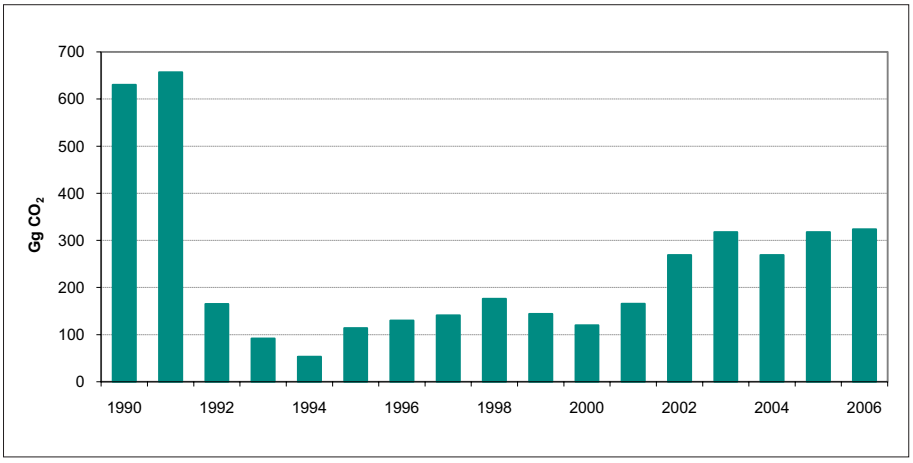


Figure 2-9 Greenhouse gas emissions in the "Industrial Processes" sector, 1990-2006

2.4.3 Solvent use

This sector inventory was prepared for 2000-2006, since the necessary data were available only for those years. The only greenhouse gases emitted from the sector are NMVOCs, which are emitted due to the use of paints. The necessary data for assessing NMVOC emissions from other sources (dry cleaning, use of deodorants, etc.) are not available, and rough expert assessments revealed that these emissions are small.

paint produced, exported and imported in 2000-2006 provided by the National Statistical Service of the Republic of Armenia served as the basis for calculations. Figure 2-10 presents the dynamics of NMVOC emissions from paint use.

From 2000-2006 NMVOC emissions increased significantly (from 0.92 Gg to 4.1 Gg), which is due to the increasing volume of construction.

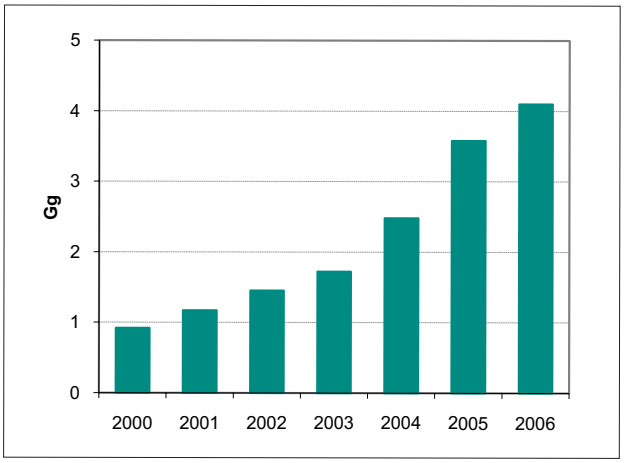


Figure 2-10 NMVOC emissions in the "Solvent Use" sector, 2000-2006

2.4.4 Agriculture

In 1990, emissions from the "Agriculture" sector accounted for 4% of the total GHG emissions and in 1997-2006 period they amounted to 17-19% (without LULUCF).

This sector includes the following emission sources:

- Enteric fermentation - CH_4
- Manure storage and use - CH_4, N_2O
- Agricultural lands - N_2O
- Burning of plant residues in fields - CH_4, N_2O, CO, NO_x.

In this sector, the main source of emissions is the "Enteric fermentation". In 1990-2006, the share of this source was 75-88% of the sector total emissions. The significant part of this source comes from livestock production (90%), especially from cattle breeding. Taking this fact into account, methane emissions from enteric fermentation in cattle were calculated with methods described in both Tier 1 and Tier 2 proposed by IPCC guidelines with the use of country specific coefficients, and for other animals the calculation was done by Tier 1 method. Emissions from other sources were also calculated using the Tier 1 method.

Table 2-8 presents GHG emissions from the "Agriculture" sector. The share of enteric fermentation accounts for 80% of the total sectoral emissions. The share of agricultural lands is 13%, manure storage and use - 6% and burning of plant residues in the fields" - less than 1%.

In 1990-2006, the share of enteric fermentation declined from 88% to 75%, emissions from agri-

Table 2-8 Greenhouse gas emissions in the "Agriculture" sector, 1990-2006 (Gg CO_2 eq)

Year	Enteric fermentation	Manure collection, storage and processing	Agricultural soils	Burning of agricultural residues in the fields	Total
1990	870.33	58.20	48.67	5.40	**982.61**
1991	780.18	55.16	23.61	6.12	**865.07**
1992	701.84	49.13	54.35	6.29	**811.62**
1993	698.41	50.29	54.64	6.75	**810.09**
1994	701.36	50.81	55.05	5.38	**812.60**
1995	699.83	50.80	47.55	5.85	**804.04**
1996	702.42	50.37	48.59	7.00	**808.37**
1997	644.17	46.54	43.44	5.54	**739.69**
1998	645.99	46.97	138.34	6.99	**838.30**
1999	660.60	47.85	131.45	6.47	**846.37**
2000	687.40	48.45	100.00	4.83	**840.68**
2001	714.02	50.34	100.63	7.44	**872.43**
2002	743.64	52.55	106.98	8.32	**911.49**
2003	780.75	52.85	113.88	6.83	**954.30**
2004	787.84	54.10	202.51	7.94	**1052.39**
2005	818.03	56.39	197.34	8.49	**1080.25**
2006	857.46	58.49	228.34	5.24	**1149.52**

cultural lands increased from 5% to 20%, as a result of the wider use of nitrogen fertilizers. Emissions from other sources of the sector have not changed significantly.

The total volume of GHG emissions in the observation period has not changed much, but a steady increase in emissions is noted since 2000.

Methane is the prevalent gas emitted from the sector (Figure 2-11).

2.4.5 Land use, land use change and forestry

GHG emissions from the sector were assessed using the IPCC Best Practices Manual (BPM IPCC, 2003). Within the framework of the First National Communication of Armenia, GHG emissions from the sector were assessed using IPCC Guidelines of 1995. The transition to the new methodology was a very complicated issue, which was overcome due to the support of capacities built under the regional program for capacity building to improve the quality of the Second National GHG Inventory.

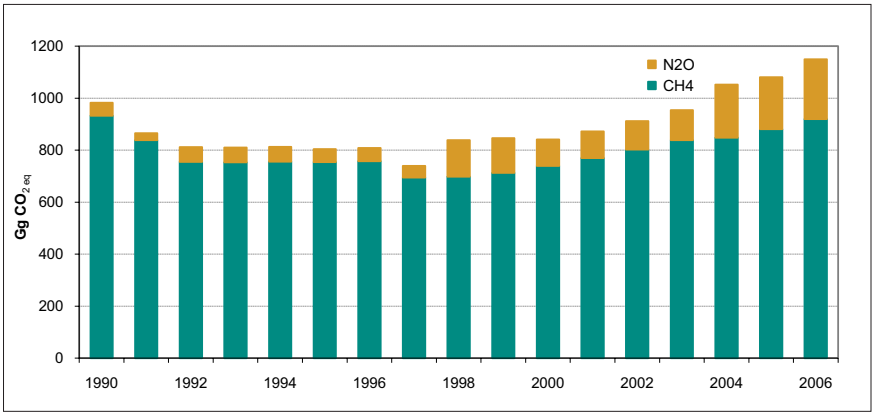


Figure 2-11 Greenhouse gas emissions by gases in the "Agriculture" sector, 1990-2006

Table 2-9 Net flows of greenhouse gases in the "LULUCF" sector, 1990 and 2000 (Gg CO_2 eq)

Sectoral categories	Net GHG flows (Gg CO_2 eq)	
	1990	2000
5. Land use, land use change and forestry, total	**-736,0**	**1 563,6**
5A Forestlands	**-837,1**	**441,0**
5A1 forestland remaining forestland	-816,4	441,0
5A2 land converted into forest land	-20,7	0,0
5B Croplands	**-134,0**	**501,8**
5B1 croplands remaining cropland	-150,2	501,8
5B2 land converted into cropland	16,2	0,0
5C Grassland	**173,4**	**598,3**
5C1 grasslands remaining grassland	173,4	305,5
5C2 lands converted into grassland	0,0	292,8
5D Wetlands	**71,2**	**27,7**
5D1 wetlands remaining wetland	55,5	28,3
5D2 lands converted into wetland	15,7	0,0
5E Settlements	**-9,4**	**-5,2**
5E1 settlements remaining settlement	-12,5	-5,2
5E2 lands converted into settlement	3,0	0,0
5F Other lands	**n/c**	**n/c**
5F1 lands converted into other land*	**n/c**	**n/c**

**According to IPCC Best Practice Guidelines the emissions are not calculated (n/c) for the lands ("Other lands") which are not subject to human interference.*

The main problem in the sector was the inadequate availability of the necessary data. In particular, land balances were not prepared for 1998-2005, and the most recent comprehensive data on state inventory of forests were available for 1988. For the baseline year of 2000, emissions/removals were calculated using the interpolation method, based on Land Balance data available for 1995, 1996, 1997, 2006 and 2007. Due to the mentioned reasons, GHG emissions from the sector were calculated only for the year 2000 and recalculated for the year 1990. According to recalculated data for 1990, net flows of CO_2 from the "LULUCF" sector amounted to -736.0 Gg, which constituted -617 Gg according to the First National GHG Inventory data. This change is not only based on the improvements in the methodology of IPCC, but also updating of the data on activities for land-use categories, as well as improvements in a number of local emission factors for the "Forestry" sector.

CO_2 emissions/removals, as well as emissions of CH_4, N_2O, NO_x and CO were assessed from forest fires and land use changes. In the "LULUCF" sector in the year 2000, compared to 1990, a sharp increase in the emission-removal net was recorded - from -736 Gg to 1563.6 Gg, which means that the sector is transformed from a sink into a source of emissions (Table 2-9). These changes are mainly due to the increase in the volume of forest logging and the deteriorating of croplands and grasslands quality.

2.4.6 Waste

The "Waste" sector inventory was prepared for the years 1997-2006. Data for 1990, 1994-1996 are also recalculated, since figures for municipal solid waste disposal (MSWD), methane correction factor (MCF) and degradable organic carbon (DOC) were updated.

The sector share in the total GHG emissions (without LULUCF) amounts to 2.5% in 1990 and 8-11% in 1994-2006.

This sector includes the following emissions sources:

- Municipal solid waste landfills - CH_4
- Industrial discharges - CH_4
- Municipal and commercial discharges - CH_4, N_2O.

GHG emissions from the "Waste" sector in 1990, 1994-2006 are presented in the Table 2-10 and Figure 2-12. For all the observed years the main source of the emissions in the sector is the municipal solid waste landfills, the share of which in the total sectoral emissions amounts to 85-90% and discharges/liquid waste emissions - 10-15%.

Table 2-10 Greenhouse gas emissions in the "Waste" sector, 1990-2006 (Gg CO_2 eq)

Year	Municipal solid waste	Liquid waste	Total
1990	512.0	53.0	**565.0**
1994	495.1	49.8	**545.0**
1995	484.0	47.5	**531.5**
1996	483.1	47.1	**530.2**
1997	471.5	61.3	**532.8**
1998	475.1	55.7	**530.8**
1999	473.7	63.2	**536.9**
2000	468.0	92.3	**560.3**
2001	435.0	74.5	**509.5**
2002	434.9	74.8	**509.7**
2003	441.1	59.4	**500.5**
2004	444.6	58.1	**502.7**
2005	451.9	57.4	**509.3**
2006	455.6	52.5	**508.0**

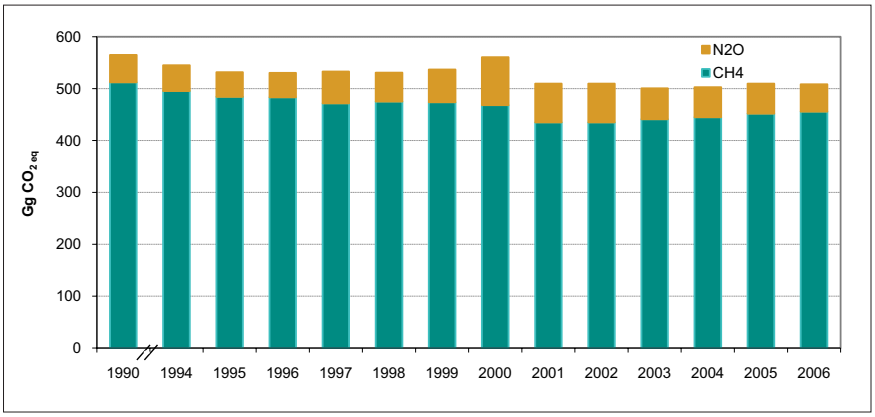


Figure 2-12 Greenhouse gas emissions by gases in the "Waste" sector, 1990-2006

2.5 Analysis of the key sources of greenhouse gas emissions

Analysis of the key sources (AKS) of GHG emissions allows determining the shares of GHG emissions from sources included in various sectors in the overall volume of emissions. The analysis categorizes sources and emissions by their importance and helps to determine emission reduction and limitation priorities during the drafting of the mitigation strategy and action plan for the given sector. The AKS is important also for determining priorities for improving the assessment methods for the inventory data and GHG emissions. According to the IPCC guidelines, the key sources are those which produce at least 95% of the overall emissions (according to the categorized list of volumes of emissions). The AKS prepared based on this "level assessment" method is presented in the Second National Greenhouse Gas Inventory report of Armenia.

According to the IPCC, assessment of the trends in GHG emissions is considered good practice, which, however, produces applicable results only in countries with relatively stable economic development and reflects the changes in the "importance" of one or another source. However, when the country is in an economic transition period, which is accompanied by crisis phenomena and is characterized by significant structural changes to the economic system, analysis of trends of key sources does not produce appropriate results and, thus, is not applicable for Armenia.

Within the framework of this study, AKS level assessments were done for 1990 and 1997-2006. According to the results of AKS level assessments, there were 13 key sources in the year 2000, where the source "1.A1 CO_2 emissions from stationery combustion of gas" was in the first place with a 25.4% share, and the source "4.D NO_2 (direct and indirect) emissions from agriculture soils" was in the 13th place with a 1.5% share. The detailed data on AKS are presented in Table 2-11.

2.6 Quality control and quality assurance

The quality control and quality assurance (QC/QA) procedures have been the integral part of the GHG inventory process in Armenia aimed at improving the quality of the inventory. The QC/QA procedures have been implemented based on the Tier 1 approach of the IPCC Good Practice Guidance, and organizations from respective sectors have taken part in the process.

QC process for all sectors has comprised the following:

- Check the incorrectness and mechanical errors of input data;
- Check the incorrectness and mechanical errors of data entered;
- Check the calculations for filling the data gaps;
- Check the entered measurement units and emission factors;
- Check the estimations of GHG emissions;
- Check the completeness/consistency of the timeline with focus on calculation methodologies, emission factors or other changing parameters;
- Check the accuracy of entered formulas in reporting sheets compliant to the national cir-

Table 2-11 Analysis of key sources

IPCC source categories	Sector	Source category, which should be assessed in key source analysis	Applicable GHG	Emissions assessment (current year, without LULUCF) (Gg CO_2 eq)	Emissions assessment (current year, with LULUCF) (Gg CO_2 eq)	Total net emissions (current year, with LULUCF) (Gg CO_2 eq)	Level assessment (without LULUCF) (%)	Accumulated level (without LULUCF) (%)	Level assessment (with LULUCF) (%)	Accumulated level (with LULUCF) (%)
1.A.1	Energy	CO_2 emissions from stationary sources (gas-A)	CO_2	1665.2		1665.2	32.8	32.8	25.2	25.2
4.A	Agriculture	CH_4 emissions from livestock enteric fermentation	CH_4	687.4		687.4	13.6	46.4	10.4	35.7
1.A.3	Energy	CO_2 from fuel combustion activities in transport	CO_2	642.0		642	12.7	59.1	9.7	45.4
5.B	LULUCF	Croplands remaining cropland	CO_2		501.8	501.8		59.1	7.6	52.8
1.B.2	Energy	CH_4 leakages from oil and natural gas activities	CH_4	473.3		473.3	9.3	68.4	7.2	60.0
6.A	Waste	CH_4 emissions from solid waste landfills	CH_4	468.0		468	9.2	77.6	7.1	67.0
1.A.2	Energy	CO_2 emissions from industrial processing and construction	CO_2	444.3		444.3	8.8	86.4	6.7	73.8
5.A	LULUCF	Forestlands remaining forestland	CO_2		441.0	441.0		86.4	6.7	80.4
5.C	LULUCF	Grasslands remaining grassland	CO_2		305.5	305.5		86.4	4.6	85.0
5.C	LULUCF	Lands converted into grassland	CO_2		292.8	292.8		86.4	4.4	89.5
1.A.4	Energy	Other sectors. Housing sector CO_2	CO_2	194.8		194.8	3.8	90.2	2.9	92.4
2.A	Industrial processes	CO_2 emissions from cement production	CO_2	119.7		119.7	2.4	92.6	1.8	94.2
4.D	Agriculture	N_2O (direct and indirect) emissions from agricultural soils	N_2O	100.0		100.0	2.0	94.5	1.5	95.7

cumstances;

- Check the calculations of national emission factors;
- Check the respective documentation and references.

The QA, as defined in the IPCC Good Practice Guidance, is "...a planned system of review procedures conducted by the third party upon a finalized inventory". The quality assurance process usually includes both expert and general public review. Expert review is implemented in two stages: review of the preliminary version of the emission calculations, and review of the calculations and inventory report. In addition, during the review process experts are selected and involved to ensure additional review of the inventory and identification of ways for assessment and improvement of inventory methodologies and data.

2.7 Assessment of uncertainties

Assessment of uncertainties is based on IPCC GPG 2000, and IPCC GPG LULUCF 2003. The uncertainties are conditioned by the uncertainties in the activity data used and emission factors. When using statistical data, the uncertainty of activity data amounts to 6-10%, uncertainty of data received from enterprises is considered to be up

to 5%. Uncertainties of emission factors taken from IPCC guidelines, depending on the source of emissions and the greenhouse gas, amount to 15-50%.

Results of the analysis of uncertainties are presented in Table 2-12.

Uncertainties of key sources in the "LULUCF" sector are:

- croplands remaining cropland subcategory - 75%;
- forest land remaining as forest land subcategory - 101%.

The analysis of uncertainties by Tier 1 method was conducted with the same categories used for the analysis of key sources.

In Armenia, similar to other countries with transition economies, the difficulties in assessing uncertainties of activity data for 1990-2006 are conditioned by the following main circumstances:

- Absence of calculation of statistical data uncertainties at national statistics;
- Difficulties in assessing uncertainties based on trends, conditioned by:
  - Sharp economic decline in 1990 and slow recovery starting in 1997;
  - Significant changes in the sources of activity data;
  - Difficulties of data collection related with the shadow economy.

Table 2-12 Uncertainties of greenhouse gas emissions from key sources

	Emission source categories	Gas	Uncertainty, %
1.A.1	Energy production	CO_2	5.3
1.A.3	Road transportation	CO_2	9.9
1.A.2	Industry and construction	CO_2	5.3
1.A.2	Other sectors	CO_2	9.9
2.A	Cement production	CO_2	8.8
	CO_2 total uncertainty		**3.7**
4.A	Enteric fermentation	CH_4	26.2
1.B.2.	Natural gas	CH_4	50.2
6.A	Solid municipal waste	CH_4	29.1
	CH_4 total uncertainty		**20.4**

Literature

1. Agriculture in the Republic of Armenia (1990-1999), National Statistical Service of Armenia, 2001

2. EMEP (1999). Atmospheric Emission Inventory Guidebook: the Core Inventory of Air Emissions in Europe.

3. External Trade of the Republic of Armenia (2001-2007), Yerevan, National Statistical Service of Armenia (2002-2008).

4. First National Communication of the Republic of Armenia under the UNFCCC. (1998). Ministry of Nature Protection of the Republic of Armenia. UNDP/GEF Armenia.

5. Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention. Decision 17/CP.8. 2002.

6. IPCC Good Practice Guidance on Land Use, Land Use Change and Forestry (2003). National GHG Inventory Program.

7. IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories. (2000).

8. IPCC Guidelines for National GHG Inventories. (1996). Reference Manual. IPCC. 1996. Volume 3.

9. IPCC Guidelines for National GHG Inventories. (1996). Workbook. IPCC. 1996. Volume 2.

10. IPCC Guidelines for National GHG Inventories. (1996). Reporting Instructions. IPCC.1996. Volume 1.

11. "Land Balance of the Republic of Armenia by Categories and Types of Land as of 1 January 1997" adopted by the National Assembly of Armenia on 16 September 1998.

12. "Land Balance of the Republic of Armenia by Categories and Types of Land as of 1 January 1996" adopted by the National Assembly of Armenia on 4 March 1997.

13. "Land Balance of the Republic of Armenia by Categories and Types of Land as of 1 January 1995" adopted by the National Assembly of Armenia on 7 February 1996.

14. Manual for National GHG inventory of Armenia. UNDP Armenia, Yerevan 2006.

15. National GHG Inventory of the Republic of Armenia. Ministry of Nature Protection of Armenia, UNDP Armenia, (1999).

16. Reports on the Availability and Distribution of Land Stock (land balance) in the Republic of Armenia for 2006 and 2007. Orders of the Government of Armenia No. 1938-N dated 28 December 2006, and No. 7 dated 10 January 2008.

17. Statistical Yearbook of Armenia (2001-2007). National Statistical Service of Armenia, Yerevan (2002-2007).

CHAPTER 3

Policies and Measures to Mitigate Climate Change

As a non-Annex I Party to the UNFCCC, Armenia does not have quantitative commitments for reducing GHG emissions; however having belief in and supporting Convention objectives, as well as taking into account that the emissions reduction is in line with the economic, energy and environmental objectives of the country, Armenia is currently implementing and also envisages future implementation of measures for GHG reductions. At the same time, due to mitigation projects implemented through the Clean Development Mechanism of the Kyoto Protocol, Armenia has certain potential for transferring emission reductions.

In recent years, Armenia has passed a number of laws and regulations, national and sectoral development programs, which are based on the sustainable development principles. Despite the fact that the mentioned documents do not clearly state that the measures are aimed at reduction of GHG emissions, the implementation of those laws and programs ultimately contribute to the reduction.

3.1 Legislation

Laws

The Law of the Republic of Armenia on Atmospheric Air Protection (1994) is ensuring clean atmospheric air, reduction and prevention of chemical, physical, biological and other hazardous impacts on atmospheric air. The Law defines the safe levels of hazardous substances' emissions, which contribute to the reduction of direct and indirect (NO_x, CO and SO_2) GHGs as well.

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) define the main principles of state policy in the energy sector:

- Ensure effective use of local energy reserves and alternative sources of energy and application of economic and legal mechanisms for that purpose;
- Ensure the energy independence and security of Armenia;
- Create new industries, organize new services, implement targeted national programs and apply new technologies to promote the development of renewable energy and energy saving;
- Promote introduction of energy-efficient and energy-saving technologies;
- Reduce environmental impacts.

The Law of the Republic of Armenia on Waste (2004) regulates waste collection, transportation, processing, utilization, dismissal, reduction of volumes and other issues related to it, as well as the legal and economic bases of the impact on human health and environment.

The Forest Code of the Republic of Armenia (2005) regulates the sustainable management of forests and forest land-relationships relevant to maintenance, protection, restoration, forestation and effective use, as well as inventory, monitoring, supervision of forests and other relationships related to forest lands. Implementation of the provisions of the Code will contribute to the improved capacities of forests as carbon dioxide sequesters.

Government Decrees

- On Approval of the Order on Examination of Plans on Standards of Maximum Permissible Emissions of Organizations with Stationary Sources of Emission that Pollute the Atmospheric Air and on Granting Emissions Permit (2008).
- On Approval of Maximum Permissible Concentration of Air Polluting Substances in Settlements and Maximum Permissible Norms of Hazardous Substances in Emissions from Vehicles Exploitable in the Republic of Armenia (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 (2006).
- On Approval of the Action Plan to Meet the Commitments of the Republic of Armenia Under a Number Environmental Conventions (2004).
- On Norms and Emission Permits of Maximum Permissible Emissions of Atmospheric Air Polluting Substances and Maximum Permissible Level of Harmful Physical Impact (1999).

3.2 National programs

The Sustainable Development Program (2008) has four main strategic directions - ensure sustainable economic growth, implement a targeted social policy for improving populations' living standards, improve the effectiveness of governance and ensure environmental protection and sustainable management of natural resources.

The Second National Environmental Action Plan (2008) provides a list of environmental measures for the period of 2008-2012. In particular, it envisages drafting of legal documents and tools for implementation of projects within the framework of the CDM under the Kyoto Protocol.

3.3 Sectoral programs

Energy

Strategy on Development of the Energy Sector within the Context of Economic Development in Armenia (2005) covers the period until 2025 and has the following objectives: contribute to the sustainable economic development of Armenia and energy security, including the classification of imported and local energy reserves; maximum utilization of renewable and nontraditional sources of energy; promoting energy saving; environmentally friendly energy supply in line with the international commitments of Armenia. By implementation periods, the strategy provides indicators for forecasted energy consumption in different sectors of economy and a list of projects for development of the electrical energy, gas supply and heat supply sectors.

Workplan of the Ministry of Energy of Armenia based on the provisions of the National Security Strategy (2007) is based on the provisions of the energy strategy and envisages the following energy capacity exploitations and measures by 2025: construction of new HPPs with 540 MW capacity (including 260 MW from small HPPs); construction of wind turbines with 200 MW capacity; modernization of the currently operational two TPPs by gas turbine installations with a total capacity of 648 MW; construction of a new energy block with combined heat and power generation facilities in the 1000 MW Armenian nuclear power plant (NPP); modernization of power transmission and distribution networks in order to reduce losses; construction of Iran-Armenia gas pipeline; restoration of underground storage facilities for natural gas with the volume of 150 million cubic meters; restoration of heat supply with the maximum use of geothermal, biogas, solar and other renewable energy sources; wide scale introduction of sustainable measures ensuring energy saving. The work plan includes timetables and financial resources for implementation of measures.

National Program for Energy Savings and Renewable Energy (2007) provides the assessment of the energy saving potential in power, heat and gas supply systems, in the industrial production, transportation, housing and public sectors, as well as the assessment of the potential of renewable energy and the measures for cost-effective exploitation of the energy saving potential.

Small Hydropower Plants Development Scheme (2009) aims to promote the construction of small HPPs and includes water energy indicators for more than 100 small HPPs.

Restoration, modernization and expansion of the gas supply system in Armenia. Measures implemented regularly by the "ArmRosgasprom" CJSC contribute to the current and future reduction of natural gas (methane) leakages. One of the projects, apt to reduce methane leakages in gas distribution system of Armenia, developed by the company, is implemented within the Clean Development Mechanism of the Kyoto Protocol.

Certain financial mechanisms are developed for promotion of renewable energy and energy efficiency in Armenia:

- *Tariff policy* currently applied in Armenia contributes to development of renewable energy and creation of favorable conditions for attracting investments. Privileged tariffs are defined for electricity produced by small HPPs, wind turbines and biogas equipment. Privileged tariffs are also defined for electricity produced in combined production systems based on useful heat demand.

- *Renewable Energy and Energy Saving Fund of Armenia* is established according to the priorities of the strategy adopted by the Government of Armenia on renewable energy and energy efficiency. The Fund implements credit and grant programs for development of the mentioned sectors under financing of the WB, the GEF and the state budget. The Fund contributes to the development of renewable energy and energy saving market. It provides grants to vulnerable families for provision of gas fired household heating systems, restores the central heating systems of schools and provides credits for construction of small HPPs and wind turbines. The Fund provides grants also to the socially vulnerable families to ensure application of gas heating system in their apartments.
- *Credit organizations* have been established in Armenia in order to support the development of renewable energy, with financing from international financial organizations (WB, EBRD, German Development Bank - KFW). Credits are provided to private companies and businessmen with favorable conditions. As of 2009, credit organizations had financed the construction of about 40 small HPPs.

As a result of the state policy on development of renewable energy, significant progress has been recorded in Armenia in the renewable energy sector in recent years. In particular, the following activities were implemented in Armenia through financing by international structures and the Government:

- construction of the wind power station Lori-1 with 2.64 MW design capacity;
- construction of 56 small (up to 10 MW capacity) HPPs, with about 250 million kW annual production capacity;
- feasibility study for construction of "Jermaghbyur" geothermal power plant with 25 MW capacity;
- installation of solar water boiler stations, with total surface of about 3000 m²;
- installation of a 10 kW photovoltaic station on the roof of Armenian-American healthcare center which will work in parallel to the power grid.

Transport

Action Plan for Reducing Emissions of Hazardous Substances from Vehicles (2005) envisages 26 measures for the period of 2005-2013, which aim to register emissions, improve road traffic and transportation flows, develop public transportation (including electrical means of transportation) and promote the use of clean engine fuels.

Yerevan Master Plan of 2006-2020 aims to reduce vehicle emissions by 20% by 2020, through developing electrical transport, introducing a new transport scheme for the city and application of neutralizers for vehicle emissions.

The increase in the share of natural gas (as engine fuel) by up to 45% and the use of biogas after 2015, as well as programs targeted at roads improvement in the Republic will contribute to the reduction of GHG emissions from vehicles.

Waste

Since 2008, several projects are implemented in Armenia aimed at extraction of biogas from large MSW landfills. Reconstruction of wastewater treatment plants in Martuni, Vardenis and Gavar is also envisaged by 2020. Meanwhile, it is envisaged to restore the Yerevan aeration station (facilities for preliminary treatment and sludge sedimentation, as a first stage).

Forestry

National Forest Policy and Strategy (2004) and National Forest Program (2005) are aimed at restoration of the degraded forest ecosystems, their sustainable use and ensuring the development of useful characteristics of forests.

For 2009-2020, it is planned to restore degraded forest ecosystems on 2-2.5 thousand hectares, forest plantation on 5-5.5 thousand hectares, create protective forest zones on 0.6-0.65 thousand hectares.

3.4 Implementation of Clean Development Mechanisms of Kyoto Protocol

By the Decree of the Government of Armenia No. 974 dated 13 July 2006, the Ministry of Nature Protection has been appointed as the designated national authority for the Clean Development Mechanism. One of the main functions of DNA is to approve the compliance of CDM projects with the requirements of the Kyoto Protocol, as well as to ensure effective participation of Armenia in international CDM processes. Procedures for submitting project proposals within the CDM framework are approved by the ordinance of the Nature Protection Minister No. 474, dated 25 December 2008. It defines the phases of project proposal submission within the framework of the CDM, and the list of documents, which should be submitted to the DNA (Ministry of Nature Protection of Armenia) by the project participants. The ordinance of the Minister of Nature Protection, which will approve the procedures for project approval within the framework of the CDM of Kyoto Protocol under the UNFCCC, as the logical continuation of the procedures for submitting documents, is currently being circulated and is in the approval phase. As of 2008, the CDM DNA in Armenia has approved 7 CDM projects, 5 of which are registered by the CDM Executive Board. 3 other CDM projects are endorsed. Information on the projects is presented in Table 3-1.

Table 3-1 CDM projects being implemented or envisaged in Armenia, 2008

	Projects	Annual reduction of CO_2 eq	Expected ivestments, USD million
Registered by the CDM Executive Board and being implemented			
1	Exploitation of biogas in Nubarashen municipal solid waste landfill of Yerevan and production of electricity	56000	5.2
2	Lusakert biogas plant capture and burning of methane produced from processing of poultry manure	62832	4.5
3	Yeghegis small hydropower project	3166	1.5
4	Argichi small hydropower project	13331	4.6
Approved by CDM authorized national body			
5	Yeghvard-2 small hydropower plant project	8741	9.0
6	Hankavan-1 small hydropower plant project	1225	1.2
7	Jradzor small hydropower plants project	8734	2.5
Projects endorsed by the CDM Designated National Authority			
8	Optimization of technological processes for cement production and introduction of energy-saving technologies in “Mika Cement” CJSC	117478	4.3
9	Restoration of heat and hot water supply in Avan district of Yerevan	36924	21.3
10	Recovery of biogas from poultry manure and thermal (electrical) energy generation in “Araks Poultry Factory” CJSC	47118	4.0

CHAPTER 4

Projection of Greenhouse Gas Emissions

Projection of GHG emissions for the period 1995-2010 was presented in Armenia's First National Communication on climate change. Later, the results of the GHG inventory for 1995-2007 revealed that the actual emissions are lower than the projected indicators, which is mainly the result of the decision to prolong the operation of the Armenian Nuclear Power Plant, faster rates of gasification, the use of natural gas as fuel in vehicles, reduced volumes of power production, as well as structural changes in the economy.

4.1 Methodology

GHG emissions are projected for 2005-2020 and the calculations are based on the expected volumes of operations in the relevant sectors of economy and the basic macroeconomic development scenario with an average 6.0% of annual growth. Assumptions for the future volumes of operations and measures for reducing emissions are based on sectoral development plans presented in Chapter 3.

For all categories of emissions sources, two scenarios of GHG emissions were considered.

"Business-as-usual" scenario, which assumes the overall continuation of practices and relationships at the national level, but also includes certain processes of modernization corresponding to international trends.

"With measures" scenario, which includes certain measures contributing to the reduction of GHG emissions planned by sectoral development programs.

GHG emissions projections are assessed by applying the LEAP long-term planning computerized model. Considering that target indicators are defined by development plans for the main sectors of the economy, the model has been used as a tool for calculating emissions and determining their sectoral distribution, and also for assessing volumes of substituted fossil fuels and the corresponding reductions in emissions due to the use of renewable energy sources and nuclear energy.

4.2 Projections of total greenhouse gas emissions

Projections of total GHG emissions for the two scenarios are presented in Tables 4-1 and 4-2 and Figure 4-1.

Table 4-1 Greenhouse gas emissions by types in 2005 and projections by 2020 (Gg)

	2005	2010	2015	2020
Business-as-usual				
CO_2	4633.2	9553.3	16222.2	19435.3
CH_4	71.8	94.9	128.4	173.5
N_2O	0.1	0.1	0.1	0.1
With measures				
CO_2	4633.2	8197.2	12932.7	11862.8
CH_4	71.8	83.5	114.5	157.5
N_2O	0.1	0.1	0.1	0.1

In the case of "with measures" scenario, the share of CO_2 in the future (2020) composition of GHG emissions will amount to 72.2% (including 67.2% from the "Energy" sector), the share of CH_4 - 27.4%, and N_2O - 0.4%.

If measures are implemented, GHG emissions by 2020 will amount to 61% of their level in 1990 (92% in the case of "business-as-usual" scenario), and the largest share of emissions (73%) will continue to fall on the "Energy" sector.

The results of the assessment of the potential for reducing GHG emissions are presented in Table 4-3.

The major part of the potential (78-93%) will be the share of the measures implemented in the "Energy" sector.

Table 4-2 Total greenhouse gas emissions by sectors in 1990-2005 and projections by 2020 (Gg CO_2 eq)*

Sector	1990	1995	2000	2005	2010	2015	2020
Business-as-usual							
Energy	22777.0	3757.2	3550.6	4315.5	9048.3	15461.2	18471.8
Industrial processes	630.3	120.0	119.7	317.7	505.0	761.0	963.5
Agriculture	982.6	804.0	840.7	1080.2	1430.1	2077.6	2954.8
Waste	564.9	531.5	560.3	509.3	607.9	665.0	735.2
Total	**24954.8**	**5200.7**	**5071.3**	**6222.7**	**11591.3**	**18964.8**	**23125.3**
With measures							
Energy	22777.0	3757.2	3550.6	4315.5	7802.2	12336.7	11108.3
Industrial processes	630.3	120.0	119.7	317.7	395.0	596.0	754.5
Agriculture	982.6	804.0	840.7	1080.2	1402.8	2030.6	2901.6
Waste	564.9	531.5	560.3	509.3	395.6	420.1	452.2
Total	**24954.8**	**5200.7**	**5071.3**	**6222.7**	**9995.6**	**15383.4**	**15216.6**

* *Without LULUCF*

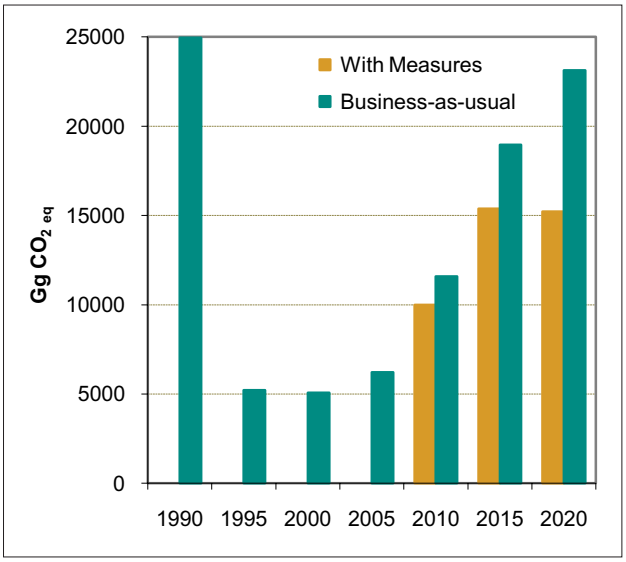


Figure 4-1 Total greenhouse gas emissions in 1990-2005 and projections by 2020

The projected proportional values of GHG emissions are presented in Table 4-4.

Table 4-3 Greenhouse gas reduction potential by sectors (Gg CO_2 eq)

Sector	2010	2015	2020
Energy	1246.1	3124.5	7363.5
Industrial processes	110.0	165.0	209.0
Agriculture	27.2	47.0	53.2
Waste	212.3	244.9	283.0
Total	**1595.7**	**3581.4**	**7908.7**

4.3 Projections of greenhouse gas emissions by sectors

4.3.1 Energy

The "Energy" sector in Armenia is the main source of GHG emissions from fossil fuel burning, as well as methane leakages from the gas distribution network. Armenia's energy development strategy aims to ensure 6% average annual growth for the period of 2000-2020. For each

Table 4-4 Proportional values of greenhouse gas emissions in 2000, 2005 and projections by 2020

	2000	2005	2010	2015	2020
GDP, million USD (prices of 2000)	1915	4900	6456	8240	10517
Population, million people	3.23	3.22	3.25	3.28	3.29
Business-as-usual					
Emissions per GDP unit, ton CO_2 eq/thousand USD	2.65	1.27	1.79	2.30	2.20
Emissions per capita, ton CO_2 eq/person	1.57	1.93	3.56	5.77	7.03
With measures					
Emissions per GDP unit, ton CO_2 eq/thousand USD	2.65	1.27	1.55	1.86	1.44
Emissions per capita, ton CO_2 eq/person	1.57	1.93	3.07	4.68	4.63

section of the mentioned period, projections of GHG emissions are calculated based on the future volumes of the operations of energy subsectors envisaged by Armenia's energy development strategy and the corresponding energy (fuel) demand. Two scenarios of GHG emissions were considered.

"Business-as-usual" scenario, which assumes a continuation of the current practices in the future, and at the same time includes a number of measures implemented after the submission of Armenia's First National Communication on Climate Change (1998-2005). In particular, the scenario takes into account the substitution of high carbon content fuel, such as coal, diesel fuel and biomass, with low carbon content fuel, such as natural gas; inclusion of new renewable energy sources, such as small HPPs and wind turbines, to the energy balance; the use of natural gas as engine fuel, etc.

"With measures" scenario, which considers the measures included in program documents approved by the Government of Armenia (Chapter 3) as well as those envisaged in sectoral programms aimed at supporting energy development strategy, which contribute to GHG emission reduction.

Armenia's energy development strategy plans a significant increase in the share of renewable energy sources, modernization of TPPs with high efficiency gas turbine installations, construction of a new energy block to replace the current energy block in the nuclear power plant (Table 4-5).

One of the main directions of development of the energy sector in Armenia is the establishment of an export oriented energy system (Table 4-6), where the share of nuclear and renewable sources will amount to 64% by 2020.

Table 4-5 The actual use of renewable energy sources in 2005 and projected use by 2020 (GWh)

Renewable energy source	2005	2010	2015	2020
Medium-sized HPPs	1617.7	1617.7	2917.7	2917.7
Small HPPs	155.3	317.3	467.3	755.3
Wind PP	0.0	78.8	236.4	394.0
Biofuel	0.0	0.0	172.0	388.0
Biogas	0.0	9.3	16.8	21.2
Total	**1773**	**2023.1**	**3810.2**	**4476.2**

Table 4-6 Energy production in 2005 and projections by 2020 (GWh)

	2005	2010	2015	2020
Electricity generation	6169.7	10601.7	15646.1	17999.8
Domestic consumption	6316.9	6921.7	7966.1	8719.8
Export	813.5	3680.0	7680.0	9280.0

The energy saving program is the use of the existing potential and includes the development of energy-saving technologies, measures for reducing losses during the transportation and distribution of energy, heat insulation of buildings, widespread use of energy-saving light bulbs and household appliances.

The energy saving program envisages the use of actual potential and includes development of energy saving technologies, measures apt to reduce energy losses in the process of energy transportation and distribution, extended usage of building code (energy performance of buildings), energy efficient lamps and routine equipments.

In the transport sector, it is planned to increase the use of natural gas as engine fuel, use of biofuel, gradual replacement of old vehicles with new ones, development of public transportation and electrical transportation, improve roads.

Projections of GHG emissions are presented in Table 4-7 and Table 4-8.

Table 4-7 Greenhouse gas emissions in the "Energy" sector in 2000, 2005 and projections by 2020 (Gg CO_2 eq)

	2000	2005	2010	2015	2020
Business-as-usual					
Electricity generation	1666.8	1158.4	3781.4	6874.6	8925.9
Industry and construction	445.5	670.2	983.0	1193.3	1329.7
Transport	647.8	853.2	1768.6	2493.3	2843.8
Commercial/institutional/housing	235.0	786.2	1064.3	3298.5	3543.9
Leakages in gas transportation system	473.4	562.6	929.9	1010.6	1211.7
Other	82.2	384.1	521.1	590.9	622.8
Total	**3550.6**	**4315.5**	**9048.3**	**15461.2**	**18471.8**
With measures					
Electricity generation	1666.8	1158.4	3297.2	5033.1	2901.6
Industry and construction	445.5	670.2	849.1	1052.9	1226.3
Transport	647.8	853.2	1588.7	1948.6	2179.9
Commercial/institutional/housing	235.0	786.2	863.9	3083.9	3411.8
Leakages in gas transportation system	473.4	562.6	704.3	651.0	780.4
Other	82.2	384.1	499.0	567.2	608.3
Total	**3550.6**	**4315.5**	**7802.2**	**12336.7**	**11108.3**

Table 4-8 Emissions of CO_2, CH_4, N_2O in the "Energy" sector in 2000, 2005 and projections by 2020 (Gg)

	2000	2005	2010	2015	2020
Business-as-usual					
CO_2	3067.60	3735.90	8256.30	14332.00	17135.00
CH_4	22.84	27.40	46.80	53.20	63.20
N_2O	0.01	0.01	0.03	0.04	0.05
With measures					
CO_2	3067.60	3735.90	7039.5	11275.60	10222.6
CH_4	22.84	27.40	36.20	35.80	41.70
N_2O	0.01	0.01	0.02	0.03	0.03

The dynamics of GHG emissions in 1990-2020 are presented in Figure 4-2. The rapid decline of emissions by 2020 in the "with measures" scenario is due to the termination of the use of outdated capacities in TPPs and the construction of the new energy block in the nuclear power plant with 1000 MW capacity. Indicators of GHG emissions for 1990-2005 are in accordance with the inventory data.

Assessments of the potential of measures for reducing GHG emissions and fuel saving measures are presented in Tables 4-9 and 4-10.

Indicators of energy consumption and the future shares of GHG emissions are presented in Table 4-11.

If the scenario including measures for reducing GHG emissions is implemented, emissions per unit of energy consumed (carbon footprint of energy consumption), in conditions of a threefold increase in energy consumption, will practically remain unchanged by 2020. At the same time, in this period, the GDP energy intensity will reduce by almost 45%.

It should be noted that GHG emissions projections in this section are based on the data and projections provided in the existing strategic documents for the energy sector development. The reliability level of GHG emissions projections for "business-as-usual" and "with measures" scenarios depends on the assumptions, uncertain ties and the implementation potential of envi-

Table 4-9 Potential for reducing greenhouse gas emissions in the "Energy" sector by 2020 (Gg CO_2 eq)

	2010	2015	2020
Small HPPs	99.3	191.2	367.6
Medium-sized HPPs	0.0	796.5	796.5
Wind Power Plants	48.3	144.8	241.4
Construction of combined cycle gas turbine units in TPPs	300.2	669.9	1039.6
Construction of the new energy block in NPP	0.0	0.0	3555.4
Use of biogas	5.7	10.3	13.0
Use of biofuel in vehicles	0.0	74.6	162.4
Modernization of gas transportation system	225.5	359.7	431.3
Energy-saving	567.8	877.5	756.3
Total	**1246.1**	**3124.5**	**7363.5**

Table 4-10 Fuel saving potential by 2020 (thousand toe)

	2010	2015	2020
Small HPPs	42.2	81.3	156.3
Medium-sized HPPs	0.0	338.7	338.7
Wind Power Plants	20.5	61.6	102.7
Construction of combined cycle gas turbine units in TPPs	127.7	284.9	442.1
Construction of the new energy block in NPP	0.0	0.0	1512.0
Use of biogas	2.1	3.8	4.8
Use of biofuel in vehicles	0.0	14.75	33.4
Energy-saving	225.3	322.1	251.9
Total	**417.8**	**1107.1**	**2841.9**

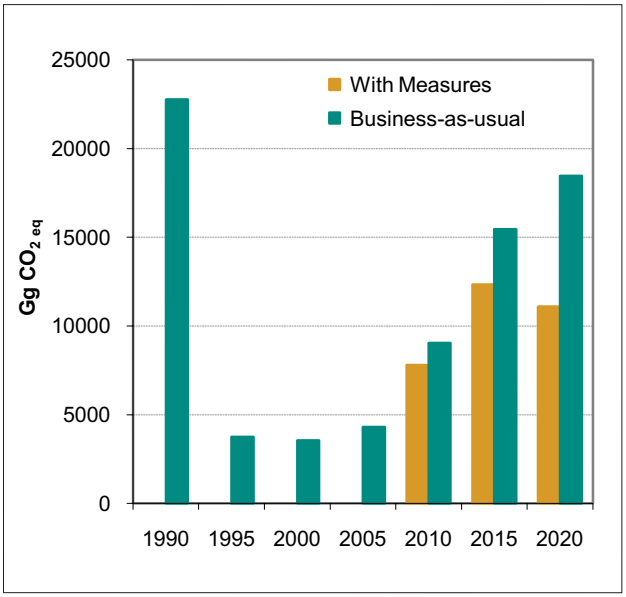


Figure 4-2 Greenhouse gas emissions in the "Energy" sector in 1995-2005 and projections by 2020

saged measures in those documents, which are based on a number of factors, including local consumption and export volumes of the electrical energy, changes in the energy policy of neighboring countries, structural changes in economic development, trends of imported gas price in crease, changes in tariff policy, population's solvency, financial schemes of new power plants, including the nuclear power plant, changes in timelines, etc.

Therefore, the given projections need to be referred to with certain "reservation". At the same, taking into account the international developments on GHG reduction/limitation, it is suggested to review the sector strategic documents within that context.

4.3.2 Industrial processes

The main source of GHG emissions in Armenia's industrial processes sector is cement production. Industrial processes in Armenia also cause emissions of indirect GHG (NMVOC) from the food industry, but their volumes are very small.

Cement in Armenia is produced in Hrazdan and Ararat factories. In 1990-2000, there was a sharp decline in cement production and consequently

Table 4-11 Energy consumption and shares of greenhouse gas emissions in 2000, 2005 and projections by 2020

	2000	2005	2010	2015	2020
Business-as-usual					
GDP energy intensity, toe/thousand USD	1.1	0.6	0.6	0.8	0.8
Primary energy consumption, thousand toe	2152.9	2679.0	4115.6	6730.3	7896.4
GHG emissions, thousand ton	3550.6	4315.5	9048.3	15461.2	18477.8
Energy consumption per capita, toe/person	0.7	0.8	1.3	2.1	2.4
Emissions per unit of energy, ton CO_2 eq/toe	1.7	1.6	2.2	2.3	2.3
With measures					
GDP energy intensity, toe/thousand USD	1.1	0.6	0.6	0.7	0.6
Primary energy consumption, thousand toe	2152.9	2679.0	3720.6	5771.2	6469.8
GHG emissions, thousand ton	3550.6	4315.5	7802.2	12336.7	11108.3
Energy consumption per capita, toe/person	0.7	0.8	1.1	1.8	2.0
Emissions per unit of energy, ton CO_2 eq/toe	1.7	1.6	2.1	2.1	1.7

in CO_2 emissions. In 2000, cement production and CO_2 emissions amounted to 19% of their levels in 1990. Since 2000, a significant growth of cement production has been recorded, due to the growth in construction and export sectors. Forecasts of cement production are based on the producers' assessments.

Two scenarios of CO_2 emissions from cement production were considered - "business-as-usual", which assumes the continued use of current technologies in the future, and "with measures", which includes implementation of technological measures for reducing emissions.

At Hrazdan cement factory it is planned to reconstruct two cement mills with complete replacement of internal equipment, grinding load and installation of a separator, which will result in the reduction of clinker consumption and CO_2 emissions. The mentioned measures will reduce specific emissions of CO_2 down to 0.11 tons per ton of clinker production. The same measures can also be implemented in Ararat cement factory.

Projections of CO_2 emissions are presented in Figure 4-3.

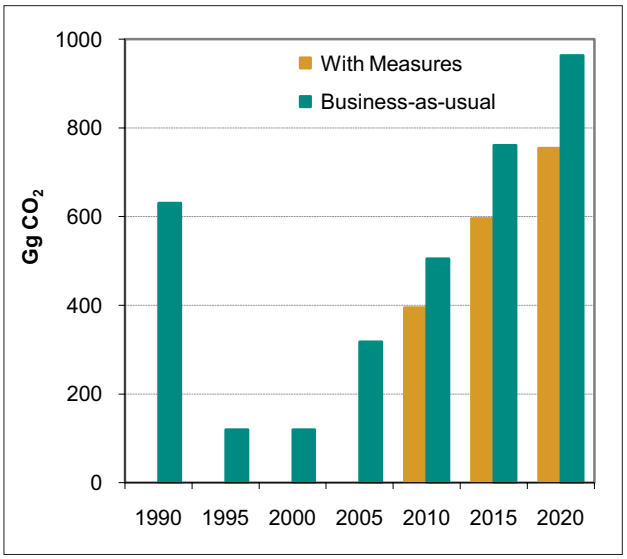


Figure 4-3 CO_2 emissions in the "Industrial Processes" sector in 1990-2005 and projections by 2020

4.3.3 Agriculture

The main source of GHG emissions in Armenia's agricultural sector is livestock production (methane emissions from intestinal fermentation and organic waste), amounting to 88-90% of emissions from the sector. Taking into account that the potential for reducing GHG emissions from other sources in the sector, is very small, the forecasts of emissions from the sector are made only for methane emissions from livestock production.

Assessment of the forecasted indicators for emissions is based on the forecasted number of livestock and its composition. For the period up to 2005, the number of livestock is taken from the data provided by the National Statistical Service of Armenia, and forecasted numbers are based on Armenia's Agricultural Development Strategy. The main potential for mitigating methane emissions from livestock production

sector in Armenia is the reduction of emissions from the management of organic waste.

Two scenarios for forecasts of GHG emissions have been considered - "business-as-usual", which assumes the continuation of current trends in the future, and "with measures", which envisages the processing of livestock waste to produce biogas, and the subsequent use of biogas as renewable source for energy production.

Forecasts of CH_4 emissions are presented in Table 4-12 and Figure 4-4.

Under "with measures" scenario the GHG emissions will reduce in the period of 2000-2020 by 8%.

Table 4-12 CH_4 emissions in the "Agriculture" sector in 2005 and projections by 2020 (Gg)

	2005	2010	2015	2020
Business-as-usual	48.1	68.1	98.9	140.7
With measures	48.1	66.8	96.7	138.2

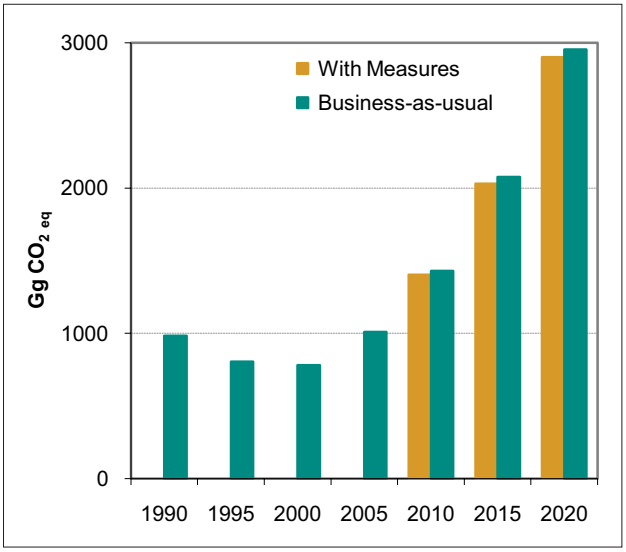


Figure 4-4 Greenhouse gas emissions in the "Agriculture" sector in 1990-2005 and projections by 2020

4.3.4 Forestry

The economic and energy crisis of 1990s in Armenia had extremely negative impacts on forestry. In those years, forests were subjected to wide-scale logging, including illegal logging, for energy purposes, which, according to the experts assessments, amounted to a volume of 0.8-1.0 million cubic meters annually. CO_2 sequestration in 1990 constituted 905 Gg. In 2000, the sequestration reduced to 786 Gg.

Since 2000, positive trends have emerged in the forestry sector of Armenia. Illegal logging has reduced sharply and reforestation, afforestation works have been done on 33,000 hectares of land. A number of programs for development of the forestry sector have been developed and approved.

Forecasts of GHG removal/emissions were made for two scenarios - "business-as-usual", which assumes a continuation of the current situation in the future, and "with measures", which plans the following measures in 2009-2020:

- restoration of degraded forest ecosystems on 2000-2500 hectares of land, 160-210 hectares per year;
- aforestation of forest lands; it is planned to plant forests on 5.0-5.5 thousand hectares of forest land through planting seedlings and seeds, 400-460 hectares annually;
- establishment of field protecting forest belts; it is planned to establish field protecting forest belts on 600-650 hectares of agricultural land, 50-55 hectares per year;
- forest protection measures; in order to prevent the massive pest outbreaks in forests, integrated aviation control measures are planned on 30,000 hectares every year;
- protection of forests from fires; in 2001-2006, forest fires affected about 400 hectares of forest area. On average, about 60-65 hectares of forests are destroyed by fires every year. Preventive measures for reducing the risks of forest fires will prevent fires on 30-35 hectares of forests every year;
- prevention of illegal forest logging, ensuring compliance with the approved annual volumes of logging.

Forecasts of CO_2 removal/emissions in forests in accordance with the two scenarios are presented in Figure 4-5, and net CO_2 flows are presented in Table 4-13.

4.3.5 Waste

GHG emissions in the "Waste" sector emerge in MSW landfills and during the treatment of wastewaters.

Those plants are not currently operational, except for Yerevan wastewater treatment plant where mechanical cleaning of wastewaters is performed. In fact, the treatment plants are surface water basins where GHGs are generated and emitted into the atmosphere due to digestion of organic matters.

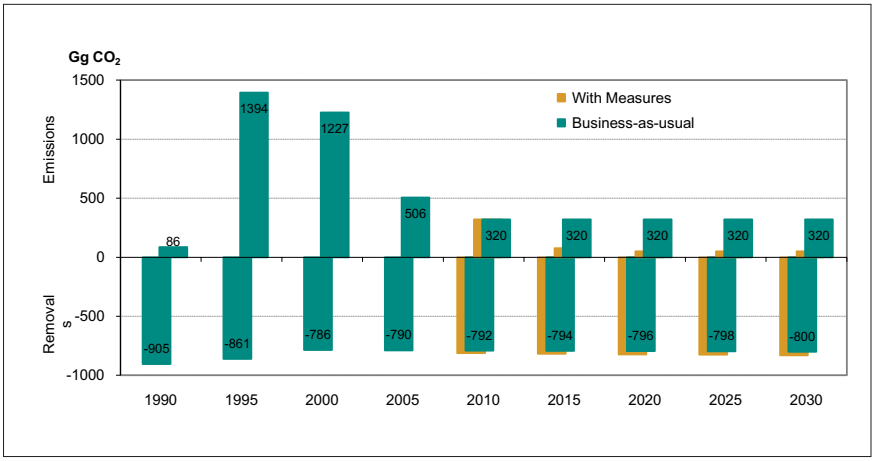


Figure 4-5 CO_2 removals/emissions in forests in 1990-2005 and projections by 2030

Table 4-13 Net CO_2 flows in forests in 2005 and projections by 2030 (Gg)

	2005	2010	2015	2020	2025	2030
Business-as-usual	- 284	- 472	- 474	- 476	- 478	- 480
With measures	- 284	- 492	- 740	- 773	- 775	- 781

Armenia has 48 city landfills with a total area of 218.8 hectares. In 2006-2007, the total volume of MSW generated in Armenia was 595,000 tons per year. The only actual way to decontaminate MSW in the country is its accumulation in landfills and later decontamination by covering it with a layer of soil. Currently, there is no legal requirement for landfill gas collection and capture from the landfill sites in Armenia.

Armenia has 20 wastewater treatment plants with a total capacity of 958,000 cubic meter/day.

Forecasts of CH_4 and N_2O emissions from waste are presented in Table 4-14 and Figure 4-6.

The forecasted volumes of MSWs and municipal-household wastewaters are determined based on the forecasted number of population, while the volumes of industrial wastewaters are forecasted based on the growth of the relevant industry.

Table 4-14 Greenhouse gas emissions in the "Waste" sector in 2005 and projections by 2020 (Gg)

	2005		2010		2015		2020	
	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Business-as-usual								
Landfills	21.52	-	24.55	-	27.15	-	30.39	-
Wastewater	2.16	0.15	2.23	0.15	2.33	0.15	2.42	0.15
Total	23.68	0.15	26.78	0.15	29.48	0.15	32.81	0.15
With measures								
Landfills	21.52	-	16.22	-	17.32	-	18.78	-
Wastewater	2.16	0.15	0.45	0.15	0.50	0.15	0.55	0.15
Total	23.68	0.15	16.67	0.15	17.82	0.15	19.30	0.15

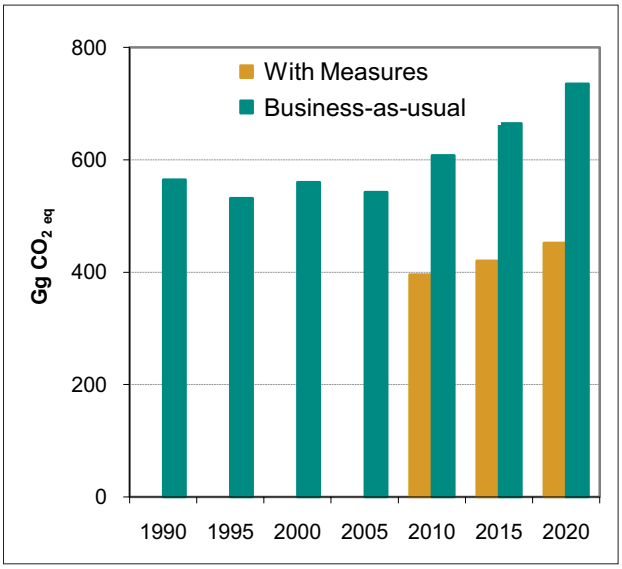


Figure 4-6 Greenhouse gas emissions in the "Waste" sector in 1990-2005 and projections by 2020

Forecasts of GHG emissions are based on two scenarios - "business-as-usual", which assumes a continuation of current trends in the future, and "with measures" scenario, which assumes the following programmatic measures:

- capture and use of landfill gases (biogas) in large landfills (Yerevan, Gyumri and Vanadzor);
- reconstruction and modernization of waste-water treatment plants in Yerevan, Martuni, Vardenis, Gavar and Jermuk.

Literature

1. Action Plan for resolving issues related to illegal forest logging. Annex to the protocol Decree of the Government of Armenia No. 38 dated 30 December 2004.

2. Armenia's Second National Inventory of Greenhouse Gases. Yerevan. 2009

3. Assessment of GHG emissions reduction potential in Gyumri and Vanadzor landfills, Shimizu Corporation 2006.

4. Biogas extraction and electricity production in municipal solid waste landfill of Nubarashen in Yerevan. CDM project document, Shimizu Corporation 2005.

5. Energy and Nuclear Power Planning Study for Armenia/ International Atomic Energy Agency, 2004.

6. Energy Sector Development Strategies in the Context of Economic Development in Armenia. Approved by the Government of Armenia on 23 June 2005.

7. First National Commutation of the Republic of Armenia under the UN Framework Convention on Climate Change. Summary October 1998. (Ministry of Nature Protection of Armenia, UNDP/GEF).

8. Future Development Scheme of the Energy System 2010, 2015, 2020, "Energatsantsnakhagits" CJSC, 2006.

9. Greenhouse Gas Emissions Reduction and Energy-Efficiency Potential in Transport Sector in Armenia ("National Gas Vehicle Association" NGO, Yerevan 2006.

10. IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, 2003.

11. IPCC Special Report on Land Use, Land-Use Change and Forestry, 2000.

12. National Forest Policy and Strategy of the Republic of Armenia, Ministry of Nature Protection of Armenia and SIDA. Program of Institutional Support for Forests, Yerevan 2004.

13. National Forest Program of the Republic of Armenia. Annex 1 to the Decree of the Government of Armenia No. 1232-N dated 21 July 2005.

14. National Program for Energy Savings and Renewable Energy. Protocol Decree of the Government of Armenia dated 18 January 2007.

15. Revised 1996 IPCC Guidelines for National GHG Inventories: Reverence Manual.

16. Statistical Yearbook of Armenia 2000-2007, National Statistical Service of Armenia, Yerevan (2001-2007).

17. Sustainable Agricultural Growth Strategy of the Republic of Armenia, Annex 1 of the Decree of the Government of Armenia No. 1826-N dated 30 December 2006.

18. Work plan of the Ministry of Energy of Armenia based on the provisions of the National Security Strategy of the Republic of Armenia. Decree of the Government of Armenia No. 1296-N dated 1 November 2007.

CHAPTER 5

Climate Change Impacts, Vulnerability Assessment and Adaptation

As a mountainous country with arid climatic conditions, Armenia, with its entire territory, is vulnerable to global climate change. According to the World Bank assessment, Armenia is among the most sensitive countries in the Europe and Central Asia region in regard to climate change. Increased temperatures and reduced precipitation accelerate the desertification processes and will have a negative impact on public health and sectors, which depend on the climate. Declining water resources will have a direct impact on agriculture (reduced possibilities for irrigation, worsened conditions for dry farming, reduced crop yields), and will result in reduction of electricity production from HPPs and scarcity of technical water. The forecasted higher frequency of extreme climatic phenomena, as a result of climate change, will have a negative impact on public health, property, agriculture and infrastructures. Climate change will result in changes to natural ecosystems, which will also reflect on biodiversity and forest, alpine, sub-alpine and wetland ecosystems of Armenia.

Significant changes have taken place in Armenia with regard to legislation and institutional structure of governance during recent years - after the preparation of the First National Communication of Armenia on Climate Change. New scenarios for climate change have been developed, which identify changes not only by seasons, but also by regions of Armenia. Based on the mentioned data, the vulnerability of different sectors have been assessed and the validity of forecasts in the First National Communication has been examined.

5.1 Climate change observed in Armenia

Deviations of annual air temperature and precipitation, recorded in Armenia in 1935-2007 from the average for 1961-1990, were estimated (Figure 5-1). Obviously, air temperature deviations since 1994 have been only positive and reached their peak of 2.1^{0}C in 1998, which is the hottest year registered in Armenia in the entire observation period. In the last 80 years, the average annual temperature increased by 0.85^{0}C, and annual precipitation decreased by 6%. However, changes in temperature in various regions of Armenia and different seasons of the year show different trends.

In summer months (June, July, August), the average air temperature has increased by 1^{0}C (Figure 5-2a), while in winter months (December, January, February) temperature increase has not been observed (Figure 5-2b). During the last 15 years, anomalies of summer temperatures were positive, summers were extremely hot in 1998, 2000 and 2006, and the summer of 2006 was the hottest in Armenia in the entire period of 1929 -2007.

Spatial distribution of annual precipitation changes in Armenia is quite irregular; north-eastern and central (Ararat valley) regions of the country have become more arid, while the southern and northwestern parts and Lake Sevan basin have had a significant increase in precipitation in the last 70 years.

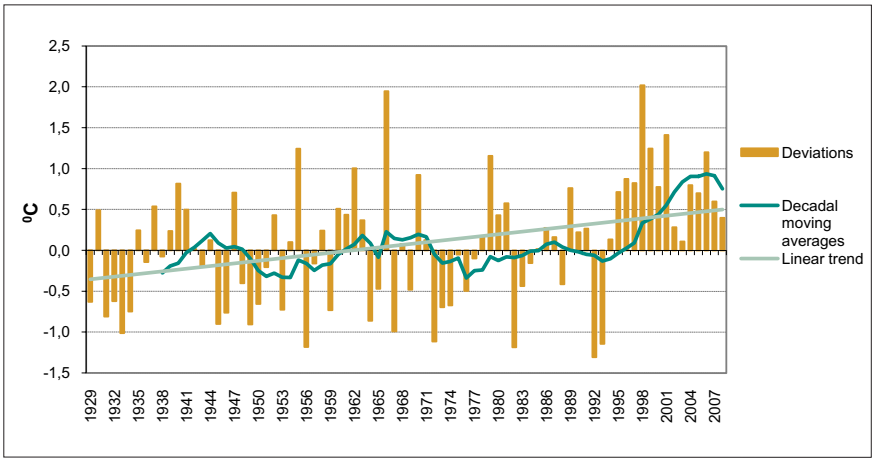
In recent decades (1975-2005), the intensity and frequency of hazardous hydro-meteorological phenomena has increased (Figure 5-3). In the last 30 years, the total number of hazardous hydro-meteorological phenomena increased by 1.2 cases, and in the last 20 years - by 1.8 cases per year.

5.2 Climate change scenarios for Armenia

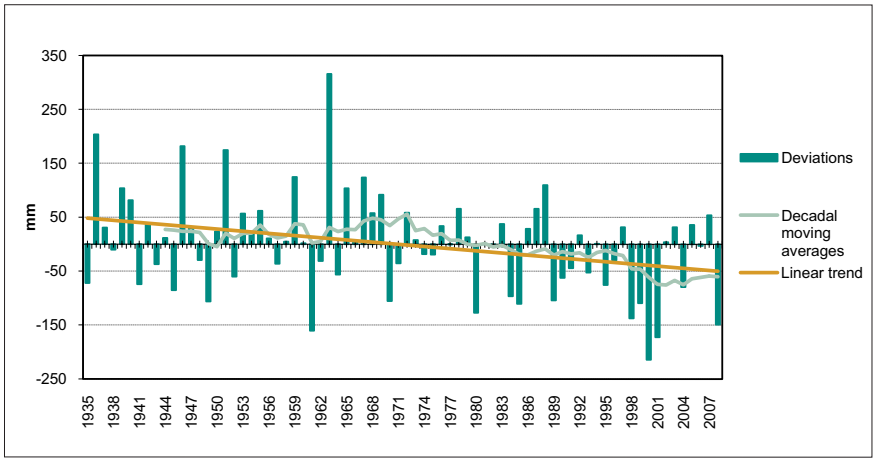
Climate change, on the territory of Armenia, is basically conditioned by the impact of the global climate change.

MAGICC/SCENGEN(5.3v2) computer software with 2.5^0 x 2.5^0 spatial resolution was used for developing climate change scenarios for Armenia. It allows averaging the output of several general circulation models (GCMs) to assess global warming, which is more reasonable than using the results of only one GCM (Santer, 1990).

Changes in the average regional temperature and precipitation in Armenia were assessed for A2 and B2 GHG emissions scenarios of IPCC by a number of GCMs. Subsequently, based on the signal/noise ratio and dispersion of models, seven were selected as the best models for the current climate of the country. The results of the combination of models - changes in precipitation and temperature - were assessed for three time periods - 2030, 2070 and 2100.

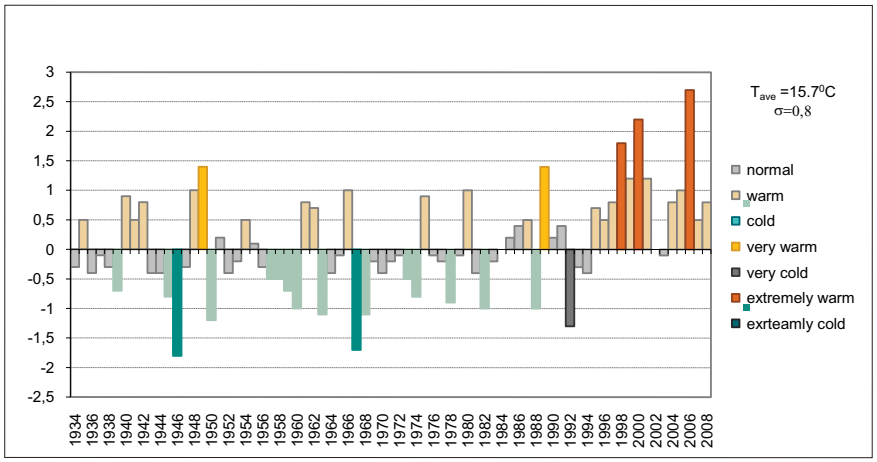


a



b

Figure 5-1 Deviations of average annual air temperature (a) and precipitation (b) from the average values for 1961-1990



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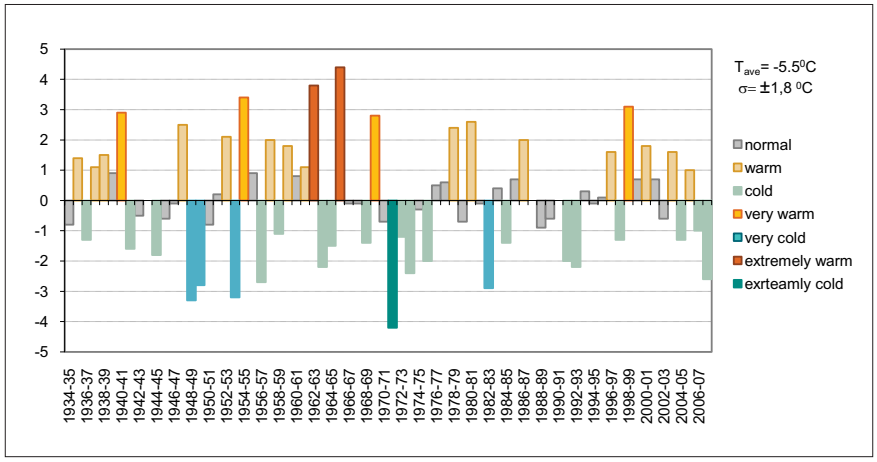

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Figure 5-2 Deviations of summer (a) and winter (b) temperatures from the average values for 1961-1990

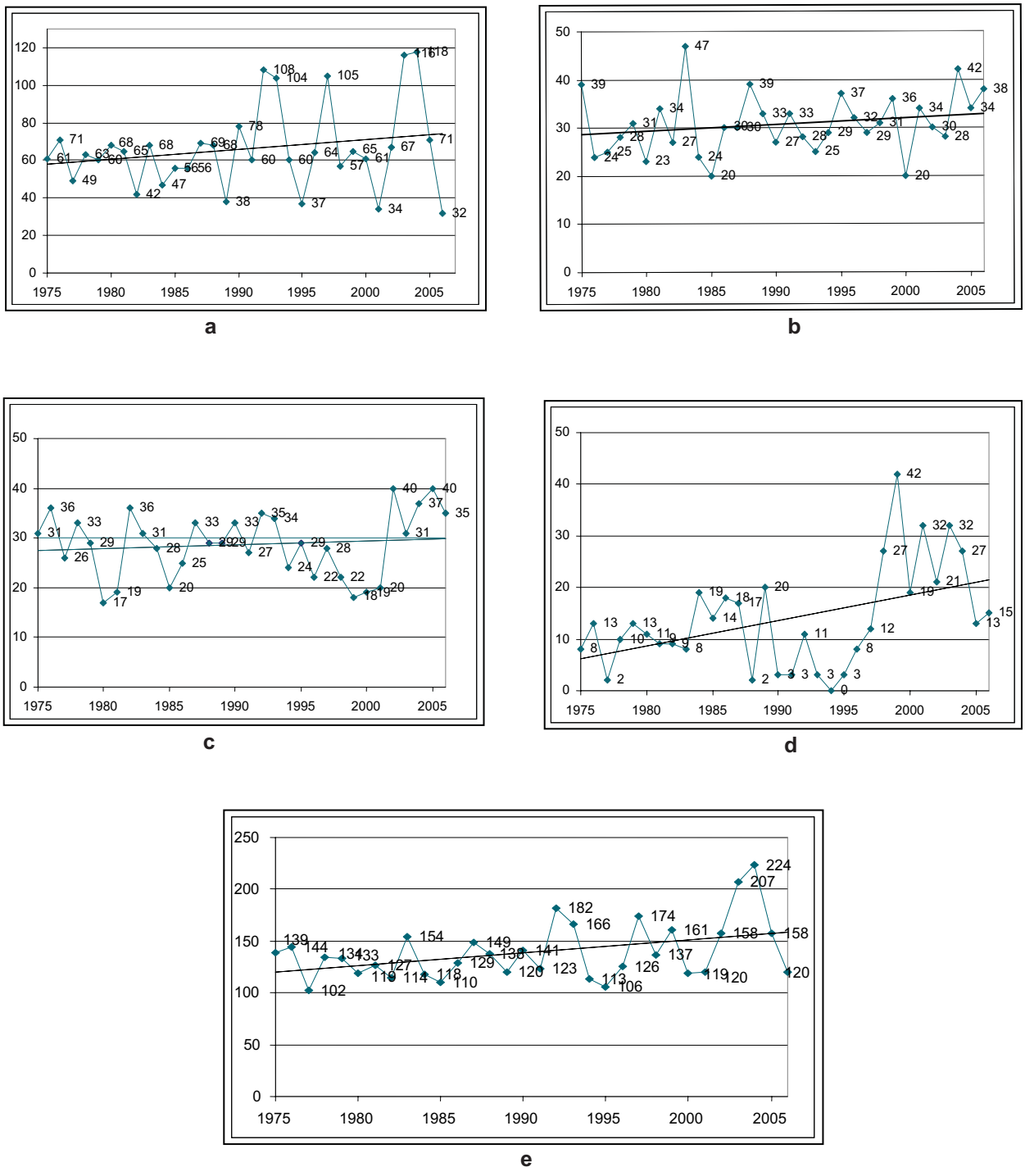

Figure 5-3 Number of extreme hydro-metereological events in Armenia, 1975-2005 – frosts (a), hails (b), heavy rainfalls (c), strong winds (d), total (e)

Averaged results of the forecasts for Armenia, made with MAGICC/SCENGEN computer software, are presented in Table 5-1. Significant and continuous increase in temperature is forecasted by both various GCMs, as well as by the ensemble mean. All GCMs indicate exceptional warming throughout the year: the increase in temperature is somewhat higher in hot months of the year, as compared to the cold ones, thus underlining the trend of continuous increase, if not intensification, from the one observed in Armenia during the 20th century.

The average annual change in precipitation by the year 2030 is expected to be reduced by 10%, which is statistically insignificant com-

Table 5-1 Changes in annual average temperature and precipitation in Armenia according to MAGICC/SCHENGEN model under A2 and B2 scenarios of IPCC

Temperature, ^{0}C		Precipitation, %	
A2	B2	A2	B2
			2030
1.1-1.2	1.0-1.1	-2 -6	-2 -6
			2070
3.2-3.4	2.9-3.0	-6 -17	-3 -15
			2100
5.3-5.7	4.8-5.1	-10 -27	-8 -24

pared to the average inter-annual variability of precipitation. Thus, considering the large standard deviations, changes in annual precipitation should be interpreted carefully. All models, in general, forecast a decrease in annual precipitation by 2100. While, according to all GCMs, winters will be abundant with precipitation, the results are somewhat contradictory for the warm period of the year. However, decrease in precipitation is more intense in summer months by the end of the 21st century (Table 5-1).

GCMs outlined a number of approaches in the case of large spatial resolutions. However the

Table 5-2 Changes in seasonal and annual temperatures (°C) compared to the average for 1961-1990, according to PRECIS model under A2 scenario of IPCC

Region	Winter	Spring	Summer	Autumn	Annual
		2030			
North east	1	1	1	0	1
Sevan Lake basin	1	1	2	2	1
Shirak	1	1	1	1	1
Aparan-Hrazdan	2	2	1	1	1
Ararat valley	1	2	0	1	1
Vayk	1	2	2	1	1
Syunik	0	1	1	1	1
Armenia	1	1	1	1	1
		2070			
North east	3	3	3	1	2
Sevan Lake basin	3	2	4	4	3
Shirak	3	3	3	3	3
Aparan-Hrazdan	4	5	2	3	3
Ararat valley	3	4	1	2	2
Vayk	3	4	4	3	3
Syunik	1	1	3	2	2
Armenia	**3**	**3**	**3**	**3**	**3**
		2100			
North east	3-5	3-5	4-5	1-3	3-5
Sevan Lake basin	4-6	3-5	5-7	5-7	4-6
Shirak	3-5	3-5	3-6	4-6	4-6
Aparan-Hrazdan	4-7	6-8	2-4	4-6	4-6
Ararat valley	2-6	4-7	1-3	2-4	3-5
Vayk	5-7	5-7	5-7	5-7	5-7
Syunik	1-3	2-3	3-5	2-4	2-4
Armenia	**4**	**5**	**4**	**4**	**4**

most noteworthy shortcoming of those models is that they cannot reproduce climate details for small spatial resolutions. In order to resolve that shortcoming, the results of the PRECIS regional model were studied.

The regional climate model used for this study is the Hadley Centre model HadRM3P, identical with the regional climate model (RCM) used within PRECIS with horizontal resolution 0.22^0 x 0.22^0 (25 x 25 km), which allows having more detailed information on climate in the regional scale. It uses data from the HadAM3P atmosphere-only global model to provide its lateral boundary conditions. The HadRM3P model simulation output data for the baseline period of 1961-1990 and the future projections of the climate (2071-2100) for A2 emission scenario have been studied in detail.

The projections made through MAGICC/ SCENGEN and PRECIS models are quite close

Table 5-3 Deviations of seasonal and annual precipitation (%) compared to the average for 1961-1990, according to PRECIS model under A2 scenario of IPCC

Region	Winter	Spring	Summer	Autumn	Annual
		2030			
North east	7	2	-9	7	3
Eastern shore of Lake Sevan	-7	-4	-9	-2	-8
Western shore of Lake Sevan	7	4	-5	5	4
Shirak	-11	-11	-7	-4	-8
Aparan-Hrazdan	-11	-7	-11	-7	-9
Ararat valley	-13	-9	-13	-9	-11
Vayk	-11	-11	-9	4	-7
Syunik	15	11	5	15	11
Aragatz	11	11	2	13	9
Armenia	**-3**	**-3**	**-7**	**1**	**-3**
		2070			
North east	15	4	-18	15	7
Eastern shore of Lake Sevan	-15	-7	-18	-4	-11
Western shore of Lake Sevan	15	11	-11	11	6
Shirak	-21	-21	-15	7	-16
Aparan-Hrazdan	-21	-15	-21	-15	-18
Ararat valley	-25	-18	-25	-18	-22
Vayk	-22	-22	-18	7	-13
Syunik	29	22	11	29	22
Aragatz	22	22	4	-25	18
Armenia	**-5**	**-5**	**-14**	**3**	**-6**
		2100			
North east	20	5	-25	20	10
Eastern shore of Lake Sevan	-20	-10	-25	-5	-15
Western shore of Lake Sevan	20	10	-15	15	10
Shirak	-30	-30	-20	-10	-22
Aparan-Hrazdan	-30	-20	-30	-20	-25
Ararat valley	-35	-25	-35	-25	-30
Vayk	-30	-30	-25	10	-18
Syunik	40	30	15	40	30
Aragatz	30	30	5	35	25
Armenia	**-7**	**-8**	**-19**	**3**	**-9**

to each other. MAGICC/SCENGEN results are averaged over the entire territory of Armenia and take into account several GCMs simulations, whereas the PRECIS is a dynamical downscaling system using single model simulations. Percentage of changes in precipitation is much higher in the case of PRECIS, compared to MAGICC/SCENGEN, since the PRECIS model strengthens the signals received from the global model. While there is a large difference between various GCMs at the basis of MAGICC/SCENGEN, their combination drastically reduces the natural variability (noise). This fact was taken into account during the analysis of the results of the models.

Thus, a continuous increase in temperature will be observed in Armenia, and the increase will reach its maximum value in spring-summer months at 5-7^{0}C (Table 5-2, Figure 5-4a). In western and central regions, particularly in Ararat valley, higher temperature rises are expected compared to other parts of the country. In the southern regions (Syunyats uplands), the increase in temperatures will be more moderate.

Figure 5-4b and Table 5-3 present the deviations (anomalies) of annual precipitation in the territory of Armenia compared to the baseline average. Obviously, significant deviations of precipitation, compared to the climatic norms, are expected in Armenia as a result of global warming. Precipitation will reduce drastically in the entire region, specially in summertime. For the rest of seasons, distribution patterns of precipitation changes are identical: areas with negative anomalies of precipitation alternate with positive ones moving from the west to the east. Spatial changes of precipitation are different: decreasing in lowlands and Ararat valley, and increasing in foothills and the eastern part of the Lake Sevan basin. Based on the assessments done for the period up to 2006 through empiric-statistical method, it must be noted that applied models for temperature and precipitation entail uncertainties: in fact, approximately 15-20% for temperature and up to 50% for precipitation.

According to the PRECIS results, in the period of 2071-2100, the total soil moisture in Armenia will increase during spring months (March, April, May) compared to the average (1961-1990), and in summertime the total soil moisture may possibly decrease. These results are in line with precipitation forecasts and the fact that snow melt will start earlier due to the increase in spring temperatures.

The relative air humidity, according to the model, will reduce in the same period in all seasons of the year except autumn, compared to the average for 1961-1990. In autumn, the humidity will reduce negligibly in the central regions, and a relative increase in humidity may be observed in northeastern and southern regions. In spring, the air will be 4-8% drier in the central regions and 2-4% drier in northeastern and southern regions of the

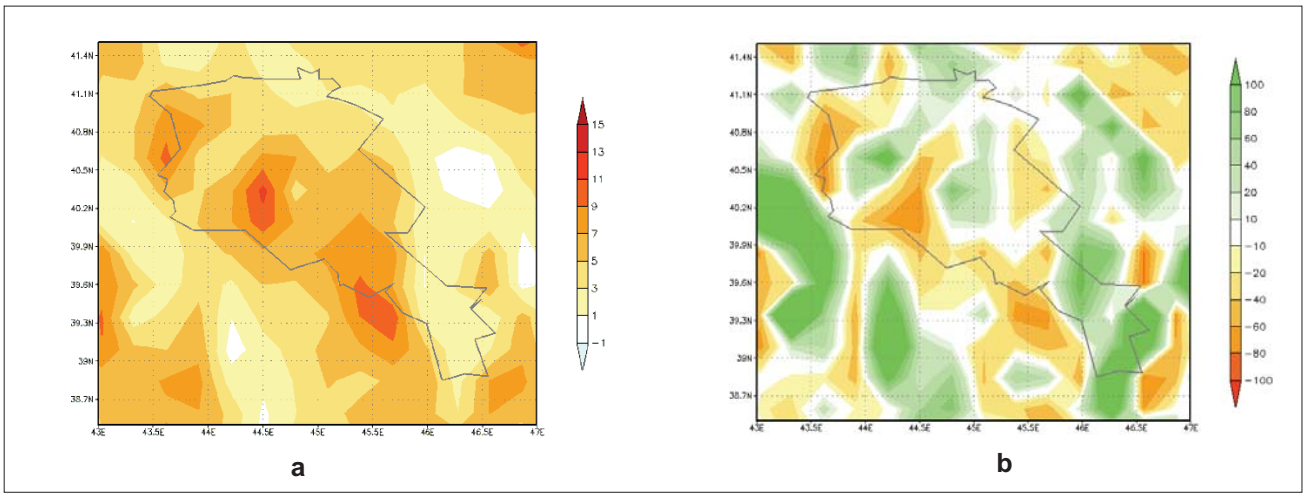

Figure 5-4 Annual (a) air temperature (°C) and (b) precipitation (%) changes in 2071-2100 compared to the average for 1961-1990, according to PRECIS model under A2 scenario of IPCC

country. The maximum decrease in humidity is forecasted for winter and summer seasons by 10-14% or 5-10% annually.

5.3 Water resources

The water resources of Armenia are distributed very unevenly in terms of spatial and seasonal distribution. Water resources are scarce, particularly in the densely populated Hrazdan River watershed in the central part of Armenia.

Around 50% of the total volume of river flow is subject to significant annual variations: the flow in dry years amounts to less than 65% of the one in an average year. In addition to annual variations, there are also significant seasonal variations in the river flow. Around 55% of the total river flow in a normal year comes from spring snow melt and rainfall, and the ratio for maximum to minimum flow can reach to 10:1.

Reforms in water resources management of Armenia started in 1999-2000 with the implementation of the "Integrated Water Resources Management Project", within the framework of World Bank, where structural reforms in water management were proposed.

The new Water Code was adopted in 2002, and includes the concept of integrated basin management. It promotes decisions on water allocation based on the supply rather than the demand, requires issuing water use permits based on information, allows using economic leverages in water resources management and cost recovery approaches.

A new water resources management institutional system was introduced in 2002, according to which:

- Water resources protection and management is coordinated by the Water Resources Management Agency of the Ministry of Nature Protection;
- State management of water systems is the responsibility of State Water Systems Committee of the Ministry of Territorial Administration;
- Public Services Regulatory Commission is responsible for tariff policy.

The Republic of Armenia law "On Fundamental Provisions on the National Water Policy" was adopted in 2005, which is a concept paper on the future development of the strategic use and protection of water resources and water systems. The Republic of Armenia law "On the National Water Program" was adopted in 2006. The laws aim to define measures for meeting the demands of the population and the economy, ensuring the ecological sustainability of the environment, forming and using strategic water reserve and protecting national water reserve through effective management of usable water resources. In order to enact the National Water Program, short-term (until 2010), mid-term (2010-2015) and long-term (2015-2021) programs were developed.

Parallel to legislative and institutional reforms, the State Water Cadastre (SWC) of Armenia was also developed. SWC registers: quantitative and qualitative indicators of water resources; composition and quantities of materials and biological resources extracted from watershed channels and river banks; information on water use permits, and water system use permits.

5.3.1 Vulnerability assessment

The Geographic Information System (GIS) software package, which enables conducting spatial analysis and assessment, was used for assessing the vulnerability of water resources in Armenia. Climate change scenarios for different regions of Armenia and its entire territory were used. The main criteria for the analysis were the annual average and extreme (maximum and winter minimum) river flow, as well as snow cover ("Armstatehydromet" data of systematic observations on precipitation in the form of snow).

While assessing the vulnerability of water resources, trends of river flow and snow cover changes were analyzed for 1991-2006; and forecasted climate change for 2030, 2070 and 2100, compared to the average for 1961-1990, were assessed using the PRECIS model under A2 scenario.

River flow. In order to assess changes in the river flow in 1991-2006, the perennial data of the series of observations of actual flow collected by 33 observation points on 28 rivers were selected. According to the analysis, the intensity of changes in actual river flow in Armenia in 1991-2006, compared to the entire period of observations, shows a trend of increase.

Until 2006, the actual river flow increase trends were observed in Dzoraget, Tavush, Kirants and Vedi Rivers, as well as in the middle and lower basins of Hrazdan and Kasakh Rivers and eastern and western rivers of Lake Sevan basin (Table 5-4). The values for increasing trends are basically very small (less than 3%). In the other rivers of the country declining trends of the flow are observed.

Table 5-4 Comparison of the actual annual river flow in Armenia in 1991-2006 with the average for 1961-1990

River/observation point	Average flow, million m^3			
	1961-1990	1991-2006	Changes	
			m^3	%
Pambak-Tumanyan	336.1	385.2	49.1	14.6
Debed-Ayrum	1063.4	1045.4	-18.0	-1.7
Aghstev-Dilijan	107.1	99.7	-7.4	-6.9
Akhuryan-Akhurik	225.8	255.2	29.4	13.0
Hrazdan-Hrazdan	243.4	254.6	11.2	4.6
Argiji-Verin Getashen	192.3	180.8	-11.5	-6.0
Masrik-Tsovak	102.2	106.0	3.8	3.7
Arpa-Jermuk	168.3	163.0	-5.3	-3.1
Meghriget- Meghri	93.8	80.9	-12.9	-13.8
Voghji-Kapan	379.6	255,8	-123.8	-32.6

In the majority of the rivers in Armenia, the maximum flow has shown a 3-5% declining trend, except for Aghstev, Hrazdan, Marmarik and Dzknaget Rivers, where a very small increase in the maximum flow is observed.

Declining trends in minimum flow were observed in Voghji-Kapan, Vorotan-Vorotan, Azat-Garni observation points - up to 3% per year. In Dzoraget, Tavush, Karjakhbyur, Vardenis, Gavaraget, Bakhtak, Argiji and Meghri Rivers the decline is very small. Relatively small rising trends of the minimum flow are noted in Pambak, Aghstev, Marmarik, Masrik, Martuni and Arpa Rivers.

The regression model was used for evaluating the forecasts of changes in the river flow. The model ensures an adequate accuracy of vulnerability assessment in Armenia's mountainous conditions. Using the multiyear observation data on the annual river flow and atmospheric precipitation and air temperature from meteorological stations in river basins, multi-correlational links were identified between the mentioned elements. Based on the above-mentioned links and the selected climate change scenarios, the vulnerability of the annual river flow of individual river basins in Armenia was assessed for the years 2030, 2070 and 2100 (Figure 5-5).

Climate change has different impacts on the actual river flow in different river basins of Armenia. Increased river flow is expected as a result of a significant increase in atmospheric precipitation only in Vorotan and Voghji River basins, while river flow will decline in other river basins. Significant flow decreases are expected in some rivers of Lake Sevan basin - Vedi, Arpa, Akhuryan, Sevjur, and lower flow of rivers - in northeastern part of the country.

If the scenario of forecasted climate change becomes a reality, the total river flow in Armenia will reduce by 6.7% by 2030, 14.5% - by 2070 and 24.4% - by 2100 (Table 5-5).

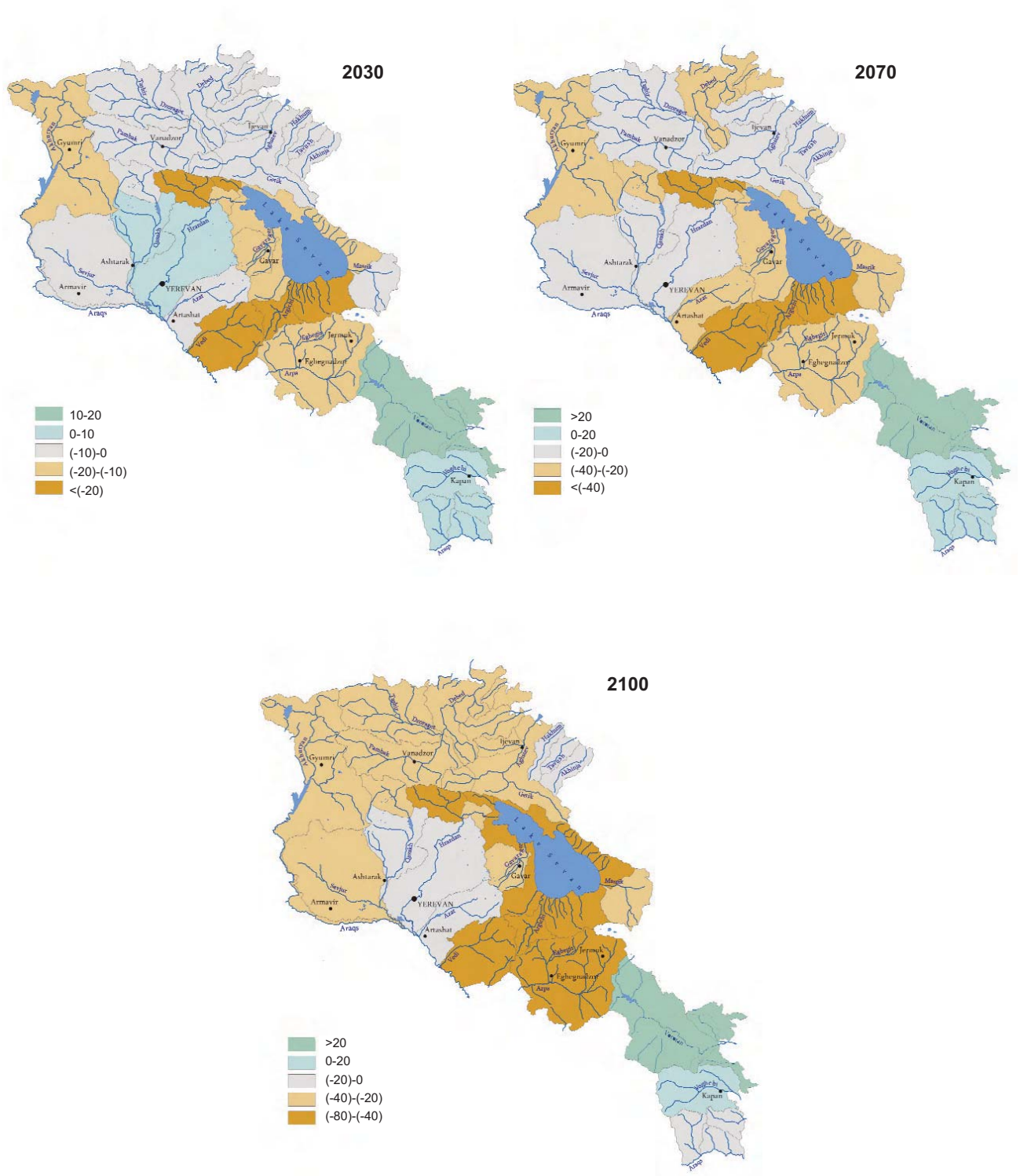

Figure 5-5 Forecasted changes in the river flow by river basins

Snow cover. In the territory of Armenia, particularly in the high mountainous areas, where main river flow is formed, data collected on snow cover and water content of snow collected in the last two decades are inadequate for making justified assessments. Consequently, precipitation in the form of snow measured in winter months (December-February) at meteorological stations was selected for calculations.

Analysis of data on precipitation in the form of snow reveals that in 1991-2006, compared to the average for 1961-1990, precipitation in the form of snow basically shows a declining trend (with the exception of meteorological stations of Dzor-

Table 5-5 Forecasted changes in the total river flow compared to the average for 1961-1990

Year	Flow, million m³	Changes in flow	
		million m³	%
1961-1990	4994.4	0.0	0.0
2030	4660.9	-333.5	-6.7
2070	4269.9	-724.5	-14.5
2100	3777.6	-1216.8	-24.4

aget, Meghri and Lake Sevan basins, for which some increase in precipitation in the form of snow is recorded). In Gyumri, Hrazdan, Fantan, Goris, Vanadzor meteorological stations there are slight declining trends, while in Amasya, Aparan, Dilijan, Ananun and Vorotan mountain passes, in Jermuk, Sisyan and Garni the decline is steep. The declining trends are predominantly noted (20-70 mm) at altitudes above 1700-1800 m.

The forecasted volume of precipitation in the form of snow in the major part of Armenia, will reduce compared to the norm for 1961-1990: 7-11% by 2030, 16-20% by 2070 and 20-40% by 2100. The highest level of vulnerability will be recorded in altitudes of 1700-1800 meters and higher, which are the main areas of river flow formation.

Lake Sevan. Compared to the average for 1961-1990, the river flow in Lake Sevan basin in 1991-2006 had a very small trend of increase in rivers of the eastern and western parts, and a very small declining trend in the rivers of the southern part and Dzknaget.

Changes in the water level of Lake Sevan during 1933-1981 were due to excessive discharge of water for irrigation and power generation purposes: the water level dropped by 18.5 m. Later, an increase by 0.9 m in 1981-1990 was achieved through diversion of water from River Arpa through a newly built tunnel designed to supply annually around 250 m³ water to the Lake. However, in 1991-2001, during the energy crisis the level was further decreased by 1.60 m (reaching the minimum level at 1896.32 m) for power generation purposes. In 2004 the second tunnel Vorotan-Sevan was built to replenish water resources of the River and in 2006 the level increased by 1.93 m.

If the forecasted scenario of climate change takes place and if water abstraction and inflow remain at current levels, the total actual river flow of the basin will reduce by 12% in 2030, by 26% in 2070 and by 41% in 2100 (Table 5-6).

The assessment of Lake Sevan water balance indicates a decreasing trend in surface flow starting from the last decade. Evaporation shows an increasing trend in recent years, which will continue also in the future and is mainly caused by changes in the temperature regime. The decrease in the water level of the Lake has had a severe impact on its temperature regime. Currently, a more rapid warming of water in the Lake in spring-summer months and a rapid coo-ling in autumn-winter months is noted. The active water yield of Lake Sevan, which currently is 252 million m³/year, will de-

Table 5-6 Vulnerability assessment of the annual actual river flow in Lake Sevan basin compared to the average for 1961-1990, according to various climate change scenarios

Scenarios	Flow, million m³	Changes of flow		Year
		million m³	%	
Baseline	758	-	-	1961-1990
T+1.5, 0.983Q	665	-93	-12	2030
T+3.3, 0.973Q	559	-199	-26	2070
T+5.1, 0.954Q	449	-309	-41	2100

***Note**: Q is the average annual precipitation in the corresponding basin. The value of Q coefficient smaller than 1 means reduction in precipitation (for example 0.75Q means 25% decrease in precipitation), while coefficients higher than 1 indicate an increasing precipitation (for example 1.25Q indicates a 25% increase in precipitation).*

Table 5-7 Forecasted changes in the main elements of Lake Sevan water balance

Year	Precipitation		Evaporation		Surface flow	
	million m	Deviation	million m	Deviation	million m	Deviation
1961-1990	457	-	1076	-	758	-
2030	449	-1.7%	1158	+7.6%	665	-12.2%
2070	445	-2.6%	1192	+9.7%	559	-26.3%
2100	436	-4.6%	1268	+17.8%	449	-40.7%

crease up to 220-225 million m³/year by 2030.

Summary of vulnerability assessment. The forecast of the water balance elements changes for the entire country shows that the river flow in Armenia, compared to the average for 1961-1990, will decrease by 0.48 billion m³ by 2030, 1.03 billion m³ - by 2070 and 1.73 billion m³ - by 2100.

5.3.2 Adaptation measures

In the last decade several projects were implemented with the financial assistance of international organizations for improvement of overall water resources management and sectoral services. Within the frameworks of those projects, the implemented measures have promoted, to a certain extent, adaptation of water resources to climate change. Nonetheless, the implemented measures are not yet adequate and it is necessary to continue measures for stronger resilience building. In order to mitigate the consequences of climate change on water resources and adapt the economy to the new natural conditions, it is proposed to implement measures for accurate assessment of water reserves, undertake institutional and technical measures for efficient use of water resources, extensive storage of water resources and reduction of losses due to leakages in the systems.

Table 5-8 Water balance elements of Armenia's water resources and their forecasted changes

Year	Precipitation, billion m³	Evaporation, billion m³	River flow, billion m³
1991-2006	17.60	10.50	7.10
2030	17.29	10.67	6.62
2070	16.83	10.76	6.07
2100	16.26	10.89	5.37

Accurate assessment of water reserve

- Refurbishment of hydrological observation points with modern equipment (preferably automatic recording equipment) in order to improve the reliability of measurement and data management processes;
- Optimization of the network of hydrological observation stations, taking into account the principles of river basin management and the decision makers' need for data;
- Resumption of the measurements and monitoring of mudflows, water reserve in the snow and other characteristics of the snow;
- Resumption of the monitoring of groundwater, in order to obtain up to date data, as well as assess their vulnerability to climate change;
- Preparation of a new reference book for water resources, where the impacts of economic activity and global climate change on water bodies in recent years will be taken into account. It will also present the scientific justifications of data on rivers, lakes and water reservoirs, in the case of data availability in adequate detail and absence of data or their inadequacy;
- Preparation of water balance and water-economic balance for individual river basins, and preparation of hydrological maps based on the results, where all the main hydrological characteristics of water bodies in the country will be presented;
- Detailed studies for developing a modern methodology for calculating the natural flow based on the actual flow data, which will allow for accurate assessment of the volume of water return after the use for drinking, household, irrigation and industrial purposes.

Legal-organizational measures

- In order to reduce losses from leakages in drinking water supply and irrigation systems, develop legal, economic and administrative

incentives;
- Initiate legislative changes contributing to the introduction of water saving technologies.

Institutional measures
- Strengthen the monitoring, management and compliance assurance organizations; train personnel in collection and management of hydro-meteorological data, forecasts, monitoring, compliance assurance and control of permit conditions for water users; build the capacity of water users associations to improve irrigation systems and irrigation culture;
- Initiate investigation/studies to identify the relevant methods and tools for mitigating the vulnerability of water resources in Armenia.

Technological measures
- Regulation of river flows, including increasing the volumes of current water reservoirs and/or building new ones;
- Reduction of losses from leakages in drinking and irrigation water supply systems;
- Application of advanced irrigation methods in agriculture (drip-subsurface irrigation, pivot irrigation, sprinkler irrigation, drip pipe irrigation, mole irrigation).

5.4 Agriculture

Positive trends are observed in Armenia's agriculture in recent years. A number of laws have been adopted, however, the consequences of climate change have not been duly taken into account in the strategies for development of the sector. The laws, recently adopted in the country, which are directly linked to climate change, include: the law of the Republic of Armenia on eliminating the consequences of droughts (2001) and the law of the Republic of Armenia on protecting selection achievements (1999), as well as the Land Code (2001); the National Action Plan for Combating Desertification in Armenia adopted by the protocol of the Government of Armenia Decree No. 13 dated 28 March 2002, the Sustainable Development Program approved by the order of the Government of Armenia No. 1207-N dated 30 October 2008; the financing agreement between the Republic of Armenia and the European community, as represented by the European Commission (Food Security Program of Armenia 2005-2006), signed on 9 August 2005 and approved by the Decree of the President of Armenia No. NH-211-N dated 19 November 2005; the Sustainable Agricultural Development Strategy approved by the order of the Government of Armenia No. 1826-N dated 30 November 2006; the law of the Republic of Armenia on Seeds (2005). Efforts have already been initiated for introducing an insurance system for agricultural production. Productive cooperation has been established between the Ministry of Agriculture and "Armstatehydromet", which regularly provides meteorological data and short- and mid-term weather forecasts and warnings in the case of dangerous hydro-meteorological phenomena. With the Strategy for Agricultural Development, Armenia aims to ensure food security and self-sufficiency. Currently, the entire demand for potato, vegetables, fruits, grape, milk, eggs and lamb meat is fully met. The demand for pork and beef is met domestically by 60-80%. The biggest problem is to ensure self-sufficiency with regard to wheat (35-45%), other cereals (45-50%), vegetable oil (12-15%), sugar (3-4%) and poultry meat (30-45%).

The main crops of Armenia are cereals, potato, fruits and grape, vegetables and melons and fodder crops (Figure 5-6).

The predominant directions of livestock production are large and small horned cattle, as well as pig and poultry breeding.

5.4.1. Vulnerability assessment

Armenia is a very high risk country for farming due to its geographical location, strongly marked vertical zonality, fragmented mountainous terrain, active anthropogenic processes, scarcity of land and inadequate soil moisture. The risk of agricultural activities increases due to scarcity of land (0.14 hectares of arable land per person).

In addition, as a result of the non-rational use of land resources, around 80% of land plots is characterized by desertification processes and various levels of land degradation. According to the assessment, land degradation in the country for

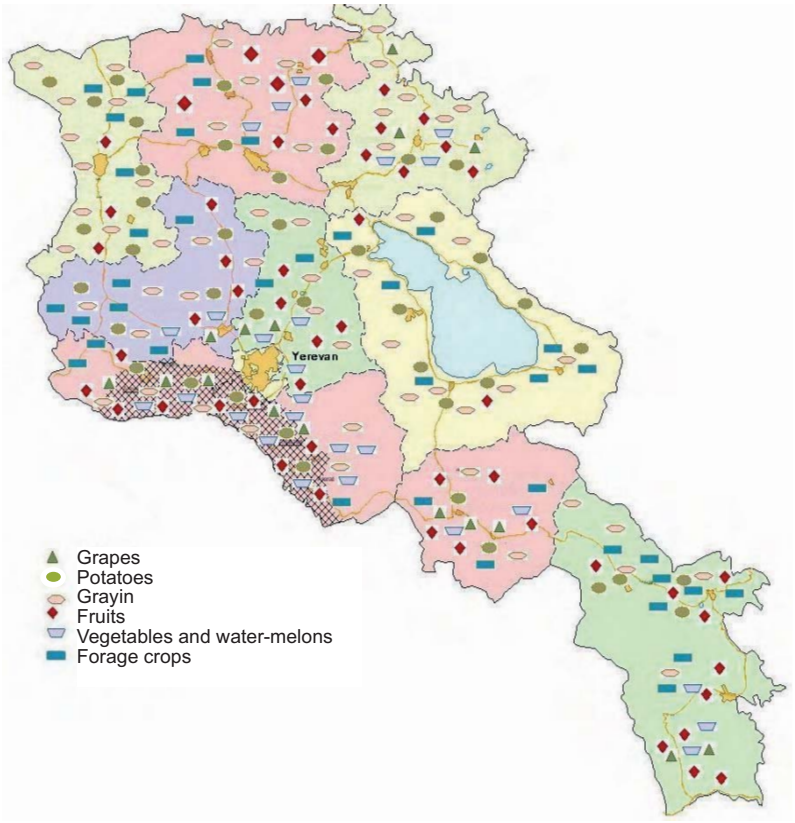

Figure 5-6 Distribution of main crops production by marzes

about 50% of land types is due to erosion, 20% - swamping, 30% - mudflows and floods, 17% - hail, 3% - landslides and 0.5% - rock fall, which have consequences on the yields of land and accumulation of carbon in the soil. The forecasted changes of climate will further worsen the situation; as a result of the temperature rise and decrease in precipitation, the areas needing irrigation will expand, and increased evaporation from the soil will result in the secondary salination. Heavy rain falls and floods will intensify water erosion, and droughts and southern winds will cause further wind erosion. Because of the inadequate availability of fodder in wintertime, the forced shifts in timeframes for animal grazing (early start and late end of grazing season) will result in intensified degradation of natural pastures.

Hazardous hydro-meteorological phenomena cause huge damages to agriculture (droughts, southern winds, hail, early spring frosts), the frequency and duration of which show a rising trend in recent decades due to climate change (Section 5.1). Hazardous hydro-meteorological phenomena cause crop losses of 10-15% in various regions of Armenia.

The vulnerability of Armenia's marzes to hazardous hydro-meteorological phenomena is presented in Figure 5-7. The main hazardous hydro-meteorological phenomena are listed according to the magnitude of damage based on the statistics of recent years. Droughts and late spring frosts mostly threaten Ararat and Armavir marzes, while hail is most dangerous in Shirak, Aragatsotn and Armavir marzes.

Droughts in the arid regions of Armenia generally occur each summer beginning in mid-June. Since 1990, the entire country has experienced more frequent and widespread droughts with negative impact on agriculture. The situation can be further aggravated by southern winds (mostly with a speed of 5-10 km/s) blowing at the same time when droughts occur. The mentioned phenomenon is periodically observed in the last 10 years in Syunik, Vayots Dzor, Armavir, Ararat and Aragatsotn marzes. The most severe drought was recorded in the year 2000 throughout the country causing a damage of 38 billion AMD (USD 110 million). The greatest demand for water in agriculture comes generally in April and May making spring droughts the most harmful. The severe drought of May-June 2008 caused extensive losses in agricultural production (USD

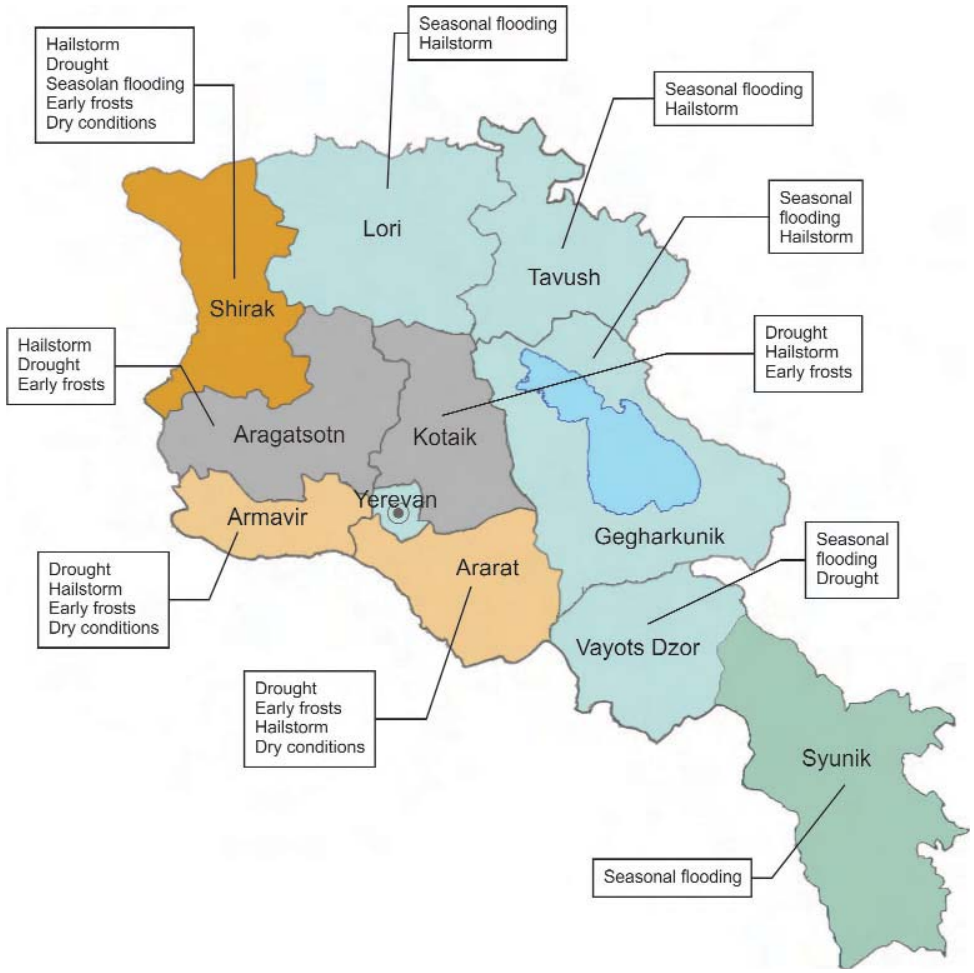

Figure 5-7 Vulnerability of Armenia's marzes to hazardous hydro-meteorological phenomena

40 million), since the spring drought overlapped with the first phase of growth of crops. In practice, relatively favorable conditions in relation to droughts and southern winds exist only in Ararat valley, where 95% of agricultural lands are irrigated.

Huge damages are caused to agriculture also by hail, mudflows, spring frosts and mudflows. In recent years, annual damages from the mentioned phenomena are estimated at USD 15-20 million. And almost half of the damage is caused by hail. According to climate change scenarios, the frequency of weather anomalies can increase in spring and summer, accompanied with tender storms and hails. In this case, croplands in the medium mountainous zone of northern and southern marzes of Armenia will be more vulnerable.

Table 5-9 presents data on compensations paid to farms which suffered from hazardous hydro-meteorological phenomena in 2003-2007.

According to the estimations, soil humidity in Armenia will reduce by 10-30%, moisture reserves of various crops will decline by 7-13%, and the water deficit of land will increase by 25-30% due to climate change. As a result, the rain fed farming in premountainous and lower mountainous areas of Armenia will become more vulnerable. In order to reduce the vulnerability of crops farming in the mentioned regions, it would be necessary to increase the land surface under irrigation, which may result in rises in the prices of irrigation water conditioned by its scarcity. In general, drought resistant crops and species should be prevalent in the structure of crops production in Armenia, the need for a new agro-climatic zoning will emerge, for example shifting the farming of cereals upwards on mountain slopes.

Currently more than half of cultivated lands in Armenia is irrigated, and its share in crops production is 70%. The forecasted decline in water resources as a result of climate change may create serious problems for the irrigated farming sector. According to the climate change scena-

Table 5-9 Compensations paid to farms that suffered from dangerous hydro-meteorological phenomena in 2003-2008

Year	Marzes	Form of compensation	Value, thousand USD
2003	Aragatsotn, Ararat, Gegharkunik, Lori,Kotayk, Shirak, Syunik, Vayots Dzor, Tavush	423 tons of winter wheat seeds	86.5
2004	Aragatsotn, Ararat, Gegharkunik, Lori, Kotayk, Shirak, Tavush	550 tons of potato seeds, 65 tons of winter barley seeds	136.3
2005	Aragatzotn, Ararat, Gegharkunik, Lori, Shirak, Tavush	1360 tons of winter wheat seeds, 300 tons of winter barley seeds	556.7
2005	Ararat	Compensation for irrigation water supply	85.6
2006	All marzes	20,000 tons of ammonium nitrate	192.3
2007	All marzes	20,000 tons of ammonium nitrate	233.9
2007*	Aragatsotn, Ararat, Gegharkunik, Lori,Kotayk, Shirak, Syunik, Vayots Dzor, Tavush	100 tons of corn seeds, 50 tons of alfalfa seeds, 1300 tons of winter barley seeds	1487.7
2008	All marzes	20,000 tons of ammonium nitrate	261.4
2008	All marzes	645 tons of winter wheat seeds	261.4

** Special drought compensation.*

rios, by 2030, a decline of 8-14% in the yields of the main agriculture crops is forecasted (9-13% for cereals, 7-14% for vegetables, 8-10% for potato and 5-8% for fruits).

Mass outbreaks of agricultural crops' diseases and increasing numbers of pests can become a serious threat to crops farming. After the drought of 2001-2002, favorable conditions were created in Armenia for reproduction of locusts. Emergency pest control measures were implemented, and in 2005 a special computer system for collecting and analyzing data on the spread of pests was created, which allows for timely and effective planning of locust control measures. A similar system has also been created for assessing the conditions of rodent populations and their areal.

Natural grasslands and pastures are the main basis for development of livestock production. According to climate change scenarios, the total surface and yields of pastures in Armenia will reduce by 4-10% by 2030, including 19-22% in more valuable pastures of sub-alpine and alpine zones. A 7-10% decrease in the yields of grasslands is possible, which, in its turn, will result in lower levels of fodder production. If the current rate of increase in the number of cattle and ruminants remains constant, based on the modern scientific norms for pasture loads, availability of fodder resources by 2030 will not be a matter of concern. At the same time, the overall conditions of the majority of pastures are obviously inadequate and if corresponding measures are not taken for improving their condition, their degradation will become more intensive.

Climate change can also have an impact on the composition and spread of livestock diseases, primarily natural-outbreak site and contagious diseases. Global warming will have a smaller effect on non-contagious pathologies of animals. Only a decline in some diseases with cold etiology can be forecasted.

5.4.2 Adaptation measures

Adaptation measures for Armenia's agriculture by main vulnerability criteria are presented in Table 5-10.

5.5 Biological diversity and natural ecosystems

Armenia's vegetation includes all main types of vegetation in the Caucasus (with the exception of humid sub-tropical vegetation) - deserts, semi-deserts, arid open forests, shibliak, mountain steppes, forests, meadow steppes, sub-alpine meadows, alpine meadows and carpets. Intrazonal vegetation types are widely represented while vegetation of wetlands, petrophile vegeta-

Table 5-10 Adaptation measures for agriculture in Armenia

Vulnerability criteria	Adaptation measures
Drop in yields of agricultural crops	Breeding and introduction of drought resistant, dry resistant hybrids adapted to local conditions, including the preservation and spread of local traditional species with the mentioned characteristics
Increased losses of crop production because of hazardous hydro-meteorological phenomena	Assessment of climate change related risks and introduction of an insurance system Development of anti-hail systems Implementation of anti-hail measures Early warning and rapid response systems for hazardous hydro-meteorological phenomena
Increased level of morbidity among livestock	Vaccinations
Drop in livestock sector productivity	More widespread use of high mountainous pastures Introduction of new livestock breeds
Decrease in productivity of grasslands and pastures	Reducing the per unit load of grasslands and pastures
Spread of agriculture crops' diseases and pests	Introduction of crops species resistant to diseases and pests
Reduced effective soil moisture and increased water demand	Implementation of measures for improving moisture preservation characteristics of the soil
Decline in land fertility	Application of crops rotation
Changes in the structure of croplands, and borders of agricultural lands	Shifting the farming zone to areas with adequate moisture. Application of new irrigation technologies in arid areas considering changes in the surface water flow and atmospheric precipitation

tion, tragakant vegetation, vegetation of disturbed areas (Figure 5-8).

Armenia's flora has about 3600 species of vascular plants (half of Caucasian flora), including 123 local endemic species. Thus, Armenia has high floristic richness - more than 100 species per square kilometer. In addition, an important characteristic of Armenia's flora is the fact that the genetic pool of wild relatives of cultivated plants is richly represented (cereals, fruits and vegetable-melon crops).

According to expert assessments, there are 17,500 species of invertebrates in Armenia, including 12,000 species of insects, and about 534 species of vertebrates, with 38 species of fish, 8 species of amphibians, 53 species of reptiles, about 350 species of birds and about 85 species of mammals.

According to the floristic division of the country, Armenia is at the border of Caucasian and Armenian-Iranian floristic provinces, and in a wider sense between Boreal and Ancient Mediterranean floristic sub-kingdoms. The Caucasian Province is more humid and the Armenian-Iranian one is more arid. The border between those two provinces coincides with the borders of Armenia's floristic regions. Borders of floristic regions do not correspond to Armenia's administrative divisions. The southern parts of Shirak, Aragatsotn and Syunik marzes, and Armavir, Ararat and Vayots Dzor marzes in their entirety belong to the Armenian-Iranian province. The rest of the Armenian territory belongs to the Caucasian province.

During the last decade, after preparation of Armenia's First National Communication, the environmental legislation and regulations of Armenia were amended with provisions that take into account the impacts of climate change on natural ecosystems. The Second National Environmental Action Plan of Armenia (2008) recommends establishment of integrated mechanisms for preventing the negative environmental impacts, defining special protection mechanisms for areas of high biodiversity significance, establishing a biodiversity monitoring system, developing and implementing a pilot project for protecting forests vulnerable to climate change from pests and fires. In the First National Communication of Armenia on Climate Change, the possible changes to

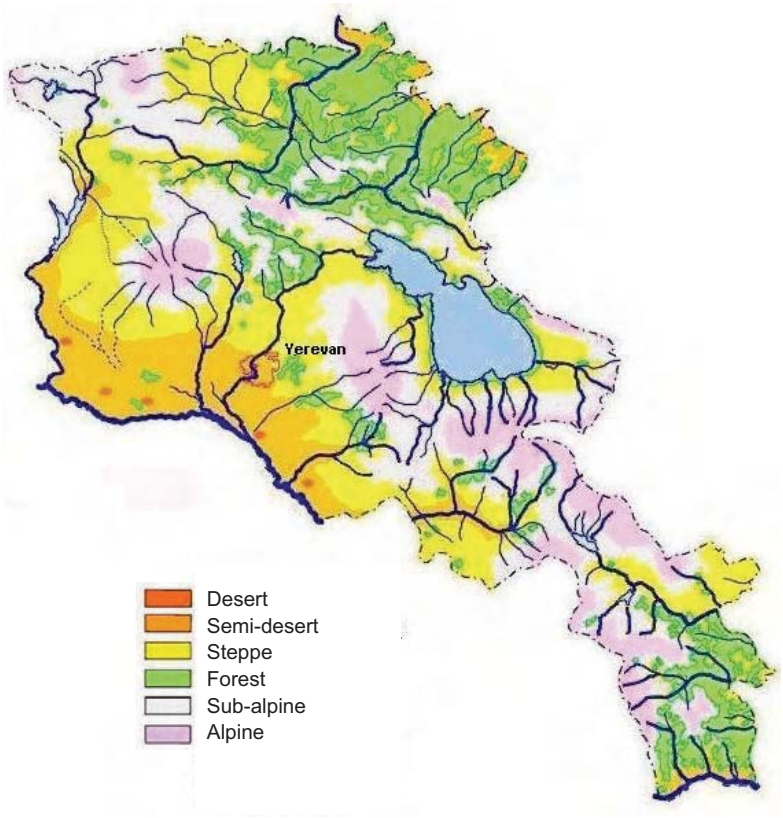

Figure 5-8 Main ecosystems of Armenia

mountain ecosystems under various climate change scenarios were analyzed. Using the climatogram method, it was shown that in the next 100 years the boundaries of natural ecosystems might shift upwards on mountain slopes by 200 m, which may result in serious changes in the structure of the ecosystems, as well as the spread of certain representatives of biodiversity. Mass reproduction of forest pest insects in southern regions of Armenia was also forecasted. The forecast proves to be totally correct in Syunik marz, where as a result of mass reproduction of pest insects, damaged areas and desiccated forests currently cover 19 to 30 thousand hectares.

Vulnerability of natural ecosystems and biodiversity was assessed from a new point of view in the light of legislative and institutional changes and more accurate climate change scenarios.

5.5.1 Vulnerability assessment

Desert ecosystem is not considered as a separate vertical belt in Armenia. It is situated at altitudes of 400-1000 m above sea level in the lower mountainous belt, with some parts in semi-desert vegetation area. It spreads in sand and saline habitats and is represented by typical sand desert, saline lands and solonchaks. Here there are a number of endemic and rare plant and animal species; Ararat Vortan Karmir and a number of endemic insect species can be preserved only here. It is expected that desert areas will expand, since the drier climate will expand areas with desert conditions, and as a result of more intense evaporation from the surface of the land new saline land areas will emerge.

Semi-desert ecosystem can be found in Armenia in pre-mountainous and lower mountainous belt at altitudes of 400-1000 (1300) meters above sea level, and is a combination of ecosystems often in a mosaic form. It is situated in relatively arid rocky areas. Due to the strong presence of arid conditions, the process of formation of new species in semi-deserts is quite intensive, and has resulted in the abundance of endemic and rare plant and animal species. It is expected that the semi-desert area will expand due to the vertical shift of its upper boundary. However, the necessary expansion of irrigated areas for agricultural development in the conditions of climate change, can result in the shrinking of semi-desert ecosystems.

Arid open forests in Armenia consist of a combi-

nation of ecosystems, which are very different from each other by their biota species, as well as their occurrence in different vertical zones. Broadleaf woodlands are basically found in the lower mountain zone. This is where shibliak is found consisting of shrubs, predominantly Christ's thorn. Juniper woodlands occur from the lower belt until the upper belt (2200 m above sea level). This ecosystem is found in relatively dry areas (especially in the lower mountain belt), which is the only habitat for endemic and rare plant and animal species. It is expected that the area of the ecosystem will expand primarily at the expense of the lower parts of the steppe and forest ecosystems. Juniper areas will not expand in the upper mountainous belt, mainly because of the absence of favorable soil conditions.

Steppe ecosystems are the most common ecosystems in Armenia. They occur in the middle-mountainous belt on all forestless mountain slopes and terraces at altitudes of 1000-2400 meters above sea level. They usually occur in relatively dry areas with fertile soil cover. The biodiversity of steppe ecosystems is extremely rich. Nearly half of the flora of Armenia, as well as numerous species of endemic and rare plants and animals can be found here. It is expected that, in case of favorable conditions for steppe ecosystems, they will shift upwards on mountain slope by 250-300 m, as a result of which their areas will shrink to a small extent, and their composition and structure will undergo significant changes. Considering the high ecological plasticity (flexibility) of the majority of dominants, it can be assumed that they will expand to new habitats, forming new steppe ecosystems different from the existing ones with new structures and composition. In addition, it is possible that steppes are expanded into previously forested areas (if reforestation work is not done).

Meadow ecosystems belong to the mezophile type and require a high level of humidity. They can develop in all mountain belts, however they are best represented in Armenia in the high mountainous belt at altitudes higher 2000 m above sea level, where they are the dominant type on terraces and relatively steep slopes with well-moisturized soft soil. Meadow ecosystems are habitats for numerous plant and animal species; here small numbers of endemic plants and rare animal species can be found. As a result of the forecasted decline in precipitation, shrinking of meadow ecosystem areas is expected. In addition, since the majority of mountain peaks and mountain ranges have altitudes of 3000 m, there are simply no favorable conditions for shifting upwards on mountain slopes.

Wetland habitats occupy 6.17% of Armenia's territory; here 5.51% (1584 km²) are open water areas (lakes, ponds, rivers, water reservoirs, water channels), 0.52% (150 km²) - temporarily water covered areas and 0.14% (42 km²) - swamps and peatlands. This ecosystem is a habitat for numerous endemic and rare flora and fauna species. This ecosystem is mainly affected by anthropogenic factors - use of water reserves and natural resources, construction of new water reservoirs and drying out the old ones, land melioration activities and drying out natural water areas. Climate change will result in changes in the composition and structure of this ecosystem; reduction in precipitation will result in declining of water reserves and shrinking of wetland areas. Changes in the temperature regime will reflect on the composition of biodiversity and the structure of the ecosystem. For instance, with the projected climate change, cold-water fish species - salmon, whitefish (Sevan trout, brook trout and whitefish) and the endemic species of Metsamor River will be affected in the period of natural reproduction. Low temperature conditions (2-8^{0}C for whitefish) are required for normal fetal development and successful reproduction in natural conditions. Temperatures above the optimum for embryogenesis may lead to an increase in various forms of deformity and mortality, which will result in gradual reduction in the number of species and their disappearance from the given area.

On the other hand, wetland ecosystems are considered to be the most conservative; they have a large ecological inertia, and if the ecological norms and rules are followed (ecological preservation of the river flow as a minimum), climate change in Armenia will have a minimum impact on the biodiversity and structure of the majority

of these ecosystems. These ecosystems, however, will be threatened under the specific conditions of climate change (for example, the forecasted climate change will result in more evaporation from the land surface and the saline swamplands of Ararat valley will turn into solonchaks).

Forest ecosystems are unevenly distributed in Armenia. 62.5% (207 thousand ha) of forests are in north-eastern, 13.5% (45 thousand ha) - in central, 2.4% (8 thousand ha) - in southern and 21.6% (72 thousand ha) - in south-eastern marzes. Armenia's forests are diverse in their structure and composition. Beech forests occur at altitudes of 800-2000 m and grow basically on northern slopes. Pure beech forests are at altitudes of 1000-1800 m. In other beech forests the accompanying trees are oak, ash, linden, elm, hornbeam, maple, etc. Oak forests are characterized by their complex and diverse type of composition, they occupy sunny southern slopes and are concentrated at altitudes of 600-2200 m above sea level. Pine forests are a component part of Armenia's forests, and the accompanying tree species are hornbeam, eastern oak and rarely beech. Mostly mixed, lowly densed subalpine woodlands are situated at altitudes of 1900-2300 m above sea level. Forests here consist of Litvinov birch, high mountainous maple and common mountain ash.

In north-eastern forested marzes, the forecasted climate change scenarios will make the forests of the lower mountainous belt (550-1200 m), especially those growing on southern slopes, more vulnerable. Currently, the annual average precipitation on those slopes does not exceed 600 mm, and the expected decrease in precipitation will have a radical impact on the conditions of growth for the forest. As a result, the natural regeneration and annual growth of the forest will decline, and desert and semi-desert plant species will infiltrate forest ecosystems and, consequently, those areas will become completely deforested. According to expert assessments (if adaptation measures are not implemented), about 10,000 hectares (about 5% of marz's forest area) will disappear. Serious changes in forest ecosystems are not expected at altitudes of 1200-1800 m, since in those conditions forests have a big potential for adaptation, and changes in climate conditions are within the ecological limits of the main force generating species. As a result of increased temperature, natural regeneration and conditions for reforestation and forestation will improve in forest ecosystems at altitudes of 1200-1800 m. The increased temperature will contribute to the burgeoning of seeds and seedling survival rates.

In central and southern forested marzes, forests are not contiguous, but rather separate islands. Climate change will worsen certain conditions for forest growth along the lower boundary of forests (1450-1550 m). It is assumed that active steppe and semi-desert plant species will infiltrate forest areas, which might result in the loss of 1700 hectares (3%) of forested areas in the region. It is expected that conditions for forest growth will improve at medium altitudes (from 2300 m to 2500-2700 m), as a result of which the area of forest ecosystems will expand upwards on mountain slopes.

In southeastern forested marzes, forests will also be vulnerable along the lower boundary of their areas (starting from 600 m). In addition to the worsening conditions for forest growth, the intensive infiltration of semi-desert plant species into forest areas is expected. As a result, it is expected that 5600 hectares (8%) of forest areas will be lost. The expected temperature rise and decline in precipitation will have a negative impact on the seeds regeneration in forests. Along the upper boundary (2600 m and higher), a small expansion of forest ecosystems is possible at the expense of meadow ecosystems.

If climate change scenarios become reality, more than 17000 hectares of forest might disappear as a result of the worsening forest growth conditions (5-5.5%). On the other hand, improved fo-rest growth conditions at the upper boundaries of forests will contribute to the expansion of forests upwards on mountain slopes. But currently, economic activity, and primarily the intensive use of sub-alpine meadows, as pastures and hay-fields, does not allow forest ecosystems to shift in the mentioned direction.

The expected climate change can have a negative impact on forest ecosystems also by worsening sanitary conditions, mass spread of pests and diseases and increased fire hazards.

Based on the biological characteristics of leaf eating insects, it can be assumed that, if climate change scenarios become reality, their mass reproduction area will increase by two times reaching 70-75 thousand hectares. In this case, forests in the southeastern forested areas will be the most vulnerable. With the expected more arid climate, the probability of more intensive forest fires will increase. This particular danger is more imminent for forests in central, southern and southeastern forested areas.

Table 5-11 presents the main indicators of forest vulnerability to climate change in Armenia.

Table 5-11 Vulnerability of Armenia's forests to climate change by 2030

Vulnerability factors	Possible losses of forest areas (ha)	Carbon accumulation reduction (T/year)
Changes in the boundaries of forest ecosystems	3000-4000	1625-2200
Fires	1200-1300	650-700
Pests and diseases	10000-12000	5420-6500
Total	14200-17300	7695-9400

Biodiversity. As already mentioned, Armenia's territory is divided into two floristic areas - humid Caucasian and arid Armenia-Iranian provinces. Climate change will have a different impact on biodiversity in those provinces. Increased aridity of the climate will contribute to the infiltration of desert and semi-desert plant and animal species from arid areas of Iran and Turkey into the southern regions of Armenia (Armenian-Iranian province). The areal of a number of mezophile species currently growing in the high mountainous belt of the mentioned areas will shrink and might even disappear. In the humid Caucasian Province, one might expect intensive spread of xerophile species, including weeds and invasive species, as well as shrinking in the areal of mezophile species. In addition, temperature rises can result in intensive spread of heat loving species in mezophyte and hygrophyte habitats, which are currently limited to the lower mountainous belt. Climate change will have a large impact on rare species with small ecological amplitudes. Using the DIVA-GIS computer software specially created for assessing plant genetic resources, the possible impact of climate change on Armenia's 20 rare flora species was assessed. Studies revealed that all 20 species assessed will end up at the verge of extinction in Armenia due to climate change.

5.5.2 Adaptation measures

The following measures are necessary for adaptation of natural ecosystems to climate change:

- Follow grazing norms and pasture rules, developed on scientific basis, in the majority of ecosystems used as pastures and hayfields (for this purpose, it is necessary to prepare the inventory of fodder lands in Armenia, and assess their current situation and yields).
- Properly zone Specially Protected Areas of Nature (SPANs) for biodiversity protection, taking into account climate change and shifting of the zones upwards on mountain slopes by 200-250 m.
- The new Law on SPANs (2006) and the Action Plan for the SPANs Development Strategy (2002) envisage buffer zones for the newly established SPANs, which will contribute to better adaptation capacities of biodiversity in the case of climate change. The mentioned Law also envisages regular monitoring of flora and fauna representatives included in the Red Book of Armenia.
- After the work on publication of the new Red Book of Armenia is finished, re-assess the risks and identify species under threat from the climate change. Based on the above-mentioned, develop recommendations on changes in the borders of already existing SPANs and new borders for practical protection of flora and

fauna species threatened to extinction.

- In all forested areas of Armenia, significant areas are currently covered by degraded forest ecosystems which are not capable to natural regeneration. Thus, priority adaptation measures should aim at restoration of the mentioned ecosystems and increasing their adaptation capacity. Based on the volume of work done in the country in recent years and the approved forest plantation plans for 2009-2011, it is re-commended to plant forests on 2.0-2.5 thousand hectares of degraded forest land during 2009-2020 (450-460 ha/year).
- In order to control the mass spread of pests and diseases, it is necessary to organize regular studies for diagnosing the phytosanitary conditions of forests, and based on the results, develop and implement integrated measures using different methods for forest pest control, including aerial spraying. It is also necessary to implement measures for improving the sanitary conditions of forests, which may reduce fire hazards in those areas.
- Within the funding of the Global Environmental Facility, the implementation of a pilot project for improving the adaptation capacity of mountain forest ecosystems to climate change in south-eastern Armenia was initiated in 2009. The state budget has financed (40 million drams) the program "Developing new environmentally friendly technologies for combating forest pests and disease spreading insects" to be implemented in 2009-2011.
- The National Forest Strategy plans to define a 200 m forest protection zone at the upper and lower boundaries of forests, which is an important adaptation measure for mitigating the negative impact of climate change on forest ecosystems. Forest building activities will be completed in 2010, and management plans for all forest areas of Armenia will be developed and will include mandatory fire, pest and disease control measures. This will also improve the adaptation of forests to climate change.

5.6 Settlements and infrastructures

Mountains and the terrain of Armenia stipulate for the spatial distribution of settlements and infrastructures. Cities and towns are basically located at the lower parts of the topography - planes, lower parts of mountains and river valleys. The majority of roads are along river valleys and mountain foothills. With such distribution, infrastructures become vulnerable to a number of natural threats related to the geological and climatic characteristics of the locality.

Various natural hazardous phenomena are characteristic to Armenia - landslides, storm falls, mudflows, spring floods, drought, frost, cold/warm flows, hail and strong winds. Those phenomena cause huge damages to Armenia's population, economy and infrastructures - an average of 10 billion AMD or USD 33 million annually. It might be necessary to study the time distribution of landslides, mudflows and floods by years in order to identify the link between those phenomena and climate change. The frequency of mudflows in 2002 and 2007, landslides in 2002 and 2006, and floods in 2003, 2004 and 2007, coincide with the years where the recorded annual average precipitation was relatively high.

5.6.1 Vulnerability and damage assessment

Within the context of climate change, assessment of vulnerability to and damages from natural disasters becomes more difficult, in the sense that the methods for calculation of spring inundation and floods in Armenia are based on the bulletin published in 1970s, but in recent decades new huge water systems have been built in the country, which have changed the former hydrological regime of almost all water bodies in the country. In addition, there is no clear correlation between climate change and landslides. According to some opinions and assumptions, the occurrence of landslide phenomena has increased in areas where increased precipitation is recorded, however, such an assumption has not been clearly justified.

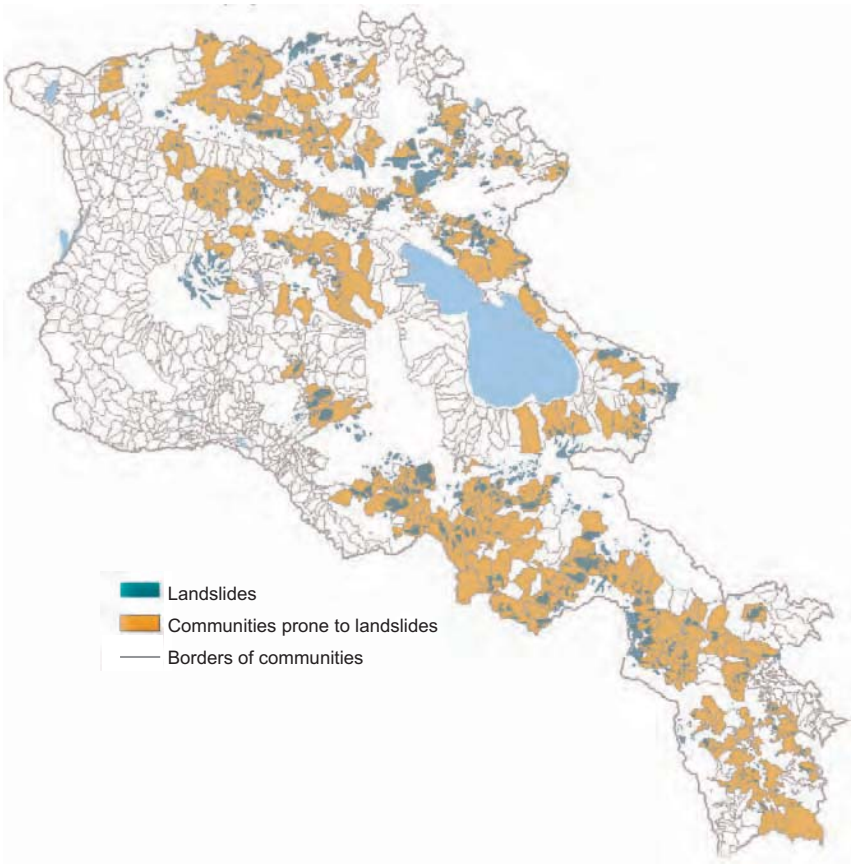

Figure 5-9 Distribution of landslides in Armenia and community areas prone to landslides

Landslides. The comprehensive study on landslides in Armenia in recent years has identified more than 2500 landslides prone areas with a total surface of 1221 km² (4.1% of total territory of the country). According to the study:

- 233 of the total 931 communities in Armenia have suffered damages from landslides;
- In 100 of the affected communities, landslides are especially active, causing damages to hundreds of houses, communication lines and utility infrastructures;
- About 3.2% of the motorway network, and around 0.5% of the railway network have suffered damages.

Distribution of landslides in the country and community areas prone to landslides are presented in Figure 5-9.

Table 5-12 presents the distribution of landslides in Armenia's marzes. From the quantitative point of view, Syunik marz has most of the landslides. With

Table 5-12 Distribution of landslides in Armenia by marzes

Marzes	Surface area, km²	Number of landslides	Surface area of landslides, km²	Relative surface of landslides, %
Aragatsotn	2763.4	19	75.5	3%
Armavir	1191.6	0	0.0	0%
Yerevan	222.3	152	13.0	6%
Kotayk	2034.0	110	77.8	4%
Tavush	2740.7	151	210.6	8%
Shirak	2682.6	23	20.6	1%
Ararat	2090.2	142	143.9	7%
Gegharkunik	5369.6	126	202.8	4%
Lori	3852.0	217	234.8	6%
Syunik	4492.2	289	246.7	5%
Vayots Dzor	2287.9	184	242.4	11%

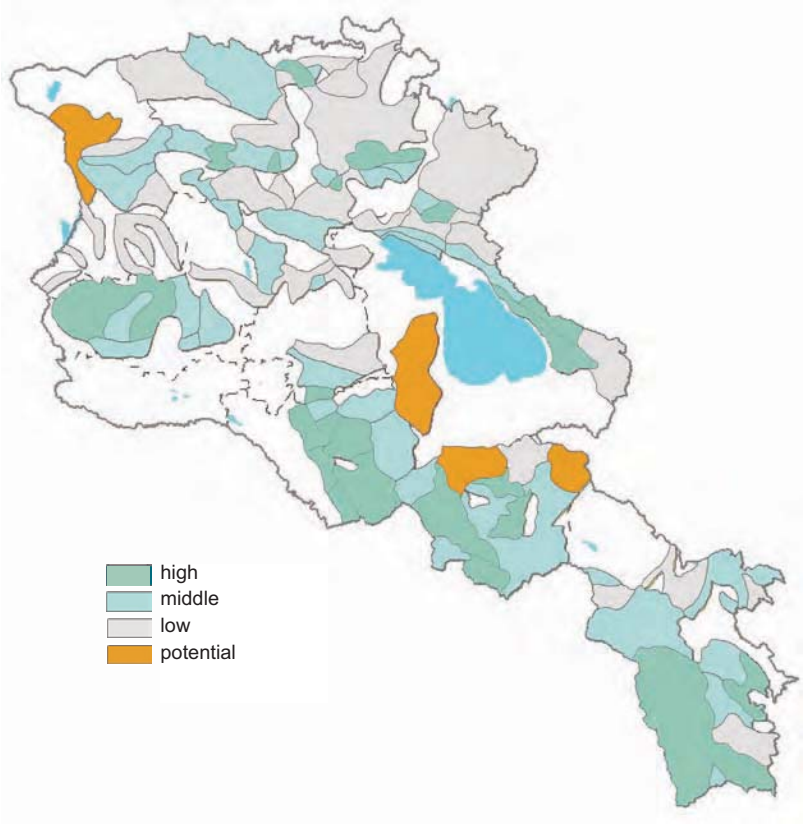

Figure 5-10 Mudflow zones of Armenia by frequency of occurrence

respect to their total surface, landslides are significant also in Vayots Dzor, Lori and Gegharkunik marzes. Per unit of the area, the number of landslides is the highest in Vayots Dzor, Tavush and Ararat marzes.

Rockfall. Not many cases of rockfall were recorded in 1994-2007. The largest number of rockfall cases was recorded in Shatin and Artabuynk communities of Vayots Dzor, where the road connects the northeastern part of Armenia with the south passes. This underlines the seriousness of the strategic and economic consequences of the phenomenon. The damage caused by rockfalls during
the observation period amounted to more than 12.3 million drams (about USD 38,000), about 8.5 million drams of which (about USD 26,500) has occurred in Vayots Dzor, and 3.7 million drams (around USD 11,500) in Lori marzes.

Mudflows. Distribution of mudflows in Armenia is presented in Figure 5-10. Areas prone to mudflows in Armenia are quite numerous (Table 5-13). Particularly in Lori, Syunik, Tavush and Aragatsotn marzes they constitute more than half of the territory, and the entire territory of the Vayots Dzor marz.

The damage caused by landslides in the country in 1994-2007 amounted to more than 5.6 billion drams (around USD 17.5 million), of which about 4.2 billion drams (around USD 1.3 million) of damages occured in Syunik marz, about 608 million drams (about USD 1.9 million) - in Tavush and about 335 million drams (about USD 1.1 million) - in Vayots Dzor marzes.

Floods. Nearly all marzes of Armenia are subject to numerous floods every year, but the levels of impact in various marzes are significantly different. The highest number of flood cases in 1994-2007 was recorded in the following marzes: Gegharkunik (159), Lori (85), Shirak (72) and Aragatsotn (71). In the same period, the total damage caused to the economy by floods amounted to more than 13 billion drams (about USD 41 million). Basically, damages were caused to the following marzes: Lori - about 5.7 billion drams (about USD 18 million), Syunik - about 4.2 billion drams (about USD 13 million), Tavush - about 1.7 billion drams (about USD 5 million) and Gegharkunik - around 817 million drams (about USD 2.5 million).

Table 5-13 Areas prone to mudflows in Armenia by marzes

Marzes	Surface, km²	Number of regions prone to mudflows	Surface of regions prone to mudflows, km²	Relative surface of mudflows, %
Aragatsotn	2763.37	8	1441.3	52
Armavir	1191.6	0	0.0	0
Yerevan	222.3	0	0.0	0
Kotayk	2034.0	7	867.3	43
Tavoush	2740.7	8	2147.0	78
Shirak	2682.6	8	1102.3	41
Ararat	2090.2	6	1033.6	49
Gegharkunik	5369.6	10	1551.4	29
Lori	3852.0	17	2494.6	65
Syunik	4492.2	13	3153.9	70
Vayots Dzor	2287.9	10	2277.3	100

5.6.2 Adaptation measures

The following adaptation measures are proposed for all communities with areas vulnerable to mudflows, landslides and floods:

- Create a legal framework to promote the introduction of mechanisms for developing an insurance system for state and private property against natural disasters and compensations;
- Allocate public financing for implementation of detailed studies on landslides, inundations, mudflows, floods and rockfalls;
- Prepare a new bulletin, which will take into account human economic activity on water bodies and impacts of the global climate change in recent years. The bulletin should include methods for calculating and forecasting mudflows and floods, as well as the probability of frequency of their occurance.

Proposed preventive measures include:

Against landslides:

- Consider landslide risks during the planning of investments and property development;
- Strictly control and regulate irrigation and site development licenses;
- Design and construct dams and reservoirs to protect settlements and infrastructures;
- Plant forests and vegetation on the slopes, as well as ensure terracing, fencing or netting;
- Create water collection and water drainage constructions or improve the existing ones.

Against floods, mudflows and spring inundations:

- Consider climate change risks during the planning of investments and settlement development;
- Regularly clean the river beds, widen or heighten the banks and their reinforcement;
- Ensure phyto-melioration in river basins of rivers causing mudflows and floods and construction of anti-mudflow and anti-flood barriers;
- Install mudflow observation points on rivers;
- Install bank protection constructions in areas where rivers are inundated, as well as install automatic warning observation points;
- In order to forecast spring inundations, restart snowpack measurement activities using contemporary methods;
- Develop short- and long-term forecasting methods for floods, mudflows and spring inundations.

In order to prevent and mitigate natural disasters, the Government of Armenia in 2008 adopted Decree No. 248-N "On regulations for organization of emergency assistance to the population during droughts and other natural disasters and technogenic accidents". In the same year, the "Program for protecting the population, settlements and infrastructures from the risks of inundations, mudflows and floods" was developed, which plans to completely restore bank protecting constructions of Araks River in Ararat and Armavir marzes in 2008-2011. It is planned to start working on the preparation of design documents for restoring Araks

River bank protection structures in Syunik marz. It is also planned to implement protection measures for rivers causing mudflows and floods. So far, the project proposal has not been approved and no single activity has been undertaken. However, during the recent years, the state budget has allocated funds on annual bases for implementation of measures against spring inundations.

5.7 Human health

Climate change has a direct or indirect impact on human health. The direct impacts include: increased number of cases with cardiovascular diseases due to the “heat island” effect, as well as deaths and injuries of people during hazardous climatic phenomena, such as floods, mudflows and landslides. Indirect consequences are manifested in higher frequencies and larger spread of infections and seasonal diseases, as well as diseases emerging because of changes in the areal of viruses, lack of access to clean water and lower level of food security.

A number of forecasts were made in the First National Communication of Armenia on Climate Change, particularly referring to epidemic situations related to dangerous, infectious and parasitic diseases. In the period following the report, some of the forecasts materialized. In particular, in August and September 1998, against the background of the highest air temperatures in the last 70 years in Armenia, there was an outbreak of El Tor cholera (288 people became sick and two of them died). The outbreak was liquidated thanks to the measures undertaken, but comma bacillus are discovered every year in Armenia's water flows and water reservoirs. However, the percentage of isolation of those vibrios increases, especially in years with unusually hot summers. The forecasts reported in the First National Communication on Climate Change of Armenia on the epidemic and epizootic situations related to plague and tularemia also came true. An increase in the areal and frequency of malaria had also been forecasted, however, the disease was averted thanks to the timely preventive measures undertaken. Assumptions on the possibility of expanded areals of Vinogradov's and Persian sand mouse (spreading plague) were also proven to be right. The area of their habitat has expanded, and they have inhabited such locations, which were formerly considered as unsuitable for them.

Current statistics on diseases does not allow for quantitative assessment of the impact of the climate change factor on population's health. Using the method of analogs, it can be assumed that groups of the population considered to be vulnerable in countries with climatic parameters similar to Armenia will be vulnerable also in our country. The primary vulnerable groups are people with cardiovascular and central nervous system diseases, as well as people who have inadequate capabilities for thermal regulation (elderly and children). People with asthma and allergies are vulnerable in the conditions of increased aridity, dust in the air and pollution of air in urban areas.

5.7.1 Vulnerability assessment

Infectious diseases

Cholera. The current pandemic of El Tor cholera continues mainly in secondary endemic outbreak sites, and these sites include also some areas of Armenia. After the outbreak of 1998, cases of El Tor cholera have not been recorded. But its vibrios continue to isolate in numerous water flows and water reservoirs of Armenia. In addition, the new O139 strain better adapted to the surrounding conditions, which causes Bengal cholera, has been discovered in recent years. If climate change scenarios turn out to be true, primarily as a result of increased temperatures in summer and autumn, new outbreaks of the disease are possible, especially if the etiological factor - the possibility of replacement with a strain (Bengal cholera) which is more toxic and better adapted to surrounding conditions, is taken into account. The highest risk is forecasted for pre-mountainous areas of the country, especially for Ararat valley. Hoever, it is possible that, due to unusually hot summers, the disease will also spread in the mid-altitude mountainous zone.

Plague and tularemia. The hot and arid conditions of 1997-2001 changed the food basis for common field-mouse, which are the main car-

riers of plague and tularemia in Armenia, and resulted in one of the most long-term and radical declines in their populations. Accordingly, the epizootic processes became less active (and even died down). The favorable year of 2002 provided biological and reproduction mechanisms for increasing the numbers of rodents. Already in 2003, the numbers of field-mouse in some places during spring time exceeded the average for a number of years by one or two times. As a simulation of the biological mechanism for regulating the increase in numbers, active tularemia epizootia were defined, as a result of which about 90% of rodents were eliminated in an area of around 3000 km². In some places it continues and is accompanied by disease outbreaks among the population and individual cases of the disease. As a result of such instability, 22 plague epizootia were discovered outside the boundaries of tularemia epizootia in 2003-2007. Increase in the frequency of hazardous hydro-meteorological phenomena (hot and dry summer, warm winter with sudden cold spells, etc.), which are forecasted in climate change scenarios, will contribute to the above described processes, when after a sharp drop in population, a similarly sharp increase accompanied by epizootia will be observed. In more humid and cool years, we can expect the worsening of plague and tularemia epizootological and even possibly epidemic situation.

Acute intestinal infections. Based on the studies of public reports on acute intestinal infections morbidity of defined or undefined etiology with bacterial dysentery, salmonellosis, it was revealed that acute intestinal infections with undefined etiology are prevalent, and the latter shows a rapid growth trend (in 2000 the intensive indicator was 59.5 per 100,000 people, while in 2007 the same indicator was 102.9). Increase in temperatures and prolonged warm and hot periods contribute to the spread and increase of intestinal diseases, especially during the times of tension in providing the population with quality drinking water and violation of sanitary norms for storing food stuff.

Parasitic invasions (Ascarids and Trichocephalus). Temperature and humidity have a huge impact on the spread of many parasites, primarily geohelmints. In areas with cold and humid climate (mid-altitude and high mountainous areas), the expected increase in temperatures will contribute to the reduction of the development period and increased level of infection in the environment, as a result of which increased morbidity can be expected in the major part of Armenia.

Malaria. Malaria of local origin has not been recorded in Armenia since 1963, however, an increase in the frequency of imported malaria cases has been recorded since 1994. The high summer temperatures recorded in Armenia in 1998-2001 seem to have modeled the climate change forecasts reported in the First National Communication. The highest number of cases of malaria was recorded in the same year of 1998 (1156 cases). As a result of measures taken, cases of malaria have not been recorded since 2006. Considering that the country has areas where there is a high risk of malaria outbreaks, prevention of malaria epidemic outbreaks remains on the agenda for the coming years. Currently, in the mid-altitude mountainous zone malaria is prevented due to low temperatures, and if climate change scenarios come true, a vertical spread of the disease will occur.

Leishmaniose. Realization of climate change scenarios will contribute to the spread of visceral leishmaniose, which was common in Armenia until 1960s. After a long break, the disease was recorded in Lori and in 2001 also in Tavush marz. Four cases of the disease were recorded in 2007, and five cases in January-May 2008. The monitoring revealed that trends of restoration of mosquito numbers around Yerevan and the entire Ararat valley, Lori and Syunik marzes, which is directly linked to the prolonged hot period in recent years, might cause the higher occurrence rate of the leishmaniose disease.

Extremely dangerous arboviral infections. Arboviral infections (Crimean-Congo hemorrhagic fever, tick-borne encephalitis and meningo-encephalite, Western Nile fever) have an important place in the infections pathology of humans. With the forecasted climate change, the highest potential danger for Armenia's population is the

Crimean-Congo hemorrhagic fever, which has an extremely dangerous nature and high lethality (15-50% of the infected). It is a zoonoses viral disease and the virus comes from animals and is spread by ticks. There is no vaccine for humans and livestock. Armenia is in the risk group countries, but since the transmitter of the disease is thermophil the conditions for circulation of the virus are not yet at the emergency threshold. The experience of neighboring countries (Iran, Turkey) reveals that when the climate becomes more arid, the disease emerges also among humans.

Other than Crimean-Congo hemorrhagic fever Western Nile fever, Sydney fever and Tyagin fever cases are also possible, if the forecasted climate change comes true. Those diseases are recorded in neighboring countries and depending on the expansion of their areal and infiltration of viruses and their main carriers into Armenia, it is possible to expect the emergence of those diseases as well.

Non-infectious diseases

Climactic conditions of summertime in densely populated urban areas of Armenia are already very tense. In all lowland areas of the country, heat discomfort happens in July-August. High temperature and intensive radiation create the threat of heat and sun strokes. The threat will increase if the climate change scenarios become reality (in addition to the increased climate aridity, prolongation of the heat discomfort period is also expected). Higher frequency of heat waves (unusual rise of temperature for a number of days in a row) is also expected, which will further exacerbate the heat discomfort stress. The forecasted climate change is especially dangerous for people with cardiovascular and central nervous system diseases. A continuous increase in cardiovascular and central nervous system diseases is recorded in Armenia since 1997 (morbidity in 2007 increased by 2.5-3 times). Unfortunately the available statistics does not allow for differentiation of the climate factor input at national or regional levels.

Table 5-14 Climate change related priority adaptation measures in the health sector

Vulnerability criteria	Adaptation measures
Heat diseases (heat stress and discomfort) due to higher air temperature, created number of hot days, frequent droughts and southern winds.	• Medical examination of the population for identifying and controlling vulnerable groups • Early warning systems • Adequate water supply • Maintenance and improvement of the temperature comfort in buildings (ventilation, air conditioning, shadowing buildings) • Improvement of settlement microclimate (fountains, green zones) • Promotion to and introduction of relevant behavior (siesta) • Protection clothes and hats
Cardiovascular diseases as a result of prolonged hot periods and heat waves, changing weather, high humidity in winter.	
Hazardous weather phenomena: frequent heavy rainfall and storms, floods and landslides, drought in the summer.	• Early warning systems • Use of protection technologies and items • Knowledge of personal safety measures
Dangerous, infectious and emergency diseases (vectoral) as a result of higher air temperature, prolonged hot periods, spread of diseases by migrating birds.	• Epidemiological monitoring • Early diagnosis • Early warning systems • Ensuring a system for preventive measures, including immunization of population • Ensuring access to clean water
Diseases related to water and foodstuff as a result of higher air temperature, prolonged hot periods, extremely hot days.	• Sanitary-hygienic monitoring • Following sanitary norms during transportation and storage of food • Improving water supply • Following personal hygiene rules

5.7.2 Adaptation measures

Adaptation measures for reducing the impacts of climate change on human health are presented in Table 5-14.

The current health care legal framework doesn't adequately address implementation of adaptation measures. However, several programmes implemented during last years aimed at mitigation of the climate change related risks. The World Health Organization and the Global Fund to Fight Malaria Programme implemented in Armenia have direct linkage to the climate change issues. WHO prepared the report "Assessment of the health care and possibilities for managing emergency situations in Armenia" in 2007, where a separate section is devoted to public health and global climate change. Assessment of the situation and the proposed adaptation measures have been submitted to the Ministry of Health of Armenia.

Literature

1. Aghajanyan G.Kh. & et. al. (1956). Agricultural zones of the Armenian SSR, Yerevan.

2. Andraghetti R., El Bushra H., & Formenty P. (2006). Surveillance and Control of Crimean-Congo Haemorrhagic Fever Outbreaks Worldwide. Joint Intercountry Workshop on Crimean-Congo Haemorrhagic Fever (CCHF) Prevention and Control. Istanbul (Turkey), 6-8 November 2006.

3. Atlas of water resources of Armenia. (2008) USAID.

4. Carter, T.R. & et. al. (1992). Technical Guidelines for Assessing Climate Change Impacts and Adaptations. IPCC WMO, UNEP.

5. Chinikar, S. (2006). Surveillance and Control of Crimean-Congo Haemorrhagic Fever in Iran. (2006). Joint Intercountry Workshop on Crimean-Congo Haemorrhagic Fever (CCHF) Prevention and Control. Istanbul. Turkey.

6. Convention on Biodiversity. Fourth National Communication (2009). Republic of Armenia, Ministry of Nature Protection, Yerevan. Nork.

7. "Establishing the "Armenian rescue service administration" state administrative organization of the Ministry of Emergency Situations of the Republic of Armenia, approving the charter and structure of administration of the Armenian rescue service of the Ministry of Emergency Situations of the Republic of Armenia. Decree of the Government of Armenia No. 634-N dated 19 May 2005, Annex 2 to the Decree No. 531-N dated 15 May 2008.

8. Fayvush, G. (2006). Flora Diversity of Armenia. Biodiversity of Armenia (2006). Yerevan. Armenia.

9. First National Commutation of the Republic of Armenia under the UN Framework Convention on Climate Change (1998). Executive Summary. Ministry of Nature Protection of Armenia, UNDP/GEF.

10. Hulme M. & et. al. (2000). Using a Climate Scenario Generator for Vulnerability and Adaptation Assessments. MAGICC/SCENGEN version 2.4. Workbook and Technical Manual. Part 2. Climatic Research Unit. Norwich. UK.

11. Issues and development strategy of the agro-food system of the Republic of Armenia (2002). Ministry of Agriculture of Armenia, Yerevan.

12. Khachatryan, H. (2006). Fauna Diversity of Armenia. Biodiversity of Armenia. Yerevan. Armenia.

13. Melkonyan H.A., Hovsepyan A.R., Hovhannisyan D.M., Vardanyan L.R.(2009). Model assessment of climate change in Armenia, bulletin of the Scientific-Technological National Academy of Armenia, Yerevan. No.1

14. National atlas of Armenia (2007). Volume A, State Committee of Real-Estate Cadaster of the RA Government, Yerevan. "Geodesy and mapping center" SNCO.

15. Report on the availability and distribution of land stock (land balance) in the Republic of Armenia. Decree of the Government of Armenia No. 2243-N dated 22 December 2005.

16. Solomon, S., Qin D., Manning M., Chen Z., Marquis M., Averyt K.B., Tignor M. and Miller H.L. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. NY.

17. Statistical yearbook of Armenia (1996-2008)/National Statistical Service of Armenia, Yerevan (2001-2009).

18. Study of landslides risks management in Armenia, Ministry of Urban Development of Armenia, International Cooperation Agency of Japan, 2006.

19. System on landslide hazard and risk assessment in the Republic of Armenia (2000). UNDP, "Georisk" Ltd.

20.The law of the Republic of Armenia on the National Water Program. Passed on 27 November 2006, HO-232-N.

21. UNFCCC. (2004). Reporting on Climate Change. User Manual for the Guidelines on National Communications from Non-Annex I Parties.

22. UNFCCC (2006).Technologies for Adaptation to Climate Change.

23. Uzun R., (2006). Surveillance and control of Crimean-Congo Haemorrhagic Fever in Turkey. Joint Intercountry Workshop on Crimean-Congo Haemorrhagic Fever (CCHF) Prevention and Control (2006). Istanbul. Turkey.

24. Watson, R.T. and the Core Writing Team (2001). Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. NY.

25. WHO (2007). Assessment of Health Security and Crisis Management Capacity. Armenia.

26. Wilson, S. & et. al. (2008). Installing and Using the Hadley Centre Regional Climate Modeling System PRECIS. Version 1.6.1.- UK MetOffice.

27. World Bank (2009). Adapting to Climate Change in Europe and Centrall Asia.

28. Xie P., Arkin P. A. Global precipitation: a 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. Bull. Amer. Meteor. Soc.- 1997, V.78.

29. Кешишян А.Ш., Алексанян Ю.Т., Манукян Д.В. (2007) Эколого-эпидемиологические аспекты малярии в Армении и перспективы ее элиминации. Медицинская паразитология и паразитарные болезни. N2.

30. Манрикян М.Г., Хачатрян Л.М. и др (2005). О выделении в 2005г. холерных вибрионов О139 из объектов внешней среды РА. Актуальные вопросы эпидемиологии инфекционных болезней. Мат. научно-практической конференции с международным участием. Ереван.

31. Саакян Л.В. и др. Разлитая эпизоотия туляремии на территории Армении и обусловившие ее факторы (2004).Млекопитающие как компонент аридных экосистем Тезисы международного совещания. Саратов.

32. Тахтаджян А.Л. (1978). Флористические области Земли. М.

33. Тахтаджян А.Л. (1954). Карта районов флоры Армянской ССР. Флора Армении.-Е, Т.1.

34. Файвуш Г.М. (2007). Эндемичные растения флоры Армении. Флора, растительность и растительные ресурсы Армении. Т.16.

CHAPTER 6

Other Information

6.1 Research and systematic observation

Systematic hydro-meteorological and climate observation in Armenia are carried out by the State Hydro-Meteorological and Monitoring Service ("Armstatehydromet" SNCO) under the Ministry of Emergency Situations of Armenia.

"Armstatehydromet" operates in accordance with the provisions of the Law on Hydro-Meteorological Activities (2001) and provides actual hydrological and meteorological data to the authorities of the Republic of Armenia, the public and various sectors of economy. Besides, "Armstatehydromet" provides information on the forecasts of weather and dangerous hydro-meteorological phenomena, climate and its changes.

6.1.1. Systematic observation of climate

The network for hydro-meteorological observations

Hydro-meteorological observations are conducted in Armenia since 1881, however initially they had a non-systematic nature. A proper observation network was established in 1920s. The maximum number of meteorological stations was 62 (1961). Currently there are 42 meteorological and 3 special stations (Figure 6-1), 79 hydro-meteorological observation points, and 7 hydrological stations with 92 water gauging observation points (Table 6-1) in the system. 12 of the stations, with 6 remote ones, are located at over 2000 m above sea level.

Three meteorological (Yerevan, Sevan, Amasya) and one aerological (Yerevan) stations are included in the global communications system (GCS), and 20 metereological stations - in the CIS intergovernmental hydro-meteorological network. Within the framework of voluntary cooperation with the World Meteorological Organization (WMO), a number of new systems and equipment were introduced in "Armstatehydromet" in 2000-2007.

Technologies corresponding to new international standards are used for obtaining data and exchanging information. The WAREP code for early warning on dangerous hydro-meteorological phenomena is being introduced. Since 2007, efforts are being undertaken to transit from the traditional letter-digit codes to the Binary Universal Form for the Representation of meteorological data (BUFR), which is widely used all over the world. The "TV-inform" system installed in "Armstatehydromet" in 2002 was replaced with the "Mitra" system in 2004, and it was integrated with UniMAS and RETIM2000 systems.

Table 6-1 Current system of hydro-meteorological monitoring in Armenia

Observations		Stations (S), observation points (O)	Years in operation		
			>30	>50	>100
Meteorological	Atmospheric pressure	47 (S)	45	36	5
	Clouds	45 (S)	45	36	5
	Humidity	45 (S)	45	36	5
	Precipitation	79 (O)	65		
	Temperature	45 (S)	45	36	5
	Visibility	45 (S)	45	36	5
	Winds	45 (S)	45	36	5
Agro-meteorological		37 (S), 3 (O)	40		
Aerological		1 (Yerevan Aerological S)	1		
Ozonometric		1 (S)	9 (restorations)		
Hydrological		7 (S) 92 (O)			
Radiological		34 (O)			
Actinometric		7 (S)			

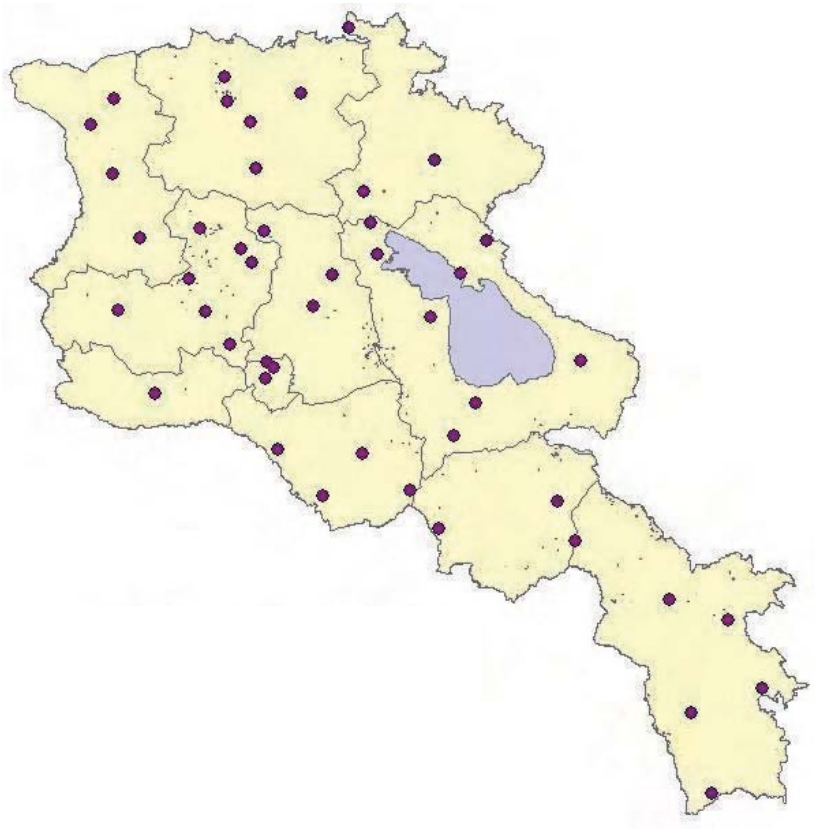

Figure 6-1 Hydro-meteorological stations in Armenia

Data storage, management and dissemination

Data from observations at all the meteorological stations, which currently operate or have ever been operational in Armenia (more than 80 stations), are collected and stored at "Armstatehydromet" central database, where all meteorological elements are included. The CLICOM system is used for storing and managing meteorological data.

In 2007, according to the recommendations of IPCC, RClimDex software was introduced for data quality control. In order to automate the receipt of observation data from stations, meteorological station were equipped with computers starting from 2006, and currently nine meteorological stations and eight hydrological observation points already have computers installed.

The Sinop software is already being used and other new softwares have been introduced as well. The KH-01 software package for decoding and binary representation of meteorological data has been developed and introduced.

The demand for hydro-meteorological information has increased significantly in recent years, which is due to the increased frequency of dangerous weather and climatic phenomena as a result of climate change. Larger volumes of hydro-meteorological information and services provided and the use of new methods for information provision contribute to establishment of a larger circle of consumers. Currently, the main consumers of hydro-meteorological information are the following sectors: energy, agriculture, construction, utilities, forestry, communications, transport and health care.

The following information (Table 6-2) is provided free of charge to the public, governmental agencies and other public organizations.

The Government of Armenia Decree No. 1186-N (2008) approved "The procedures for forecasting, warning and response to dangerous hydrometeorological phenomena related to the above-normative pollution of the atmosphere, climate change and conditions of the ozone layer". The Decree specifies warning and response measures to be implemented by governmental bodies and other agencies during unfavorable, dangerous and emergency phenomena.

Table 6-2 System of hydro-metereological information provision

Frequency	Hydro-meteorological data
Daily	Maximum and minimum temperatures of the previous day, quantity of precipitations, meteorological phenomena, clouds, depths of snow cover on the territory of the country
	Weather forecasts for marzes and Yerevan for the next 1 to 5 days
	Series of multi-year data on Yerevan climate
	Real-time satellite pictures
	Characteristics of heliophysical and radiation regime (for the given day and the next day)
	Level of Lake Sevan, the quantity of its water inflow and outflow
	Forecast of hydrological phenomena
	River regimes
	Weather in large cities of the world
Regularly	Weekly review of the weather
	Monthly review of the weather
	Monthly climate characteristics
	Monthly weather forecasts
	Seasonal weather forecasts
	Ten-day agro-meteorological forecasts
	Hydrological forecasts

Participation in regional and global systems

After the submission of the First National Communication on Climate Change, significant efforts have been made in the field of international cooperation through further developing former programs and ties and establishing new ones.

Since 2003, the Yerevan aerological station of "Armstatehydromet" is included in the Global Upper Air Network (GUAN) of the Global Climate Observation System (GCOS). The ”Amberd” high-altitude station is included in the global ozone observation network of WMO (GAW/GO3OS). According to the procedures defined by WMO, the data from observations at Yerevan aerological and Amberd stations are regularly communicated to the relevant centers. Since 2007, the "Aragatz" high-altitude station (3226 m), the only station in the region operating above 3000 m of altitude, is included in the GCOS Surface Network (GSN). The station is operational since 1929 and has a huge significance for climate change studies in the region.
"Armstatehydromet", which is included in the European Climate Assessment & Dataset (ECA&D) since 2003, regularly provides observation data, which are used by IPCC for calculating indices used for the assessment of climate change. In 2007, the software developed for calculating those indices, was introduced in "Armstatehydromet".

Within the framework of WMO world weather information service and global atmosphere watch program, data on meteorology, climate, ozone content and aerology are communicated to relevant global and regional data centers. "Armstatehydromet" has provided data to the global precipitation climatology center (Offenbach, Germany) established within the framework of the global climate observation system, where studies of precipitation distribution and its global changes are conducted based on the collected data. "Armstatehydromet", jointly with the German Meteorological Organization (DWD), is implementing the program "The use of CM-SAF satellite products for monitoring of the climate on Armenia's territory". Based on the technological advances and satellite data available for any timescale, advanced models and algorithms are developed for rapid processing and targeted use of satellite data.

In 2009, the "Armstatehydromet" participated in

the program of the Asian Center for Disaster Preparedness and UNDP "Technical support to climate risk management".

Research activities

Research activities are conducted in "Armstatehydromet" by the Climate Study Center, which includes divisions for climatology, digital modeling of hydro-meteorological processes, global and regional climate change studies, applied climatology and atmosphere pollution studies.

The Climatology Division processes data from 280 stations and observation points operating at various periods on the territory of Armenia, prepares climate yearbooks where climate resources of the territory are presented in detail.

In the Division for Digital Modeling of Dangerous Hydro-meteorological Phenomena, dynamic statistical models for short-term forecasts are developed and further elaborated. The developed algorithms are used for assessment and forecasts of precipitation, river flow, mudslides, yields of agricultural crops, droughts, and atmosphere pollution.

The Global and Regional Climate Change Studies Division develops models, with the help of which climate change scenarios for the territory of Armenia are developed taking into account the changes to the global climate. Long-term forecasting methods (monthly, seasonal, annual) are developed and used for solving various problems.

The Division for Applied Climatology develops methodologies for forecasting hydrological and water resources, agro-meteorological, bio-meteorological, alternative energy related phenomena, as well as frequency and intensity of droughts.

6.1.2. Programs and studies contributing to climate change mitigation measures

In 2000, the National Assembly of Armenia passed the Law on Scientific and Scientific-Technical Activities. According to the Law, one form of public financing of scientific and scientific-technical activities is baseline funding, which is allocated to state scientific organizations for fundamental and significant applied research. According to the same Law, one of the main objectives of the state policy on scientific and scientific-technical sector is to improve the environmental conditions in the country.

On 11 July 2007, the Government of Armenia approved the concept paper on reforms in the science sector; the strategy for development of science and the relevant action plan for the next 10-15 years are currently being drafted.

Despite the fact that the annual financing of the science sector from the state budget is low and amounts to around 0.9% of the total budget expenditures, a significant increase in allocations is noted - from 2730.1 million drams in 2001 to 8374.6 million drams in 2009.

In 2009, over 70 scientific themes relating to environmental problems have been financed through the state budget of Armenia, the majority of which refer to biodiversity and desertification problems, and are, at the same time, relevant to climate change related issues.

Climate change related studies and programs in Armenia are basically devoted to vulnerability assessment of climate change consequences and developing adaptation measures. Since 2008, the following studies have been financed from the state budget:

- Dynamics and nature of changes in Armenia's flora as a result of the spread of invasive plant species and global climate change;
- Study of zoocomplexes of Armenia's invertebrate animals in order to identify climate change biomarkers and to develop the scientific basis for monitoring biodiversity vulnerability;
- Assessment of water-temperature and radiation impact on crops yields based on modern approaches;
- Assessment of the changes in water resources of large river basins in Armenia;
- Development of methodologies for assessing and forecasting drought conditions and the losses to agricultural crops and piloting of those methodologies in Armenia's regions;

- Development of a methodology for forecasting crops yields on the territory of Armenia;
- Testing of the methodology for assessment and forecasts of Lake Sevan active water exchange zone, as a precondition for the management of the Lake's water resources.

With the support of the UNDP, the "Greenhouse Gas Emissions Reduction and Energy-Efficiency Potential in Transport Sector in Armenia" Project was implemented in 2006, in the frames of which the potential for motor fuel saving and GHG emission reduction in the transport sector by 2020 was assessed.

In 2008-2009, with the financial support of the UNDP, the following pilot projects were implemented to assess climate change impacts on various sectors of the economy and develop adaptation measures:

- *"Assessment of climate change impact on the economy of Shirak region"*. Based on the vulnerbility assessment, relevant adaptation measures for mitigating the impacts of climate change on the region's economy were proposed. Public perception on climate change was also assessed and public awareness building measures were implemented.
- *"Social-economic impact of climate change in Armenia".* The study was conducted in cooperation with the Stockholm Environmental Institute (USA). In the framework of the study, the impacts of climate change in the following sectors were analyzed: water resources, agriculture, electricity production, forestry and natural disasters. Adaptation measures and policies for mitigating climate change impacts were proposed.
- *"Assessment of climate change impacts on Lusadzor community of Tavush region"*. In the framework of the study, which was targeted on a community, where the UNDP CO is implementing a community development project, the current and forecasted changes to the climate were analyzed in detail, climate proofing of community development activities were conducted, and the priority adaptation measures were selected, which will later be considered and addressed by the UNDP, local authorities and other donors.
- *"Assessment of climate change impact on water resources in Marmarik River basin"*. In the framework of the study changes in the water resources of the Marmarik River basin up to 2007 were assessed, the vulnerability of water resources by 2030, 2070 and 2100 was forecasted, and impacts of climate change on financial-economic losses of the water system were analyzed. At the same time, adaptation measures with economic justifications were proposed according to the following categories: a) no regret measures; b) low cost measures; c) economically justified measures; and d) long-term measures.
- *"Climate change related risk assessment in Ararat region*". The survey was conducted in the framework of the UNDP Natural Disasters Risk Assessment Project, implemented in the region for more than 30 communities. The survey revealed public opinion on the dynamics and risks of dangerous hydro-meteorological phenomena and natural disasters in Ararat region.
- *"Adaptation to climate change impacts in mountain forest ecosystems of Armenia"*. In the framework of the preparatory stage of the UNDP/GEF project, climate change related risks were revealed and measures to be implemented in cooperation with national partners within 2009-2012 were developed. Since 2009 the "Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia" UNDP/GEF Project is under implementation.

A number of other studies were conducted to assess the potential sources and use of renewable energy in Armenia, which will contribute to the limited use of fossil fuel in the country, and, thus, reduction of GHG emissions.

Wind Energy Resource Atlas

In 2003, a comprehensive study on wind energy resources was conducted in Armenia by the National Renewable Energy Laboratory (NREL) of the United States, the key output of which was development and publication of the "Wind Energy Resources Atlas of Armenia". The results of the study suggest that the economically justified potential for wind energy in Armenia is more than 4000 MW. About 1000 km^2 of land areas of

Armenia have been assessed by NREL as areas with good-to-excellent wind resource potential.

Bio-ethanol

In 2008, the "Assistance to bio-ethanol production in Armenia" Project was implemented in Armenia under the GEF funding, in the frames of which the bio-ethanol production potential was assessed, a pre-feasibility study was prepared and recommendations were proposed on fostering the bio-ethanol production in the republic. According to the pre-feasibility study results, it is suggested to create two fields of feedstock plants in Syunik and Tavush marzes for production of bio-ethanol in the Republic of Armenia.

Renewable Energy Potential Assessment in Gegharkunik Marz

During 2006-2007, the "Support to Energy Policy of Armenia" Project was implemented in Armenia with the funding of the EU. In the frames of this project, the renewable energy potential (hydro, wind, solar, biomass and geothermal) in the Lake Sevan basin (Gegharkunik Marz) was assessed, as well as a number of feasibility studies were developed on renewable energy projects. In the frames of the project, the CO_2 emission factor (baseline) in the energy system of Armenia for the year 2007 was calculated, as well as the CDM project document on construction of a wind power plant with 14.5MW capacity in the mountain pass of Semenovka was developed.

Geothermal Energy Project

By the funding of the World Bank and the Government of Armenia, a two-phase project is being implemented to assess the potential for geothermal energy in Armenia.

During the first phase geological field scouting, as well as magneto-telluric sounding and analysis of investigation results at two potential geothermal fields: Karkar and Gridzor, were conducted. The overall objective of the first phase of the project was to assess the reasonability of future investigations and works, and select a more prospective geothermal site for implementation of the second phase of the project.

During the second phase, it is envisaged to conduct a three dimensional seismic survey of the site, which will enable generating the outline of the subsurface structure and the depth of potential geothermal reservoir, its thickness and size, and the presence of major fault zones.

Solar Energy

A number of organizations and educational establishments (the American University of Armenia, the Yerevan State University, the State Engineering University, the Institute of Physics, "SolarEn" LLC etc.) have conducted joint studies on renewable energy, particularly, on solar technologies during the recent years. Through their joint efforts, a number of projects on preparation and installation of solar water heaters and PV solar panels were implemented.

6.2 Education, personnel training and public awareness

6.2.1 Education and personnel training

Several laws on educational system and ecological education have passed in Armenia since the submission of the First National Communication on Climate Change (1998). The Law of the Republic of Armenia on Education (1999) defines the principles of education strategy in Armenia. The Law of the Republic of Armenia on Ecological Education and Awareness of the Population (2001) stipulates permanent ecological education and defines the principles, legal, organizational and financial fundamentals of state policy on permanent ecological education of the population. The National Assembly of Armenia adopted the Strategic Programme on Ecological Education in 2007, which replaced the one adopted in 2001. The implementation of the policy on ecological education and coordination of respective activities is carried out by the Ministry of Education and Science and the Ministry of Nature Protection. The issues of ecological education are reflected in the Second National Environmental Action Plan (2008) as well.

Measures have been undertaken in the country towards implementation of the New Delhi Work Programme on Article 6 of the UNFCCC. The issues of education and public awareness on climate change are reflected in the Government of

Armenia Decree No.1840 (02 December 2004), which approves the action plan on implementation of cross-cutting issues under three UN global environmental conventions. In 2005, Armenia joined the UN decade of Education for Sustainable Development and is involved in the processes under the Strategy on Education for Sustainable Development.

Currently, ecological education forms part of the educational system in Armenia, covering all the levels - preschool, secondary, vocational, higher education and postgraduate studies.

At preschool level, reforms related to ecological education are still underway. The Law of the Republic of Armenia on Preschool Education (2005) and the Preschool Education Reform Strategy of 2008-2015 (2008) consider the issues of ecological education.

At the secondary education level, there are 1472 public and 59 private schools in Armenia. At the secondary education level of the continuous education, which is currently in transition to a 12-year educational system, environmental topics are taught based on the specific aspects of age groups and curricula subjects. Environmental topics are included in curriculum subjects of "Me and the surrounding world", "Biology", "Geography", "Physics", "Chemistry", as well as in social sciences. Climate change issues are included in the mandatory courses of the secondary school. Besides, a number of projects were implemented to ensure the progress in ecological education in the country. UNDP, UNEP, USAID, and ATP Charitable Foundation's projects are among those.

Vocational education in Armenia is comprised of 30 trade schools, 80 public and around 25 private colleges. Curricula of almost all vocational education institutions include either the course on "Fundamentals of Ecology" or "Fundamentals of Ecological Education", which include climate change related topics.

The higher education in Armenia comprises 88 higher educational institutions: 19 public, 65 private, 3 intergovernmental, and one operating with state participation. In addition, there are also seven branches of foreign universities.

At all levels of the higher education system, ecology and environmental protection are mandatory courses. Some voluntary courses also cover topics related to environmental protection. Depending on the profile of the higher educational institution, courses on ecology and environmental protection are offered in eight different directions, which allow the graduates to retrain in the issues of climate change.

A special course on "Fundamentals of Climate Change" is taught in the Faculties of Geography and Chemistry of the Yerevan State Univrsity. Seven specialists in hydro-meteorology graduate from the Faculty of Geography each year. The curriculum includes climatology and climate change courses.

The courses of "Geo-ecology in the Context of Sustainable Development" and "Theory of Sustainable Social Development (Sustainable Development Project)" are also taught in the mentioned faculties of Yerevan State University. These courses include climate change global issues and developments under the UNFCCC.

Since 2007, the course on "Implementation of Clean Development Mechniasms in the Energy Projects" is taught to the students of several concentrations in the Faculty of Energy at the Yerevan State University of Architechture and Construction.

In the recent years, 10 graduates of higher education institutions all around the country have defended Master theses related to climate change issues.

Post-graduate studies are conducted in higher educational institutions, as well as scientific institutions of the National Academy of Sciences. In the recent years, several dissertations for Ph.D. and Doctor's degrees on climate change related areas where defended.

"Armstatehydromet" specialists regularly participate in retraining courses in international me-

teorological centers.

In order to ensure the progress of ecological education, governmental institutions and other local organizations actively cooperate with international organizations. The Yerevan State University, with the support of the UNDP and the WB, organized an international conference on the "Importance of Ecology and Nature Protection in the Sustainable Development Perspectives" in 2008. The conference included a session devoted to global and local climate change issues.

In order to promote ecological education, numerous seminars were organized with the support of international organizations in 1999-2008. Besides, a number of materials related to climate change issues were translated into Armenian and published, including the following:

- How do We Understand Climate Change? A Guide for Beginners. The United Nations Framework Convention on Climate Change and the Kyoto Protocol.
- Poster on climate change and explanatory guide for teachers.
- Climate Change. Guidebook for Students of Higher Educational Institutions in Armenia.
- Climate Change. Methodical Guidelines for Delivering Courses on Climate Change at Higher Educational Institutions in Armenia.

The mentioned materials were distributed to experts, teachers and civil servants.

Public awareness building on climate change is implemented in the country through the following activities:

- Organization of seminars;
- Publication and dissemination of thematic materials;
- Information dissemination through mass media;
- Presentation of the results of studies in Armenia on issues related to climate change; organization of discussions with participation of representatives from the state and non-governmental organizations.

Training courses and seminars were organized in the country for raising the awareness of stakeholders, specialists and the wide public on climate change issues. Some of those include the following:

- Seven trainings on implementation of CDM in Armenia under the Kyoto Protocol of the “UNFCCC” were organized for stakeholders in 2005.
- Five national seminars were organized in the marzes of Armenia by the Ministry of Nature Protection, in cooperation with the UN Environment Programme (UNEP) in 2007. During the seminars, the main issues of climate change, implementation of Armenia's commitments under the UNFCCC, issues related to hydrometeorological observations and forecasts, as well as extreme weather events were discussed. Representatives of regional authorities and local self-governing bodies, the rescue service, environmental NGOs, educational institutions and students participated in seminars.
- 10 training courses on reducing the vulnerability of agriculture to climate change were organized in Regional Agricultural Support Centers of Armenia in 2008-2009. More than 200 farmers and agronomists participated in the training courses.

A number of guidelines, manuals and informational bulletins devoted to climate change issues for specialists, lecturers and decision-makers were published in 1999-2008, which also contributed to public awareness building. Some of the published materials include:

- Utilization of Renewable Energy in Armenia. Review of the Last Five Year Practical Activity;
- All About Climate Change. Climate Change Information Brochure;
- Caring for Climate: A Guide to the Climate Change Convention and the Kyoto Protocol, UNFCCC;
- Clean Development Mechanism manual for Armenia;
- Climate change and its impacts, guideline-explanations;
- Implementation of the Kyoto Protocol's Clean Development Mechanism in Armenia;
- Forest Biodiversity of Armenia's Syunik Marz and Global Climate Change;

- Main Approaches of Agriculture Sector Vulnerability Reduction to Global Climate Change;
- Armenia: Climate Change Problems. Collected Articles. I and II issues;
- Proceedings of Conferences on Renewable Energy and Energy Saving (2001, 2003, 2005 and 2008);
- A 2008 calendar reflecting consequences of climate change impact in Armenia.

The website of the Climate Change Information Center of Armenia was created in 1997 in order to make information on climate change impacts in Armenia and the corresponding efforts available to stakeholders and the broader public. Currently, the website includes information on climate change issues, mitigation of climate change impacts, international and national action plans, global environmental conventions, international and national partners, CDM projects in Armenia, as well as thematic literature. The website is updated regularly. In 2008, the website received the main prize in producing the best website in Armenia at the Third E-content Pan-Armenian Competition.

In 2009, the publication of the "Climate Change Newsletter-Armenia" electronic journal was launched. The newsletter is distributed through electronic networks to governmental agencies, international organizations, embassies, educational institutions, NGOs, representatives of the business sector, etc. Issues of the newsletter are published on the website of the Climate Change Information Center of Armenia.

In cooperation with the Ministry of Nature Protection, an Armenian TV channel regularly airs the "Environmentalist's Diary" Program since 2005 which includes climate change related broadcasts. Some TV channels also refer to climate change issues with increasing frequency.

The coverage of environmental issues in the Armenian printed and online press has increased since 2005 and numerous references to climate change issues have been made.

Popular films and video materials have been produced, such as Climate Change (1999), Life-Giving Land (2004) and GHG and Climate Change (2007).

Environmental NGOs are actively involved in promoting ecological education and public awareness in the country. With the support of NGOs, a series of environmental education booklets and posters under the common title of "We and Our Planet", "Sowing Thoughts - the Same as Planting Trees" manual for teachers and "Energy: Know, Use, Save" manual in three volumes, among other materials, were published. Some of the mentioned posters and manuals have been approved by the National Education Institute of the Ministry of Education and Science as complementary manuals for teaching Ecology in secondary schools of Armenia and have been distributed to secondary schools.

Since 2002, 14 Public Ecological Information (Aarhus) Centers are operational in all regions of Armenia, which aim to build public awareness on environmental issues and promote public participation in decision-making processes.

Literature

1. D. Elliott, M. Schwartz, G. Scott & et. al. (2003). Wind Energy Resource Atlas of Armenia. National Renewable Energy Laboratory. USA.

2. E. A. Stanton, F. Ackerman, F. Resende. The Socio-Economic Impact of Climate Change in Armenia. Stockholm Environment Institute – U.S. Center Tufts University, 2009.

3. Government of Armenia Decree No. 1872-N on "Establishment of the State Hydro-meteorological Service of Armenia" SNCO and Approval of the Regulation of the Organization, dated 28 November 2002.

4. Ministry of Education and Science of the Republic of Armenia. Official website (2009): http://www.edu.am/.

5. Statistical Yearbook of Armenia (2009)/ National Statistical Service of the Republic of Armenia.

6.Yerevan State University. Official website (2009): http://www.ysu.am/.

CHAPTER 7

Gaps, Constraints and Capacity Building Needs

The Convention implementation process in Armenia is defined by the Decree of the Government of Armenia No. 1840 "On approving the list of activities for implementation of the commitments of the Republic of Armenia stemming from a number of environmental conventions" dated 2 December 2004. The Second National Eenvironmental Action Plan of Armenia plans to revise that Decree in 2010, and include in it the new developments under the Convention and international development mechanisms, as well as the identified needs.

During the preparation of the Second National Communication on Climate Change, a number of institutional, organizational, technical, informational, financial and personnel gaps and constraints in national capacity building for implementation of the Convention were identified (Table 7-1).

The shortage of specialized personnel capacities and financial resources is notable in all areas of operation.

Table 7-1 Gaps, constraints, limitations and needs to address climate change issues

Gaps, constraints	Comments	Needs
National inventory of greenhouse gases		
Absence of an authorized body consistently responsible for preparing GHG inventories.	To date, GHG inventory related work is conducted by ad hoc working groups within the framework of the GEF financed projects.	Define the regulations for GHG inventory management, by a Decree of the Government of Amenia, which will set the powers and functions of central, regional and local authorities. Amend the Law on atmospheric air protection, and include a provision on the procedure of preparation of GHG inventories. Establish a sustainable inter-agency institution responsible for conducting GHG inventories and updates on regular basis.
Inadequacy of the system for input data collection, quality assurance and control, and ensuring accessibility of data.	A complete system for collecting statistical data, in line with the current economic system, has not been established yet.	Based on the IPCC guidelines for preparation of national GHG inventories and financial mechanisms of the Convention, develop agency guidelines for collection of data necessary for preparing GHG inventories.
Inventory of substances emitted into the atmosphere defined by various conventions and the national legislation is prepared in different formats, which creates difficulties in data collection and comparability.	GHG inventory includes also data on substances emitted into the atmosphere, which are regulated by the “Montreal protocol on ozone depleting substances”, “Convention on long range trans-boundary air pollution in Europe”, as well as the national legislation on atmosphere protection.	Prepare the inventory of emissions indicated in the mentioned documents and manage the corresponding inventories in one system. Improve the computer software for preparation of the inventory, ensure its accessibility and inclusion of a wider range of data.
Incomplete data in the “LULUCF” sector results in high level of uncertainties in assessment of emissions.	The Decree of the Government of Armenia No. 276 “On approving the regulations for land monitoring” defines a number of criteria characterizing land use change, including carbon content in soil, but the actual monitoring is still in the formation phase.	Based on the international experience in application of modern technologies, develop a system for consistent monitoring of the “LULUCF” sector, and assessment of GHG emissions from the sector. Include carbon accumulation assessment component in forest management plans.

Gaps, constraints	Comments	Needs
High uncertainty in fugitive emissions from fuels (CH_4) in the gas supply system.	The official data on fugitive emissions from fuels (CH_4) in the gas supply system are contradicting and not consistent with the emission assessments done through the IPCC methodology.	Conduct a comparative analysis and develop national factors for fugitive emissions from fuels in the gas supply system. Calculate fugitive emissions based on on-site measurements at gas supply systems, distribution networks and gas consumption sites.
Absence of SO_2 emissions assessment from copper and molybdenum production.	SO_2 emissions from copper and molybdenum production have not been assessed in the country due to the absence of a corresponding methodology.	Develop a methodology for assessing SO_2 emissions from copper and molybdenum production.
A shortage of necessary specialized personnel to conduct GHG inventory.	The inconsistent nature of preparation of GHG inventories hinders the maintenance of the few personnel with relevant qualifications on board.	In the framework of Convention's financial mechanisms train and periodically re-train specialized personnel.
Reduction and projection of GHG emissions		
Limited capacity for application of the models recommended by IPCC to assess GHG emissions reduction potential.	Difficulties in application of the models are conditioned by the specific aspects of country's development, incompleteness of necessary database and absence of specialized personnel.	Analyze the potential for application of the IPCC recommended models in Armenia, adjust them to local conditions and train personnel on application thereof.
Inadequate and insufficient forecast data on developments in the "Industrial Processes", "Agriculture" and "LULUCF" sectors.	Forecast of GHG emissions by expert assessments reduces the reliability level of forecasts.	Adjust the perspective indicators of development in the mentioned sectors in order to develop sectoral baselines and improve forecasts of future GHG emissions.
Absence of comparative analysis for the energy system development alternatives in Armenia.	Due to the absence of the energy system development alternatives, it is impossible to conduct a comparative analysis of GHG emissions reduction scenarios under those alternatives.	Conduct a comparative assessment of the energy system development alternatives according to GHG emissions indices.
Absence of a concept for GHG emissions reduction.	Development of a concept and implementation mechanisms will contribute to the development of a realistic and comprehensively justified program for limitation of GHG emissions.	Develop a concept on GHG emissions reduction/limitation, which will include: • Financial and economic mechanisms • Technology transfer • Capacity building and development • International cooperation • Involvement of the private sector.
Vulnerability and adaptation		
Water resources		
Absence of reliable models for assessing water resources vulnerability.	The existing models require quite detailed and accurate data on both water resources balance, and climate change forecasts on water basin level.	Evaluate the applicability of the existing models. Improve the climate change forecast scenarios, including through regional studies.
Incomplete database of water resources and water	The annual series of data on water resources, water use,	Evaluate the possibility of restoring the annual series of monitoring data

Gaps, constraints	Comments	Needs
sector in the State Water Cadastre.	quality and quantity, available at the State Water Cadastre, are not complete. Therefore, it is impossible to make a comprehensive comparison and assessment of the climate change impact on water resources.	on the quantity and quality of water resources with the available methods, including computer models for restoring data series by time periods and anthropogenic impacts.
Absence of modern methods for transforming actual flows to natural flows.	Outdated methods are used for this purpose. Methods, used for calculation of water return after water use, do not take into account the developments of recent years; and the quantity of water return after water use is only approximately assessed.	Develop modern methods for transforming actual flows to natural flows. Make an accurate assessment of the volume of water return.
Elements of the surface water regime, water and water system balance, as well as methods for calculating flood flows and inundations are based on outdated date.	Currently applied calculation methods do not take into account the changes of water systems in the last decades, which have significant impact on the hydrological regimes of water bodies.	Develop a new water resources reference book for Armenia. Develop new methods for calculating flood flows and inundations taking into account the impacts of economic activity and climate change thereon.
Absence of monitoring data on groundwater resources.	Currently outdated archived data are used, which do not reflect the changes in groundwater resources in the last 15 years, including those under the context of climate change.	Study the current international experience, adjust it with the local condition of Armenia and introduce a monitoring system.
In the system of water use regulation, the principle and rules for “ecological flow limitations” are not adequate for protection of water systems and their ecosystems.	Current normative and regulatory principles and rules are not acceptable for mountain rivers with huge seasonal changes, since only a very small amount of water is allowed to be left after the water intake, which creates inadequate conditions for ecosystems. Application of the current principle, under the forecasted climate change scenarios, will further reduce the volume of ecological flow.	Develop new principles and a new system for water intake, which will be based on the “ecosystem approach” for adaptation to climate change.
Climate change impacts on water objects are practically not studied.	Armenia’s water objects, rivers and lakes (except for the Lake Sevan), as ecosystems, are not properly studied. Climate change impacts have been assessed only from the aspect of water resources vulnerability.	Conduct a comprehensive study on water ecosystems vulnerability and make recommendations for their adaptation to climate change and variability.
Climate change component is not considered in the Lake Sevan Ecosystems Restoration Program.	In the framework of the First National Communication on Climate Change, only the vulnerability of the water resources of the Lake was studied and presented. The Lake was not considered as an ecosystem, and the climate change component is currently missing from the Lake Sevan Ecosystems Restoration Program.	By introducing the climate change impacts component in the ecological balance restoration program of the Lake Sevan and its water basin, make relevant amendments/corrections in the Program’s list of measures.

Gaps, constraints	Comments	Needs
Agriculture		
Insufficient methodological/informational basis and personnel capacity for application of modern climate change impact assessment models.	The assessment of climate change impact on the yields of the main agriculture crops is conducted in an approximate manner.	Prepare detailed information by regions and crops. Select and apply relevant models to assess the yields of crops under the projected climate change. Enhance qualifications of experts in agro-climatic modeling.
Absence of information on the yields of natural grasslands and pastures.	Absence of accurate information on natural grasslands and pastures hinders assessment of their yields under climate change.	Initiate studies and regular monitoring of the conditions and yields of natural grasslands and pastures.
Absence of data on possible changes of agro-climatic zones related to climate change.	Climate change will result in shifting agro-climatic zone borders.	Develop recommendations for distribution of crops taking into account the forecasted climate change impacts. Develop maps with the use of GIS technologies.
Weak insurance system.	The weak insurance system hinders addressing climate change and other hazardous hydro-meteorological phenomena related risks for the rural farming in Armenia.	Further develop the existing insurance system based on scientific, statistical and socio-econommic studies and analyses.
Biological diversity and natural ecosystems		
Lack of data on natural ecosystems.	Monitoring of climate change impacts on natural ecosystems is practically not conducted.	Establish natural ecosystems' monitoring system and conduct studies on climate change impacts thereon.
Imperfect methodology for forecasting changes in natural ecosystems.	Very approximate methods are used for assessing changes.	Conduct a special study on data collection in model natural ecosystems, adjust the new methods with local conditions of Armenia.
Absence of regular studies and monitoring of water ecosystems, especially for fish populations.	Management powers over water ecosystems are not clearly defined, and the monitoring and state registration system was formed only recently, as a biodiversity component of that sector.	Considering the fact that fish resources are the only biological resources in the wild nature, which have food significance, develop a program based on "ecosystem approach" for restoration of fish populations in water ecosystems of Armenia. In order to develop the mentioned program, cooperate with neighboring countries in Kura and Araks watersheds and evaluate the vulnerability of water ecosystems of the mentioned Rivers and their tributaries under anthropogenic impact and climate change.
Lack of "ecosystem approach" in forest management.	As GHG sinks, forests play a significant role in climate change mitigation and ecosystems' vulnerability reduction. Introduction of the "ecosystem approach" in forest management will promote the improved and more effective nature use both in the mid- and long-term perspective.	Introduction and application of the "ecosystem approach" in forest management.

Gaps, constraints	Comments	Needs
Optimal afforestation issue is not considered in the National Forest Strategy.	Without optimal afforestation targets, forest sector development programs are random in nature and may hinder ecosystem protection ideology and conservation of natural environment.	Introduce optimal afforestation ideology in the National Forest Strategy, and implement measures, which will strengthen forest management in the country, with an over goal to: • provide accurate justification of long-term quantity indices of carbon sequestration and storage in soils, • identify relevant areas for forest restoration and afforestation, • protect forest biodiversity and natural environment.
Absence of ecologically safe measures for pest control in forest ecosystems.	Currently chemical methods are applied for pest control in forest ecosystems.	Develop and introduce biological methods for pest control in forest ecosystems.
Human health		
Inadequacy and lack of access to statistical data on health.	Statistical data on health have a general nature, with no time or regional distribution data on diseases. Infectious disease control data are fragmentary.	Improve statistical reporting. Identify more sensitive diseases and risk groups under climate change. Create a database on diseases in hot seasons. Map human health vulnerability; identify the most vulnerable regions taking into account meteorological parameters. Model morbidity and health as a result of climate change for the future warning system.
Adaptation		
Absence of a concept and approach for vulnerability and adaptation.	Adaptation measures proposed for various sectors have a fragmentary nature, without considering the cross-cutting issues between sectors and the “ecosystem approach”.The development of the concept and implementation mechanisms will contribute to the development of the program for reducing the negative impacts of climate change on vulnerable sectors in Armenia.	Study international experience and methodologies. Develop a climate change adaptation concept taking into account the “ecosystem approach”, which will include: • Financial mechanisms, • Technology transfer, • Capacity building and development, • International cooperation, • Involvement of the private sector.
Systematic observations		
Low level of reliability of climate change forecasts.	There are a number of objective reasons behind this: the complexity of the climate change phenomenon, scientific development not being adequately advanced in this field, limitations for the application of the recommended models in small territories and mountainous conditions, lack of specialized personnel, low level of reliability of input data, etc.	Ensure constant cooperation with neighboring countries (Turkey, Georgia, Azerbaijan, Russia, Iran) in order to develop and continuously improve the regional climate change scenarios. Involve scientific institutions from countries prominent in this field (Hadley Center and others).

Gaps, constraints	Comments	Needs
Lack of alternative methods for climate change research.	Application of alternative methods in climate change research will contribute to development of different climate change scenarios.	Apply alternative (non-hydrometeorological) methods in cliamte change research (including astronomical cliamtic, paleoclimatic, paleontological, historic analogues, public surveys and other types of methods).
Weak system for forecasting and monitoring of dangerous hydro-meteorological phenomena.	Weak system for forecasting and monitoring of dangerous hydro-meteorological phenomena hinders implementation of effective early warning measures and development of an insurance system.	Improve the forecasting and monitoring system of dangerous hydro-meteorological phenomena, strengthen regional networks for data exchange.
Inadequate conditions of the hydro-meteorological observations system.	Measurement equipment in the majority of meteorological stations and observation points are outdated, which result in the low level of reliability of monitoring data.	Refurbish the hydro-meteorological observations system with modern measurement equipment, automatic and semiautomatic meteorological stations.
Some of the formerly operating hydrometeorological stations and observation points are currently non-operational.	Reduction of the number of stations and observation points hinders further expansion of the data series during corresponding analyses.	Rehabilitate hydro-meteorological stations and observation points. Conduct studies on establishment of an optimal hydro-meteorological system and a network, develop and implement a corresponding program aimed at climate change mitigation.
Inadequate level of communication and telecommunication.	The inadequate level of communication and telecommunication hinders the development of the system for data collection, processing, storage and exchange.	Modernize means of communication and telecommunication. Develop the database management system using modern information technologies.
Absence of a radar network.	The radar system operates for serving the aviation. Its radius is less than 150 km, therefore, its use for forecasting hazardous hydro-meteorological phenomena is limited.	Create a national radar network. Create a regional climate center on the basis of “Armstatehydromet” database.
Inadequate level of measurements and monitoring of snow cover, water layer in the snow and snow melt characteristics.	Currently, the mentioned characteristics are practically neither measured nor monitored although they are necessary for recording and forecasting hazardous hydro-meteorological phenomena.	Restart the measurement and monitoring of ice fields, snow cover, water layer in the snow and snowmelt characteristics in at least six high mountainous observation points.
Low level of access to hydro-meteorological data.	Hydro-meteorologicl data are provided free of charge in a limited and certain format, which hinders their application in scientific and other experts assessments. The “Hydro-meteorological bulletin” is not published any longer.	Taking into account wide technical possibilities for archiving data (CLICOM, hydrological database, etc.) and the fact that hydro-meteorological data are obtained through public funding, create an open, free and accessible database for the wide public, including primarily an electronic database.

Gaps, constraints	Comments	Needs
Technology transfer		
Ineffectiveness of the information system	Local enterprises are practically not aware of modern and environmentally clean technologies. Investors also lack the information on technology market.	Create a database on environmentally safe technologies for all sectors. Establish and develop specialized information services.
Financial constraints	The majority of local enterprises has limited access to long-term credits with special conditions, grants and subsidized financing support for investment in ecologically safe technologies. National banks do not participate in technology transfer processes.	Ensure state support in provision of grants, concessional loans and attracting foreign investors. Involve banks in provision of concessional loans for acquisition of environmentally safe technologies.
Organizational constraints	Absence of centers for provision of consultancy service on technological needs and for coordination of technology transfer activities.	Establish an inter-agency advisory center for effective participation, coordination and management of the technology transfer process under the Kyoto Protocol.
Science, education, public awareness, personnel training		
Limited number of climate change topics covered in educational and scientific processes.	Climate change issues are merely limited to description and study of the phenomenon and its consequences. Elucidate on climate change adaptation and mitigation measures, as well as on ongoing international processes.	Develop a comprehensive programme for in-depth inclusion of climate change problems in the systems of science, education, personnel training and public awareness.
Synergism under the global environmental conventions		
Climate change mitigation policy and measures do not take into account the effect of synergism under global environmental conventions.	Consideration of the objectives and the cross-cutting issues under global environmental conventions will contribute to optimization of measures and financial resources.	Develop a coordination and cooperation concept for implementation of country commitments under global and regional environmental conventions with due consideration of the effect of the synergism.
Lack of adequate linkages between climate change related processes and relevant regional and international processes, which often lead to non-agreed and divergent outcomes.	In particular, there are non-agreed actions under the UNFCCC and the UN Convention on Long Range Transboundary Air Pollution (LRTAP), whereas agreed actions under both Conventions would be complementary to one another and would enable avoiding divergent outcomes.	Study and identify the cross-cutting issues and synergies under the UNFCCC and LRTAP. Develop a project and agreed procedures to ensure joint efforts in preparation of GHG inventories, development and transfer of climate change adaptation and mitigation technologies.

Annex

National inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, for the years 1990, 2000 and 2006.

Year 1990

GHG SOURCE AND SINK CATEGORIES	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**21615.958**	**-793.418**	**152.399**	**0.547**	**76.590**	**279.132**	**50.439**	**0.393**
1. Energy	**20985.633**	**0.000**	**82.144**	**0.214**	**76.410**	**274.320**	**50.439**	**n/e**
A Fuel Combustion (Sectoral Approach)	20985.633		2.613	0.214	76.410	274.320	50.439	n/e
1 Energy Industries	11335.113		0.355	0.158	30.037	2.985	0.840	n/e
2 Manufacturing Industries and Construction	2052.716		0.140	0.008	5.480	0.849	0.171	n/e
3 Transport	3757.741		0.746	0.031	37.499	253.418	47.711	n/e
4 Other Sectors	3524.871		1.372	0.017	3.394	17.068	1.717	n/o
5 Other	315.192		n/o	n/o	n/o	n/o	n/o	n/o
B Fugitive Emissions from Fuels	0.000		79.531		n/o	n/o	n/o	n/o
1 Solid Fuels			n/o		n/o	n/o	n/o	n/o
2 Oil and Natural Gas			79.531		n/o	n/o	n/o	n/o
2. Industrial Processes	**630.325**				**n/o**	**n/o**	**n/o**	**0.393**
A Mineral Products	630.325				n/o	n/o	n/o	0.393
B Chemical Industry	n/e		n/o	n/o	n/o	n/o	n/o	n/o
C Metal Production	n/o		n/o	n/o	n/o	n/o	n/o	n/e
D Other Production	n/o		n/o	n/o	n/o	n/o	n/e	n/o
E Production of Halocarbons and Sulphur Hexafluoride								
F Consumption of Halocarbons and Sulphur Hexafluoride								
G Other	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
3. Solvent and Other Product Use	**n/e**			**n/e**			**n/e**	
4. Agriculture			**44.394**	**0.162**	**0.180**	**4.812**	**n/o**	**n/o**
A Enteric Fermentation			41.444					
B Manure Management			2.767	n/e			n/o	
C Rice Cultivation			n/o				n/o	
D Agricultural Soils				0.157			n/o	
E Prescribed Burning of Savannas			n/o	n/o	n/o	n/o	n/o	
F Field Burning of Agricultural Residues			0.183	0.005	0.180	4.812	n/o	
G Other			n/o	n/o	n/o	n/o	n/o	
5. Land-Use Change and Forestry	**0.000**	**-793.418**	**1.480**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**
A Changes in Forest and Other Woody Biomass Stocks	0.000	-985.690						
B Forest and Grassland Conversion	23.380	n/o	n/o	n/o	n/o	n/o		
C Abandonment of Managed Lands		-7.048						
D CO_2 Emissions and Removals from Soil	151.510	0.000						
E Other	24.430	0.000	1.480	n/o	n/o	n/o		
6. Waste			**24.381**	**0.171**	**n/e**	**n/e**	**n/e**	**n/o**
A Solid Waste Disposal on Land			24.381		n/e		n/e	
B Wastewater Handling			n/e	0.171	n/e	n/e	n/e	
C Waste Incineration					n/o	n/o	n/o	n/o
D Other			n/o	n/o	n/o	n/o	n/o	n/o
7. Other	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**
Memo Items								
International Bunkers	**404.796**		**0.003**	**n/e**	**n/e**	**n/e**	**n/e**	**n/e**
Aviation	404.796		0.003	n/e	n/e	n/e	n/e	n/e
Marine	0.000		n/o	n/o	n/o	n/o	n/o	n/o
CO_2 Emissions from Biomass	**90.249**							

Year 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)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**4723.505**	**-23**	**83.867**	**0.486**	**12.126**	**63.604**	**14.539**	**0.636**
1. Energy	**3067.569**	**0.000**	**22.839**	**0.011**	**11.967**	**59.277**	**11.081**	**0.561**
A Fuel Combustion (Sectoral Approach)	3067.569		0.299	0.011	11.967	59.277	11.081	0.561
1 Energy Industries	1665.190		0.030	0.003	4.474	0.596	0.149	0.170
2 Manufacturing Industries and Construction	444.330		0.033	0.002	1.207	0.197	0.038	0.250
3 Transport	642.014		0.201	0.005	5.938	58.270	10.867	0.128
4 Other Sectors	316.035		0.035	0.001	0.348	0.214	0.027	0.013
5 Other	n/o		n/o	n/o	n/o	n/o	n/o	n/o
B Fugitive Emissions from Fuels	n/a		22.540		n/a	n/a	n/a	n/a
1 Solid Fuels			n/o		n/o	n/o	n/o	n/o
2 Oil and Natural Gas			22.540		n/a	n/a	n/a	n/a
2. Industrial Processes	**119.676**	**n/o**	**0.000**	**0.000**	**0.000**	**0.000**	**2.538**	**0.075**
A Mineral Products	119.676				n/a	n/a	n/a	0.075
B Chemical Industry	n/a		n/a	n/a	n/a	n/a	n/a	n/a
C Metal Production	n/a		n/a	n/a	n/a	n/a	n/a	n/a
D Other Production	n/o		n/o	n/o	n/o	n/o	2.538	n/o
E Production of Halocarbons and Sulphur Hexafluoride								
F Consumption of Halocarbons and Sulphur Hexafluoride								
G Other	n/o		n/o	n/o	n/o	n/o	n/o	n/o
3. Solvent and Other Product Use	**0.000**			**0.000**			**0.92**	
4. Agriculture			**35.203**	**0.327**	**0.159**	**4.327**	**0.000**	**0.000**
A Enteric Fermentation			32.733					
B Manure Management			2.305	0.0002			n/a	
C Rice Cultivation			n/a				n/a	
D Agricultural Soils				0.323			n/a	
E Prescribed Burning of Savannas			n/o	n/o	n/o	n/o	n/o	
F Field Burning of Agricultural Residues			0.165	0.004	0.159	4.327	0.000	
G Other			n/o	n/o	n/o	n/o	n/o	
5. Land-Use Change and Forestry	**1536.260**	**0.000**	**1.330**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
A Changes in Forest and Other Woody Biomass Stocks	564.260	0.000						
B Forest and Grassland Conversion	n/a	n/a	n/a	n/a	n/a	n/a		
C Abandonment of Managed Lands		-23						
D CO_2 Emissions and Removals from Soil	994.600	0.000						
E Other	0.400	0.000	1.330	n/o	n/o	n/o		
6. Waste			**24.495**	**0.148**	**0.000**	**0.000**	**0.000**	**0.000**
A Solid Waste Disposal on Land			22.284		n/e		n/e	
B Wastewater Handling			2.211	0.148	n/a	n/a	n/a	
C Waste Incineration					n/o	n/o	n/o	n/o
D Other			n/o	n/o	n/o	n/o	n/o	n/o
7. Other	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**
Memo Items								
International Bunkers	**116.833**		**0.038**	**0.004**	**0.540**	**0.653**	**0.410**	**0.037**
Aviation	116.833		0.038	0.004	0.540	0.653	0.410	0.037
Marine	n/o		n/o	n/o	n/o	n/o	n/o	n/o
CO_2 Emissions from Biomass	**362.079**							

** 6A. n/e – Emissions are probably available as there is waste incineration in the result of waste outbreak in the landfill; however due to the lack of the methodology no calculations have been done.*

Year 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)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**4157.018**	**n/e**	**94.594**	**0.901**	**15.070**	**62.525**	**17.267**	**0.362**
1. Energy	**3833.240**	**0.000**	**28.763**	**0.013**	**14.893**	**57.882**	**10.298**	**0.161**
A Fuel Combustion (Sectoral Approach)	3833.240		0.721	0.013	14.893	57.882	10.298	0.161
1 Energy Industries	955.225		0.017	0.002	2.567	0.342	0.086	0.003
2 Manufacturing Industries and Construction	679.102		0.059	0.001	1.827	0.351	0.060	0.003
3 Transport	935.659		0.507	0.005	9.162	56.273	10.043	0.062
4 Other Sectors	1263.253		0.138	0.005	1.336	0.916	0.109	0.003
5 Other	n/o		n/o	n/o	n/o	n/o	n/o	0.089
B Fugitive Emissions from Fuels	0.000		28.041		n/o	n/o	n/o	n/o
1 Solid Fuels			0.000		n/o	n/o	n/o	n/o
2 Oil and Natural Gas			28.041		n/o	n/o	n/o	n/o
2. Industrial Processes	**323.778**				**n/o**	**n/o**	**2.719**	**0.202**
A Mineral Products	323.778				n/o	n/o	n/o	0.202
B Chemical Industry	n/e		n/o	n/o	n/o	n/o	n/o	n/o
C Metal Production	n/o		n/o	n/o	n/o	n/o	n/o	n/o
D Other Production	n/o		n/o	n/o	n/o	n/o	2.719	n/o
E Production of Halocarbons and Sulphur Hexafluoride								
F Consumption of Halocarbons and Sulphur Hexafluoride								
G Other	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
3. Solvent and Other Product Use	**n/o**			**n/o**			**4.250**	
4. Agriculture			**43.791**	**0.742**	**0.177**	**4.643**	n/o	n/o
A Enteric Fermentation			40.831					
B Manure Management			2.782	0.000			n/o	
C Rice Cultivation			n/o				n/o	
D Agricultural Soils			n/o	0.737			n/o	
E Prescribed Burning of Savannas			n/o	n/o	n/o	n/o	n/o	
F Field Burning of Agricultural Residues			0.177	0.005	0.177	4.643	n/o	
G Other			n/o	n/o	n/o	n/o	n/o	
5. Land-Use Change and Forestry	**n/e**	**n/e**	**n/e**	**n/o**	**n/o**	**n/o**	**n/o**	**n/o**
A Changes in Forest and Other Woody Biomass Stocks	n/e	n/e						
B Forest and Grassland Conversion	n/e	n/e	n/o	n/o	n/o	n/o		
C Abandonment of Managed Lands		n/e						
D CO_2 Emissions and Removals from Soil	n/e	n/e						
E Other	n/e	n/e	n/e	n/o	n/o	n/o		
6. Waste			**22.041**	**0.146**	**n/e**	**n/o**	**n/e**	**n/o**
A Solid Waste Disposal on Land			21.695		n/e		n/e	
B Wastewater Handling			0.346	0.146	n/o	n/o	n/o	
C Waste Incineration					n/o	n/o	n/o	n/o
D Other			n/o	n/o	n/o	n/o	n/o	n/o
7. Other	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
Memo Items								
International Bunkers	**121.553**		**0.028**	**0.004**	**0.512**	**0.548**	**0.330**	**0.039**
Aviation	121.553		0.028	0.004	0.512	0.548	0.330	0.039
Marine	n/o		n/o	n/o	n/o	n/o	n/o	n/o
CO_2 Emissions from Biomass	**197.691**							

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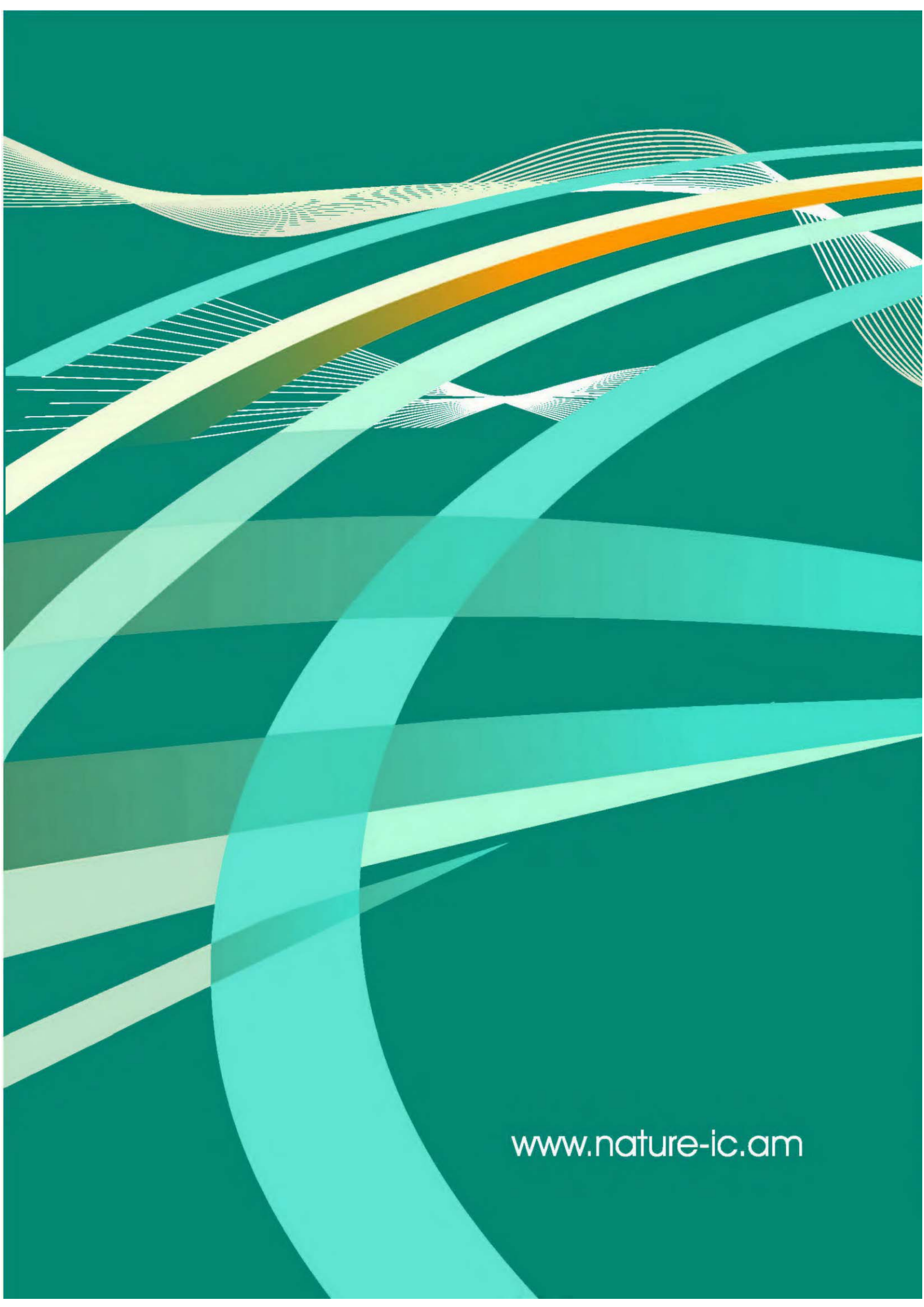
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