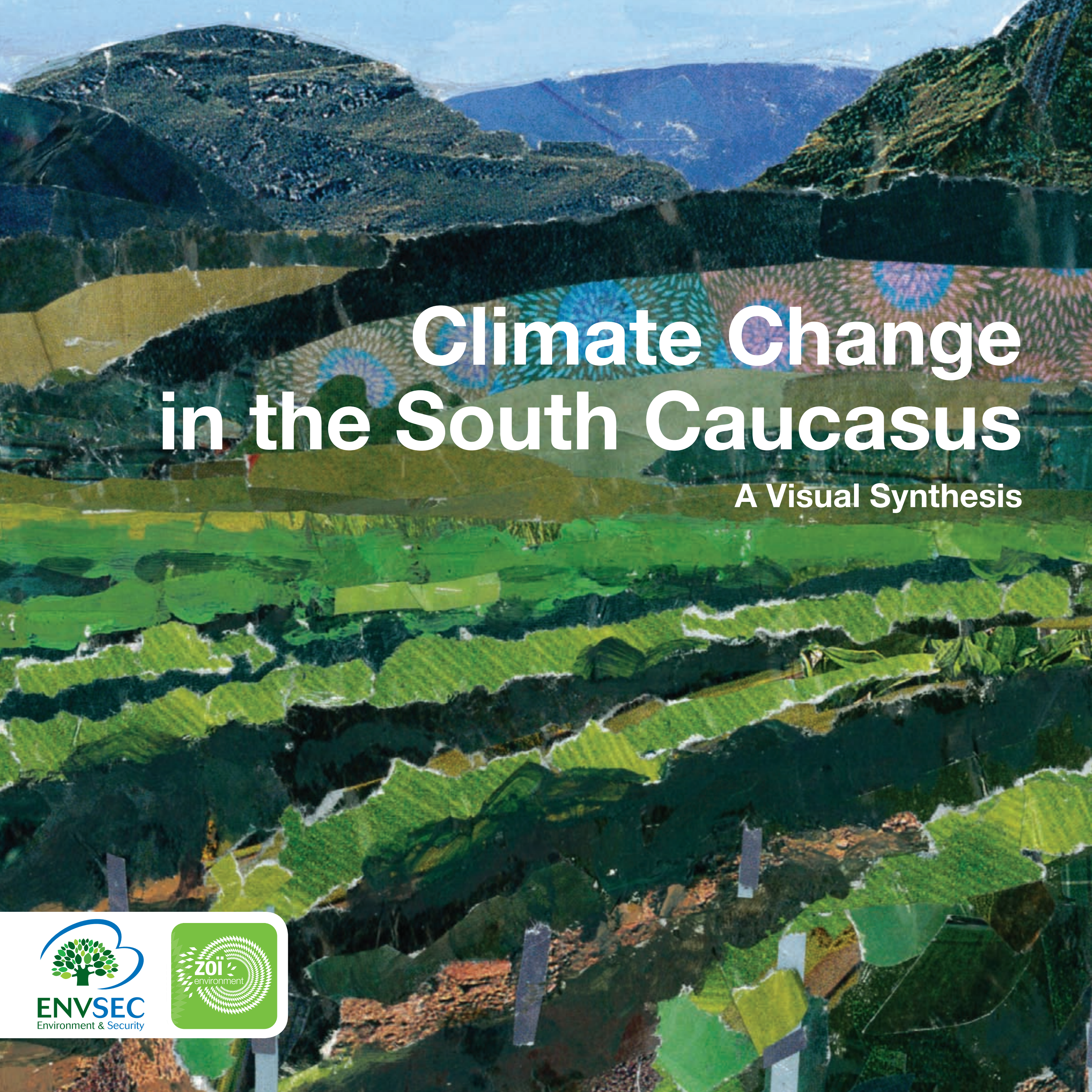

Climate Change in the South Caucasus

A Visual Synthesis

ENVSEC
Environment & Security

ZOÏ
environment

Climate Change in the South Caucasus

Based on official country information from the communications to the UNFCCC, scientific papers and news reports.

This is a Zoï Environment Network publication produced in close cooperation with the ENVSEC Initiative and the Governments of Armenia, Azerbaijan and Georgia. Valuable inputs were received from the Regional Climate Change Impact Study for the Caucasus Region facilitated by the UNDP. OSCE has provided support for printing and dissemination. Additional financial support was received from UNEP Vienna — Environmental Reference Centre of the Mountain Partnership.

Printed on 100% recycled paper.

The Environment and Security Initiative (ENVSEC) transforms environment and security risks into regional cooperation. The Initiative provides multi-stakeholder environment and security assessments and facilitates joint action to reduce tensions and increase cooperation between groups and countries.

ENVSEC comprises the Organization for Security and Co-operation in Europe (OSCE), Regional Environmental Centre for Central and Eastern Europe (REC), United Nations Development Programme (UNDP), United Nations Economic Commission for Europe (UNECE), United Nations Environment Programme (UNEP), and the North Atlantic Treaty Organization (NATO) as an associated partner. The ENVSEC partners address environment and security risks in four regions: Eastern Europe, South Eastern Europe, Southern Caucasus and Central Asia.

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Contents

Foreword

CLIMATE CHANGE IN THE CAUCASUS — A MYTH NO LONGER

In Greek mythology the Caucasus is known as the place where Prometheus was chained to the mountain as punishment for stealing fire from Zeus and giving it to mortals. His liver is eaten by an eagle during the day, only to regenerate at night, until he is freed by Heracles who kills the eagle.

In the Book of Genesis, and the Koran, Mount Ararat — close to the Caucasus — is the place where Noah's ark is stranded, saving Noah himself, his family and the world's animals from the great floods.

So much for mythology and religion, but strangely enough, both narratives can be linked to climate change: on the one hand Prometheus bringing fire to mankind, starting a long chain of burning and releasing CO_2 to the atmosphere, eventually contributing to climate change; on the other hand Noah escaping the floods — one of the potential impacts of climate change.

As a stark contrast to its rich cultural diversity and beautiful environment, in the modern day Caucasus there are several unresolved — frozen — conflicts hampering the "normal" economic development of the region since the breakup of the Soviet Union in 1991. Predicted impacts of climate change will not make the region more secure.

With this publication, Zoï Environment Network aims to communicate the known facts of climate change in a well illustrated, easily understandable manner, accessible to everyone. For this we could rely on the rich Caucasian tradition of geographic analysis, map making and visual arts. Unfortunately, the format did not allow the use of other Caucasian specialities, such as music, film, cuisine or toasts, it will be up to the reader to accompany his or her lecture with some of this. We do however want to make the point that also in the Caucasus, climate change is no more myth.

Otto Simonett
Director, Zoï Environment Network
Geneva, January 2012

Atlas and Prometheus. Laconian Kylix, 6th c. BCE. Vatican Museums

Climate Change in the South Caucasus: key findings, trends and projections

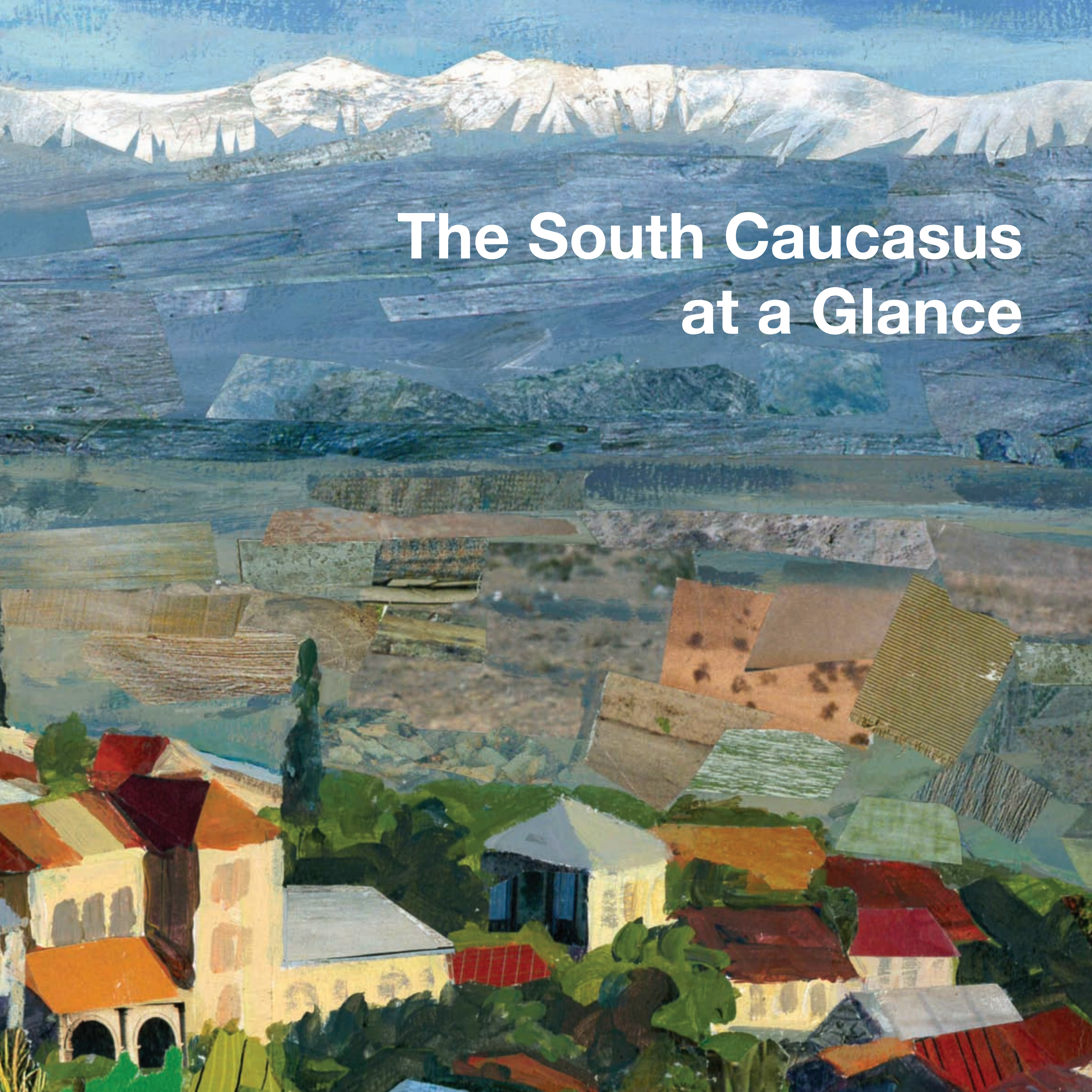
INDICATORS	Armenia	Azerbaijan	Georgia
Air temperature (last half century)	↑	↑	↑
Precipitation and snow (last half century)	↓	↓	↑ (some areas)
Desertification	↑	↑	↑ (some areas)
Extreme weather events and climate-related hazards (1990–2009)	↑	↑	↑
Melting ice (last half century)		↑	↑
Water resources availability in the future (2050–2100)	↓	↓	↓
Health Infectious and vector-borne diseases	↑ (some areas)	↑ (some areas)	↑ (some areas)
Greenhouse gas emissions 1990–2005	↓	↓	↓
Greenhouse gas emissions 2000–2005	↑	↑	↑
Policy instruments, actions and awareness	↑	↑	↑
Climate observation and weather services (1990–2009)	↓	↓	↓

↑ increase, enchancement ↓ decrease, reduction ↑ (some areas) increase in some areas

Sources: Second National Communications of Armenia, 2010; Azerbaijan, 2010; Georgia, 2009.

Alazani valley from Sighnaghi, GEORGIA

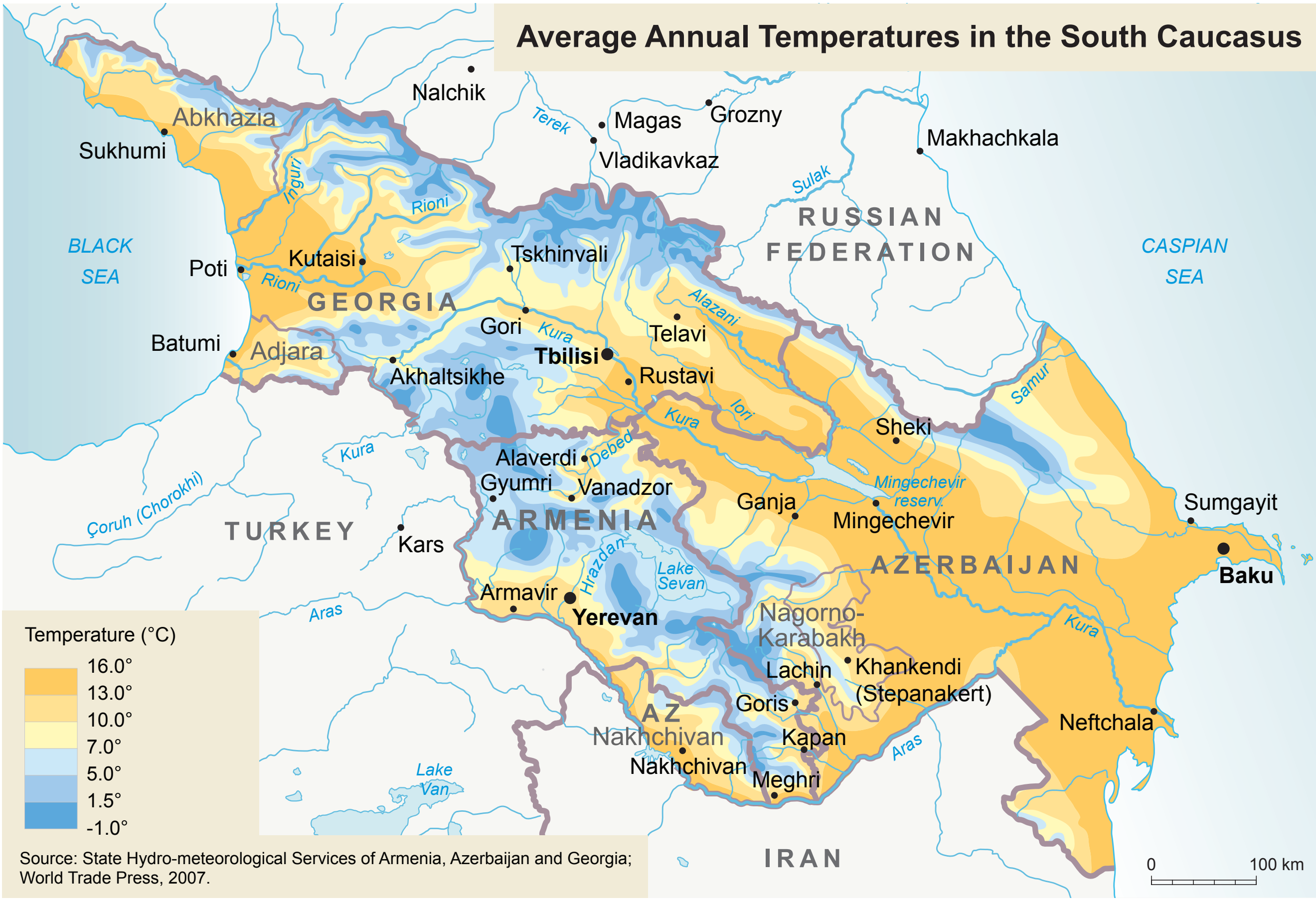
The South Caucasus at a Glance




Sochi
Sukhumi
Abkhazia
Elbrus
5 642
Nalchik
Grozny
Magas
Vladikavkaz
Caspian
Depression
Terek
Shkhara
5 068
Inguri
Rioni
5 033
Kazbek
Sulak
RUSSIAN
FEDERATIO
BLACK
SEA
Colchis
Plain
Poti
Kutaisi
Tskhinvali
Rioni
GEORGIA
Gori
Kura
Telavi
Alazani
Batumi
Adjara
Akhaltsikhe
Tbilisi
Iori
Rustavi
Kura
Kura
Alaverdi
Debed
Sheki
Gyumri
Vanadzor
Mingechevir
reserv.
Mingechevir
Ganja
Pontic Mountains
Çoruh (Chorokhi)
Kars
ARMENIA
4 090
Aragats
Hrazdan
Lake
Sevan
Armenian
Armavir
Yerevan
Aras
TURKEY
Ararat
5 165
Nagorno
Karabakh
Lachin
Khankendi
(Stepanakert)
Goris
Highland
AZ
Nakhchivan
Nakhchivan
Kapan
Aras
Meghri
Lake Van
Van
IRAN
metres
4,000
3,000
2,000
1,500
1,000
500
200
0
Depression
0
-500
-1,000
-1,500
Glaciers

GENERAL OVERVIEW

The South Caucasus is located in the south-eastern part of Europe, between the Black and Caspian Seas. The furthest western and eastern boundaries of the region lie between 40°01' and 50°25' E, while the northern and southern ones are between 43°35' and 38°23' N. The region is bordered by Turkey and the Islamic Republic of Iran in the South and by the Russian Federation in the North. The three South Caucasian republics — Armenia, Azerbaijan and Georgia — gained independence after the fall of the former Soviet Union in 1991. Shortly after independence the region underwent devastating ethnic and civil wars, the consequences of which are still to be overcome.



Source: State Hydro-meteorological Services of Armenia, Azerbaijan and Georgia; World Trade Press, 2007.

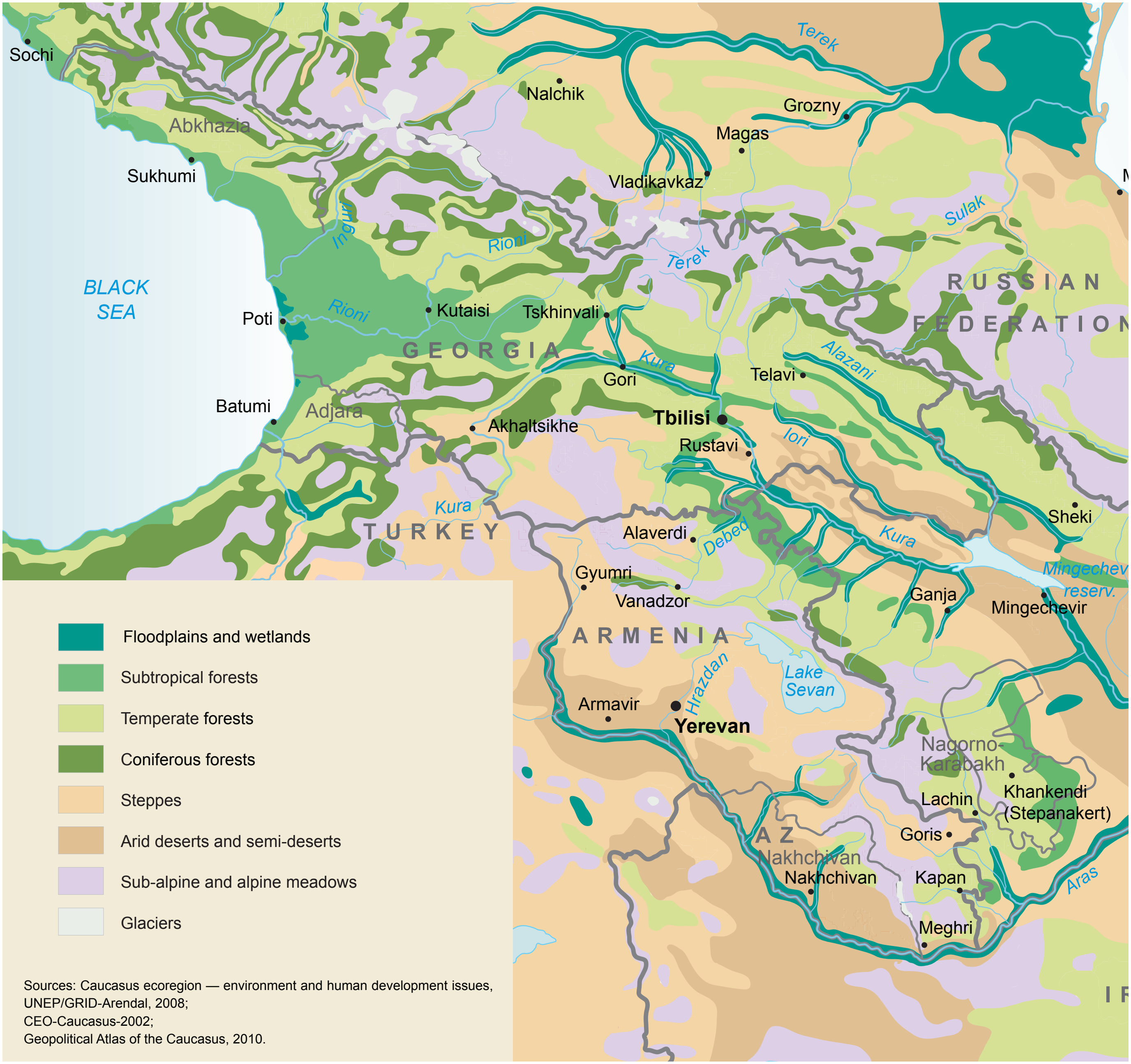
GEOGRAPHY AND CLIMATE

Almost every climatic zone is represented in the South Caucasus except for savannas and tropical forests. To the North, the Great Caucasus range protects the region from the direct penetration of cold air. The circulation of these air masses has mainly determined the precipitation regime all over the region.

Precipitation decreases from west to east and mountains generally receive higher amounts than low-lying areas. The absolute maximum annual rainfall is 4,100 mm in south-west Georgia (Adjara), whilst the rainfall in southern Georgia, Armenia and western Azerbaijan varies between 300 and 800 mm per year. Temperature generally decreases as elevation rises. The highlands of the Lesser Caucasus mountains in Armenia, Azerbaijan and Georgia are marked by sharp temperature contrasts between summer and winter months due to a more continental climate.

The average annual temperature in Armenia is 5.5°C. The highest annual average temperature is 12–14°C. At altitudes above 2,500 m the average annual temperatures are below zero. The summer is temperate; in July the average temperature is about 16.7°C, and in Ararat valley it varies between 24–26°C.

The average annual temperature at the Black Sea shore is 14–15°C, with extremes ranging from +45°C to -15°C. The climate in the plains of East Georgia and most of Azerbaijan is dry: in the lowlands, it is dry subtropical, and in mountainous areas alpine. The average annual temperature varies from 11 to 13°C in the plains, from 2 to 7°C in the mountains, and around 0°C in alpine zones. Depending on the altitude and remoteness from the Caspian Sea, climatic types in Azerbaijan vary from arid subtropical in the lowlands to temperate and cold in the high mountains.



Sources: Caucasus ecoregion — environment and human development issues, UNEP/GRID-Arendal, 2008;
CEO-Caucasus-2002;
Geopolitical Atlas of the Caucasus, 2010.

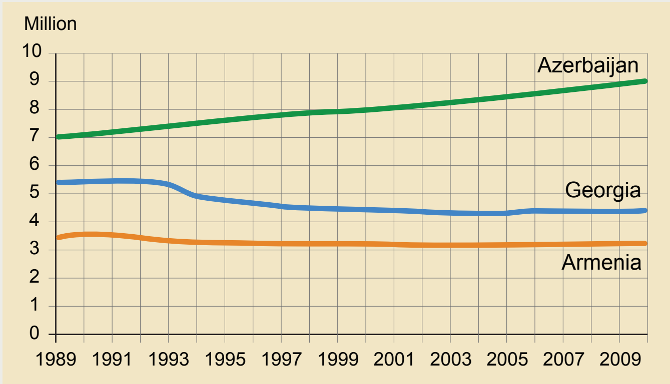
Alazani River in the border of Georgia and Azerbaijan

ECOSYSTEMS

The complex topography and diverse vegetation cover of the Caucasus is a main reason for an unusually large number of climatic zones and natural ecosystems on a relatively small piece of land like South Caucasus. The region ranges from the subtropical rainy type of forest of the south-east Black Sea coast to the high peaks of the Greater Caucasus, with their glaciers and snow caps, to the steppes and semi-deserts of the lowland east.

Debed river at Northern Armenia

Population dynamics in 1989–2010



Sources: Statistical Year Books of Armenia, Azerbaijan and Georgia, 2010; World Bank statistics.

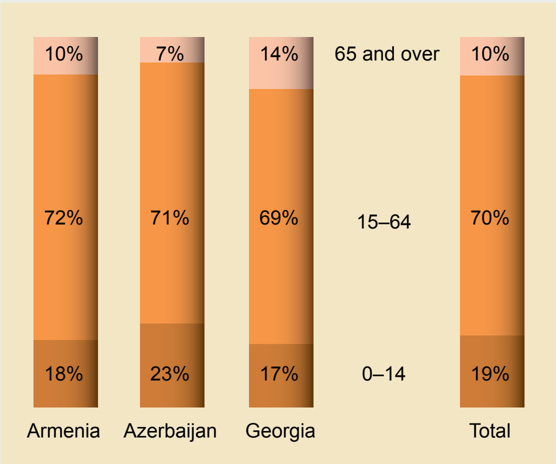
MAIN FIGURES

Armenia: Total Population 3.249 millions (2010). Total area 29,743 km². Population density 108.4 per km². Life expectancy 74 years. Net population migration -1.7 per 1,000 population.

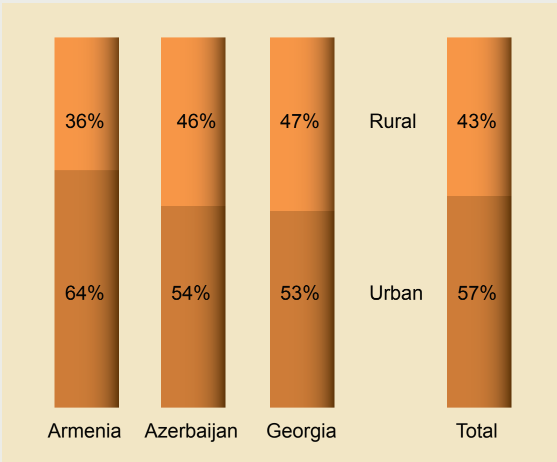
Azerbaijan: Total Population 8.997 millions (2010). Total area 86,600 km². Population density 105.8 per km². Life expectancy 70 years. Net population migration -1.4 per 1,000 population.

Georgia: Total Population 4.436 millions (2010). Total area 69,700 km². Population density 68.1 per km². Life expectancy 72 years. Net population migration -18.1 per 1,000 population.

Population by age groups in 2010



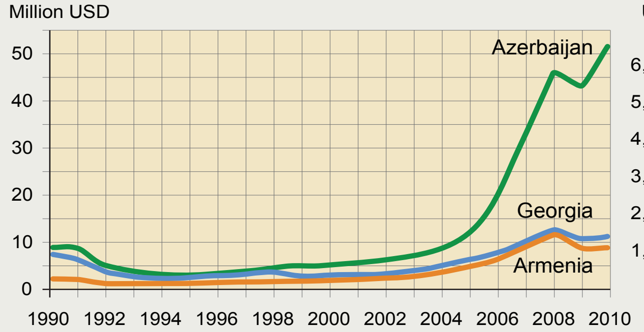
Urban and rural population in 2010



Sources: Statistical Year Books of Armenia, Azerbaijan and Georgia, 2010.

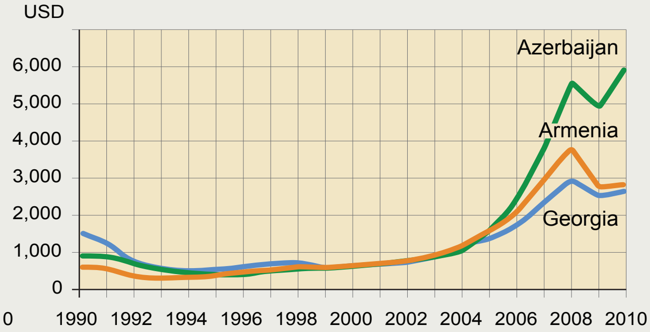
Little Cavemen from Gobustan, AZERBAIJAN

GDP in 1990–2010



Source: World Bank statistics.

GDP per capita in 1990–2010



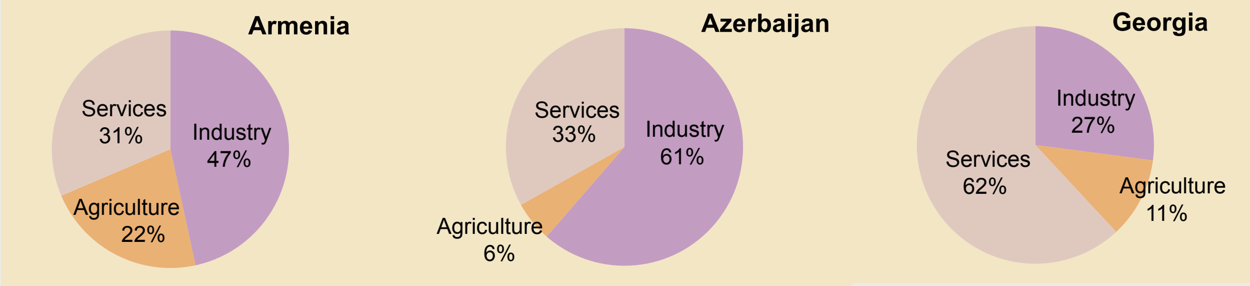
Source: UN statistics.

ECONOMIC OVERVIEW

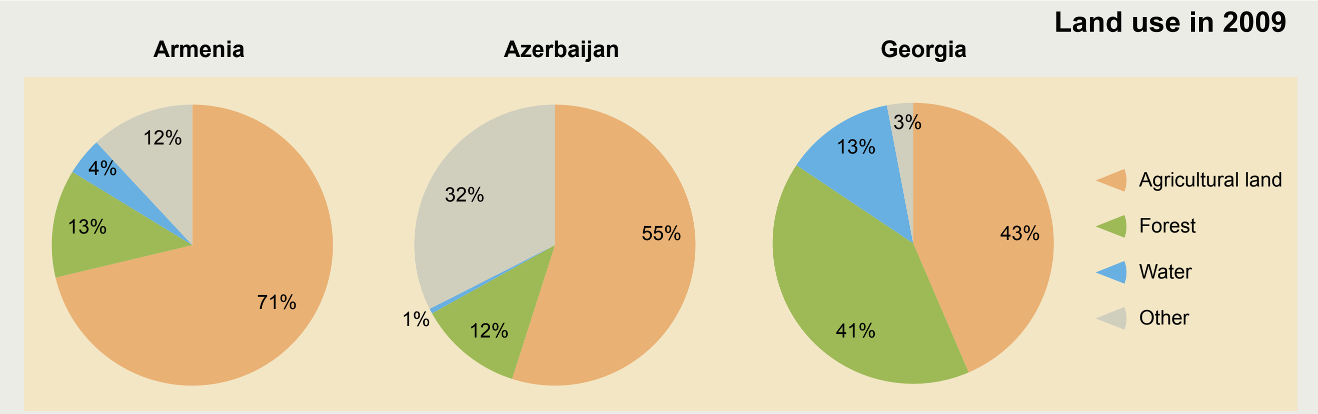
Following the disintegration of the former Soviet Union the economies of Armenia, Azerbaijan and Georgia experienced dramatic economic declines at the start of the 1990s. For example in Armenia, between 1990 and 1993, the average annual decrease in GDP was about 18%; In Azerbaijan GDP fell by an annual average of about 13%, while in Georgia, it declined by 70–75% from 1991 to 1994.

However, the launching of economic reforms and the achievement of political stability by the second half of the 1990s meant the economies started to revive and then grow rapidly. In Armenia and Azerbaijan, they grew at nearly 9% a year from 1997 to 2002. In these countries growth rates were even higher in 2003 and 2004 (see table 16). In Georgia economic growth has been unstable in recent years, varying between about 1.8% in 2000, 10.6% in 1997, and 6.2% in 2004. The real growth of GDP of Georgia in 2010 amounted to 6.4%.

GDP by sectors in 2010



Source: www.indexmundi.com



Sources: Statistical Year Books of Armenia, Azerbaijan and Georgia, 2010.

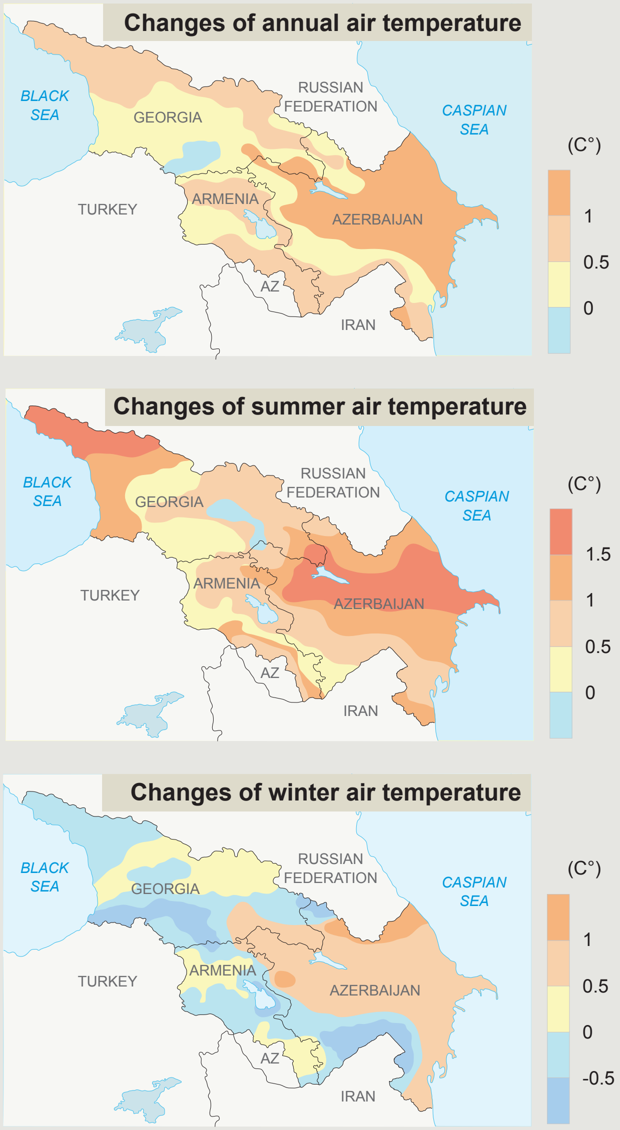
The Peace Bridge, Tbilisi, GEORGIA

Ararat Valley, ARMENIA

Climate Change Trends and Scenarios in the Region

Changes of air temperature in the South Caucasus

1935–2008 for Armenia, 1936–2005 for Georgia, 1960–2005 for Azerbaijan



Sources: UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus, 2011.

REGIONAL CLIMATE CHANGE TRENDS

To study global warming scenarios and risks associated with climate change trends on a regional level in the South Caucasus, the Environment and Security (ENVSEC) Initiative launched a project on Climate Change Impact for the South Caucasus implemented by UNDP. The project brought together leading national experts engaged in the preparation of the second national communications of Armenia, Azerbaijan and Georgia under the UNFCCC.

Precipitation and temperature data from the key meteorological stations of the three South Caucasus countries were examined in the following sequence: Armenia — 32 stations for 1935–2008; Georgia — 21 stations for 1936–2005; Azerbaijan — 14 stations for 1960–2005. Temperature changes were assessed for the summer, winter and the whole year.

During the period from 1935 to 2009 in Armenia the annual average temperature increased by 0.85°C, and in Azerbaijan by 0.5 to 0.6°C since the 1880s, with the highest registered temperatures during the last 10 years. In Georgia from 1906 to 1995 the mean annual air temperature has increased by 0.1 to 0.5°C in the eastern part of the country, whilst it has decreased by 0.1 to 0.3°C in the west (Georgia's Initial National Communication, 1999). However, if calculating for the last 50 years the data shows a different trend: during the 1957 to 2006 the mean annual temperatures increased by 0.2°C in the western part and by 0.3°C in the eastern Georgia (Georgia's Second National Communication, 2009).

Regional differences are also reported from Azerbaijan, with the highest temperature increase in the Greater Caucasus and Kura-Aras lowlands, and from Armenia, with the warmest regions in the Ararat lowlands and in the zone from the border of Georgia to Lake Sevan.

Values of heat Index (human thermal comfort)

Relative humidity	Temperature (C°) 26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°
90%	28.0	30.7	33.8	37.1	40.7	44.7	48.9	53.5	58.5	63.7	63.7	75.1	81.2	87.7	94.5	101.6
85%	27.9	30.2	32.9	35.9	39.1	42.7	46.6	50.8	55.2	60.0	65.1	70.4	76.1	82.1	88.3	94.9
80%	27.7	29.7	32.1	34.7	37.7	40.9	44.4	48.1	52.2	56.5	61.2	66.1	71.3	76.8	82.5	88.6
75%	27.5	29.3	31.4	33.7	36.3	39.2	42.3	45.7	49.4	53.3	57.5	62.0	66.8	71.8	77.0	82.6
70%	27.3	28.9	30.7	32.7	35.0	37.6	40.4	43.5	46.8	50.3	54.2	58.2	62.5	67.1	71.9	77.0
65%	27.1	28.5	30.0	31.8	33.8	38.7	38.7	41.4	44.4	47.6	51.0	54.7	58.6	62.7	67.1	71.7
60%	26.9	28.1	29.5	31.0	32.8	34.9	37.1	39.5	42.2	45.1	48.1	51.4	55.0	58.7	62.6	66.8
55%	26.7	27.7	28.9	30.3	31.9	33.7	35.6	37.8	40.2	42.8	45.5	48.5	51.6	55.0	58.5	62.3
50%	26.6	27.4	28.5	29.7	31.1	32.6	34.4	36.3	38.4	40.7	43.1	45.8	48.6	51.6	54.8	58.1
45%	26.4	27.1	28.0	29.1	30.3	31.7	33.3	34.9	36.8	38.8	41.0	43.4	45.9	48.5	51.3	54.3
40%	26.3	26.9	27.7	28.6	29.7	30.9	32.3	33.8	35.4	37.2	39.1	41.2	43.4	45.8	48.3	20.9
35%	26.0	26.6	27.4	28.2	29.2	30.3	31.5	32.8	34.3	35.8	37.5	39.3	41.3	43.3	45.5	47.8
30%	25.8	26.4	27.1	27.9	28.8	29.7	30.8	32.0	33.3	34.7	36.2	37.8	39.4	41.2	43.1	45.1

Note: Exposure to full sunchine can increase heat index values by up to 10°C

Source: UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus, 2011.

HEAT WAVES The UNDP/ENVSEC regional climate study group constructed a regional model on the urban heat wave trends for some South Caucasian cities, including Tbilisi, Baku and Vanadzor. The study assessed one of the important indicators of climate change — the *Heat Index* that is a combination of air temperature and relative humidity during the warm periods of a year.

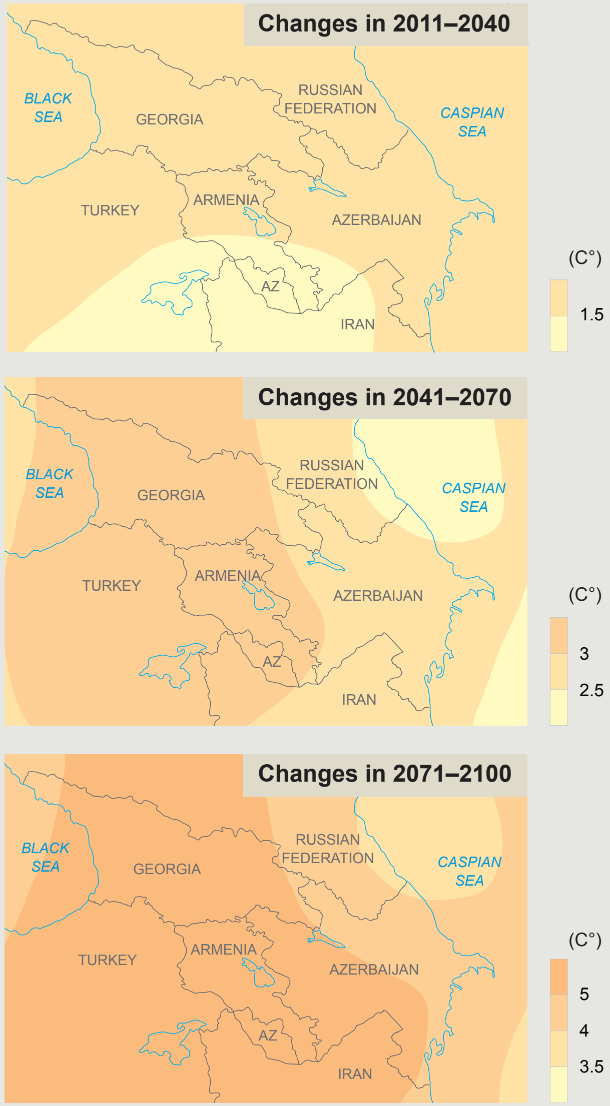
The table above demonstrates how Heat Indexes are “translated” to an actual feeling of human comfort when the temperatures (C°) are combined with the relative humidity (%). The team explored daily meteorological data for warm periods (May to September) of the 1955–1970 and 1990–2007 time sequences, using PRECIS statistical analysis, and generated a forecast for 2020–2049. The calculation was based on the Global Climate Model — ECHAM. Analysis of the calculation and forecast models show that four out of six classes of Heat Indexes have risen during the last 15–20 years (1990–2007) and are expected to increase dramatically for one of three critical classes (orange/hot class with extreme warning of risk) during the coming decades.

Comparison of “dangerous” days in Vanadzor, Tbilisi and Baku in the past and future

	Vanadzor			Tbilisi			Baku		
	1955–1970	1990–2007	2020–2049	1955–1970	1990–2007	2020–2049	1955–1970	1990–2007	2020–2049
Normal	1,283	773	868	1,338	1,349	1,525	508	872	1,037
Warm	682	1,551	2,558	796	843	1,161	463	607	1,063
Very warm	482	736	745	310	545	1,527	331	749	1,858
Hot	1	0	305	4	17	287	13	63	539
Very hot	0	0	113	0	0	0	0	0	3
Extremly hot	0	0	1	0	0	0	0	0	0
Number of dangerous days	483	736	1,164	314	562	1,814	344	812	2,400

Source: UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus, 2011.

Forecasted changes of annual air temperature in the South Caucasus
(by HadCM3 modeling of MAGICC/SCENGEN)



Source: UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus, 2011

GCM PRECIS MODELS

The analysis of climate change scenarios developed for all three South Caucasus countries using PRECIS outputs and the MAGICC/SCENGEN modelling tool revealed that changes of temperature by the end of the century will vary in the range of 3–6°C.

According to the forecast made by the most appropriate models for the years 2070–2100 the highest increment in temperature, 7.7°C, should be anticipated in West Georgia in the summer. The lowest increment, for the same time period, 2.1°C, is expected in Armenia during the winter.

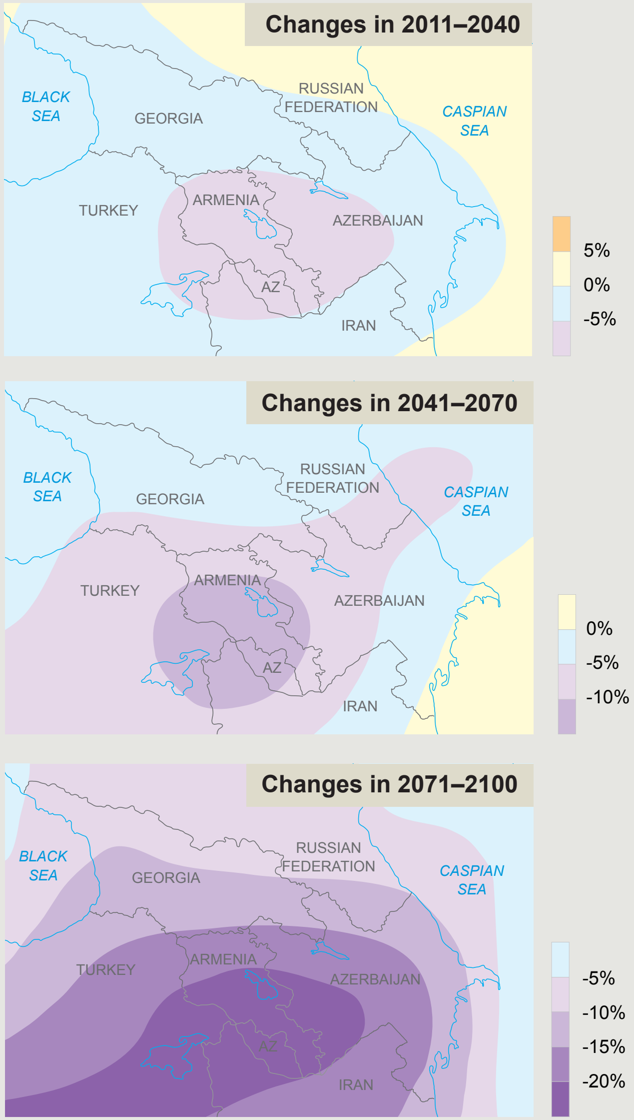
The expected increase in mean annual temperature is similar for Armenia and Georgia and is likely to be about 5°C. In Azerbaijan the expected increase is lower, around 3.6°C.

According to the results shown by the HadCM3 climate modelling tool (which is a modification of HAD300 and is considered as best suited model to the Caucasus region) the decrease in annual precipitation in the period 2070–2100 will be around 15% for Azerbaijan and Georgia, rising to 24% for Armenia.

The highest decrease in precipitation is forecast for Georgia — 80.8% in summer and 68% in spring. The lowest decrease is expected in Azerbaijan, 11% in summer. The highest increase (22%) is likely also to be in Azerbaijan in the winter.

Forecasted changes of annual precipitation in the South Caucasus

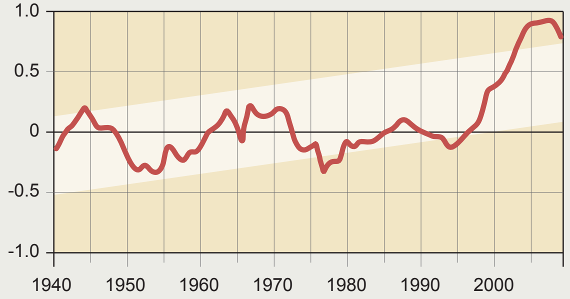
(by HadCM3 modeling of MAGICC/SCENGEN)



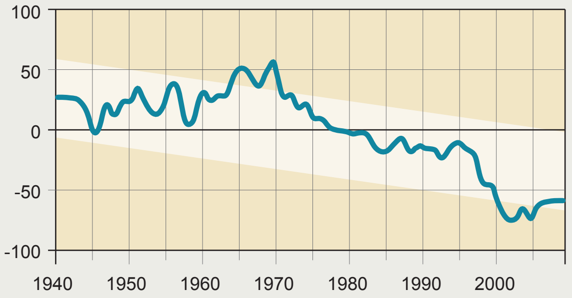
Source: UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus, 2011

Changes in average annual Temperature and Precipitation in Armenia, 1940–2008 compared to 1961–1990

Temperature change (C°)



Precipitation change (mm)



Source: Armenia's Second National Communication, 2010.

CLIMATE CHANGE TRENDS IN ARMENIA

As a mountainous country with an arid climate, Armenia is highly vulnerable to global climate change. It's Second National Communication to the UNFCCC estimated deviations of annual air temperature and precipitation recorded in 1940–2008 from the average of the period of 1961–1990. According to the study average annual temperatures have increased by 0.85°C, while annual precipitation decreased by 6% during the last 80 years.

However, the changes show different trends by regions and seasons. In general, the average air temperature has increased by 10°C in summer months, while it stayed stable in winter months. During the last 15 years summers were extremely hot, especially in 1998, 2000 and 2006. The 2006 is considered the hottest recorded in Armenia between 1929 and 2008.

The 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 north□western parts and the Lake Sevan basin have had a significant increase in precipitation in the last 70 years.

Changes in seasonal and annual Temperature and Precipitation in Armenia, compared to 1961–1990

(C°) Temperature change

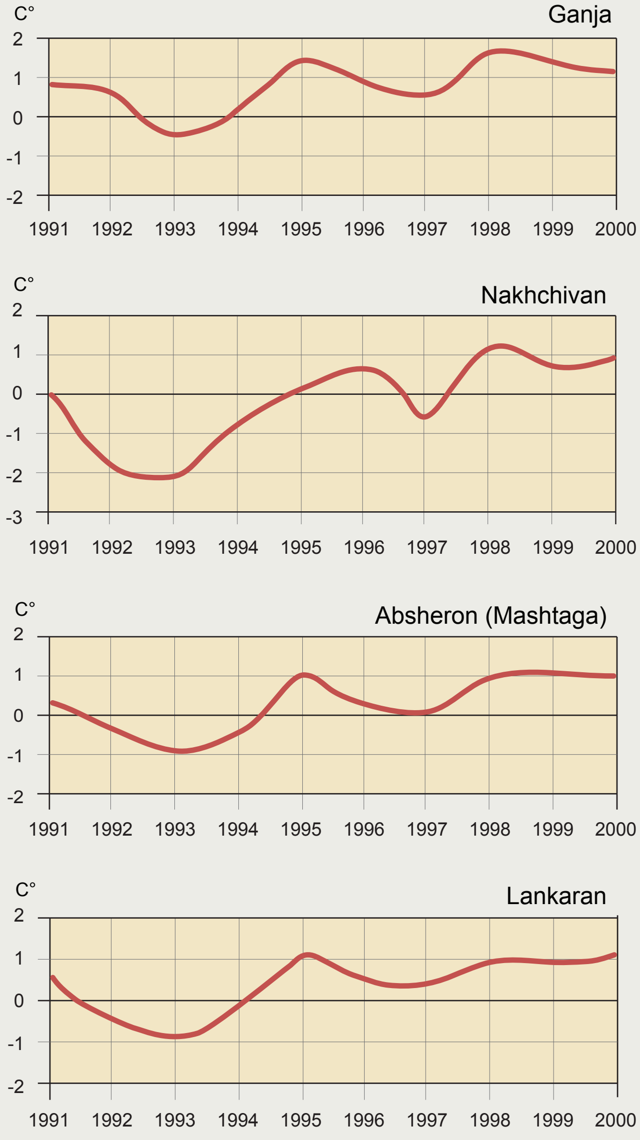
	Winter	Spring	Summer	Autumn	**Annual**
2030	1	1	1	1	**1**
2070	3	3	3	3	**3**
2100	4	5	4	4	**4**

Precipitation change (%)

	Winter	Spring	Summer	Autumn	**Annual**
2030	-3	-3	-7	1	**-3**
2070	-5	-5	-14	3	**-6**
2100	-7	-8	-19	3	**-9**

Sources: Armenia's Second National Communication, 2010.

Changes in average annual Temperature in Azerbaijan, 1991–2000 compared to 1961–1990



Sources: Azerbaijan's Second National Communication, 2010.

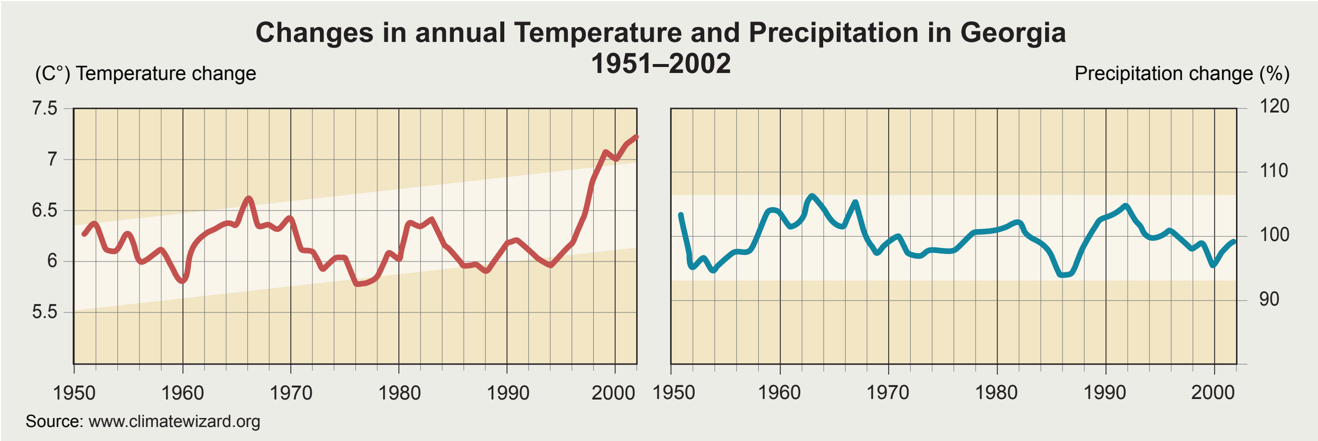
CLIMATE CHANGE TRENDS IN AZERBAIJAN

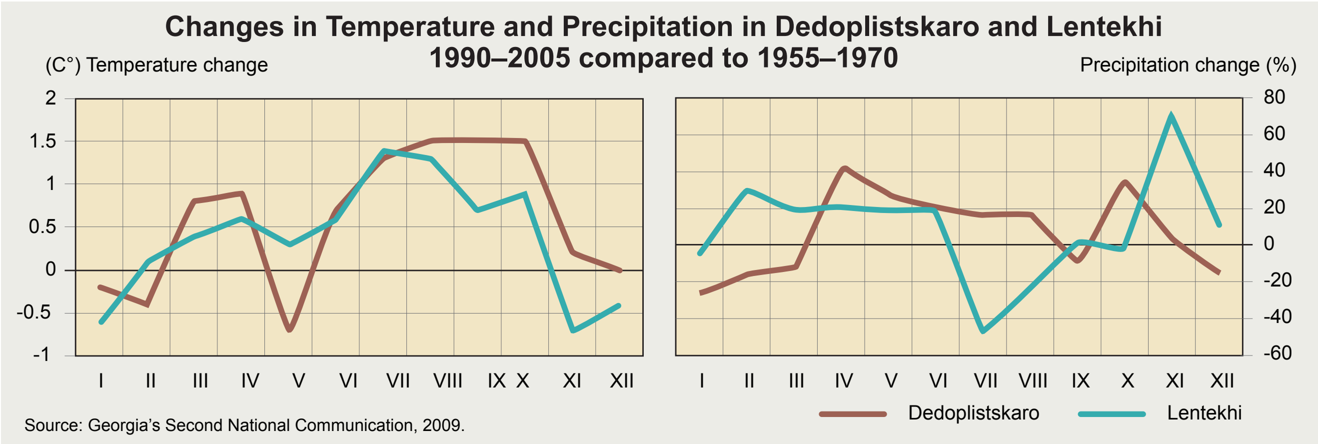
Climate change trends have been visible in Azerbaijan for some decades too. The data from the National Hydrometeorology Department for 1991–2000 show an increase in temperature by an average 0.41°C, which is three times larger than the increase from 1961 to 1990.

As part of the National Communication study, the average annual temperature and precipitation anomalies have been analysed in 7 regions of Azerbaijan for the period 1991 to 2000. Compared to the 1961–90 level, temperature anomalies were particularly visible in the Kura-Aras Lowland and ranged from -1.12°C to +1.91°C.

The average annual precipitation was below the norm in almost all regions. However, differences seemed more significant in the Kura-Aras Lowland, where they were 14.3% lower, in Ganja-Gazakh (17.7%), and in Nakhchivan (17.1%).

In summary, over the past 10 years the rainfall level in Azerbaijan has fallen by 9.9%.

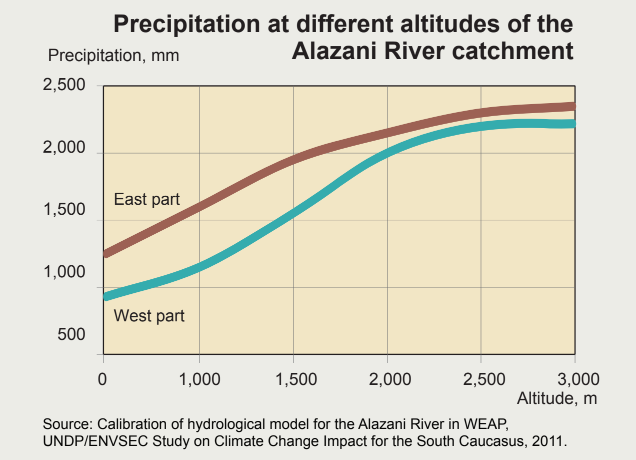




CLIMATE CHANGE TRENDS IN GEORGIA

The latest studies of climate patterns in Georgia show changes of major parameters — mean and extreme air temperatures, relative humidity, moisture regimes, average annual precipitation, etc. — which clearly indicate an overall trend of changing climate in the region. The UNFCCC Second National Communication from Georgia identifies three areas as most sensitive to climate change and therefore vulnerable to future extremes: the Black Sea coastal zone, Lower Svaneti (Lentekhi district) and Dedoplistskaro district of the Alazani river basin.

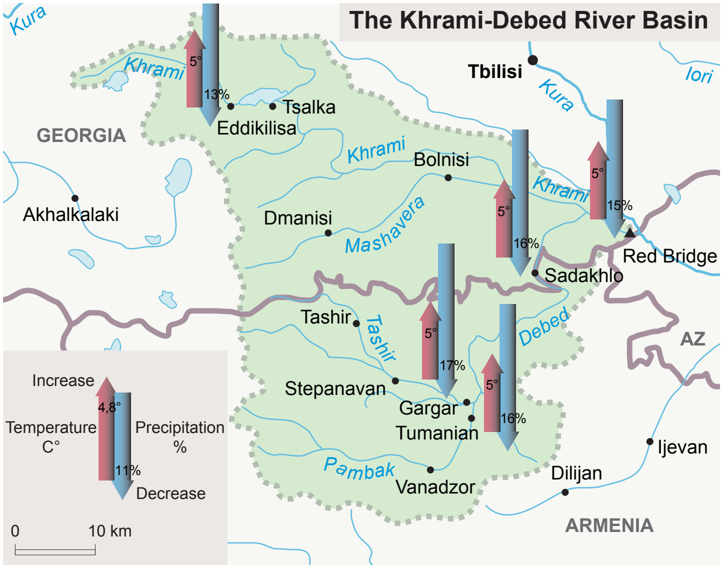
To investigate the climate change process in Georgia, a survey of climate parameter trends was undertaken for the whole territory and for the priority regions in particular. The trends of change in mean annual air temperatures, mean annual precipitation totals and in the moistening regime were estimated between 1955–1970 and 1990–2005.



The statistical analysis revealed increasing trends in both mean annual air temperature and annual precipitation total from the first to the second period in all three priority regions, accompanied by a decrease in hydrothermal coefficient (HTC) in the Dedoplistskaro region, and its increase in the other two priority regions. At the same time, the rates of air temperature and precipitation change in priority regions were assessed for four time intervals of different duration (1906–2005; 1966–2005; 1985–2005 and 1995–2005). This survey demonstrated an exceptionally steep rise in annual air temperature in all three priority regions over the last 20 years.

Alazani River

Expected annual changes in air temperatures and precipitation in the Khrami-Debed and Alazani river basins 2071–2100 compared with 1961–1990



CHANGES IN HYDROLOGICAL BALANCE IN THE KHRAMI-DEBED AND ALAZANI RIVER BASINS

The Khrami-Debed and Alazani river basins are two important trans-boundary watersheds and major sub-basins of the greater Kura river, sharing scarce water resources between Armenia and Georgia (Khrami-Debed) and Azerbaijan and Georgia (Alazani).

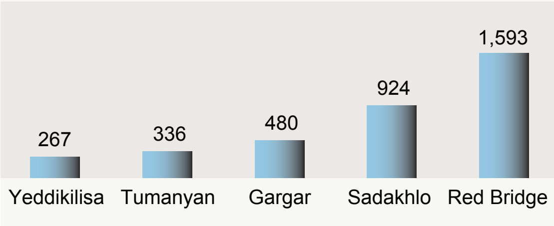
This area is prone to land degradation and desertification from the forecast extremes of climate change, translating to economic losses and increased poverty for local population

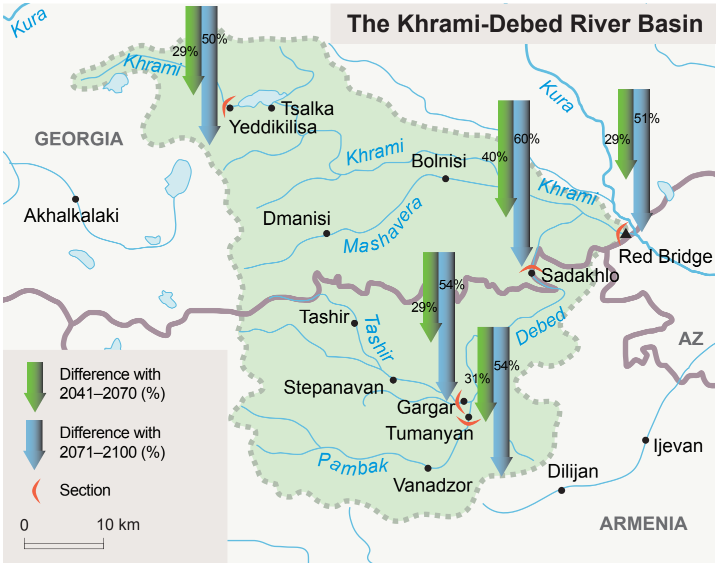
The UNDP/ENVSEC Study on Climate Change Impact for the South Caucasus evaluated the vulnerability of these river basins to climate change using PRECIS and WEAP (Water Evaluation and Planning Model) tools to assess the changes expected in mean annual temperatures, precipitation and annual stream flows compared with the baseline years of 1961–1990.

The results of the study showed that immediate adaptation measures have to be taken by all riparian countries to overcome the expected losses to the economy of the region.

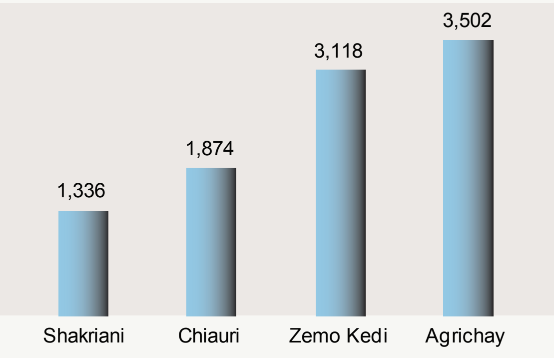
Changes in average annual stream flows at different points of the Khrami-Debed and Alazani rivers, baseline 1961–1990

Average annual stream flow in the Khrami-Debed River (mln m³) in 1966–1990





Average annual stream flow in the Alazani River (mln m³) in 1966–1990

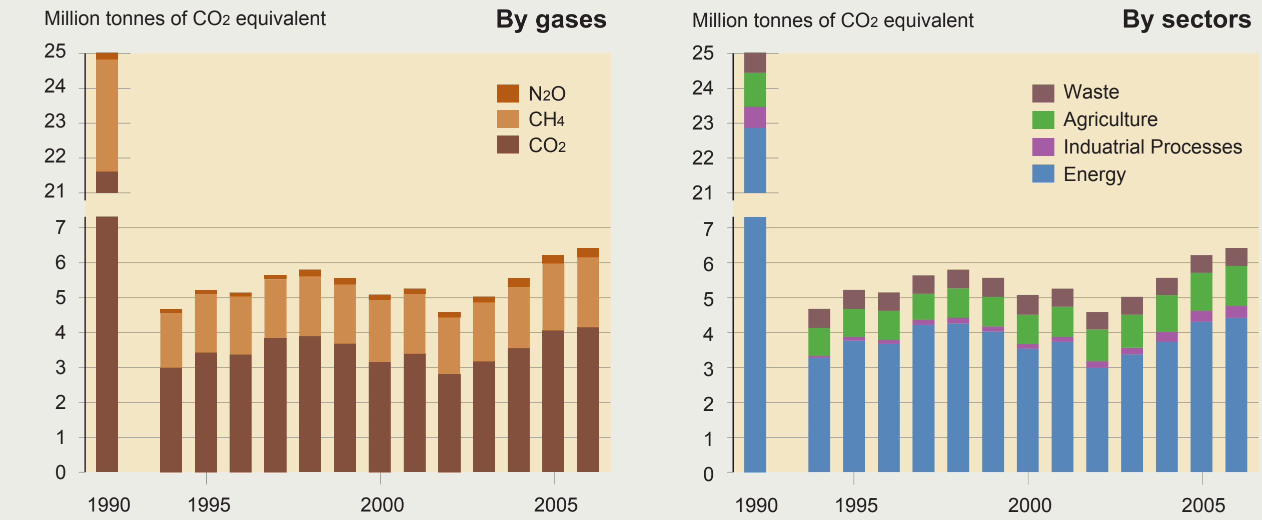


Sources: Assessment of vulnerability of water resources to climate change, 2011; Georgia's Second National Communication, 2009.

Neft Dashlari (Oily Rocks), AZERBAIJAN

Greenhouse Gas Emissions and Climate Change Mitigation

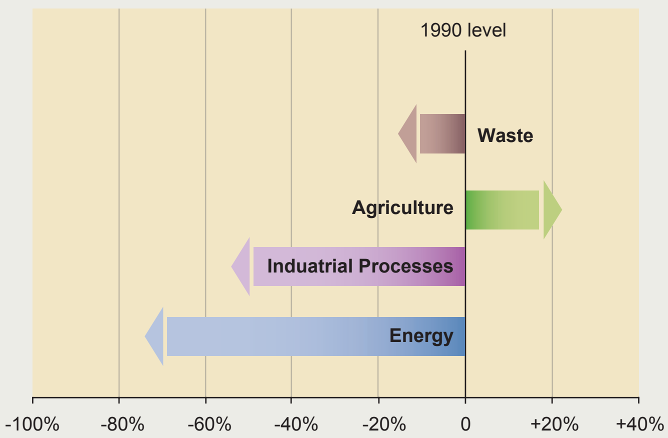
Greenhouse gas emissions in Armenia, 1990–2006*



* Without LULUCF

Source: Armenia's Second National Communication, 2010.

Greenhouse gas emissions change from 1990 to 2006 in Armenia



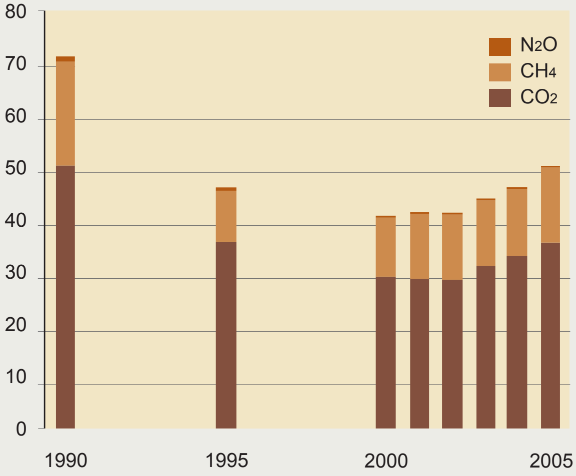
Source: Armenia's Second National Communication, 2010.

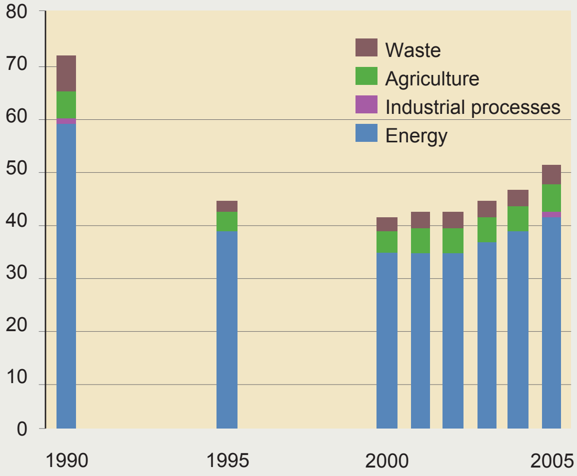
ARMENIA: GHG EMISSIONS BY ECONOMIC SECTORS

After the sharp economic decline of 1991–1994, Armenia was able to achieve 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%. These shifts have positively influenced the decline of Armenia's greenhouse gas (GHG) emissions. Carbon dioxide emissions in 2006 declined by 81% compared with the 1990 level, methane by 38% and nitrous oxide by 42%.

The energy sector accounted for the major part of the total GHG emissions in 1990–2006. However, energy-related emissions fell in that period — from 91% in 1990 to 64.7% in 2006 (Armenia's Second National Communication, 2010).

Greenhouse gas emissions in Azerbaijan, 1990–2005

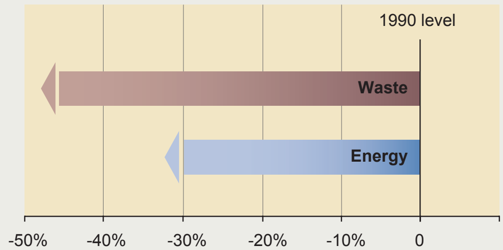




Source: Azerbaijan's Second National Communication, 2010.

Baku, AZERBAIJAN

Greenhouse gas emissions change from 1990 to 2006 in Azerbaijan



Source: Azerbaijan's Second National Communication, 2010.

AZERBAIJAN: GHG EMISSIONS BY ECONOMIC SECTORS

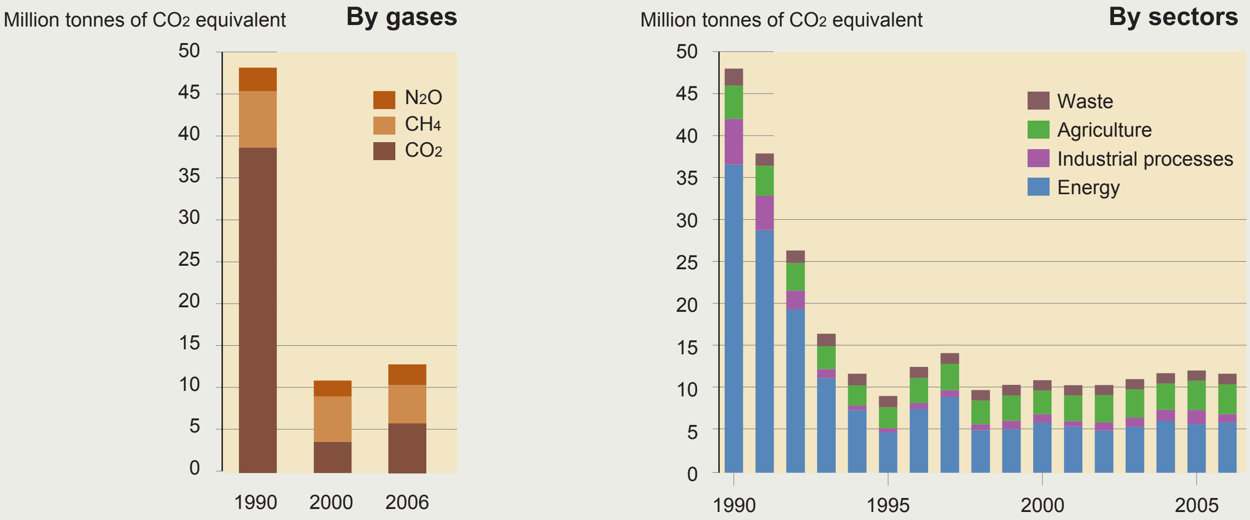
The economic potential of Azerbaijan is mainly determined by its oil and gas industry, the production of chemicals and petrochemicals, metallurgy, mechanical engineering, textiles and the food industry.

The agricultural sector consists mostly of wheat, cotton, wine, fruit, tobacco, tea, vegetables and cattle breeding.

The predominant part of Azerbaijan's exports comes from oil and oil products, electrical energy, cotton and silk fibres.

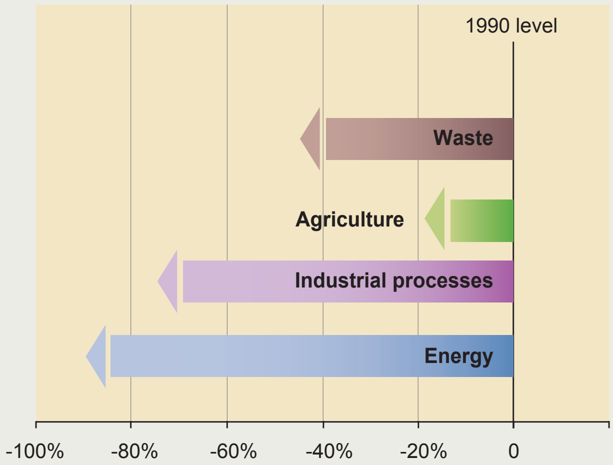
The level of GHG emissions in Azerbaijan in 2005 amounted to 70.6% of the 1990 base year level. The main sources of CO_2 emissions are the energy and industrial sectors, especially from burning fuel for energy production, oil and gas extraction, transport, and human settlements (Azerbaijan's Second National Communication, 2010).

Greenhouse gas emissions in Georgia, 1990–2006



Source: Georgia's Second National Communication, 2009

Greenhouse gas emissions change from 1990 to 2006 in Georgia



Source: Georgia's Second National Communication, 2009

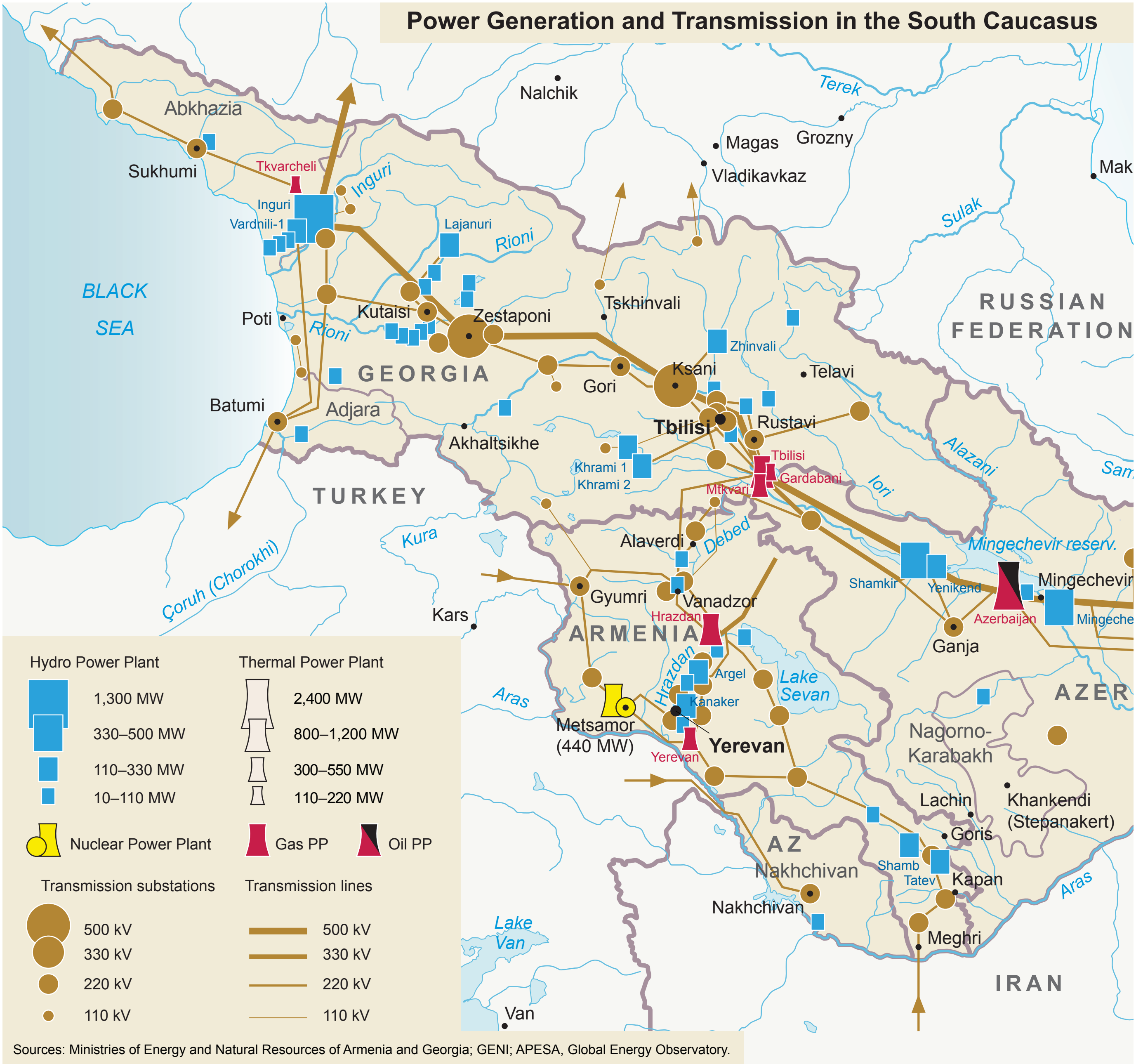
Source: Geopolitical Atlas of the Caucasus, 2010; GRID-Tbilisi data.

GEORGIA: GHG EMISSIONS BY ECONOMIC SECTORS

Georgia's economic growth has become irreversible since 2004. Georgia's industry consists of machinery, mining, the chemical industry, ferroalloys, wood, wine and mineral water.

Agriculture has been a leading sector since Soviet times. Traditional crops include grapes, wheat, maize, fruit (including citrus), and tea.

Total GHG emissions in Georgia began to sharply decrease after 1990. Since 1991, the share of the energy sector in total emissions has been decreasing almost continuously. In 2006, its share comprised 45.6%, while in 1990 it had been 76.3%. The share of emissions from industrial processes in 2006 was approximately the same as in 1987, though the actual emissions decreased by about four times. Key sources of GHG emissions in 2000 and 2006 did not change significantly compared with 1990. However, the relative importance of different sources has changed (Georgia's Second National Communication, 2009).



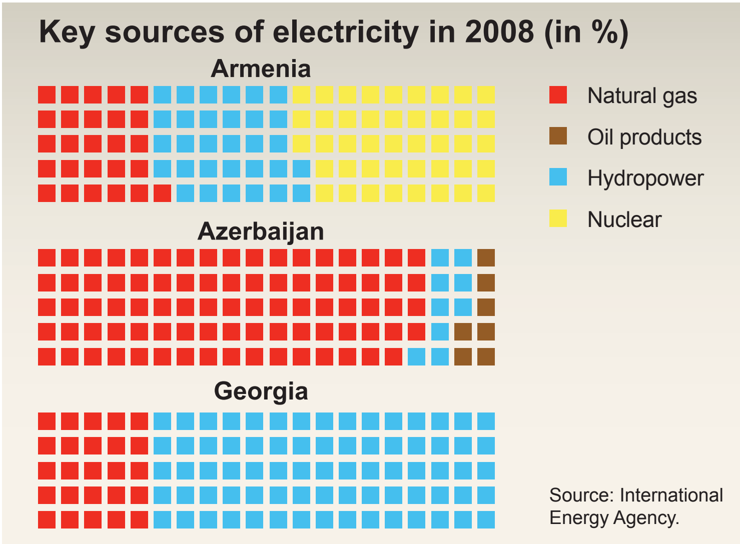
Sources: Ministries of Energy and Natural Resources of Armenia and Georgia; GENI; APESA, Global Energy Observatory.

THE ENERGY SECTOR IN THE SOUTH CAUCASUS

The sources and means of energy generation, despite coexisting in the same region, differ greatly in the South Caucasus countries. In a country rich in fossil fuels, oil products and natural gas are commonly consumed in Azerbaijan. Energy production there is based on natural gas, fuel oil and hydropower. Thermal power plants account for 89% and hydro-power for 10% of total energy generation.

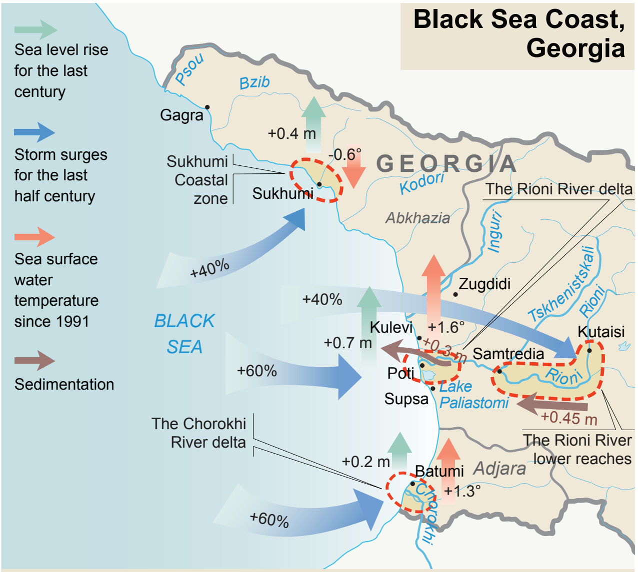
Armenia does not possess its own fuel resources and satisfies its demand for fuel through imports. Its own primary energy resources (hydro, nuclear) cover 31% of the country's total energy consumption. The main type of fuel consumed is natural gas. In 2000–2006, the share of natural gas in total fuel consumption reached 70–79%.

Over 80% of Georgia's electricity is produced by hydropower. The rest mainly comes from thermal power plants, using gas exported from Azerbaijan and Iran. There is an economically viable potential of 32 TWh of hydropower production capacity, one of the largest in the world, of which only 18% is currently being utilized. Georgia became a net electricity exporter in 2007. With its massive unused capacity and its current per capita electricity consumption, one of the lowest in Europe, Georgia can easily increase its electricity exports while satisfying fast-growing domestic electricity consumption, which is rising by 8–9% annually (Second National Communications of Armenia, Azerbaijan and Georgia).



Hatsvali with Ushba Mountain,
Upper Svaneti, GEORGIA

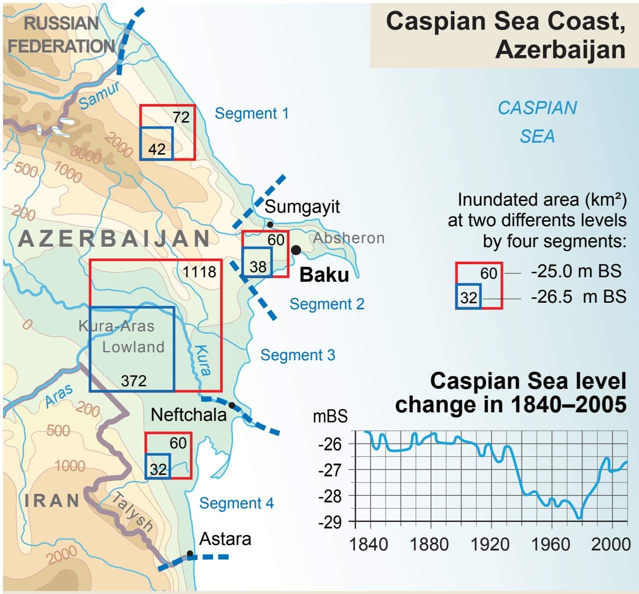
Impact of Climate Change and Adaptation Measures



Source: Georgia's Second National Communication, 2009.

IMPACTS OF CLIMATE CHANGE: THE BLACK SEA COAST, GEORGIA

The Georgian Black Sea coastal zone is considered the area most vulnerable to climate change in Georgia. Highly developed coastal infrastructure, with a dense network of railways and highways stretched along the coast, the important transportation and industrial hubs of port cities like Batumi, Poti and Sukhumi, and the great number of settlements all play a significant role in the regional economy. Georgia's Second National Communication to the UNFCCC defines several specific sensitive areas along the coastal zone: Rioni river delta, Chorokhi river delta, the lower reaches of the Rioni river and the Sukhumi coastal area. Some studies suggest the Rioni delta is the most vulnerable area, already experiencing sea level rise and increased storm surges. This situation will trigger more change in the future, with a predicted temperature rise and consequent negative impact on the environment (Georgia's Second National Communication, 2010).



Source: Azerbaijan's Second National Communication, 2010; MENR-Azerbaijan.

IMPACTS OF CLIMATE CHANGE: THE CASPIAN SEA COAST, AZERBAIJAN

Sea level fluctuations are a major cause of concern for the Caspian Sea shoreline. As the largest naturally enclosed water body on Earth, with no outflow to the oceans, the Caspian Sea is particularly vulnerable to global climate change processes. Starting from 1961 a level of -28.0 m below sea level (BS) was conditionally taken as the zero point for the Caspian Sea for observation and planning purposes. Azerbaijan's Second National Communication predicts a further increase of sea level for another 30 to 40 years within the range of -26.5 to -25.0 m BS. Projected damage to the economy would be within the magnitude of USD 4.1 bn. Consequently Azerbaijan is preparing to take adaptation measures (Azerbaijan's Second National Communication, 2010).

Changes in seasonal and annual Temperature and Precipitation in the Lake Sevan basin, compared to 1961–1990

Temperature change (C°)

	Winter	Spring	Summer	Autumn	**Annual**
2030	1.4	0.9	1.8	1.8	**1.5**
2070	3.2	2.1	3.9	3.9	**3.3**
2100	4–6	2.5–4.5	5–7	5–7	**4.1–6.1**

Sources: Vulnerability of water resources in the Republic of Armenia under climate change, Yerevan, 2009.

Precipitation change (%)

		Winter	Spring	Summer	Autumn	**Annual**
2030	East shore	-7	- 4	-9	-2	**- 5.5**
	West shore	7	+4	-5	5	**2.8**
2070	East shore	-15	-7	-18	-4	**-11**
	West shore	15	11	-11	11	**6**
2100	East shore	-20	-10	-25	-5	**-15**
	West shore	20	10	-15	15	**7.5**

Calm and nice Lake Sevan, sometimes as stormy as any sea

IMPACT OF CLIMATE CHANGE: NATURAL DISASTERS

There are major climate change impacts taking place in the South Caucasus, as shown by the observations of the national hydrometeorology services of Armenia, Azerbaijan and Georgia. In particular, there is a recorded increase in both mean and extreme air temperatures, in addition to changes in rainfall amounts and patterns. Climate change projection models predict even more increase of extreme weather conditions, translating to a heavier and uneven seasonal distribution of precipitation with possible dramatic consequences. As a result, the probability of devastating natural disasters such as landslides, avalanches, river floods, flash floods and mudflows, causing human casualties and economic losses, is expected to rise in the near future (Second National Communications of Armenia, Azerbaijan and Georgia).

Georgia is particularly exposed to weather extremes, most likely because of its closer proximity to the Black Sea, abundance of water resources, larger amount of annual and seasonal precipitation, high soil humidity, etc. The damage caused by the flooding during the last three years was put at USD 65 m. An increasing frequency and intensity of avalanches has been detected since the last decades of the 20th century. More than 20,000 people were displaced from their homes between 1970 and 1987. About 53,000 locations damaged by gravitational landslides had been identified by 2009. Mudflows are estimated to cause damage of approximately USD 100 m annually. Overall, economic damage caused by mudflows in Georgia over the period 1987 to 1991 exceeded USD 1 bn; the damage caused by mudflows from 1995 to 2008 was over USD 330 m (State of the Environment Georgia, 2010).

IMPACT OF CLIMATE CHANGE: GLACIER MELTING

In these pictures: Melting of the Laboda Glacier in Georgia: photos taken in 1972 and 2002.
Source: Institute of Geography, Javakhishvili State University, Tbilisi, Georgia.

GLACIER MELTING IN THE CAUCASUS

Glaciers are sensitive to climate change. Some climatologists suggest the contribution of melting glaciers to sea-level rise may have been increasing by as much as 27% for the last few decades (Dyurgerov, 2003). The climate change scenarios published by the IPCC predict up to 60% glacier loss in the northern hemisphere by 2050 (Schneeberger *et al* 2003). The Earth Policy Institute (www.earth-policy.org) says glacial volume in the Caucasus has declined by 50% during the last century and will decrease more severely in the foreseeable future. Glaciers are very important water resources for local communities, and play a significant role in the water budget. Smaller glaciers are known to respond more rapidly to climate change and are therefore more important in calculating overall impact.

Glaciers cover an area estimated at around 1,600 km² in the Caucasus. Exact up-to-date information on the changes in their mass balance is not available. There is visual evidence of glacier recession in the Caucasus, but information concerning the latter stages is limited. However those studies that have focused on glacier change in the Caucasus (Bedford and Barry, 1994) reported a strong retreat trend for 51 glaciers between 1972 and 1986. Chris R. Stokes, Stephen D. Gurney, Maria Shahgedanova, Victor Popovin (*Late 20th-Century Changes in Glacier Extent in the Caucasus Mountains, Russia/Georgia*) analysed glaciers of the central Caucasus region, extending the analysis of Bedford and Barry, and showed that the retreat trend has continued throughout the 1980s and 1990s. Melting rates have greatly accelerated since the mid-1990s. Moreover, the study indicates that the retreat of Caucasus glaciers from the mid-1970s to 2000 correlates well with the temperature record.

In this picture: retreat of two glaciers on the South slope of the central Caucasus — the Loboda and Zopkhito glaciers, between 1971 (yellow) and 2009 (blue). The data on the image is a combination of CORONA imagery dating from 1971, a SPOT image of 2007 and a Digital Globe image (Google Earth) of 2008.
Source: Lambrecht, A., et al (2011).

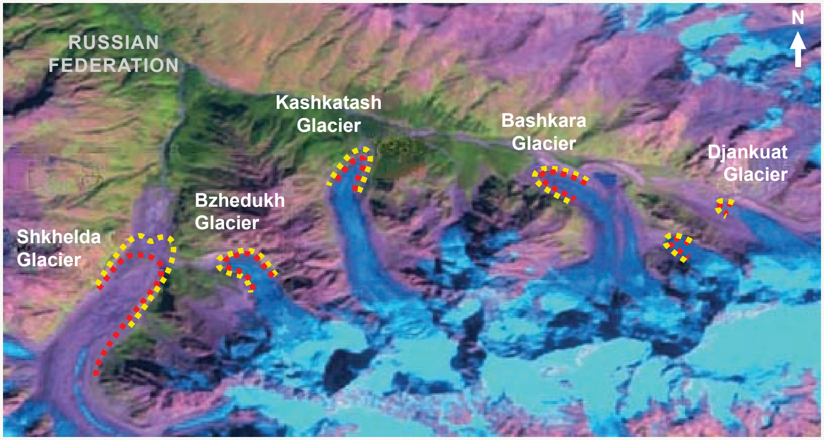
Glaciers melting in south part of the Central Caucasus

Glacier boundary in 2009
Supra-glacial debris cover (trace of glacier) in 1971
0 500 m

Source: Lambrecht A., et al (2011).

In this picture: retreat of six neighbouring glaciers in the central Caucasus between 1985 (yellow) and 2000 (red), including Djankuat glacier (furthest east), which has an extensive mass balance record, and Shkhelda glacier (furthest west) with one of the largest retreat rates in the Caucasus
Source: Stokes, C. R., et al (2006).

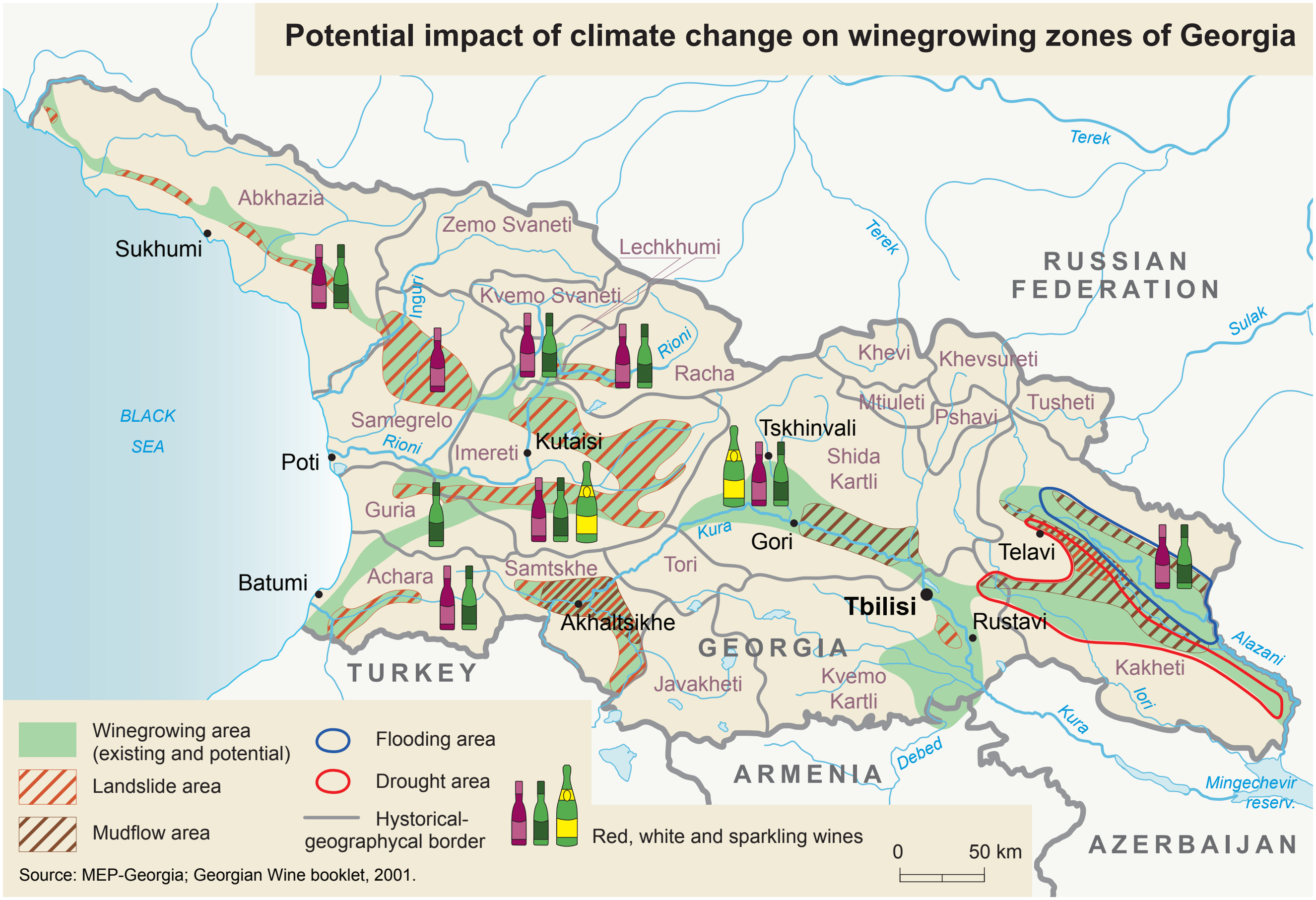
Glaciers melting in north part of the Central Caucasus



Glacier line
in 1985 in 2000
0 1 km

Source: Stokes, C. R., et al (2006).

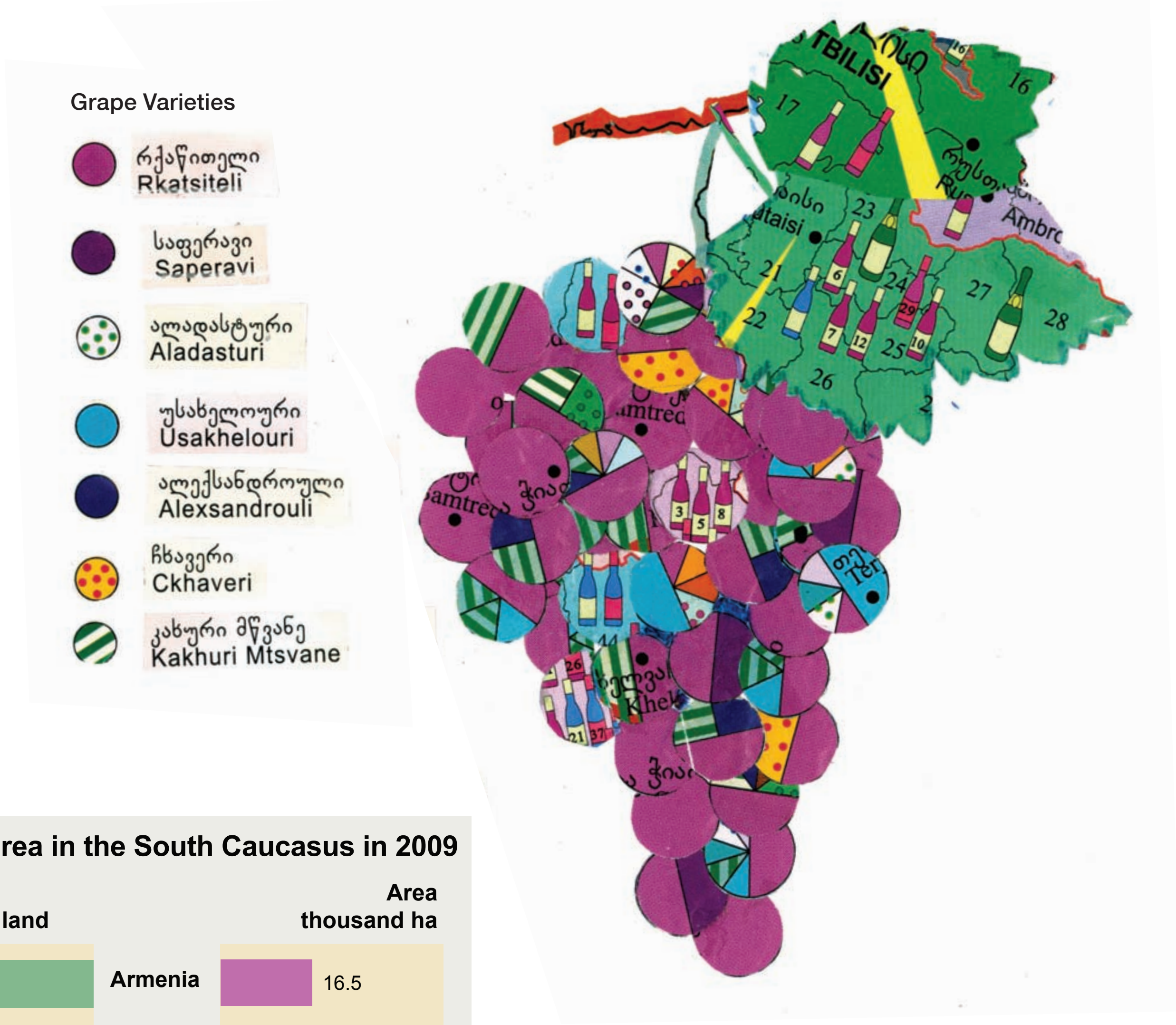
Another group of scientists (Lambrecht *et al*, 2011) focused their study also on the central part of the Greater Caucasus — the Djankuat glacier (Russia) and the Zopkhito glacier (Georgia). The results of the study show that at the southern end of the Caucasus range the exposition (southern slope) causes higher radiation input and thus more intensive ice melt. However, high cloudiness due to higher radiation input also provides higher precipitation in the south than in the north. As a result, the effective glacier melt is about 20% less in the south. Both regions experienced strong glacier area loss during recent decades and a gradual increase in debris cover (Lambrecht, *et al*, 2011).



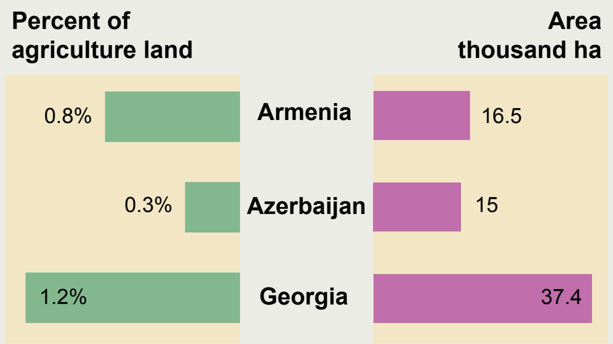
IMPACT OF CLIMATE CHANGE ON WINEGROWING ZONES OF GEORGIA

Viticulture and wine production is one of the most viable and oldest agricultural activities that have been carried out for centuries in South Caucasus and particularly Georgia. Both archaeology and history show that Georgia was cultivating grapevines and practicing ancient wine production more than 7,000 years ago (Ministry of Agriculture of Georgia, 2011 — www.samtrest.gov.ge). In many regards Georgia's identity was closely connected with wine production, which was very popular among the former Soviet states and always highly prized.

Georgia has excellent conditions for viticulture. A moderate climate with a sufficient number of sunny days, frost-free winters and moist air, in combination with fertile soils, mineral-rich and clean spring waters and a vast diversity of endemic agricultural species provide outstanding conditions for it. The total share of agriculture in the country's GDP is about 10–14%, with viticulture and wine production playing a very important role (Georgia's Second National Communication, 2009). However, increasing natural disasters and specific weather extremes caused by global climate change that is already affecting Georgia and especially its grapegrowing zones may jeopardize the sector considerably.

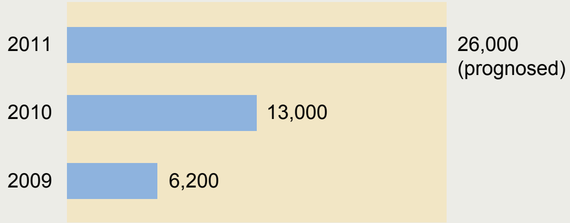


Vineyard area in the South Caucasus in 2009



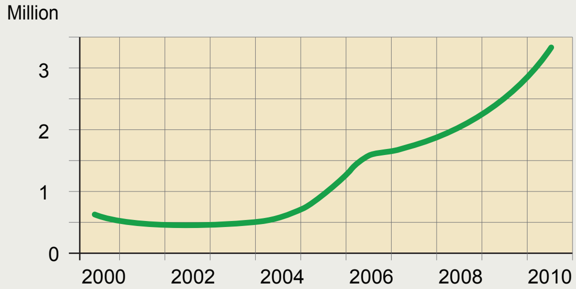
Sources: State statistical services of Armenia, Azerbaijan and Georgia, Year Books, 2010.

Number of tourists in the Upper Svaneti in 2009–2011

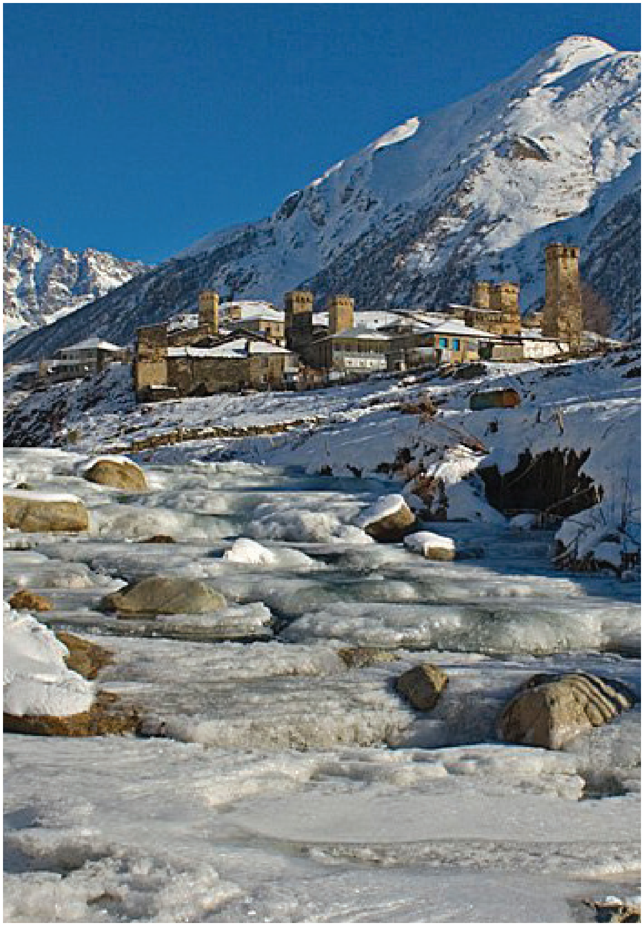


Source: www.komersanti.ge (6.01.2011)

Number of tourists in Georgia in 2000–2011



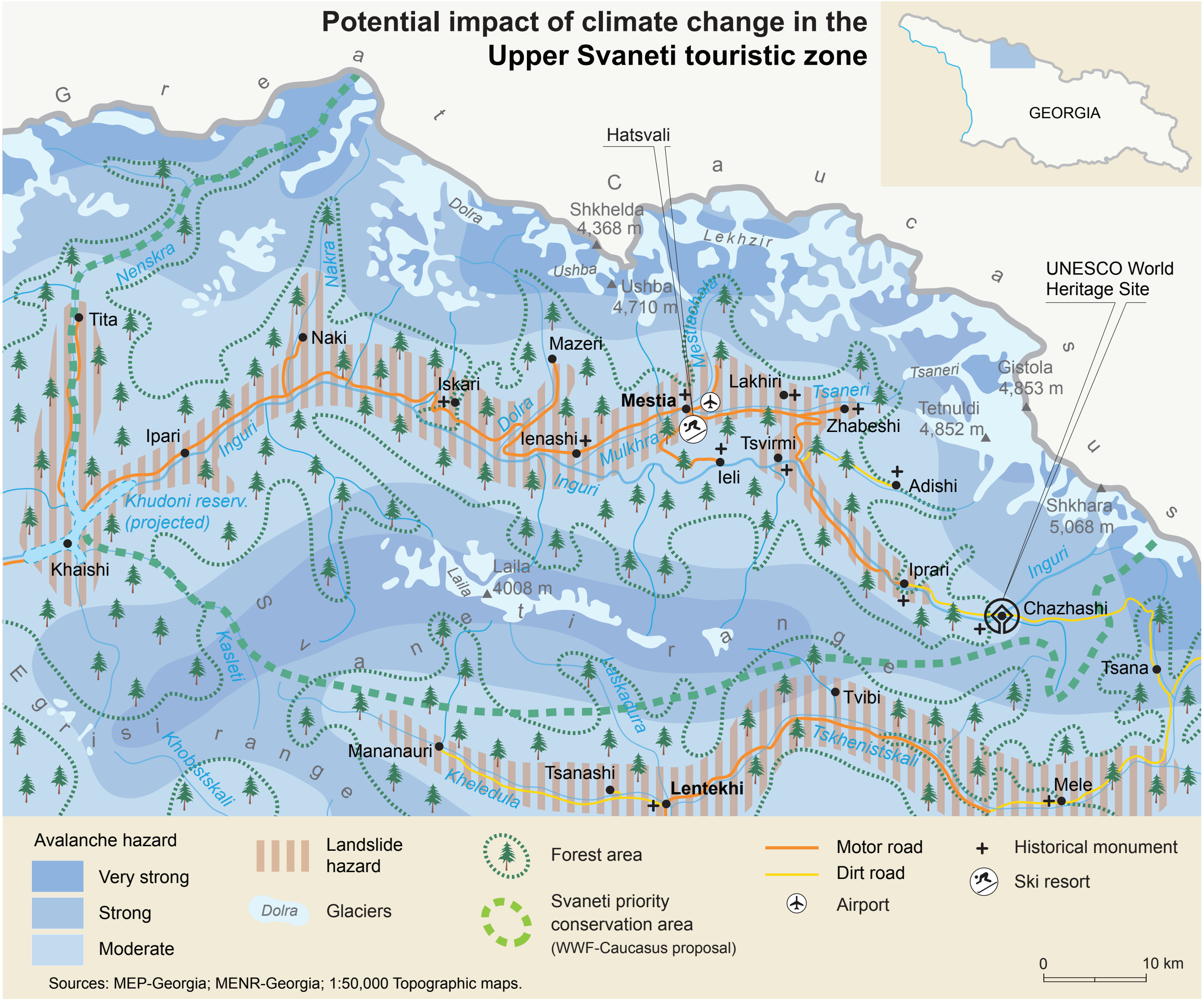
Source: Georgian National Tourism Agency.



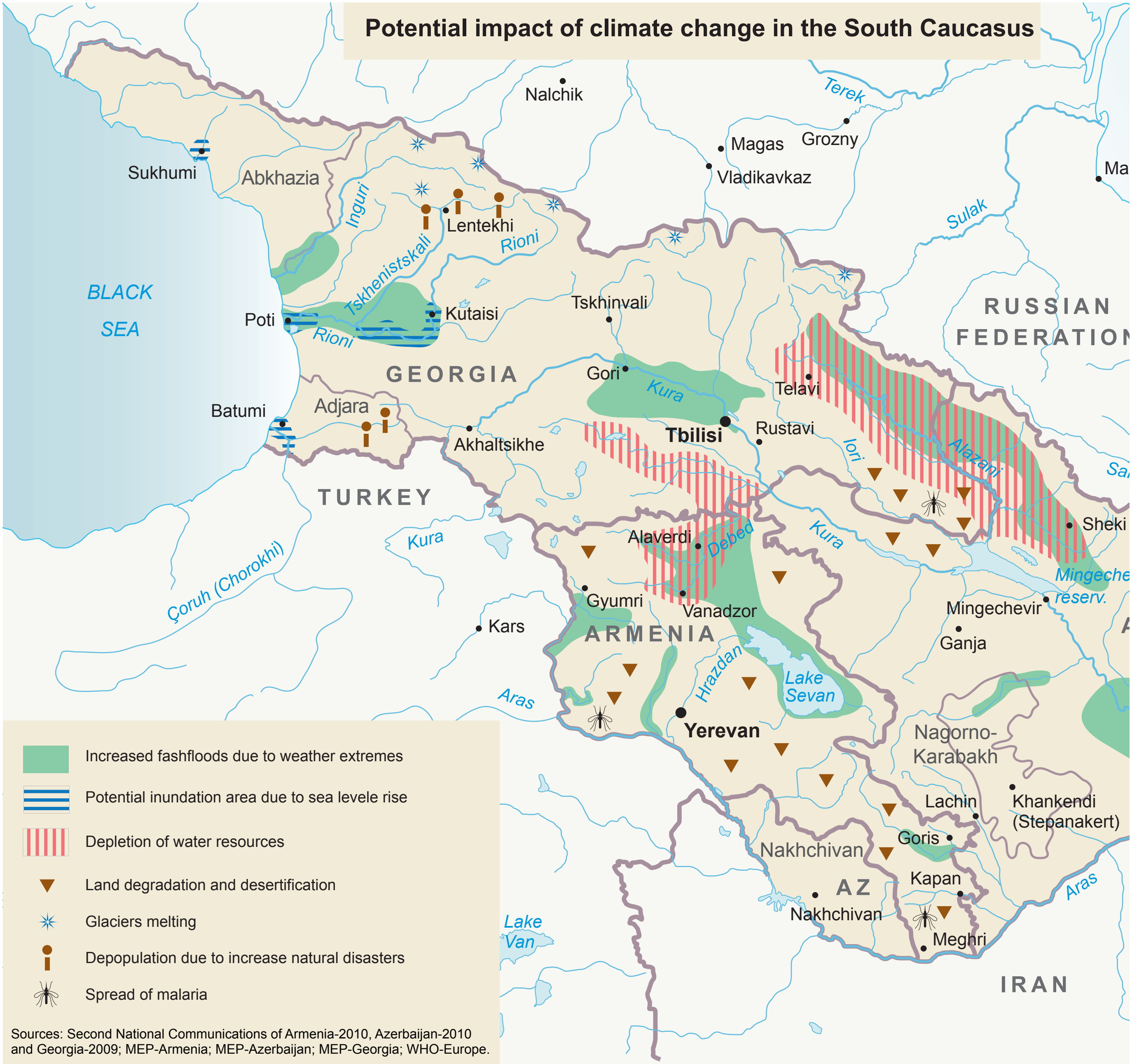
Upper Svaneti, GEORGIA

THE IMPACT OF CLIMATE CHANGE ON GEORGIA'S TOURIST SECTOR: UPPER SVANETI

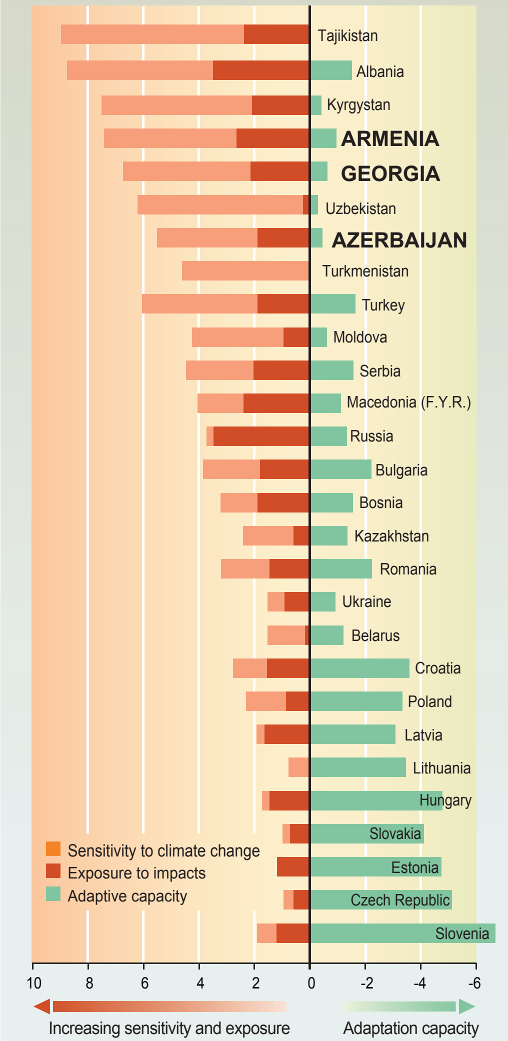
The Upper Svaneti region of Georgia has been a very popular tourist destination for a long time. Unique and mostly untouched natural landscapes, high mountains, abundant historical monuments and its exceptional cultural heritage are only few of the wonders ensuring this popularity. Access to this region has never been easy though, due to its rigid topography and the dilapidated infrastructure in post-Soviet Georgia, exhausted by ethnic conflicts, civil wars and consequent economic devastation. Attention to Svaneti has increased considerably in recent years, after the launch of infrastructure rehabilitation projects and the construction of hotels and a brand new airport in Mestia (the regional capital). The airport now has a modern navigation system and connects Svaneti to major Georgian airports, as well as some international destinations. The number of visiting tourists has doubled compared with recent years, since a ski resort (operating for about six months each year) was developed in Hatsvali, a highland



resort close to one of the most charming mountain peaks of Georgia — Ushba (4,710 m above sea level). Access to the UNESCO world heritage site at Ushguli has also been restored. However, an increased number of tourists will also mean increased pressure on the fragile natural ecosystems in coming years. This will become an even more sensitive issue as the region is located in the landslide and avalanche high-risk zone and changing climate patterns, with the predicted temperature rise and precipitation decrease, are cause for serious concerns.


Potential impact of climate change in the South Caucasus
BLACK SEA
GEORGIA
ARMENIA
TURKEY
RUSSIAN FEDERATION
IRAN
AZ
Sukhumi
Abkhazia
Poti
Batumi
Adjara
Lentekhi
Kutaisi
Tskhinvali
Gori
Tbilisi
Rustavi
Telavi
Akhaltsikhe
Alaverdi
Gyumri
Vanadzor
Yerevan
Kars
Nalchik
Magas
Grozny
Vladikavkaz
Sheki
Mingechevir
Ganja
Nagorno-Karabakh
Lachin
Khankendi (Stepanakert)
Goris
Kapan
Meghri
Nakhchivan
Inguri
Rioni
Tskhenistskali
Kura
Iori
Alazani
Debed
Hrazdan
Lake Sevan
Aras
Çoruh (Chorokhi)
Terek
Sulak
Lake Van
Increased fashfloods due to weather extremes
Potential inundation area due to sea levele rise
Depletion of water resources
Land degradation and desertification
Glaciers melting
Depopulation due to increase natural disasters
Spread of malaria
Sources: Second National Communications of Armenia-2010, Azerbaijan-2010 and Georgia-2009; MEP-Armenia; MEP-Azerbaijan; MEP-Georgia; WHO-Europe.

Index of vulnerability to climate change*



*Vulnerability to climate change is a combination of: i) exposure to hazards, measuring the strength of future climate change relative to today's climate; ii) sensitivity, indicating which economic sectors and ecosystem services are likely to be affected in view of climate change, e.g. renewable water resources, agriculture and hydro-power production; and iii) adaptive capacity to climate change, e.g. social, economic, and institutional settings to respond to weather shocks and variability.

Source: Climate Change in Central Asia, 2009.

Climate Change-related Issues in the South Caucasus

Water resources

Food security

Biodiversity

Social problems

LAND AND WATER

Land contamination by pesticides and heavy metals, salinization of soils, overgrazing pastures, illegal and ill-maintained waste dumps close to water streams, glacier melting, depletion of freshwater sources (eastern part of South Caucasus) lack of safe and good quality of drinking water.

Impact on livelihoods, agriculture, human health

FLOODS AND NATURAL DISASTERS

Increased number of catastrophic floods due to weather extremes (Black Sea coast, Alazani Valley, Kura lowland in Azerbaijan), devastating natural disasters — landslides, mudflows, flash-floods, avalanches in mountainous zones, inundation of croplands, settlements at lowlands.

Impact on livelihoods, infrastructure, threat to human life and health, local and transboundary problems, deterioration of social conditions

AGRICULTURE

Land degradation and desertification (eastern part of South Caucasus), salinization, droughts, coastal inundation and bogging (Black and Caspian Sea coastal zones), loss of soil fertility, decrease of crop production, degradation of wine- and citrus-growing zones.

Impact on livelihood and food security

FORESTS, FAUNA AND FLORA

Displacement of natural boundaries at sensitive areas of eastern South Caucasus (temperate forest ecosystems), loss of resilience of flora and fauna to invasive species, loss of natural ecosystem “corridors” for migration of rare and endemic species, increased cases of forest fires, degradation of landscape diversity, loss of biodiversity.

Impact on livelihoods, biodiversity, freshwater resources, agriculture, human health

SEA AND COASTAL

Sea level rise, land inundation, coastal erosion, increased number of storm surges, pollution of sea water by oil products (Caspian Sea) and by untreated wastewater discharge (Black and Caspian Seas), coastal line change, lack of safe drinking water, decrease in number and diversity of marine specifies, deterioration of coastal infrastructure, spread of Malaria at inundated areas (eastern part of South Caucasus).

Impact on coastal and sea biodiversity, livelihoods, agriculture, transport and other infrastructure, tourism

PEOPLE AND WELLBEING

Depopulation and eco-migration due to increased number of devastating natural disasters — landslides, mudflows, avalanches at highland zones of Adjara and Svaneti (Western Georgia), lack of safe drinking water and food, increase of poverty, spread of infectious diseases, increased stress due to heat waves, increased cases of cardiovascular diseases.

Threat to human life, health and social conditions

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Abbreviations and Glossary

APESA	Association of the Power Engineers and Specialists of Azerbaijan
AZ	Azerbaijan
BS	Baltic Sea
CEO	Caucasus Environment Outlook
CORONA	Series of American strategic reconnaissance satellites produced in 1959–1972
ECHAM	Global climate model for climate research. The model was given its name as a combination of its origin, the “EC” being short for ECMWF (European Centre for Medium-Range Weather Forecasts) and the place of development of its parameterisation package, Hamburg.
ENVSEC	The Environment and Security Initiative
GCCP	Global Climate Change Processes
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEL	Georgian Lari
GENI	Global Energy Network Institute
GHG	Greenhouse Gas
GRID	Global Resource Information Database
HAD300	One of the global circulation model (GCMs)
HADCM	Hadley Centre Coupled Model (Coupled atmosphere-ocean general circulation model developed at the Hadley Centre in the United Kingdom)
HADCM3	Hadley Centre Coupled Model, version 3
HTC	Hydrothermal Coefficient
LULUCF	Land Use, Land-Use Change and Forestry
MAGICC/ SCENGEN	*MAGICC*: User-friendly software package that takes emissions scenarios for greenhouse gases, reactive gases, and sulphur dioxide as input and gives global-mean temperature, sea level rise, and regional climate as output. *SCENGEN*: Regionalization algorithm that uses a scaling method to produce climate and climate change information on a 5° latitude by 5° longitude grid.
MENR	Ministry of Energy and Natural Resources
MEP	Ministry of Environment Protection
Mil	Million
PP	Power Plant
PRECIS	In French précis — “PRAY-sea” — is based on the Hadley Centre’s regional climate
SoE	State of the Environment
SPOT	In French: Système Probatoire d’Observation de la Terre. Probationary System of Earth Observation — high-resolution, optical imaging Earth observation satellite system operating from space
TWh	Terawatt hour
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WEAP	Water Evaluation and Planning Model
WHO	World Health Organization

Chemical Combinations

CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide

The Georgian artist, Nina Joerchjan, has produced a set of collages to illustrate the Zoï Environment Network publication, *Climate Change in the South Caucasus*. At first sight: beautiful renderings of mountain landscapes, vineyards, fruits, animals and archaic architecture. In the long tradition of the region's folk art, many scenes — such as Ararat mountain — are immediately recognizable as Caucasian icons. The images evoke Pirosmani, although people — the main subject of the famous Georgian painter at the turn of the twentieth century — are almost completely absent. But why use such a traditional and happy style to illustrate such a grim and existential subject as climate change? The answer comes in a second, closer look that the artwork deserves. New elements appear: an oil platform, a ski lift and a somewhat strange, turtle-like structure giving the Tbilisi skyline a new look. Even without these modern elements, a sense of fragility becomes obvious. An idyll in the process of being destroyed, nature and livelihoods being threatened, climate change being real. The artist has found a silent, non-alarmist tone to show that things are still there, however fragile. It is up to us to preserve this unique heritage. There may still be time.

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