Ministry of Environment
and Natural Resources
Protection of Georgia

Georgia's Third National Communication to the UNFCCC

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Tbilisi
2015

The Third National Communication of Georgia to the UNFCCC was prepared by a large group of decision makers, experts and other stakeholders, representing: the Ministry of Environment and National Resources Protection of Georgia and its National Environmental Agency; the Ministry of Energy of Georgia; the Ministry of Economy and Sustainable Development of Georgia; the Ministry of Agriculture of Georgia; the Ministry of Labor, Health and Social Affairs of Georgia; the Ministry of Regional Development and Infrastructure of Georgia; the Ministry of Education and Science of Georgia; Georgian National Agency of Cultural Heritage Protection; the Ministry of Agriculture of Ajara Autonomous Republic, Ajara Environment Protection and Natural Resources Administration, Batumi Municipality, other municipalities of Ajara, Kakheti municipalities, Municipality of Mestia, Institute of Geography; Institute of Hydrometeorology, individual academic institutes; representatives of local authorities and local consultants engaged in tourism, health and agriculture, independent national experts and NGOs.

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TNC preparation process was coordinated by the Ministry of Environment and Natural Resources Protection of Georgia

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Abbreviations

A/R – Autonomous republic
ADA – Austrian Development Agency
AWMS – Animal Waste Management System
AWS – Automatic Weather Station
BAU – Business-As-Usual
BOD – Biochemical Oxigen Demand
BUR – Biennial Update Report
C – Carbon
CDD – Consecutive Dry Days (index)
CDM EB – Clean Development Mechanism Executive Board
CENN – Caucasus Environmental Non-Governmental Network
CH_4 – Methane
ClimaEast – Support to Climate Change Mitigation and Adaptation in the Eastern Neighbourhood Countries and Russia (EU project)
CO – Carbon oxide
CO_2 – Carbon dioxide
COM – Covenant of Mayors
CWD – Consecutive Wet Days (index)
DOC – Degradable Organic Carbon
EBRD – European Bank for Reconstruction and Development
EC-LEDS – Enhancing Capacity for Low Emission Development Strategy
ENVSEC – Environment and Security Initiative
EU – European Union
FAO – Food and Agriculture Organization
FD (0) – Frosty Days (index)
GCF – Green Climate Fund
GDP – Gross Domestic Product
GEF – Global Environment Facility
Gg – Gigagram (10^3 ton)
GHG – Greenhouse Gas
GIZ – German Agency for International Cooperation
GPG – Good Practice Guideline
GW – Gigawatt (10^9 W= 1 million KW)
HI – Heat Index
HPEP - Hydro Power and Energy Planning (USAID Project)
HPP – Hydropower plant
ICE-Internal Combustion Engine
ID(0) – Icy Days (index)
IEA – International Energy Agency
INDC – Intended Nationally Determined Contribution
INTAS – International Association for the promotion of cooperation with scientist from the
IPCC – Intergovernmental Panel on Climate Change

KfW – German Reconstruction Credit Bank
LCV-Light Commercial Vehicle
LEDS – Low Emission Development Strategy
LEPL – Legal Entity of Public Low
LULCF – Land Use, Land-Use Change and Forestry
MARKAL – Integrated energy system model
MOENRP – Ministry of Envrionmental and Natural Resources Protetcion
MRV – Monitoring, Reporting and Verification
MW – Megawatt (10^6 W)
NAMA – Nationally Appropriate Mitigation Action
NAPA – National Adaptation Programmes of Action
NEEAP – National Energy Efficiency Action Plan
NMVOC – Non-Methane Volatile Organic Compound
QA/QC – Quality Assurance/Quality Control
R90 – Abundant Precipitation (≥90 mm) Days (index)
RH – Relative humidity
Rx5 day – Consecutive 5 Days Precipitation (index)
SEAP – Sustainable Energy Action Plan
SPI – Standardized Precipitation Index
SSP – SYNERGY, Strategy Planning
SU25 – Hot summer days (>25 ^{0}C) index
TCI – Tourism CLimat Index
TNA – Technology Needs Assessment
TNC – Third National Communication
toe – ton of oil equivalent
TR20 – Tropical Nights (>20 ^{0}C) (index)
UNDP – United Nations Development Program
UNFCCC – United Nationa Framework Convention on Climate Change
USAID – United States Agency for Internation Development
WB – World Bank
WHO – World Health Organization
WMO – World Meteorological Organization
WWF - World Wildlife Fund

Foreword

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Foreword

Since 1996 Georgia is involved in implementation of the United Nation Framework Convention on Climate Change (UNFCCC) processes coordinated at the national level by the Ministry of Environment and Natural Resources Protection of Georgia.

International community puts all efforts to combat the threats increased and intensified by the climate change. Development and application of renewable and energy efficient technologies have leading role in this process in which Georgia is actively involved through ongoing international projects and programmes addressing climate change issues.

Activities implemented in the field of climate change are being adequately reflected in Georgia's National Communications. In 2006-2009 the Second National Communication (SNC) was prepared and submitted by the country. Climate Change Strategy of Georgia was the part of the SNC along with other sections. The majority of activities planned in the Strategy were implemented, some of them are in the process of implementation by the Government of Georgia with the support of international donors.

The Third National Communication (TNC) of Georgia was prepared in 2012-2015 and includes the national inventory of Greenhouse Gases (GHGs). GHGs inventory gives opportunity to evaluate aspects of sustainable development of the economy. On a sector level, emission trends is one of the "clean development" indicators and gives enough basis for conclusions for the future.

The TNC document widely considers climate change mitigation and adaptation issues. It focuses on 3 regions of Georgia: Ajara, Upper-Svaneti and Kakheti. Such approach facilitates identification of local challenges at the region level that require particular attention.

The TNC also includes Georgia's Climate Change Strategy by 2025. The main objective of the Srategy is to identify concrete ways for mitigation of ecosystems vulnerability and abatement of GHGs from emitter sectors.

Strategic vision provided in the TNC of Georgia opens door for implementation of environmental projects and programmes that are important for Georgia and at the same time are contributing to the worldwide efforts to combat climate change.

I would like to express my sincere gratitude to the United Nations Development Programme and Global Environment Facility for support provided in the process of preparation of presented TNC document.

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Executive Summary

National Circumstances

The priorities of national and regional development of Georgia are conditioned by its geopolitical location, historical contacts and relations, social and cultural traits as well as current needs.

After disintegration of the Soviet Union, Georgia restored political independence, charted a course towards European integration and started reforms in all spheres. Constituent part of Association Agreement with EU is an "Agreement on Deep and Comprehensive Free Trade Area" (DCFTA), which opens the way for goods and services produced in Georgia to internal EU market and facilitates the increase of investment attractiveness of the country. Association Agreement stresses the necessity of cooperation on climate change issues in the following spheres: mitigation of climate change, adaptation to climate change, carbon trade, integration into industrial policy on climate change issues and development of clean technologies. In this direction, several initiatives are being implemented at a national level: development of Low-emission Development Strategy (LEDS), development of Biannual Updated Report (BUR), development of Nationally Appropriate Mitigation Plan (NAMA) for the reduction of greenhouse gases, determination of Intended Nationally Determined Contribution (INDC), etc. Since 2010, mayors of big cities of Georgia began joining the EU initiative "Covenant of Mayors", which gave substantial impetus to the rising of the level of inventory of greenhouse gases in the country. In addition, Georgia actively cooperates at regional level on the issues of climate change, participating mainly in the group with Azerbaijan, Moldova, Armenia and is also involved in EU ClimaEast project implementation together with Azerbaijan, Belarus, Moldova, Russia, Armenia and Ukraine.

From climatic viewpoint, Georgia is characterized by great diversity. Almost all types of climate areas are represented here, with the exception of desert, savanna and tropical forests. Likhi Ridge, going through the center of the country, divides the territory into two regions with dramatically differing climate – humid subtropical West Georgia and its eastern part, mainly having dry subtropics. In lowlands of West Georgia and the Black Sea coastal zone, average annual temperature makes 14-15 ^{0}C, and annual precipitation varies in the range of 1 500-2 700 mm. Alpine zone of the same region contains mountain massif included in the powerful system of the Greater Caucasus, covered with permanent snow and glaciers, the height of which is more than 5 000 m above the sea level. In plains of East Georgia average annual temperature is up to 11-13 ^{0}C and annual precipitation makes 400-600 mm, and in the mountainous regions it increases up to 800-1 200 mm. During the last 25 years, under the impact of global warming, average annual temperature in West Georgia increased by 0.3^{0}C, and in East Georgia the increase made 0.4- 0.5 ^{0}C.

The main natural resources of the country are water and forests. Total annual runoff of rivers in West Georgia (38.0 km^3) three times exceeds that of rivers in East Georgia (13.4 km^3). About 850 small lakes and over 40 reservoirs with irrigation and hydro-energy function are registered on the territory of the country. Hydro-energy potential of Georgia is high and its technically usable component makes 40 billion kWh per year. Over 600 glaciers are currently registered on the territory of the country with total area of 355.8 km^2 and approximate ice volume of 20 km^3. As for forests, currently they occupy about 40% of the territory of Georgia with total wood resource of 443 million m^3. Over 800 species of plants are registered in forests, among which, in particular in reserves of West Georgia, are several relic and endemic species.

In the beginning of 2014 population of Georgia made 4 490 500, out of which 53.7% live in urban areas. The number of internally displaced persons from Abkhazia and South Ossetia makes 273 thousand based on the data of 2013. Ethnic composition of the population is diverse. According to the data of 2002: 83.8% ethnic Georgians, 6.5% Azeris, 5.7% Armenians, 1.5% Russians and 2.5% other ethnos (Kurd, Greek) representatives are living here. Diversity also exists in religious confessions, nevertheless, major part of the population (84%) is Orthodox Christian.

Like most of former USSR republics Georgia is still attributed to the category of countries with economy in transition. By 2007 economic revival was recorded, which was conditioned by extensive inflow of private capital, peak of which was recorded in 2007 based on official statistical and International Monetary Fund data. Agriculture, industry, construction, trade and transportation branches conditioned 50.8% of GDP increase as compared with the previous year. According to 2013 data, basic fields of economy comprised the following shares of GDP: industry (12%), trade (13%), transport and communication (10%), agriculture (9%), construction (7%) and services (49%). On the basis of processes going on in the economy of the country, it was revealed that the main hampering factors of economic development of the country are low competitiveness of private sector, improperly developed human resources and limited availability of funds.

As for the activities related to the fulfillment of obligations under the UNFCCC, as per 2014, almost all main ministries, other governmental institutions, municipalities, scientific institutions, technical and expert groups, non-governmental organizations and other stakeholders are involved in it. Each of them, within its competence, participated in the development of the Third National Communication, for which 3 basic groups were established: inventory of greenhouse gases, vulnerability and adaptation, and mitigation. In the process of preparation of the TNC, climate change strategy handbooks were published for the three selected regions (Ajara, Kakheti and Upper Svaneti), which were distributed in the regions and among other stakeholders.

National Inventory of Greenhouse Gases

The third national inventory of greenhouse gases in Georgia covered the period of 2006- 2011. It was based on the IPCC methodology, which consists of two basic documents: Revised 1996 IPCC Guidance on National Greenhouse Gas (GHG) Inventory[1] and IPCC Good Practice Guidelines (GPG) and Uncertainty Management in National GHG Inventory[2]. In accordance with the format of general reporting of IPCC methodology, the following 6 sectors were considered: Energy; Industrial Processes; Solvent and Other Product Use; Agriculture; Land Use, Land Use Change and Forestry; Waste. The group of experts, personnel of Climate Change Devision of the Ministry of Environment and Natural Resources Protection and invited experts participated in the preparation of the TNC. The data sources were National Statistics Office of Georgia, Georgian Oil and Gas Corporation, International Energy Agency, the Ministry of Environment and Natural Resources Protection, Statistical Service of UN Food and Agriculture Organization (FAO), individual large industrial enterprises, companies, etc. After consideration of overall emissions in 2011 and their trends, 29 key source- categories were selected for the inventory, covering almost 98% of total emissions with the exception of Land Use sector.

Summary emissions and trends were examined for the following greenhouse gases: CO_2, CH_4, N_2O, HFC, SF_6. The data of their emissions in the inventory were specified for 1990-2011, and following methodological considerations – taking into account the structural integrity of data series – assessment of trends was conducted for the period of 2000- 2011. Assessment of emissions for individual gases showed that out of the main 3 greenhouse gases, during the last year of inventory (converting into CO_2 equivalent), 58% of summary emissions from the territory of Georgia was conditioned by carbon dioxide, 29% - by methane and 13% - by nitrogen monoxide. Besides, emissions of indirect greenhouse gases – nitrogen oxides (NOx), carbon oxide (CO), NMVOCs and sulfur dioxide (SO_2) were examined but their share occurred to be insignificant in total emissions.

In addition to emissions of individual greenhouse gases, overall emissions and trends were also assessed according to sectors. For the last year of inventory, out of the basic sectors, energy sector turned out to be the greatest contributor in emissions (almost 55% of total emissions), which is followed by industrial processes (23%) and agriculture (15%). In the land use sector, against the background of forest land and perennial crops, CO_2 emissions from hay fields and pastures had no substantial impact on summary indicator of carbon dioxide absorption and this sector remained to be the major sinkof CO_2, which absorbs 5 600- 6 500 Gg CO_2 annually.

[1] IPCC 1996 revised. http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html
[2] IPCC GPG. http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html

Assessment of indirect greenhouse gases and SO_2 emissions according to different sectors for the period of 2006- 2011 showed certain trend of increase of emissions in this period of time. Uncertainty analysis of the obtained data was also conducted, as a result of which it was determined that emission level uncertainty is in the range of 9.12%, and trend uncertainty makes 17.27%.

Activities Planned for Implementing the Convention

In 2012-2014 Georgia prepared the TNC on Climate Change in the framework of which anticipated climate change scenarios were developed, vulnerability of various ecosystems and branches of economy, as well as individual municipalities and regions were assessed, adaptation strategies and project proposals were prepared for individual municipalities and regions. One of the alternatives (conservative) of greenhouse gas emission reduction strategy, together with specific actions was considered, number of awareness- raising measures was implemented. Climate Change Strategy – 2014 for Georgia has been developed.

The mentioned document is structured considering the analysis of implementation of activities recommended in Strategy-2009 and results obtained in the process of preparing the TNC of Georgia. Unlike the Second National Communication, which was oriented on ecosystem vulnerability, in the framework of the TNC priority sectors (agriculture, tourism, healthcare) of economy of the country were brought to the foreground, which, correspondingly, was reflected in interim documents as well as in Final Strategy-2014.

After consideration of short-term goals (development of NAPA and LEDS strategies, determination of INDC contributions, facilitation of COM implementation, etc.), the strategy reviews the issues of local capacity building for implementation of principles of the Convention, objectives related to conducting the next inventory of greenhouse gases - including development of biannual updated report, vulnerable ecosystems with regard to climate change, economy sectors and regions, and problems of their adaptation to climate change, as well as activities, related to reduction of greenhouse gas emissions. The prospects of development and introduction of low-emission and adaptation technologies and objectives related to awareness raising, education and staff training are discussed separately. Long-term strategy for 2020-2050 is intended for the development of complete adaptation plan, implementation of strategy of low-emission development and facilitation to transfer of Georgian economy on sustainable development principles.

In the strategy the following institutions have been identified as target groups: Georgian Government and Parliament, Ministry of Environment and Natural Resources Protection; Ministry of Energy; Ministry of Economy and Sustainable Development; Ministry of Agriculture; the Ministry of Labor, Health and Social Affairs; Ministry of Sport and Youth Affairs; Ministry of Culture and Monument Protection, Ministry of Regional Development and Infrastructure; National Statistics Office of Georgia; Cities which are parties to the Covenant of Mayors; Local self-governments of vulnerable to climate change municipalities; Academic institutions; Agency of Protected Areas; Farmers and their associations; Non-governmental organizations; Local communities, etc.

Vulnerability of Economy Sectors and Ecosystems to Climate Change

Climate change in Georgia. Current climate changes in Georgia were assessed based on the observation data of 33 stations of hydrometeorological network during the period of 1961- 2010, and prognostic scenarios for the periods of 2021- 2050 and 2071- 2100 were compiled using Regional Climate Model RegCM4. Seasonal and annual values of the following climate elements were mainly considered: air temperature, sums of precipitation, average wind speed, relative humidity, extreme indices of temperature and precipitation.

It was revealed that during the last 50 years average annual temperature on the whole territory of Georgia demonstrated only increasing trend and its maximum increment in East Georgia (+0.7 ^{0}C) is in Dedoplistskaro, and in West Georgia (+0.6 ^{0}C) in Poti. According to forecast, by 2050, as compared with 1986- 2010, warming will mostly occur in coastal zone and mountainous regions of Ajara (1.6-1.7 ^{0}C), and by 2100 the biggest increment of temperature (+4.2 ^{0}C) is anticipated in Batumi. Annual summary precipitation, during the past period, have mostly increased in low-mountain zone of Svaneti and middle-mountain regions of Ajara (+14%). In general, precipitation increased in most regions of West Georgia, and decreased in East Georgia by 6-8%. Up to 2050, according to the forecast, sustainable trends of increase of precipitation is anticipated in West Georgia, further their decrease will begin on the whole territory by 10-20% till 2100.

Relative humidity of air in the period of 1961- 2010 increased by 2% on the entire territory of Georgia, although change of this trend in declining direction is anticipated for 2050-2100, except of several some (Mestia, Khaishi, Keda). Average annual wind speed significantly decreased on the whole territory and according to the forecast, this decrease will continue till the end of the century.

In the second half of the past period (1986- 2010) reduction of number of frosty days occurred on the whole territory of the country, with the exception of Upper and Lower Svaneti regions. Along with the increase of average temperature, very hot days and tropical nights, frosty days will be characteristic only for mountainous territories by the end of the century.

Impact of Climate Change on the Agricultural Sector of Georgia. In the framework of the Third National Communication of the country, this issue was studied for two regions – Ajara and Kakheti.

Currently, the major problem in the leading branch of agriculture in Ajara – citrus growing – is climate factor, which is expressed in insufficient provision of these crops with heat, in spite of the increase of vegetation period and active temperature sums during the last 20-25 years. Besides, the increase of active temperatures during vegetation period at the expense of very hot days facilitates spreading of diseases in citruses. Another problem is erosion of agricultural lands. Intensified and more frequent precipitation as a result of warming causes washing down of soil on mountain slopes, which, against the background of extensive exploitation of grass cover, is accompanied by dramatic decrease of productivity of hay lands and pastures and erosion of pastures, that, in its turn, has negative impact on the development of livestock farming.

As for agriculture in Kakheti, current climate change was expressed in more frequent droughts, increase of extreme hot days and intensification of hail. The latter particularly damages perennial plantations in the region, where vine growing and fruit growing is developed. At the same time, for some municipalities (Akhmeta, Dedoplistskaro, Signage) soil degradation, caused by wind erosion and soil salinization turned into serious problem. Droughts, occurring more frequently, pasture erosion and reduction of productivity hampers the development of livestock farming in the region.

Recommendations were worked out for both examined regions, which are reflected in adaptation strategies for these regions.

Extreme Geological Phenomena. Currently about 53 thousand landslide bodies and sites of their possible formation are registered on the territory of Georgia; About 3 000 water currents transformable into mudflows; About 5 000 forming of avalanche sites; scavenging of sea coasts and river banks on over 1 000 sites with total length of 1 500 km. About 57% of settlements, populated up to 70% of all residents, with about 400 000 households are under the risk of geological natural phenomena of various scale. Research showed that the frequency of natural phenomena in Georgia substantially increased since 1980s; Activation of atmospheric processes (mainly abundant precipitation) as a result of global warming, as well as intensification of anthropogenic impact is stated to be the main reason.

In particular, if, according to landslide and mudflow hazard, Ajara was attributed to medium and significant risk category (with coefficient of 0.3 – 0.5) by 70s of the past century, by 2000 this region has moved to the high and very high risk category (with risk coefficient of 0.5- 0.9). In another high-mountainous region of

Upper Svaneti 1 600 households abandoned Mestia municipality since 80s of the past century due to natural disasters.

Based on conducted investigation, it was determined that in annual respect, in the case of increase of annual precipitation amount by 100 mm as compared with multi-year norm, natural geological phenomena stay within the standard range. Positive diversion of precipitation from average annual norm by 100-200 mm causes considerable activation of natural phenomena, which reach maximum in the case of increase of precipitation sums by 200- 400 mm as compared with climatic average.

Furthermore, slowing down of natural geological processes is related to the deficit of atmospheric precipitation as compared with multi-year norm.

In the conditions of projected climate change, the reduction of avalanche risk hasn't turned out to be expected in Ajara mountainous region by 2050; nevertheless, by 2100 the forecast of probable slow down of avalanche hazard was obtained for Khulo and Goderdzi Pass. At the same time, considering the forecasted significant increase of days with abundant precipitation (> 90 mm) up to 2050, further activation of landslides and mudflows is supposed in Ajara mountainous region. As for Upper Svaneti, on the basis of projected data is assumed that active dynamics of geological processes will be maintained here till 2050 and further period, and if adaptation measures are not taken in timely manner, the risks will be sustainably higher.

In the third studied region – Kakheti, according to climate forecast, increase of abundant precipitation is expected by 2020-2050, that will facilitate triggering of mudflow processes and, consequently, will increase the risk of transformation into extreme mud torrents. This circumstance makes the need of timely implementation of recommendations for anti-mudflow measures for Telavi and Kvareli more urgent.

Forests. Currently about 40% of the territory of Georgia is covered by forests. In the process of preparation of the Third National Communication on climate change, forests of three important regions – Ajara, Upper Svaneti and Borjomi-Bakuriani were considered. The analysis of observation data on climatic changes in 1961-2010 showed that average annual temperature has increased in the range of 0.3-0.6 ^{0}C in these regions. In Ajara and Upper Svaneti it was followed by the decrease of summary annual precipitation by 10-16%, and insignificant decrease – in Borjomi-Bakuriani region. Against the background of these climatic trends no changes were observed in the distribution of species in Ajara and Borjomi Gorge forests, while in Upper Svaneti, Mestia high mountain region, substitution of birch with spruce and pine was observed in the areas covered with birch. Out of abiotic disturbances, increase of the cases of forest fires was recorded in Borjomi. At the same time, spreading of pests and diseases increased in Ajara and Borjomi Gorge.

Considering the climatic parameters by 2050 and 2100, the increase of average annual temperature by 1.0-1.5 ^{0}C and 3.4-4.2 ^{0}C respectively is anticipated in all three regions, and summary annual precipitation will first increase and then decrease within ±10%. As a result of these changes, fire risks will probably increase in Ajara and Borjomi Gorge, thus extending the area of spreading of pests and diseases; New types of diseases will appear while and in Upper Svaneti forest system no significant disturbances are anticipated. The relevant recommendations were included in Ajara and Upper Svaneti adaptation strategies in regard to climate change.

Vulnerability of Health Sector. In accordance with the analysis conducted in the framework of the Third National Communication, climate-related diseases in Georgia are not evenly distributed among regions and depend on the type of manifestation of climate change.

Among climate-related diseases, diarrheal diseases turned out to be the most widely spread in Ajara region, incidence of which exceeded average indicator of Georgia 5 times in 2009-2010 in adults as well as in children. In recent years the cases of Weil's diseases, as well as borreliosis were recorded here, which, supposedly, is related to the formation of climatic conditions, favorable for their emergence and existence.

Out of climate-related diseases, the most actual in Upper Svaneti was trauma, and out of chronicle pathologies – cardio-vascular and respiratory system diseases. Significant increase of cardio-vascular diseases was also recorded in Kakheti region, where, according to the data of 2010-2011, lethality caused by these pathologies in Kakheti was twice as much as in Tbilisi. For all the three examined regions it was revealed that the increase of air temperature, activation of heat waves and decrease of precipitation contribute to the persistence of the trend of increase of total number of incidences of cardio-vascular diseases. This effect was particularly clearly revealed on the example of Tbilisi for the data 2003-2013, which, according to the indicators of spreading of cardio-vascular diseases, twice exceeds the parameters of Kakheti and Imereti.

Along with climate change, the shortcomings existing in the Healthcare system, which make this sector even more vulnerable, were reviewed in all the three regions and the relevant recommendations have been developed for their elimination, which were included in the adaptation strategies of these regions.

The impact of climate change on tourism sector. Given that tourism is one of priority sectors of Georgian Economy, for regions selected in third National Communication, along with Tourism Climate Index (TCI) the vulnerability of tourism and recreational resources to climate change has been assessed.

According to data from the weather stations, over the past fifty years, favorable weather conditions for tourist season (May-October) due to climate warming were registered even in April in the Black Sea coastal zone, as well as the worsened conditions- in August due to high temperatures. Similar changes were not observed in the highland resorts of Ajara. It has been determined that over the last 25 years in Batumi, unlike Kobuleti, the number of hot days significantly increased. Based on the predicted data on climate change, it is assumed that by 2050 the worsening of climate conditions is expected in summer in Batumi, while in mountainous areas weather conditions will improve.

Similar study conducted in Upper Svneti showed that over the last 50 years there have been favorable conditions for tourism from April to October. By 2100, due to expected warming tourist season might be prolonged from March to December, which will require improvement in all rings of tourism infrastructure.

In Kakheti, for which TCI never is lower than "acceptable" category, favorable tourist conditions have not been changed during the past half-a-century. According to predicted data, by the end of 21^{st} century, further improvement of favorable climate conditions in a relatively cold period (October - April) is expected, while in warm period weather will probably worsen due to increased temperatures especially in July-August. Therefore, intensive development of agro-tourism in Kakheti is required as well as tourist resource utilization in Mtatusheti highland region and revival of Akhtala and Ujarma balneotherapy potential to advanced levels.

Impact of climate change on glaciers in Upper Svaneti. According to latest data there are 269 recorded glaciers in Upper Svaneti with total area of 223.4 km^2, which makes up 63% of the area covered by glaciers in Georgia. Since glacier is one of the most sensitive indicator of climate change, the analysis of the expected glacier dynamics due to projected climate conditions in the Enguri River and possible impact of these processes on the Enguri basin runoff is included in the Third National Communication.

According to measurements, as an initial position was considered the fact that in 1890-1965 in Enguri basin area occupied by glaciers reduced by 13%, and in Upper Svaneti in the same period the average annual temperature has increased by 0.3 ^{0}C. Based on these data, the linear extrapolation of the mentioned processes to a first approximation showed that if by the end of 21^{st} century Upper Svaneti air temperature will increase by 4 ^{0}C compared with 1960s data, glaciers area in the Enguri River Basin will decrease down to 100 km^2, while their complete melting should be expected in 2170-2180. Besides, by 2100 the Enguri River runoff will be reduced by 13% and will amount to average annual 3.0 km^3.

Protected areas . In the Third National Communication, the impact of climate change on protected areas has been assessed on the example of Ajara region protected areas; As for Kakheti region, the issue was tackled in Georgia's Second National Communication. In protected areas of Ajara, the same problems occur that are observed in Ajara forests in general, namely, the higher spread of old diseases in forests and the appearance of new diseases (e.g. Kolkheti buxus disease). In Batumi Botanical Garden ivy plant lowering to the land is observed, which is typical to a tropical climate. The problems also concern the brook trout population. As long as brook trout is a cold water-loving form, increase in temperature caused migration of its population towards cool environment - the river heads, where there is a lack of space and food compared to lower and middle reaches of the river. As a result of migration adolescence generation of trout is especially damaged due to cannibalism and other behavior characteristics of this form, which is one of the main reasons for the reduction of number of trout.

Impact of Climate change on the Upper Svaneti historical monuments. Geographical location of Upper Svaneti region created historical condition for accumulation of national cultural monuments granting the region a status of historical and architectural reserve. Upper Svaneti is rich with religious and secular monuments of architecture (tower houses), typical for this part of the country, which because of their identity have a special ethnographic value. Climate factors, along with anthropogenic influence have negative impact on the monuments of both categories. Studies revealed that historical monuments are mostly affected by precipitation and air humidity causing dampening the walls and the collapse of the mortar that bonds the stones. In Upper Svaneti, as well as across the entire territory of Georgia, the relative air humidity increased by 2%, and total annual rainfall in Mestia over last 25 years increased on the average by 10%.

According to the forecast, by the year 2050 in Upper Svaneti the increase in average annual and daily maxima of rainfall is expected, as well as growth of air humidity, which could lead to the intensification of erosion processes posing risk to Upper Svaneti historical monuments due to high humidity and precipitation. Therefore, planning of preventive measures and constant monitoring of the processes are required to ensure protection of historical sites and further development of tourism, which in its turn will contribute to the improvement of living standards, resettling and sustainable development of the region.

Greenhouse gas reduction policies and measures

Early in 2015 Georgia needs to fix the quantities of emissions, which should be cut starting from 2020. With this respect, two important processes are going on in the country: government of Georgia is preparing low emission development strategy (LEDS), and since 2010 nine Georgian cities have joined the Covenant of Mayors (COM). For these cities, Sustainable Energy Action Plan (SEAP) is being elaborated. These activities and mitigation measures are implemented under the assistance of various donors including the EU and the USAID. Preparation of Intended Nationally Determined Contributions (INDC) and biennial update reports (BUR) is planned.

The third GHGs inventory for 2006-2011 conducted within the Third National Communication revealed the energy sector (including transport sub-sector) as the main source of emission in Georgia. Therefore, while planning the emission reduction measures, emphasis was made on that sector. The sector analysis was based on MARKAL/Georgia model. Analysis aims to assess emission reduction impact on the process of Electricity Demand for 2015-2030 to ensure sustainable economic growth taking into consideration LEDS objectives.

Through MARKAL/Georgia, (Developing a Business as Usual) BAU scenario and emission reduction strategies by 15, 20 and 25% were analyzed. Within the LEDS framework, BAU scenario is being designed (however, it has not yet been approved by the country).

Based on projected data of economic development and population growth, according to BAU scenario, energy consumption is going to rise by 76.6% for 2030. Growth of energy demand, in parallel with the use of the opportunity to export electricity to the Turkish market will require to increase the power generation system capacity from 3 260 MW to 5 731 MW. Accordingly, carbon dioxide emission from Georgia's energy sector due to fuel combustion will increase by 72.3% amounting 11 179 thousand tons by 2030[3].

According to the current state of the energy sector, the bulk of natural gas is consumed by households, commercial and industrial sectors. From 2024 the consumption will be significantly reduced due to expired term of exploitation of 2 large thermal power stations and increased hydro-electric power generation. Nevertheless, due to substantial growth of gas consumption in household and transport sub-sectors its import will increase in 2030 by 57% compared to 2012. High gas consumption by end-use sectors clearly demonstrates the vulnerability of the country's economic and social development to the external factors and urgent need for diversification of energy resources.

Increase in the capacity of hydro-electric power plants is a visible trend that will result in two cumulative additional capacities of 2 601 MW by 2030. According to BAU scenario, following the construction of coal, natural gas and wind power plants, installed capacity of power plants will reach 5 731 MW by 2030 in Georgia. For this reason, an annual average of 290 million Euros shall be spent until 2030. In addition, more than 4 000 million Euros will be needed every year to cover the high costs associated with modern technologies.

According to BAU scenario, the increased CO_2 emission (over 72%) will require LEDS implementation by 2030. The calculations showed that emission reduction just by 15% to 2030 will result in more than 13% reduction in import of energy carriers, which will foster the country's energy security. In case the emissions are reduced by 20%, the import will decline by 18%, while in case of 25%-reduction, the import will decrease by 23%. To facilitate this process, LEDS implementation is required. As for the renewable energies (hydro and wind), their share in power generation shall grow from 90% to 93-94% of 2030 BAU scenario.

Among the non-energy sub-sectors, solid waste and wastewater sub-sectors have a considerable potential for reducing GHG emissions. Assessments conducted for four CoM signatory cities of Georgia (Tbilisi, Batumi, Kutaisi and Zugdidi) concerning the SEAP implementation showed that about 292 thousand tons of methane can be saved through the collection and incineration of emitted gas from solid waste landfills by 2030 in CO_2 equivalent.

Greenery zones in the above listed 4 cities have relatively lower potential of carbon dioxide absorption, annual quantity of which made up approximately 17 300 tons.

Other information

During 6 years following the implementation of the Second National Communication, number of weather stations and hydrometeorological posts acting in Georgia increased from 40 to 116 with 21 weather stations and 95 posts by the end of 2014. Number of operating automatic weather stations increased to 30. Within this period, approximately 4.2 mln USD of foreign grants and 1.7 mln USD state funds were invested for strengthening hydrometeorological network and move to the electronic databases, including the installation of monitoring systems for underground fresh water resources being one of the priorities of the government since 2013.

Based on the National Climate Change Strategy (NCCS) through 2025, presented in Georgia's Second National Communication, in 2009-2014 up to 70 medium and large projects were implemented in Georgia with the support of foreign grants from main donor organizations such as GEF, EU, USAID, GIZ, as well as the governments of Austria, the Netherlands, Norway, Sweden, Switzerland and the Czech Republic. Implementing organizations are UNDP, the Ministry of Environment and Natural Resources Protection of Georgia, CENN, REC Caucasus, Energy Efficiency Center, WEG, and others. Majority of projects are of regional scale being implemented in a group of countries.

[3] Before publishing the TNC this BAU emission by 2030 was recalculated within the LEDS preparation process using updated data and new amount obtained is approximately 16 million ton CO_2eq. Still these are not final results because calculations ongoing. Calculations and analysis made by August 2014 are only provided in this document.

According to incomplete data, within the mentioned period, 24 projects on vulnerability and adaptation have been implemented with total financing of USD 47.2 million, and 33 projects on mitigation with total funding of USD 128.9 million. As for the project distribution by sectors, two of them have a lead position in terms of the number of completed projects and financing: Energy and transport sector (13 projects with total financing of USD 93 million), and forests and biodiversity (7 projects with total financing of USD 31. 5 million), that makes up about 60% of overall funding. Next come climate change policy and natural disasters management sectors, while the agriculture received the smallest funding. The list of completed projects does not include the ones related to health and tourism that demonstrates the necessity of enhancing the relevant activities in these fields along with agriculture.

Given that the provided data is incomplete, it can be roughly assumed that 70-80 projects were implemented in Georgia during the 6-year period addressing the climate change problems with total financing over USD 180 mln. In addition, 4 projects have been implemented over the past period with local financing concerning the monitoring of glaciers in Svaneti (total funds USD 225 thousand).

Investments in GHG national inventories mainly are made in Tbilisi and other cities since 2010 in preparation of CoM SEAP, for which based on rough estimation USD 7-8 mln grants were invested. In addition, GHG inventory and emission reduction monitoring is carried out within the six GHG monitoring projects.

Analysis of the completed projects proved their significant contribution to the implementation of 2009 NCCS and recommendations, though, in most cases partial implementation took place due to imperfect recommendations and shift in national and international donors' priorities.

1 National Circumstances

Georgia started the process of preparing the Third National Communication on Climate Change in 2012. Democratic elections were held in the country in the same year and a new political force came to power, which reaffirmed European integration as the cornerstone of the its internal and external policies.

In 2013 fundamental changes were done in the Constitution of Georgia and the country moved to a semi-presidential system of the Republic. President of Georgia is Supreme Commander-in-Chief, but is no longer the head of the executive government. The executive authority rests within the Cabinet of Ministers headed by the Prime Minister, who also supervises the law enforcement Ministries (Ministry of Internal Affairs and Ministry of Defence). Parliament is the supreme legislative power.

Georgia's capital Tbilisi with its 1.2 million inhabitants is located in Eastern Georgia, on both banks of R.Kura. Other important Georgian towns are: Kutaisi, Batumi, Rustavi, Gori, Zugdidi, Poti, etc. Large industrial facilities are mainly concentrated in the towns. The Georgian language is an official state language on the whole territory of the country.

National and Regional Development Priorities. Georgia's national and regional development priorities are determined by its geopolitical position, historical relations, socio-cultural features and requirements of the current moment.

Georgia, one of the oldest countries in the world, is located in the South Caucasus, between the Black and Caspian seas, south of the Great Caucasus Mountains. Because of its geographical location, Georgia, throughout its history played a special role in political processes of the region and always represented a subject of geopolitical interests of its neighboring countries. Its location significantly determined specificity of the country's socio-political and state development.

Georgia regained its independence after the collapse of the Soviet Union and firmly embarked on the path of building a democratic state. Since regaining its independence, Georgia has always taken further steps towards European integration and launched reforms in all areas. Georgia gradually joined European institutions and on 27 June 2014, Georgia, Ukraine and Moldova signed the Association Agreements with the EU. In parallel with these processes, the country is actively preparing for the accession to NATO.

The Association Agreement is part of the Deep and Comprehensive Free Trade Agreement (DCFTA), which has already entered into force on 1 September 2014. The DCFTA enables Georgia to gradually receive three of the four freedoms of the EU's internal market: Freedom of movement of goods, services and capital. The DCFTA opens the trade space to the goods and services produced in Georgia at the EU internal market and will increase investment attractiveness of the country.

The deep and comprehensive trade area means elimination of tariff and non-tariff barriers. It regulates a wide range of trade-related issues (e.g. food safety, product safety, competition policy, intellectual property protection, customs issues, public procurement, etc.).

Unlike other trade agreements, the DCFTA envisages gradual harmonization of the trade legislation and institutions with relevant EU regulations and administration mechanisms. The establishment of the deep and comprehensive free trade area between Georgia and the EU will facilitate:

- Establishment of the market trading system compatible with the EU requirements;
- Establishment of transparent and stable business environment;
- Increasing Georgia's investment attractiveness and therefore, foreign investments;

- Emergence of new enterprises and export products;
- Creation of new jobs as a result of growing local production;
- Diversification and expansion of export markets for Georgian products;
- Reduction of export-related costs for Georgian exporters;
- Supplying Georgian consumers with safe and harmless products;
- Development of state administration bodies in line with the best European practices;
- In general, promotion of economic growth and country's economic development.

Of course, integration of sustainable development and green economy principles in the country's development strategy, which is discussed below in more detail, plays a significant role in this, as well as in the process of deepening cooperation with the EU.

In particular, Chapter 4 of the Section 6 of the EU-Georgia Association Agreement defines climate-related activities, which is one of the Georgia's obligation. The agreement emphasizes the need for cooperation on climate change issues on the basis of equality and mutual benefit in the following areas: Climate change mitigation, adaptation to climate change, carbon trading, integration of climate change issues into sectoral policies and development of clean technologies. In addition to various cooperation issues, the following should be developed and implemented:

- National Adaptation Programmes of Action (NAPA);
- Low Emission Development Strategy (LEDS) including Nationally Appropriate Mitigation Action (NAMA);
- Promotion of technology transfer on the basis of the technology needs assessment;
- Measures related to ozone-depleting substances and fluorinated greenhouse gases.

One of the necessary conditions to efficiently implement the decentralization process within the stages defined by the Association Agreement is building expert, technical and financial capacity (at the municipal level).

The climate change decentralization process started at the stage of developing Georgia's Second National Communication and was significantly intensified after 2010, when Tbilisi, the capital of Georgia, first joined the European Union Covenant of Mayors (CoM), which envisages taking voluntary commitment by the city or the municipality to reduce by 20% greenhouse gas emissions on its territory for 2020.

Decentralization related to climate change also significantly contributed to the ongoing decentralization process in Georgia, which has significantly intensified since 2014[4], when the Organic Law of Georgia Local Government Code was adopted by the Parliament of Georgia.

Based on this Code, instead of five self-governing towns, the number of the self-governing towns increased to 12. Nine of them have been already connected to the abovementioned initiative of the European Union and other towns (as well as municipalities and provinces) are actively preparing for the CoM signature.

This initiative and the participating towns and municipalities are supported and actively assisted by the European Union, the US Agency for International Development (USAID) and other donors. From the USAID-funded projects it is noteworthy to mention: Institutionalization of the process of climate change adaptation and climate change mitigation measures in the regions of Georgia and Enhancing Capacity for Low Emission Development Strategies (EC-LEDS). One of the components of these projects is to support towns that are CoM signatories in developing Sustainable Energy Development plans.

[4] On 5 February 2014, the Parliament of Georgia approved the Organic Law Local Government Code. https://matsne.gov.ge/index.php?option=com_ldmssearch&view=docView&id=2244429&lang=ge

A number of initiatives are already underway to prepare and introduce in practice at the national level several issues listed in the EU-Georgia Association Agreement: Preparing Low Emission Development Strategy (LEDS), Biennial Update Reports (BUR), Nationally Appropriate Mitigation Action (NAMA), some of the examples of which are: Energy efficiency of the construction sector, sustainable forest management practices and massive popularization of water heaters powered by solar photovoltaic systems and Intended Nationally Determined Contributions (INDC). The EU, the German and US governments are supporting these initiatives.

Peaceful, mutually beneficial relations with all states and especially the neighbouring countries, protection of human rights (free and independent judiciary), strong and independent civil society and creating conditions for the maximum development of all citizens are principles recognized by the Government of Georgia.

Regional development priorities include development of mutually beneficial economic and cultural ties with neighboring countries, as well as strengthening economic cooperation among the countries of BSEC.

The new political force that came to power as a result of 2012 democratic elections in Georgia was very keen (and it was one of its challenges) to regulate relations with Russia, but the past two years and processes ongoing in Ukraine have shown that at this point this challenge remains as the challenge and its solution exceeds capacities of one single country. Overcoming this (as it seems) may require common efforts by the international community.

The free trade regime operates between Georgia and Azerbaijan, which is legally regulated both in bilateral, as well as multilateral formats (within the GUAM[5]). Over the years, Azerbaijan maintains the 2nd place among Georgia's main trade and economic partners. Energy is one of the main areas of cooperation between Georgia and Azerbaijan, which is expressed in jointly implemented major international projects, such as Baku-Supsa and Baku-Tbilisi-Ceyhan oil pipelines and the South Caucasus gas pipeline, as well as Gardabani-Samukhi high voltage power line. Active interaction in terms of the implementation of the South Energy Corridor projects and Baku-Tbilisi-Kars railway project is ongoing. Georgia-Azerbaijan-Turkey trilateral format, which in 2012 was initiated by the Ministers of Foreign Affairs ("Trabzon Declaration") is also an important political tool.

A regular political dialogue between Georgia and Armenia in the bilateral and multilateral formats is ongoing. Telecommunications, tourism and other important areas are covered by these formats. The countries actively cooperate in the regional forums, such as the Organization of the Black Sea Economic Cooperation (BSEC).

At this stage, the first priority for the country is to create state security guarantees and become the member of the North Atlantic Alliance (NATO). The establishment of the energy corridor (Baku-Tbilisi-Ceyhan and Baku-Supsa oil pipelines and the South Caucasus gas pipeline), which supplies energy products to Europe bypassing Russia served this purpose. The corridor, in addition to economic benefits, creates additional security guarantees for Georgia. As for regional cooperation on climate change issues, Georgia is actively cooperating with all countries, but mainly is united in the Azerbaijan, Moldova and Armenia group. Currently, the implementation of the EU-funded project: Support to Climate Change Mitigation and Adaptation in the Eastern Neighbouring Countries and Russia (ClimaEast) is ongoing, which covers Azerbaijan, Belarus, Moldova, Russia, Georgia, Armenia and Ukraine. The duration of the project is 4 years and it envisages technical assistance, as well as implementation of specific pilot projects in the participating countries. Georgia cooperates closely with Ukraine within the framework of the Covenant of Mayors.

Geography. Georgia is located in the south-eastern part of Europe, south to the Great Caucasus mountains, in the South Caucasus area between the Black and Caspian Seas. Georgia is bordered by Russia to the north, Turkey, Azerbaijan and Armenia by south and east. According to the website[6] of the Ministry of Environment and Natural Resources Protection, certain changes were made in the total area of Georgia's territory in 2002. Particularly, in 2002, according to the Law of Georgia on Water, the total area of territorial waters (Black Sea aquatorium) amounting to 6 790 km^2 was included in the territory of the country, after which the entire area of

[5] GUAM-Georgia, Ukrine, Azerbaijan, Moldova
[6] http://moe.gov.ge/index.php?lang_id=GEO&sec_id=43

the country from 1 January 2002 was defined at 76 284 km^2, of which land area is 69 494 km^2. Changes in land use made during 1992-2011 are given in Annex 1.1 .

Physical geography determines diversity of Georgia's mountainous relief: There are mountains, plateau, low-land-plains, glaciers, wetlands and arid areas (semi-deserts), lakes and rivers. A significant part of Georgian territory is occupied by mountains: More than 54% of the country's territory is located at the altitude above 1000 m. In addition to the Greater Caucasus Mountain Range, which surrounds the country from the north, there are several mountain systems in Georgia. Likhi Range stands out from these mountains. It runs from north to south along the middleof the country and divides it into the western and eastern parts.

The central part of East Georgia is occupied by Kura Valley, which starts from Likhi Range and runs through plains of Shida Kartli and Kvemo Kartli and flows evenly downwards to the east.

From the south, Kura Valley borders the Javakheti Volcanic Plateau, the height of which changes within the range of 2 000-3 300 m above sea level. The extreme eastern part of the region is Kakheti, which to the north is bordered by the southern slopes of the Caucasus.

Climate. Almost every climate zone is represented in Georgia, except for deserts, savanna and tropical forests. The Greater Caucasus protects the country from direct cold air intrusion from the north. Peculiar circulation of these air masses largely determines the precipitation regime on the whole territory of Georgia. Likhi Range contributes to having completely different climate in Georgia devided by west and east parts.

Climate in West Georgia is very diverse and in some places sharply changes from a humid subtropical zone to the zone covered with permanent ice. Climate here is determined by the Black Sea coast from the west, as well as by the Kolkheti Lowland located inside three large mountain ranges.

In 1960-1990, Georgia's climate was characterized by the following parameters[7]:

The Black Sea coast is characterized by humid subtropical climate. The average annual temperature here is 14-15^{0}C, while the sums of precipitation vary in the range of 1 400-2 700 mm. The temperature extremes are: +45 and -16^{0}C. The impact of the Black Sea on the climate in West Georgia is expressed in mild winter, hot summer and excess precipitation. Here, the annual average air temperature varies in the range of 9-14 and

(-2)-(+ 7)^{0}C in the hilly and high mountainous areas, with the absolute minima of -31 and -35^{0}C and accordingly, annual precipitation varies in the range of 1 100-2 300 mm and 900-1 900 mm.

Climate is drier in East Georgia: Dry subtropical in the lowlands and Alpine in mountain regions. The average annual temperature in the lowlands equals to 10-13^{0}C and (-6)-(+ 10)^{0}C in the mountains, respectively with the absolute minima of -28 and -36^{0}C. The absolute maximum temperature reaches +43^{0}C and the absolute minimum -42^{0}C on glacier slopes. Sums of annual precipitation are 400-1 000 mm in the plain, while they reach 500-1 300 mm in mountainous districts.

Natural Resources. The country's main natural resources are water and forests. In addition, Georgia has some reserves of a wide variety of mineral resources, the most important of which are manganese, as well as iron, copper, gold, coal and marble. Diverse nature, wonderful climate and abundance of healing geothermal and mineral waters determine the high number of resorts in Georgia.

Water. Georgia is rich in fresh water: 26 000 medium and small size rivers are registered here. The size of the rivers does not allow to use them for navigation, but they have rich fish production and significant hydropower potential (about 40 billion kWh according to the 1987 estimates), particularly due to their large inclination. More than 20 reservoirs are built on the rivers.

[7] The average values are given for the period of 1960-1990 . The absolute observation average values for the whole period.

The uneven distribution of precipitation determines significant difference between two major climate regions and their hydrographic networks. Glacier supplied abundant rivers of Bzifi (110), Kodori (84 km), Enguri (213 km) and Rioni (327 km) run on the southern slopes of the Caucasus in West Georgia. As for the East Georgia, less abundant rivers of Liakhvi, Aragvi, Alazani and Iori run from the Caucasus mountains. Annual runoff of West Georgian rivers (48.0 km^3) exceeds river runoff of East Georgian rivers by 3 times (13.4 km^3).

Kura (Mtkvari) is the largest river passing through the territory of Georgia (the total length of the river is 1 384 km and 351 km passes on the territory of Georgia). It originates in Turkey, crosses the whole East Georgia and flows into Mingechaur Reservoir (Azerbaijan) and afterwards in the Caspian Sea. Two other large East Georgian rivers also flow into the Kura River, namely: Alazani (362 km), which is the second longest river in Georgia and Iori (320 km). Both of them originate in the Great Caucasus Mountains and flow on the territory of Kakheti Region. Other East Georgian rivers include Liakhvi, Khrami and Aragvi.

From more than 850 lakes registered in Georgia, all of them are small in size. Their total area is 170 km^2 or 0.24% of the country's land area. Lake water reserves do not exceed 723 million m^3 and a part of these lakes participates in the formation of river flow. Among relatively great lakes, Tabatskuri (total volume of 221 million m^3), Didi Ritsa (94 million m^3), Paravani (91 million m^3) and Paliastomi (52 million m^3) are noteworthy to mention.

Glaciers existing on the territory of Georgia are mainly located in the central part of the Caucasus, in the basins of Enguri, Rioni and Kodori rivers. According to the 2014 data, 637 glaciers with the total area of 356 km^2 and estimated ice volume of 20 km^3 are registered in Georgia. During the last half-a-century, the number of glaciers in Georgia decreased by 13% and the area decreased by 30% respectively. In conditions of global warming, their full melting is projected by 2160.

Wetlands are mostly preserved in the western part of Kolkheti Lowland. Their total area is 627 km^2 and water reserves are 1.9 km^3.

A significant part of Georgia's water reserves is accumulated in the reservoirs. At present, their number reaches 45, while full capacity totals to 3.3 km^3 (useful - 2.3 km^3). From large reservoirs the following should mentioned: Jvari (Enguri River), Jinvali (Aragvi River), Sioni (Iori River), Tsalka (Khrami River) and Tbilisi (Iori River). The useful volume of each reservoir is more than 300 million m^3. Georgia is also rich in underground water resources, the total reserves of which are estimated at 21.7 km^3. This is 43% of total area surface runoff.

Forests. In addition to water resources, forests are the second unique natural resources of Georgia. Currently about 40% of Georgia's territory is occupied by forests. Their total wood reserves is estimated to be 443 million m^3. More than 800 species of trees, bushes, lianes, ferns and other perennial plants are registered in Georgia's forests, which are disseminated differently on the territory of the country according to the climate and soil. From tree species, deciduous species are dominant in lowland areas of Western Georgia, namely: Beech, oak, alder, chestnut and hornbeam and from shrub varieties: Rhododendron and cherry-laurel. With the increase of the height, they are replaced by coniferous species in high mountain regions - spruce, fir and pine, which are replaced by birch trees in high mountainous areas. In addition, Kolkheti's forests are rich in relict and endemic species (the zelkova tree, box-tree, yew, etc.), which makes biodiversity maintained in the protected areas (Kolkheti and Mtirala National parks, Kintrishi and Ajameti protected areas, ect.).

Eastern Georgia plains are mostly occupied by agricultural crops. Groves are rarely met here and there. Forests are mostly represented above 600-800 m and are dominated by hornbeam, beech and oak. From 1 200 meters above sea level they are gradually replaced by fir and pine, which are distributed up to 2 000 meters. The Borjomi protected area occupies a special place in the distribution of forests in the region. Along with Algeti protected area, it covers the richest areas of pine forests. Tusheti National Park, rich in pine forests also plays a very important role in this respect. Both districts, along with Georgia's other protected areas, play the important role in creating the country's tourist and recreational potential.

Southern (Meskhet-Javakheti) and eastern (Qiziki) regions of East Georgia are virtually devoid of forest cover. Only in the southern part of Qiziki, on the territory of Vashlovani Nature Reserve, small groves of cistus, juniper and Eldar pines (Pinus brutia subsp. eldarica) are preserved. Until 1990s, artificial windbreaks forests were planted on 1 700 hectares, which are currently in need of restoration and expansion. With regard to the ongoing climate warming, in the forest massifs of Georgia, especially in Western Georgia, various pests and diseases were disseminated in a number of varieties (chestnut tree, fir, pine) during the last 15-20 years. Fight against them represents a serious challenge to the forestry sector of Georgia.

Population. To the beginning of 2014, the population of Georgia was 4 490 500 persons[8] and its average density is 66 persons per 1 km2.

Two-thirds of the population (67%) is from 15 to 64 years of age; out of which, 45% is the working-age population. 53.7% of the total population lives in towns and this number varies between ± 0.3% in recent years.

Some variation in the population is observed in recent years within the range of 0.32%, which is mainly due to the high level[9] of migration and not the birth-death ratio changes (12.9 births and 10.8 deaths per 1 000 person in 2013). According to information provided by the Ministry of Internally Displaced Persons from the Occupied Territories, Accommodation and Refugees of Georgia, 272 954 Internally Displaced Persons (IDPs) from Abkhazia and South Ossetia were registered in Georgia in 2013.

Georgia's ethnic composition is diverse (Results of the 2002 National Census[10]: 83.8% ethnic Georgians, 6.5% ethnic Azerbaijani, 5.7% ethnic Armenians, 1.5% ethnic Russians and 2.5% - representatives of other ethnic groups). Georgian is the native language for 71%, Russian for 9%, Armenian for 7% and Azerbaijani for 6% of the country's population. A similar trend is observed in terms of religious faiths: In traditionally and historically tolerant Georgia, along with Orthodox Christians, who comprise 83.9% of the population, 9.9% Muslims, 3.9% Gregorian Christians, 0.8% Roman Catholics and followers of other religions reside peacefully with each other.

Economy. Like most former Soviet republics[11], Georgia still belongs to the category of countries with economies in transition.

Economic reforms aimed at ensuring transition to a market economy started immediately after the collapse of the Soviet Union, but were always implemented in conditions of political turbulence and for this reason they are still unfinished, although significant progress has been achieved. Last time, Georgia's economy has undergone serious changes in both quantitative and structural terms. Before the collapse of the Soviet Union, industry, agriculture and service sectors were the main branches of the country's economy with about equal share of the gross domestic product.

After the disintegration of the Soviet Union, the industrial sector collapsed in Georgia, as well in the majority of the member ex-Soviet republics, which was mainly caused by disrupting links between the former Soviet Union countries and the rise in energy prices. Problems in the energy sector in turn led to staggering in other sectors. This situation gradually changed as a result of starting reforms (since 1997) and after 2003, the country embarked on an even more intense path of economic reforms. Priorities and stages for economic development were defined. Creating the investment-friendly environment and removal of barriers to economic development were defined as the number one objective: Ensuring energy security/self-reliance and road construction as a necessary condition for the development of business and tourism. With gaining independence, stopping energy blockades and diversification of energy importers, it became possible to partly ensure energy security and relative recovery of agriculture and

[8] http://geostat.ge/

[9] Migration balance (-2.6 thous. persons) in 2013 was lowest after 2000 . During these years the balance was changing within the interval of -20 thous. persons +35 thous. persons and it was highest in 2005 equal to +76 thous. persons.

[10] Results of 2014 Census in Georgia will be available in 2016.

[11] The Union of Soviet Socialist Republics (USSR), to which Georgia was a part dissolved on 8 December 1991

other sectors. Existing factories were partially rehabilitated and equipment was updated, new enterprises were set up and private entrepreneurial activities were strengthened. Trade was expanded, construction, banking and service sectors started to develop intensively. Economic recovery was significantly determined by the intensive inflow of private capital. According to official statistics and the IMF data, 2007 was the pick year for the private capital inflow in the country within the period of 2007-2013. Relatively low rates were observed after the 2008 Georgia-Russia armed conflict, during the 2009-2010 post-war period. In comparison with the previous year, agriculture, industry, construction, trade and transport sectors determined 50.8% of the gross domestic product's overall increase in 2007.

Table 1.1. Dynamics of direct foreign investment in Georgia (in million USD)

	2007	2008	2009	2010	2011	2012	2013
Direct Foreign Investment	2 014.8	1 564.0	658.4	814.5	1 117.2	911.6	941.9

Strong anti-corruption policies also contributed to revitalization of the economy. Slowly, but firmly, unemployment rate started to decrease and social conditions improved. Dynamics of economic growth became irreversible, which is reflected in the dynamic growth of the economic indicators. Budget revenues exceeded 7 billion GEL in 2012[12]. Real annual GDP growth exceeded 6% on an average in 2010-2012. GDP composition (2013 estimates[13]) includes industry (17.2%), trade (17.3%), transport and communications (10.7%), agriculture (9.3%), construction (6.7%), health care (5.8%), public administration (10.1%) and other sectors (22.9%). In comparison with GDP, construction, hotels and restaurants, transport, financial activities and real estate, leasing and commercial service sectors were developing at an impressive speed. Progress in these sectors has been the most striking in recent years.

On 17 June 2014, the Government of Georgia approved the country's socio-economic development strategy until 2020, according to which the achievement of following estimates is scheduled for 2020[14]:

Table 1.2 Georgia's socio-economic parameters for the current year and forecasted estimates for 2020

Indicator	Current value	Projected value
GDP per capita (GEL, nominal)	5 811.70	13 000.00
GDP per capita (GEL, constant prices)	5 811.70	9 200.00
Gini coefficient	0.41	0.35
Inflation rate (%)	2.40	3.00
Unemployment (%)	15.00	<12.00
Taxes (percentage of GDP,%)	24.00	25.00
Exports (goods and services, the share of GDP,%)	45.00	65.00
Current account deficit (percentage of GDP,%)	>10.00	6.00
State debt to GDP (%)	34.00	<40.00

The strategy is based on three basic principles: Fast and effective economic growth focused on the manufacturing sector; implementation of inclusive economic growth policies, which implies involvement of the general population in the process of economic development and ensuring welfare of each member of the society as a result of economic growth; rational natural resource management in the process of economic development, ensuring environmental safety and sustainability (minimizing the risk of natural disasters). An analysis of the processes taking place in the economy revealed that at this stage, factors hindering implementation of the Georgia 2020 strategy are: Low competitiveness of the private sector, underdeveloped human capital and limited access to finances. In addition, special emphasis should be made on the part of the strategy related to innovation and technology. Low levels of innovation and technology in Georgia determines nonrational use of natural resources. This in turn threatens Georgia's natural wealth. In particular, Georgia ranked 73th in the

[12] http://geostat.ge/?action=page&p_id=313&lang=geo
[13] http://geostat.ge/cms/site_images/_files/georgian/nad/pres-relizi_2013_GEO.pdf
[14] Georgia's Socio-Economic Development Strategy - Georgia 2020. Tbilisi, 17 June 2014 http://www.government.gov.ge/index.php?lang_id=geo&sec_id=382&mod_id=0&info_id=0&new_year=0&limit=0&date=&new_month=&entrant=2

Global Innovation Index (GII 2013) and 44 among 131 countries according to the Innovation Capacity Index (ICI) in 2012. As for the Global Competitiveness Index (GCI), Georgia held the following positions in 2013-2014 among 148 countries:

- ICI – 118th position
- Company Spending on Research and Development (R&D) - 128th position.

Access to modern technologies, as well as the level of technological development is low. According to the index, Georgia has the following indicators:

- Access to the latest technology - 100th place;
- Introduction of new technologies by companies - 117th place.

The level of intellectual property protection is unsatisfactory, which is one of the important factors for the implementation of innovations. Georgia ranked 124 in terms of intellectual property protection[15].

From priority areas/activities discussed to achieve the objectives set within the strategy with respect to the climate change problem, some of them were emphasized:

Consistent decentralization and development of competitive regions, which are necessary to reduce the risks of climate change and promotion of modern technologies and innovations by the state, which is essential for sustainable development of the economy.

The strategy clearly reveals that the state undertakes an obligation to encourage introduction of environment-oriented modern technologies and development of “green economy” and to this end, the Government of Georgia will encourage inflow of direct foreign investments in the country, the main objective of which is to import-introduce the advanced technologies, especially environment-oriented resource saving technologies and development of the green economy.

One of the main directions of the strategy is energy independence. According to the Global Competitiveness Report 2013-2014, Georgia is ranked 52nd according to the energy supply quality indicator. World Bank’s Doing Business 2014 ranks Georgia 54 according to the access to electricity index.

The main task of the state policy in the field of energy should be reducing energy imports and increasing energy independence, improving the business environment and attracting foreign direct investment. Further improvement of the regulatory mechanisms is also very important, which, in turn, will help to attract investment in the energy sector and the sector’s rapid development. In order to increase energy independence and reduce energy imports, with the help of local and foreign investments, the state will promote implementation of energy- including strategic-energy projects, rational utilization of domestic energy resources so as to consider the factor of environmental impact in each project.

The strategy also focuses on energy efficiency issues and determines that with the aim to promote energy savings, energy efficiency will be supported and relevant legislative mechanisms in line with international and European norms will be developed in the country. Efficient use of energy in turn leads to the growth of energy independence and rational use of resources, as well as reduction of the energy costs. It can be said based on this strategy that at present, Georgia’s development scenario is the closest to the IPCC’s socio-economic development B2 scenario[16].

[15] Global indicators are taken from the Strategy http://www.government.gov.ge/index.php?lang_id=geo&sec_id=382&mod_id=0&info_id=0&new_year=0&limit=0&date=&new_month=&entrant=2

[16] The scenarios are presented in Annex 4.1

- Institutions related to the implementation of the Convention on Climate Change. Georgia joined the UNFCCC in 1994. Commitments taken by Georgia within the Convention on Climate Change imply providing full support, introduction and implementation of the Convention principles in Georgia. In particular:
- Development and implementation of the relevant legislation;
- Considering the problem of climate change during the implementation of measures to mitigate emissions, as well as in adaptation measures;
- Periodic preparation of the country's National Communications on Climate Change and submitting them to the CoP (Conference of Parties) of Climate Change Framework Convention;
- Conducting periodic national inventory of greenhouse gases and presenting it to the UNFCCC;
- Raising awareness on climate change and its impact among the population and decision makers;
- Reducing greenhouse gas emissions and planning and implementation of measures to mitigate the negative impact of climate change.

From these commitments, the most important is to periodically prepare and submit the national communications, which is performed with financial support from the Global Environment Facility (GEF).

The Government of Georgia is responsible for the implementation of the Convention on Climate Change, which through relevant sub-divisions of the Ministry of Environment and Natural Resources Protection directs and coordinates full implementation of the activities in Georgia in terms of fulfilling obligations under the Convention.

All the relevant authorities are involved in its preparation and contribute to data collection, processing, academic research, analyzes, preparing and implementing practical measures, dissemination of information and raising awareness on climate change. The following institutions are involved in fulfilling the requirements of the Convention:

Ministry of Energy, Ministry of Economy and Sustainable Development, Ministry of Regional Development and Infrastructure, Ministry of Agriculture, Ministry of Labour, Health and Social Affairs, Ministry of Education and Science, other governmental agencies, municipalities, academic institutions (institutions, research centers), technical and expert groups, NGOs and other interested parties.

Table 1.3 Structures and their functions related to the fulfillment of Georgia's obligations under the UNFCCC

Structures		Functions
Structures directly related to the implementation of the Convention on Climate Change	Ministry of Environment and Natural Resources Protection (the national body responsible for the Convention, the CoM coordinator); Ministry of Environment and Natural Resources Protection/Climate Change Service (the main responsible and implementing structure); Ministry of Environment and Natural Resources Protection/NEA (the main source for climate data and studies); Ministry of Energy (CoM coordinator)	Coordination, management and monitoring of policies and measures implemented for fulfilling obligations under the Convention; development of the legal framework/preparation of proposals to be submitted to the relevant parliamentary committees; monitoring and implementation of measures to achieve objectives and UNFCCC reporting.

Other governmental agencies	Ministry of Foreign Affairs (participation in the process of defining new obligations); Ministry of Energy (energy efficiency legislation and action plan, renewables); Ministry of Economy and Sustainable Development (energy efficiency in buildings, transport, green economy); Ministry of Agriculture (development of agriculture sustainable to climate change); Ministry of Regional Development and Infrastructure (vulnerability of infrastructure, waste management, social buildings); Ministry of Labour, Health and Social Affairs (control of new, climate-dependent diseases); Ministry of Education and Science (trainings, research, learning); Ministry of Finance (promoting innovation and introduction of modern technologies); National Agency for Cultural Heritage Preservation (considering climate change manifestations in the restoration of monuments); National Statistics Office (the main source of the sectoral data).	Exchange of data and proposals; Sector development plans to take into account the problem of climate change; Raising awareness; Strengthening local potential; Full participation in preparing the strategies.
Legislative branch of the government	The following parliamentary committees: Environmental Protection and Natural Resources; Sectoral Economy and Economic Policy; Agricultural Issues; Health and Social Affairs; Regional Policy and Self-Governance; Education, Science and Culture; Foreign Relations; European Integration; And Local councils;	UN Framework Convention on Climate Change (UNFCCC), Kyoto Protocol's Clean Development Mechanism (CDM), Low Emission Development Strategies (LEDS), Nationally Appropriate Mitigation Action for greenhouse gas reduction (NAMA); National Adaptation Programmes of Action (NAPA), energy efficiency legislation and facilitating development of necessary legislative framework for the implementation of the Action Plan; Facilitating incorporation of the problem of climate change in the sectoral and regional development plans.
Academic institutions	Ivane Javakhishvili Tbilisi State University after (TSU); Ilia State University (ISU); Georgia Technical University of (GTU); Agricultural University of Georgia; GTU Institute of Hydrometeorology; TSU Vakhushti Bagrationi Institute of Geography ISU Institute of Botany; Vasil Gulisashvili Forest Institute at the Georgian Agricultural University; TSU Mikheil Nodia Institute of Geophysics.	Data exchange and processing; Monitoring of the negative consequences of climate change; Academic research and analysis of the impact of climate change.
Local self-governments	Municipalities; Councils; Self-governing communities and farmers' associations; Other regional institutions.	Considering the risks of climate change in local development plans; Data and experience exchange/sharing; Local capacity building through the engagement in the processes; Awareness raising and training; Proposal development.
Other participants	Non-governmental organizations; Private sector; Media; National experts.	Data collection, exchange and processing; Expert analysis of materials, document preparation; Developing proposals on climate change mitigation and adaptation measures; Dissemination of obtained results.

In order to increase their credibility, data are collected from the official bulletins of the National Statistics Office of Georgia (annual books[17]), the National Environmental Agency, relevant ministries and enterprises. The data obtained from different sources is reconciled and analyzed by expert as much as possible.

Representatives of academic institutions and industrial-research organizations mainly participate in data processing, academic research and analysis.

Georgia's Third National Communication on Climate Change was jointly prepared by the United Nations Development Programme and the Government of Georgia.

local and regional authorities and experts in Ajara, Kakheti and Upper Svaneti were actively involved in this process. 3 major working groups were established under the project: GHG inventory, vulnerability and adaptation, and greenhouse gas emission reduction. National experts from different agencies were involved in these groups. The present document was developed by the selected expert groups in close cooperation with the relevant agencies and independent experts. The document takes into account UNFCCC and IPCC recommendations and guidelines to the maximum extent.

[17] http://geostat.ge/

2 National Inventory of Greenhouse Gases

2.1 Introduction

On 9 May 1992, the world's countries adopted the United Nations Framework Convention on Climate Change with a main goal to stabilize greenhouse gas concentrations in the ambient air at the level that will not cause irreversible processes in the climate system. At the same time, stabilization of the concentration at the maximum permissible level should be ensured in terms, which will be enough for the natural adaptation of the ecosystems to climate change. This will reduce threats related to food production and will ensure development of an economy in a sustainable manner.

The ability of the international community to achieve its goal by reducing greenhouse gas emissions, largely depends on good knowledge and awareness of the GHG emission trends. According to Article 4(1)(a) and Article 12(1)(a) of the Convention, all parties to the Convention[18] mentioned above, shall provide information on emission and absorption sources to the highest body of the Convention - the National Conference of the Parties.

For the countries that did not join Annex I to the Convention, the National Communication was the main reporting mechanism until 2010[19]. Following the decision[20] made by the participants at the 16th Conference, from 2014, all countries are obliged to submit independent and comprehensive biennial update reports (BUR[21]) on GHG emission trends and climate change mitigation measures.

The first GHG inventory in Georgia was conducted based on materials from 1980-1996 years within the framework of the First National Communication (1997-1999). The Second National Communication (2006-2009) covered 1998-2006. The Third National Inventory covered the inventory conducted in 2007-2011. In addition, results of previous years for industrial processes and waste sectors were re-counted.

This section describes the results of the Third National Inventory of Greenhouse Gases. The inventory is based on the methodology of the Intergovernmental Panel on Climate Change (IPCC), which consists of the following two main documents (hereinafter referred as the IPCC methodology for both):

- The 1996 IPCC revised guidelines for the national greenhouse gas inventories[22] - afterwards referred to as the IPCC 1996.
- The IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories[23] - afterwards referred to as the IPCC GPG;
- In addition, the 2006 IPCC guidelines for national inventory of greenhouse gases were also used (IPCC 2006[24]). The IPCC 2006 is not a binding document, but contains additional and useful information.

According to the IPCC Common Reporting Format (CRF), the following six sectors are discussed in the inventory:

- Energy (CRF sector 1)
- Industrial processes (CRF sector 2)

[18] Conference of Parties - COP

[19] At the 16th Conference of Parties (CoP), in 2010, Cancun, Mexico decisión was made by Parties on preparation of separate periodic reports including GHGs national inventory and mitigation measures.

[20] 1/CP16; http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2.

[21] BUR -Biennial Update Report.

[22] IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Emission Inventories. Reference Manual. IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK. http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html.

[23] IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC-TSU NGGIP, Japan. http://www.ipcc-nggip.iges.or.jp/ public/gp/english/

[24] IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

- Solvents and the use of other products (CRF sector 3)
- Agriculture (CRF sector 4)
- Land use, changes in land use and forestry[25] (CRF sector 5)
- Waste management (CRF sector 6)

The Climate Change Convention requires information on the following gases:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbon (PFCs);
- Sulfur hexafluoride (SF6).

These gases are often called the "six greenhouse gases", but in reality, HFCs and PFCs are the gas groups. Each of them individually contributes to the "greenhouse effect".

The contribution of the gas compounds depends on the gases composing the mix and their proportions. The so-called industrial gases: SF_6, HFCs and PFCs are the gases with the highest global warming potential.

As for the natural greenhouse gases, methane holds 21 times more heat than carbon dioxide and nitrous oxide 310 times more heat than carbon dioxide. The Global Warming Potential (GWP) was introduced to control greenhouse gas emissions and characterize the heat absorption capacity of gases, which allows expressing all gases in CO_2 equivalents (CO_2eq).

According to the IPCC methodology, in the Second IPCC Assessment Report[26], the GWP values are given in the span of 100 years. These GHG global warming potential values are shown in the Table below.

Table 2.1 Global Warming Potential (GWP) of direct GHGs

Gas	Lifetime, years	GWP for 100 years time horizon		Gas	Lifetime, years	GWP for 100 years time horizon
CO_2	Variable (50-200)	1		HFC-227	36.5	2 900
CH_4	12±3	21		HFC-236	209	6 300
N_2O	120	310		HFC-245	6.6	560
HFC				PFCs:		
HFC-23	264	11 700		CF_4	50 000	6 500
HFC-32	5.6	650		C_2F_6	10 000	9 200
HFC-125	32.6	2 800		C_3F_8	2 600	7 000
HFC-134a	10.6	1 300		C_4F_{10}	2 600	7 000
HFC-143	48.3	3 800		C_6F_{14}	3 200	7 400
HFC-152	1.5	140		SF_6	3 200	23 900

Georgia's Third National Inventory reviews all direct gases[27] and indirect greenhouse gases, such as: Nitrogen oxides (NO_X), carbon monoxide (CO) and non-methane volatile organic compound (NMVOCs). The IPCC methodology also recommends to calculate sulfur dioxide or sulfur anhydride (SO_2) emissions.

[25] Hereinafter referred as the land-use sector
[26] IPCC Second Assessment - Climate Change 1995. IPCC, Geneva, Switzerland, p. 64
[27] Direct gases or direct GHG gases are listed in Table 2.1.: GHG Gases

2.2 Institutional Arrangements

The Ministry of Environment and Natural Resources Protection of Georgia is the agency responsible for the greenhouse gas inventory in Georgia, but due to the lack of human and financial resources, the inventory cannot be performed without external assistance.

This inventory was conducted within the framework of Georgia's Third National Communication on Climate Change, which the country prepares with the financial assistance provided by the Global Environment Facility (GEF). The inventory at this stage is conducted with UNDP support.

The expert group involved in the development of Georgia's Third National Communication, the personnel of the Department of Climate Change at the Ministry of Environment and Natural Resources Protection and invited experts participated in the development of this Inventory Report.

At this stage, the process of drafting the national communications is not a continuous process in Georgia. In the process, services of hired experts are mainly used. Therefore, the process of inventory of greenhouse gases is not permanent and continuous. It is not so far possible to ensure development and utilization of accumulated knowledge and experience in the continuous mode.

In addition, it is problematic to receive statistical data necessary for the inventory as this process is organized within the projects and does not depend on the organized supply of information from various state or private organizations.

Taking the abovementioned into account, at this stage, the most important issue for improving quality of the inventory is the improvement of the institutional arrangement. In this respect, it is necessary to discuss the issue of establishing the agency responsible for conducting the inventory, defining its functions and funding sources. In this process, mechanisms for receiving statistical and other types of information and ways to increase the expert potential should be clearly defined. As mentioned above, Georgia starts the process of drafting the BUR in 2015. It is important to pay attention to the continuity of conducting the greenhouse gas inventory, strengthening the local potential, as well as assessing barriers to this process and developing recommendations to overcome them.

The greenhouse gas inventory and its monitoring at the national, municipality and town levels become more and more important for attracting new investments in terms of the mitigation of the climate change processes and assessing the country's contribution in global processes.

2.3 Data Sources and Methodology

In order to conduct the inventory of the greenhouse gasses, it is necessary to search for the ongoing activity data (statistics), the main source of which is the National Statistics Office of Georgia. In the process of this inventory, the data received from other organizations were also used. The full list of these organizations by the categories is given in the Annex 2.1.

The values of the emission factors are mainly taken from the IPCC methodology. Detailed information on the emission factors according to the source-categories is also given in Table 2.1.

As it was already mentioned, the methodology for conducting this inventory is based on the IPCC guiding documents. Detailed information on methodologies used according to the sub-categories is given in Table 2.2.

Table 2.2 Methodological approaches used for the inventory

IPCC Source-category	Gas	Methodology
1A. Fuel combustion	CO_2, CH_4,N_2O	IPCC 1996 Tier 1, Sectoral approach, for calculation of CO_2 Reference approach was applied as well
1B1. Fugitive emissions from solid fuel	CH_4	IPCC 1996, Tier 1 (Global Average Method – GAM)
1B2. Fugitive emissions from oil extraction	CH_4	IPCC 1996, Tier 1
1B2. Fugitive emissions from gas production	CH_4	IPCC 1996, Tier 1
1B2. Fugitive emissions from gas transportation and distribution	CH_4	Adapted Clean Development Mechanism (CDM) methodology (Tier 3)
2A1. Cement production	CO_2	IPCC 1996 Tier 1, If the data on clinker content in cement is not available, cement annual production data are used
2A2. Lime production	CO_2	IPCC 1996 Tier 1, according to which CO_2 emission is assessed multiplying EF (CO_2 emitted when producing 1t lime) by the amount of lime produced in tons.
2A3. Limestone and Dolimite use	CO_2	IPCC 1996 Tier 1, CO_2 emission is calculated multiplying EF (CO_2 emitted when processing 1t raw material) by the amount of limestone produced in tons.
2A4. Glass (soda ash) production	CO_2	IPCC 2006, Tier 1
2B1. Ammonia production	CO_2	IPCC 1996, Tier 1
2B2. Nitric Acid production	N_2O	IPCC 1996, Tier 1
2C1. Iron and Steel production	CO_2	IPCC 1996, Tier 1 b
2C2. Ferroalloys production	CO_2	IPCC 1996, Tier 1 b
2E. Sulfur Hexalouride use	HFC	IPCC 1996, Tier 1
2F. Halocarbons use	SF_6	IPCC 1996, Tier 2
3. Solvent and other product use	N_2O	Simplified mthod for calculation of per capita averaged emission factors of NMVOC for European countries, (EMEP/CORINAIR (EEA, 2005) table. 8.1.1.).
4. Agriculture, all sub-categories	CH_4 N_2O	IPCC 1996, Tier 1
5. Land use, Land-Use Change and Forestry, all sub-categories assessed	CO_2	IPCC GPG (Good Practice Guidance for Land Use, Land-Use Change and Forestry).
6A. Solid waste disposal	CH_4	IPCC 2006, FOD (First Order Decay model)
6B1. Industrial wastewater	CH_4	IPCC 1996
6B2. Domestic and commercial wastewater	CH_4	IPCC 2006 Tier 2
6B2. Domestic and commercial wastewater	N_2O	IPCC 1996

2.4 Key source analysis

The methodology to assess greenhouse gas emissions according to the key categories is described in the IPCC GPG Chapter 7. According to the IPCC definition, key is the source, which should be given a priority in the process of conducting the national inventory (or in the system of the national inventory), as it has an impact on the absolute values of country's greenhouse gases.

It is accepted that the main effort in the process of conducting the national inventory should be directed towards improving the inventory of the key source-categories and reducing uncertainty of their emissions. This section discusses analysis of the key sources of greenhouse gas emissions in Georgia in 2000-2011 for the absolute values of emissions (the analysis of emission levels), as well as for trends (trend analysis).

The year of 2000 and not 1990 was determined as the baseline year during the trend analysis, as the economy in 1990, in comparison with the current period, had entirely different structure and management principles.

The use of 1990 as the baseline year would have identified the source-categories, which, after the breakdown of the Soviet Union underwent the highest number of structural and qualitative changes and therefore, would not have been informative for evaluating ongoing trends and processes.

The analysis is made without considering the sector: Land use, changes in land use and forestry. The identified key source-categories are presented in Table 2.3. In 2011, the total value of the key source categories amounted to 15 740 Gg CO_2eq. and included 97.8% of the total emissions (without the land use sector).

Table 2.3 Key source-categories of Georgia's GHG inventory according to 2011 year Level and Trend assessment approaches

No	Source-category	Gas	2011 Emissions (Gg)	Level assessment (%)	Trend assessment, (%)	Reason to select as Key- category
1	1B2. Fugitive emissions from gas transport and distribution processes	CH_4	2357	15%	13%	Level, Trend
2	1A3. Road transport (gasoline)	CO_2	1236	8%	1%	Level, Trend
3	4A. Enteric fermentation	CH_4	1189	7%	9%	Level, Trend
4	1A1. Electricity and heat production (gas)	CO_2	1179	7%	2%	Level, Trend
5	1A3. Road transport (diesel)	CO_2	1000	6%	7%	Level, Trend
6	2A1. Cement production	CO_2	983	6%	7%	Level, Trend
7	1A4b. Residential gas	CO_2	926	6%	4%	Level, Trend
8	6A. Solid waste	CH_4	904	6%	3%	Level, Trend
9	2F. Halocarbons use	HFC	804	5%	8%	Level, Trend
10	2B2. Nitric Acid production	N_2O	721	4%	0%	Level
11	1A2. Manufacturing industries and construction (gas consumption)	CO_2	553	3%	3%	Level, Trend
12	1A2. Manufacturing industries and construction (solid fuel consumption)	CO_2	438	3%	5%	Level, Trend
13	2C2. Ferroalloys production	CO_2	413	3%	4%	Level, Trend
14	4D3. Indirect emissions from soils	N_2O	390	2%	3%	Level, Trend
15	4D1. Direct emissions from soils	N_2O	364	2%	4%	Level, Trend
16	2B1. Ammonia production	CO_2	348	2%	1%	Level
17	2C1. Iron and steel production	CO_2	341	2%	4%	Level, Trend
18	1A4c. Agriculture/Fishing/Forestry (Liquid fuel)	CO_2	253	2%	0%	Level
19	1A4b. Residential liquid fuel	CO_2	245	2%	3%	Level, Trend
20	4D2. Animal production	N_2O	238	1%	2%	Level, Trend
21	6B2. Residential and commercial wastewater handling	CH_4	218	1%	1%	Level
22	4B. Manure management (CH_4)	CH_4	214	1%	2%	Level, Trend
23	1B1. Fugitive emissions from solid fuel	CH_4	99	1%	1%	Trend
24	1A. Fuel combustion	CH_4	79	0%	4%	Trend
25	1A2. Manufacturing industries and construction (liquid fuel consumption)	CO_2	75	0%	2%	Trend
26	1A4c. Agriculture/Fishing/Forestry (Gas)	CO_2	72	0%	1%	Trend
27	4B. Manure management (CH_4)	N_2O	44	0%	1%	Trend
28	1A4a. Commercial gas	CO_2	41	0%	1%	Trend
29	1A. Fuel combustion (biomass)	N_2O	16	0%	1%	Trend
	Total		15 740	97.8%	97.3%	

As the Table shows, according to the level and trend assessments, fugitive emissions are on the first place from the natural gas transportation and distribution sector. If we take into account that the emission uncertainty contribution of this sector's is also very high in the total uncertainty of the inventory, it is clear that this sector should be considered as the priority. Moreover, it is necessary to find ways for improving its methodology, activity data and emission factors.

According to the evaluation level, gasoline consumption in road transport ranks second. According to the assessment of the trend - methane emissions from enteric fermentation are on the 2nd place, which clearly demonstrates the particular importance of this sector in both inventories.

Liquid fuel and gas consumption in the energy sector is also key in almost all source-categories. Biomass (wood) consumption in this sector is also central in terms of methane and nitrous oxide emissions. Lately, due to the activation of coal mining activities, fugitive emissions from fuel production/processing and solid fuel combustion from the industry sector are in the key categories.

The industrial processes sector is represented in key source-categories with cement, nitric acid, ferroalloys, ammonia, iron and steel production. The key agricultural categories are enteric fermentation, manure management (CH_4) and all three sub-categories of agricultural soils (4D1, 4D2 and 4D3). The waste sector is represented with methane emissions from the solid waste sector and domestic and industrial waste waters.

2.5 Total Emissions and Trends by Greenhouse Gases

GHG (CO_2, CH_4, N_2O, HFC, SF_6) emission trends for the years of 1990-2011 are given in Table 2.4 (without considering the land use sector). In 1990, emissions amounted to 47 187 Gg CO_2eq. After the collapse of the economic system in the Soviet period, emissions started to decrease and reached their minimum value in 1995 (8 799 Gg CO_2eq.). In 1995, emissions started to increase, but the growth rate was lower than the reduction trend in the years of 1990-1995.

It should be mentioned that relatively high emissions of 1996-1997 are determined by the significant error in the data of the transport sector[28]. With the exception of these two years, the trend was steadily growing until 2007, when the economy reached its peak growth, but the trend was again characterized by the decrease in emissions until 2010.

There were several reasons for this and the economic recession due to the global economic crisis, the 2008 war and the increased share of hydropower electricity generation sector in these years were the main reasons. The year of 2011 was marked with the sudden and very rapid growth in emissions (19% compared to last year), which was caused by the following several factors working jointly: Economic recovery, growth on electricity demand and relatively poor hydrological year, as well as the increase in the use of coal in the processing industry sector. A more detailed analysis of the trends in greenhouse gas emissions by gas, as well as by the sector are given in the relevant chapters.

Data on greenhouse gas emissions and removals from the land use, changes in land use and forestry sector are given in Table 2.5.

This sector is the stable source of emission absorption in Georgia, although simultaneous emissions of carbon dioxide (39 583 Gg) from the arable land sector was observed in 2004. These emissions were associated with the new data obtained as a result of the land registry conducted in 2004, according to which, drastic changes were observed in almost all land categories, particularly in the agricultural land category, where the areas with perennial crops were almost halved.

[28] National GHG Inventory Report, Georgia's Second National Communication, Tbilisi, 2008. p. 24-25.

It can be said with high probability that the reduction in the area did not take place in one year and it was stable in the previous years too. This is why it should be analyzed and appropriately corrected in the future.

In total, during 20 years (1992-2011), 87 000 Gg of carbon dioxide emissions were generated in this sector, while 146 576 Gg were absorbed. This is why, this sector still remains as the source of absorption/removal of CO_2.

Without considering the land use, changes in land use and forestry sector, greenhouse gas emissions in Georgia amounted to 16 096 Gg CO_2eq. in 2011. For the same year, the annual GHG emissions amounted to 11 470 Gg CO_2eq. with the data from the land use, changes in land use and forestry sector.

Table 2.4. GHG Emissions Trends in Georgia in 1990-2011 (Gg CO_2eq.)

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2	38 543	29 947	18 078	9 727	6 145	4 177	6 875	7 339	3 373	3 680	3 710
CH_4	5 920	5 030	5 827	4 689	3 952	3 222	3 393	4 445	4 510	4 468	5 230
N_2O	2 724	2 459	1 996	1 624	1 297	1 401	2 003	2 168	1 703	2 058	1 833
HFC								33	40	85	90
SF_6								0.02	0.02	0.02	0.03
Total	47 187	37 436	25 902	16 040	11 394	8 799	12 272	13 985	9 625	10 290	10 864

Gas	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2	3 880	3 685	3 936	4 847	5 047	6 250	7 161	7 116	6 613	6 684	8 354
CH_4	4 579	4 453	4 782	4 755	4 439	6 017	5 592	5 075	4 477	4 233	5 098
N_2O	1 728	2 075	2 181	1 989	2 402	2 083	1 881	1 650	2 030	1 981	1 839
HFC	97	112	152	176	221	279	368	467	547	632	804
SF_6	0.03	0.03	0.03	0.03	0.03	0.05	0.06	0.14	0.17	0.22	0.25
Total	10 284	10 326	11 051	11 767	12 110	14 628	15 002	14 309	13 667	13 529	16 094

Table 2.5. GHG Emissions and Absorption Trends in Georgia in the Land Use, Changes in Land Use and Forestry Sector in 1990-2011 (Gg CO_2eq.)

Source	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO_2 emission	2 673	2 547	2 508	2 508	2 507	2 514	2 525	2 469	2 468	2 470
CO_2 removal	-9 764	-9 111	-9 146	-3 390	-3 899	-7 441	-7 205	-8 884	-8 557	-8 625
Total	-7 091	-6 564	-6 638	-882	-1 392	-4 928	-4 680	-6 415	-6 089	-6 155

Source	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2 emission	2 470	2 470	39 583	2 470	2 470	2 470	2 470	2 470	2 470	2 470
CO_2 removal	-7 992	-8 831	-6 691	-7 363	-6 568	-6 568	-6 911	-6 911	-5 621	-7 095
Total	-5 522	-6 361	32 892	-4 893	-4 098	-4 098	-4 440	-4 440	-3 151	-4 624

Fig. 2.1 shows the share of the direct greenhouse gas emissions in the country's total emissions (excluding the land-use sector). As Figure 2.1. demonstrates, the carbon dioxide had the largest share - 81.7% in 1990, methane was on the second place and nitrous oxide ranked third with 5.8%.

With the collapse of the economy, carbon dioxide emissions were reduced and for a long time (1998-2004), methane was leading in the greenhouse gas emissions from the territory of Georgia. In 2005, the economy began to move forward and related carbon dioxide emissions increased. Also, fluorinated hydrocarbon emissions increased considerably in recent years, which is connected to the increase in the number of refrigerators and air conditioners loaded with fluorinated hydrocarbons.

In 2011, the GHG emission shares according to the gases were as follows: Carbon dioxide - 51.9%, methane 31.7%, nitrous oxide - 11.4%, fluorinated hydrocarbons - 5%. The SF6 emission share was tiny.

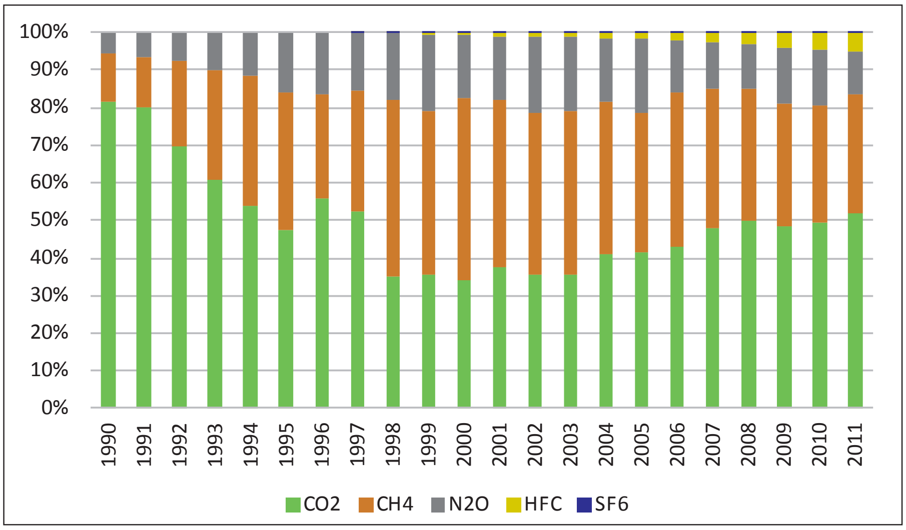

Fig. 2.1. Share of each GHG in total emission of the country, 1990-2011

Below, the reasons for the change are discussed individually for each reviewed gas.

A) Carbon dioxide (CO_2)

Carbon dioxide emissions amounted to 38 543 Gg in 1990 and 8 354 Gg in 2011. In 2011, in comparison with 1990, carbon dioxide emissions were less by 4.6 times and 2.3 times more than emissions in 2000. The main source of carbon dioxide emissions is the energy sector and carbon dioxide emissions are actually repeating the trends in this sector. With the disintegration of the Soviet Union, carbon dioxide emissions fell sharply and were at the very low level until 2000. In 2001, they again started to increase, which was related to economic growth. Growth of the transport sector and improved living conditions of the population also contributed to this.

Due to the economic recession of 2008-2010, carbon dioxide emissions continued to decline, and in 2011, the sharp increase in emissions was again observed. The main reason for this was the improved economic situation, which lead to the increase in emissions in the energy, as well as the industrial processes sector. One of the reasons for increased carbon dioxide emissions in 2011 was the high rates of thermal power generation. The carbon dioxide emission rates for 2000-2011 are shown in Figure 2.2.

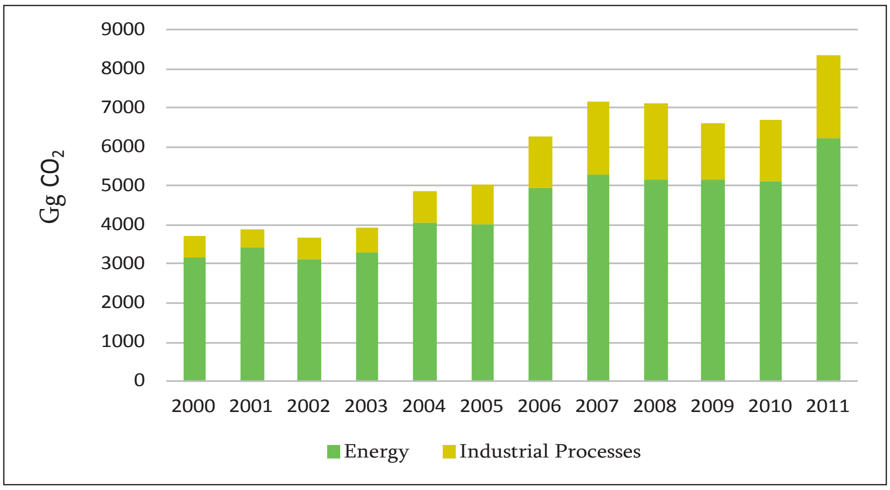

Fig. 2.2. Sectoral emissions of CO_2 in 2000-2011

B) Methane (CH_4)

Methane emissions amounted to 5 920 Gg CO_2eq. in 1990 and 5 098 Gg in 2011. In 2011, methane emissions were reduced by 14% in comparison with the year of 1990, while in comparison with 2000, they were reduced by 3%. The main source of methane emissions is the energy sector, where its share in 2000 was 51.3% and 50.0% in 2011.

The main source of methane emissions in the energy sector is losses of natural gas from the natural gas transportation and distribution sectors, which was characterized with the declining trend in the years of 2006-2010. Such decline was related to the reduction of gas consumption for heat generation, as well as the reduction in gas transportation.

The agricultural sector is on the second place in terms of methane emissions. Since 2005, emissions in this sector are characterized with the declining trend. The declining trend of these two dominant sectors leads to the decline in the overall trend of methane emissions in 2005-2010.

In 2011, the increase in gas consumption in the energy sector, which was accompanied by the increase in losses and methane emissions in the waste sector, was the main reason for the growth of methane emissions. Fig. 2.3 shows methane emissions in 2000-2011 by the sectors.

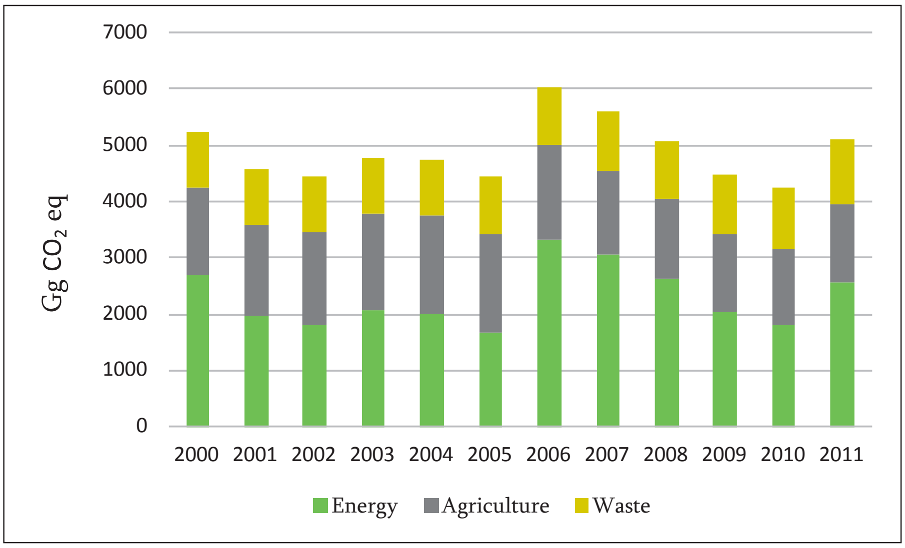

Fig. 2.3. Sectoral emissions of CH_4 in 2000-2011

C) Nitrous Oxide (N_2O)

Nitrous oxide emissions amounted to 2 724 Gg CO_2eq. in 1990 and 1 839 Gg. in 2011. In 2011, emissions of nitrous oxide were reduced by 32.5% in comparison with 1990 and were increased by 0.3% in comparison with 2000.

The main source of nitrous oxide emissions was the agriculture sector, which made 68.1% of nitrous oxide emissions in 2000 and 56.5% in 2011.

The industrial processes sector is on the second place, where N_2O is generated from the chemicals industry. The trends of these two sectors mainly determine the variability of nitrous oxide trend.

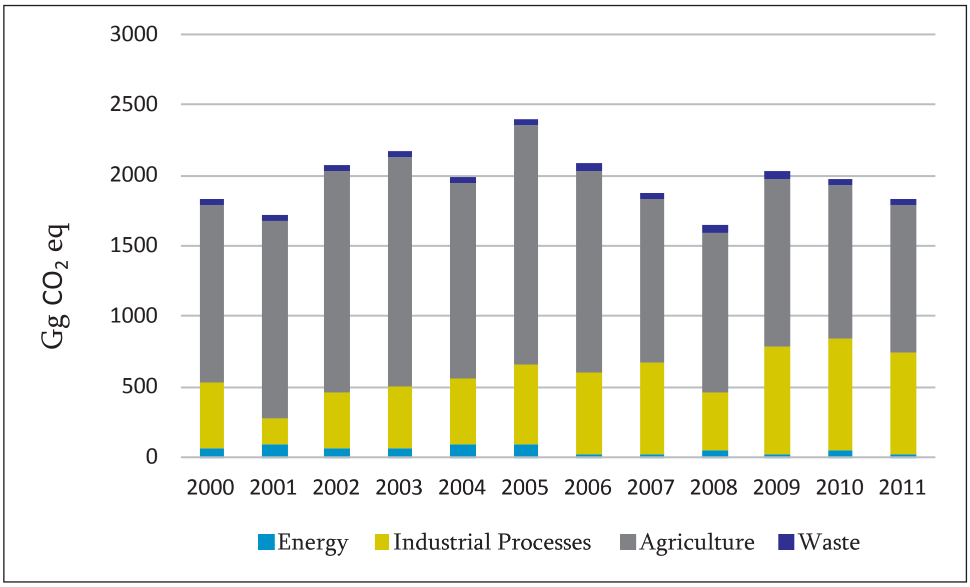

Fig. 2.4. Sectoral emissions of N_2O in 2000-2011

D) Hydrofluoridecarbons (HFC) and Sulfur Hexafluorines (SF_6)

Counting of HFC emissions started in 1997. HFC emission values are shown in Table 2.4 - they are completely generated by the industrial processes sector. In 1997, their emissions in CO_2eq. were 33 Gg., 90 Gg in 2000 and 804 Gg in 2011.

HFC emissions have the pronounced growth trend determined by accumulating HFC containing machinery in the country. The largest share of these emissions is generated from operating industrial refrigerator-devices.

SF_6 emissions in Georgia are generated from the operation of electrical equipment containing SF_6. Since 1997, SF_6 has been used in communication devices in Georgia, namely, in different voltage circuit breakers located on energy facilities. SF_6 emissions are very low in Georgia and amounted to only 617 tons CO_2eq. in 2011.

2.6 Greenhouse Gas Emissions by Sector

The emission trends by the sectors[29] for the years of 1990-2011 are given in Table 2.6. This Table includes all sectors except the land use sector[30].

The change of the contributions of each sector in total emissions (without the land use sector) is given in Figure 2.5.

As the Table and the Figure demonstrate, the dominant sector is the energy sector. Its share makes more than half of the country's total emissions since 1998.

After the collapse of the Soviet Union, the share of the agricultural sector is gradually increasing in the share of total emissions. The agricultural sector ranks second and was stably maintaining this position in 2000-2005 (in the range of 25%). Since 2007, the industrial processes sector has been again ranking second.

In 2011, the share of the industrial sector in the total emissions was 22.7% and the share of the agricultural sector amounted to 15.2%.

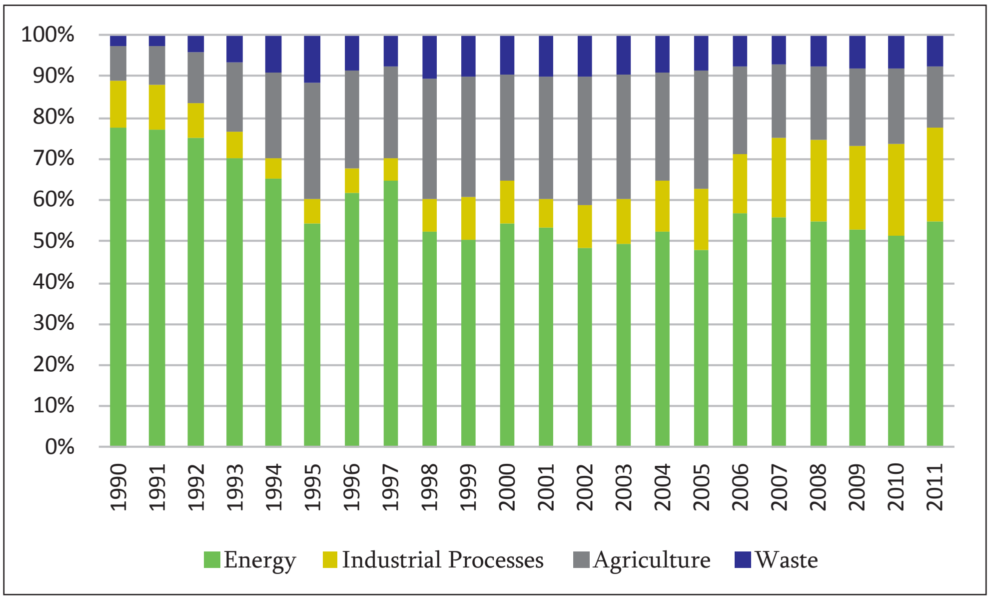

Fig. 2.5. Share of sectoral emissions in total emission of the country (excluding Land- use sector), 1990-2011

[29] Industry sector also includes emissions from "Solvent and other products" category.
[30] Emissions and absorption from the land-use sector are presented in Table 2.5.

Table 2.6. Trends in GHG Emissions by Sector for 1990-2011 (Gg CO_2eq.)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy	36 587	28 815	19 395	11 246	7 445	4 790	7 585	9 018	5 057	5 183	5 925
Industrial processes	5 383	4 084	2 245	1 068	543	520	703	810	744	1 070	1 096
Agriculture	3 985	3 525	3 242	2 703	2 386	2 461	2 954	3 124	2 790	2 991	2 802
Waste	1 232	1 011	1 020	1 024	1 020	1 028	1 030	1 033	1 034	1 043	1 041
Total	47 187	37 436	25 902	16 040	11 394	8 799	12 272	13 985	9 625	10 287	10 864

Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Energy	5 466	5 006	5 449	6 144	5 786	8 301	8 378	7 849	7 216	6 977	8 800
Industrial processes	748	1 058	1 220	1 452	1 810	2 138	2 890	2 822	2 749	2 987	3 658
Agriculture	3 025	3 214	3 331	3 120	3 460	3 115	2 651	2 552	2 604	2 451	2 445
Waste	1 045	1 049	1 051	1 052	1 054	1 073	1 083	1 086	1 097	1 114	1 191
Total	10 284	10 326	11 051	11 767	12 110	14 628	15 002	14 309	13 667	13 529	16 094

2.6.1 Energy Sector (CRF Sector 1)

In 2011, **emissions from the energy sector** constituted 54.7% of the total emission share (excluding the land-use sector). In 2011, emissions from the energy sector were 75.9% less than in 1990 and increased by 48.5% in comparison with 2000.

The collapse of the Soviet economy, halting of the industry and sharp deterioration in living conditions in the years of 1990-1995 resulted in the reduction of total emissions.

Since 1995, emissions fluctuated, but began to rise slowly in 2002. Fig. 2.6 shows emissions from the energy sector for the years of 2001-2011. Economic growth, improving living conditions, the increase in the quantities of vehicles and rapid gasification were the factors affecting the emission trends of the energy sector in 2001-2007. In 2008-2010, emissions showed the downward trend. This was determined by economic recession due to the global economic crisis, the 2008 war and the increased share of hydropower generation in the electricity generation sector of these years.

In 2011, emissions from the energy sector remained high, they were ahead of the 2007 values and reached the new peak of the recent years - 8 800 Gg CO_2eq.

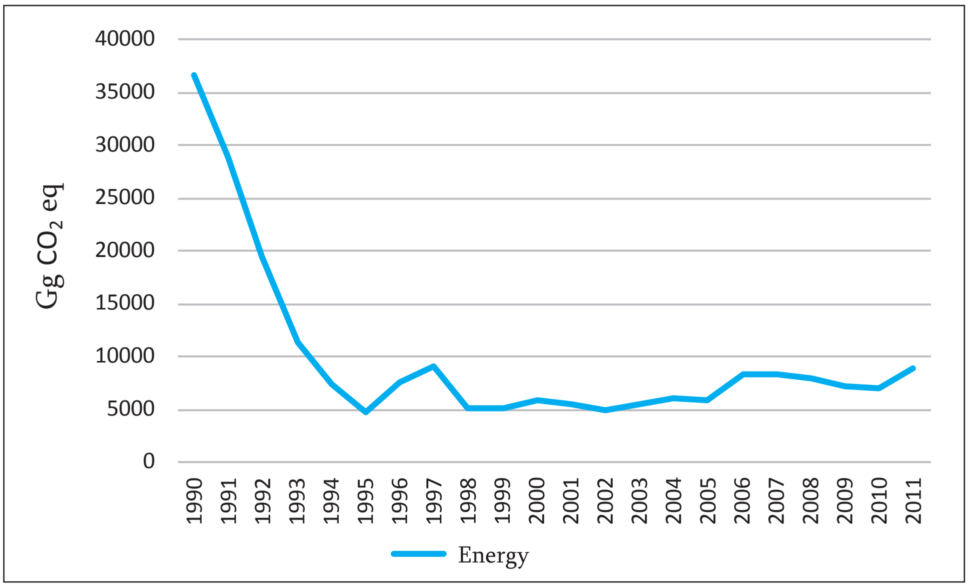

Fig. 2.6. Emissions from the Energy Sector in 1990-2011

The sharp jump in 2011 was facilitated by the recovery of the economic situation, which lead to the increase in emissions from the energy sector in almost all sub-categories. The increase in emissions was especially revealed in the heat and electricity power generation sub-sectors, where emissions increased by 126% compared to 2010. It should be noted that the capacity of hydro resources has great influence on emissions from the energy sector and often is the main cause of variation in this sector. The last two years have been marked by the sharp increase in the demand for electricity (10% increase from the previous year). It should be also noted that in 2010, it was possible to satisfy the growing demand with the help of the hydroelectric power stations. But in 2011, the power stations were unable to generate the same amount of energy as in the previous years. The increase in the demand was added to the factor. The deficit of the year was satisfied at the expense of the increased thermal power generation.

In 2011, the cause of the increase in emissions from the energy sector was also related to the sharp rise in the consumption of coal in the fuel processing industry sector, as well as the increase in gas losses, which was related to the increased use of gas in all sectors. Fig. 2.7 shows the trend of emissions from the energy sector in the years of 2000-2011 according to various source-categories. As the Table demonstrates, the large share of emissions in the energy sector was generated from fuel combustion (72% in 2011), but the share of fugitive emissions was also quite high (28% in 2011) in comparison to other countries.

Among the source-categories of emissions, fugitive emissions from solid fuel transformation underwent the highest growth in comparison with the year of 2000 (2 Gg in 2000, 99 Gg in 2011), which in recent years was determined by the activation of coal mining industry. But the share of this sector was still very low in the share of total emissions.

Also, emissions from the fossil fuel processing industry significantly increased (158% growth in 2011 in comparison with 2000), which is due to the increased use of coal and emissions in the transport sector (108% growth in 2011 in comparison with 2000).

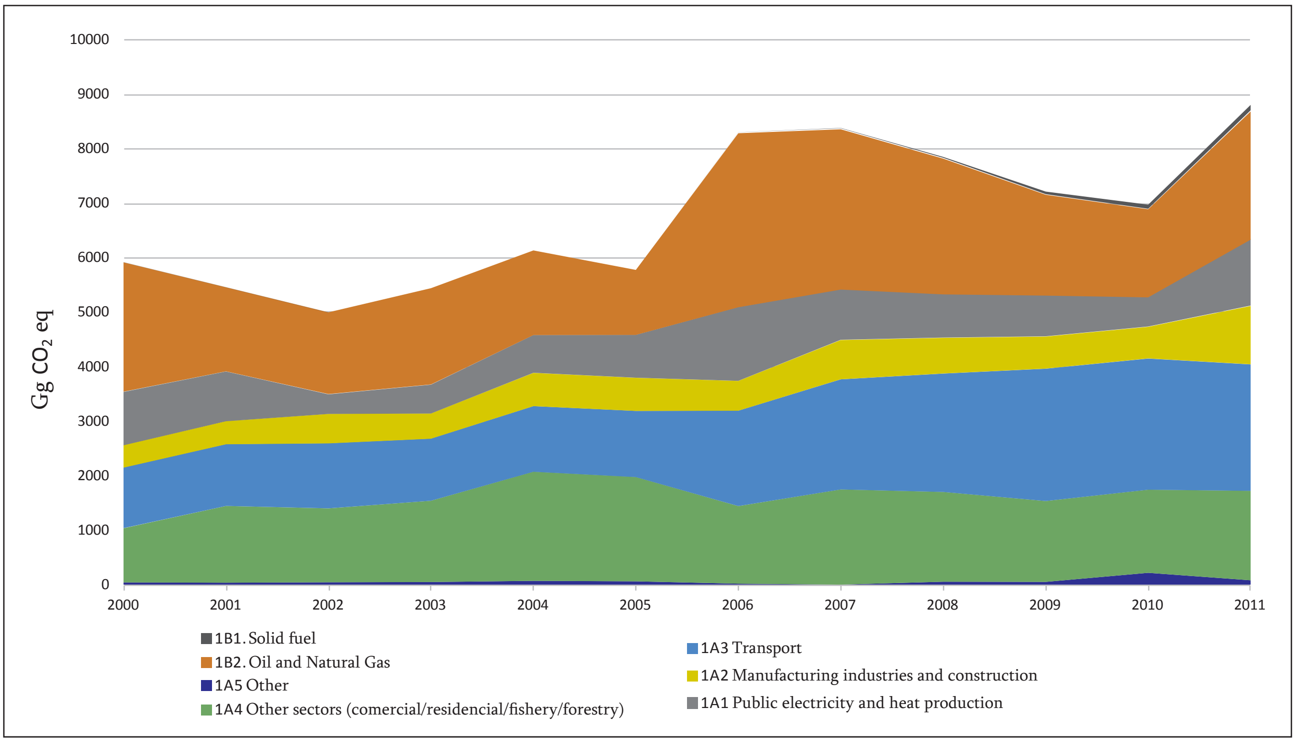

Figure 2.7. Trend of GHG emissions from Energy sector in 2000-2011 (Gg CO_2eq)

2.6.1.1. Fuel Combustion (1.A)

2.6.1.1.1. Source-Category: Electricity and Heat Production (1A1)

Electricity in Georgia is mainly generated by hydro power plants and gas-fired thermal power stations. The dynamics of power generation (together and separately for the hydro and thermal power plants) are given in Table 2.7. As the tables show, the local electricity generation of the country increased over the years. The Table shows the increase in the share of total hydropower generation until 2011. The share of plants in the total hydro power generation was 93% by 2010. The share of thermal power plants was 7%.

2011 was marked by the sharp increase in electricity production through the thermal power plants, which on the one hand was determined by the fact that the year was not particularly abundant in water and on the other hand, the demand increased significantly and the existing hydropower capacity of the hydropower plants was not enough for the average hydrological year.

In 2009-2011, the demand for electricity grew at the annual rate of 10%.

Table 2.7. Electricity production in Georgia, 2006-2011

Year	Electricity generated at TPPs, million KWh	Electricity generated at HPPs, million KWh	Total
2006	2 225	5 396	7 621
2007	1 515	6 831	8 346
2008	1 279	7 162	8 441
2009	991	7 412	8 403
2010	679	9 368	10 047
2011	2 216	7 890	10 106

As for heat production, in the Soviet period, until 1991, natural gas and fuel-fired centralized heating systems were operating in large cities of Georgia. Afterwards, these systems were almost completely out of order. As a result, greenhouse gas emissions from this sub-sector were reduced to almost zero. Currently, the majority of the population uses wood for heating. And in large cities, where natural gas is supplied, gas stoves are used. Emissions from the consumption of these fuels are given in the relevant household sub-category. The use of natural gas for electricity production in the thermal power plants was the main reason of emissions from the electricity source-category.

Table 2.8. Emissions of GHG from Electricity and Heat Production source-category (Gg)

Gas	2006	2007	2008	2009	2010	2011
CO_2	1 349	924	795	749	538	1 216
CH_4	0.03	0.02	0.02	0.02	0.01	0.02
CO_2eq.	0.55	0.38	0.33	0.38	0.28	0.48
N_2O	0.002	0.002	0.003	0.002	0.002	0.003
CO_2eq.	0.92	0.65	0.57	0.82	0.63	0.75
TotalCO_2eq	1 350	925	796	750	539	1 218

2.6.1.1.2. Source-Category: Manufacturing Industries and Construction (1A2)

The sub-sector: Processing Industry and Production of Construction Materials includes emissions generated by fuel combustion from different industry branches, such as: Production of iron and steel, ferroalloys, chemicals, paper, food, beverages and tobacco, etc. Also, emissions from the production of construction materials.

In 2006-2011, natural gas, as well as small amounts of oil products (diesel, fuel oil) and coal were mainly used in this sector. In 2011, coal consumption increased considerably in this sector, which also impacted emissions.

Table 2.9 Emissions of GHG from manufacturing industries and construction source-category (Gg)

Gas	2006	2007	2008	2009	2010	2011
CO_2	546	719	653	587	578	1 066
CH_4	0.05	0.06	0.05	0.04	0.05	0.10
CO_2eq.	0.96	1.31	1.12	0.92	1.10	2.06
N_2O	0.00	0.00	0.00	0.00	0.00	0.01
CO_2eq.	0.40	0.47	0.53	0.60	0.75	2.52
Total CO_2eq.	547	721	655	589	580	1 071

2.6.1.1.3. Source-Category: Transport (1A3)

The transport sector in Georgia, as well as in most of the countries of the world, is the major GHG emitter and therefore, great attention is paid to the emission inventory and implementation of the emission-reduction measures in this sector.

In Georgia, the increase in emissions from the transport sector is mainly determined by several factors: Annual growth of the car fleet, the large share of the used vehicles in this fleet, the increase in transit and the absence of vehicle monitoring and restrictions on local or global pollutants (standards).

Georgia is the transit country and the increase in the car fleet and quantities of the transit vehicles that use fuel purchased on the territory of the country, leads not only to the increase in carbon dioxide and other greenhouse gases, but also pollutants, which seriously impact human health.

Georgia's GHG inventory in the transport sector reviews road and rail transports, pipelines and aviation. The International Energy Agency provided data for the latter only for 2011.

Taking into account the fact that oil consumption in energy balances is calculated based on the estimates of the total exports and imports, the greenhouse gas inventory from the energy sector is complete. However, the distribution[31] in the sub-sectors is incomplete, as fuel consumption is unknown until 2011 for instance, for internal navigation, non-road transport and civil aviation.

The GHG trend from the transportation sector is given in Table 2.10. As the Table shows, carbon dioxide is dominant for other fuel combustion sources-categories, as well as for the transport sector (99.3% of emissions). The dominant sub-sector is the road transport (97.2% of emissions in 2011). As the rail transport in Georgia is almost entirely electrified, it is negligible in terms of emissions.

Table 2.10. Emissions of GHGs from Transport sub-categories (Gg)

Source/Gas	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
1A2a Civil Aviation total in CO_2eq	NA[1]	NA	NA	NA	NA	57
CO_2	NA	NA	NA	NA	NA	57
CH_4	NA	NA	NA	NA	NA	0.0004
CO_2eq.	NA	NA	NA	NA	NA	0.0100
N_2O	NA	NA	NA	NA	NA	0.0020
CO_2eq.	NA	NA	NA	NA	NA	0.5000
1A2b Road Transportation total in CO_2eq	1 730	1 991	2 146	2 405	2 387	2 265
CO_2	1 718	1 977	2 131	2 388	2 370	2 250
CH_4	0.37	0.45	0.47	0.50	0.47	0.44
CO_2 eq.	7.78	9.41	9.82	10.53	9.86	9.27
N_2O	0.01	0.02	0.02	0.02	0.02	0.02
CO_2eq.	4.45	5.10	5.52	6.26	6.18	5.89
1A2c Railways total in CO_2eq	NA	NA	NA	24	17	NA
CO_2	NA	NA	NA	24	17	NA
CH_4	NA	NA	NA	0.0020	0.0010	NA
CO_2eq.	NA	NA	NA	0.0300	0.0200	NA
N_2O	NA	NA	NA	0.0002	0.0001	NA
CO_2eq.	NA	NA	NA	0.0600	0.0400	NA
1A2e Other (Pipelines) total in CO_2eq.	30	45	37	11	15	9
CO_2	30	45	37	11	15	9
CH_4	0.0	0.0	0.0	0.0	0.0	0.0
CO_2eq.	0.0	0.0	0.0	0.0	0.0	0.0
N_2O	0.0	0.0	0.0	0.0	0.0	0.0
CO_2eq.	0.0	0.0	0.0	0.0	0.0	0.0
Total from the sector CO_2eq.	1 759	2 036	2 183	2 440	2 419	2 331

Methane and nitrous oxide emissions from the transport sector are not the key categories. However, the assessment of emissions was conducted according to the COPERT[32] model with the purpose of comparing emissions and calculating the values of local pollutants. The assessment results are given in Table 2.11.

[31] After 2000, the energy balance of Georgia was prepared only in 2014 and became available in early 2015, when this inventory was already completed. According to information provided from the National Statistics Office of Georgia, it is planned to prepare energy balances on an annual basis, which will significantly improve future inventories.
[32] http://www.scor.com/en/sgrc/pac/environment-climate-change/item/1868/1868.html?lout=sgrc

Table 2.11. Emissions of GHG from Road Transportation calculated with COPERT (Gg)

Gas	2006	2007	2008	2009	2010	2011
CO_2	1 875	1 949	2 083	2 389	2 346	2 266
CH_4	0.56	0.65	0.76	0.83	0.98	1.05
CO_2eq	21	23	24	25	25	26
N_2O	0.04	0.04	0.04	0.05	0.07	0.80
CO_2eq	12	13	15	16	17	17
Total *CO_2eq*	1 909	1 984	2 122	2 430	2 388	2 309

Taking into account that there is no reliable information on technical characteristics of motor vehicles in Georgia's fleet, as well as the composition of the different types of fuel, it is necessary to use assumptions and analogies, which do not improve the accuracy of the inventory.

Accordingly, it is only possible to use information generated by COPERT for determining trends in local pollutants. Results obtained through Level 1 are included in the IPCC inventory (Table 2.10).

2.6.1.1.4. Source-Category: Other Sectors-Commercial/Residential/Agriculture/Fishing/Forestry (1A4)

Emissions from this source category include emissions from the following sectors:

- 1A4a Commercial (Trade)
- 1A4b Residential
- 1A4c Agriculture, Fishing and Forestry

Greenhouse gas emissions according to the sub-categories for the years of 2006-2011 are given in Table 2.12. In comparison with other source-categories, the shares of methane (5% in 2011) and nitrous oxide (1.06% in 2011) are relatively high here and are determined by the high rates of the wood consumption in the household sector.

The residential sector is the dominant sub-sector (76.7% of emissions in 2011), which is characterized by the increasing trend, while emissions decreased in the commercial and agricultural sectors.

Table 2.12. Emissions of GHG from Commercial/Residential/Agriculture/Fishing/Forestry source-category according to sub-categories (Gg)

Source/Gas	2006	2007	2008	2009	2010	2011
1A4a. Commercial total in CO_2eq.	99	149	241	241	57	57
CO_2	92	136	225	228	45	47
CH_4	0	1	1	1	0	0.4
CO_2eq.	7	11	12	11	8	9
N_2O	0	0	0	0	0	0
CO_2eq	1	2	5	3	3	2
1A4b. Residential total in CO_2eq.	912	1 121	998	1 162	1 189	1 258
CO_2	805	1 007	872	1 052	1 070	1 171
CH_4	4.23	4.54	4.36	4.39	4.03	3.45
CO_2 eq	89	96	92	92	85	72

N_2O	0.06	0.06	0.11	0.06	0.11	0.05
CO_2eq.	18	19	36	18	34	15
1A4c. Agriculture, Fishing and Forestry total in CO_2eq.	412	476	407	79	279	326
CO_2	404	474	406	79	272	324
CH_4	0.282	0.040	0.034	0.012	0.296	0.024
CO_2 eq.	5.93	0.83	0.72	0.25	6.21	1
N_2O	0.006	0.002	0.002	0.0002	0.0023	0.002
CO_2 eq.	1.72	0.75	0.62	0.05	0.71	0.69
Total Sectoral emission CO_2eq.	1 423	1 746	1 647	1 483	1 525	1 641

2.6.1.1.5. Comparing Results of the Sectoral and Reference Approaches

The IPCC methodology involves calculation of carbon dioxide emissions from the fuel combustion source-category using two different first level methodological approaches: Reference and sectoral. Emissions received from both approaches can be used for calculating emissions. However, as a rule, the country's final emission calculations include emissions estimated using the sectoral approach.

The IPCC methodology for countries included in Annex 1 determines that the difference between carbon dioxide emissions calculated by the reference and sectoral approaches should not be more than 2%. Otherwise, the reason for the difference should be explained in detail.

Table 2.13 shows emissions of carbon dioxide from the territory of Georgia in 2006-2011 counted by using two approaches for different types of fuels and further explanation of the differences.

Table 2.13. Comparison of the Carbon Dioxide Emissions Calculated with Reference and Sectoral Approaches

Fuel type	Year	2006	2007	2008	2009	2010	2011
Liquid fuel	Standard approach, Gg	2 269	2 503	2 705	2 992	2 941	2 928
	Sectoral approach, Gg	2 250	2 482	2 664	2 973	2 925	2 908
	Difference,%	0.8	0.8	1.5	0.6	0.5	0.7
Solid fuel	Standard approach, Gg	8	28	86	242	380	507
	Sectoral approach, Gg	8	28	84	242	380	507
	Difference,%	0.0	-0.5	2.0	0.0	-0.2	0.0
Gaseous fuel	Standard approach Gg	3 381	3 259	2 826	2 256	2 100	3 256
	Sectoral approach, Gg	2 702	2 772	2 425	1 954	1 819	2 806
	Difference,%	20.1	14.9	14.2	13.4	13.4	13.8
Total	Standard approach Gg	5 658	5 790	5 617	5 490	5 421	6 691
	Sectoral approach, Gg	4 960	5 282	5 173	5 169	5 124	6 221
	Difference,%	12.3	8.8	7.9	5.9	5.5	7.0

Differences in emissions given in Table 2.13 are determined by the fact that the use of fuel for non-energy purposes is deducted from the data of fuel consumption used in the sectoral approach. In the reference approach, only a portion of this number is defined as stored in products (33% for natural gas, 50% for lubricating oils). For gaseous fuel, the difference is determined by losses of natural gas during transportation/distribution, which is considered as the source for methane and in the reference approach is regarded as combusted and converted to carbon dioxide. Transportation and distribution losses are quite high in Georgia.

2.6.1.1.6. International Bunker Fuel

In the inventory for the period of 2006-2011, emissions are presented only from International Aviation Bunker Fuel. Information about the consumption of this fuel is taken from the energy balances of the International Energy Agency. Information about marine bunker fuel is unavailable. These emissions are attributable to global emissions and should not be reflected in national emissions.

Table 2.14. Emissions from fuel used by International Aviation Bunkers

Year	Fuel use, PJ	CO_2 emissions, Gg
2006	35.68	112.62
2007	45.32	143.04
2008	34.91	110.19
2009	34.32	108.32
2010	38.72	122.21
2011	35.00	110.47

2.6.1.1.7. Use of Fuel as Raw Material and for Non-Energy Purposes

A certain number of fossil fuel is stored in non-energy products. The part of this carbon is usually oxidized after a long time. In fact, all types of fossil fuels are used for non-energy purposes. This includes the use of energy as the raw material in the chemical industry (the use of natural gas in ammonia, naphtha, ethane, paraffin and wax production), construction (bitumen production) and the variety of products, such as car oil, industrial oil, lubricants and others. Emissions generated during the use of fuel (e.g., the use of natural gas in the production of ammonia) for non-energy purposes to avoid double recording, are discussed in the industrial processes sector. The figures for the use of fossil fuel products for non-energy purposes are given in Table 2.15.

Table 2.15. Fossil fuel use for non-energy purposes

Year	Lubrication oils, thousand tons	Natural gas, million m^3
2006	12.82	305.77
2007	14.09	154.18
2008	15.21	122.85
2009	13.25	96.17
2010	10.16	94.34
2011	13.69	210.80

2.6.1.2. Fugitive Emissions (1B)

Fugitive emissions include “methane (CH_4) emissions from coal mining and processing” and “methane emissions from oil and natural gas-related activities”. The following sub-categories are discussed in this sector according to the methodology:

- Solid Fuels (1B1);
- Oil production and processing (1B2a);
- Oil production;
- Oil processing;
- Natural gas production, transportation and distribution (1B2b)
- Natural gas production;
- Natural gas transportation and distribution.

The trend of methane emissions from the (1B) sub-sector is summarized in Table 2.16.

Gas losses from the gas transportation and distribution sector are characterized by the highest emissions. According to information received from the Gas Transportation Company, natural gas losses consisted of about 2% of Georgia's full gas import (for gas received for Georgia and Armenia) in 2006. Now, the same figure constitutes 0.4%. Gas losses are quite high in Georgia's gas distribution systems. The report published on the web-page of the Ministry of Energy of Georgia and the Water Regulatory Commission in 2012[33] provided information/figures about losses for the majority of the gas distribution companies. These losses are divided into normative and non-normative parts.

The analysis demonstrated that technical (normative) losses in the natural gas distribution networks of Georgia amount to the average 7.4%, but according to the expert assessments, technical losses are higher and reach approximately 9%. The latter was used in the greenhouse gas inventory for calculating gas distribution losses. The assumption was used in the calculation of emissions that these losses will be fully emitted and the gas composition consists of 90% methane.

Table 2.16. Fugitive emissions of methane (Gg)

Source	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
1B1. Solid fuel transformation	12.78	0.57	0.00	0.00	0.06	0.25	0.78	2.25	3.58	4.72
1B2. Oil and natural gas	113.79	42.73	113.30	56.96	113.34	114.00	96.25	62.22	65.80	75.83
Total Fugitive emissions CH_4	126.57	43.30	113.30	56.96	113.40	114.25	97.03	64.48	69.38	80.55
Total Fugitive emissions, CO_2 eq.	2 658	909	2 379	1 196	2 381	2 399	2 038	1 354	1 457	1 692

2.6.2 Industrial Processes (CRF Sector 2)

Emissions from the industrial processes sector made 22.7% of the total emissions (excluding the land-use sector) in 2011. Emissions generated from the industrial processes sector in 2011 were 32.0% less than in 1990 and increased by 233.8% in comparison with 2000. The industry downturn after the collapse of the Soviet Union lead to the reduction in emissions in 1990-1995. Since 1995, emissions from this sector gradually increased and reached 2 890 Gg in 2007. The trend is related to the development of this sector. The increase in HFC emissions also played an important role.

Fig. 2.8 shows the trend in greenhouse gas emissions from industrial processes sector for 1990-2011. In 2008-2009, emissions demonstrated the downward trend in the energy sector, as well as in this sector. The downward trend was determined by the economic recession due to the global economic crisis.

Since 2010, the trend has been still upward and emissions from the industrial processes sector in 2011 were ahead of the 2007 figures and reached their new peak - 3 658 Gg CO_2eq.

The increase in 2011 was determined by the economic growth, which in turn resulted in the increase of carbon dioxide, nitrogen oxide and HFC emissions. This trend was determined by the growing number of devices containing these materials (refrigerators, air conditioners) in the country.

[33] http://www.gnerc.org/uploads/2012.PDF

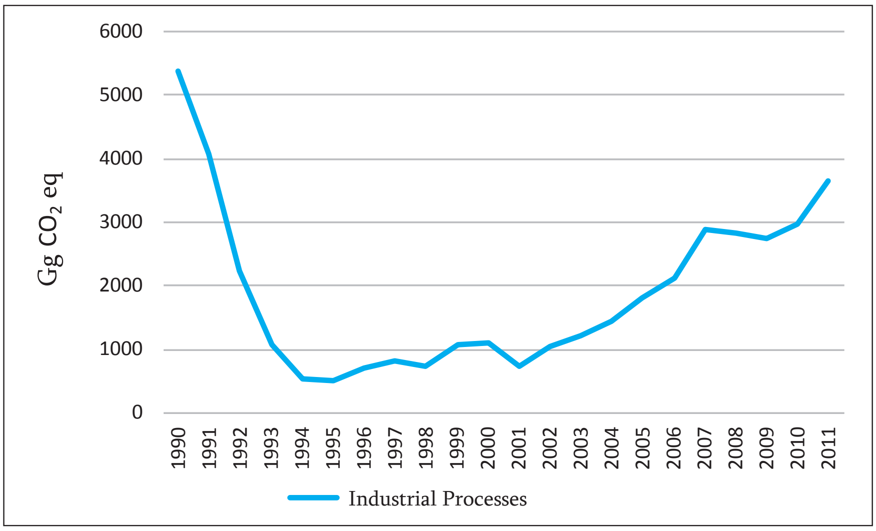

Fig. 2.8. Emissions from Industrial Processes sector, 1990-2011

The industrial processes sector includes the following source-categories: Minerals, chemical industry, metal production, other industries, such as paper, drinks and food production, consumption and production of halocarbons. The inventory within Georgia's Third National Communication was conducted for the following sub-categories: Cement and lime production, asphalt production and paving roads, glass, ammonia, nitric acid, iron, steel and ferroalloys, food and beverage production. Paper production has not been reviewed in the current inventory, because paper in Georgia is only produced by processing imported or raw materials, which does not generate greenhouse gas emissions. The other categories discussed in the industry sector are not functional in Georgia today and therefore, were not considered.

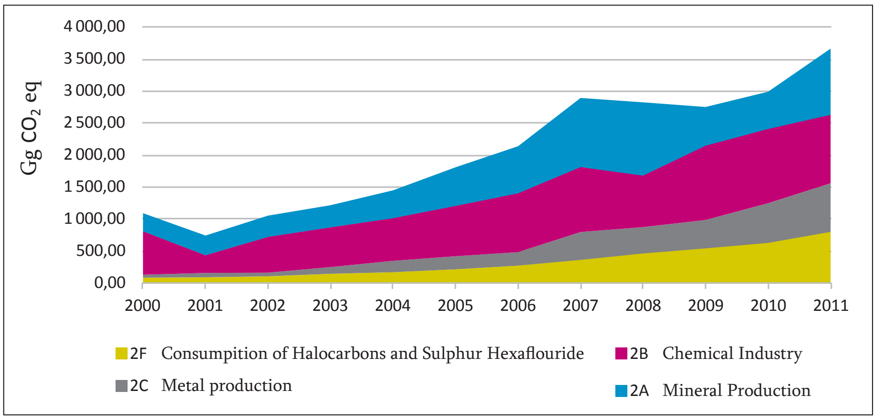

Fig. 2.9. Emissions from Industrial Processes sector according to categories, 2000-2011

In 2011, the highest share of emissions in the sector was generated by the chemical industry sub-category (29.2%), but since 2000, the increase in emissions has been observed in mining and metal production, as well as the increase in emissions of carbon halide.

In 2011, the share of the minerals sub-category almost equaled to the share of chemical production with 28.2%. The highest increase in comparison to the previous year was detected for cement and clinker production (83.4%), as well as cast iron and steel production (26.4%) and HFC emissions (27.2%).

2.6.2.1. Source-Category Mineral Products (2A)

In Georgia, the following areas from the industrial processes were mainly operating in 2006-2011: Cement (2A1), lime (2A2), asphalt (2A5), glass and ceramics (2A3) productions. Other types of production, in which the thermal processing of carbonate (2A3) was used, were not officially declared. Georgia does not produce soda (2A4) now or in the past.

Despite the fact that the construction industry was thriving in Georgia, the products produced for the sector: gravel, sand, basalt and various stone processing did not generate greenhouse gas emissions in the ambient air.

The main source of emissions in this sub-sector was CO_2 emissions from cement and clinker production, which was the key source of income. CO_2 emissions were also generated in the production of lime and thermal processing of carbonate minerals (for instance, glass and ceramics productions).

Three large cement plants operated in 2006-2011 in Georgia. All three belong to Heidelberg Cement (two cement plants in Rustavi and Kaspi). Several other small enterprises (12) also belong to Heidelberg Cement. They are producing cement with purchased clinker.

According to the official data, only Heidelberg Cement (Kaspi and Rustavi factories) and Ltd. Evrotsementi (Kaspi district) are producing clinker in Georgia.

Georgia produces the Mark-400 and Mark-300 types of Portland cement. The percentage of clinker is the same (97%) in both types and they only differ from each other with the type of aggregates. It should be noted that the substantial amount of clinker produced in Georgia in the past was exported.

The major producer of lime in Georgia is JSC Georgian Steel, which was established on the basis of Georgian Rustavi Metallurgical Plant and Georgian Steel. It owns approximately 72% of lime production in Georgia. In addition, a number of small enterprises also produce lime, namely, small factories in Kutaisi, Surami, Dzirula, Ozurgeti and Zugdidi. All of them mainly use limestone as raw material and dolomite in relatively small quantities.

As for glass, JSC Mina - Ksani Glass Factory produces glass in Georgia. The company is located in Mtskheta District, Ksani Borough.

Carbon dioxide emissions in this sub-category are given in Table 2.17.

Table 2.17. Emissions of CO_2 (Gg) from Mineral Products (2A)

Emission source	2006	2007	2008	2009	2010	2011
Cement production	394	630	673	434	452	749
Clinker production	312	413	447	117	84	234
Total cement production (2A1)	706	1 043	1 120	551	536	983
Lime production (2A2)	19	22	14	45	37	40
Limestone production	2	3	2	2	2	2
Dolomite production	2	2	1	1	2	2
Total Limestone and Dolomite use (2A3)	4	5	3	3	4	4
Soda Ash/Glass production (2A7)	5	6	4	4	4	4
Total CO_2 emission, Gg	*733*	*1 076*	*1 141*	*603*	*580*	*1 031*

2.6.2.2. Source-Category: Chemical Industry (2B)

Carbon dioxide emissions in this category are generated from ammonia and nitric acid productions.

Most of the ammonia produced in Georgia is produced through the Haber-Bosch process where the ammonia synthesis occurs: Nitrogen and hydrogen are entering in the mutual reaction. Required hydrogen is generated as a result of conversion of natural gas. According to the 1996 IPCC guidelines, it is better to calculate the amount of CO_2 emitted from suggested ammonia production based on the volume of consumed natural gas and its carbon composition. The calculations during the ongoing inventory were conducted according to the amount of consumed gas, as well as the mass of produced products. Although, the sums only include emissions calculated based on the consumed natural gas.

As for the nitric acid (HNO_3), it is produced as the result of high-temperature catalytic oxidation of ammonia, during which nitric oxide and nitrogen oxides (NOx) are produced as related products. The amount of emitted gases is proportional to the used ammonia. Their concentration in exhaust gas emissions depends on the plant technology and the level of emission control.

In Georgia, nitrogen acid is mainly produced by Rustavi Synthetic Fertilizer Factory. So-called weak nitric acid is produced through catalytic oxidation of ammonia, through oxygen received from the air, under the average pressure and subsequent absorption of oxides formed during water vapor.

Carbon dioxide emissions from this sub-category are given in Table 2.18.

Table 2.18. Emissions of GHGs (Gg) from Chemical Industry (2B)

Source/Gas	2006	2007	2008	2009	2010	2011
CO_2						
Ammonia production (2B1)	347	369	393	400	363	348
N_2O						
Nitric Acid production (2B2)	1.84	2.08	1.33	2.45	2.57	2.33
CO_2eq.	570	645	412	760	797	722
Total CO_2eq.	917	1 014	805	1 160	1 160	1 070

2.6.2.3. Source-Category: Metal Production (2C)

Industrial metal production from ore requires the use of carbon as the reducing agent. If ores contain carbonate, generated carbon dioxide is emitted in the ambient air.

As the main purpose for coke (reducing) oxidation is to produce cast iron "sheets", these emissions are considered in the industrial sector. Carbon dioxide emissions in this category are generated from the iron and steel production (2C1) and ferroalloy production (2C2).

Currently, construction reinforcing bars and tube-rolling workshops, which produce seamless pipes, are operating in Rustavi. In addition, the steel melting and reinforcing bar and foundry shops also operate. GHG emissions are also generated from melting cast iron and steel. From ferroalloys, ferromanganese was not produced in Georgia in 2006-2011; only silicon-manganese was produced. The calculated CO_2 quantities emitted in 2006-2011 from these sub-categories are given in Table 2.19.

Table 2.19. Emissions of CO_2 (Gg) from Metal Production (2C)

Emission source	2006	2007	2008	2009	2010	2011
Steel production	0	212	199	251	270	342
Silicon-Manganese production	209	221	210	190	346	413
Total CO_2 emissions, Gg	209	433	409	441	616	755

2.6.2.4. Consumption of Halocarbons and Sulfur Hexafluoride (2F)

Today, industrial gases (HFCs, PFCs and SF_6) are not produced in Georgia. They are imported for the domestic consumption and therefore, emissions are generated only from their use. Calculation of halocarbons emission is important, because they are characterized by stability and the high global warming potential (GWP). According to official statistics, part of halocarbons consumed in Georgia is controlled by the Montreal Protocol. This is why their emissions are not counted in the present work.

Production of industrial gas, as already mentioned, is not taking place in Georgia. Only its import in the pure form, as well as in different product compositions is taking place in the country. The following products must be taken into account:

- Refrigerators and air conditioners (2F1);
- Foam generators (2F2);
- Extinguishers (2F3);
- Solvents (2F5);
- Aerosol containers (2F4). They are usually loaded with fluorine carbon mixture, the amount of which is calculated separately, as they are characterized by the different global warming potential;
- JSC Georgian State Electrosystem (GSE). Communication devices, namely different voltage circuit breakers (2F6).

Real emissions from the cooling-freezing-conditioning processes are calculated in the inventory. The term for devices used in these processes are defined by 15 years (according to the 1996 IPCC Guidelines).

Industrial (new) gas emissions from other areas, such as: Fire extinguishers, aerosols, solvents used in dry cleaning, foam-generators were not counted. Despite the fact that import statistics for these products are available, the types and quantities of reagents loaded in them are unknown. This is why the calculations were not made in the inventory. Hexachloride emissions from the communication equipment in the GSE, in particular, the different voltage circuit breakers were also calculated. Table 2.20 presents the total emissions of carbon halide from the territory of Georgia in 2005-2011 in Gg, as well as Gg CO_2eq. for HFC-134a carbon halide. The devices imported in Georgia are mainly load with carbon halide.

Table 2.20. Halocarbons emitted from Georgia's territory in 2005-2011 (Gg and Gg CO_2eq)

Year	Industrial	Residential	Split Air-conditioners	Heavy-Duty Trucks with refrigerators	Total, Gg	Total Gg in CO_2eq
	Refrigerators	Fridges				
2005	0.15648	0.000072	0.00147	0.01214	0.170162	221.21
2006	0.19791	0.000128	0.00151	0.01476	0.214308	278.60
2007	0.26191	0.000217	0.00299	0.01758	0.282697	367.51
2008	0.33356	0.000344	0.00510	0.02058	0.359584	467.46
2009	0.39054	0.000413	0.00578	0.0238	0.420533	546.69
2010	0.45078	0.000541	0.00725	0.02727	0.485841	631.59
2011	0.57656	0.000676	0.00989	0.03098	0.618106	803.54

SF_6 emissions from electrical appliances characterize every phase of its use: Production, installation, use, maintenance and utilization. Only SF_6 containing equipment was used in Georgia during the reporting period. According to official information provided by the GSE, SF_6 is used on energy facilities in Georgia in the communication equipment, in particular, the different voltage circuit breakers.

Since 1997, these breakers have been in use. Currently, 304 sets of elegas circuit breaker are listed in the GSE balance sheet. The total sum of SF_6 in these devices is 5 672.2 kg. The hermetic type of circuit breakers is used, their lifetime term is 30-40 years.

It should be noted that according to information provided by experts, quality of this type of equipment (hermeticity) significantly improved in the recent years and subsequently, SF_6 emissions from electric utilities were reduced (by 50-90%). During the operation of the communication equipment at the GSE facilities, SF6 were not added in these devices, nor were emergency works conducted for taking out this type of equipment from the operation.

Table 2.21. Emissions of SF_6 from electric appliances in Georgia in 2006-2011

Year	Used SF_6, ton	Losses of SF_6, Share	Emission SF_6, Ton	Emission SF_6, Gg	Emission of SF_6, Gg CO_2 eq.
2006	1.0502	0.002	0.00210	0.0000021	0.05019
2007	1.2683	0.002	0.00254	0.00000254	0.060706
2008	2.9866	0.002	0.00597	0.00000597	0.142683
2009	3.6111	0.002	0.00722	0.00000722	0.172558
2010	4.6704	0.002	0.00934	0.00000934	0.223226
2011	5.2740	0.002	0.01055	0.00001055	0.252145

2.6.3 Use of Solvents and Other Products (CRF Sector 3)

Solvents and their associated components represent one of the main sources of greenhouse gas emissions. They basically determine emissions of non-methane volatile organic compounds (NMVOCs). This sector also considers nitrous oxide (N_2O) emissions, the main source of which is the use of anaesthesia in the medical field.

N_2O quantities emitted in the ambient air in 2006-2011 after its use for anaesthesia in the medical field were calculated for this sub-sector. Nitrogen monoxide-containing substance in the medical sector was actively used in anaesthesia. In addition, inhaled anaesthetics also contain N_2O.

The estimations were based on the assumption that anaesthesia used for N_2O was fully discharged in the ambient air, i.e. N_2O emissions equal to its use. As the National Statistics Office of Georgia does not register N_2O utilized in the country, the number of surgeries conducted in Georgia in 2006-2011 were used for the calculations. The data on the surgical operations were provided by the Ministry of Labour, Health and Social Affairs of Georgia. It was assumed that spent N_2O was proportional to the total number of surgical operations conducted in the country in the given period. These data and the results of the calculations are presented in Table 2.22.

Table 2.22. N_2O Emission from subsector "Solvent and Other Product Use; 2006-2011

Emission source	2006	2007	2008	2009	2010	2011
Solvent and other product use	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003
CO_2 eq.	0.0062	0.0062	0.0062	0.0062	0.0093	0.0093

2.6.4 Agriculture (CRF Sector 4)

Emissions from the agricultural sector amounted to 17% of the total emissions in 2011 (in addition to the land-use sector). In 2011, emissions from the agricultural sector were 38.7% less in comparison with 1990 and 12.7% less than in 2000. The collapse of the collective farms resulted in the reduction of the agricultural sector and subsequently, emissions from this sector in 1990-1995.

Since 1995, emissions from this sector have been gradually increasing. Figure 2.10 shows the trend in greenhouse gas emissions from the agricultural sector in 1990-2011. Figure 2.10 demonstrates that by 2005, emissions reached the peak of recent years - 3 460 Gg of CO_2eq. Since 2005, the reduction in emissions has been observed in this sector. Several reasons contributed to such reduction, namely: The economic crisis, the 2008 war with Russia and Russia's ban on the import of Georgian agricultural products, which affected this sector.

Another reason contributing to the reduction was the fact that time series for the years of 1998-2005 and 2006-2011 were inconsistence due to the different sources of the activity data. The source of the activity data for 2006-2011 in Georgia's Third National Communication is the official publication of the National Statistics Office of Georgia[34]. It is more reliable than the data generated from various sources that were used in Georgia's Second National Communication.

In addition, it should be mentioned that the inventory from the agricultural sector conducted in 2006-2011 was not full. The data on emissions from certain agricultural crops were missing as they were not provided in the statistical publication of the previous years. Therefore, in order to make exact conclusions about the trends in this sector, it will be necessary to re-count the time series for the whole period.

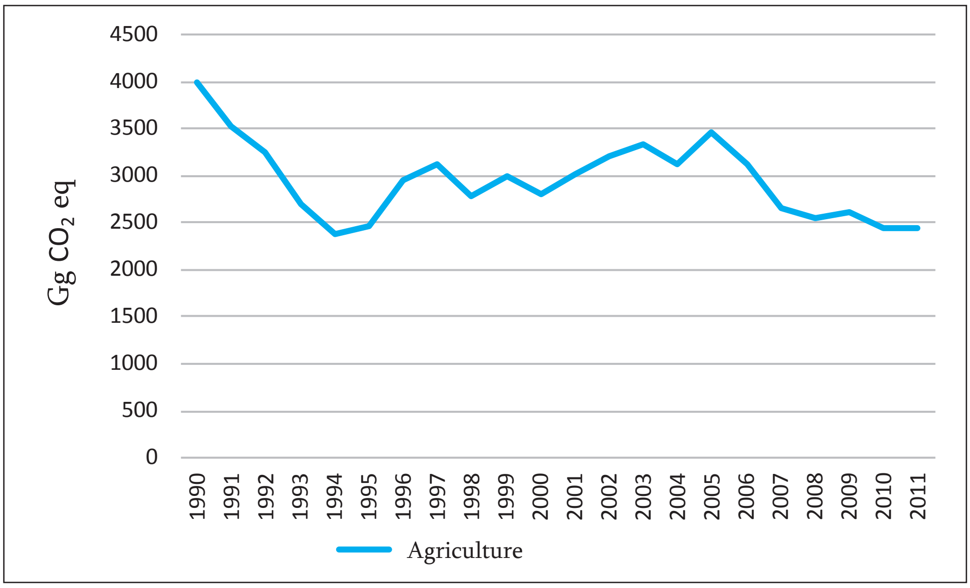

Figure 2.10. Emissions from Agriculture sector in 1990-2011

The agricultural sector of Georgia, as the source of greenhouse gases, includes the following categories according to IPCC classification:

4A Enteric (internal) fermentation
4B Manure management
4D Agricultural soils
4F Field burning of agricultural residues

[34] Statistical Publication: Agriculture of Georgia 2011. National Statistics Office of Georgia. Tbilisi, 2012. http://geostat.ge/

From other activity categories - 4C: Rice Cultivation and 4E: Prescribed burning of savannas is not carried out in Georgia.

The use of manure envisages emissions from the following manure management systems: Anaerobic ponds, wastewater systems, daily scattering and solid waste storage and feeding-rack. Pasture and fenced grazing plots are reviewed in the livestock production category.

The share of methane emissions from the agricultural sector varies in the range of 53.9-57.6% and the share of nitrous oxide varies in the range of 42.4-41.6%.

The share of enteric fermentation is the highest from the sub-categories. In 2007-2011, it constituted about 50% of the total emissions from the agricultural sector. Figure 2.11 shows GHG emissions from the different agricultural sub-sectors.

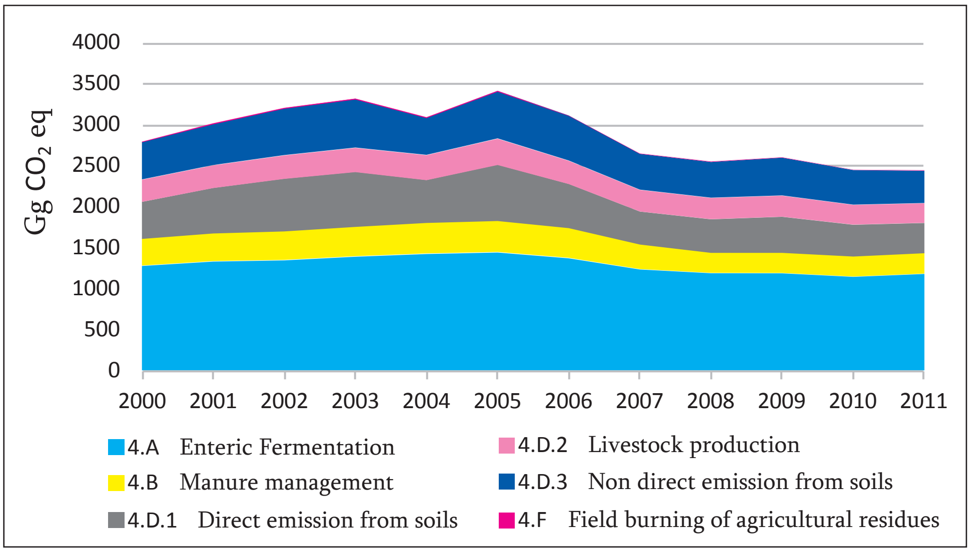

Figure 2.11. Emissions of GHGs from Georgia's Agriculture sector in 2000-2011 according to subsectors (Gg CO_2eq)

2.6.4.1. Source-Category: Enteric Fermentation (4A)

The category: Enteric Fermentation, included in the agricultural section of Georgia's national inventory, namely in the emission source-categories, includes the following sub-sources: Dairy cattle, non-diary cattle, buffalos, sheep, goats and pigs.

In the "intestinal fermentation", the main "key source" is enteric fermentation from cattle. Its contribution makes 85-90% of the total emissions from enteric fermentation. CH_4 emissions in this category are presented in Table 2.23.

Table 2.23. CH_4 Emissions (Gg) According to Animal Categories (2006-2011)

Animal category	2006	2007	2008	2009	2010	2011
4A1. Cattle	59.33	53.20	51.24	51.35	49.76	51.53
4A1a. Dairy	39.75	33.11	30.30	31.39	30.11	31.46
4A1b. Non-Dairy	19.58	20.09	20.95	19.96	19.65	20.07
4A2. Buffalo	1.96	1.73	1.73	1.73	1.67	1.73
4A3. Sheep	3.63	3.48	3.56	3.45	3.01	2.98
4A4. Goats	0.45	0.46	0.43	0.40	0.36	0.29
4A8. Swine	0.00	0.34	0.11	0.09	0.14	0.11
Total	65.37	59.27	57.07	57.01	54.94	56.64
CO_2eq.	1 373	1 245	1 198	1 197	1 154	1 189

2.6.4.2. Source-Category: Manure Management (4B)

CH_4 and N_2O are excreted during the livestock manure processing and storage.

Emissions of these gases, in addition to the quantities of processed manure, depend on the properties of manure and the type of the manure management system. More methane and less nitrous oxide are usually generated in poorly ventilated systems, whereas less methane and more nitrous oxide are generated in properly ventilated systems. Methane in this category is emitted when using manure (4Ba).

Manure, after its discharge, soon begins to decay. When mixed with the small amount of oxygen, decay is mainly anaerobic and methane is produced. The amount of methane depends on the type of the manure management system. Methane emissions from the various manure management systems for different categories of animals are given in Table 2.24.

Table 2.24. Methane Emissions (Gg) from Manure Application (4Ba) by Animal Categories (2006-2011)

Animal category	2006	2007	2008	2009	2010	2011
4A1. Cattle	11.80	9.92	9.14	9.42	9.05	9.44
4A1a. Dairy	11.36	*9.46*	*8.66*	*8,97*	*8.60*	*8.99*
4A1b. Non-Dairy	0.44	*0.46*	*0.48*	*0.45*	*0.45*	*0.46*
4A2. Buffalo	0.07	0.06	0.6	0.06	0.06	0.06
4A3. Sheep	0.12	0.11	0.11	0.11	0.10	0.10
4A4. Goats	0.02	0.02	0.01	0.01	0.01	0.01
4A8. Swine	1.82	1.37	0.44	0.35	0.54	0.44
4A9. Poultry	0.13	0.10	0.11	0.12	0.12	0.12
Total	13.96	11.58	9.87	10.07	9.88	10.17
CO_2 eq	293	243	207	212	208	214

Nitrous oxide is formed from the animal husbandry sector during the manure storage and processing as a result of nitrogen nitrification and denitrification. The animal waste management systems (AWMS) are an important regulatory factor in nitrous oxide emissions.

N_2O emissions from several AWMS types (anaerobic ponds, wastewater systems, solid waste storage and feeding-rack and other systems) are reviewed in the manure management sub-category and dung, applied in agricultural soils, is included in the N_2O direct emission calculation methodology from agricultural soils. N_2O emissions from various waste management system are given in Table 2.25.

Table 2.25. N_2O Emissions (Gg) from Manure Management Systems (4Bb) in 2006-2011

Manure management system	2006	2007	2008	2009	2010	2011
Anaerobic lagoons	0.004	0.003	0.003	0.003	0.003	0.003
Liquid systems	0.007	0.006	0.003	0.003	0.003	0.003
Solid disposal and stalls	0.200	0.172	0.113	0.103	0.115	0.110
Other systems	0.028	0.026	0.028	0.029	0.028	0.027
Total	0.239	0.207	0.148	0.138	0.149	0.143
CO_2eq.	74	64	46	43	46	44

2.6.4.3. Source-Category: Agricultural Soils (4D)

Nitrous oxide emissions from agricultural soils are generated from the direct and indirect sources. The direct source means that emissions take place directly from soil. Emissions from indirect sources are generated as a result of nitrogen vaporization and leaching in synthetic fertilizers and manure.

2.6.4.3.1. Source-Category: Direct Emissions from Soils (4D1)

N_2O direct annual emissions are generated from synthetic nitrogen fertilizers, manure applied in soil, nitrogen fixing plants, agricultural waste and rotting.

Table 2.26. Direct emissions of N_2O from soils (Gg) in 2006-2011

Source	2006	2007	2008	2009	2010	2011
Synthetic nitrous fertilizers	1.188	0.826	0.905	1.024	0.887	0.765
Manure applied to soil	0.342	0.288	0.227	0.234	0.236	0.242
Nitrogen fixing vegetation	0.006	0.007	0.008	0.006	0.004	0.007
Rotting of harvest residues	0.180	0.168	0.172	0.152	0.114	0.174
Total N_2O	1.716	1.229	1.312	1.416	1.241	1.188
Total in CO_2eq.	532	381	407	439	385	368

2.6.4.3.2. Source-Category: Emissions from Livestock Production (4D2)

Nitrous oxide emissions from animal waste discharged during cattle grazing (pasture and fenced graze fields) are reviewed in this sub-category. When grass grazing animals discharge dung on pastures and graze fields, nitrogen in manure is transformed and experiences ammonification, nitrification and denitrification. N_2O is generated from these transformational processes. Calculated emissions are given in Table 2.27.

Table 2.27. Emissions of N_2O from animal production sub-category (Gg) in 2006-2011

Year	2006	2007	2008	2009	2010	2011
N_2O	0.910	0.846	0.832	0.823	0.772	0.767
CO_2eq.	282	262	258	255	239	238

2.6.4.3.3. Source-Category Indirect Emissions from Soils (4D3)

The synthetic fertilizer applied in agricultural land and some portion of nitrogen in manure is separated from soil via vaporization, leaching, erosion and surface wash-off. Nitrogen separated from agricultural soils this way form additional amount of nitrogen elsewhere, which later, after nitrification and denitrification generates N_2O.

Agricultural soils remaining in the agricultural soil may not become engaged in nitrification and denitrification processes for many years, namely in cases, when nitrogen will be leached in ground waters. N_2O emissions calculated from the soil as a result of these processes are given in the Table 6.28.

Table 2.28. Indirect emissions (Gg) of N_2O from soils in 2006-2011

Source	2006	2007	2008	2009	2010	2011
Nitrogen volatilization and precipitation	0.288	0.237	0.229	0.234	0.221	0.213
Nitrogen leaching, erosion and washing off	1.475	1.163	1.159	1.219	1.128	1.054
Total N_2O	1.763	1.400	1.388	1.453	1.349	1.267
CO_2 eq.	547	434	430	450	418	393

2.6.4.4. Source-Category: Field burning of agricultural residues (4F)

Burning of the harvest residues does not constitute the carbon dioxide source, as carbon emitted during the incineration in the ambient air will be re-absorbed (absorbed) over the next vegetation period. Burning of the harvest residues is the insignificant source of methane and nitrous oxide. The assumption was made during the calculations that 25% of waste is incinerated in fields, while the oxidized fraction equals to 0.9. The calculations revealed that methane and nitrous oxide emissions produced from incineration of agricultural waste are very limited. The results are presented in Table 2.29.

Table 2.29. Emissions of N_2O and CH_4 from burning of agricultural residues (Gg), 2006-2011

GHG	2006	2007	2008	2009	2010	2011
CH_4	0.19	0.20	0.22	0.17	0.12	0.21
CO_2eq	3.9	4.2	4.6	3.5	2.6	4.4
N_2O	0.003	0.004	0.004	0.004	0.002	0.004
CO_2eq	1.0	1.3	1.3	1.1	0.6	1.2
Total CO_2eq.	4.9	5.5	5.9	4.6	3.2	5.6

2.6.5 Land Use, Land-Use Change and Forestry (CRF Sector 5)

The National GHG Inventory Report[35] produced by Georgia in 2008 reviewed only the (5A) sub-categories from this source-category: Changes in forestry reserves of other types of forest biomass. Changes ongoing in the carbon reserves on the forest areas and relevant CO_2 and GHG emissions were assessed separately for coniferous and deciduous forests by using the 1990-2007 activity data.

Later, Georgia's Second National Communication[36] published in 2009, assessed carbon dioxide emissions and absorption from soils in addition to the forests. The net carbon absorption trend from soils was determined for 1998-2002.

Based on the new data[37] searched for the years of 1992-2011 within the ongoing process of drafting Georgia's Third National Communication, re-counting took place for this source-category for the years of 1992-2007 and carbon reserves were calculated for the years of 2008-2011.

The IPCC Guidelines in general recommends to conduct the GHG inventory in the reviewed sector (LULUCF), according to the land-use categories, for the following modules: 1) Forest lands (5A); 2) Agricultural lands (5B); 3) Pasture (5C); 4) Wetlands (5D); 5) Settlements (5E); 6) Other lands (5F).

[35] GHG Inventories, Tbilisi, 2008
[36] Georgia's Second National Communication on Climate Change, Tbilisi, 2009
[37] Statistics of UN FAO Georgia Representation for the years of 1992-2011, http://www.fao.org/statistics/en/

According to the IPCC requirements, it is important to have the complete annual land cadastre for conducting the inventory for this source-category and taking into account changes registered in the cadastre in the land-use area.

In the sector: Land use, changes in land-use and forestry, calculations were mainly made by using standard values of emission factors (Tier I approach), which is approximately in line with Georgia's climate conditions.

Table 2.30 presents carbon dioxide emissions for three main sub-sectors (forest lands, arable lands and grassland-pastures) and their total emissions for the years of 1992-2011. In this table, CO_2 emissions in the ambient air are marked with (+) sign and CO_2 absorption from the ambient air is marked with (-) sign.

Drastic changes from the assessed sub-sectors are mainly observed in the arable land sub-sector (it includes perennial orchards), especially in perennial plantations and gardens. As a result of verifying the data of the land- use in 2004, the reduction in the area of the perennial plants (gardens) were observed in this sub-sector. Consequently, the calculations demonstrated 37 113 Gg CO_2 carbon emissions, which in turn affected the data of the whole sector and became the emitter of the carbon dioxide sector during this year. As already mentioned, this was determined by the land registration (cadastre) conducted in 2004, which specified boundaries of the perennial gardens.

The graphs presented in Annex 2.2 demonstrate that 1995-1996 were marked with the decrease in the arable areas. Because of this reason, the sharp rise in emissions was reported for this sub-sector in the reported period. Namely, CO_2 emissions in 1995 amounted to 3 186.4 Gg CO_2 and 2 659.8 Gg CO_2 in 1996.

The sub-sector: Grasslands-pastures (5C) is the emitter of carbonic emitters for all assessed years, which is determined by pasture degradation, especially in Eastern Georgia.

As a result of intensive grazing and excessive exploitation, carbon accumulation in the soil is very small, which turns this sub-sector into the carbon emitter. Emissions from this sub-sector are steadily within 2 470-2550 000 CO_2 tons.

However, Georgia's forest sector is the accumulator of carbon dioxide for every assessed year and the dynamics of carbon absorption varies equally annually in the range of 6 500 - 5 600 Gg CO_2.

The low absorption rate was observed in 2008 (-5 639.3 Gg CO_2), which was determined by the large-scale forest fires of that year. The dynamics of carbon dioxide absorption in the forestry sector (5A) for 1992-2011 is shown in Table 2.30.

Table 2.30. Removals and emissions of CO_2 in LULUCF sector in 1992-2011

Year	Forest lands		Agricultural lands				Pastures-Hayfields		Net emission/ removal	
			Arable		Orchards					
	1000 tC	Gg CO_2	1000 tC	Gg CO_2	1000 tC	Gg CO_2	1000 tC	Gg CO_2	1000 tC	Gg CO_2
1992	-1899	-6 962	-63	-231	-701	-2 571	729	2 673	-1 934	-7 091
1993	-1 785	-6 547	-63	-231	-636	-2 333	694	2 547	-1 791	-6 564
1994	-1797	-6 588	-63	-232	-634	-2 325	684	2 508	-1 810	-6 638
1995	-1 794	-6 576	-61	-225	930	3 411	684	2 508	-240	-882
1996	-1 789	-6 559	-62	-228	787	2 887	684	2 508	-380	-1 392
1997	-1824	-6 688	-62	-143	-143	-525	685	2 513	-1 429	-4 928
1998	-1 814	-6 652	-64	-231	-63	-232	689	2 525	-1 252	-4 680

1999	-1793	-6 575	-63	-230	-567	-2 079	673	2 469	-1 750	-6 415
2000	-1769	-6 485	-63	-231	-502	-1 840	673	2 468	-1 661	-6 089
2001	-1 789	-6 561	-63	-232	-500	-1 833	674	2 470	-1 680	-6 155
2002	-1749	-6 412	-63	-233	-367	-1 348	674	2 470	-1 506	-5 522
2003	-1 853	-6 795	-64	-234	-491	-1 802	674	2 470	-1 735	-6 361
2004	-1 787	-6 553	-37	-137	10 122	37 113	674	2 470	8 972	32 892
2005	-1738	-6 374	-34	-142	-231	-847	674	2 470	-1 334	-4 893
2006	-1803	-6 610	-38	-140	-244	-893	674	2 470	-1 411	-5 173
2007	-1640	-6 014	-37	-138	-113	-416	674	2 470	-1 117	-4 097
2008	-1538	-5 639	-37	-136	-241	-885	674	2 470	-1 143	-4 191
2009	-1596	-5 851	-37	-136	-252	-924	674	2 470	-1 211	-4 440
2010	-1 574	-5 770	-33	-120	73	269	674	2 470	-859	-3 151
2011	-1 660	-6 088	-33	-121	-241	-885	674	2 470	-1 261	-4 624

In all other sub-categories (wetlands, settlements and other areas) calculations were not made due to the absence of the relevant data.

2.6.6 Waste (CRF Sector 6)

Emissions from the waste sector constituted 8% of the total emissions (excluding the land-use sector) in 2011. In comparison with the year of 1990, emissions of the waste sector were 8% less in 2011 and 9% more than in 2000. Like in all other sectors, emissions in this sector gradually decreased in 1991-1995, which was mainly related to the reduction of emissions from industrial wastewater (emissions in this sector were not estimated in 1991-1994 because data for these years are unknown); it is only known that the quantities for the industrial wastewater were reduced dramatically in 1995. The trends were stable in 1995-1999, while the gradual increase in emissions from this sector has been observed since 2000. Figure 2.12 shows the trend in greenhouse gas emissions from the waste sector in 1990-2011.

The increase in emissions is related to the increase in the quantities of the industrial wastewater (which in turn was provoked by economic growth), as well as the process of disposing waste on existing landfills, arrangement of the managed landfills and wastewater treatment systems (Norio Landfill was opened and Batumi Wastewater Treatment Plant was constructed). The main greenhouse gas emitted from this sector is methane. Its share was 95.3% in 2011. The share of nitrous oxide in this sector was only 4.7%.

It should be noted that the share of methane since 1990 has been slightly reduced - by 0.9%, while the share of nitrous oxide increased by the same number. Assessment of carbon dioxide emissions did not take place, as direct monitoring of CO_2 emissions is usually not taking place[38].

Besides, carbon dioxide originated from the landfills are of organic (biogenic) origin and they are not considered as additional emissions, as they participate in the carbon cycle and are not calculated in the waste sector according the 1996 IPCC Guidelines (they are included in the forestry sector as carbon reserves or are not at all calculated in the cadastre).

[38] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html (p.5.33)

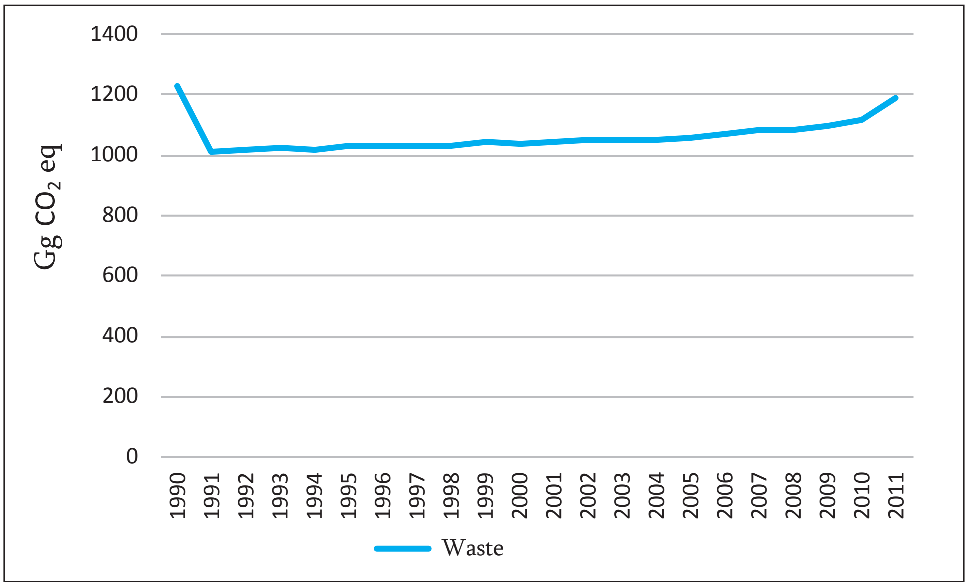

Fig. 2.12. Emissions from waste sector in 1990-2011

The waste sector includes emissions from the following source-categories:

- Solid waste disposal on land (6A)
- Wastewater handling (6B, 6B1, 6B2)
- Waste incineration (6C)
- Other waste - (6D)

Within Georgia's national inventory, the inventory in the waste management sector was only conducted for two sub-categories: Solid waste management (6A) and wastewater treatment (6B).

The IPCC sub-categories: Waste incineration and other waste are not considered, because waste incineration is not taking place in Georgia (only a small amount of medical waste) and other wastes are not registered.

Table 2.31 presents the amounts of greenhouse gas emissions in the waste management sector of Georgia by the sub-sectors for the years of 2000-2011. Figure 2.13 shows the largest part of emissions coming from the solid waste management/depositing (on average 75%). The trends in both sub-categories are quite stable, characterized with the growing trend. This is connected to the fact that methane emissions from this sector are taking place at a slow pace.

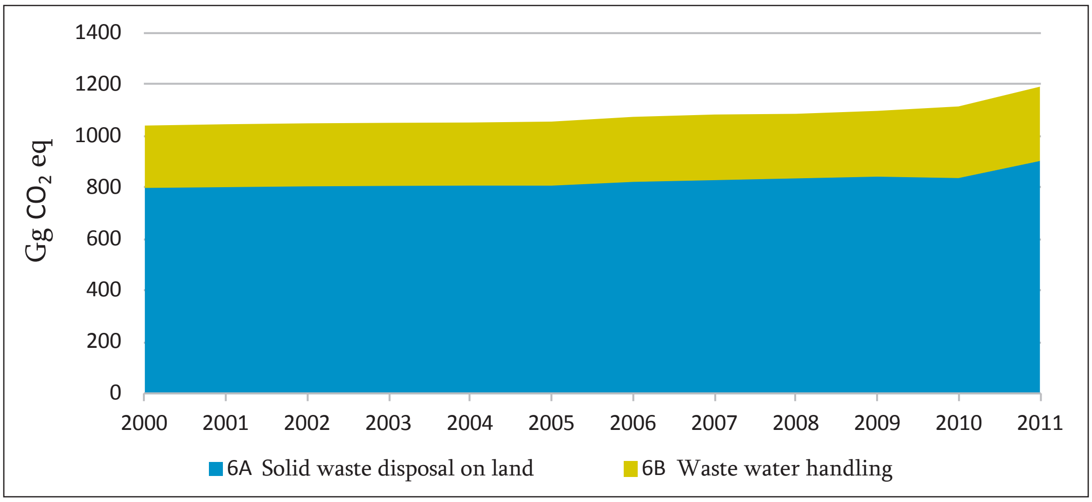

Fig. 2.13. Emissions from waste sector in 2000-2011 by source-categories

2.6.6.1. Source-Category: Solid Waste Disposal on Land(6A)

Based on information collected from various sources, the estimated annual volume of solid waste in Georgia is about 3.42 million m^3 [39]. The total area of operating landfill sites is more than 300 hectares. The large-size organized trash or waste processing plants are not operating in any of the cities or urban areas of Georgia. The only exception is Rustavi (where the waste sorting plant has been functioning since 2011)[40]. At present, waste separation is not organized in Georgia, but there are some secondary material recipient enterprises (metal, paper, plastics, glass). The population collects these materials from various areas, including garbage and rubbish containers and brings them to the receiving areas. Some of the waste fractions (paper, plastic, glass, etc.) are used as raw material in the production; however, the volume of recycled materials is very small. The population uses waste timber as fuel. Small enterprises operate in the country that are recycling non-hazardous, as well as hazardous waste.

There are enterprises engaged in the recovery/processing of used oils, as well as scrap and waste, enterprises processing outdated and malfunctioning batteries and enterprises generating hydrocarbons from used tires and residues of elastomeric material. Productivity of these enterprises is very low. 1.2 million m^3 household waste and residuals are collected annually in Tbilisi. In 2000-2010, these volumes were transferred to 2 landfills located in the suburbs of the city (Gldani and Iaghluja). In addition, "the Becker's Pit" functioned near the Gldani Landfill, where carrion of domestic animals was buried. According to the rough estimates, 36% of solid waste generated in Georgia is produced in Tbilisi (Fig. 2.14).

[39] The National Report on the State of the Environment for 2007-2009, the Ministry of Environment and Natural Resources Protection of Georgia. http://www.soegeorgia.blogspot.com/p/blog-page_01.html
[40] http://rustavi.ge/?p=7448

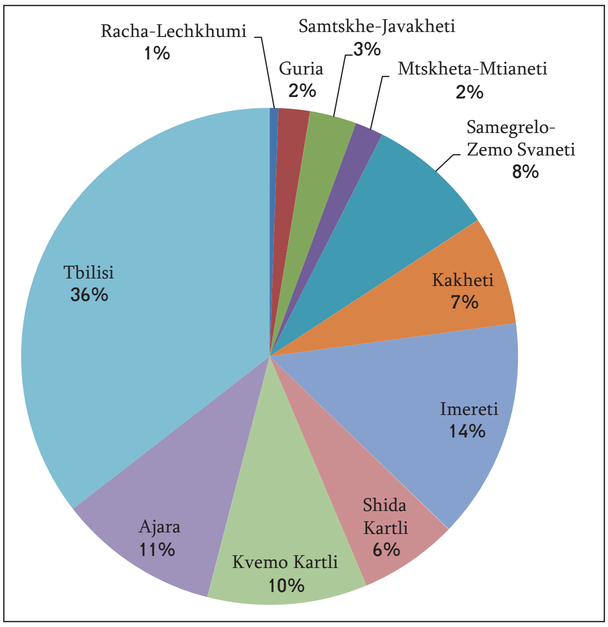

Fig. 2.14. Relative amount of residential waste generated in Tbilisi and regions[23]

It is expected that the number of municipal solid waste will increase in the future. The composition of the waste will also most likely change. It is important to introduce modern systems of waste utilization in the country, including waste separation by the population, which will reduce the amount of wastes at landfills.

Table 2.31. Emissions of CH_4 calculated for solid waste sub-category (Gg) in 2006-2011

Year	2006	2007	2008	2009	2010	2011
CH_4	38.65	38.96	39.34	39.6	39.9	40.26
CO_2eq.	812	818	826	832	838	845

Since 2006, the increase in methane emissions has been observed. The trend was determined by the improvement of the waste management system, migration of the population to urban areas and changes in the territorial area of some regions (expanding the boundaries of Batumi).

2.6.6.2. Source-Category: Wastewater (6B)

Wastewater is water used in household, industrial and commercial facilities that flow toward surface waters and reservoirs through the sewage system or by gravity.

Domestic and commercial (shopping facilities) wastewater contains wastewater from kitchens, toilets, and baths, etc. Sources of industrial wastewater are different branches of industry, such as the food industry, paper, cellulose, cast iron and steel productions, etc. Methane and N_2O are generated during the treatment or utilization of anaerobic wastewater[41].

The centralized sewerage systems operate only in 45 towns of Georgia. Most of them were constructed in the 1980s. Due to the systematic violation of the operation rules of these systems, most of them do not meet technical standards. In addition, only 33 towns have the communal wastewater treatment plants with the total design capacity of 1 640.2 thousand m^3/day. Most of them are also outdated. From these, only 26 towns have the biological treatment facilities with the total design capacity of 1 476.6 thousand m^3/day. But most of them are also outdated and inactive.

[41] http://en.wikipedia.org/wiki/Nitrous_oxide

These treatment facilities were mainly built in 1972-1986. The mechanical cleaning phase operates only in Tbilisi-Rustavi (Gardabani), Kutaisi, Tkibuli, Gori and Batumi treatment facilities. Adlia wastewater treatment facility started to operate with full capacity in August 2012. In addition to the mechanical wastewaters, biological wastewater collected from Batumi is also treated. The construction of the Adila water treatment system was funded by the German Development Bank (KfW)[42]. The construction of the new treatment facility is currently ongoing in Mestia and the construction of the treatment facilities is planned in Anaklia and Ureki[43].

The share of the pollutants sector in wastewater is the following: Water supply and sewerage system - 344.1 million m^3/yr (67%); heat power engineering - 163.8 million m^3/yr (31%); industry - 9.6 million m^3/year (2%)[44].

CH_4 and N_2O emissions from the wastewater sub-sector for the period of 2006-2011 years are provided in Table 2.32.

Table 2.32. Emission of GHGs from Wastewater subsector (Gg) in 2006-2011

Sub-category	2006	2007	2008	2009	2010	2011
6B CH_4 – Wastewater handling	9.59	9.70	9.51	9.73	10.66	11.15
6B1 Industrial wastewater handling	0.77	0.88	0.55	0.74	0.77	0.77
6B2 Domestic and Commercial wastewater handling	8.82	8.82	8.96	8.99	9.89	10.38
CO_2eq	201	204	200	204	224	234
6B2 N_2O Domestic and Commercial wastewater handling	0.16	0.16	0.16	0.16	0.17	0.17
CO_2eq	50	50	50	50	53	53
Total CO_2eq	251	253	249	254	276	287

Indirect Greenhouse Gas Emissions and SO_2 Emissions

The Third National Inventory of Greenhouse Gas Emissions for the period of 2006-2011 years estimated indirect GHG emissions. Nitrogen oxides (NO_X) and carbon monoxide (CO) emissions are shown in Tables 2.33 and 2.34 respectively. As the tables show, their main source is the energy sector and this is why they are repeating the trend of the energy sector.

Sulfur dioxide or sulfur anhydride (SO_2) are also emitted from the energy sector. SO_2 emissions are given in Table 2.36.

Non-methane volatile organic compounds from three sectors - energy, industrial processes and the use of solvents and other products are actually equally emitted. Non-methane VOCs are given in Table 2.35.

Table 2.33. Emissions (Gg) of nitrous ixides (NO_X) in 2006-2011

Sector/year	2006	2007	2008	2009	2010	2011
Energy	28	45	31	30	31	35
Industrial processes	3	4	2	4	5	4
Total	32	49	33	34	35	39

[42] Batumi Mayor's Office
[43] MRDI, 2013 Annual Action Plan, http://new.mrdi.gov.ge/ge/news/actionplan/52945ee50cf2a3f8e334c5c7
[44] http://ekofact.com/2010/05/30/76/

Table 2.34 Carbon monoxide (CO) emission (Gg) in 2006-2011

Sector/year	2006	2007	2008	2009	2010	2011
Energy	207	115	242	263	241	226
Agriculture	4	4	5	4	3	4
Waste	0	0	0	0	0	0
Total	211	119	246	266	243	231

Table 2.35 NMVOCs emissions (Gg) in 2006-2011

Sector/year	2006	2007	2008	2009	2010	2011
Energy	34	16	40	44	40	38
Industrial processes	17	32	56	47	55	64
Use of solvents and other products	53	53	53	53	53	54
Total	104	101	149	144	148	156

Table 2.36. SO_2 emissions (Gg) in 2006-2011

Sector/year	2006	2007	2008	2009	2010	2011
Energy	1.0	0.4	1.3	1.8	2.4	3.6
Total	1.0	0.4	1.3	1.8	2.4	3.6

Uncertainty Analysis

The uncertainty analysis of the GHG inventory prepared within Georgia's Third National Communication on Climate Change is based on the Tier I approach and covers all source-categories and reviewed direct GHGs. The year of 2011 was chosen for the uncertainty assessment. The year of 2000 was selected as the baseline year.

The calculations revealed that the level of emission uncertainty is in the range of 9.12% and the trend uncertainty - 17.27%.

The methane and nitrous oxide emission assessment, as well as fugitive emissions from coal, oil and gas production and indirect emissions from agricultural soils, have the highest uncertainty rate from the biomass combustion.

Fugitive emissions from the gas transportation and distribution, methane emissions from enteric fermentation and indirect emissions from soils make the highest contribution in the total uncertainty.

Accordingly, during the next inventory, efforts should be directed towards reducing uncertainty of these categories.

3 Activities Planned for the Implementation of the Convention

In 2012-2014, Georgia prepared the Third National Communication on Climate Change, which will be presented at the Conference of the Parties (CoP) to the UN Framework Convention on Climate Change. In the process of preparing this document, the following activities were implemented: National inventory of greenhouse gases, development of climate change scenarios, assessing vulnerability of various ecosystems and sectors of economy, as well as individual municipalities and regions, development of municipal and regional adaptation strategy and project proposals and discussing one of the (conservative) choices to the strategy for reducing greenhouse gas emissions (with specific measures). In addition, a series of awareness raising activities were conducted and Georgia's climate change strategy for 2014 was prepared.

The 2014 climate change strategy is based on the quality analysis for the performance of activities recommended within the strategy for the year of 2009 and the results obtained in the process of Georgia's Third National Communication on Climate Change. Unlike Georgia's Second National Communication, which was more focused on vulnerability of the ecosystems, the Third Communication raised the country's priority sectors (agriculture, tourism, health care) to the foreground and this was consequently reflected in interim documents, as well as the final 2014 strategy.

In 2006-2009, Georgia prepared the Second National Communication on Climate Change with the financial support from the Global Environment Fund (GEF). One of the main parts of the Communication was the climate change strategy, based on which serious investments related to the climate change sector were attracted to Georgia.

Since 2009, a number of projects have been implemented in Georgia. These projects assessed various issues related to climate change. In addition, pilot projects were developed and funded.

The projects implemented in 2009-2014, as well as contributions to the existing strategy on climate change were analyzed and evaluated in the process of preparing the Third National Communication on Climate Change.

The analysis (the extended version of the analysis is presented in Chapter 6 of this document) demonstrated that most of them were consistent with the actions planned within the strategy and the actions planned or implemented within the strategy were fulfilled by almost 80% or works are also currently ongoing.

The Strategy on Climate Change for 2009 mainly considered the following issues within its short-term goals: (1) Considering effects of climate change in the development plans. These plans are partially supported by donors and (2) Developing the full-scale adaptation strategy. The process of drafting the strategy has not started yet, but a large part of the preparatory works to develop the regional/municipal adaptation strategies was already completed.

In the process of implementing the 2009 strategy, particular attention should be paid to important projects and processes, namely to:

Developing Local Capacity

- Recognition of climate change as a priority by the Government of Georgia (Paragraph 5 of the Strategy) - processes have not been fully understood at the national level and coordination is lacking, which in some cases weakens the government's declared priority on climate change related issues.
- Strengthening capacities and powers of the body responsible for the Climate Change Convention (Strategy Paragraph 2) - donors are quite active in this direction and works are ongoing in different directions (Negotiations, developing strategies, determining estimated contributions at the national level and so on). Insufficient personnel qualifications are one of the main barriers in this process.

- Building local capacity in other ministries (Strategy Paragraph 6) - other concerned ministries are quite active and engaged, but their active involvement is largely determined by the donors' support. The process did not actually stop at the level of the ministries, as it was expected by the recommendation and unfolded in the regions and municipalities, which led to significant results.

Greenhouse Gas Inventory

- Ensuring the process of the greenhouse gas inventory with local resources and funding (Paragraph 5 of the strategy) - Unfortunately at this point this is not done at national level, but is taking place at the level of towns within the framework of the Covenant of Mayors and various projects. The system is not working at this point, however, Georgia has started to prepare the biennial update reports (BUR), within which qualification of the national experts should be developed and the system should be set up that is necessary for monitoring greenhouse gases in the country. The inventory strategy should be also updated within these BURs.
- Constant improvement (Strategy Paragraph 6) of various elements of the greenhouse gas inventory (data, ratios, quality control, archive, etc.) - Mainly within the framework of the implementation of the Covenant of Mayors, in the process of developing the low emission strategy, during planning and implementation of acceptable mitigation measures at the national level and within the framework of various projects. However, it should be noted that not all sectors are equally covered by this point.

Vulnerability/Adaptation

- Recommendation about the need for surveillance systems (Strategy Paragraph 7) - Periodic observation on several glaciers, including rivers feeding glaciers in Western Georgia; a constant monitoring and early warning system is being set up on Rioni River; the local climate monitoring station must be installed within the pasture management improvement project; monitoring is going on the Black Sea Batumi-Adlia section.
- Strengthening adaptation capacity (Strategy Paragraph 8) - Mainly various projects are implemented by the government, as well as by the donors, but there is no coordination from the unified responsible body.
- Assessing runoff changes in large rivers of Georgia by taking climate change into account (Strategy Paragraph 9) - Assessing Rioni, Enguri, Iori, Alazani and Adjaristskali river runoff changes within various projects and in conditions of the existing climate change prognosis. It should also be noted that these estimates are theoretical (using WEAP model) and are in most cases based on old data. Unfortunately, except the upper reaches of River Rioni, a hydrological observation network has not been so far set up.
- Climate change impact on the healthcare sector (Strategy Paragraph 10) - Evaluation was first conducted within the Second National Communication and afterwards, the ENVSEC-funded regional project and the Third National Communication. The Red Cross Society began to work on these issues in 2014.
- Promoting implementation of adaptation measures in Dedoplistskaro district (Strategy Paragraph 11) - A very active work to mitigate negative impacts of climate change is ongoing in this district in terms of windbreak and forest rehabilitation, as well as on protected areas and in the agriculture sector.
- Assessing the impact of climate change on arid and semi-arid areas of Georgia (Strategy Paragraph 12) - The expected impact of climate change was assessed on 5 main semi-arid areas of Georgia and project proposals were identified.
- Assessing the impact of climate change in Ajara and Upper Svaneti mountainous regions (Strategy Paragraph 14) - More than 20 project proposals were prepared and the strategies were published within the framework of the project.
- Promoting the project proposals developed for the Black Sea coastal line within the Second Communication (Strategy Paragraph 15) - Is partially executed for the Batumi-Adlia section, the Poti section is still under threat.

Greenhouse Gas (GHG) Emissions Reduction

- Enacting Kyoto Protocol's Clean Development Mechanism (CDM) (Strategy Paragraph 16) - 5 projects were registered and are currently being implemented. At present, activities in this direction are considerably weakened in anticipation of new negotiations and transition to the new market and non-market mechanisms when it comes to activating the donors.
- Assessing the potential for increasing the renewable energy share in the electricity and thermal power generation sectors (Strategy Paragraphs 17, 18) - Assessments and discussions on these issues are actively ongoing within the framework of developing Georgia's Low Emission Strategy. The MARKAL-Georgia model is mainly used for the assessments.
- Assessing the potential for increasing energy efficiency in the generation, supply and consumption sectors (Strategy Paragraph 19) - Georgia starts to prepare the Energy Efficiency Action Plan with EBRD support. Activities to be implemented under this paragraph (19) will be included in the Plan. The Nationally Appropriate Mitigation Action (NAMA) for the construction sector is being prepared with GIZ support. In addition to these activities, which are coordinated at the government level, important, but uncoordinated activism is demonstrated by the NGO sector in the direction of energy efficiency. Since 2011, Georgia's towns (now already 9 towns) have been actively involved in the process of the EU Covenant of Mayors, the main theme of which is to increase energy efficiency in urban areas (buildings, street lighting, transport sectors).
- Promoting the use of energy forests and other (existing) biomass in thermal and electricity generation (Strategy Paragraph 21) - Georgia received a grant in the amount of 1 million USD from the Global Environment Fund to prepare this strategy and implement the pilot projects. Due to the existence of cheap hydro resources for power generation, the priority for the Government of Georgia is the development of power plants and therefore, in terms of the biomass, the focus is shifted to the thermal supply, which mainly depends on imported gas or firewood.
- Assessing a potential for reducing greenhouse gas emissions in the transportation sector (Strategy Paragraph 22) - This issue became especially urgent and assessments are ongoing at the level of towns (disaggregated) in line with the requirements of the Covenant of Mayors in the process of preparation Sustainable Energy Action Plans (SEAP). In parallel, at the national level, this sector will be evaluated within the framework of the Low Emission Strategy document. Results obtained for the towns will be considered to the maximum extent in the process of assessing the emission potential in this sector at the national level. The project proposals are also prepared at the town level.
- Promoting import of new technologies (adaptation/mitigation of greenhouse gas) (Strategy Paragraph 23) – In 2011-2012, the GEF-funded project: Climate Change and Technology Needs Assessment was implemented. Within this project, a necessary technological basis was established and the project proposals were developed. Although it must be said that the country needs to activate its work in this direction, both inside, as well as outside of the country. It is necessary to improve the existing basis; more attention should be paid to the process of developing joint technologies.
- Education, Training and Awareness Raising (Strategy Paragraph 24) - A lot has been done in this direction. Decentralization of processes is especially important, which is being facilitated by the Covenant of Mayors. The process of preparing the National Communication is mainly going on in the regions, as well as with the support of the projects implemented by a variety of donors (USAID, EU, GIZ) to institutionalize climate change in the municipalities of Georgia.
- Implementation of the long-term strategy, which according to the 2009 Strategy covered the period until 2020 and mainly included transition of Georgia's economy to the principles of sustainable development and preparation of Georgia's National Plan for the possible reduction of greenhouse gases has already begun, especially its second part.

The Climate Change Strategy 2014 is prepared on the basis of the assessments and conclusions derived from the Third National Communication and other projects implemented in Georgia. The 2009 Strategy, as well the 2014 Strategy does not so far cover the entire area, but includes the majority of its territory and the population at large and mostly discusses major economic sectors. Below are summarized the main risks, which were identified during the preparation of the Third National Communication on Climate Change.

Impact of Climate Change on Agriculture

Agriculture is one of the most vulnerable sectors to climate change in any country's economy. This issue was discussed in some detail in the Third National Communication on an example of two significantly different regions in terms of climate: Ajara and Kakheti. Results obtained within the framework of the regional project were also analyzed for Kvemo Kartli and Shida Kartli semi-arid areas. In addition, the projected climate change impact on the transformation of the climate zones were also assessed for Upper Svaneti by the end of this century.

Land erosion is the main problem for the agricultural sector on the territory of Ajara. In the region, this problem is related to washout of fruitful soils in conditions of abundant precipitation, which as a result of climate change, along with heavy rainfall exacerbates urgency of the problem.

The second most acute issue for Ajara is late spring and early autumn frosts, which are caused by the fact that Ajara is the extreme north-east region of the Mediterranean citrus production sector and more often suffers from the invasion of cold air masses from the north. It was estimated that acuteness of the problem would decrease in conditions of predicted climate warming, determined by the **prolongation of the vegetation period** and the increase in the sum of the active temperatures, but the reality demonstrated that the temperature increase only is not enough to have high-quality citrus harvest. **Harmful insects and plant diseases** are spread in conditions of the temperature rise, new types of diseases are disseminated, which has already caused problems for citrus and other crops in Ajara. Given the fact that over the past half-a-century the average temperature of the subtropical vegetation period increased by 0.6 ^{0}C in Ajara and the increase by another 1.0 ^{0}C is expected until 2050, the possibility of exacerbating this problem and the need for preventive measures become clear.

From extreme climate events, **drought, temperature increase (extremely hot days), wind erosion and hail** create serious problems for the agricultural sector of Kakheti. Meteorological observations demonstrated that recurrence of droughts during the last 10 years started to have an annual character and their duration has almost doubled. As a result of damaging the large part of the irrigation systems and cutting down windbreaks, the effect of intensified droughts on the key sector of the regional economy - agriculture becomes more and more catastrophic. The negative impact of droughts is also increased by continuous rise in air temperature. In particular, in 1961-2010, the temperature during the vegetation period increased by 0.6-0.8 ^{0}C on the territory of Kakheti, while the number of hot days during the year increased by 11. According to the weather forecast, it is expected that this number will still increase by 40 until 2050.

Wind erosion, mainly manifested in plain areas, is mainly prevalent in Kakheti Region (Dedophlistskaro, Akhmeta, Sighnaghi). The semi-arid Shida and Kvemo Kartli districts are also facing the same problem, although high winds frequent in Dedophlistskaro, are not common here.

Hail is a specific and severe problem for three municipalities (Sagarejo, Telavi, Kvareli) in Kakheti Region. Along with climate warming, its intensity has increased in recent years. This natural phenomenon is particularly damaging vine. Not only is the annual harvest lost after heavy hail, but also plants need another 2-3 years to overcome its consequences and restore fertility. Given that viticulture is one of the leading agriculture sectors in these municipalities, the importance of the problem becomes clear for these districts, as well as for Kakheti Region in general, as hail also quite heavily damages fruit trees. Together with private insurance companies the government developed the insurance package to provide insurance against hail. Despite this, it is necessary to work with farmers.

A deficit of high-quality certified seed materials and vine saplings was also identified as the high-priority problem for Kakheti Region. Poor quality vine sapling cannot survive root diseases and low quality seed material is followed by weeds, which adapts and extends well in conditions of high temperatures. In addition to the diseases, grain seed material produced in the region has to meet new requirements by taking climate change into account, which makes this direction even more urgent. The same is true about the production of different types of virus-free vine seedlings.

It was revealed for Shida Kartli semi-arid districts that if the main problems of the agricultural sector for the semi-arid territories of Kakheti Region are associated with agricultural droughts[45], these problems in Shida Kartli and Kvemo Kartli regions are mainly determined by strong winds and high average daily temperatures.

Assessments conducted for the above-discussed four regions revealed common and individual agriculture vulnerability characteristics in all of them for current and future climate changes. In particular, the problem of land erosion is the main and most painful for Ajara, while the problems related to drought, winds and temperature rise are important for Kakheti and Kartli regions.

In some municipalities, as in Ajara, as well as in other regions, washout of agricultural lands by rivers is another serious problem. With the increase in precipitation intensity, the washout process becomes increasingly important in Ajara and Kakheti. It puts the need for conducting large-scale river bank reinforcement activities on the agenda in both regions. It is noteworthy to mention that the process leads to the secondary bogging of land in Kakheti, which requires implementation of land reclamation activities.

In the Third National Communication, the existing climate change-related problems facing the agricultural sector were discussed in the context of the past half-a-century developments, as well as in the context of projected changes in climate conditions till 2050. In this respect, the abovementioned document also reviews Georgia's fifth region - Upper Svaneti. Expected transformation of the agro-climate zones as a result of projected warming were assessed by taking into account data from Khaishi and Mestia meteorological stations, agro-climate resources of Western Georgia, as well as findings of the studies conducted by other authors. The overall results revealed the possibility of substantial expansion of agricultural production including further dissemination of pastures and hayfields to the alpine zone as a result of glacier retreat and degradation.

The details of these studies, along with other agricultural problems are discussed in special editions dedicated to the climate change strategies for Ajara Kakheti and Upper Svaneti regions, which represent separate parts of Georgia's Third National Communication.

Impact of Climate Change on Extreme Geo-Ecological Events

From three regions selected in Georgia's Third National Communication, extreme geological events, by taking into account damage caused by past and possible future risks, are especially threatening populations in Ajara and Upper Svaneti, leading sectors of the economy, infrastructure facilities and natural ecosystems.

As for the natural geological events in Ajara, landslides, rock falls, mudflows, river bank washoffs and snow avalanches were assessed. Statistical analysis for the period of 1967-2009 demonstrated that in comparison to the period until 1987, its aftermath in the region is characterized by 63% increase in landslides, while mudflow incidents increased by 162%. Until 1989, the total length of washed out river embankments was 60 km, while this number increased to 196 km in 2009. 82% of Ajara's total territory is covered with avalanche hazards of the different degree. The connection of these catastrophic events to abundant precipitation was revealed, recurrence of which according to the data from meteorological stations was increased by 32% in the period of 1986-2010 in comparison with the previous 25-year period. By taking into account the future climate change forecast data, the possibility of further activation of landslides and floods were accepted for the period until 2100. Within the framework of the Third National Communication, the adaptation project proposal to establish

[45] Defined by SPI

the monitoring network of geological processes and the early warning systems was developed. The potential of the local geological service should be strengthened.

Similar to Ajara, among extreme geological events, the statistics of landslides, mudflows, rockfall and snow avalanches for the period of 1960-2013 were reviewed on the territory of Upper Svaneti. It was concluded that in comparison to the period of 1960-1991, in 1992-2013, the total number of landslides in the region increased by 4.1, while the number of registered floods increased by 1.9. Because of the absence of data on snow avalanches, the similar assessment could not be conducted. It is only known that 95% of the territory of Upper Svaneti is under avalanche hazard, from which almost 35% is characterized by extreme avalanche danger. The direct connection of the above-mentioned extreme events to the cases of abundant precipitation and the increase in the volume of annual precipitation was established. In particular, the volume of annual precipitation in 1987, which was the year distinguished with natural geological events, exceeded the climate norm by 43%.

Based on the climate-meteorological characteristics and forecasts (at least 10% precipitation increase), vulnerability of geological environment, nature and trends of exo-geodynamic processes, anthropogenic and other factors, it was concluded that further escalation of geological processes is expected until 2050. Development of the plan of preventive measures for natural disasters, as well as for natural geological processes is an objective that has paramount importance for Upper Svaneti Region, in which the establishment of the monitoring network and the early warning system will play one of the leading roles. It is necessary to establish the permanently functioning local geological service.

Scales of the geological events in Kakheti Region are much more modest than in Ajara and Upper Svaneti (Mestia). Mudflows (Sagarejo, Telavi, Kvareli), landslides (Sagarejo, Telavi), flood/freshets (Akhmeta, Lagodekhi) and river bank washouts (Akhmeta) were assessed for the municipalities of this region. In Kakheti, these natural disasters mainly have the impact on agriculture and agricultural lands. For Kakheti, these problems may be resolved by the active involvement of local authorities and farmers in the state programs that promote preservation of agricultural lands and their fertility.

Thus, it can be said that in all three reviewed regions, landslide-mudflow processes reactivated under the influence of abundant precipitation contain the greatest risks related to climate change and associated extreme geological processes.

Snow avalanches for Ajara and Upper Svaneti, river bank washouts for Kakheti Region represent the second greatest risks. These processes too are interlinked with abundant precipitation.

Impact of Climate Change on the Tourism Sector

A variety of natural conditions and rich historical heritage determines the priority of the tourism sector in Georgia's economy. At the same time, tourism, like agriculture, is also highly vulnerable to climate and its change, that is why this issue was relevantly addressed in Georgia's Third National Communication.

The current climate change on Ajara's tourism sector was assessed by using the Tourism Climate Index (TCI) and the Heat Index (HI). Estimations made by using the data of Ajara's different climate zone characteristics during the half-a-century period (1961-2010) from 4 meteorological stations demonstrated that as a result of climate warming, in the last 25 years, in addition to the May-October period, favorable conditions for the summer tourist season were also created in April. At the same time, the temperature increase deteriorated comfortable conditions in August. In the alpine zone, tourism conditions were improved in all three seasons, except winter.

It has been also determined that the number of hot days has increased considerably in Batumi during the above-mentioned last period, while this has not happened in Kobuleti. The calculation made by using the projected warming data till 2050, demonstrated that climatic conditions for tourism are expected to worsen in the summer season in Batumi, but will be improved in the mountainous and high-mountain areas. According to the estimations conducted for the period until 2100, further deterioration of favorable conditions for tourism in the coastal area was projected for July-August, which will lead to the need to implement relevant adaptation measures.

Among Georgia's regions, due to distinctive natural and ethnographic conditions of Upper Svaneti, climate and its change has specific aspects of its impact on this region. This is determined by the severity of the climate in most parts of Upper Svaneti, as well as low temperatures and abundant precipitation. This is why winter continues for almost half a year here.

This circumstance negatively impacts cultural and archaeological monuments, in which Upper Svaneti is so rich. Also, mountaineering and mountain tourism depend heavily on the snow cover, which is highly vulnerable to climate warming. Thus, climate change in Upper Svaneti affects not only cognitive tourism and mountainous sport sectors, but also cultural and architectural monuments, which represent one of the main subjects of cognitive tourism. Existence of few meteorological stations and shortness of the observation period determined the fact that the Tourism Climatic Index (CTI) calculations were conducted by using the actual weather station data for Mestia for 1961-2010 and the projected 2013-2100 data. For the first period, the existence of unfavorable conditions for tourism were revealed for the winter months and very good conditions for June-September. By the end of this century, the improvement of climate conditions conducive to tourism was got from February including December except three summer months, when transition of Mestia to the "acceptable" TCI category is possible due to temperature rise. The temperature rise most likely will be accompanied with the increase in air humidity, which will negatively affect the condition of historic monuments, as well as will reduce snow cover and cause glaciers retreat, which will not of course contribute to the development of tourism in Svaneti.

Similar assessments were done for Kakheti Region based on the data from 5 meteorological stations. According to the assessment results, the TCI categories have not changed on all assessed weather stations during the past half-a-century. This demonstrated that since the beginning of the 1970s, global warming has not had a material impact on the region's tourism-related conditions, which through the year round do not go below the "pleasant" and "acceptable" categories (in contrast to Ajara, where in the winter months, the TCI index moves to the "unfavorable" category). The estimations conducted by the forecast data for the year of 2100 demonstrated that during the cold period of a year (October-March), improvement of environmental conditions favourable forconducive to tourism is expected on Kakheti's all five weather stations. But, the inverse process is expected during the warm period. This trend is clearly revealed in July-August, when transition of the TCI index in Telavi and Kvareli was marked to the "unpleasant" category due to high temperatures.

Impact of Climate Change on the Healthcare Sector

Vulnerability of the healthcare sector to climate change for all three main selected regions was assessed under the Third National Communication. Climate-related diseases defined by the World Health Organization (WHO) were mainly discussed: Infectious and parasitic diseases, diarrheal and, in general, water, food and insect/animal transmitted infections, cardiovascular diseases, mental disorders and injuries, abnormal conditions caused by solar radiation and heat waves.

In comparison with the previous ten-year period, the number of diarrheal diseases in Ajara increased 3-fold during 2000-2010.

Cases of new diseases (leptospirosis, borreliosis) related to climate warming were observed in Ajara. In the 1961-2010, the recurrence analyses of heat waves revealed the increase of "very warm" days in Batumi by 125% during the last 25-year period and their reduction in Kobuleti by 15%.

The vulnerability parameter values for Ajara municipalities were assessed by using the multi-criteria analysis in conditions of the current and projected climate changes. The results revealed that until 2050 the healthcare sector is the most vulnerable to current and projected climate changes in Batumi Municipality, which creates the need to strengthen appropriate adaptation measures.

By taking into account the alarming increase in diarrheal diseases, appropriate recommendations were developed and prepared for Ajara's health sector. In addition, adaptation project proposal was also developed.

For assessing vulnerability of the healthcare sector to the climate change in Upper Svaneti Region, the data for the years of 2009-2011 were analyzed using statistics of the prevalence of injuries in Upper Svaneti and it was compared with the overall index from the region. The assessment revealed that the number of cases in Upper Svaneti is about 3-4 times higher than the national average, which was explained by the frequency of natural disasters and high risks associated with the mountainous tourism. According to the statistics for the years of 2002-2011, cases of hypertension increased by about 60% in this period.

Similar studies were conducted in Kakheti Region. Based on the data of 2002-2011, the increase in the number of cases of heart diseases by 70% was revealed before 2009 and afterwards, its slight decrease was observed. Quite close correlation between cases ($r = 0.62$) of myocardial heart attacks and hot days (SU30) was observed. The potential of the region's health care system was assessed.

Thus, according to the presented data it can be concluded that from the selected regions, climate change in Ajara was revealed mostly with the increase in diarrheal diseases, which along the temperature increase can be explained by the significant increase in the number of tourists during summer.

During the last 10 years, in the healthcare sector of Kakheti region, climate change had the most significant impact on the prevalence of the diseases of cardiovascular system and in particular, hypertension. As for the Upper Svaneti region - on the prevalence of respiratory diseases and injuries.

Impact of Climate Change on Forest Ecosystems

Almost 40% of Georgia's territory is covered by forest ecosystems. The Third National Communication assessed the impact of climate change on these ecosystems on the example of Ajara, Upper Svaneti and Borjomi-Bakuriani forests.

The major factors of climate impact on the forest ecosystems of Ajara, which cover 66% of the region's territory, are: The increase in temperature and precipitation, which in the last few decades led to the annual increase in the prevalence of pests and diseases.

Presently, the total area of infected forests amounts to 6% of the forest fund (192.5 thousand ha). From phytopathological diseases, chestnut endotic cancer is the most widespread in relatively lower zone of the region, while the great spruce bark beetle (Dendroctonus micans), Ips tipographus L and Ips acuminatus Eichh dominate the higher part of the region.

In the lower zone, where the temperature increment in the beginning of the century was 0.5 ^{0}C, while the annual precipitation surplus amounted to 8%, 28% of the total chestnut-covered area withered and the process is increasing every year. It was concluded that with the gradual increase of the average annual temperature, the disease area advanced to the high mountainous chestnut forests. In addition, new diseases (Cameraria ohridella Deschka, Tischeria complanella Hb= Tischeria Ekebladellia Bjerkande, Cylindrokladium buxicola) emerged in the forests of Ajara in 2006-2011, which is expected to cause catastrophic damage to host relict and endemic species in conditions of climate warming. In addition, the upper forest border moved lower by 300-400 m during the last 50 years, which is mainly due to land erosion processes and anthropogenic pressure (pasture overgrazing and forest felling) associated with heavy rains. According to the climate change forecast, temperature in Ajara will increase by 1.5 ^{0}C in the middle of this century; by the end of the century this number will reach 4.2 ^{0}C. In addition, the number of hot days and tropical nights will significantly increase, which will create a favorable environment for further activation of forest pests and diseases. In addition, with the slight increase in precipitation, their decline by approximately 10% is expected by the end of the century. Based on this future forecast, it could be said with high probability that the risks of fire and plant diseases will increase in the forests of Ajara, but at the same time, the risk of disappearing the subalpine forests and the process of moving down their boundaries will decrease. Recommendations included in the Climate Change Strategy of Ajara were developed in order to implement climate change adaptation measures discussed in this sector.

The study of the impact of climate change on the forest sector of Upper Svaneti revealed that boreal forest species (pine and birch) gradually occupied the areas vacated by glacier retreat.

During past 50 years, birch was replaced by coniferous variety, namely spruce on quite large areas in Mestia Climate Zone. It was also revealed that on the northern mountain slopes, where the upper spruce-fir forest belt moved to the alpine zone, spruce-fir forests are now widespread. The analysis also demonstrated that climate warming, which in the last half-a-century amounted to 0.3 ^{0}C, especially impacted dissemination of birch forests in the Upper Svaneti Region, which was reflected in the rise of their border above the territory. By taking the future climate change forecast into account, a conclusion was reached that in the section of the alpine zone, where anthropogenic pressure is less, the forest area will increase. While in the forest massifs along alpine pastures, biomass stocks will increase with warming in proportion with the capacity growth. It was also noted that negative manifestations of climate change, such as fires and increased incidence of pests and diseases are not observed in Svanetian forest massifs, which has a tendency to increase in other regions of Georgia.

In the lower Khaishi Climate Zone, unlike the Mestia Zone, the impact of climate change on the forest massifs has not been clearly established. However, by taking into account the observed changes in Mestia Zone, it was concluded that in Khaishi Zone, coniferous forest species may be replaced by deciduous species during the current century. As for the Borjomi-Bakuriani forest ecosystem, during the past 50 years, abiotic (increase in fire incidences), as well as biotic (the systematic recurring of pests and diseases) disorders were observed. The summer temperatures in the region increased by 1^{0}C in the abovementioned period, while precipitation decreased by 14%. Almost all time-scale droughts increased and the number of hot days increased by 11 annually. At the same time, the number of days with abundant precipitation also increased, as a result of which mudflow and landslide risks were also increased. It was concluded based on the analyzed materials that current climate change facilitated the increase in fire hazard and expansion of the favorable areas and spread of pests in Borjomi-Bakuriani forests. This trend will be even further strengthened considering future climate change.

Reduction of Greenhouse Gas Emissions

Since November 2013, the Government of Georgia has been preparing the **Low Emission Development Strategy of Georgia**. This document intends to present a long-term, common economic plan, which on the one hand will promote the country's economic development and on the other hand, reduction in greenhouse gas emissions. In order to ensure management of the processes, the United States Agency for International Development (USAID) funded the Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) project. The goal of the project is to support the Government of Georgia in this direction. The Association Agreement signed with the European Union in June 2014 clearly outlined cooperation issues within the Nationally Appropriate Mitigation Action (NAMA) to be adopted under the Low Emission Development Strategy of Georgia at the national level.

The German Government has been intensively working with Georgia to introduce the monitoring, reporting and verification (MRV) systems, as well as for the institutional capacity building within the program promoting climate change mitigation measures that needs to be adopted at the national level. Within the framework of this **program, cooperation** is ongoing with the German Society for International Cooperation (GiZ). According to the program that promotes implementation of the **mitigation measures at the national level**, the first project launched in Georgia involves implementation of sustainable forest management practices to climate change. This project has been already registered by the governments of Georgia and Austria. In 2014, the second project for the climate change mitigation measures to be adopted at the national level was launched. It deals with the energy efficiency of buildings in Georgia and the Ministry of Economy and Sustainable Development is actively involved in the implementation of the project. The third **NAMA** project: "Cooperation of Civil Society Organizations with the Government and Other Interested Stakeholders on Climate Change **Mitigation Measures to be adopted at the National Level - NAMA**, Sustainable Energy Development in Rural Areas" is implemented by the non-governmental sector ("The Green Movement of Georgia"). The project envisages installation of 10 000 solar water heaters and 10 000 energy efficient wood stoves in various municipalities.

In order to reduce greenhouse gas emissions, Georgia from the beginning was actively involved in the Kyoto Clean Development Mechanism (CDM). 5 projects were registered from the country, out of which 3 were related to the hydro power generation facilities (Enguri HPP, Dariali HPP and Adjaristskali HPP) and 2 above ground gas distribution networks reducing methane leakages. Annual savings generated by these five projects are estimated to be 1 745 748 tons of carbon equivalent.

In 2008, the EU launched the **Covenant of Mayors (CoM)** initiative to assist local authorities in the implementation of sustainable energy policies. Towns and territorial units, who desire to join to sign the agreement are obliged to honor certain procedures and implement certain measures. For instance, the undersigned should create a detailed greenhouse gas inventory system at the town level in order to quantitatively determine the greenhouse gas emissions, develop a **Sustainable Energy Action Plan (SEAP**) and establish **sustainable energy offices** or **sustainable energy resource ce**nters at the regional level. Currently, 9 Georgian towns signed the Covenant of Mayors, namely: Tbilisi, Kutaisi, Batumi, Rustavi, Gori, Zugdidi, Poti and Telavi and Akhaltsikhe has recently joined the signatories. These towns are at the different stages of the **CoM** process. Seven donors, including the European Union and the USAID support these towns in developing the sustainable energy action plans and implementation of the mitigation measures identified in these plans.

Implementation of other initiatives, such as development of the Intended Nationally Determined Contributions (INDC) and the Biennial Update Reporting (BUR) within the United Nations Framework Convention on Climate Change (UNFCCC) is planned in the near future. Disaggregation of greenhouse gas inventory process was actively supported within Georgia's Third National Communication on Climate Change. In particular, the greenhouse gas inventory was conducted in the Ajara Autonomous Republic and the Emission Reduction Strategy was prepared. In addition, the simplified Sustainable Energy Action Plans (SEAP) were developed for Batumi and Poti.

Greenhouse Gas Reduction Strategy

The Emissions Reduction Strategy presented in Georgia's Third National Communication is adopted by taking into account the above-mentioned activities and is based on works implemented until July 2014 within Georgia's Third National Communication. USAID funded Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) project and the CoM.

Georgia's Third National Communication includes energy, waste, land use, land-use change and forestry (LULUCF) and agricultural sectors. Apart from the energy sector, measures presented in other sectors were incomplete.

In particular, agricultural measures are copied from the Strategy of Reducing Greenhouse Gas Emissions in Ajara and the remaining two (waste and greening) are taken from the Sustainable Energy Action Plans of the respective towns. Chapter 7 of this document analyzes the barriers existing in the country that impede implementation of the general principles of the Convention, as well as import of environmentally friendly technologies, integration of climate change issues into sectoral development plans and concepts, development and implementation of adaptation measures for the sectors and systems vulnerable to climate change, renewable energy development and implementation of the energy policy, development of local capacity, etc. The climate change strategy below is drafted to overcome these barriers.

3.1 Climate Change Strategy of Georgia - 2014

Main Strategic Goal	Main Target Groups*	Activity	Potential Leading Organization (within their competency)	Result	Potential Donors
Short-Term Strategy Goals					
• Considering climate change results in the development plans and concepts; • Developing National Adaptation Programme of Action (NAPA); • Development of the Low Emission Development Strategy (LEDS) • Determining the Intended Nationally Determined Contributions (INDC); • Coordination of the towns participating in CoM and promoting implementation of the obligations under CoM; • Provision of Government's maximum support to processes included in the Association Agreement with the European Union	• Government of Georgia • Parliament of Georgia		Ministry of Environment and Natural Resources Protection of Georgia; Ministry of Energy; Ministry of Economy and Sustainable Development; Ministry of Agriculture; Ministry of Regional Development and Infrastructure; Ministry of Labour, Health and Social Affairs; Ministry of Finance; Ministry of Education and Science.		Government of Georgia; Bilateral and multilateral donors; USAID; GiZ; GEF; GCF; EU.
Strengthening Local Capacity to Implement the Principles of the Convention on Climate Change					
1. Recognition of the problem of climate change as a priority by the Government of Georgia	• Cabinet of Ministers; • Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy	• Systematic evaluation of the impact of climate change on Georgia's economy and separate ecosystems and developing the reports for the country's government; • Organizing information and consultation meetings with the	• Ministry of Environment and Natural Resources Protection of Georgia;	• Government of Georgia encounters the climate change problem and recognizes it as one of the country's development priorities; • The possible impact of	Government of Georgia; Parliament of Georgia; Ministry of Environment and Natural Resources Protection of Georgia;

* In this strategy the target groups are stakeholders whose activities are directly or indirectly related to the climate change process and who are beneficiaries of or vulnerable to the results of planned actions.

	and Sustainable Development; • Ministry of Agriculture; • Ministry of Labour, Health and Social Affairs; • Ministry of Sports and Youth Affairs; • Ministry of Culture and Monument Protection of Georgia • Ministry of Education and Science; • Ministry of Finance; • Ministry of Foreign Affairs; • Parliament of Georgia.	participation of EU experts; • Involving representatives of all relevant ministries in the delegations participating in international climate change meetings; • Strengthening capacity of local self-governments for the successful implementation of energy efficiency measures and the sustainable development policies; • Initiating and promoting debates on these issues in the country; • Preparing the country for 2015 and 2020 Agreements.		climate change is considered in the sectoral development plans and concepts; • Georgia is ready and has a clear position on the 2015 and 2020 agreements by taking the country's interests into consideration.	
2. Establishing the coordination council/committee on climate change issues, which will include representatives of all interested ministries (the existing LEDS Committee may be expanded and granted with relevant authority)	• Government of Georgia • Parliament of Georgia • Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Labour, Health and Social Affairs; • Ministry of Culture and Monument Protection of Georgia; • Ministry of Education and Science; • Ministry of Finance; • Ministry of Foreign Affairs.	• Persons in charge of climate change policy issues in all ministries related to climate change should be authorized; • Awareness raising of the personnel authorized by the ministries and their intensive training of the relevant sectoral issues, risks and mitigation options, providing information on current negotiations going on at the international level and trainings.	• Government of Georgia • Parliament of Georgia • Ministry of Environment and Natural Resources Protection of Georgia;	• A coordinating and decision-making permanent body on climate change is established.	Government of Georgia

3. Establishing the LEPL[46] at the Ministry of Environment and Natural Resources Protection of Georgia that will implement the Convention on Climate Change and technical capacity building of the LEPL for providing technical support in the process of implementing the Climate Change Convention (the greenhouse gas inventory, monitoring of the saved emissions as a result of the implementation of the specific projects, importing and promoting new methodologies and technologies in the country, training technical experts, etc.).	• Ministry of Environment and Natural Resources Protection (Climate Change Service). The LEPL can be established on the basis of the Climate Change Service.	• Participation in international meetings and seminars; • Inviting international experts to discuss various climate change issues; • Technical capacity building of the employees in order to promote their involvement in the process of developing strategic plans and concepts; • Preparing project proposals and their implementation; • Coordination of ongoing projects implemented in the country that are related to climate change.	• Climate Change Service of the Ministry of Environment and Natural Resources Protection	• Capacity of the agency responsible for implementing the Climate Change Convention is enhanced; • The Georgian delegation fully participates in the negotiation process (including knowledge of technical and political issues, funding is a separate issue).	Government of Georgia; Ministry of Environment and Natural Resources Protection of Georgia; EU; USAID; GiZ; ADA; UNEP.
4. Building local capacity in Georgia for the efficient implementation of the principles of the UNFCCC and ensuring	• Ministry of Environment and Natural Resources Protection; • Ministry of Energy;	• Promotion of the local capacity of all those ministries, activities of which are connected with the climate change problem; • Informing constantly persons in	• Ministry of Environment and Natural Resources Protection (Climate Change Service).	• All relevant institutions related to the climate change problem are involved in the implementation of the	Government of Georgia International donors (UNEP, WB). Various EU programs (Europe AID).

46 LEPL-Legal Entity of Public Law

participation in global processes on a parity basis.	• Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Labour, Health and Social Affairs; • Ministry of Culture and Monument Protection of Georgia; • Ministry of Education and Science; • Ministry of Finance; • Ministry of Foreign Affairs; • Local self-governments.	charge of the relevant ministries on the possible negative consequences of climate change and providing recommendations for taking into account threats in the planning process; • Strengthening the potential of the self-governing bodies on climate change issues; • Strengthening technical capacity in municipalities of Georgia.	• NGO sector.	principles of the Convention (according to their respective sectors); • Assessing climate change risk at the level of sectors and areas and the assessment results are foreseen in the development plans.	Bilateral donors.
5. Improving the legislative framework necessary for the implementation of the main obligations under the UNFCCC (GHG inventory, GHG mitigation and implementation of adaptation measures) and the Kyoto Protocol mechanisms and its harmonization with the relevant EU legislation.	• Parliament of Georgia • Ministry of Environment and Natural Resources Protection	• Preparing recommendations for amending the legislative framework, which is necessary for: • Conducting the annual inventory of greenhouse gases; • Implementing climate change adaptation measures; • Promoting the development of renewable energy resources; • Implementing the energy saving policy; • Efficient implementation of the Low Emission Development Strategies (LEDS), the Clean Development Mechanism (CDM) and the Nationally Appropriate Mitigation Actions (NAMA).	• Parliament of Georgia • Ministry of Environment and Natural Resources Protection. • Climate Change Service at the Ministry of Environment and Natural Resources Protection.	• The country has a legal framework that provides for: • Conducting the annual inventory of greenhouse gases; • Developing and implementing climate change adaptation measures; • Reduction in greenhouse gas emissions; • Importing clean and adaptation technologies.	Ministry of Environment and Natural Resources Protection Various EU programs (Europe AID) Bilateral donors (Netherlands)
Greenhouse Gas Inventory					
6. Establishing the permanent national team and the inventory system within and with the help of the Biennial Update Reporting (BUR),	• Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office;	• Establishing the permanent unit responsible for conducting the inventory throughout the country with the purpose of ensuring continuity and sustainability of the greenhouse gas inventories or	• Ministry of Environment and Natural Resources Protection of Georgia;	• The continuous process of conducting the inventory of greenhouse gases is functioning in the country.	Government of Georgia With GEF support

which will be responsible for conducting the inventory and preparing reports.	• Ministry of Energy; • CoM signatory towns; • The private sector included in the Clean Development Mechanism (CDM) and other market mechanisms.	outlining the drafting system/process in detail on how the Ministry for Environment and Natural Resources Protection prepares inventories in case of availability of local or grant funds, so that the process is in compliance with the Georgian legislation; • Developing the national legal system for conducting the greenhouse gas inventory; • Permanent update of the registry of local experts (having national and international statuses); • Analysis of the GHG key sources and assessment of trends; • Verification of the inventory conducted within the framework of Georgia's National Communications and documenting notes (QA/QC) in the process of preparing the Biennial Update Reporting (BUR); • Improving data archiving and performance and constant updating of the archive; • Constant renewal of the inventory strategy.			
7. Preparing the Biennial Update Reporting (BUR) for the years 2015-2016.	• Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office; • Ministry of Energy; • Ministry of Agriculture; • Ministry of Regional Development and Infrastructure; • CoM signatory towns;	• Assessing national circumstances (economic, social and other trends); • The greenhouse gas inventory for the years of 2011-2013, which should be prepared in the IPCC computer database developed in 2006 based on the 2006 Guidelines; • Assessing the climate change mitigation potential and strategy; • Assessing the needs for building technical, financial and local capacity; • Processing the monitoring, reporting	• Ministry of Environment and Natural Resources Protection of Georgia;	• The decision of the Convention about preparing the BURs is fulfilled; • Georgia's first BUR is prepared and submitted to the Conference of the Parties; • The monitoring, reporting and verification schemes of the national system are prepared and discussions are launched.	Government of Georgia With GEF support

	• The private sector included in the Clean Development Mechanism (CDM) and other market mechanisms. • Stakeholders involved in preparing the Low Emission Development Strategy.	and verification schemes of the national system.			
8. The process of inventory disaggregation started under Georgia's Third National Communication on Climate Change (at the town and municipality levels) continues, which helps the CoM signatory towns and municipalities in fulfilling their obligations. This process contributes to the improvement of the process of national inventory.	• Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office; • Ministry of Energy;	• Conducting GHG inventory by Georgian CoM signatory towns and municipalities within territorial entities comprising of the following sectors: Buildings, transportation, street lighting, waste and waste water management and planting of trees; • Creating local activity and emission factor data bases and their utilization in the process of preparing decisions.	• CoM signatory towns (9 towns), as well as other cities and municipalities that are going to get involved in the Covenant of Mayors; • Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office; • Ministry of Energy.	• GHG inventory is conducted at the level of different towns and municipalities for the following sectors: Buildings, transportation, street lighting, waste and waste water management and planting of trees • Local emission coefficients for disaggregated activity data and different sectors are calculated and used for assessing and reducing inaccuracies in the aggregate inventory; • The national activity database is improved; • The potential for managing independent governing units and decision-making has increased; • The foundation for producing disaggregated statistics is being laid.	USAID EU Ministry of Environment and Natural Resources Protection of Georgia Ministry of Energy
9. Constant monitoring of the past and future trends and assessing reasons for changes.	• Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office;	• Assessing GHG future trends (BAU scenario) for the years of 2020, 2030 by using different available methods (LEAP, MARKAL-Georgia, Times, etc.); • Analysis of the reasons for the	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy.	• Scenarios for the future GHG emissions changes at the national level are developed and the reasons are analyzed; • Scenarios for the future	Government of Georgia CoM (EU) NAMA (GiZ, Austria) LEDS (USAID) INDC (GiZ)

	• Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Regional Development and Infrastructure; • CoM signatory towns.	growth of emissions from different sectors; • Assessment of emissions from the towns and municipalities (BAU scenario) for the year of 2020 and analysis of the reasons for changes.		GHG emissions change at the level of Georgian towns (CoM signatories) are prepared, at least for the building and transportation sectors. The GHG emissions future scenarios for the key sectors of the Georgian economy are prepared, at least for the building and transportation sectors;	BUR (GEF) And other future initiatives.
10. Systematic improvement of the individual elements of the greenhouse gas inventory (quality assurance/quality control, inaccuracy analysis, data collection system and archiving, emission factors, etc.) by taking into account lessons learned from various targeted projects.	• Ministry of Environment and Natural Resources Protection of Georgia; • National Statistics Office; • Ministry of Energy; • CoM signatory towns.	• Improvement of activity and emission factor data for the priority sectors (buildings, transportation, tourism, industry, etc.); • Updating the national guidelines for conducting the greenhouse gas inventory; • Systematic use of the QA/QC procedures for the key sectors.	• Ministry of Environment and Natural Resources Protection of Georgia; • Standing Group on Inventory.	• National inventory is continuously improved and its accuracy is increased; • Inaccuracy at the regional and town levels is significantly reduced, which helps them to more effectively fulfil their obligations (less additional costs).	Government of Georgia CoM (EU) NAMA (GiZ, Austria) LEDS (USAID) INDC (GiZ) BUR (GEF) And other future initiatives.
Vulnerable to Climate Change Ecosystems, Economic Sectors, Regions and Adaptation					
11. Organizing and where it has started to continue monitoring of the impact of climate change on different ecosystems: **Semi-arid territories** (Taribana, Udabno, Gardabani, Gori Municipality, etc.); **protected areas, where the ecosystems are relatively free of human anthropogenic**	• Land Resources Protection and Natural Resources Department of the Ministry of Environment and Natural Resources Protection. • National Environmental Agency of the Ministry of Environment and Natural Resources Protection;	• The constant (or periodic) monitoring systems measuring climate changes on ecosystems (land degradation, glaciers, mountainous regions, arid zones, Black Sea coastal zone, country's economically important rivers). Where such systems have been already developed, to continue the monitoring process; • Prepare reports of ongoing and impending threats; • Assessing the risks;	• Climate Change Service of the Ministry of Environment and Natural Resources Protection.	• Permanent/periodic monitoring on the natural ecosystems is ongoing; • Reports on the impact of climate change observed in different ecosystems are systematically prepared; • Government of Georgia is informed about current processes; • Local self-governing units have information about their natural resources and	Government of Georgia; Local self-government bodies; GEF; GiZ; EU; Bilateral assistance

interference (Protected areas of Dedoplistskaro District and Ajara, Batumi Botanical Garden, etc.); **glaciers feeding large rivers** (Tsaneri, Koruldashi, Dolra and Kirtisho), **Black Sea Coastal Zone** (the entire coast of Batumi-Adlia and Ajara Region, Poti Zone); **river sources and drainage basins of Enguri, Rioni, Aragvi and other large rivers important for the country,** where the initial runoff of the river is formed; **land degradation** (Ajara, semi-arid regions, Racha-Lechkhumi, Mtskheta-Mtianeti and particularly vulnerable municipalities of Kakheti Region).	• Ministry of Agriculture; • Institute of Geography of the Tbilisi State University; • Agency for Protected Areas; • Local self-governing structures; • HPP owners.	• Preparing recommendations for the prevention of expected risks and threats, national and local (municipal level) strategies and action plans; • Provide information to the relevant ministries and responsible persons (Government of the country).		the risks in the ecosystems.	
12. **Strengthening the promotion of the climate change adaptation activities inside the country** (to establish the agency with relevant authority, create project proposals, investment environment and insurance packages, where possible).	• Government of Georgia; • All ministries, activities of which are influenced by climate change; • Leadership of especially vulnerable regions and municipalities; • Farmers; • Local population; • Business.	• To establish the body/council coordinating climate change adaptation activities comprised of representatives of all stakeholder ministries; • The responsible persons should be appointed in the municipalities (as it is done by appointing energy managers within the CoM); • To promote involvement of the municipalities and towns in the new EU initiative, which includes mitigation of risks caused by climate	• Government of Georgia • Ministry of Environment and Natural Resources Protection of Georgia	• The body/council coordinating climate change adaptation activities comprised of representatives of all stakeholder ministries and the NGO sector is established; • Persons responsible for the climate change risk reduction and adaptation are designated in the municipalities (as it is done by appointing energy	Government of Georgia GEF; GiZ; EU; ADA; USAID.

		change in urban and rural areas; • To develop the legal framework promoting implementation of adaptation measures; • Continuous update of the Adaptation Strategy to Climate Change and the National Adaptation Action Program based on the new research and facts.		managers within the CoM). • Individual elements/laws of the local legislative framework promoting implementation of adaptation measures is developed (e.g., the law on windbreaks, land degradation, etc.); • The adaptation strategy of vulnerable ecosystems, economic sectors and regions to climate change and the National Adaptation Action Program are drafted and approved. These strategies and programs are constantly updated.	
13. Assessing the impact of climate change on Georgia's **agricultural sector.** Drafting the Adaptation Strategy and the Action Plan.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Agriculture; • Parliament of Georgia; • Local self-governments; • Farmers and farmers' associations; • Self-governing communities.	• To assess vulnerability of the agricultural sector (water shortage, land degradation, harmful insects and diseases, extreme weather events - drought, hail, heavy rains, strong winds/blows) to climate change in the regions that have not been so far appropriately assessed (Upper Svaneti, Mtskheta-Mtianeti, Racha-Lechkhumi, Imereti, Guria, Samtskhe-Javakheti, etc.); • To identify the most vulnerable areas for each region (cereal production, horticulture, pomiculture, animal husbandry, apiculture, etc.) and adaptation priorities (rehabilitation of drainage and irrigation systems and windbreaks, artificial forest cultivation, reducing land degradation, rehabilitation of degraded lands, seed material and	• Ministry of Agriculture	• The territory of Georgia is divided according to the impact of climate change on agriculture and the risk and danger degrees; • The country has a climate change adaptation strategy for this sector and the national action plan. The local self-governing bodies are responsible for the implementation of these documents; • Pilot projects are implemented; • The impact of climate change on agriculture is considered in all sectors of agriculture (food safety and quality, animal husbandry, etc.); • The potential of the	Government of Georgia EU; USAID; GiZ; FAO.

		seedling quality assurance, strengthening of the Veterinary Service, sustainable management of pastures and herding tracks, promoting establishment of farmers' associations/ cooperatives); • Developing the strategies and the action plans for each region; • To draft the action plan for the adaptation of the agricultural sector to climate change based on the adaptation strategies for individual regions; • Developing pilot projects; • The obtained results should be fully reflected in the Development Action Plan; • Strengthening capacity of the agricultural service centers to first of all reduce the risks of the negative impacts of climate change and increase land productivity;		agricultural service centers has increased.	
14. Assessing the impact of climate change on Georgia's **healthcare sector**. Developing the Adaptation Strategy and the Action Plan.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Labour, Health and Social Affairs; • Local healthcare services; • Ministry of Agriculture; • Parliament of Georgia • Local self-governments;	• Examining the impact of climate change on the healthcare sector in different regions of Georgia and defining regional priorities for developing adaptation measures and action plans; • Monitoring the trends of climate-dependent diseases and identification of the new diseases should be carried out. • Raising awareness of the medical staff on climate-dependent diseases; • Developing the action plans at the regional and national levels for the reduction of the risks of climate-dependent diseases.	• Ministry of Labour, Health and Social Affairs; • Local healthcare services.	• The impact of climate change on the healthcare sector and risks causing heat waves are assessed for all regions and at the national level; • The action plan to increase the capacity of the healthcare sector is developed in order to reduce the risks of climate change.	Government of Georgia; Czech Development Agency; WHO; Red Cross Austria; USAID.

15. Assessing the impact of climate change on Georgia's **tourism sector**. Developing the adaptation strategy and action plan for each tourist region.	• Office of Climate Change at the Ministry of Environment and Natural Resources Protection; • Department of Tourism; • Ministry of Labour, Health and Social Affairs;	• Assessing the impact of climate change on the tourism sector; • Assessing heat wave and the Tourism Climate Index trends in large towns of Georgia and the tourist areas, where they were not so far assessed; • Developing recommendation packages for tourists in the tourist zones by taking into account risks related to climate change (heat waves, injuries, diarrheal diseases, cardiovascular problems, etc.); • Developing the strategy for mitigating risks associated with climate change.	• Department of Tourism;	• The impact of climate change on the tourism sector is assessed for all tourist regions of Georgia; • The country has a strategy to mitigate the risks associated with climate change.	Government of Georgia
16. Assessing the impact of climate change on **land resource**s (wind and water erosions, lands washoffs by rivers and the sea). Developing the strategy and the action plan for reducing land degradation.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Agriculture; • Parliament of Georgia; • Local self-governments; • Farmers and farmers' associations; • Self-governing communities.	• Monitoring of lands and assessing the current and future impact of climate change on land resources; • Establishing the land bank by locating all of its parameters and especially fertility indicators in the bank; • Alleviation of anthropogenic pressure, especially through replacing agricultural practices on degraded soils with more soil friendly practices, reducing forest degradation, designing populated areas and infrastructure projects by using sustainable principles; • Rehabilitation and maintenance of high risk degraded areas/soil; • Improvement (if necessary) and enactment of provisions for the prevention of land degradation in the existing Law on Land; • Increasing the role of local self-government in the process of sustaining local land resources.	• Land Resources Protection and Natural Resources Service of the Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Agriculture.	• The land bank is established; • The impact of climate change on land degradation process is assessed; • The action plan for the protection of soil from risks related to climate change is developed at the regional and national levels.	Government of Georgia; Local self-governments; GiZ; ADA; WWF; FAO.

17. Assessing the impact of climate change on the **forest sector** of Georgia. Developing the adaptation strategy and action plan by taking into consideration negative influences observed in different forests of the country.	• National Forestry Agency of the Ministry of Environment and Natural Resources Protection; • Ministry of Agriculture; • Leadership of the local municipalities (self-governing bodies); • Forestry Institute	• It is necessary to complete the inventory of forest fund and the assessment of its agro-ecological and socio-economic potential according to the regions. The state priority related to the forest resources should be determined; • Based on the results of the inventory it is necessary to assess the impact of climate change on the forest ecosystems in Georgia (the Upper Svaneti and Borjomi-Bakuriani forest ecosystems are evaluated at present, with relatively low precision and using the old data); • In order to reduce adverse impact identified in each forest massif, it is necessary to prepare a specific action plan for the sustainable to climate change management of concrete woodlands; • The forest sector management strategy should be developed for the whole territory; • Constant monitoring to be carried out on forest change trends, as a sink of carbon dioxide; • To conduct academic research and assess the impact of climate change on the forests and study the necessary parameters; • In case of forests in borderline areas, it is necessary to carry out joint research and measures against the spread of diseases in cooperation with neighboring countries; • Georgia needs to review and assess the country's participation in the	• National Forestry Agency of the Ministry of Environment and Natural Resources Protection;	• The inventory of forests is conducted within optimal intervals; • The impact of climate change on different forest massifs of Georgia is assessed; • The role of forests in Georgia's adaptation strategy to climate change in terms of reducing greenhouse gas is defined; • The sustainable management strategy for different types of forest massifs is developed; • Studies to assess and monitor the impact of climate change on the forest sector are ongoing.	Government of Georgia; GiZ; ADA; WWF; FAO.

		mechanisms of the Climate Convention, namely REDD[47] + and NAMA[48] adopted for reducing forest degradation.			
18. Assessing the impact of climate change on those **protected areas of Georgia**, which were not assessed in the Second and Third National Communications. Developing the adaptation strategy and the action plan by taking into account identified adverse effects on various protected areas.	• Agency for Protected Areas of the Ministry of Environment and Natural Resources Protection of Georgia; • National Forestry Agency of the Ministry of Environment and Natural Resources Protection; • Leadership of the local municipalities (self-governments);	• Monitoring of biodiversity and various ecosystems should be going on constantly on protected areas; • The impact of climate change on these areas should be assessed based on the monitoring results (There is no anthropogenic pressure here and we actually use background information); • The results of observations made on the protected areas should be used for assessing the impact of climate change on other areas; • Where possible, adaptation activities and projects should be developed.	• Agency for Protected Areas of the Ministry of Environment and Natural Resources Protection of Georgia;	• Monitoring of the impact of climate change is ongoing in the major part of the protected areas; • The results of the observations on the protected areas are used to assess the impact of climate change on other areas; • Adaptation projects are developed.	Government of Georgia; GiZ; ADA; WWF; FAO.
19. To study the impact of climate change on the **process of melting glaciers** and micro climate change.	• Climate Change Service of the Ministry of Environment and Natural Resources Protection; • Institute of Geography of the Tbilisi State University; • National Environmental Agency of the Ministry of Environment and Natural Resources Protection;	• Periodic (where possible and needed constant) monitoring is conducted on the main glaciers of Georgia and a link of these processes with climate change is established, which at this point is one of the most important directions for ensuring security of the economy (energy), as well as population and infrastructure (pipelines, highways, etc.); • Change of the micro climate caused by melting glaciers and the increase in other risks should be considered and integrated in the relevant development strategy, the risk reduction action plan should be developed.	• Institute of Geography of the Tbilisi State University	• Risks caused by the degradation of Georgia's main glaciers (smelt) is assessed. • The vision/strategy for mitigating risks caused by the degradation of glaciers (melting) is developed.	Government of Georgia Shota Rustaveli National Science Foundation; INTAS.
20. Assessing the impact of	• Climate Change	• It is necessary to arrange	• National Environment	• The impact of climate	Georgia's Fourth

[47] REDD+ - Reduced Emissions from Deforestation and Degradation
[48] NAMA - Nationally Appropriate Mitigation Action

climate change on Georgia's **large rivers,** which are important for agriculture (Rioni, Alazani, Iori and Kura), the energy sector (Enguri, Rioni) and supplying the population with drinking water (Aragvi, Iori and Khrami). Considering obtained results in the development plans and construction of irrigation systems.	Service of the Ministry Environment and Natural Resources Protection • National Environment Agency of the Ministry of Environment and Natural Resources Protection; • Water Resources Management Service of the Ministry of Environment and Natural Resources Protection; • Institute of Hydrometeorology of the Georgian Technical University.	hydrological observations on the rivers, where hydrological posts are not functioning; • To coordinate and gather in one place hydrological data obtained by various agencies (HPP owners, projects, NEA, etc.); • To assess the impact of climate change on those Georgian rivers, where such assessments were not conducted (Aragvi, Khrami and Enguri) by using the WEAP (or any other) model; • To establish the monitoring and early warning system in the middle course and delta of R. Rioni; • Recommendations for the management of highly vulnerable rivers (floods, water shortage) should be developed.	Agency of the Ministry of Environment and Natural Resources Protection;	change on large, economically important rivers is assessed; • Adaptation measures for the most vulnerable rivers are developed (right management, prevention of floods and water shortages).	National Climate Change Communication; Various projects; GEF; USAID;
21. To assess the impact of climate **change on groundwater in East Georgia** and develop the risk reduction strategy and the action plan.	• National Environmental Agency of the Ministry of Environment and Natural Resources Protection; • Climate Change Service of the Ministry Environment and Natural Resources Protection • Local authorities.	• Organizing the ground water quantity and quality monitoring system; • Assessing the possible impact of climate change on the groundwater resources in East Georgia and developing its sustainable exploitation strategy.	• National Environment Agency of the Ministry of Environment and Natural Resources Protection;	• Constant monitoring of the quantity and quality of groundwater and assessing the impact of climate change; • The groundwater sustainable exploitation strategy to climate change is developed for East Georgia.	Government of Georgia Czech Development Agency
22. Facilitating the implementation of already developed adaptation strategy[49] for the **Black Sea coastal zone**	• Government of Georgia; • National Environment Agency of the Ministry of Environment and Natural Resources	• Establishing the continuous monitoring and early warning system for examining Black Sea level rise, storm intensity and direction of the waves in the Rioni River Delta; • Establishing the Permanent	• Government of Georgia • Government of Ajara Autonomous Republic; • Road Department of Georgia and Local Municipalities • Local coastline protection services; • where such services exist	• Local authorities are constantly informed about processes ongoing in terms of climate change and their possible consequences; • The sea-level rise and storm	Government of Georgia; Government of Ajara Autonomous Republic; EU; ENVSEC;

[49] The Black Sea coastal zone adaptation strategy is presented in Georgia's Second and Third National Communications

	Protection; • Government of Ajara Autonomous Republic; • Local authorities in Poti and Batumi. • Local coastal line protection services/experts; • Administration of Kolkheti Protected Area.	Coordination Council on climate change adaptation planning and implementation or assigning this duty to the existing similar body; • Implementation of the river bank protection measures and organization of the early warning system in the Rioni Delta; • Implementation of the protection measures on the Adlia-Batumi section with the purpose of protecting the Batumi coastline; • Planning and implementation of desalinization measures for Paliastomi Lake; • Assessing the impact of climate change on tourism development (heat waves, infectious diseases, water temperature, degradation of beaches) and developing adaptation measures; • Periodically informing local authorities on ongoing processes and their economic consequences; • Considering the potential impact of climate change in the development of local infrastructure;		intensity monitoring system is established in the Rioni Delta and Ajara beach. For cases of catastrophic events, this system in the Rioni River Delta is equipped with the early warning system for the local population and corresponding structures. • The systematic protection measures are carried out in the Rioni Delta and Ajara coast line (Batumi-Adlia section, Kobuleti); • The portfolio of the adaptation measures is developed for Lake Paliastomi; • The possible impact of climate change on the R. Rioni Delta and Ajara coastline is considered in the infrastructure planning and development process.	GEF; GCF; CDM AB.
23. Developing the risk reduction strategies for **arid** areas	• Government of Georgia; • Ministry of Agriculture; • Land Resources Protection and Natural Resources Service of the Ministry of Environment and Natural Resources Protection; • Relevant non-	• To arrange agro-meteorological observation stations on semi-arid areas; • Constant monitoring of the arid regions, which can be especially vulnerable to climate change; • Developing portfolio and concrete project proposals for the rehabilitation of arid areas and implementation of adaptation measures; • To develop the adaptation strategy	• Local authorities; • Farmers;	• Vulnerability of all regions of Georgia under the high risk of climate change and prone to aridity is assessed; • The portfolio of adaptation measures and strategies is developed for the most vulnerable regions; • Potential for implementing adaptation measures is established locally.	Government of Georgia; Parliament of Georgia; EU; ENVSEC; GEF; GCF; GiZ.

	governmental organizations; • Scientific research institutes; • Local authorities; • Farmers; • Population.	for the areas prone to aridization and/or relevant ecosystems; • To attract local and international donors for the implementation of adaptation measures; • To build local capacity for planning and implementing adaptation measures.			
24. Assessing the possible impact of climate change on **mountainous regions** (Mtskheta-Mtianeti, Racha-Lechkhumi, Upper Imereti, Mta-Tusheti, Khevsureti), which have not yet been evaluated within Georgia's Second and Third National Communications	• Ministry of Environment and Natural Resources Protection; • Local self-governments; • Population; • Relevant non-governmental organizations; • Scientific research institutes; • Parliament of Georgia.	• To assess vulnerability of the mountain ecosystems to climate change; • To develop a portfolio of adaptation measures and concrete project proposals for the ecosystems of mountainous regions that are particularly vulnerable; • To develop the adaptation strategies for vulnerable regions or ecosystems; • To attract local and international donors for the implementation of adaptation measures; • To develop local capacity for planning and implementing preventive and adaptation measures.	• Local authorities • Ministry of Environment and Natural Resources Protection;	• Risks caused by climate change are identified for the mountainous zones; • The adaptation strategy and the national prevention strategy are developed for each vulnerable region; • Local capacity is created for planning and implementing adaptation measures; • The population and Self-governing communities are fully involved in the implementation of preventive measures.	Government of Georgia; Parliament of Georgia; EU; ENVSEC; USAID; GEF; GCF; CDM AB.
25. Assessing the impact of climate change on **extreme geological events** (landslides, mudflows, etc.) and developing the expected risk reduction strategy and action plan.	• National Environmental Agency of the Ministry of Environment and Natural Resources Protection; • Emergency Situations Management Department of the Ministry of Interior Affairs; • Parliament of Georgia; • Local self-governments; • Self-governing communities; • Local population.	• To assess the trends of increasing extreme geological events caused by climate change in the most vulnerable regions of Georgia in this regard, which have not yet been evaluated in other projects (Mtskheta-Mtianeti, Racha-Lechkhumi, etc.) • In places, where along with increasing weather extremes the hazardous geological events are also intensifying growing, the establishment of monitoring network and early warning systems and modification of the existing ones should be carried out for which an	• Emergency Situations Management Department of the Ministry of Interior Affairs; • Local self-governments.	• Anthropogenic risk factors causing geological processes are reduced; • Geologists and rescue groups are organized in high-risk areas; • The local population is quite prepared and involved in prevention activities; • The strategy for preventing landslide and mudflow sections has been developed;	Government of Georgia; Parliament of Georgia; EU; ENVSEC; USAID; GEF; GCF; CDM AB.

		experience of advanced countries should be used; • It is necessary to establish professional geological services/units along with the standby emergency services; • It is necessary to improve the coordination mechanism for managing natural geological processes; • It is necessary to develop the strategy for preventing landslide and mudflow losses, which will clearly distinguish what actions might be taken independently with local forces and when the help of the central government is required; • Active involvement of the local communities in the prevention (landslides, mudflows) and rescue works should be provided.			
26. **Assessing migration increased** as a result of climate change and working out the environmental and social risk reduction strategy	• Government of Georgia • Parliament of Georgia • Ministry of Environment and Natural Resources Protection of Georgia • Ministry of Labour, Health and Social Affairs • Non-governmental sector	• To assess risks increasing environmental migration and number of eco-migrants; • To develop the environmental migration risk (natural geological phenomena, land degradation, etc.) prevention strategy and in general, the environmental migration reduction strategy; • To estimate the negative impact of environmental migration/eco-migrants on a new environment and plan measures to reduce this impact. • To develop the strategy for harmonious integration of environmental migrants in the new surroundings and reduction of the adverse impact on the new environment.	• Government of Georgia • Non-governmental sector	• The prevention strategy and in general, the strategy for mitigating environmental migration is developed (natural geological phenomena, land degradation, etc.); • The strategy for harmonious integration of eco- migrants in the new environment and reduction of the adverse impact on the new environment is developed.	Government of Georgia; EU; USAID.

27. Attracting investments and promoting the implementation of **adaptation measures in Lentekhi Region[50].**	• Government of Georgia • Local authorities (municipality); • Population; • Non-governmental sector.	• To update the adaptation strategy to climate change for Lentekhi District; • To establish the local geological service in the district in order to continuously monitor landslides and implement preventive measures; • To establish the flood monitoring and early warning system; • It is necessary to regularly inform families living in landslide hazard zones and organize trainings on preventive measures; • To implement anti-landslide pilot projects (for instance, cultivating small hazelnut plantations); • To rehabilitate and correctly manage the most damaged forest sections; • To restore the forest ecosystem function as a deterrent of landslides and implement permanent restoration works in places, where they were already implemented and plan new sections.	• Local authorities;	• The local continuous monitoring service for landslides that are observed near households is established; • Climate-triggered landslides are systematically recorded and recommendations for their reduction are prepared, where possible; • The population living in high risk landslide zones is constantly aware of possible dangers and the measures, which they can implement with their own resources in order to prevent landslides; • Pilot projects to cultivate soil retaining crops (e.g., hazelnut) are implemented; • Measures to rehabilitate the most damaged forest sections and support anti-degradation are systematically implemented; • Floods are monitored, river bank protection and other preventive measures and effective risk reduction mechanisms are implemented.	DM AB; GEF; GCF; USAID.
28. Attracting investments and promoting the implementation of adaptation **strategy to**	• Government of Georgia • Local authorities • Government of Ajara	• The coordination mechanism for reducing the risks associated to climate change should be established locally and the local potential for	• Government of Ajara Autonomous Republic	• The local coordination mechanism to reduce the risks caused by climate change is established and	Government of Ajara Autonomous Republic; EU; CDM AB;

[50] The adaptation strategy to climate change for Lentekhi region was developed in Georgia's Second National Communication on Climate Change.

climate change for Ajara[51]	Autonomous Republic; • Population • Non-governmental sector • Scientific research institutes	independently managing this risk should be increased; • Withstanding the land degradation should be recognized as the first priority of Ajara's government in the process of reducing climate change risks; • Implementation of any activity (including tree planting, implementation of agricultural works, etc.) should be subject to preliminary geological expertise and should be implemented in accordance with these recommendations; • It is necessary to enlarge small farming in Ajara, establish cooperatives and farms; • It is necessary to establish the local geological service in separate districts in order to continuously monitor landslides and implement preventive measures; • Changes in the marine ecosystem caused by climate change should be considered in the coast protection works implemented at the particularly vulnerable sections of the Black Sea coastline (sea level rise, increase in wave power, intensity and direction); • To implement measures to prevent emergence and spread of new tropical diseases; • To reduce tourism development		the continuous process of building local capacity necessary for independently managing these risks is ongoing; • The leadership of the Autonomous Republic recognizes land degradation as having the highest priority among the risks caused by climate change; • The recommendations envisaged in the Ajara Autonomous Republic Adaptation Strategy are gradually and purposefully implemented; • The pilot projects related to various issues discussed in the strategy are being implemented.	GEF; GCF; FAO.

[51] The Adaptation Strategy of Ajara Autonomous Republic to Climate Change is discussed in Georgia's Third National Communication on Climate Change. http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/climate-change-strategy-of-ajara-/

		hindering factors triggered by climate change (heat waves, changes in tourism index, infectious diseases, degradation of beaches, etc.); • Continuous monitoring of the impact of climate change on biodiversity (protected areas, forests, aquatic ecosystems, etc.) and study of possible results; • Continuous monitoring of forest degradation and implementation of plant disease preventive measures in close coordination with the neighboring country (Turkey).			
29. Attracting investments and promoting the implementation of Agriculture Adaptation[52] **Strategy to Climate Change for Kakheti Region**	• Government of Georgia • Ministry of Agriculture • Local authorities (municipality) • Farmers • Administration of the Protected Area	• Continuous monitoring of the negative impact of climate change; • Rehabilitation of windbreaks; • Energy forest cultivation; • Rehabilitation of eroded soils; • Mobilizing farmers' associations, establishing cooperatives; • Ensuring proper management of pastures and herding tracks; • Designing the optimal scheme of irrigation systems and their rehabilitation; • Assessing the impact of climate change on animal husbandry and the spread of dangerous diseases and developing the veterinary risk reduction action plan.	• Local authorities (municipality) • Local authorities • Farmers	• Continuous monitoring of the negative impact of climate change; • Windbreaks are rehabilitated; • Pilot energy forests are planted; • A set of measures for the rehabilitation of eroded soils is prepared; • The number of farmers' associations and cooperatives is constantly increasing; • Pasture management is improved; • Vitally important sections of the irrigation systems are rehabilitated; • The strategy for preventing dangerous, high risk veterinary diseases and the action plan are developed in	Government of Georgia; Local self-government units; EU; GEF; GCF; FAO.

[52] The Agriculture Adaptation Strategy to Climate Change for Kakheti Region was developed in Georgia's Third National Communication on Climate Change. http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/climate-change-and-agriculture-in-kakheti.html;

				the municipalities having the priority of developing the animal husbandry sector.	
30. Attracting investments and promoting the implementation **of Upper Svaneti Adaptation Strategy to Climate Change**[53]	• Government of Georgia • Local authorities • Ministry of Environment and Natural Resources Protection of Georgia • Local population • Local Non-governmental sector	• Considering risks caused by climate change in the Mestia tourism development action plan; • To organize a local tourism safety assurance service with the main function to enable safe tourism and implementation of rescue works, provision of medical services to the tourism sector; • To assess the impact of climate change on the agriculture sector; • It is necessary to establish the local geological service in the district in order to continuously monitor landslides and implement preventive measures; • To develop the avalanche risk reduction program.	• Local authorities	• The tourism development action plan for Mestia is developed, which takes into account risks caused by climate change; • The local tourism safety assurance service is organized. One of its main functions is to ensure safe tourism and implementation of rescue works, providsion of medical services to the tourism sector; • Extreme geological events (landslides, mudflows) and avalanche risk reduction action program is developed.	Government of Georgia; Local authorities; EU; GEF; GCF;
31. Developing the National Adaptation Plan to	• Ministry of Environment and	• To assess current (for recent years) **climate change trends** (using	• Ministry of Environment and	• The National Adaptation Plan to Climate Change is	Government of Georgia;

[53] The Upper Svaneti Region Adaptation Strategy to Climate Change was developed in Georgia's Third National Communication on Climate Change. http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/_-_-_-_-_-_.html;

Climate Change and starting its implementation	Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Regional Development and Infrastructure; • Ministry of Finance; • Ministry of Education and Science; • Private sector; • Representatives of CoM process; • Representatives of scientific-research institutes.	statistical methods) and **future scenarios** by using global and regional models. Particular attention should be paid to recent extreme weather trends; • To assess vulnerability of **land resources and land-use activities to climate change** for all regions of Georgia, which were not assessed in the Second and Third National Communications and to plan adaptation measures at the national level; • To assess **vulnerability of forest ecosystems to climate change** for all regions of Georgia, which were not assessed in the Second and Third National Communications and to plan adaptation measures at the national level; • **To assess vulnerability of protected areas/ecosystems** to climate change for those protected areas, which were not assessed in the Second and Third National Communications and to plan adaptation measures at the national level; • **To assess the impact of climate change on Georgia's glaciers** and the local micro-climate, the impact of their melting process in East Georgia on groundwater and major river runoff in West Georgia and to plan adaptation measures at the national level; • To assess the impact of climate change on the **major rivers of Georgia** in terms of water shortage and freshets and to plan adaptation measures at the national level;	Natural Resources Protection of Georgia;	drafted; • Agencies responsible for the implementation and their responsibilities/duties and obligations are defined; • The plan is presented to the donors for co-funding.	UNDP; USAID; EU; GEF; ADA; WB;

		• To assess the impact of climate change on the **Black Sea coastal zone** and the impact of changes in the marine ecosystem on the coastal zone, tourism, agriculture, infrastructure development, the marine ecosystem, etc. To plan adaptation measures at the national level by taking the adaptation priorities into account; • To assess the impact of climate change on Georgia's **mountain ecosystems**, which were not assessed in Georgia's Second and Third National Communications. Special attention should be paid to the current change in the climate zones of the mountainous regions and how these changes affect living conditions of the local population. To plan adaptation measures by taking into account local conditions for each mountainous region; • To assess the impact of climate change on **groundwater resources in East Georgia** and in case of detecting changes, to assess the estimated impact of these changes on living conditions of the local population (for drinking and irrigation water) and to examine the possibility of developing adaptation measures; • To assess the impact of **climate change on extreme weather and geological events** and the impact of these events on the development of infrastructure. To develop the adaptation measures; • To assess the impact of climate change on the **number of**			

		environmental migrants and their living conditions, to plan complex risk reduction measures at the national level; • To assess vulnerability of the **agricultural sector** for each municipality and region of Georgia, to plan adaptation measures at the national level; • To assess the impact of **climate change on the development of animal husbandry**, outbreak and dissemination of especially dangerous veterinary diseases, to plan adaptation measures for the livestock sector and develop the national strategy; • To assess the impact of climate change on **all potential tourist zones**, which were not assessed in Georgia's Third National Communication and plan adaptation measures for each of these zones at the national level; • To assess vulnerability of the **healthcare sector for all regions of Georgia**, which were not assessed in Georgia's Second and Third National Communications and plan adaptation measures at the national level; • To assess infrastructure **development risks initiated by extreme climate events and caused by dangerous geological events** for all regions of Georgia, which were not assessed in Georgia's Second and Third National Communications on Climate Change and plan adaptation measures at the national level; • To assess the impact of climate			

		change on Georgia's **historical heritage/monuments**, particularly in places, which were not assessed within the framework of Georgia's Third National Communication. To plan adaptation measures at the national level.			
Reducing GHG Emissions					
32. Developing the Low Emission Development Strategy (LEDS) for the country's economy together with relevant project proposals	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Regional Development and Infrastructure; • Ministry of Finance; • Ministry of Education and Science; • Private sector; • CoM signatory towns.	• To develop the Business As Usual (BAU) scenario and relevant GHG emissions for the main economic sectors of Georgia (energy, transportation, agriculture, waste and waste water management, land use and forests, industrial sector); • To draft the list of activities and technologies, relevant strategies and project proposals for ensuring low emission development; • To develop the legislative framework promoting implementation of the Low Emission Development Strategy; • To draft the final document; • To organize consultations with the stakeholders and to ensure the approval of the LEDS.	• Ministry of Environment and Natural Resources Protection of Georgia; • Coordination Council tasked for preparing the Low Emission Development Strategy	• LEDS is developed for Georgia; • The Action Plan for the implementation of the Strategy and project proposals/GHG reduction measures are prepared; • The environment favourable for LEDS implementation is created in the country.	Government of Georgia USAID
33. Developing the Intended Nationally Determined Contributions (INDC)	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Regional Development and Infrastructure;	• Based on the results of ongoing and completed projects implemented in the country, to assess the potential of reducing GHG emissions and outline the sectors and measures, which Georgia will present to the Convention Secretariat as the Intended Nationally Determined Contribution (INDC); • To particularly assess capacity of the forest and transportation sectors in terms of GHG emission reduction; • To summarize and assess the role	• Ministry of Environment and Natural Resources Protection of Georgia;	• The Intended Nationally Determined Contributions (INDC) are developed. • The contribution is presented to the Convention Secretariat. • Georgia's international obligation for presenting the INDC is fulfilled.	Government of Georgia German Government (GiZ)

	• Ministry of Finance; • Ministry of Education and Science; • Private sector; • Participants of CoM process;	and the contribution of towns in the Intended Nationally Determined Contribution (INDC); • To draft the final document; • To arrange consultations with stakeholders and provide the approval of INDC by the Government.			
34. Preparing Nationally Appropriate Mitigation Action for reducing GHGs together with project proposals (forestry, construction, transportation and tourism sectors).	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Finance; • Private sector (Construction, tourism service); • Participants of CoM process.	• To develop the NAMA project proposal based on the ongoing Borjomi-Bakuriani forest project for ensuring climate-sustainable management of Georgia's forestry sector; • To develop the NAMA project proposals for increasing energy efficiency in the construction sector, cooperation with donors and implementation of the project; • To develop and implement the NAMA for the transportation sector (including transit); • To develop and implement the NAMA for the tourism sector (including transit).	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Economy and Sustainable Development; • Forest Department of the Ministry of Environment and Natural Resources Protection of Georgia.	• NAMAs to reduce GHG emissions are developed at the national level for several sectors; • Some NAMAs are in the process of implementation; • Activities are ongoing for attracting additional investment from donors for the implementation of some of NAMAs. • Pilot projects are implemented and an environment/system enabling full NAMA implementation is created.	Government of Georgia; German Government (GIZ); Austrian Government (ADA).
35. Preparing the Sustainable Energy Development Plans for EU CoM signatory towns and municipalities together with project proposals.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Finance; • Participants of CoM process.	• To develop the Sustainable Energy Action Plans (SEAPs) for 10 towns of Georgia; • To train the personnel working for the local municipalities to acquire skills and knowledge necessary for developing, implementing and monitoring the SEAP; • To develop project proposals and work with co-investors for attracting co-funding and technologies; • To draft biennial monitoring report on implemented activities and send it to the CoM secretariat;	• CoM signatory towns; • CoM signatory municipalities; • Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy;	• The Sustainable Energy Action Plan (SEAP) for 10 towns of Georgia and the potential project proposals are developed; • The SEAP from signatory towns are submitted to the CoM secretariat; • GHG emission reduction measures are implemented in SEAP signatory towns; • Monitoring of GHG emissions reduction measures is carried out in SEAP signatory towns and	Government of Georgia; Local governments; USAID; EU (Various programs and grants); GIZ.

		• To draft monitoring report on implemented activities in every 4 years and to send it to the CoM secretariat;		the results are presented to the CoM secretariat.	
36. Preparing the NEEAP together with project proposals, to define the upper energy efficiency margin for various sectors and at the national level that will be necessary to achieve for 2020, 2025 and 2030.	• Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Environment and Natural Resources Protection of Georgia.	• To select the sectors having the largest potential for increasing energy efficiency and direct the action plan towards these sectors; • To accurately assess existing barriers to increasing energy efficiency and outline the plan for overcoming these barriers (for instance, annual energy balances, enterprise energy consumption statistics, increasing comfort instead of savings, etc.) for the years of 2020, 2025 and 2030; • To develop the energy efficiency action plan under the leadership of the Ministry of Energy by taking into account the GHG reduction potential evaluated through MARKAL-Georgia; • To create the database of technologies that the country needs for NEEAP implementation.	• Ministry of Energy;	• The National Energy Efficiency Action Plan (NEEAP) is drafted; • Activities to prepare the implementation of the NEEAP that also envisages implementation of specific activities are ongoing. The action plan for the implementation of the strategy and project proposals/greenhouse gas reduction measures is developed.	Government of Georgia EBRD
37. Specifying the share of renewable energy in energy generation and thermal generation for 2020, 2025 and 2030, to promote and attract investments to these sectors aimed at the increase the share of renewable energy.	• Ministry of Energy; • Large energy consumers; • Private sector operating in the renewable energy sector; • CoM signatory towns; • Non-governmental sector.	• To assess reserves of existing technically usable renewable resources, utilization of which will be possible for 2020, 2025 and 2030 taking into account the fact that changes in renewable resources linked with climate change are already observed in Georgia (e.g., wind speed on Mta-Sabueti already decreased from the 11.2 m/s annual average to 4.6 m/s); • To intensify work with potential foreign investors and the local private sector in order to develop and implement renewable energy	• Ministry of Energy; • Non-governmental sector; • CoM signatory towns.	• The trend of changes in the technical potential of renewable energy is studied; • The strategy for the efficient utilization of renewable energy for heat generation (locally), as well as for electricity generation (export) sectors is developed; • The strategy is discussed with stakeholders and is approved by the government;	Government of Georgia (Renewable Energy Revolving Fund) Japanese Government (solar) Turkish Government (wind); Private sector (Geothermia)

		investment projects in the renewable energy sector; • To assess the potential of increasing renewables in the local thermal power sector and the renewable electricity export capacity (including solar power); • To develop the state strategy with the purpose of effective utilization of each resource and gaining maximum economic benefits.			
38. Developing the GHG emission reduction strategy for the transportation sector (increasing energy efficiency, increasing the share of low carbon fuel and assessing the potential for using renewable fuel)	• Ministry of Economy and Sustainable Development; • Ministry of Energy; • Ministry of Environment and Natural Resources Protection of Georgia; • Private sector operating in the renewable energy sector; • CoM signatory towns.	• To develop specific project proposals (optimization of the transport network in large cities, increasing the share of liquid gas-powered vehicles by ensuring appropriate security) to reduce greenhouse gases in the transportation sector (energy efficiency and the use of low-carbon fuel); • To attract investments for the implementation of pilot projects; • To examine the potential of clean/renewable biofuel production for Georgia's transportation sector (areas for production of biomass, access to technology, economic parameters); • In case of confirming the existence of such potential, to assess the potential of increasing the share of renewable energy in the transportation sector for 2020, 2025 and 2030, to facilitate and attract investment to the transportation sector in order to increase the share of renewable energy investments.	• Ministry of Economy and Sustainable Development (Transport Department); • Ministry of Energy; • Private sector.	• The strategy for reducing emissions in the transportation sector of Georgia is developed (the increase in energy efficiency and the use of low-carbon fuel); • Concrete project proposals are developed and presented to the potential donors; • The potential for producing clean/renewable biofuel for Georgia's transportation sector is assessed; • The strategy for producing renewable biofuel for Georgia's transportation sector and pilot projects are developed; • The NAMA concept is developed for the transportation sector and project proposals are designed.	EU; USAID; German Government; (NAMA); GCF
39. Developing the legislative basis promoting renewable	• Ministry of Energy; • Parliament of Georgia; • Ministry of	• To study and analyse the requirements of the EU-Georgia Association Agreement and EU	• Ministry of Energy • Parliament of Georgia	• The legislative framework promoting energy efficiency is developed, which is	Government of Georgia EBRD

energy and energy efficiency	Environment and Natural Resources Protection of Georgia; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture.	legislation in the context of renewable energy and energy efficiency in Georgia; • To analyse possible barriers hindering the introduction of appropriate processes; • To assess different possibilities for overcoming these barriers; • To develop the legislative framework promoting the development of renewable energy and energy efficiency that will be consistent with the requirements of the EU-Georgia Association Agreement.		consistent with the requirements of the EU-Georgia Association Agreement; • The legislative framework promoting the increase in the share of renewable energy consumption is developed, which is consistent with the requirements of the EU-Georgia Association Agreement.	
40. Continuing multilateral discussion regarding the use of energy forests (and other types of biomass) in heat and electricity generation. Estimating the role of biomass resources in ensuring the independence of Georgia's energy system. Assessing the potential share of biomass in heat supply in 2020-2025.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Agriculture; • Representatives of CoM process,	• To attract investment for the implementation of pilot bio-energy forest projects in different regions of Georgia (Ajara, Dedophlistskaro, etc.); • To develop new proposals to ensure optimal utilization of biomass (including timber) in heat generation; • To assess the real potential of this resource; • To develop the strategy that promotes biomass development and utilization.	• Ministry of Environment and Natural Resources Protection of Georgia;	• Capacity of Georgian energy forests and other biomass is estimated; • The biomass development strategy is developed.	Government of Georgia; GEF; German Government (GiZ); Austrian Government (ADA); NAMA Mechanism; GCF.
41. Strengthening the role of the forest sector in the process of reducing GHG emissions/strengthening the CO_2 removals. Promoting the implementation of the reducing emissions	• Forest Agency of the Ministry of Environment and Natural Resources Protection of Georgia; • Forest Institute; • Ministry of Agriculture. • Ajara Forest Agency.	• To assess the degree of Georgian forest degradation and a share of illegal forest felling; • To designate the contact person for the REDD + mechanism in Georgia; • To draft the illegal felling and forest degradation mitigation strategy and action plan; • To develop pilot projects mitigating	• Forest Agency of the Ministry of Environment and Natural Resources Protection of Georgia	• Georgia is included in REDD+ mechanism	Government of Georgia; German Government (GiZ); Austrian Government (ADA); NAMA Mechanism; GCF

from deforestation and forest degradation mechanism (REED +) in Georgia		forest degradation and facilitating sustainable to climate change forest management to climate change.			
42. Processing elements of the greenhouse gas monitoring and reporting system and developing the necessary legislative framework	• Ministry of Environment and Natural Resources Protection of Georgia; • CoM participant towns and municipalities.	• To assess the forest degradation degree and the share of illicit forest felling; • To designate the contact person for the REDD+ mechanism in Georgia; • To prepare the illicit forest felling and degradation mitigation strategy and action plan; • To develop pilot projects mitigating Georgia's illegal forest felling and forest degradation and forest management sustainable to climate change; • To develop the legislative framework ensuring sustainability and continuity of the National GHG inventory and disaggregated (at the municipality level) inventory system; • Statistics should be systematized at the municipal level and the quality should be ensured; • Statistics services should be established at the municipalities, which along with other parameters will collect energy consumption statistics; • In line with the short-term strategy, GHG monitoring should be carried out within the CoM (at the town and municipality levels), CDM projects and NAMA process; • Based on the experience gained from individual projects and monitoring carried out on certain areas, the monitoring plan for	• Ministry of Environment and Natural Resources Protection of Georgia; • CoM participant towns and municipalities;	• The greenhouse gas monitoring plans are prepared for CoM signatory towns and municipalities; • Monitoring and reporting with the European Union is ongoing; • The legislative framework for ensuring GhG monitoring is developed; • Units responsible for GHG monitoring are clearly defined at the national and municipal levels; • Monitoring of GHG reduction/ sink increase (strengthening) is going on within the framework of NAMA projects.	Government of Georgia; CoM participant towns and municipalities; German Government (GIZ); USAID

		sectors of economy and for the whole territory of the country should be prepared.			
Importing and Developing Low Emissions and Adaptation Technologies					
43. Promoting the development of local technologies (by removing barriers), to import and introduce advanced foreign technologies for reducing greenhouse gas emissions, as well as for adaptation purposes.	• Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Energy; • Ministry of Economy and Sustainable Development; • Ministry of Agriculture; • Ministry of Education and Science; • Private sector; • Representatives of CoM process.	• Taking into account LEDS and INDC priorities, project priorities within NAMA, CDM and CoM, to develop the list of those concrete technologies (energy efficiency and renewable), which are required for the implementation of the abovementioned strategies, programs and projects. • To clearly determine those barriers, which hinder import of energy efficient and renewable technologies and set options for overcoming these barriers. • To develop the data base of local technologies/ideas related to the climate change and attract funds for their development.	• Government of Georgia • Ministry of Environment and Natural Resources Protection of Georgia • Private sector • Representatives of CoM process	• More and more projects are implemented using modern, environmentally friendly technologies; • Local technologies are developed and introduced, they are refined and given the commercial outlook; • The climate change mitigation and national adaptation technology development strategy is developed.	Government of Georgia CDM NAMA GEF GCF Local private sector
44. Promoting the introduction of clean, energy-efficient and renewable energy technologies and renewable fuels (with an emphasis on the towns and the industrial sector having commitments)	• Ministry of Energy; • Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Economy and Sustainable Development; • Energy efficiency centers in Georgia and its regions, also, in CoM signatory municipalities; • Private sector.	• Taking into account activities outlined in the National Energy Efficiency Action Plan, goals of the renewable energy development national program, project proposals developed within GHG reduction Nationally Appropriate Mitigation Actions (NAMA), CDM and CoM, to develop the list of those concrete technologies (energy efficiency and renewable), which are	• Ministry of Energy; • Ministry of Environment and Natural Resources Protection of Georgia; • Private sector; • Representatives of CoM process.	• The National Energy Efficiency Action Plan is accompanied with the list of technologies that are necessary for the implementation of this plan, but are not yet available in Georgia. • Promotion of popularization/disseminatio n of energy efficient and renewable technologies; • Local energy efficient and	Government of Georgia; Private sector; Non-governmental sector; EBRD; GEF; GCF.

		required for the implementation of the abovementioned strategies, programs and projects; • To clearly determine those barriers, which hinder import of energy efficient and renewable technologies and set options for overcoming these barriers.		renewable technologies are developed, introduced and are given commercial outlook.	
45. Establishing the Trust Fund (the state program) for promoting the development and popularization of renewable energy and energy efficiency technologies (The Renewable Energy and Energy Efficiency Technology Development and Promotion Fund (State Program)	• Ministry of Finance; • Ministry of Energy; • Ministry of Environment and Natural Resources Protection of Georgia; • Ministry of Education and Science.	• To study barriers to the establishment of the Trust Fund promoting energy efficiency and popularization of renewable energy (The Renewable Energy and Energy Efficiency Technology Development and Promotion Fund (State Program); • To develop the strategy/vision for mitigating these barriers based on their studies.	• The Renewable Energy and Energy Efficiency Technology Development and Promotion Fund (State Program) is established and functions successfully. • More projects are being implemented in the country because there is a serious co-funding possibility (this Fund promotes import of new technologies and new investments to to country).	• Ministry of Finance	Government of Georgia; Various bilateral and multilateral donors;
Awareness Raising, Education, Personnel Training					
46. Education, Personnel Training and Awareness Raising	• Ministry of Education and Science; • Secondary and high schools students; • School teachers and lecturers of higher institutions; • Professionals, managers, other stakeholders; • Politicians; • Experts; • Mass-media representatives;	• Integration of climate change related issues in learning programs; • Organization of trainings for academic and technical personnel and persons holding managerial positions and their support for ensuring fulfillment of the Article 6 of the UNFCC. • Strengthening participation of various stakeholders and target groups in processes related to	• Ministry of Education and Science; • Non-governmental sector; • Independent private institutes.	• The constantly updated database of national experts is created for each sector; • Climate change phenomenon and its results are taught in schools and at the relevant university faculties (chemistry, biology, geography, modeling, etc.); • Decision-makers are constantly informed about the recent results.	Ministry of Environment and Natural Resources Protection of Georgia; EU; USAID; GiZ; WWF; Friends of the Earth Norway.UN

	• Local authorities; • Farmers; • Business representatives; • Non-governmental organizations; • Municipality representatives.	the climate change; • Support and promote preparation of information materials on climate change issues for the dissemination among the public (drafting materials, printing and dissemination); • To raise awareness of the decision-makers on potential climate change results (ministries, municipality representatives, Self-governing communities, banks and private sector)			
Long-Term Strategy (2020-2030) • To prepare the adaptation plan by taking into account specificities of Georgia’s regions, ecosystems and economic factors; • To implement the Low Emission Development Strategy (LEDS); • To transform Georgia’s economy to the principles of sustainable development.	• Government of Georgia; • Parliament of Georgia; • Coordination Council tasked for preparing the Low Emission Development Strategy.		• Government of Georgia		Government of Georgia; Donor organizations and countries.

4 Vulnerability and Adaptation

4.1 Climate Change in Georgia

Current climate change was assessed based on observations of 33 stations of hydro meteorological network of Georgia, in the period of 1961-2010, while the forecast scenarios for 2021-2050 and 2071-2100 were developed using regional climate model RegCM4[54]. Basically, the following climate parameters were examined: mean annual temperature, total annual precipitation, average wind speed and relative humidity, as well as extreme climate indexes (SU25, TR20, ID0, FD0,Rx1day, Rx5day, R50mm, R90mm, CCD and CWD[55]). Average values calculated in each period for different climate parameters were compared, and the trend (increase, decrease) and the nature of territorial distribution were identified. Seasonal and annual trends were determined and their statistical reliability was assessed. (Used methodology and results according to 33 weather stations see in Annexes 4.1.-4.5.)

Average annual air temperature - had just increasing trend on the whole territory of Georgia during current 50 years (1961-2010). Between two periods of time (1961-1985; 1986-2010) this parameter most of all has increased in Dedoplistskaro (0.7 ^{0}C). In the same period maximal increase in West Georgia made 0.6 ^{0}C (Poti). Relatively small, but important trend of warming was revealed in Mtskheta-Mtianeti and Kakheti Regions (Fig. 4.1.1.a). According to forecasts, Sachkhere will be mostly warmed (2.1 ^{0}C), followed by Ajara coastal zone and the Goderdzi Pass. The lowest increase (0.9 ^{0}C) is expected in Poti and Pasanauri (Fig. 4.1.1 b). The biggest increase of temperature by 2071-2100 is expected in Batumi – up to 4.2 ^{0}C and the temperature will rise by 3.7 ^{0}C in Sachkhere, Ambrolauri and Mestia. On all other territories increase is lower, however more than 3 ^{0}C. In this regard Poti is an exception, where the temperature is expected to rise by 2.9 ^{0}C (Fig. 4.1.1 c).

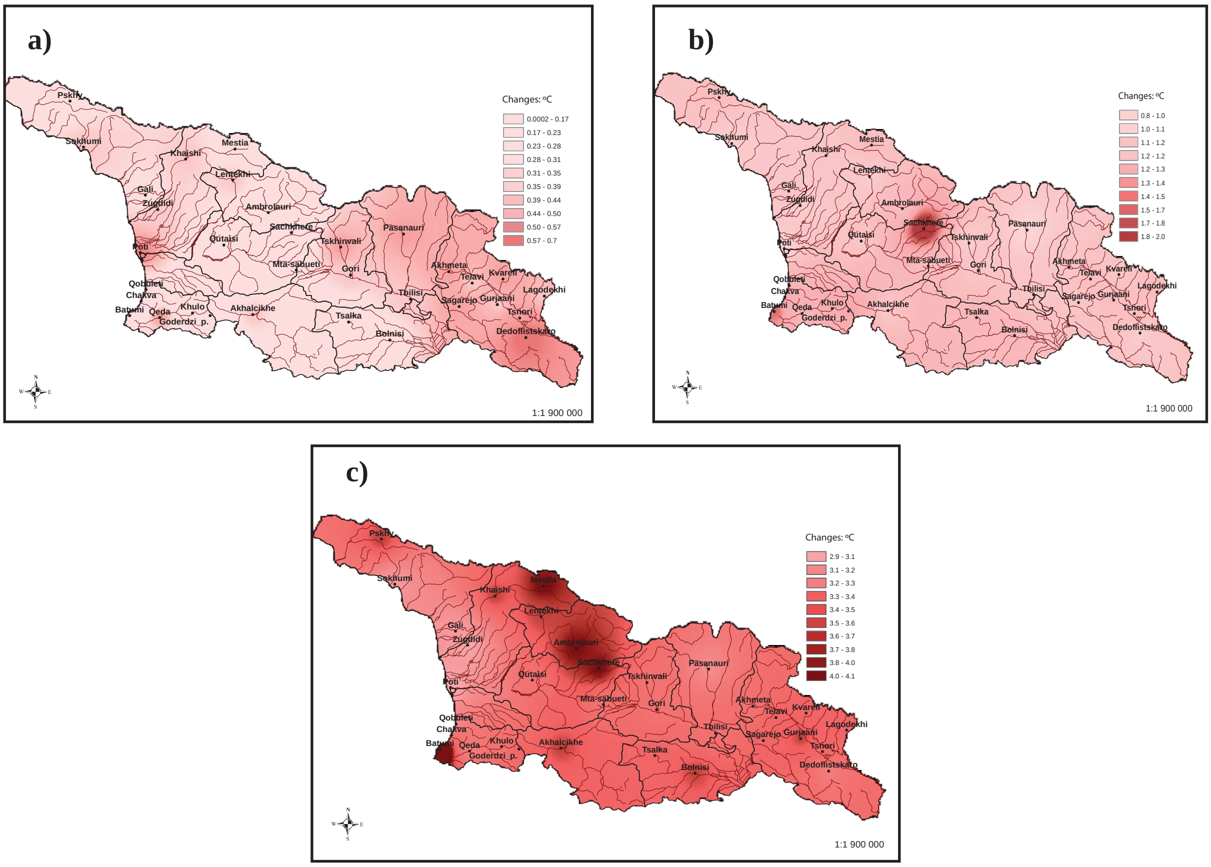

Fig. 4.1.1. Change of average annual temperature: a) Increment between the periods of 1961-1985 and 1986-2010; b) 1986-2010 and 2021-2050; c) 1986-2010 and 2071-2050

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[54] Regional climate model of International Center for Theoretical Physics. http://www.ictp.it/research/esp/models/regcm4.aspx

[55] Details for these parameters are provided in the end of this chapter

Although between two observation periods warming is more intensive in East Georgia, average annual temperature remained warmer in West Georgia (Fig. 4.1.2.a). This picture will be maintained in future as well, since in the current century intensive increase will move to the West. With average annual temperature 14.9 ^{0}C the hottest station on the whole territory was and still is Kutaisi, which by 2100 will be substituted by Batumi – with average annual temperature 19.4 ^{0}C. While the coolest is Goderdzi Pass, with the average annual temperature 2.6 ^{0}C, this will be maintained in future, with annual average temperature 7.5 ^{0}C (Fig. 4.1.2 b).

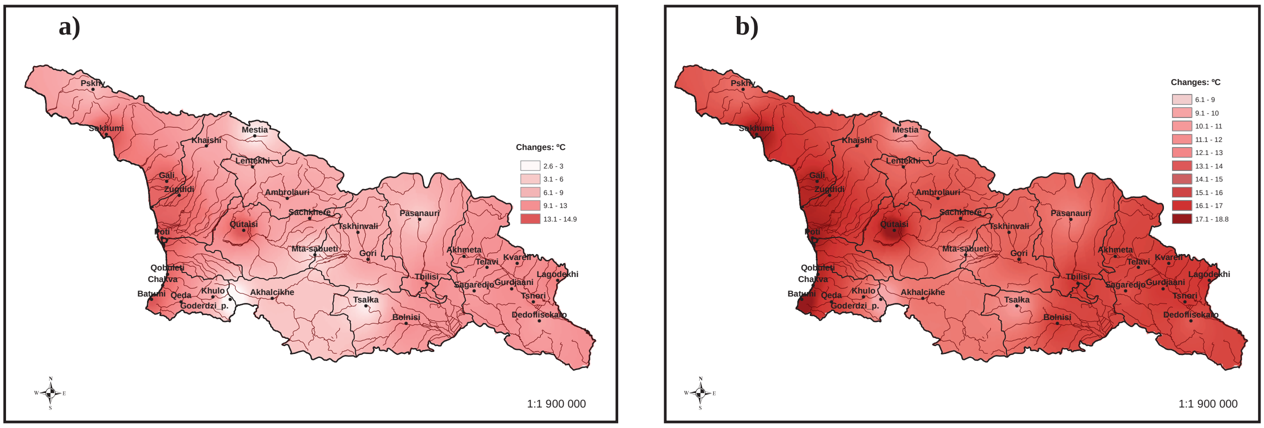
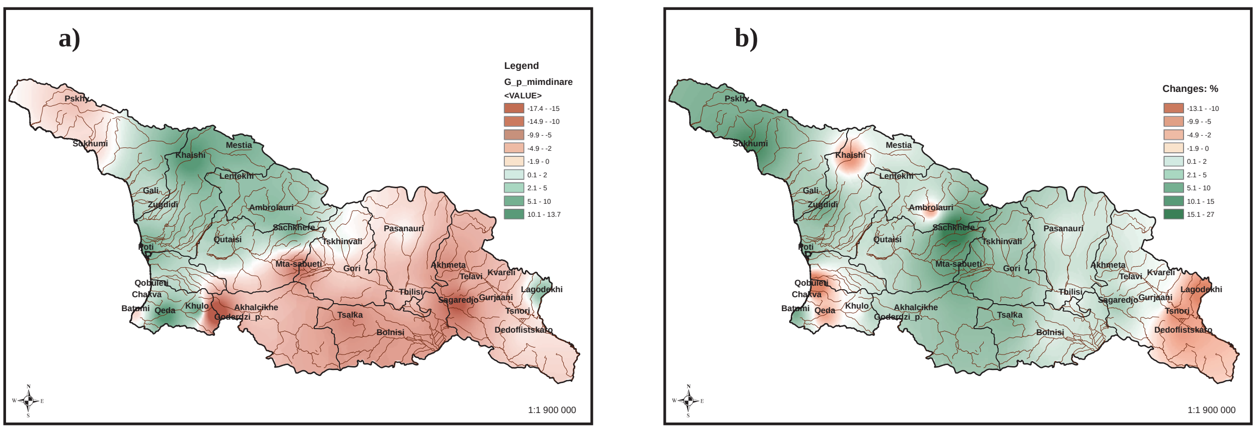


Fig. 4.1.2. Average annual values of temperature: a) 1986-2010; b) 2071-2100

Total Annual Precipitation – between two periods (1961-1985; 1986-2010) the most increased in low mountain zone of Svaneti and mountain areas of Ajara (up to 14%). In general precipitation has increased in West Georgia, besides some exceptions (significant decrease was in eastern part of mountain area of Ajara, (Goderdzi Pass -17%), and decreased in Meskheti (-6%), central part of Likhi Range (Mta-Sabueti -8%), Javakheti and Kvemo Kartli. In East Georgia - in Pasanauri and Lagodekhi precipitation got increased by 2% and 8% respectively (Fig. 4.1.3. a).

Sustainable trends of the increase of precipitation are basically observed in West Georgia, especially in its mountain areas. This trend will be increased until 2050, and after that the decrease will be started, except for some areas (Batumi, Pskhu and Mta – Sabueti). In East Georgia decreasing trend is changed to increase and by 2050 the growth of precipitation on the average by 3, 4% is expected; However Lagodekhi is still an exception and the precipitation decrease by 6.3% is predicted (Fig. 4.1.3. b). Significant decrease of precipitation is expected by 2100 on whole territory of Georgia, mostly in Samegrelo, Kvemo Kartli and Kakheti (22%). Central part of Likhi Range, where total annual precipitation is being increased by 93% is an exception in this period (Fig. 4.1.3. c).



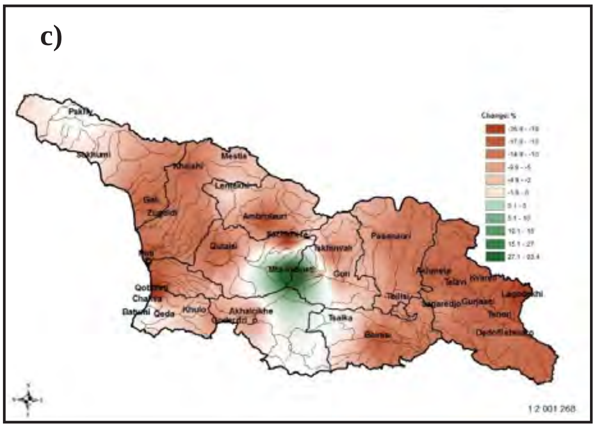


Fig. 4.1.3. Maps of total annual precipitation change between the periods of: a) 1961-1985 and 1986-2010; b) 1986-2010 and 2021-2050; c) 1986-2010 and 2071-2100

Peculiarity of distribution of total annual precipitation is invariable in future forecasts. In particular, the most precipitation fell on Ajara coastal zone (2 300 mm and more) and in East Georgia the most precipitation under conditions of current change will still be observed at Mta-Sabueti (1 101 mm) by 2010 (Fig. 4.1.4 a, b). Besides in East Georgia total precipitation is higher in Pasanauri, Lagodekhi and Kvareli compared to other stations. This trend will be maintained in future as well as the smallest amount of precipitation in Kvemo Kartli.

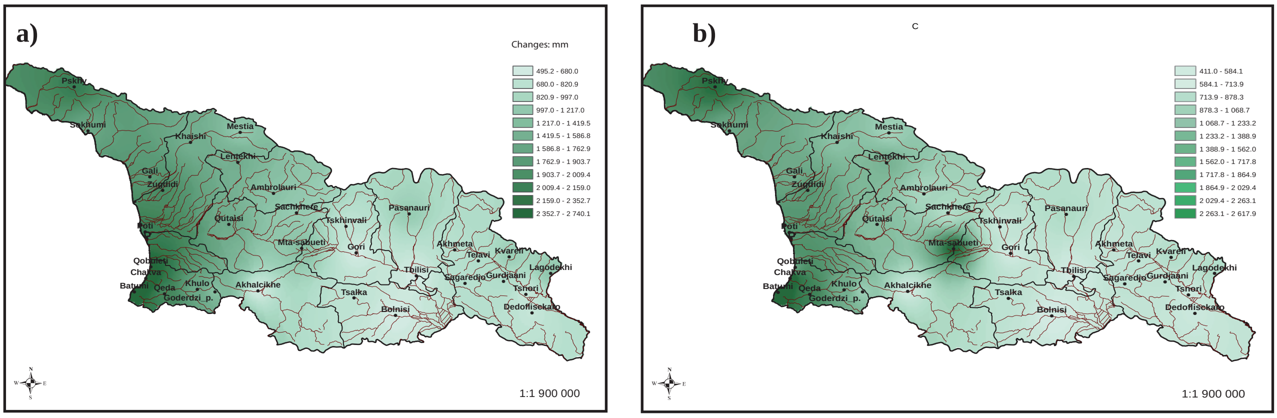


Fig. 4.1.4. Average values of total annual precipitation: a) 1986-2010; b) 2071-2100.

Relative humidity has basically increased by 2% on the whole territory of the country, between first and second periods. The biggest increase (5.4%) with sustainable trend is recorded on Goderdzi Pass (see Fig. 4.1.5. a). This increasing trend will be changed by decreasing on the majority of stations by 2050 and 2100. There are some exceptions, where this parameter will continue to rise significantly: Khaishi (4.7%), Keda (4.6%) and Mestia (2.2 %) (see Fig. 4.1.5. b, c).

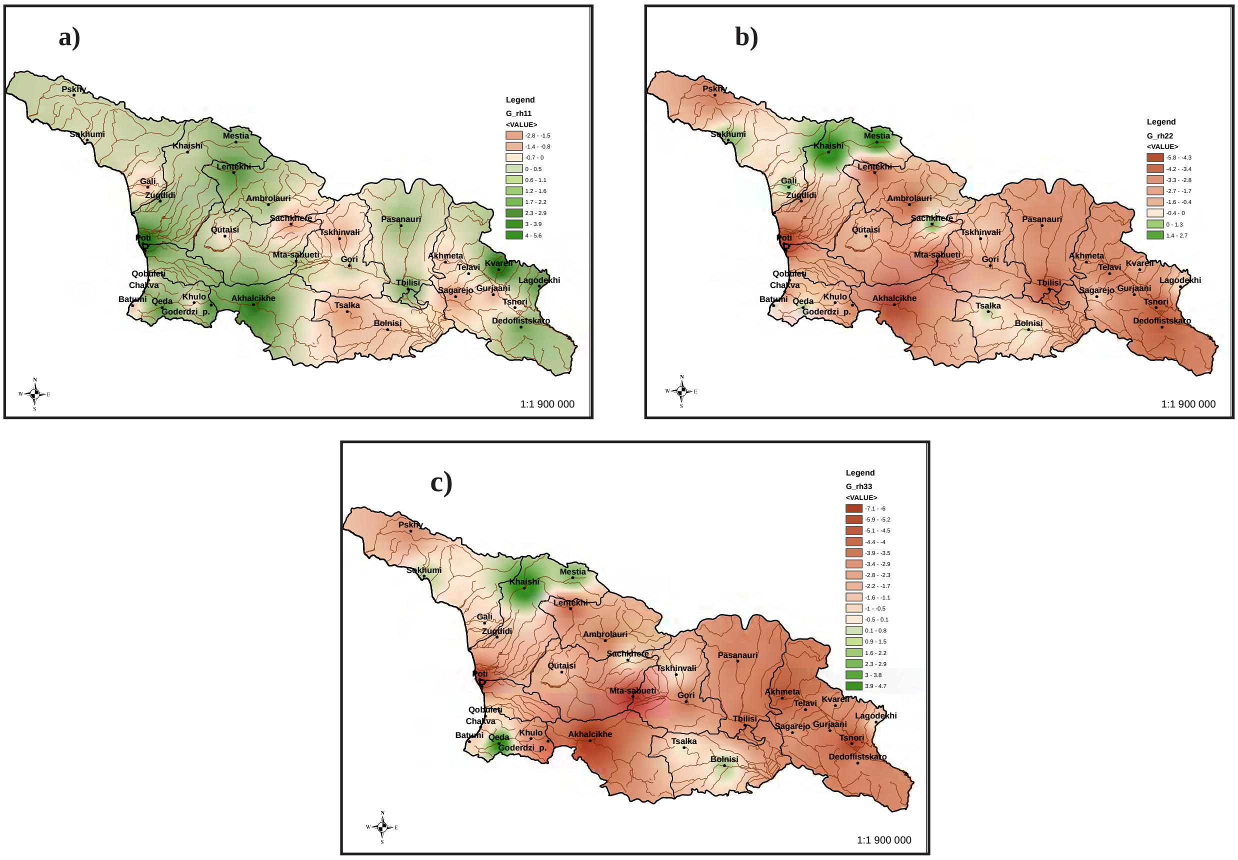
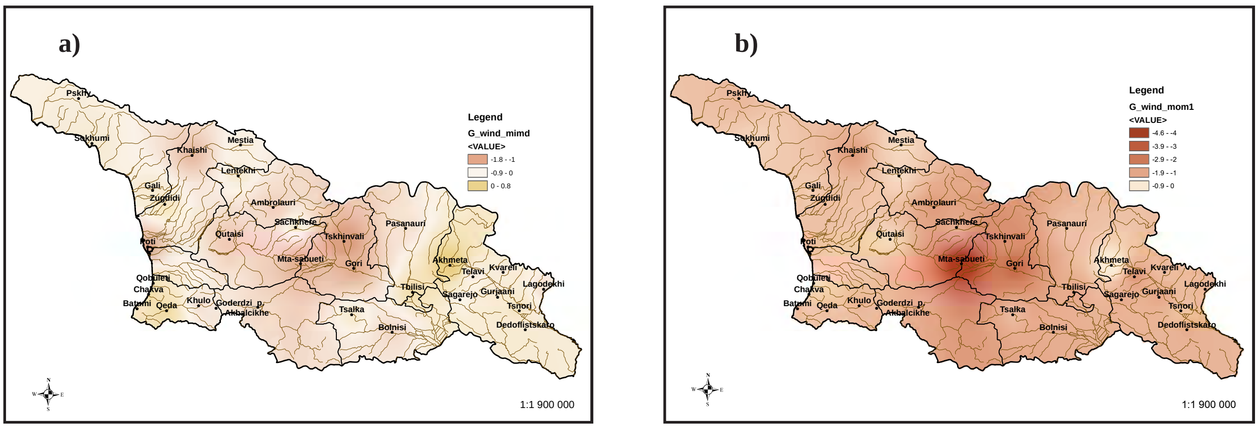


Fig. 4.1.5. Change of average annual values of relative humidity between the periods of: a) 1961-1985 and 1986-2010; b) 1986-2010 and 2021-2050; c) 1986-2010 and 2071-2100

Average annual wind speed significantly decreased on the whole territory of Georgia, the most decrease with sustainable trend was observed on the stations considered in the Wind Atlas as the most prospective for the development of wind energy (Mta – Sabueti, Poti) (Fig. 4.1.6. a). The trend of decreasing average wind speed on whole territory of Georgia will be continued in future, by the end of the century. During this period the speed will go down from 9.2 m to 4.3 m on Mta-Sabueti. Average speed of wind will increase in Akhmeta, however by the end of the century Kutaisi, Batumi and Goderdzi Pass are supposed to be the most windy stations (5.1 m) (Fig. 4.1.6. b), c).



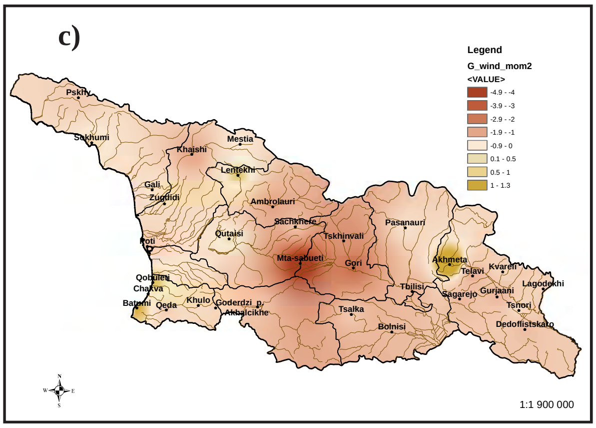
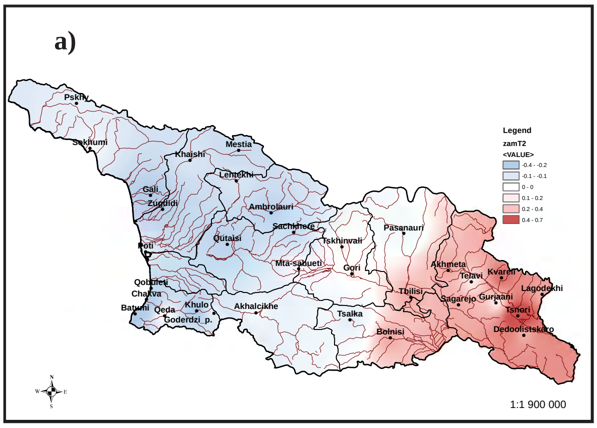


Fig. 4.1.6. Change of annual average values of the wind speed between the periods of: a) 1961-1985 and 1986-2010; b) 1986-2010 and 2021-2050; c) 1986-2010 and 2071-2100

In winter, in the second period of observations warming trend was revealed in East Georgia; However the trend is not sustainable on none of the stations. At 10 stations of West Georgia cooling trend is observed, out of them on 2 stations the trend is sustainable. On major part of the country winter precipitation has increased by 10%. Warming of winter is supposed to be more intensive in West Georgia. By the end of the century winter will be by 0.4 ^{0}C warmer in West Georgia. All trends of cooling will be changed to warming, including in Gali and Lentekhi, where decreasing trends were revealed before. Whole territory of the country will be warmed on the average by 1.3 ^{0}C and totals of precipitation will continue to increase by 2050. Increase of the temperature will be 3.2 ^{0}C by 2100 and increasing trend of precipitation will be changed to decrease. In winter unchangeable trend of the increase of precipitation was revealed only on following five stations: Dedoplistskaro, Akhaltsikhe, Tsalka, Sokhumi and Lentekhi. At other stations direction of change is different by periods.



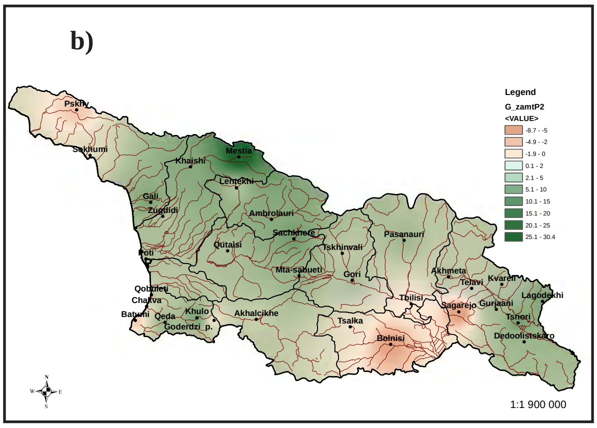


Fig. 4.1.7. Current change in winter temperature (a) and precipitation (b) between the periods of 1961– 1985 and 1986 – 2010

In spring increasing trend of air temperature is sustainable only on two stations of East Georgia – Pasanauri and Bolnisi. Decreasing trend is not sustainable on any of the stations. In future warming trend is being continued and is more intensive in East Georgia than in West. The biggest increment by 2050 is 2.6 ^{0}C, while by 2100 it reaches 4 ^{0}C.

In terms of change of precipitation, the majority of sustainable trends was revealed in West Georgia, pointing to the increase of precipitation from 5 to 28% on this season. In future increasing trend is changed to decrease; The trend is maintained only on Goderdzi Pass. Amount of precipitation is being stably increasing in Batumi; However current trend does not prove this.

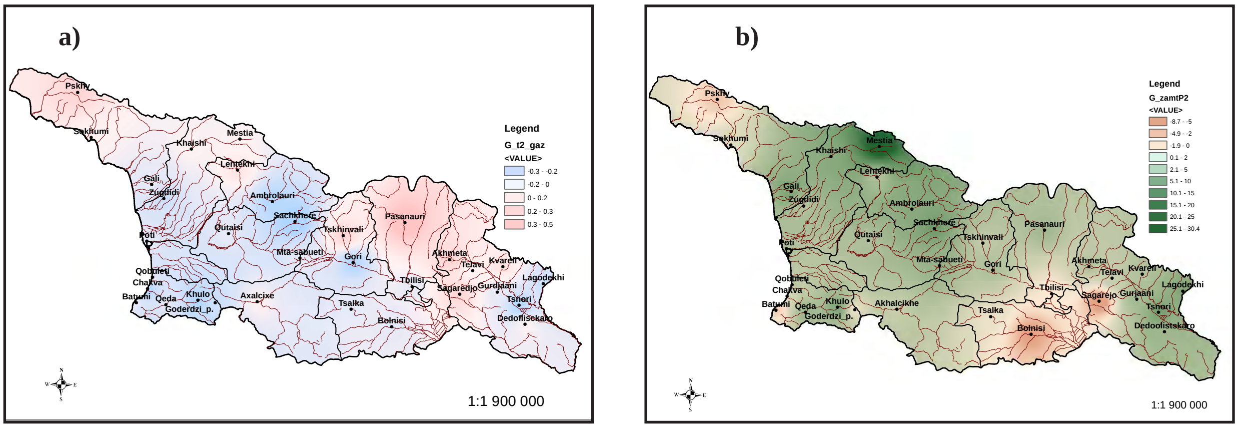


Fig. 4.1.8. Change of spring temperature and precipitation between the periods of 1961-1985 and 1986-2010

In the period of 1961-2010 warming of ***summer*** demonstrates stable trend almost everywhere. At 23 stations of East and West Georgia the temperature increased up to 1 ^{0}C during 50 years. As for precipitation, sustainable trend was observed only on three stations (Bolnisi, Goderdzi Pass and Mta – Sabueti), and it was decreasing at all three stations. Thus summer demonstrates the trend of temperature increase and decrease of precipitation. In future rise of temperature is being continued everywhere and reaches the highest value - 4.7 ^{0}C, while in the middle of the century total precipitation is being grown on the largest part of the country, including the stations demonstrating decreasing trends before. After 2050s until the end of the century increase of seasonal precipitation is changed to decrease and on the majority of stations is reduced below the value existing in the observation period.

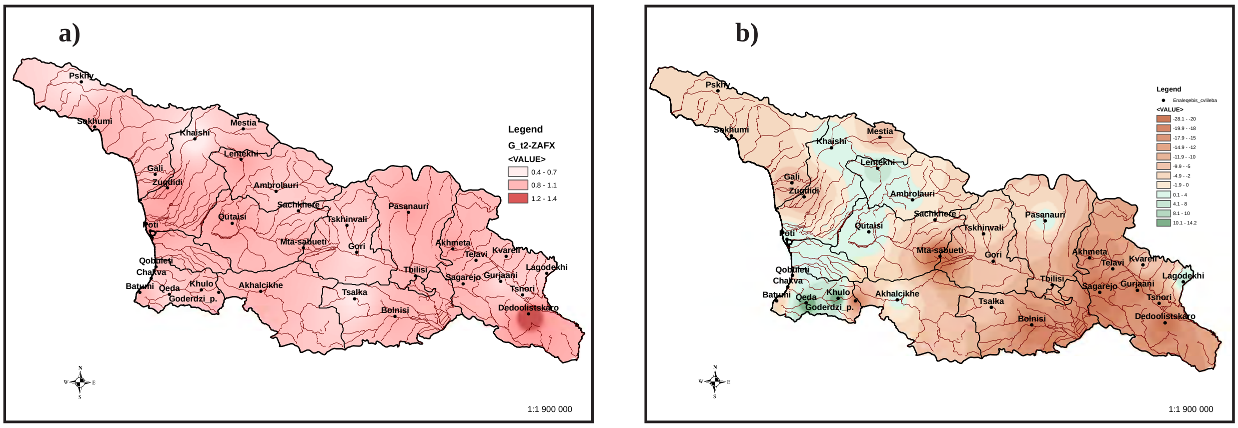


Fig. 4.1.9. Current change of summer temperature and precipitation between the periods of 1961-1985 and 1986-2010

In autumn temperature and precipitation trends are increasing on the whole territory of Georgia. In terms of precipitation some stations demonstrate exceptions (Gori, Tskhinvali, Tsalka, Mta – Sabueti, Pskhu and Goderdzi Pass). Thus autumn will be warmer with abundant precipitation. In the period of 2021-2050 the warming will still continue, and precipitation will increase together with temperature, that will be altered by intensive warming and decrease of precipitation by 2100.

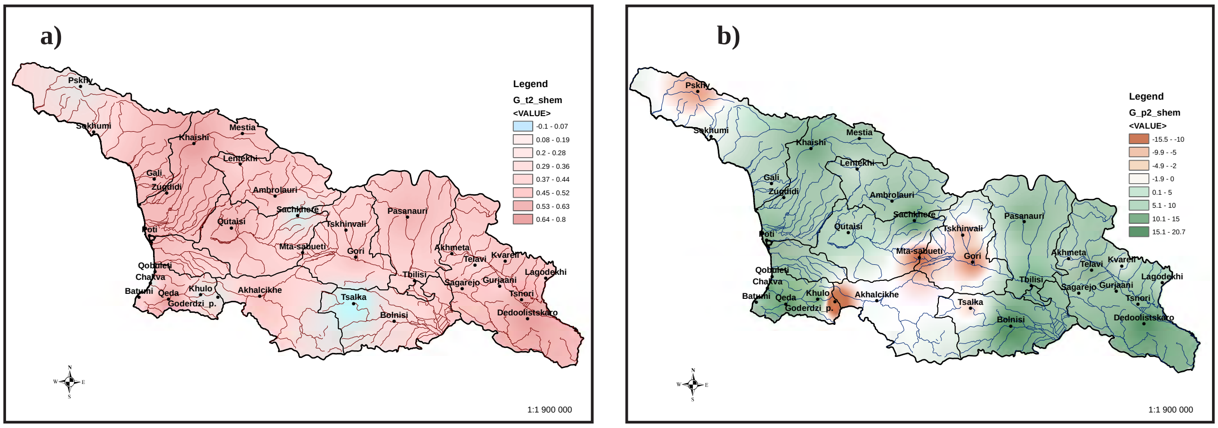


Fig. 4.1.10. Current change of autumn temperature (a) and precipitation between the periods of (b) 1961-1985 and 1986-2010

Reduction of the number of ***frosty days*** (IDO) takes place on whole territory of the country in second period of observation. However reliable/sustainable trends are revealed neither seasonally nor annually. Increasing annual and winter sustainable trends are characteristic for IDO in Mestia and Lentekhi. In all following periods the number of frosty days will be decreased together with increase of average value of temperature; However the risk of this event still exists in lowlands of Georgia by 50s of this century, in winter and especially in spring. However, frosty days will be characteristic mainly for highland areas by the end of this century (Fig. 4.1.11 a).

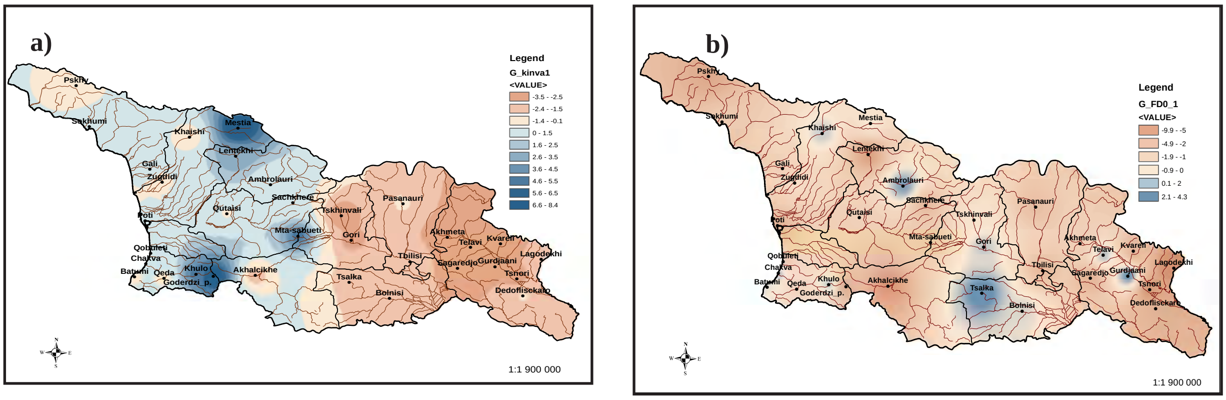


Fig. 4.1.11. Current change of frosty days ID0 (a) and frosty nights FD0 (b) between the periods of 1961-1985 and 1986-2010

Number of ***frosty nights*** is being decreased more rapidly than that of frosty days. By 2050s this event becomes slightly more frequent in transition seasons on lowland stations in both East and West Georgia, that will increase the risk of frosts. By the end of the century the risk of such cases will be reduced in half in highland areas of East and West Georgia, while in lowland of West Georgia, it will be reduced by 70% (Fig. 4.1.11. b).

Number of hot days (SU25) will be increased on the territory of Georgia basically in summer and autumn and consequently annually as well. On the majority of stations this is proved by sustainable trends. The increase is more evident at lowland stations, where number of hot days is increased by 15%. In autumn the increase is more intensive than in spring, when cooling cases are revealed and sustainable trends are less. By 2021-2050 increase in the number of hot days will be less intensive on lowland stations than in observation period. On the majority of stations of Kakheti, Kvemo Kartli and lowlands of West Georgia (except Batumi and Chakvi) this number is even decreased, mainly in summer. On mountain stations this value in some cases is increased by 100% (Tsalka, Pasanauri, Ambrolauri, Goderdzi Pass). By the end of the century average annual number of hot days will be by 50 days more on all stations. The exception is Ambrolauri, where this value is increased by 110 days in the period of 2071-2100 (Fig. 4.1.12. a).

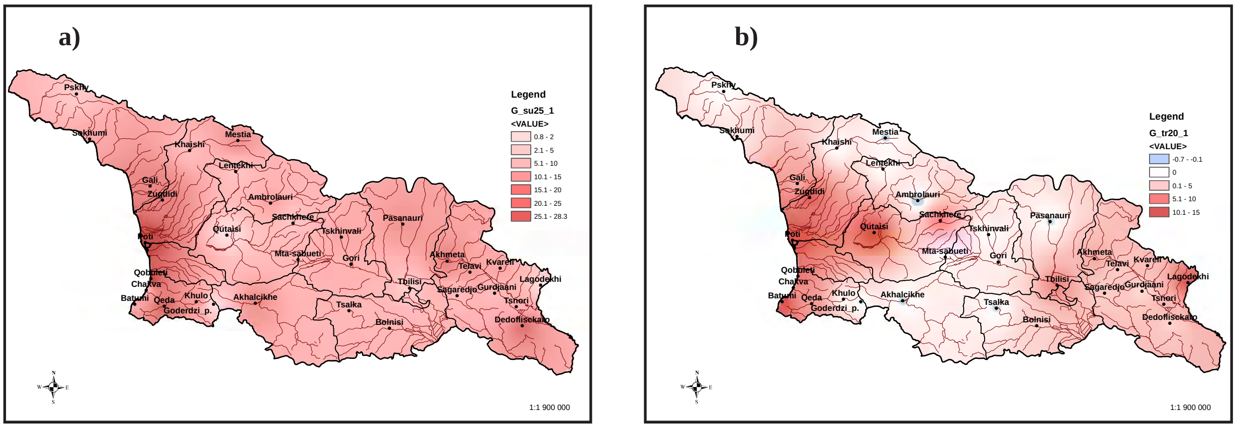


Fig. 4.1.12. Current change in the number of hot days SU25 (a) and tropical nights TR20 (b) between the periods of 1961-1985 and 1986-2010

TR20 index is being increased on the whole territory of Georgia. The increase is especially significant (≈1.5-times) on lowland stations. On transitional seasons this parameter is observed only at lowland stations and its more intensive increase takes place in autumn. In 2071-2100 TR20 index will be increased on the whole territory of Georgia three more times, compared to 2050s. This parameter is observed in all seasons except winter, but not on highland stations. By the end of the century hot days will appear in winter in Poti (once in 10 years) (Fig. 4.1.12. b).

Analyses of the change of temperature indeces – increase of TR20 index and decrease of FD0, indicates the rising of minimal temperatures on the whole territory of the country. This is especially visible at the background of SU25 increase, however, increase of ID0 in Svaneti and highland Ajara indicates that warming of maximal temperature has less intensive nature.

Change of maximum amount of precipitation falling continuously during one and five days is reduced at the half of the stations in East Georgia, this trend is proved just by one station (Tbilisi), while in Telavi and Sagarejo these parameters are being increased. Increase of Rx5day is proved by the trend as well. In West Georgia changes of one and five days precipitation have contradictory nature. The trend just in Sokhumi and Abrolauri shows increase of both parameters. By the period of 2021-2050 amount of maximum precipitation in one day is maximally being increased on the whole sea costal area (except Poti) in Ajara and Samegrelo, while increase in the amount of maximal precipitation in five days is expected in just Zugdidi and surroundings of Gali, where at the background of one day maxima will increase flash flood/flood risk. By the period of 2071-2100 both these parameters are reduced on the most of the territory of the country, however they are increased at the territory of Kvareli and Lagodekhi, as well as in highland areas of Georgia, where the risk of flash floods and floods is high anyway. In West Georgia – Sasmegrelo the risks associated with maxima of one day precipitation are still maintained. (Fig. 4.1.13. a, b).

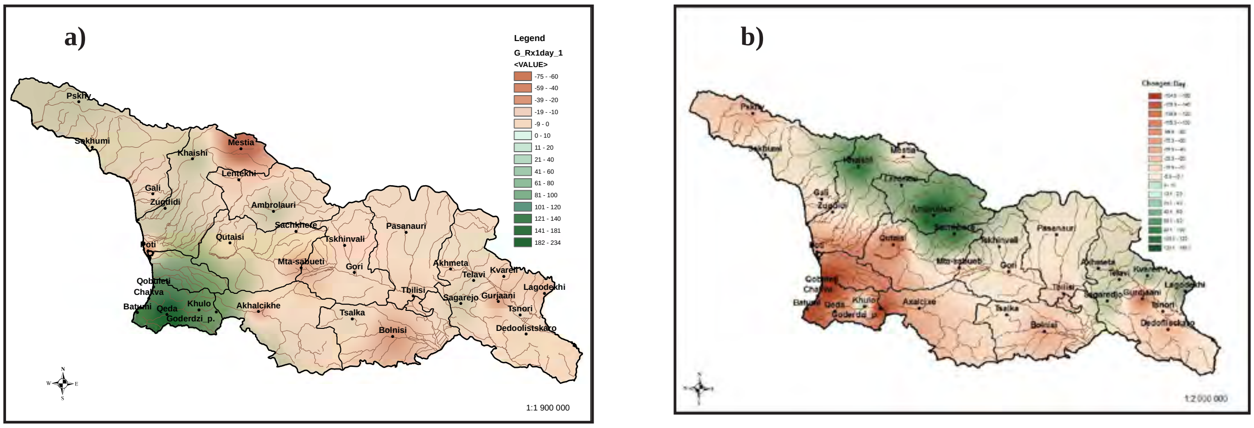


Fig. 4.1.13. Change in the amount of continuous precipitation in one day Rx1 (a) and in five days Rx5 (b) between the periods of 1961-1985 and 1986-2010

According to the examined data **the number of days with extremely abundant precipitation** is slightly reduced in East Georgia, that is proved by the trend in Tskhinvali and Mta – Sabueti. In lowlands of West Georgia these parameters are mostly increased. Rising trends of R50 are observed in Poti, Keda and Ambrolauri. Number of days with more than 50 mm rainfall is reduced in East Georgia by 2050 and is maintained almost invariable by the end of the century. In West Georgia reduction is expected for mountain territory, and in the coastal area number of such days is increased. Their number by the end of the century is less than in 2050s and consequently the risk of flash flood/floods caused by them is higher in this period. Increase in the number of days with more than 90 mm precipitation is expected by 2050 and then it will decrease slightly, however will be still more than during observation period (Fig. 4.1.14 a, b).

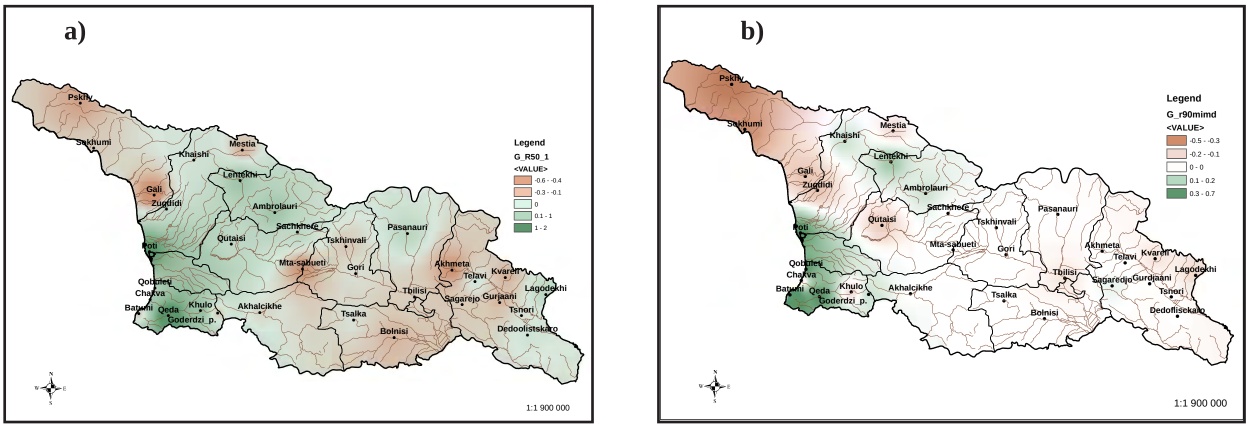


Fig. 4.1.14. Change in the number of days with more than 50mm precipitation R(50) (a) and 90mm precipitation R(90), between the periods of 1961-1985 and 1986-2010

Current change of maximum duration of the period without precipitation (CDD) and with precipitation (CWD). Trend of change of these parameters in East and West Georgia demonstrates that the risk caused by such events will be even more higher, in particular increase of CDD will make the deficit of potable and irrigation water even more acute in Kakheti and Shida Kartli. However the duration of periods with precipitation increase and water deficit is compensated this way. In West Georgia the increase of this latter index means intensification of the risk of floods, flash floods, mudflows and landslides. In future maximal duration of dry and wet periods mostly increases on the whole territory of the country by 2050 and frequency of the risks associated with that will grow. Besides some exceptions the territory of Shida Kartli is distinguished, where increase of CDD and decrease of CWD go in parallel and develop threat of water deficit. By the end of the century, the trend of increasing dry periods and decrease of the periods with precipitation is common for whole Georgia, and all risks indicated in current period will become more acute (Fig. 4.1.15 a, b).

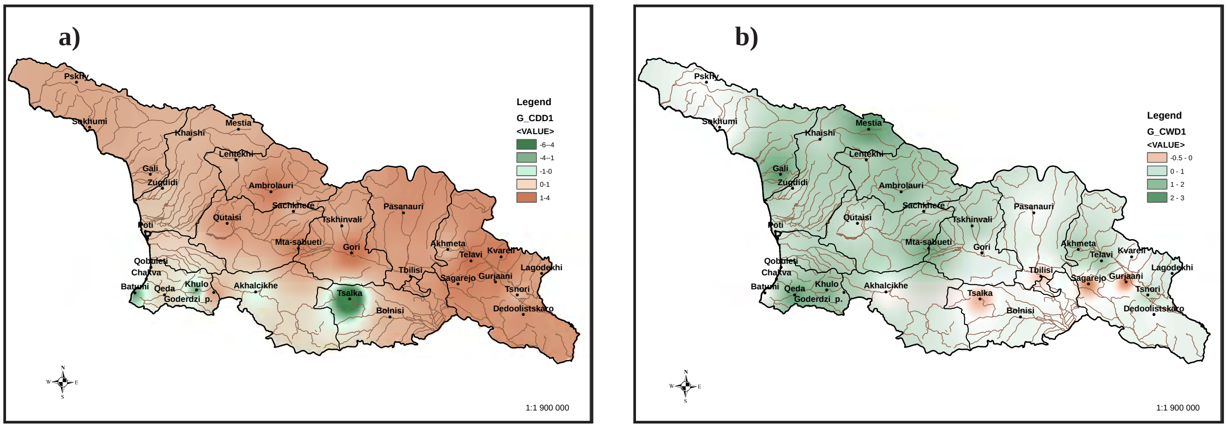


Fig. 4.1.15. Change of maximum duration of continuous dry (CDD) and wet (CWD) periods between 1961-1985 and 1986-2010

Out of 33 observation stations of Georgia, 16 are located in East and 17 – in West. For East and West Georgia annual values of average, average maximum and minimum temperature were derived by simple averaging. It is to be mentioned that the majority of mentioned stations are located in lowland areas, while climate characteristics of highland part of Georgia (Caucasus mountains, as well as Lesser Caucasus) were derived based on certain stations. Thus, climate of topographically the highest and consequently the coldest territories was not reflected respectively, due to objective reasons. Besides, for comparison purposes the CRU[56] (Climate Research Unit) was used – gridded data for the whole earth provided in the database (50 km grid). This database is set up with information obtained from observation stations by spatial and time methods. Average annual values for each parameter are calculated for the periods of 1961-85 and 1986-2010. As it was expected, the values got by simple averaging of observation station data are much higher than in CRU. In particular, average temperatures are higher in East Georgia by about 5 ^{0}C and in West Georgia – by 4 ^{0}C degrees. Maxima are higher within 4.5 ^{0}C and minima are higher by 6 ^{0}C in East and by 5 ^{0}C – in West Georgia. As for precipitation in East Georgia averaged precipitation on stations is about 50 mm less and in West Georgia– by 500 mm more. The trends of change between two periods are in good compliance in terms of values obtained by both methods (averaging observations and CRU). In particular all three parameters of temperature are increased by 0.3-0.5 ^{0}C on the whole territory of the country, and annual total of precipitation are increased by 5% in West Georgia, while in East Georgia they are almost invariable (0.1%).

Table 4.1.1. Annual values of mean, average maximum and average minimum temperatures in East and West Georgia for the periods of 1961-1985 and 1986-2010

	East Georgia						West Georgia					
	Observation		Cru		Δ		Observation		Cru		Δ	
	1961-1985	1986-2010	1961-1985	1986-2010	$Δ_1$	$Δ_2$	1961-1985	1986-2010	1961-1985	1986-2010	$Δ_1$	$Δ_2$
T	10.8	11.3	6.0	6.4	0.5	0.4	11.6	11.9	7.5	8.0	0.3	0.5
Tmax	16.3	16.8	11.7	12.1	0.5	0.4	17.2	17.5	12.8	13.2	0.3	0.4
Tmin	6.4	6.8	0.3	0.8	0.4	0.5	7.5	7.8	2.2	2.7	0.3	0.5
P (mm)	748.0	733.0	791.0	792.0	2.0%	0.1%	1 624.0	1 706.0	1 100.0	1 150.0	5.0%	4.5%

[56] http://www.cru.uea.ac.uk/

4.2 Climate change impact on Georgian agricultural sector

4.2.1 General overview

Impact of climate change on Georgian agriculture has been discussed in all climate change national communications of Georgia. Based on the research conducted by the experts working in the field of agro-climatology, it was determined that the impact of climate change on the agriculture in Georgia will be both positive and negative. Talking of negative impact, the following must be taken into consideration: 1) Intensification of drought regions area, increase of moisture deficiency on the account of evaporation and losses of yield; 2) Strengthening of soil salination process along with increase of evaporation intensity; 3) Rapid mineralization and exhausting of organic mass of soil; 4) Better hibernation (wintering) of agricultural crop diseases and pests and, as a result, their intense reproduction; 5) Strengthening of erosion processes and increase of the risk of high-waters and hail as a result of increase of precipitation intensity and frequency.

In Georgia's TNC (2012-2014) the study of the impact of climate change on agriculture was conducted as a case study for two regions – Ajara and Kakheti. Unlike the second national communication, in which one of the strongest agrarian regions of Georgia – Kakheti – was represented by only Dedoplistskaro municipality, in the TNC the influence of the climate change on agriculture was studied in more detail for all the eight municipalities of Kakheti[57]. Regarding Ajara region the impact of CC on agriculture is in details considered in Ajara Climate Change Strategy. Below are delivered main results of the study conducted for both regions.

4.2.2 General overview of agriculture in Ajara

Diverse natural conditions of Ajara determine the multi-sectoral structure of its agriculture. However, the relief creates complicated conditions for the development of this sector. In the structure of the land reserves (290 000 ha) agricultural lands occupy 72 862 ha (25.1% of total area), out of which, only 5.0% is lowlands.0.19 ha of agricultural land comes per capita, out of which 0.03 is arable land. The main part of the region is occupied by slopes and mountains. In addition to this, excessive precipitation (2 000-3 000 mm) leads to activation of soil erosion processes. This in its turn reduces soil fertility due to washing out of plant nutrition elements. Intense and excessive precipitation causes high waters, landslides and avalanches. As a result, the number of agricultural land plots decreases: if in 1980 the area of agricultural land was 78 718 ha, by 2010 it decreased to 72 862 ha, out of which 15 899 ha are lands under perennial plants, 10 309 – arable lands, 7 159 – mowing, 1 736 – rested and 37 759 are grazing lands. Activation of soil erosion processes is facilitated by intense cultivation and production of annual plants without relevant protective measures. In the same period, the area under perennial plants was reduced.

According to statistical data, the agricultural sector of Ajara satisfies the population of the region only by production of potatoes with some surplus. The biggest deficit is with the production of eggs and meat. If we also take into consideration, that during the summer season as a result of inflow of tourists the population of the region increases 3 or even more times, we can clearly see the necessity of modernization of the agrarian sector of the region.

One of the main reasons for the crisis in the sector is that in the past years, the agriculture of Ajara was mainly oriented towards the production of perennial subtropical crops, while the production of crops determining food security (wheat, vegetables) was considered to be a number two task. The recent political and socio-economic changes required restructuring of agricultural production to ensure dominance of products of local consumption.

Soil fertility and agricultural soil erosion is an important problem in Ajara. Average yield of agricultural crops in his region is 3-4 times less that similar indicator of advanced countries.This is first of all caused by the fact, that for the last 15 years nothing has been done in terms of artificial fertilization of state-owned agricultural

[57] http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/climate-change-and-agriculture-in-kakheti/

lands. In the near future, for the farmers in the region, to have high yields on small agricultural lands, attention should be paid to the measures for improving the soil fertility, which means enrichment of the soil with organic and mineral fertilizers.

For the development of agriculture in Ajara and increase of farmers' income, it is important to produce ecologically clean products and develop agro-tourism, since tourists are attracted by landscape exotics, as well as by local safe and ecologically clean products. With this regard, Ajara has adequate resource. Existence of traditional and biological farms of various crops by municipalities guarantees that visitors coming from different parts of the world will get acquainted with local products.

Impact of current climate change on agricultural sector of Ajara

Citrus production in Kobuleti and Khelvachauri municipalities of Ajara Autonomous Republic is the only main and priority sector. Production of subtropical crops here is supported by favorable climate, but it must be taken into consideration, that subtropical zone of Ajara represents the extreme northern part of the world subtropical zone, climatic characteristics of which is conditioned by two factors: 1) Black Sea, which in summer accumulates big amount of warmth and gradually emits it in winter, that softens the climate; and 2) High mountains of the Caucasus Range, which prevents the direct inflow of cold air masses from the north.

It is considered, that the main factors influencing the yield of citrus production are climate and agro technical measures. The comparison of 1981-1990 (planned production of the socialist state) and 1991-2010 (individual production) showed, that in the first period, average yield of citrus (14.8 t/ha) was almost twice as much as the average yield of the second period (7.7 t/ha).

In terms of climate characteristics, the first and the second periods do not differ by any extreme deviations, like lengthy and strong frost, drought or hail; but observation shows certain changes in vegetation period duration, increase of very hot days and tropical nights and generally the warming tendency. Regrettably, at the present stage, it was not possible to link directly such a slump of the yield of citrus crops to the above changes. Such a reduction of the yield can be explained by lack of attention to the plants during the transition period and impossibility of implementing the full range of agro technical measures in the conditions of general decline of the economy. At the same time, recently, alongside with the increase of average temperature and the number of hot days, variety and intensity of plant diseases has considerably increased, which is a significant problem in case of citruses as well and leads to early deterioration (rotting) of the fruits. Based on the existing data, without conducting additional research, it would be difficult to talk about the impact of the recorded changes of the climate on the yield of citruses and the quality of the yield, since during the last 20 years maintenance of the citruses was influenced by numerous negative factors and it is not easy to distinguish their impact from the impact of climatic factors.

Despite of the above, it still can be said that presently the main problem for citrus growing is the climatic factor which is expressed in insufficient provision of warmth for the plants, with no regard to the increase of vegetation period and sums of active temperatures. At the present stage, to solve this problem, introduction of early varieties of citruses is considered as one of the main measures; in the above lowland zone, kiwi is thought to be a promising crop.

The issue of heat supply is less relevant for **horticulture and viticulture** in both lowlands and highlands of Ajara. Local varieties of fruits and grapes have adapted to the current climatic conditions and they face no ripening problems.

As far as potato crop is concerned, in the conditions of highland and mountainous zones of Ajara this crop presently produces good yield and the recent climatic conditions are very favorable for its productivity, which will be worsened by 2050.

Influence of climate on **potato crop** was assessed for Khulo municipality, in which potato is a leading crop. For this assessment FAO AquaCrop program and climate data of Khulo meteorological station was used. The model showed, that in the current period, the conditions in Khulo District are favorable for growing potatoes and the yield has increased by 10-13%, which complies with the actual statistics. Under the current conditions of the climate, potato yield will remain in this state for a certain period (the model doesn't take into consideration anthropogenic influence, such as maintenance methods, fertilizers, etc.).

Current climate change has already influenced **cattle breedin**g. Frequent precipitation, strengthened as a result of warming, causes washing-off of the soil from the slopes, which, against the background of intense utilization of the grass cover, is accompanied by harsh reduction of productivity of mowing and grazing lands.

Assessment of water deficiency of pastures was carried out by means of FAO CropWat model and climatic parameters observed at the Goderdzi Pass meteorological station. Modeling showed that these grazing lands do not suffer from the lack of water.

Within the framework of the project, using the multi-criteria analysis method[58], general assessment of vulnerability of the agricultural sector of Ajara Autonomous Republic in terms of the climate change was conducted for all five municipalities (Khelvachauri, Kobuleti, Khulo, Keda, Shuakhevi). In total, 26 parameters were assessed. Assessment of vulnerability was carried out in three directions: impact of climate change on agriculture, sensitivity of agriculture towards the changes and ability of the population to adapt to the changes. Changes of climatic parameters were taken for two 25-year periods: 1961-1985 and 1986-2010. The data of meteorological observations of five meteorological stations were used.

To assess the influence of climate change the increase of heavy rain days (when the daily amount of precipitation exceeds 50mm (R50), increase of the number of days when maximum temperature exceeds 25°C (SU25) and increase of agricultural drought calculated with SPI[59] index. i.e., when during three months, precipitations are much less than average norm, were used.

The assessment revealed, that the climate change (by the above three parameters) was most of all influential in Keda municipality. Kobuleti is on the second place and the rest three municipalities show almost similar results, which are much less (in the following order: Shuakhevi, Khelvachauri and Khulo). In Khelvachauri and Khulo these changes are very close to each other (Fig. 4.2.1).

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[58] Version of this method, adapted for agriculture, was provided by EU project, which was implemented by Caucasus Regional Environmental Center (REC Caucasus). "Introduction of Adaptation Measures Related to Climate Change Influence for the Purpose of Protection of Agro Diversity and Safe Use of Bio Diversity, in Dry and Semi-dry Ecosystems of the South Caucasus".http://www.rec-caucasus.org/projects.php?lang=en

[59] SPI(Standard Precipitation Index). http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html

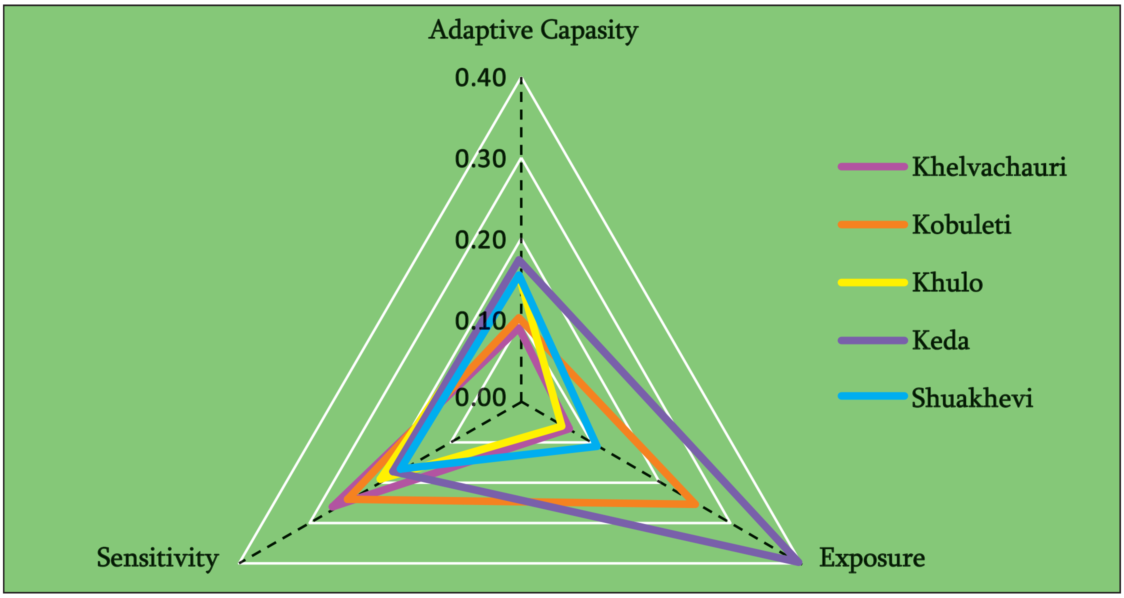


Fig. 4.2.1. Vulnerability of Ajara Agriculture to climate change in 1961-2010

In terms of sensitivity to the changes in soils and bio diversity, Khelvachauri proved to be the most sensitive municipality, and then comes Kobuleti, Khulo, Keda and Shuakhevi. No significant difference is observed in this sensitivity.

As far as the adaptation potential is concerned, the lowest adaptation ability was shown by Khelvachauri[60] and Kobuleti (i.e., where population is biggest and the infrastructure is most developed). Highest adaptation potential was shown by Keda and Shuakhevi. As a result of joint assessment of all the three parameters, it was revealed that agriculture is most vulnerable tothe climate change in Keda (0.75) and then in Kobuleti (0.60). The rest three municipalities show almost the same level of vulnerability.

In 1980-2010, the analysis of development of agriculture in Ajara Autonomous Republic and the climate change showed, that both natural and anthropogenic systems necessarily need the assessment of climate risks, establishment of the level of vulnerability to expected climate change and elaboration of relevant adaptation measures.

By 2050, from the point of view of expected impact of climate change, estimated increase of average annual temperature and especially, the temperature of the warm period of the year will make significant corrections to the qualitative and quantitative indicators of citruses. As it is known, West Georgia is situated within the Mediterranean Sea basin and at the northern border of adjacent territories of distribution of citrus production. During the vegetation period such heat-loving crops as orange, grapefruit, lemon, etc., suffer from frequent lack of temperature sums. Namely, according to the existing data, full ripening of orange and grapefruit in Ajara is presently possible only 5 or 6 times every 10 years. According to the forecasted data obtained within the framework of the ongoing project, by 2050, in the sea coast zone increase of average annual temperature by 1.5 °C is expected and by 2100 – by 4.2 °C. by 2100, lowlands of Ajara will equalize in climate terms (average annual temperature 18.3 °C) with coastal regions of the Mediterranean Sea, where average annual temperature now varies within 18 °C. All this, including prolongation of the vegetation period by almost one month by 2050, will probably create in the lowlands of Ajara favorable environment for achieving high quality stable yield, provided that relevant agro-technical methods are applied. However, since the current events show the increase of the active temperature sums, if it does not increase equally during the vegetation period but increases mainly on the account of very hot days, it will be followed by the increase of plant diseases and pests, which will eventually reduce the quality of the fruit.

[60] In terms of agriculture, Batumi is not considered as a separate municipality and it is not included into Khelvachauri either

Expected warming of the climate in the first half of the current century, will probably have a more positive influence on horticulture and viticulture and these crops against the background of almost unchanged precipitations on the account of the increase of vegetation period by almost one month. In the second half of this century, during the vegetation period, compared to the second half of the previous century, temperature will increase by 4.5 °C and precipitation will decrease by 30%; in such conditions, the above two sectors of agriculture will probably face serious problems in terms of moisture supply of the plants. Taking this into consideration, it will become necessary to introduce new varieties that can adapt to the changed climatic conditions.

In the present climatic conditions, when during 5 months from November to April, production of vegetables is possible only in greenhouses, this requires significant expenditures. With the expected climate change, before 2050, increase of vegetation period by almost one month in lowlands and mountains will reduce the greenhouse costs by 10-20%, but will probably increase the cost of pesticides.

By 2050, against the background of further and noticeable increase of temperature (by the end of the century, average temperature in the coastal zone during winter months will exceed 10 °C), present disease condition of tomatoes will become even more severe, which will bring to the agenda the necessity of introducing new varieties, adaptable to the changed climate.

In case of the expected warming by 2050, it will be possible to further extend potatoes in higher mountainous zones (this process has already started). However, this process should be very well organized and planned, to ensure that spontaneous increase of potato plantations, which will cause reduction of mowing and grazing lands, doesn't negatively impact the development one of the leading sectors of agriculture – cattle breeding and increase of soil erosion.

According to the climate forecasts, expected increase of temperature by 1.6-2.2 °C in the warm period of year in the mountainous zone of Ajara before the middle of the current century, should be beneficial in terms of the increase of the productivity of pastures. As for possible slight reduction of precipitation level by 1-8%, this will not probably significantly influence improvement of grazing lands in terms of reduction of erosion (this means that anthropogenic factor/overgrazing is not considered).

In general, vulnerability of agriculture by municipalities was assessed also for the future period (2050). In this case also, the same method of multi-criteria method was used, but the changes in future was taken into account only for climatic parameters, which makes the results less precise, since in reality other macroeconomic, social and infrastructural parameters will also be changed and the adaptation potential of some municipalities will significantly increase. As a result of this assumption the following picture was obtained (Fig. 4.2.2):

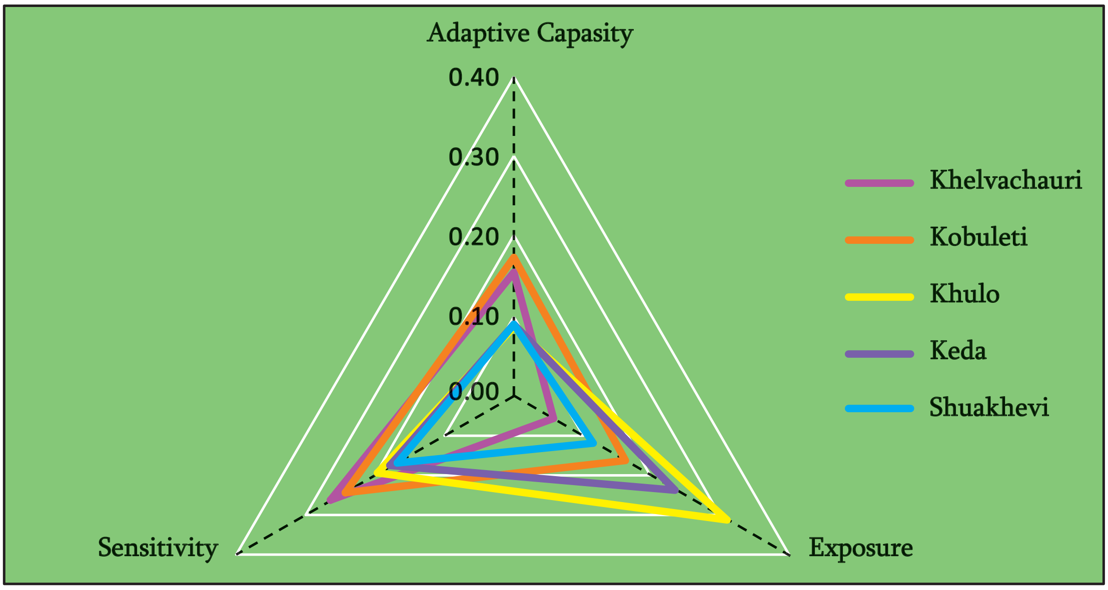


Fig. 4.2.2. Projected vulnerability of Ajara Agriculture sector to climate change, taking into consideration only climate parameter changes by 2050

This figure shows that by 2050, climatic parameters selected for agriculture will have strongest impact in Kobuleti municipality and the summary value of all the three indicators also show that Kobuleti municipality will be the most vulnerable (0.75). In Keda situation significantly improves and it will move to the category of the least vulnerable (0.31).

Recommendations

The analysis of problems faced by agriculture of the region makes it clear that in Ajara the most problematic is soil degradation, caused by water erosion and reduction of fertility, oxidation, pollution and ignoring of modern agro-technical achievements. To solve these problems it is necessary to develop an integrated policy for land use, which will regulate land use, protection of soil from pollution, avoiding soil degradation and many other issues related to land.

The **agricultural strategy** of Ajara considers following measures for the process of adaptation to the negative impact of climate change:

- For the reduction of pressure over the soils and proper management of agricultural lands/soils, consolidation of small farmers using various alternatives (e.g., facilitation of farmer associations; creation of cooperatives, moving population to lowlands, and usage of geologically stable lands for large farms, where preventive measures and measures for improvement of fertility are more effective, etc.);
- Management of natural resourses (particularly lands) must be implemented with clearly distributed responsibilities;
- Land resource legislation needs revision and renewal, to create relevant legislative bases for sustainable management of land resources, which takes into consideration interests of different sectors. The revised legislation should ensure effective control and monitoring of law enforcement in the land use practice;
- Facilitation of strengthening of the potential of agricultural service centers, especially for the purpose of risk reduction of the negative impact of climate change and increase of land fertility must be ensured. At the same time, the function of such agricultural service centers should include: technical

service for private land owners; veterinary support; consulting on recent achievements in agriculture for the introduction of advanced practices; also, consulting on production economy, marketing and legal issues. Agricultural service centers can make an important contribution in the development of sustainable agriculture in Ajara and whole Georgia;

- It is necessary to conduct permanent observations on climate change against the background of current warming for the purpose of proper assessment of the potential of shifting of agro-climatic zones and in case of revealing such changes, develop relevant recommendations for reducing risks caused by expected changes for population, particularly for farmers;
- Taking into consideration, that successful agriculture is greatly dependent on weather and climate, for the purpose of protection from expected risks, it is necessary to develop an effective insurance system;
- Development of agriculture in the region should also be supported by flexible performance of the banking system. Presently, majority of banks refrains from financing agriculture, which is to certain extent conditioned by the absence of insurance policy in this sector of economy;
- An action plan for sustainable development of agricultural sector should be elaborated, taking into consideration maximum usage of locally produced ecologically clean products for tourism sector.

4.2.3 General overview of agriculture in Kakheti

38% of agricultural lands of Georgia are disposed in Kakheti region. Particularly big are pastures and hayfield. According to this category of agricultural lands, Kakheti holds the first place in Georgia, due to which it is the leading region in the fields of grain farming and cattle breeding. In terms of the size of agricultural lands, Dedoplistskaro municipality is distinguished. It is followed by Sighnaghi, Sagarejo and Akhmeta. One of the serious problems revealed in Kakheti is that like Ajara and other regions of Georgia, farmers do not maintain soil properly, they don't enrich it with mineral or organic fertilizers sufficiently. Due to lack of maintenance, the lands are full of weeds. Due to large number of cattle grazing in the fields, the desertification process has already started, especially in Sagarejo and Dedoplistskaro districts. In many sections of agricultural lands water and wind erosion of soils is in progress.

Windbreaks. For several municipalities of Kakheti region, planting of windbreaks was vital and urgent. Yields of leading crops and land productivity (apart from exceptional years) in these municipalities fully depends on existence of windbreaks. Wind-belts protect the fertile humus layer of soil from destruction. These municipalities are, first of all, Dedoplistskaro and Sighnaghi. Out of 3 000 ha of windbreaks existing previously in these two municipalities at least 75% has been cut. Rehabilitation of windbreakers is strategically extremely important for retention of mowing and grazing lands and, accordingly, grain growing and cattle breeding in Dedoplistskaro. At the present stage, rehabilitation of windbreaks is impeded by certain barriers, without overcoming which it will be practically impossible to retain them:

- **Ownership issue**. It is not clear, who owns different types (60 m and 10 m wide) windbreaks. Legislative base related to windbreaks is often controversial, which creates a serious barrier for rehabilitation and protection of wind-belts. Presently, the work in this direction is ongoing in Georgia. Alongside with other ministries and Agrarian Committee of the Parliament of Georgia, the Ministry of Environment and Natural Resources Protection is actively involved in this process;
- **The issue of management and maintenance** is also very vague in the legislation. Division of the functions, existing previously, between Forestry Department, Road Department and Ministry of Agriculture is not valid any more;
- This legislative confusion is accompanied by the problem of **grazing and fires**. Fires are caused by two reasons: one is cleaning from straw and weeds after harvesting by means of fire and second – burn-

ing of pastures by shepherds to ensure fast growth of new grass (green practice). These two types of fire are uncontrolled and destroy both old and new windbreaks. As for grazing lands, the problem is very similar here: due to lack of control and protection, shepherds do not care, if their cattle destroys the young trees of the windbreaks.

Half of the area under wheat in Georgia and more than a half of produced wheat is from Kakheti. In the recent years, against the background of general reduction of local wheat production, the share of Kakheti in the country has increased even more, since wheat production in other regions has reduced. Dedoplistskaro and Sighnaghi municipalities, which are distinguished by abundance of non-irrigated arable lands, are leading districts in terms of wheat production. **Traditionally, Kakheti was considered as the main region producing wheat, rye and other grains.**

Kakheti is also a leading region in Georgia in terms of **production of melons** (watermelon, melon, pumpkin). Kakheti produces 70-80% of melons in Georgia. During the recent years, volume of production of melons has significantly increased. In Kakheti, Lagodekhi and Kvareli municipalities are leaders in vegetable production. Due to conditions similar to subtropical, Lagodekhi district is leader in production of vegetables, namely cucumber in protected fields (without greenhouse heating).

Kakheti is the main region in terms of **viticulture and wine production**. Vineyards, producing grapes for the best quality wines are situated within Alazani and Iori basins, at 400-700 m above sea level, on humus-carbonate, black and alluvial soils. Out of 18 locally produced wines, registered in Georgia, 14 belong to Kakheti. Viticulture in Kakheti is presently represented by old vineyards, planted in 1960-70 (85-90% of total area of vineyards) and newly planted vineyards (10-15% of total area of vineyards). Old vineyards have already amortized by now, they are hallow and yields per ha are low (2-2.5 t/ha). In order to increase the quality of grapes and efficiency of vineyards, the above vineyards require rehabilitation. In Kakheti, in the second part of the 1990s, intense planting of new vineyards started and this process was the most rapid in Telavi, Kvareli and Gurjaani municipalities, since here are the well-known viticulture micro-zones: Kindzmarauli, Akhasheni, Mukuzani, Tsinandali, Vazisubani, Napareuli. Interest of investors was also very high.

Kakheti also produces many **varieties of fruit**. In terms of commercial horticulture, Gurjaani and Telavi districts are distinguished, where stone fruit – peach and nectarine production is well developed. In Gurjaani district, since 1970s, the area of stone fruit gardens has increased almost 4 times (from 900 ha to 4 300 ha) on the account of reduction of vineyards area (from 13 200 ha to 7 000 ha) and grain crops area. Market diversification is considered to be the reason for this.

Cattle breeding holds an important place in the economy of Kakheti. Moreover, Kakheti is one of the leaders of cattle breeding of Georgia. Development of this sector is facilitated by existence of grazing land tracts, as well as usage of agricultural crops, produced in Kakheti, as the fodder for cattle.

Impact of current climate change on agriculture in Kakheti

As a result of the conducted research, one of the most frequent problems in Kakheti is intensification of **droughts**. The impact of droughts is obvious with the reduced yields of annual and perennial plants and crops used as feed. At the same time, as a result of intensified droughts, production of certain crops has become senseless in some municipalities as these direction have proved to be inefficient. For instance, sunflower and maize. Although new, productive hybrids of maize have emerged recently, in number of districts of Kakheti region, like Sagarejo and Dedoplistskaro, it was not possible to have high yields due to drought. The best way to eliminate the risks associated to droughts is rehabilitation of irrigation systems and introduction of modern irrigation technologies. At the same time, it is necessary to test varieties and popularize them with population. This requires existence of strong variety testing centers.

Increase of average temperature and extremely hot days may have both negative and positive effect, since the increase of temperature may create for certain regions the opportunity to introduce new crops and establish commercial production. But there can also be an adverse effect, which is particularly relevant for production of stone and seed fruits. Measures associated with the change of temperature include agro-climatic zoning of the districts, which has not been done in Kakheti region for a long time. There are some objective reasons for that, which is that it requires existence of sufficient number of agro-meteorological stations within the region. Relatively simple way out could be installation of mobile agro-meteorological stations in the districts, which allows for the climate change observation and agro-climatic zoning of the districts.

Soil swamping is encountered in many districts of Kakheti, particularly in Gurjaani and Sighnaghi. The main reason for that is improper maintenance of drainage systems, depreciation/filtration of irrigation canals and popular practice of surface irrigation. In this case, rehabilitation of irrigation and drainage canals is within the competence of the government, namely the Ministry of Agriculture. The Ministry carries out such measures through the United Amelioration Company. In 2014, over 71 million GEL was allocated. As far as refining of irrigation technologies is concerned, it necessarily requires activation of private sector and support of donor organizations. Modern technologies require major investments and knowledge. Kakheti region, as well as Georgia in general, suffers from the lack in both directions.

In the eastern part of Kakheti, the main danger for agricultural lands is created by Alazani River in the Georgian-Azerbaijani border section. During the last 15 years, the river has washed away more than 100 ha of pastures and such a loos increases every year due to intense precipitation. Another danger is spread of underground pests (especially, Caucasian Polyphyllafullo) in the soils of Kakheti, which damages the roots of newly planted grapes. Although in 2009-2012, the National Food Safety Agency of Georgia implemented intense measures against locust, the risk of migration from neighboring countries is still very high, since the climatic conditions have become very favorable for its propagation.

The risk of natural disasters in Georgia has increased significantly, which is caused by many factors, starting from the climate change to improper farming. This problem concerns Kakheti region as well. The losses resulted from natural disasters are growing every year. Droughts in spring and rains during harvesting are becoming frequent, hail is now possible in every season; intensity of high winds has also increased. The cycle of these climatic phenomena has drastically changed and has become a hazard for agriculture.

Hail badly damages perennial plants, particularly in the districts (Gurjaani, Telavi, Kvareli), where viticulture and horticulture is developed. To suppress the hail, at the present stage there is an option to rehabilitate anti-hail systems based on the already existing practice, or installation of protection nets in private farms. The latter requires quite big investments from the part of the private sector, which is directly linked to accessibility of financial resources for the farmers.

The damage made by hail and storms on 19th of July 2012 was unprecedented. The hail in Telavi and Gurjaani municipalities in July 2013 also inflicted serious damage to agriculture. Seasonal floods and droughts are also worth of mentioning. Presently, the whole region of Kakheti is facing the risk of natural disasters.

Hail together with drought is one of the main risk factors for agriculture in Kakheti. According to the data of many years, distribution of hail in Kakheti is shown in the Fig. 4.2.3.

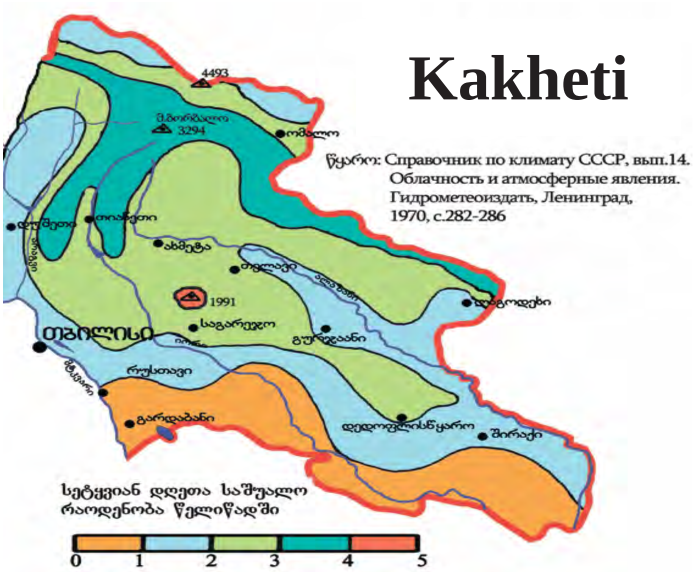


Fig. 4.2.3. Distribution of hail frequency in Kakheti (1970)

Probably, in this situation, the most effective solution would be the introduction of insurance system and this process has already started in Kakheti Region. However, much work will still need to be done in this direction. Against the background of the climate change and extreme climate phenomena, it is necessary to share the experience of western countries. These countries see the way out of the situation with reduction of the losses associated with climate risks in insurance of agricultural production. The World Bank has created a re-insurance organization for local insurance companies, which is based in Switzerland and it re-insures the agricultural insurance portfolios of the insurance companies operating locally. Balkan states are currently involved in this process. Insurance systems based on climatic index are quite popular in the USA. Such system operates according to the principle of insuring temperature and precipitation parameters.

Similar to other regions of Georgia, the influence of **climate change on soils** in Kakheti has the background of significant anthropogenic loading, which strengthens even more the adverse impact of these changes. The impact of climate change on agriculture is particularly noticeable in Dedoplistskaro, Sighnaghi, Sagarejo and Akhmeta municipalities and is mainly conditioned by strong spring winds (Dedoplistskaro, Sighnaghi), droughts (Sagarejo) and river high-waters (Akhmeta, Kvareli). Problem is also the salination of soil in Dedoplistskaro and Sighnaghi, which is not directly linked to climate change but is a direct result of drought. By now, based on rough assessment, total area destroyed, washed out or eroded in Kakheti is 27 000ha of agricultural land, which makes 5% of total agricultural lands. These are mainly pastures and arable areas.

Land degradation is a serious problem especially for two municipalities – Dedoplistskaro and Sighnaghi. Here we mainly face wind soil erosion and soil salination. The latter is often caused by excessive watering, since the above territories are quite dry and droughty. Taking into consideration these processes, main measures, without which these municipalities can no count on efficiency of agricultural production, are rehabilitation of windbreaks, introduction of modern irrigation systems (which are connected to soil humidity and automatically regulate water amount) and ensuring systematic agro-amelioration measures necessary for sodic soils.

In Kakheti, main climatic problems existing in production of **grain-crops** are associated with absence of windbreaks, which leads to wind soil erosion. Drought and low level of precipitation result in the reduction of grain yields and often cause reduction of planted areas.

The main problem for **vegetable crops** are still drought and hail. At the same time, it must be noted, that Lagodekhi district, where big amounts of early cucumbers are produced in protected fields, often suffers from floods and high waters, causing the damage to greenhouse plants.

The highest risk for **vineyards** is intensification of hail, which damages the crops for several years and root diseases, which easily adapt to increased drought and extremely hot days.

Horticulture, particularly stone fruit producing regions suffer mainly from hail. E.g., in 2012 hail and its accompanying storm destroyed not only the yield of that year, but also 50% of plants. With this regard, the risks related to perennial plant production are very high.

It must be noted that droughts and such factors as pasture erosion and reduction of fertility intensified due to the climate change impedes development of **cattle breeding** sector and often forces cattle owners to reduce the number of their animals. On the other hand, it is important to take into account that in the Soviet times certain part of herds of sheep, spent winter in Kizlar grazing lands in Dagestan. The population of mountainous part of Georgia used there approximately 60 000 ha of pastures. Since 1994, Georgia has stopped using these lands and almost 100% of sheep spends winters in Kakheti, mainly Dedoplistskaro and Sagarejo municipalities and Kvemo Kartli. Such overgrazing is one of the most important reasons for erosion of pastures, which is strengthened by current climate change, especially intensified droughts.

In the municipalities, where cattle breeding is a leading sector (**Akhmeta, Sagarejo, Dedoplistskaro, Sighnaghi)** the biggest problem is supplying quality forage for the cattle and coping with their diseases. These problems are directly linked to the climate and are strengthened or weakened as a result of changing climatic parameters. This particularly concerns cattle diseases, the risk of which is bigger for small farms and establishment of farmer cooperatives, which could jointly take care of the reduction of this risk, would be one of the most effective measures in the conditions of current climate change.

In terms of cattle feed and diseases, special attention should be paid to cattle (mainly sheep) herding tracks and the infrastructure, existing here. The infrastructure of the herding routes is totally underdeveloped, which facilitates damaging of pastures in the process of cattle migration and spreading of diseases. One of the main reasons for this infrastructure to be underdeveloped is the absence of relevant legislative basis.

It must be noted, that in the municipalities, where cattle breeding is a leading sector and the grazing land area is large, the tendencies of intensification of drought and increase of the number of hot days is particularly noticeable, which, against the background of overgrazing and improper maintenance, causes the degradation of the pastures and reduction of fertility. For these municipalities it is also very important to use for pastures technologies admissible for windy and droughty regions.

Lack of water

In Kakheti, ground water is mainly used for drinking. These ground waters are also very important for agriculture, as to certain extent they determine the amount of moisture in the soil. Last study of ground waters in the region was conducted in 2003 and it was renewed in 2014. According to local population, the aridization processes can be noticed in many places, especially at the territory of Dedoplistskaro municipality, which is quite scarce in terms of ground waters. It is necessary to conduct periodic monitoring of ground waters in Kakheti and assessment of risks, related to the changes.

In the process of assessing vulnerability of agriculture in Kakheti region to climate change, together with many other parameters, lack of water for different agricultural crops and the influence of such lack on the yield and obtained biomass was assessed.

Water deficiency assessment was conducted by two different methods of FAO (CropWat[61] and AcquaCrop[62]). Following crops were assessed by CropWat model:

[61] http://www.fao.org/nr/water/infores_databases_cropwat.html
[62] http://www.fao.org/nr/water/aquacrop.html

- Kvareli – tomato, melon
- Lagodekhi – water melon, cucumber
- Sagarejo – water melon

AcquaCrop model was used to assess wheat, maize and sunflower in different municipalities.

The values of the water lack were compared for the following periods: baseline period (1) – 1960-1985; baseline period (2) – 1986-2010 and forecast period – 2070-2099. The calculations showed that the biggest lack of water among the studied agricultural crops was recorded for watermelon in Sagarejo. The same crop in Lagodekhi requires almost 50% less water. In the second study period, despite the reduction of the evapo-transpiration, the need for irrigation of watermelons increases due to the decrease of precipitation level and intensification of drought.

As for tomato crop, according to the obtained results, among the three municipalities, tomatoes need most water in Kvareli. In the second period, the need of tomatoes for water in absolute values slightly decreases, but by the end of the century, it increases again by 33 mm/m^2 and by 2100 tomatoes will lack 39% of water requirement instead of 34%.

Requirement of grain crops for irrigation and the link of this process to the yield was assessed by AcquaCrop (FAO) method. According to the obtained results, the best moisture conditions and less requirement for water in the current period is in Lagodekhi and Kvareli and indeed, the yield is the best here. No big difference is observed between the first and the second periods, but in future requirement for water will increase in Telavi and it will become equal to Dedoplistskaro, where presently maize yield is very low due to lack of water as a result of destroyed irrigation systems.

Multi-criteria analysis

Similar to Ajara, by using the multi-criteria analysis method[63] the vulnerability of agriculture in Kakheti region to climate change was generally assessed within the framework of the project in all eight municipalities. In total, 27 parameters were assessed. In this case also,the climate change parameters were taken for two 25-year periods: 1961-1985 and 1986-2010. The results of observations of eight meteorological stations were used, the results of which more or less adequately reflect corresponding climatic zones. Agricultural lands of Sighnaghi municipality were characterized according to Tsnori meteorological station.

For assessment of the impact of climate in Kakheti region were used climate parameters different from those used in Ajara: in the given two periods, increase of the number of days when maximum daily temperature is 30°C (SU30), intensification of agricultural drought calculated with SPI index, i.e., when during three months, precipitation is much less than average norm of this one month (this is known as agricultural drought) and change of the aridity index.

In the process of selection of climatic parameters, representatives of the municipalities admitted that in Kakheti hail is the most serious hazard caused by climate, particularly for the municipalities, where leading sector of agriculture is viticulture. This is conditioned by the fact that strong hail damages not only the yield of the current year but also the grape plants, which for the next 2-3 years doesn't give harvest. Due to the fact that hail is a local phenomenon and it is not always registered by the nearest meteorological station, and presently it is also impossible to forecast it, hail was replaced by aridity index, which is a similarly serious problem for Kakheti region. The Fig. 4.2.4 shows the present vulnerability of municipalities (in the conditions of the current changes) of climate.

[63] http://www.rec-caucasus.org/projects.php?lang=en

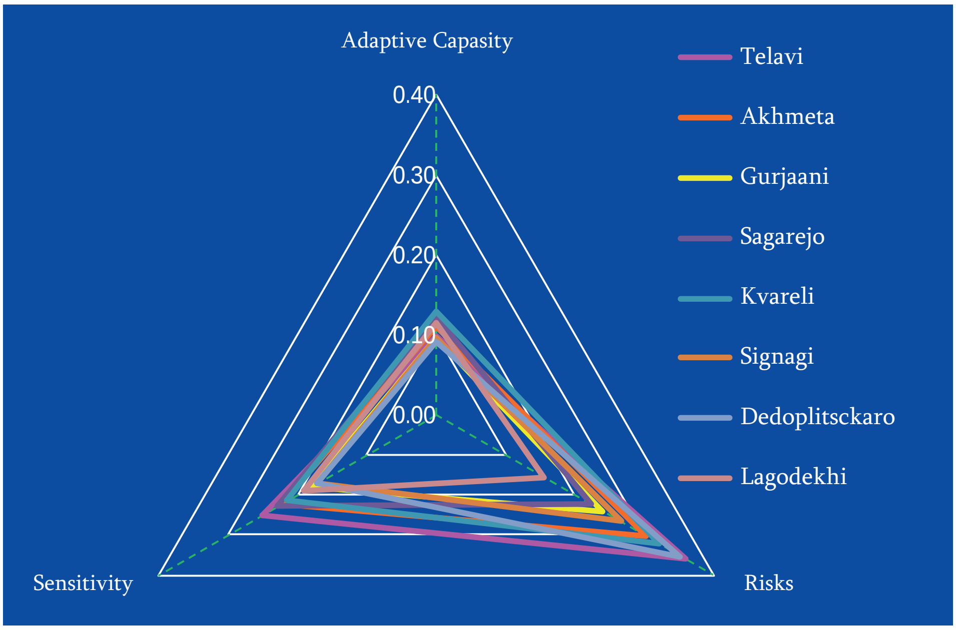


Fig. 4.2.4. Vulnerability of agriculture in Kakheti to climate change in 1961-2010

The assessment showed that the climate change (with the above three parameters) is presently most of all revealed in Telavi, Dedoplistskaro and Kvareli municipalities. They are least in Lagodekhi, Sagarejo and Gurjaani municipalities.

The most sensitive municipalities in terms of soil and biodiversity sensitivity are Telavi, Sagarejo and Akhmeta. And the least (equally)sensitive are Sighnaghi and Dedoplistskaro.

As far as the adaptation potential is concerned, Kvareli was assesses as one having the weakest adaptation potential and Lagodekhi and Akhmeta showed equal results. The strongest in terms of adaptation potential (i.e., where population is bigger and infrastructure is better developed) proved to be Dedoplistskaro, which is followed with equal points by Gurjaani, Telavi and Sighnaghi.

As a result of joint assessment of all these three parameters, it was revealed that the agricultural sector is most vulnerable to climate change in Telavi (0.71), then Kvareli (0.67) and Akhmeta (0.63). The least vulnerable in the current conditions is Lagodekhi agriculture.

The analysis conducted for individual municipalities of Kakheti to assess the hazard caused by climate change finally showed that out of extreme climatic phenomena, the biggest problems for Kakheti region are: drought, increase of temperature (increase of the number of extremely hot days), wind soil erosion and hail.

Expected impact of the climate change on agriculture in Kakheti

The same method was used to assess the types of changes expected in future (2071-2100) in the municipalities of Kakheti region in terms of vulnerability of agriculture. The results are shown in the figure 4.2.5.

Lagodekhi replaces Akhmeta and becomes one of the three most vulnerable municipalities (0.69). The main reason for the increase of vulnerability in Lagodekhi is progressive drying of the climate (aridity index). The least vulnerable municipalities are Dedoplistskaro and Sighnaghi. Generally speaking, the risks caused by the climate according to the discussed three parameters will significantly decrease in future over the entire territory of Kakheti apart from Lagodekhi, where this risk increases.

It must be noted here, that the discussed climate risks did not include the spring strong winds and hail, which presently involve significant danger for some of the municipalities. These two parameters – strong wind and hail – were not discussed here, because they can not be forecasted.

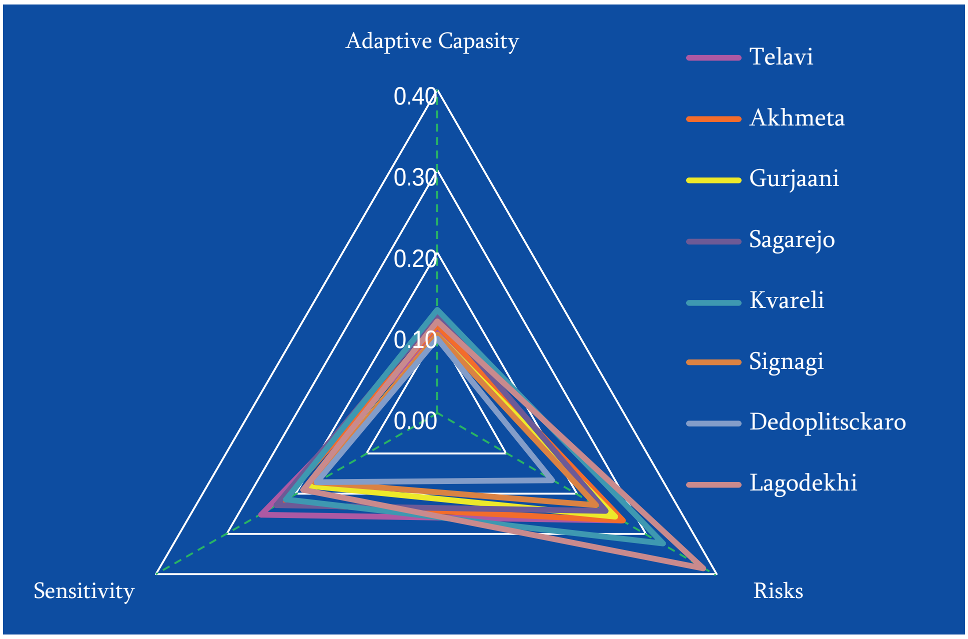


Fig. 4.2.5. Projected vulnerability of the agriculture in Kakheti to climate change in 2071-2100

Recommendations:

In 1960-2010 the analyses of development of agriculture and change of climate conditions in Kakheti region demonstrated that climate risk assessment, determination of vulnerability to expected climate changes and elaboration of respective adaptation measures are essential both in natural and in anthropogenic systems. Taking into consideration leading role of agriculture in economy of Kakheti region, it is essential to identify priorities and assess climate change risks associated with them.

Taking into consideration these results, in the process of preparation of Georgia's Third National Communication, the strategy of the measures for climate change adaptation of agriculture of Kakheti region has been developed, basically focused on the measures to be implemented for climate risk assessment and mitigation in agricultural sector of Kakheti region, which is fully provided in separately printed document "Climate Change and Agriculture in Kakheti region[64]". The strategy consists of three parts. First part outlines the actions essential for improving the region's adaptation, among them:

- In general, for the purpose of monitoring soil condition it is necessary to develop soil bank, besides types of soils providing information about their productivity and the results of monitoring of this productivity as well as monitoring of climate change impact. The soil bank by all means shall include information about agro climate zoning, which has not been conducted for long time and restoration of this tradition is essential for Kakheti, however modern methods and technologies of zoning should be used. Land resource data base should be available for whole Kakheti and its every municipality, taking into consideration agro-climatic zoning. At the first stage the focus should be made on zoning of vine species and cereals (wheat, corn), since at this stage they are leading crops for majority of the municipalities;
- For the assessment and determination of agricultural zones, it is essential to restore and develop the network of agro meteorological stations, which will be close to the area where crops are grown and which will improve preciseness of parameters against agro-climatic zones. To date, majority of exist-

[64] http://www.ge.undp.org/content/dam/georgia/docs/publications/GE_UNDP_ENV_Climate_Change_and_Agriculture_Kakheti.pdf

ing meteorological stations are located at such altitudes which do not provide real picture, especially in arid and draught areas, where aridity is being increased;

- Development of large farmers' associations/farmers' cooperatives shall be promoted;
- Provision of existing extension, service and information consultation centers with respective information basis;
- Permanent system for monitoring on protected areas shall be developed, in order to assess climate change impact on background environment;
- Local farmers shall be supported in selection and import of modern technologies.

Second part of the strategy provides the list of the actions, which shall significantly reduce impact of extreme climate events on agrarian sector:

- Facilitating rehabilitation of all kinds of windbreaks, first of all regulation of legislative framework;
- Rehabilitation of irrigation systems and development of new ones. Mistakes made in irrigation regimes, which accelerated soil erosion process in Dedoplistskaro and Sighnaghi districts shall be ultimately taken into consideration in the process of rehabilitation of irrigation systems or development of new ones and together with modern irrigation technologies, respective agro melioration works (gypsuming or other modern technology) shall be provided, which will protect soils from losing productivity. At the same time, the trends of increasing demand for water in each municipality and sufficiency of water supplies shall be assessed on the background of enhanced droughts and reduced precipitation. Provision of new reservoirs might become necessary in some municipalities;
- In parallel with irrigation systems, the measures against secondary swamping of soil shall be implemented in certain municipalities (Sighnaghi, Gurjaani). Especially in Sighnaghi district such marshy areas were quite large (4 000 ha), where draining systems were provided.
- Renewing hail suppression activities, using modern technologies;
- Provision of riverbank protection measures for reducing flood and flash flood risks.

Third part of the strategy provides activities, which should reduce sensitivity of agriculture as of sector against climate change:

- Cultivation of plantation tree coppices for the vegetative reclamation of abandoned and eroded lands;
- The municipalities (Dedoplistskaro, Sighnaghi) for which key direction is cereal farming, have problem of deficit/lack of high quality seeds. Development of seeds certification system and at the same time production of high quality weeds and disease-free and drought- resistant seeds locally, in accordance with market demand, is one of key recommendations in the process of climate change adaptation for cereal farming regions;
- The spreding of underground pests (especially Polyphylla Olivier) in Kakheti soils highly damages vine. To date vine saplings are produced mainly by population. Big farmers buy vine seedlings from population. In Kakheti, there is just one modern nursery, located in village Kondoli. Knowledge available in private sector shall be transferred to local population, the way not to reduce or infract compatibility of private sector. Promotion of production of disease resistant young plants is also important recommendation;
- Selection of optimal methods for preventing plant diseases and proposing to farmers;
- Selection of leading crops on the level of single municipalities and determination of irrigation needs and norms;

- Provision of melons and vegetable sector with warehouses and fridge facilities. Promotion of development of canning industry, proposing modern technologies;
- Development of the portfolio of activities for reducing risks for the development of animal husbandry in conditions of global warming (termination of degradation of pastures; high-quality food production; prevention of disease outbreaks);
- Elaboration of recommendations for using bee's capacity in climate change adaptation measures in beekeeping.

Long term strategy for the development of agriculture of Kakheti region (after 2025) shall be combined with development of agro tourism, taking into consideration resources of each municipality and global warming risks.

The recommendations of Kakheti region development strategy 2014 – 2021, approved by the government of Georgia in 2013, as well as the results of Second National Communication of Georgia and the materials of USAID project - "Institutionalization of Climate Change Adaptation and Mitigation in Georgian Regions" implemented by NALA[65] were ultimately taken into consideration in the process of preparation of the strategy. Besides, the recommendations of Regional Development Strategy of Kakheti 2009 – 2014 prepared jointly by Romanian Government and UNDP, as well as the results of all other surveys conducted in Georgia, were also taken into consideration.

The strategy is accompanied by 10 project proposals, implementation of which should pilot the measures recommended in the strategy and demonstrate their capacity.

While implementing these recommendations, the results[66] given in midterm publication "Agriculture of Kakheti and Climate Change" published within the frame of Georgia's Third National Communication on Climate Change, shall be taken into consideration.

4.3 General Overview of Disaster Dynamics in Georgia

Territory of Georgia is distinguished among highland areas in the world, with the extent of development of multispectral disasters (landslides, floods, flashfloods and water based erosion, snow and glacier avalanches and so on) recurrence frequency and negative impact to population and economy of the country.

Territory of Georgia is in 7-9 magnitude earthquake intensity risk area, impact of which is directly reflected on stimulation/provocation of landslide and flash flood events.

Major part of population of Georgia, lands, roads, oil and gas pipelines, hydro technical – melioration sites, energy transmission lines and mountain tourism sites periodically suffer with disasters, and area of this threat is being increased constantly. This is confirmed by disastrous processes recorded by geological office on territory of Georgia; increase of the areas damaged or under risk (Fig. 4.3.1). Besides, great part of populated and urbanized areas of Georgia are in ecologically dangerous zone (Fig. 4.3.2), where West Georgia is distinguished with active manifestation of disastrous processes.

[65] National Association of Local Administration of Georgia .http://www.nala.ge
[66] http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/climate-change-and-agriculture-in-kakheti/

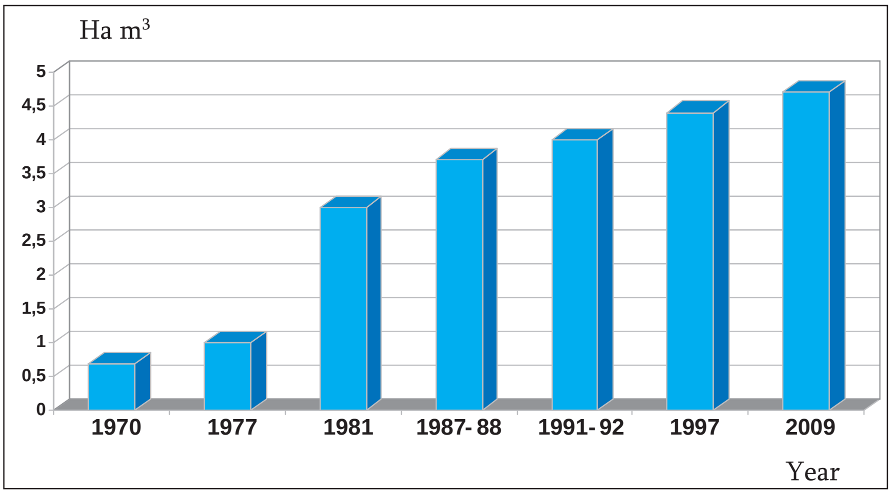


Fig. 4.3.1. Territory of Georgia damaged by disastrous geological processes in different yeas and placed in risk zone[67]

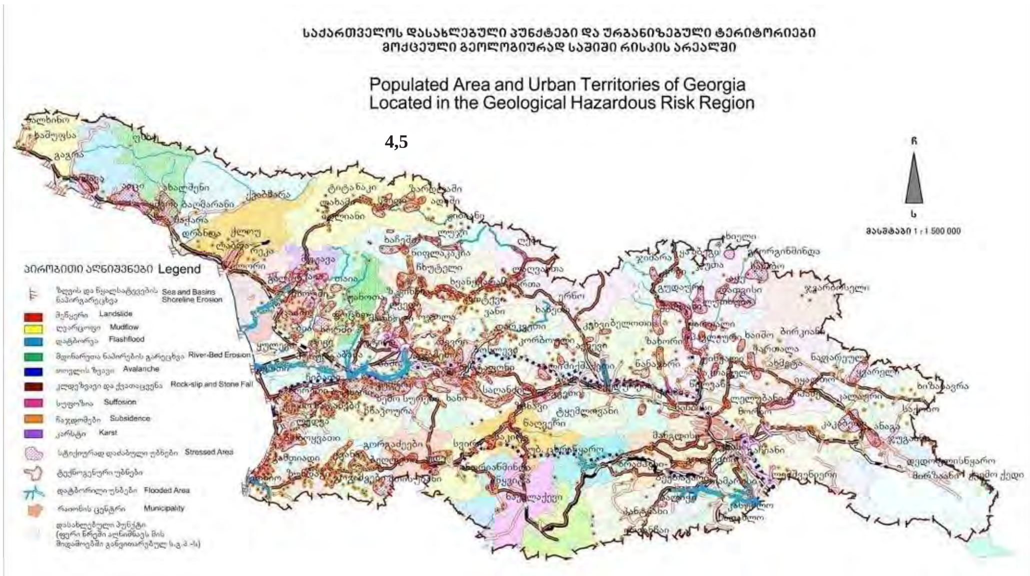


Fig. 4.3.2. Settled areas of Georgia and urbanized territories placed in geologically dangerous zone[67]

To date, almost 53 thousand landslide gravitation bodies and their possible development areas; about 3 000 flash flood transformable waterways, about 5 000 avalanche fall areas, washing river and sea banks on about 1 000 districts, with the total length of 1 500 km are recorded on the territory of Georgia (Fig. 4.3.3).

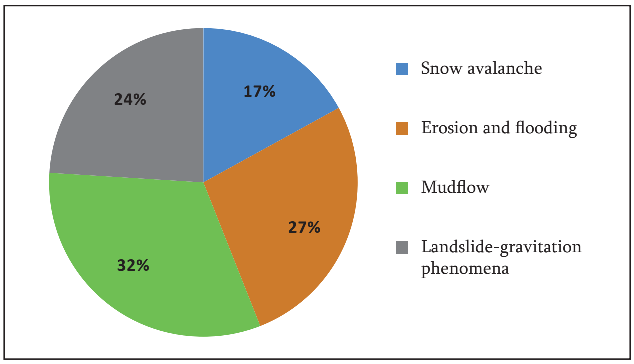


Fig. 4.3.3. Parts of whole territory of Georgia (%), which are under the risk of hydrologic geological desaters[67]

[67] Naitonal Environmental Agency (NEA) of the Minsitry of Environemnt and Natural Resources Protection

Almost 70% of the territory of the country is under the risk of geological disaster of different extent, which means 57% of settlements with 400 000 households.

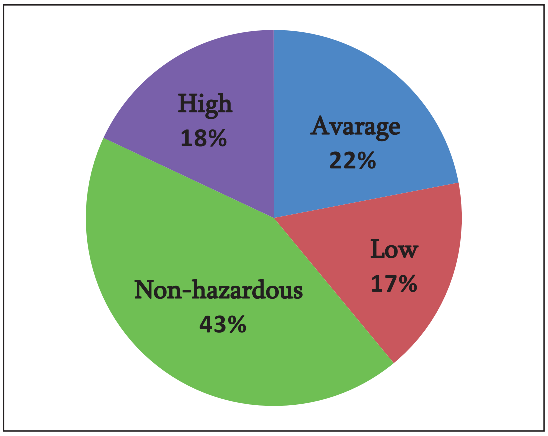


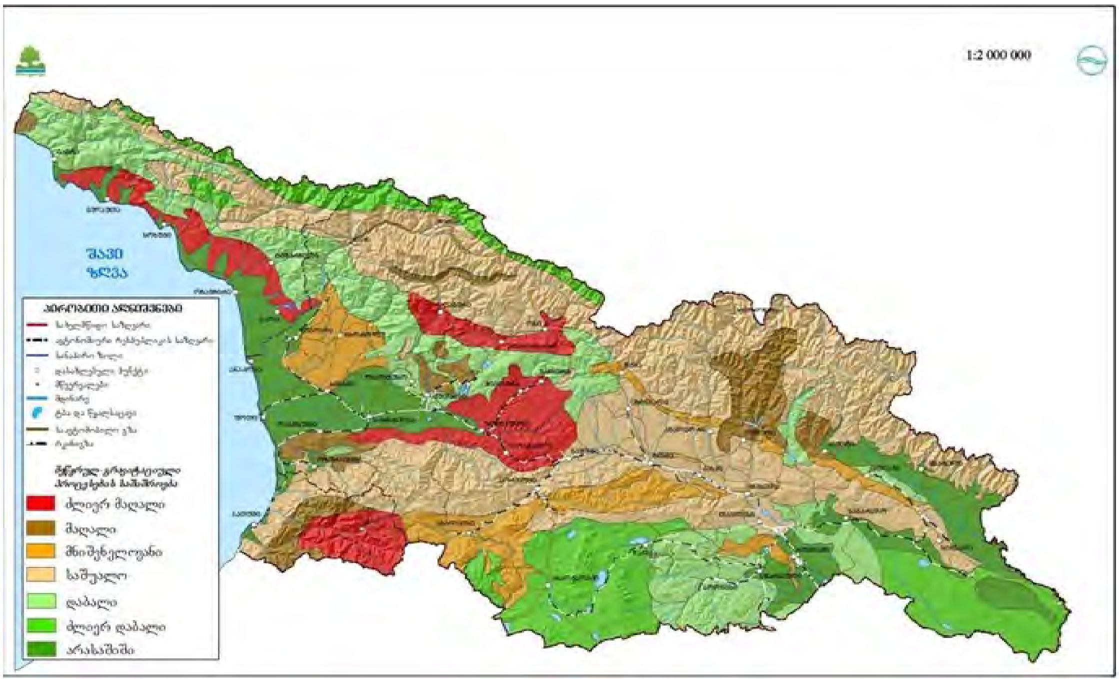
Fig. 4.3.4. Number of settlements under the risk of geological processes in Georgia[67]

Obtained data demonstrate that geological disasters cover all landscape geographic zones of Georgia, from seaside to highlands and the same applies to all economic sectors.

Geoecological extreme events preconditioned by natural disasters basically take place in mountain areas, which cover 71% of the territory of the country and where about 20% of population lives. Besides, potential of mountains in terms of political and economic development is indefinite.

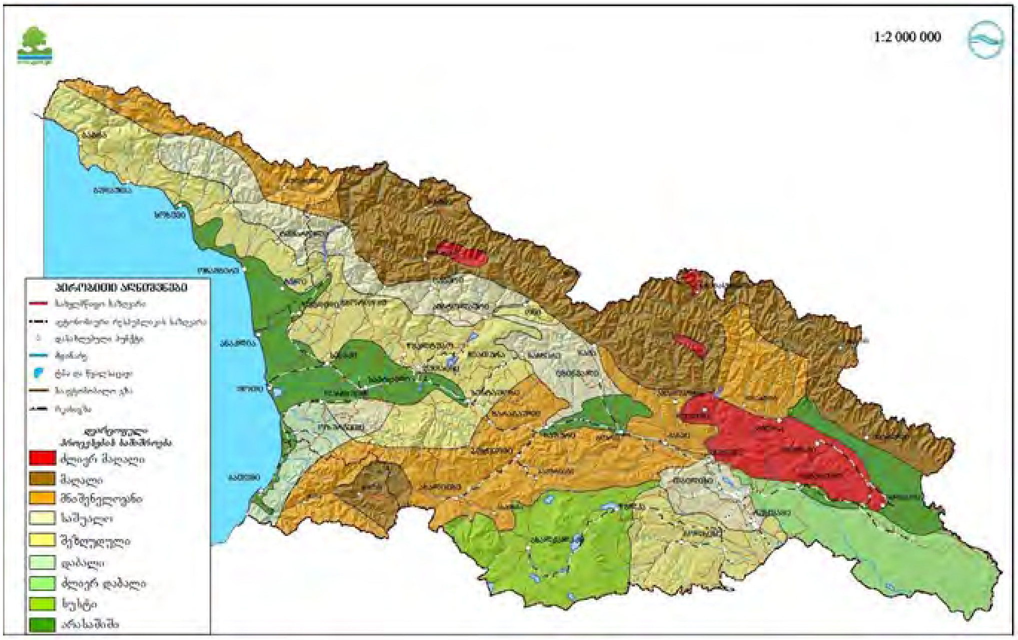
Two third of landslides recorded in the country happen in highland areas, while disasters like mudflows, snow avalanches, glacier falls and transformed glacier flows are fully characteristic for mountains.
More than 80 % of the victims, economic damage caused by disasters, and eco-migrants come from highland areas, which results in abandonment of villages.

In terms of multispectral geological processes risk the most dangerous are landslide gravitation and mudflow disasters (Fig. 4.3.5 and Fig. 4.3.6), also down washing of the banks of the sea and rivers in areas of settlements.



■ Very high ■ High ■ Important ■ Average ■ Low ■ Very low ■ Non-hazardous

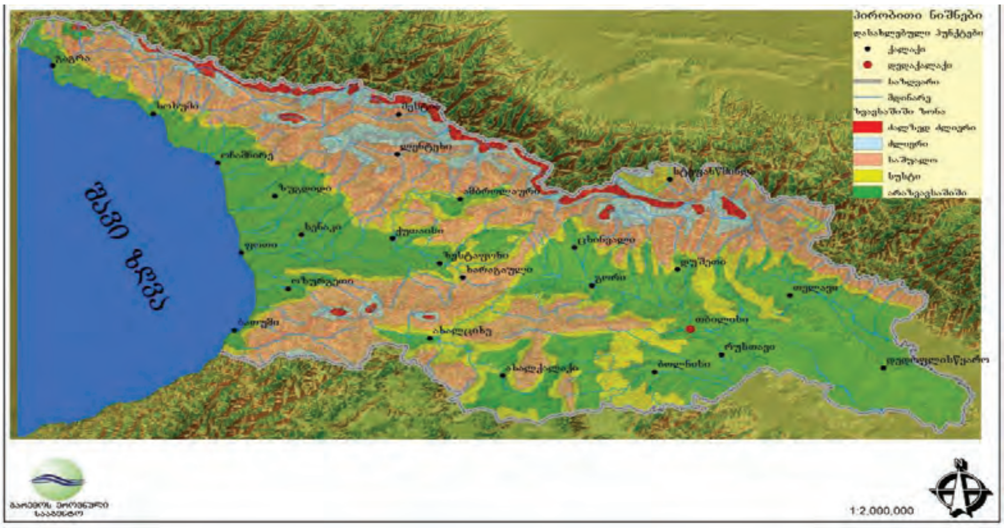
Fig. 4.3.5. Distribution of landslide hazard on the territory of Georgia (2014)[67]



■ Very high ■ High ■ Important ■ Average ■ Limited ■ Low ■ Very low ■ Non-hazardous

Fig. 4.3.6. Distribution of mudflow hazard on the territory of Georgia (2014)[67]

Snow avalanches create real danger to mountain regions of Georgia (Southern slopes of Caucasus Range, mountain regions of Ajara). The map of their distribution is presented on Fig. 4.3.7.



■ Very high ■ Strong ■ Average ■ Weak ■ Non-hazardous

Fig. 4.3.7. Distribution of avalanche hazards on the territory of Georgia[67]

Special surveys confirm that the processes of landslide gravitation, mudflow disasters and washing of river-banks are being increased with geometrical progression.

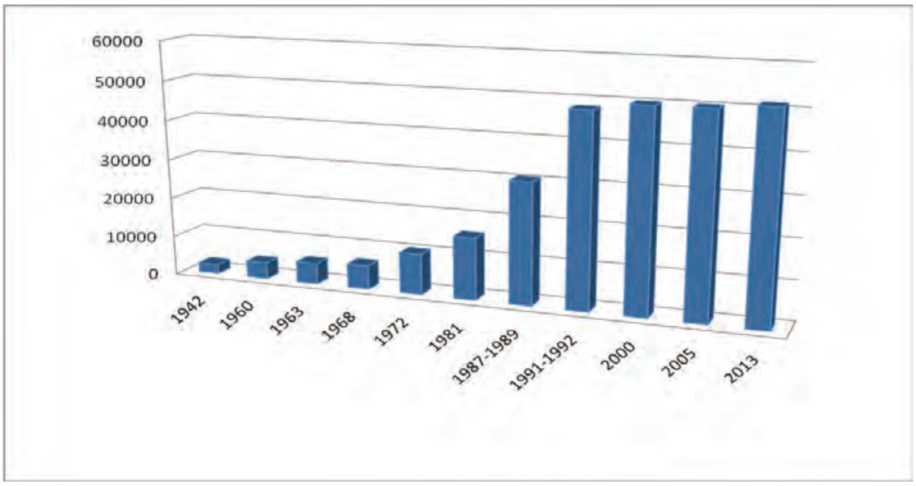


Fig. 4.3.8. Landslide -gravitation events mapped on the territory of Georgia in different years[67]

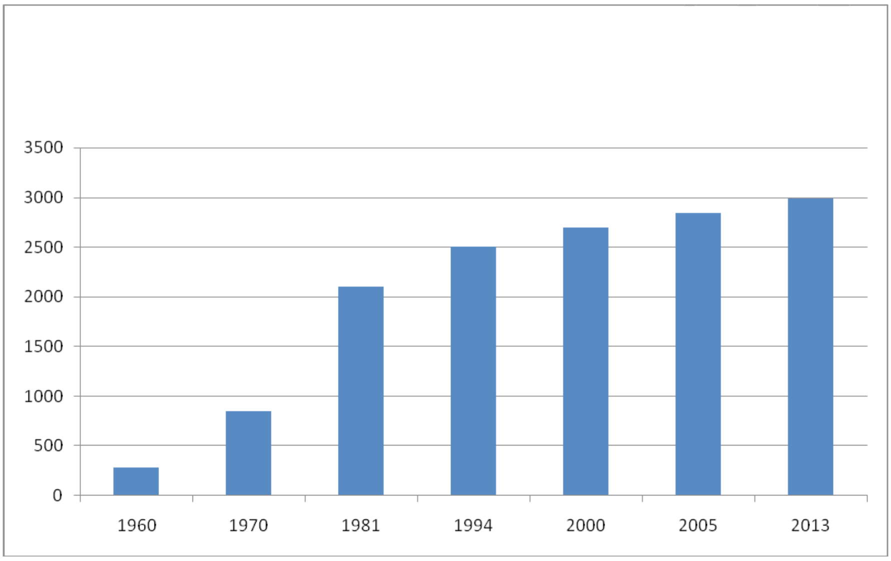


Fig. 4.3.9. Mudflow transforming river gorges mapped on the territory of Georgia in different years[67]

As demonstrated by provided data, the frequency of disasters in Georgia got dramatically increased since 1980s. The reasons for this are atmospheric processes (basically abundant rainfall) activated as a result of global warming, as well as increase of impact on anthropogenic loading. This issue is discussed in details on the example of three regions - Ajara, Upper Svaneti and Kakheti selected in the Third National Communication of Georgia.

4.3.1 Disastrous geological processes in highland areas (Ajara, Upper Svaneti)

Due to landscape diversity and complex geo morphological structure, also closeness to the sea, frequency and intensity of disasters, **Ajara** is one of the distinguished regions of Georgia. Prolonged abundant rainfalls, including heavy snow precondition floods/flashfloods, landslide and mudflow processes, snow avalanches as well as high recurrence of disasters. The processes of land erosion in the sea shore area and along the riverbanks should be added to this. During last decades activation of mentioned processes became obvious, which increases number of the victims and impacts economy of region and natural ecosystems. The reason for this is climate warming with its negative manifestations (frequent rainfalls), increase of tectonic activity and increase of anthropogenic load on natural environment.

Due to complex landscape and diverse climate conditions, exogenous process had been developing in Ajara historically, however recently natural increase of population (800% during last 100 years), extreme constraints on the lands and increasing anthropogenic pressure brought geological complications to critical threshold.

Out of anthropogenic load existing here, which at the background of frequent extreme climate events, especially is reflected on worsening of geo-ecological condition of environment, should be highlighted agricultural activities, cutting of geologically hazardous slopes, construction of heavy houses, construction of local roads, assimilation of floodplain and erosion washing points on the river banks, narrowing the river channels with constructions, blocking with construction waste and so on. Quite negative results have massive and unsystematic cutting of forests on steep slopes, construction of temporary roads for transporting wood, sliding of logs and development of artificial waterways, recent wiping out of tea plantations on large slopes, overgrazing of alpine fields, deterioration of meadows and so on. To date the coefficient of technogenic loading in highland Ajara is within 0.7-0.9, while taking into consideration sensitivity of its geological environment this value should not be more than 0.4-0.5.

Today, Ajara population is under the threat of landslide and mudflow processes, frequency and intensity of which is significantly increased during last 20 years. Whereas in 70s of the last century Ajara belonged to medium risk category, according to landslide and mudflow damages and threats (with coefficient - 0.3-0.5), by 2000 according to disastrous processes and damage this region moved to very high danger category (coefficient 0.5-0.9). The situation becomes even more complicated due to the fact that more than 80% of mudflow forming spots developed in the region is directly connected with periodical reactivation of landslide processes and their risk is greatly related to the extent of activation of these processes.

Snow avalanche is a disaster, which in winter creates significant threat to settlements of highland Ajara, because of abundant snowfalls.

Mestia district - in Upper Svaneti development of geological processes such as landslide, avalanche and rock fall, mudflow, water erosion and snow avalanche is preconditioned by the complex of factors – high energy of fragmented terrain and geodynamic potential, complicated tectonics and geological composition, dense hydrographic network, landscape – zonal heterogeneity, local climate meteorological conditions and anthropogenic pressure.

Small livable territory determines insufficiently safe location of settlements, in terms of geological hazards. Majority of settlements are located on terrace steps and output cones of the River Enguri and its tributaries.

In the context of the abovementioned circumstances, the connection between hazardous geological processes and demographic situation in the region is obvious. Eco-migration in Upper Svaneti, together with socio-economic conditions and natural increase is significant factor of demographic state of the region. Since 80s of the last century up to now, about 1 600 families left Mestia municipality due to disasters. Almost all settlements of the municipality are in zones of geological risk, of course to different extents.

Statistics of disastrous geological processes demonstrates the fact of intensification of the process in last decades. This condition could be explained just by global climate change, which is added by anthropogenic pressure on geological environment. The latter is reflected in activation of erosion and other geological processes due to unsystematic, excessive logging, using slopes for agricultural purposes, cutting slopes during road construction and large scale hydro energetic construction, the example of which is Enguri hydropower complex.

4.3.2 Climate Change Impact on Geological Processes Underway in Highland Areas of Georgia (Ajara, Upper Svaneti)

The disasters provocation in mountains is directly associated with deviation of meteorological elements, in particular of atmospheric precipitation, form climate norm. This contains the highest probability of risk for population and engineering facilities. In general, it is identified that in mountain regions of Georgia:

- In case of increase of annual precipitation by 100 mm compared to multiyear norm, geological events are within the frame of background activity;
- Redundancy of precipitation compared to average annual norm within 100 – 200 mm causes noticeable intensification of natural disasters;
- Intensification of extreme geological processes reaches peak in the event of increase of precipitation by 200 – 400 mm compared to annual norm;
- At the same time, it is determined that slowdown of geological processes in the region is related to the lack of precipitation compared to climate norm.

This pattern applies to both cold and warm periods of the year. After snowy winter, in spring melting of abnormally deep snow cover causes increase of water level higher compared to regular (regime) flood, which is followed by anomalous washing of the banks and other disasters. Besides, excess wetting of topsoil as a result of gradual melting of redundant snow, provides favorable conditions for intensification of landslide and mudflow processes. In case of abundant snow, avalanches also become frequent. As for the warm period of the year, this time high intensity rainfalls are frequent in mountainous Ajara, which in case of availability of adequate geological conditions in gorges of big inclination slopes are rapidly transformed into landslide and mudflow processes. The example of such development of events is intensification of landslide mudflow processes in the gorge of the river Ajaristskali in 2009, due to redundant precipitation of September, when total precipitation exceeded the norm by 200% on the whole territory (see Table 4.3.1).

Table 4.3.1. Deviation of total precipitation in Ajara from average norm of 1961-1990 in September 2009

Weather station	Kobuleti	Keda	Khulo
Total precipitations for month (mm)	563.8	227.6	207.0
Deviation from norm (%)	207.0	160.0	219.0

For this period, the biggest deviation in the last 50 years was recorded for Khulo district. It is to be mentioned that daily maxima were not increased in this period, however the number of days with precipitation, when daily total exceeded 100 mm, was grown.

In the last century development of landslide-mudflow processes were somehow cycled in Ajara, with peaks in every 5-6 years. Recently with the rise in the frequency of heavy precipitation and seismic processes, this cycle was broken and landslide – mudflow processes are every year revealed more often than admitted background. If similar to redundant precipitation data we divide the data on landslides and mudflows in to two groups of almost same duration – before 1987 and after, we will see that landslides are increased by 63%, and the cases of mudflow transformation are increased by 162%. This preconditions the fact that today more than 70% of Ajara population are under permanent risk of disasters[68] and that serious ecomigration is characteristic for this region.

More than 5 000 landslides and mudflows, the areas of erosion downwash and spots of avalanches were recorded in Georgia by 2010. 75% of 330 settlements are under periodic threat, which causes stress of local population and consequent increase of mental disorders. Thousands of hectares of arable lands are falling into disuse, hundreds of kilometers of roads and their communications are deformed and require rehabilitation, resettlement of eco-migrants became serious problem.

In case of Upper Svaneti, the observations demonstrated that intensification of processes recorded in 1986 -2010 was related to the increase of precipitation in the same period.

Average annual and seasonal values of temperature and atmospheric precipitation are provided below, for the years considered as abnormal in terms of disasters (1987,1988,1996-1998 and 2004), which is within the period 1986-2010 of increase of average annual precipitation by 97 mm (10%).

Table 4.3.2. Seasonal values of climate elements for the years of abnormal intensity of disastrous geological processes (Mestia, 1987)

1987 yr.					
	Winter	Spring	Summer	Autamn	Year
Average temperature (^{0}C)	-4.1	2.7	15.5	6.2	5.3
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sum of precipitation (mm)	461.9	225.2	504.0	187.0	1 378.0
1986-2010 Sum of average precipitation (mm)	241.8	277.6	270.8	271.1	1 058.0

[68] LEPL NEA under the Ministry of Environment and Natural Resources Protection

Daily distribution demonstrated 22 mm and more rainfall per day i.e. in total about 66 mm and then in one day (1987, July 6) 67 mm. After that 20 – 35 mm was recorded for several days, which caused the disasters developed in 1987-1988 (see Table 4.3.3). 1988 was also abnormal in terms of amount of precipitations.

Table 4.3.3. Seasonal values of climate elements for the years of abnormal intensity of disastrous geological processes (Mestia, 1988)

1988 yr.					
	Winter	**Spring**	**Summer**	**Autamn**	**Year**
Average temperature (^{0}C)	-4.8	5.2	15.4	5.9	5.4
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sum of precipitation (mm)	249.3	193.2	353.2	268.5	1 064.2
1986-2010 Sum of average precipitation (mm)	241.8	277.6	270.8	271.1	1 058.0

Similar to 1987, in 1988 abundant precipitation was observed, especially in summer. In both years average annual temperature compared to average multiyear was by 0.7 ^{0}C lower and in both years the temperature fell down in autumn. We should assume that in this case the impact of melting the glaciers on geological processes contrary to 2006, when average temperature was by 0.9 ^{0}C higher than average multiannual, was not recorded. The data on excess intensity of geological processes for other years in Mestia are provided in the Annex 4.6.

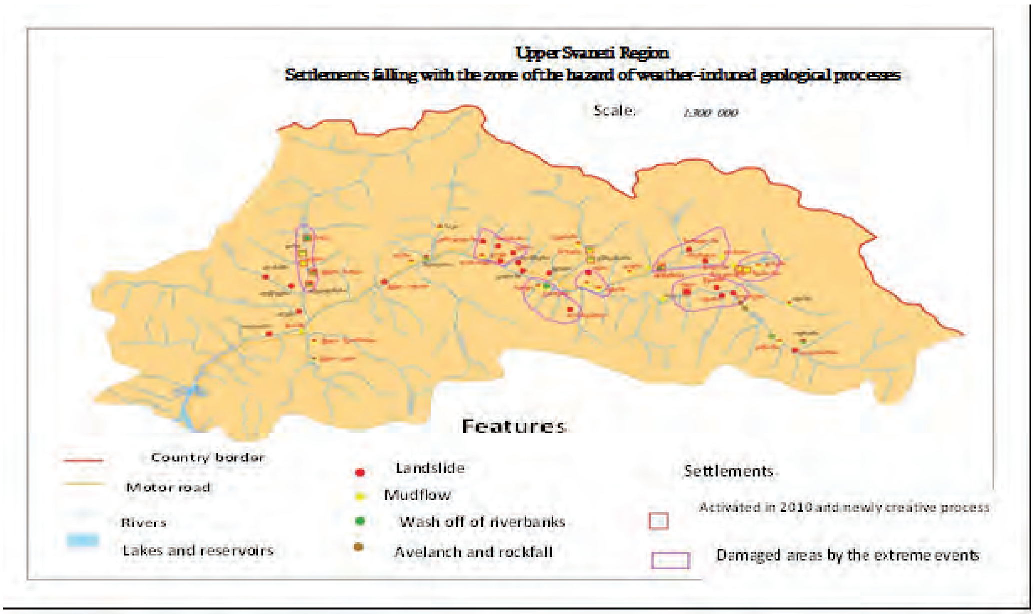
Despite the gaps in observations (monitoring was not provided in single years), statistics gives possibility for detecting the trends. In particular, cycles of intensity of dangerous geological processes are observed (1987; 1997-1998; 2004; 2011-2012), which does not contradict to determined general trend – the raise in the requency of dangerous geological processes – concerning intensification of abundant rainfalls. It should be mentioned especially that attack of the disaster in winter 1986-1987, on the background of which the situation of 1988 had rather the "aftershock" nature. Disaster triggered by abnormally abundant precipitation in fact fully covered southern skirts of the Caucasus Range. Unprecedented intensification of avalanches was recorded in January – April. According to incomplete data more than 300 avalanches were recorded in settlements and surrounding areas, as well as on the roads, as a result of which residential houses, tens of industrial buildings, roads and other elements of infrastructure. The disaster damaged historical buildings – Svanetian towers were damaged and destroyed in Ushguli and Mulakhi. The disaster did not pass without victims - 68 persons died. It could be said for sure that history does not remember such misfortune, which is one more argument for proving climate change as of happened fact. 350 families were evacuated from the peril zone in Mestia municipality in 1987 – 1988.

Abundant snow in winter of 1986-1987 pushed landslide process in spring – summer, which on their side contributed to provision of solid material for the formation of mudflows.

Debris flows in the gorge of River Nakra were developed on the right side of the gorge at the western bank. The upper reaches of the Nakra are located higher than hypsometric marks of 3000 m. Hence, it should be taken into consideration that melting of small glaciers also contribute to the formation of mudflows. The mudflows damaged roads, houses and industrial buildings in Nakra and Nenskra gorges.

Erosion wash down of the riverbanks and subsequent direct or indirect damage to roads are frequent in Mestia municipality. Mentioned geodynamic process took place in 1982, 1987-1988, 1997-1998 and 2004, as a result of which Zugdidi – Mestia – Ushguli motorway was damaged at 60, 63, 67, 105, 114,141, 145 and 149 kilometer sections.

The map of settlements under the risk of geological processes as for 2013 demonstrates the geography of occurrence of disasters in Upper Zemo Svaneti (Fig. 4.3.10). In the beginning of 2000s in Zemo Svaneti landslide damage coefficient was Km$_=$ 0.2, mudflow and erosion processes - 0.5-0.6. Given figures were revised in 2011 and it was determined that the coefficient of landslide damage became than mentioned and is within 0.25-0.30.



Information source – LEPL NEA

Fig. 4.3.10. Settlements within the zone of geological processes risk in Upper Svaneti (2013)

4.3.3 Impact of projected climate change on geological processes of highland regions (Ajara, Upper Svaneti)

As for projected change in frequency of avalanches in Ajara and duration of risk period due to climate change, based on the results of survey[69] conducted for different avalanche risk regions, in winter in case of reduction of air temperature by 2 ^{0}C and 20% increase of atmospheric precipitation, risks of avalanches can be increased up to 100%, while in case of increase of temperature by 2 ^{0}C and reduction of precipitation by 20%, avalanche risk indicators can become equal to zero, in almost all climate zones of Ajara, i.e. avalanche risk area might become non risk. However according to the forecasts of climate change for Ajara, the temperature will increase by 2 ^{0}C by 2050, but precipitation insufficiently but still is anticipated to increase in avalanche risk areas in winter, which means that the reduction of risk is not expected. While increase of average winter temperature is expected on Khulo and Goderdzi Ridge to 2010 by 3.3 and 3.0 ^{0}C-respectively, which will be followed by the increase of precipitation within 4-7%. Thus, we can assume that the risk of avalanche will be reduced by the end of the century.

As for landslides and mudflows, the increasing of intensity of which is directly related to abundant rainfall days and average annual or seasonal precipitation, based on existing forecasts these extreme geological processes will be more intensified, since in 2020 – 2050 increase in the number of abundant rainfall days(>90 mm) is projected in Keda municipality.

Concerning the second examined region, based on forecast data on annual total of precipitation and its seasonal distribution, it could be said that active dynamics of geological processes will be maintained in Upper Svaneti by 2050; And due to the impact of various meteorological and non-meteorological, including anthropogenic factors, the intensification of the processes is forecasted. Later on, the extent of manifestation of dangerous geological processes will be steadily high, unless timely measures are implemented.

[69] T.Basilashvili,M. Salukvadze, V.Tsomaia, G.Kherkheulidze. Disastrous floods, mudflows and avalanches in Georgia and their safety Georgian Technical University, Tbilisi 2012

Recommendations

Disaster risk reduction efforts in Georgia's studied highland regions in the first place should be aimed at:

- Development of proper monitoring network and early warning system and modification of existing one, using experience of advanced countries;
- Prevention and reduction of risk factors causing geological processes is essential;
- Development of rescue brigades for response to disasters is essential, including on municipal level and engagement of volunteers as of reserve force in the activities aimed at mitigation and liquidation of disaster;
- Georgia and its the most complex regions in terms of geological processes – Ajara and Upper Svaneti are so vulnerable to disasters that, training of school children for better preparation of population would be required;
- The process of management of geological processes is distributed in the republic between different agencies of executive government, which in conditions of weak coordination (which is unfortunately the case), makes difficult the elaboration of joint vision of disaster management. This preconditions the need for the improvement of coordination mechanism. The same issue is topical and requires improvement in relations between Ajara and Upper Svaneti municipalities and public agencies - Department of Emergency Situations of the Ministry of Internal Affairs and NEA of the Ministry of Environment and Natural Resources Protection.

4.3.4 Mudflows in Kakheti

Kakheti region, which includes over 17% of the territory of Georgia, due to its natural landscape conditions, holds leading position in the development of country's economy, especially in agriculture. As the same time, the region is the most complex part of Georgia and even Caucasus in terms of the extent of development of mudflows, recurrence frequency, economic damage and risks (Fig. 4.3.6). Debris flows have damaged or there is danger of damage of all geo-morphological units, except for plane terrain, out of that half of the territory is in category of very high and high risk (with coefficients 0.6-0.9).

Mountain area of Kakheti is almost fully unpopulated. Majority of population is concentrated in foothills of the Caucasus Range and the Tsiv-Gombori piedmont zones, most part of which are located in mudflow high-risk areas; among them are cities – Sagarejo, Telavi, Kvareli, Sighnaghi, Lagodekhi and Gurjaani. Mud torrents periodically damage motorways, amelioration – irrigation communications, rock and mud mass covers thousands of hectares of highly productive lands and vineyards. Besides, it is important that extreme manifestations of mudflows are always followed by floods, which normally are formed as a result of discharge of free water after blowing down the energy form mudflows full of solid material, and then in plain terrain starts washing down of river banks and flooding of large areas, as the well as damage and destruction of houses.

Photo. 4.3.1. High structure mudflow of the River Kabala

Photo. 4.3.2. The stone brought out by mudslide of River Duruji

According to historical data, in Kakheti, mudflow processes were widely developed in the past and caused serious problems to population. Majority of settlements are developed on cones of old mudflow processes (including the cities Telavi, Sagarejo, Kvareli), due to which these processes often brought casualties. Good example for this is River Duruji, mudflows developed in which (in 1899, 1906, 1947, 1949, 1963, 1967, 1975, 1978) killed almost 200 residents of Kvareli, and in June 1997 mud torrent formed in the River Telavi ravine on the Gombori Range caused 30 million USD damage to infrastructure.

To date in Kakheti region about 250 mudflow river basins are registered, which impose risk to population, its infrastructure and engendering sites. However, real number of waterways transforming mudflows is five times more.

In general it should be mentioned that the degree of intensification of mudflows formed on the Kakheti territory and risk of danger at the background of high sensitivity of geological environment fully depends on climate change conditions and marginal deviation values of intra annual and daily mudflow forming precipitation in time and space. With this regard, more than 50 mm daily precipitation is enough for forming mudflows in

Kakheti region, while on the Tsiv-Gombori Range it should be more than 30-40 mm. Besides, intensity of rainfall in particular period of time and values of their annual deviation are greatly important together with total of daily precipitation.

Based on expected climate change trend for 2020 – 2050, precipitation index shows that daily maximum amount of precipitation will be increased in future 30 years, as well as total of daily precipitation exceeding 90 mm. Number of the days when daily total of precipitation is more than 10, 20 and 25 mm will also be increased. Consequently, annual total of precipitations is also increased, even by more than 200 mm, which will contribute to landslide processes and increase the risk of mudflows transformation respectively. Thus, we should consider that in Kakheti region the risk of landslide – mudflow and erosion processes still remains.

Within the frame of different projects several recommendations were provided for protecting Telavi and Kvareli (river Duruji), majority of which was not technically admissible and only limited number of activities could be used against Kakheti mudflows, just in case of precise assessment of geology of particular site and effective engagement of population and local government.

Recommendations

- Aiming the reduction of risks caused by mudflows in Kakheti region, local government shall implement permanent monitoring of mudflow risk areas and provide the engagement of local population in implementation of preventive measures;
- Rising awareness of population and local government about their role in effective implementation of measures against mudflows is essential;
- Arranging river-bank dams according to the recommendation of geologists is important, providing that periodic cleaning of riverbeds could be considered as one of the most effective way protection from high structure rock and mud torrents in Kakheti. This could be done just by local population, upon having respective trainings.

Photo. 4.3.3. River dike protection on R. Duruji coast


Photo. 4.3.4. Dam arranged to protect the bank of the Duruji

4.4 Forestry sector

Forests Review

Among renewable natural resources of Georgia, forests have leading multifunctional value. Due to complex terrain and contrast climate conditions the forests of Georgia represent unique ecosystem. Forests cover about 2.77 million hectares of the land of Georgia that is 39%[70] of the country's territory. 97-98% of the forests in Georgia are of natural origin, their composition, constitution, conditions for growing - development and other features stipulate rich biodiversity – almost 800 types of trees and bushes grow in the forests of Georgia. Abundance of plants with endemic timber points to dendroflora diversity; in particular 61 local and 43 Caucasian endemic species are distributed in the forests of Georgia.

Forestation varies in different regions. The most forested regions are as follows: Ajara located in south–west of the country (63%) and Racha – in north–west (56%). About 98% of forests grow in mountains. Average supply is about 1.8 m^3 per ha, average annual increment about 160 m^3 per hectare. Main species in Georgian forests are: oriental beech (Fagus orientalis), oak (Quercus sp), Caucasian hornbeam (Carpinus caucasuca), alder (Alnus sp), birch (Betula sp), Caucasian fir (Abies nordmanniana), Oriental spruce (Picea orientalis), pine (Pinus sp). Their distribution is demonstrated in relative units on the Fig. 4.4.1.

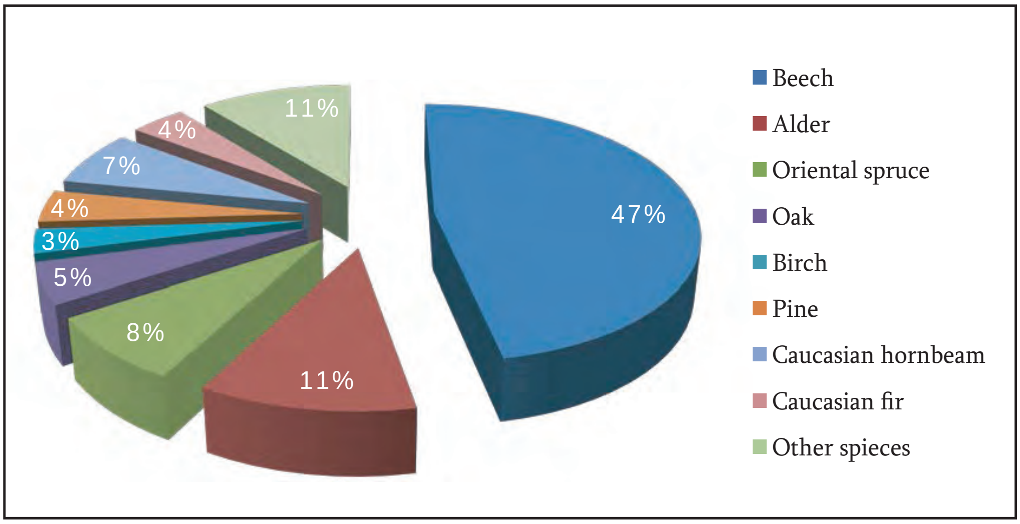


Fig. 4.4.1. Plants dominating on forested areas in Georgia

[70] Forest areas of Abkhazia and South Ossetia are included

More than 60% of forest plantations are distributed on the slopes, the inclination of which is more than 25 degrees. More than 24% of forests are growing on the slopes with more than 35 degrees of inclination. Their use is prohibited by the law. Just 14% of forests are deployed under 750 meters above sea level. However, more than 60% are on more than 1 000 meters above sea level (Figure 4.4.2).

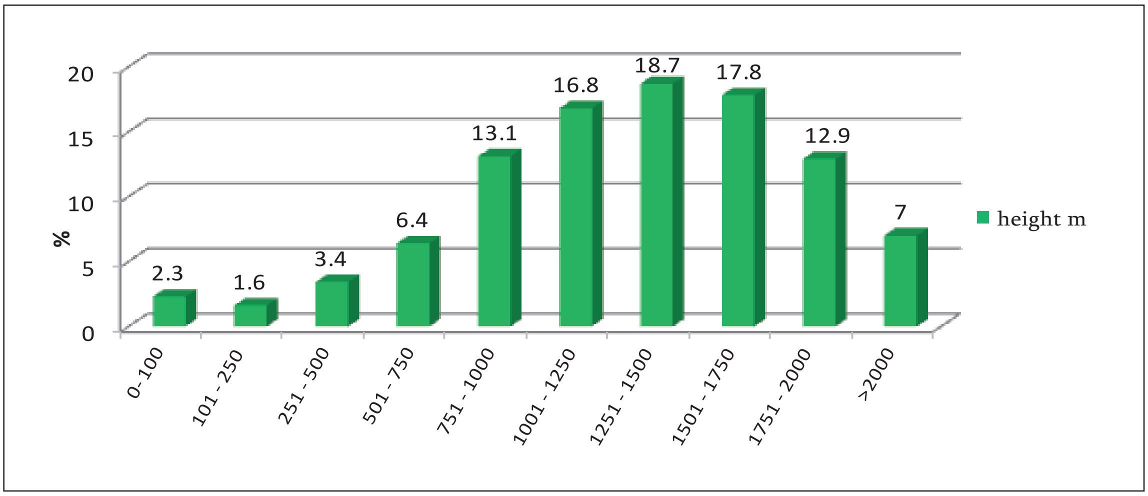


Fig. 4.4.2. Percentage distribution of forest areas by the height above sea level

Forest fund of Georgia is managed by LEPL National Forest Agency, LEPL the Agency for Protected Areas and LEPL Ajara Forest Agency. Forest areas of Abkhazia and Samachablo are not managed and controlled due to well known events.

Main function of the forests of Georgia is determined by soil protection, water protection, recreation and other features. Forest sector of Georgia is facing several challenges especially climate change, which is relatively new problem for Georgia's forest sector. The problem requires different management of ecosystem, which should be respectively reflected in the strategy for the development of forestry sector. Besides, it is necessary to reanalyze the problems of forest. Within the frame of Third National Communication, vulnerability of local forest ecosystems to climate change was analyzed in certain regions of Georgia, in parallel with the inventory of carbon absorption and accumulation in the forests of the country. Adaptation measures were identified based on above mentioned results and the project proposals were prepared. Changes in climate characteristics revealed by this time and future forecasts were analyzed in order to assess vulnerability of forest to climate change. Besides, the influence of climate change on timber species dominating in forest areas was analyzed, which could be either negative or positive.

Climate change impact on forest ecosystem can be direct, such as changes in growth of plants against the background of changes of precipitation and temperature, or indirect, such as increased frequency of fires or distribution of new species of pests and diseases.

Certain analysis was conducted to assess the impact of climate change on forest ecosystem, which demonstrated that the area of distribution of plants in all regions of the earth is basically determined by spatial and temporal distribution of **temperature and precipitation**[71]. Complex biological processes such as soil reproduction, assimilation, transpiration, species exchange, renewal, self cuts and other phenomena are the result of natural interrelations between these live organisms of forest and environmental factors.

It is determined that existence of forests in temperate zone requires temperature not less than 10 °C and relative humidity not less than 50%[72]. Humidity of air and soil is really important for existence of woody plants,

[71] V. Gulisashvili Forestry 1974. (in Georgian)
[72] V. Darakhvelidze, P. Metreveli, L. CHikhladze – Basics of Forestry 1965. (in Georgian)

which depends on amount of precipitation and evaporation. In temperate climate, majority of woody species start and finish vegetation above 10 °C. If temperature drops lower, vegetation is terminated. In case of optimal temperature (20 °C) growth of woody species is maximal. The growth becomes slower upon further increase of temperature and finally terminates fully at about 40 °C and more.

There are three temperature indicators for assimilation process: minimum -when assimilation starts, optimum – when assimilation reaches the highest level and maximum – when this process is terminated. In conditions of temperate climate majority of woody species start assimilation process at 5-6 °C(3). In this climate zone optimal temperature is 20-30 °C, and maximal +40 °C. Breath of woody species can continue below 0°. While optimal temperature for breath is high - 45-50 °C; breath stops on higher temperature (above 55 °C). Optimum of photosynthesis is 25 °C and of breath - 40-45 °C, thus in conditions of high temperature breath prevails photosynthesis and increase in single trees as well as in forest is much less, than in conditions of cool weather. As a result of strong breath and reduced photosynthesis some plants might even dry.

Besides above mentioned, temperature conditions determine the nature of distribution of woody species. In conditions of temperate zone, according to modern conception, the essential condition for existence of woody species is particular number of cold and hot days during the year. For example beech can exist where temperature is not less than 5 °C, during at least 210 days in vegetation period.

Vegetation period of beech and other prevailing deciduous (oak, hornbeam), starts and ends within 10°C. Beginning and end of vegetation period for mentioned species is given in the Table 4.4.1.

Table 4.4.1. Vegetation period for prevailing deciduous species in temperate zone[73]

Height above sea level, m	Vegetation period, 10 °C		Period (days)	Sum of temperatures above 10 °C
	Start	End		
Under 500l	8.IV	27.X	203	3 530
500-1 000	24.IV	15.X	175	2 465
1 000-1 700	18.VI	15.IX	90	964

Within the frame of Georgia's Third National Communication, vulnerability of forest systems to climate change was assessed for three regions of Georgia, in particular: in A/R Ajara, Mestia municipality (Upper Svaneti) and Borjomi municipality (forests of Borjomi and Bakuriani). The research in Borjomi and Bakuriani was conducted under the financial support of Austrian government. At the same time, several measures for adaptation to climate change were identified.

As mentioned above, spatial and temporal distribution of temperature and climate basically determines the area of plant dissemination in all regions of the earth. Consequently, these are two key factors of climate impact, which regulate vital processes for plants, such as: vegetation period, assimilation, breathing periods. Two types of disorders (abiotic and biotic) of forest ecosystem were discussed, which could be associated with changes in current regimes of temperature and precipitation. Abiotic disorders mean extreme events such as: fires, storms, floods, draughts; biotic disorders include changes in the frequency of activation of different pathogens and pests and geographic areas of their distribution.

The Table below provides main figures of the forests in selected three regions, which are key characteristics of forests.

[73] Kaludski K. K. Oak Forests of Caucasus and their management. Moscow 1972. (in Russian)

Table 4.4.2. Key characteristics of forest areas

Regons	Areas covered with forests, ha	Timber stock		Average annual increment		Average density	Average yield class
		m³/ha	Total, thousand m³	m³/ha	Total, thousand m³		
Ajara	192 488	266	51 202	2.70	519.7	0.56	II.3
Upper Svaneti	125 147	239	29 973	1.95	244.0	0.49	III
Borjomi-Bakuriani	42 407	212	8 977	2.30	97.5	0.50	III

In all three given regions more than 60% of forests are located on the slopes inclination of which is more than 25 degrees, which makes difficult accessibility of forests. 24% of forests are growing on slopes with the inclination of 35 degrees and their use is restricted by the law.

Table 4.4.2 demonstrates that administrative territory of Ajara which is distinguished by high humidity is featured by diversity of forests. Forests of Upper Svaneti are located in the basins of the River Enguri and its main tributaries and in contrary to the percentage of forests cover typical for mountain areas in West Georgia, here this percentage is not very high. Climate characteristics of this basin are closely related to orographic conditions. The determinant of main features of climate of this district is its location surrounded by mountain ridges from all sides.

Forests of Borjomi and Bakuriani are located in cenral part of Georgia and are spread on the slopes from 500-750 meters above the sea level to 2 500 – 2 800 meters. Mentioned location greatly influences natural climate features of these forests; in particular biodiversity of forest ecosystem is preconditioned by climate of two different neighboring regions: continental moderately dry of East Georgia and moderately humid of West Georgia.

The forests of all three regions are distinguished by diversity of woody species, here are subalpine, as well as Colchic mixed deciduous forests, basically represented by beech, chestnut, oak, fir and pine. The Table below provides the percentage distribution of prevailing plants in forests of all three regions.

Table 4.4.3. Distribution rate of prevailing woody species in the forests of Georgia (%)

Prevailing species	Ajara	Upper Svaneti	Borjomi - Bakuriani	Georgia
Fir	10.0	40.0	7.0	7.0
Spruce	13.0	7.0	32.0	4.0
Pine	1.0	8.0	17.0	3.0
Beech	42.0	23.0	32.0	47.0
Oak	3.0	4.0	2.0	11.0
Hornbeam	3.0	2.0	2.0	8.0
Chestnuts	14.0	1.0	0.8	3.0
Birch	0.5	10.0	4.0	0.4
Others	13.5	5.0	4.0	13.6
Total	100	100	100	100

The data given above demonstrate that beech covers the biggest area in the forests of Ajara, in Upper Svaneti – pine, in Borjomi and Bakuriani spruce and beech are dominating; beech is prevailing specie in ecosystem of whole Georgia.

As for distribution of forests be vertical zones, data of all three regions are given in Table 4.4.4, which demonstrates that unlike the Ajara region data distribution percentage is almost the same in Borjomi and Upper Svaneti.

Table 4.4.4. Forest areas distribution rates at different elevations above sea level (a.s.l.)

Elevation a.s.l. (m)	Ajara (%)	Vegetation Cover	Upper Svaneti (%)	Vegetation Cover	Borjomi (%)	Vegetation Cover	Georgia %
0-250	3	Humid Subtropical vegetation - Colchis Oak, Imeretian Oak, Colchis Holly and etc.	-	-	-	-	3.9
251-500	9		-		-		1.6
501-750	11	Colchis wide-deciduous species -Alder, Eller, Chestnut tree	8	Colchis wide-deciduous species forest – Chestnut. Lime tree and etc.	3	Georgia Oak Forests	3.4
751-1000	14		9		10		6.4
1001-1250	17	Beech forest	13	Beech forests	14	Beech forests	13.1
1251-1500	20		25		25		16.8
1501-2000	14	Spruce and Fir tree forest	28	Spruce and Fir tree forests	28	Spruce and Fir tree forests	39.2
2001>	12	Subalpine Species-Birch, Maountain Maple, Fir-tree and etc.	14	Subalpine forests- Birch, Maountain Maple	10	Subalpine forests - Birch, Pine-tree, Deka and etc.	15.6
	100		100		100		100

In all three regions the biggest share of forest is located within 1 000-2 000 meters above sea level and compiles 51-67 %.

Assessment of the vulnerability to climate change of forests in Ajara, Upper Svaneti and Borjomi – Bakuriani

Following indicators were selected to assess climate change impact on forests: abiotic disorders (fires, storms, floods, draughts), biotic disorders (changes in the frequency of activation of different pathogens and pests and geographic areas of their distribution), species substitution (change of species areas, disappearance, appearance of new species). Changes of mentioned indicators, except for anthropogenic impact are caused by climate changes such as temperature, precipitation, air humidity, increase of very hot days, and changes in vegetation period, increase of days with frost.

Analysis of the forest eco system of **Ajara** demonstrates that key influencing factors are increase of temperature and precipitation, which basically caused biotic disorder such as annual increase of the area of disease and pests distribution. Total area covered by disease in the region compiles 11 788 ha that is 6% of forest fund. In relatively low zone of the region, basically in chestnut forests of Kobuleti, Khelvachauri and Keda the most widespread disease is Chriphonectria parasitica, while higher in spruce and fir forests of Kobuleti, Shuakhevi and Khulo, entomologic indicators are distributed. In particular ips tipographus L, Dendroctonuc micans and Ips acuminatus Eichh are dominating in coniferous forests of this district. Mentioned pest diseases cause massive drying of trees.

The study of chestnut coppices of Kobuleti, Khelvachauri and Keda demonstrated that drying in chestnut is group focal as well as of scattered nature. More than 28% of total area of chestnut forests (18 897ha) i.e. 5 209 hectares are drying or dry already. This is forest of 209 725 m^3 and this area is been increasing annually. Kobuleti and Keda are the municipalities where the increase of temperature on the territory of Ajara was the highest, and reached 0.5 °C in the last century. The number of very hot days and tropical nights increased namely in these municipalities, as well as precipitation and number of days with abundant rainfall.

As mentioned above, diseased areas increased up to 5 209 ha by 2010, making 28% of total area. Together with the increase of temperature the diseases also move to highland chestnut forests (Shuakhevi, Khulo). Unfortunately no case of stepping back of diseases was recorded.

The studies demonstrated that relatively new diseases of chestnut moth (Cameraria ohridella Deschka), monotonous oak moth (Tischeria complanella Hb=Tischeria Ekebladellia Bjerkander) and box disease (Cylindrokladium buxicola) were recorded in Ajara forests with different intensity in 2006 – 2010, which at the background of climate warming might have disastrous impact on relict and endemic host species. In particular, above mentioned box-tree disease during last 2-3 years covered 55-65% of protected landscape of the river Kintrishi, and about 60% of boxwood population in Mtirala National Park.

Concerning problems caused by climate change in subalpine forests of Ajara it should be mentioned that during last 50 years upper border of the forest in Ajara moved down for some hundreds of meters (300-400 m). This is basically caused by washing down of soils under coppices in the upper reaches of catchment basins and development of erosion processes during heavy rains. However the share of anthropogenic factor is also significant (overgrazing, logging).

The forecast of climate change on Ajara territory showed that by the end of first half of this century the temperature could rise by +1.5 °C and to the end of the century the increase by +4.2 °C is expected. Besides the number of hot days and tropical nights is being increased dramatically that provides favorable conditions for intensification of pest diseases in Adara forests. As for precipitation, after small increase (1%) a 10% decrease is possible by the end of century. Based on which we can assume that risks of wild fires and diseases will increase in the forests of Ajara, while the process of disappearing of subalpine forests and moving down of their upper boarder will be reduced.

Climate of **Mestia** (Upper Svaneti) is moderately continental, with relatively warm climate and less annual precipitation, which is conditioned by its location in hollow area. In past the climate here was even more continental and dry, that is proved by remained groves of Eastern oak (Quercus macranthera), which in past occupied huge territories here[74].

Abiotic and biotic changes are not observed in forests of Upper Svaneti, substitution of species rather takes place. In past, when glaciers started to step back in southern parts of Upper Svaneti, boreal forest species (pine and birch) gradually occupied places released from glaciers. As a result of climate change pine and birch forests got reduced significantly, however these species are not yet fully substituted by other more shadow loving and respectively stronger defector[75] species (beech, spruce and fir)[76]. This was also greatly influenced by the types of soil, in this case basically composed of clay, which is the factor preconditioning soil dryness. According to generation born in 1900s, in 1898-1903 the Kakhuri Ridge was fully covered with birch forest. The photos taken in 1969 prove that by that time spruce was key element of forest cover. To date birch is quite rarely met here. The photos taken in 1969 also show that on the northern slope of this ridge upper zone of spruce and fir moves to alpine zone forest, while the photos taken in 2005 demonstrate that northern mountain slope is fully covered with spruce and fir.

As made out from existing photo materials and different sources, climate warming produced significant impacton the forests in southern part of Mestia climate zone. In particular, increased temperature at first place influenced the areas of distribution of birch, since this tree is of boreal forest type and is characterized by cold short vegetation period. Thus, the increased temperature and vegetation period stresses birch groves. It is to be highlighted that accompanying adverse developments such as increased incidence of fires, pests and diseases are not observed in forests of Upper Svaneti, though this is a case in other regions of Georgia.

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[74] Makhatadze L.B. Svanidze M.A., Pine-tree forests and distribution of forests vegetation cover in the river Engury basin, 1970
[75] Wood plants dominating in forest ecosystem
[76] Makhatadze L.B. Svanidze M.A., Pine-tree forests and distribution of forests vegetation cover in the river Engury basin, 1970

The analysis of interaction of climate parameters and forest ecosystem of Upper Svaneti demonstrated that in future key indicator of impact on forests will be the increase of average temperature and vegetation period, which in some places will have positive and in some negative impact. It is to be mentioned that in alpine zone conditions are favorable for birch, to get border higher. However hindering factors shall by all means be taken into consideration, such as non favorable soil conditions, grazing, in particular in sections of alpine zone where anthropogenic load is lower, the forest area will be increased and together with the increase of productivity in forests along alpine pastures, biomass supply will get increased.

Contrary to the Mestia zone, climate change signs are not clearly revealed in forests located in lower elevation – the **Khaishi** zone. Materials proving changes were not found in archives. At this stage possible extent of changes in climate parameters were analyzed for this forest ecosystem. In particular, we can conclude that according to data of weather station Khaishi, the trend of sustainable increase of temperature is observed here (warming basically takes place at an extent of summer and especially of autumn, when temperature growth reaches almost 1 °C). As a result of increase of temperature, conifers (spruce, fir) probably will have problems, since fir and mostly spruce are demanding cool microclimate. In particular increase of temperature does not give possibility to cones of conifers to mature fully and continued vegetation period hinders the timely timbering of annual growth, which increases the risk of freezing of annual growth in winter[77]. Consequently growth and development of conifers is hampered and capacity of groves is reduced. Increase of temperature will have negative impact on conifers, especially near lower zone of their distribution, where from starts area of their distribution. However conditions will be more favorable for deciduous compared to coniferous plants. At the same time, on upper boundaries of confers distribution more acceptable conditions will be developed for them and if soil conditions are also adequate, the upper zone of coniferous forests might move higher.

Abiotic and biotic disorders are clearly manifested in **Borjomi – Bakuriani** forest ecosystem; in particular increase of the incidence of fires is observed (in 2003 two incidences of forest fire were recorded, while from 2006-from 3 to 6 almost every year), and from biotic disorders systematic intensification of pest diseases was observed.

The problems developed in Borjomi-Bakuriani forests are intensified by climate changes started since 60s of last the century, which influenced the ecosystem. In particular, temperature in region got increased by 1^{0}C in summer; maximum speed of wind is also increased in summer (by +3 m/s). Annual regime of precipitation is also changed, in particular precipitation is altered at an extent of spring (5 mm, -3 %) and especially of summer (27 mm, -14 %). Almost all time scale draughts are increased. Number of hot days in summer is increased (+ 11 days per year); vegetation period of plants is also increased (+5 days, total of active temperatures by +206 °C). Despite of the reduction of total precipitation, number of days with abundant precipitation is increased that might intensify land erosion and facilitate the development of mudflows and landslides, in places where such danger did not exist (like this happened near the village Chumatelelti in 2011, Photo 4.4.1).

[77] John Grace,Frank Berninger and Laszlo Nagy, Impacts of Climate Change on the Tree Line, 2002.

Photo 4.4.1. On 18 June 2011 more than 100 mm of rainfall happened during 2 hours in Chumateleti. As a result 6 persons died and more than 100 households were flooded and destroyed by the mudflow. Mud torrent was not recorded on this territory before.

Revealed climate change started from 1960s, presumably facilitated the spread of European Spruce Beetle brought from Russia with logs with bark in 60-70s of last the century, which significantly damaged timber resources of Borjomi-Bakuriani forests. Later, in 1965-1980 for purpose of improving sanitary condition production – the cutting of damaged and dry wood was started, which made spruce groves significantly sparse. In particular, low density (0.3-0.4) forest areas were increased by about 15%. The surveys suggest that dry coniferous forests are natural reserves for pests[78].

In 2001-2005 the pest - engraver beetle was raging in the gorge, which is known as secondary pest and contrary to Dendroctonus micans dries tree unconditionally. This caused deterioration of significant part of spruce in Borjomi Gorge that caused destabilization of forest function and macro ecological conditions for its production. Consequently, forest pest deeply influenced Borjomi-Bakuriani forests, despite of implemented measures. Information provided here basically is based on materials collected in Borjomi-Bakuriani forest, in particular in Charkhistskali. On 3 400 hectares of forested area were registered dry 39 421 m^3, out of which 31 040 m^3 were damaged by fires, 5 289 m^3 – by pests and the rest 3 092 m^3 is not clarified. Based on these data it was concluded that besides the increase of risk of fire, the spots favorable for pests distribution were identified.

The issue of dynamics and forecasting of mass propagation of pests is key element of forestry monitoring, which represents topical problem in terms of maintenance of diversity of Borjomi-Bakuriani forests and proper implementation of pests combating measures.

Increased dynamics of fire-damaged and fired areas in Borjomi-Bakuriani forests area also should be highlighted (70% of which is caused by human factors and 30% by natural processes).

Analysis of current and expected scenarios of climate change are important for assessing vulnerability of forest ecosystem to climate change. The results of current and projected changes assessment in factors impacting forest ecosystems in all three regions are given in the Table below:

[78] Berozashvili T. Impact of ecological factors and forests types on intensification of bark beetles in pine-trees.

Table 4.4.5. Current and expected changes in factors of climate change impact on forests and vulnerability indicators

Current Changes	**Assessed Forests**		
	Ajara	**Upper Svaneti**	**Borjomi-Bakuriani**
Current changes (1961-2010 yr.)			
Atmospheric CO_2	Increase CO_2 consentration		
Average annual temperature	increase +0.5°C	increase Mestia: +0.3°C; Khaishi: +0.5°C;	increase +1°C
Sum of annual precipitation	increase. Qeda +16%; Khulo +11%.	increase Mestia: 97mm, +10%; Khaishi: 57mm, +22%;	insignificant increase 20 mm, -3%
Number of wet days	increase (≥50 mm) number of days: Qeda- 48 day; Khulo-17 day.	increase (≥50 mm) number of days: Khaishi-0.1; Decreae Mestia -0.2.	increase (≥50 mm) number of days 0.04.
Species substitution	are not observed	areas covered by poplar replaced by fir-trees and pine-trees	are not observed
Abiotic Disorders	are not observed	are not observed	increase in frequency of droughts and fires
Biotic Disorders	increase in harmful diseases	changes are not observed	increase in spreading of harmful diseases
Expected changes (2021-2050 and 2071-2100 yr.)			
Atmospheric CO_2	Increase CO_2 concentration		
Temperature	increase 2050 +1.5°C; 2100 +4.2°C;	increase 2050 +0.8 °C; 2100 +.04 °C	increase 2050 +3°C;
Precipitation	increase 2050 +1%; 2100 -10% decrease	increase 2050 +12-14%; 2100 -8% decrease.	increase 2050 +3%
Number of wet days	increase (≥50mm) 2050 Khulo +10 day	decrease, (≥50 mm) Mestia : 2050 -6 day 2100 -7 day increase, (≥50 mm) Khaishi: 2050+5 day 2100+7 day	increase, (≥50 mm) 2050 +5
Abiotic Disorders	high probability in increase of fires	increase, increase in droughts in 2071-2100	high probability in increase of fires
Biotic Disorders	high probability in increase of harmful diseases/ intervention of new diseases	no changes are expected	high probability of increase in harmful diseases/intervention of new diseases

The measures to be implemented in forestry sector, aiming the adaptation to climate change are given in Climate Change Strategy of Georgia, and detailed adaptation strategy for discussed regions is given in midterm documents[79] developed for these regions, in the process of preparing the TNC, published and provided to mentioned regions and municipalities.

[79] http://www.ge.undp.org/content/georgia/en/home/operations/projects/environment_and_energy/enabling-activities-for-the-preparation-of-georgias-third-nation.html;

Key recommendations for the forests of Ajara and Upper Svaneti are given below:

- Action plan for sustainable development of forestry sector shall be prepared;
- Soil protection measures shall be strengthened for the restoration of degraded forests;
- It is necessary to implement monitoring of diseases (especially caused by climate change) and to cooperate closely with forestry sectors of neighboring regions and countries, for preventing risk of dissemination of mentioned diseases;
- Potential of forests as of CO_2 sink shall be increased, which means reduction of its age and increase of quality (density) up to high quality forest level;
- It is necessary to study alternative ways for forest privatization (community forests, tourism sector forests and so on) and assessment of their risks for ensuring sustainable management in conditions of climate change.

4.5 Vulnerability of Healthcare sector in regions of Georgia and Tbilisi

Within the frame of TNC vulnerability of healthcare sector was assessed in three regions of Georgia, where the climate change is clearly expressed. These regions are Ajara, Upper Svaneti, and Kakheti. At the same time the impact of "heat waves" on urban environment – Tbilisi, was assessed within the frame of Red Cross project – "Climate Change – East", which was included in this final report.

The assessments were made taking into consideration the recommendations of WHO. In particular, WHO has provided the list of diseases, associated with climate change either directly or indirectly. Climate based diseases include: traumas, infectious diseases, cardiovascular and respiratory diseases, pathologies caused by the extremely high temperature and so on.

Climate-related diseases are not homogenously distributed by the regions of Georgia; this depends of the type of climate change manifestation.

Dissemination of climate-related diseases by the regions

In Ajara the most widespread climate based diseases are diarrhea and infectious diseases in general, mental disorders, traumas and cardiovascular diseases. However among mentioned diseases the most topical for Ajara are diarrhea pathologies, since the indicator of their incidence[80] significantly (4-5times) exceed the indicators of other regions of Georgia[81] (Table 4.5.1).

Table 4.5.1. The incidence of diarrheal diseases - Ajara 2009-2010

Year	Incidences in Ajara (adults)	Incidences in Georgia (adults)	Ratio Ajara-Georgia	Incidences in children (Ajara)	Incidence in children (Georgia)	Ratio Ajara-Georgia
2009	925	225	4.1	3 638	873	4.2
2010	14 768	2 626	5.6	9 368	1 743	5.4

Besides, on the territory of Ajara recently infectious pathologies, such as leptospirosis and borreliosis are observed, which presumably is related to the development of friendly climate conditions for these diseases[82].

[80] Incidence - primary morbidity;
[81] Health protection. The National Center for Disease Control and Public Health. 2010
[82] The Center for Disease Control and Public Health of Ajara, 2012

In Ajara the most frequent out of climate-related diseases is mental disorder. According to 2009 – 2010 data, the incidence among adults is by 13% higher than the rest of Georgia, however in children category this figure increased up to 58%. Such high indicator of mental disorder could be explained basically by the fact that in Ajara natural disasters are much frequent (landslides, mudflows, flash floods) compared to other regions of Georgia, which is the reason of chronic and acute stresses and consequently is reflected in the status of population. This trend is maintained for traumas, which are revealed in high figures as well.

Although **Upper Svaneti** similar to Ajara is highland region and is also inclined to disasters, different climate based diseases are distributed here, out of them the most topical are traumas and cardiovascular diseases (especially arterial hypertension), respiratory diseases and mortality caused by them. Incidences[83] and prevalence[84] of mentioned pathologies in Upper Svaneti are higher than in other regions of Georgia.

Based on 2009, 2010 and 2011[85] statistical data of, frequency of traumas in Upper Svaneti Region is significantly higher than in whole Samegrelo Upper Svaneti and other regions in terms of incidence as well as of prevalence (per 100 000 persons) (Fig. 4.5.1).

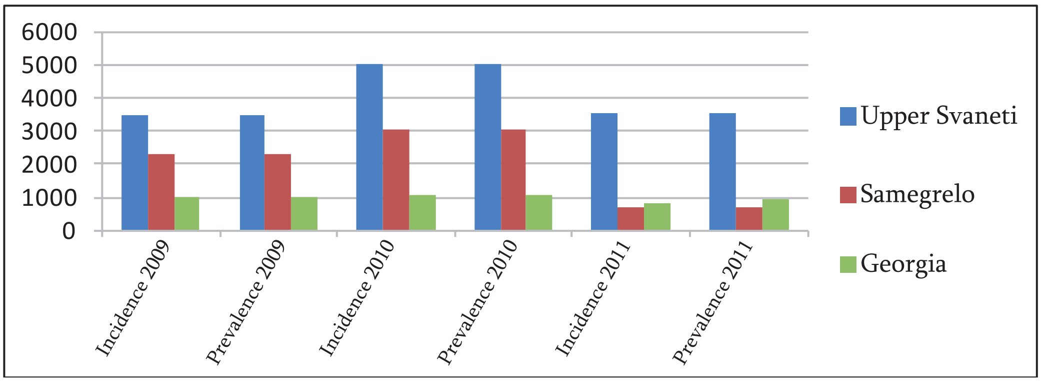


Fig. 4.5.1. The incidence and prevalence of traumas in Samegrelo -Upper Svaneti, (evaluated per 100 000 inhabitants)

According to local specialists[86], high rate of accidents is associated with complex terrain of the region, low awareness of the representatives of tourism sector concerning the risks, which could be associated with traumatism, insufficient state control of tourism activities such as alpinism and hiking.

High rate of traumas might also be preconditioned by disasters (landslide, mudflow, snow avalanches), to which Upper Svaneti region is really inclined. Besides, the reason could be not taking into consideration periods of melting snow on mountains, which develops inadequate and risky conditions for alpinism.

After traumas the highest Upper Svaneti are cardio vascular diseases in, frequency of which in this region is higher than in other part of Georgia. The most widespread cardiovascular disease in Upper Svaneti is arterial hypertension, the trend of which is increasing annually (Fig. 4.5.2).

According to local specialists[87], high rate of cardio vascular diseases, in particular of arterial hypertension, might be associated with unhealthy lifestyle as well as with location – high above the sea level. The latter is characterized with lack of oxygen, which hinders the adequate operation of cardiovascular system.

[83] Incidence - the primary morbidity, first identified disease in life. Calculated 100 000 per capita;
[84] Prevalence - the total morbidity, all cases registered during the year. Calculated 100 000 per capita;
[85] The National Center for Disease Control and Public Health. National Statistics Office, 2012
[86] Local medical staff survey results
[87] Local medical staff survey results.

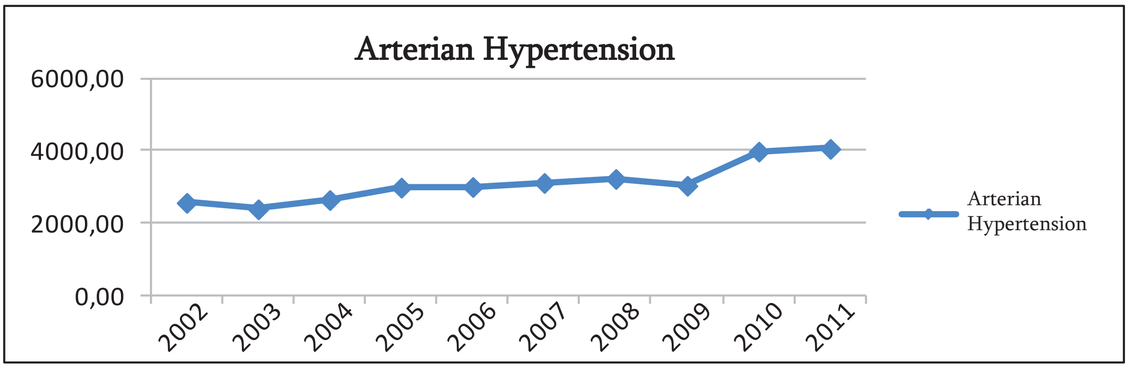


Fig. 4.5.2. Dynamics of the prevalence of arterial hypertension in Upper Svaneti, 2002-2011

Cardiovascular system, as well as respiratory system (diseases of the latter are not frequent, however the trend is increasing) is quite sensitive to climate change. According to WHO data[88], alteration of air temperature and composition as a result of climate change has a negative impact on the functioning of cardiovascular and respiratory systems: composition of ozone and solid particles in the atmosphere has been increasing following to the increase of air temperature, which has negative impact on the functioning of cardiovascular and respiratory systems, exchange of air in lungs is also complicated and that could be considered as a mechanism for originations of different pathologies[89]. Increase of concentration of solid suspended particles significantly increases hospital referral and mortality rate due to cardio vascular diseases[90].

Based on international data[91] climate produces direct and indirect impact on the functioning of cardiovascular system. According to the data of National Institute of Environmental Health Science and CDC number of ambulatory and hospital referrals increases during extremely cold and hot weather. According to the data of WHO, there are direct relations between high and low temperature and beating of the heart and blood pressure. Besides, strong heat causes exacerbation of pathologic processes among people chronically ill with cardio vascular diseases. According to IPCC Third Assessment Report, (2001) frequency and mortality rate of cardio vascular diseases significantly depend on intensity and duration of heat waves.

The same could be the explanation for high rate of cardio vascular diseases in **Kakheti**, where the rate of cardiovascular diseases is the highest compared to other regions of Georgia (after Tbilisi).

Kakheti is among three top regions having the highest rate of dissemination of cardio vascular diseases according to 2010-2011 data[92], (prevalence evaluated per 100 000 inhabitants)–basically due to arterial hypertension. As for lethality caused by cardiovascular diseases, in Kakheti region this indicator is much higher than in Tbilisi: Kakheti - 11.3, Tbilisi - 5.2.

Besides, high rate of cardio vascular diseases in Kakheti, prevalence trend is also being increasing here (Fig. 4.5.3).

[88] http://www.who.int/globalchange/en/
[89] Gong H, et al., American Journal of Respiratory and Critical Care Medicine; 1998. p. 920-927.
[90] Pope, cA, et al. Journal of the Air and Waste Management Association, 2006, p. 709-742.
[91] A Human Health Perspective on Climate Change; A Report Outlining the Research Needs on the Human Health Effects of Climate Change; April 22, 2010; www. niehs.nih.gov/climatereport
[92] Health care, Statistical Yearbook, 2010 and 2011.

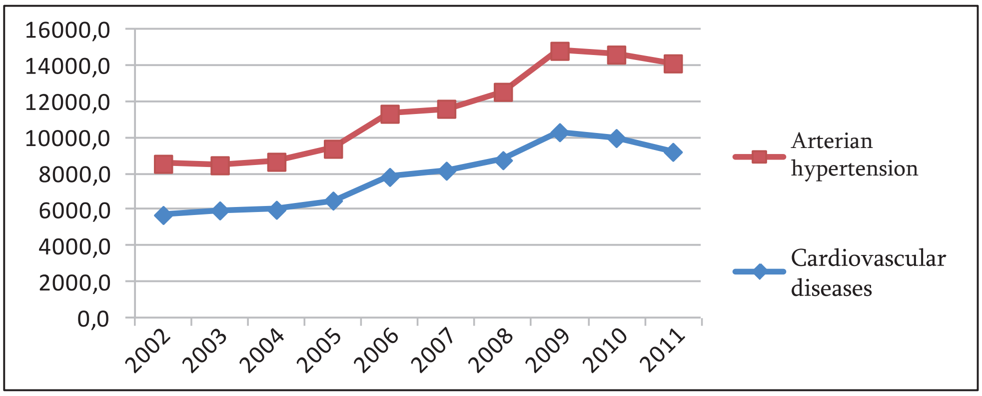


Fig. 4.5.3. Cardiovascular diseases and arterial hypertension trends in Kakheti 2002-2011

Current change of climate, in particular increase of air temperature, intensification of heat waves and reduction of precipitation facilitate the maintenance of increasing trend of cardiovascular diseases in Kakheti.

It is to be mentioned that climate-related disease such as malaria, which for years was a challenge for Kakheti, recently is controlled strictly by public healthcare and no cases of these pathology are recorded.

As we have already mentioned, according to the distribution of cardiovascular diseases Tbilisi holds a leading position among the regions of Georgia (Table 4.5.2). According to 2011 medical statistics, prevalence of cardio vascular diseases in Tbilisi is the highest in Georgia. According to in patient service of patients with cardiovascular diseases Tbilisi has first position.

Table 4.5.2. Distribution of cardiovascular diseases by regions, 2011

Region	Incidence	Prevalence
Tbilisi	2 422.1	13 577
Kakheti	1 976	7 380
Imereti	2 949	7 216

Within the frame of Red Cross Georgia project – "Climate Forum–East" a survey was conducted, which studied impact of heat waves on Tbilisi population. At first stage the frequency of cardiovascular diseases was studied by years and months (according to data of inpatient and outpatient facilities of Tbilisi 2003-2012[93]).

As demonstrated by data analysis, it is difficult to identify relation between cardio vascular diseases and high temperature on monthly basis, since high number of cardiovascular diseases is not revealed in hot season, when heat waves are observed.

It is possible to identify closer connection between extremely hot days and number of cases of hospital referral or emergency services due to cardio vascular diseases, by means of monthly comparison[94]. However such statistical survey was not conducted within the current project, since it is too labor consuming and requires much time and resources, thus is not considered as reasonable when frequency of cardio vascular diseases and number of extremely hot days are increased anyway.

Connection of diseases dissemination with climate change

Aiming to identify connection between climate change and climate-related diseases, correlation of the statis-

[93] Medical Statistics Department of the National Center for Disease Control and Public Health
[94] The Impact of Recent Heat Waves on Human Health in California; Rupa Basu, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Oakland, California, 5 August 2013

tics of important diseases with climate parameters was studied, as well as changes of heat waves and tourism comfort index. In some cases the potential of healthcare sector with current changes was studied for more precise assessment of vulnerability of the sector.

In order to identify connection of diarrheas with climate change on the territory of **Ajara** during last 20 years, average figures of diarrheas were calculated per 100 000 persons for 1990 – 2010 (Table 4.5.3).

Table 4.5.3. Correlation between diarrhea and average annual temperature in Ajara, 1990-2010

Year	Average annual temperature (^{0}C)	Increase (^{0}C)	Average number of Diarrhea	Increase (%)
1990-1999	11.4		81	
2000-2010	11.8	0.4	252	211

As demonstrated by this Table, in these two decades number of cases of diarrheal diseases increased significantly together with increase of temperature and number of abnormally hot days. If in these two decades annual average temperature got increased in 0.4 ^{0}C, and abnormally hot days –by 11 and 19, which was followed by the increase of diarrheal diseases by 211%, we could assume that increasing trend of diarrheal diseases will be maintained in future, since the forecast of minimum increase of annual average temperature is 2 ^{0}C up to 2050, while the number of hot days and nights is anticipated to be increased by 33 and 39 per year respectively.

While examining correlation by months in Kobuleti, Keda and Khulo municipalities, quite close connection is revealed between diarrheal diseases and average monthly temperature. Correlation coefficient by months at all four studied territories is changed within 0.6-0.9 and on the average compiles 0.74. Correlation defined by months is especially close on holiday season (June – September), when the most cases of diarrheal diseases are recorded.

Correlation between mental disorders and extreme events is also quite high. In particular, correlation coefficient with landslides is 0.60, and with mudflows - 0.65. Given to that, stress caused by natural disasters could be considered as one of the reasons of mental disorders.

Trauma diseases also reveal significantly high correlation with landslides and mudflows - 0.70 and 0.85 respectively. This indicates that landslides and mudflows increase risk of traumas, health complications and in some cases lethal outcomes.

In purpose to assess climate change impact on the recurrence of heat waves, based on weather stations of Batumi and Kobuleti heat index values were calculated for 2 equal periods of time: 1961-1985 and 1986-2010. Based on these values number of warm and hot days was calculated with indexes of respective category for Batumi and Kobuleti (Table 4.5.4).

Table 4.5.4. Changes in total number of “hot” and “warm days” in two periods in Batumi and Kobuleti

Features	Batumi		Kobuleti	
	1961-1985	1986-2010	1961-1985	1986-2010
Extremely hot	0	0	0	0
Very hot	0	0	0	0
Hot	1	6	1	0
Very warm	142	320	174	147
Warm	976	1104	938	1231

This Table demonstrates that “warm” heat waves are more frequent on territory Batumi and Kobuleti, while the number of so called “very warm days” is increased by 125% in the same period in Batumi, and decreased by

15% in Kobuleti. The obtained results might demonstrate that in case of maintenance of recent trend of climate change, increase of number of hot days is expected, which will increase the risk of negative impact on human organism. As demonstrated by future trend, in 2020-2050 compared to baseline period of 1961-1990, number of "very warm days" will be increased by 200% in Batumi and by 230% - in Kobuleti in contrast to previous decrease (Table 4.5.5), which will stipulate intensification of pathologies associated with high temperature (cardiovascular diseases, diarrheal pathologies, heat strike, heat exhaustion, etc.).

Table 4.5.5. Changes in average annual number of "hot" and "warm" days by 2050 (Batumi, Kobuleti)

Features	Batumi		Kobuleti	
	1961-1990 1961-1990	Difference Δ 2020-2050	1961-1990	Difference Δ 2020-2050
Extremely hot	0.00	0.00	0.00	0.00
Very hot	0.00	0.00	0.00	1.33
Hot	0.03	2.19	2.42	24.37
Very warm	5.53	22.65	28.35	36.03
Warm	36.20	2.26	33.81	24.70

In general the impact of heat waves on human organism could be precisely determined by the Heat Index (HI) (Table 4.5.6).

Table 4.5.6. Categories of Heat Index and their impact on health

Risk category	HI	Possible heat disorders
No risk	26-27	Comfortable conditions for body
The risk margin	27–32 Very warm	Tiredness because of long stay on high temperature or physical activity
Extreme risk margin	32–41 Hot	Sun strike, mascule cramp, and/or heat exhaustion, heat strike develops in case of being on high temperature for long time or in conditions of or physical activity
Risk	41–54 Very hot	Mostly – sun strike, mascule cramp, and/or heat exhaustion, heat strike develops in case of being on high temperature for long time or in conditions of or physical activity
Extreme risk	54 or more extremely hot	Sun or heat strike

Multi-criteria analysis was used to assess current and future impact of climate change on human health and identify the level of municipality's vulnerability. Methodology of mentioned analysis is based on the assessment of three key components: capacity of healthcare system to adapt with changes, sensitivity of the risks caused by climate change and healthcare sector.

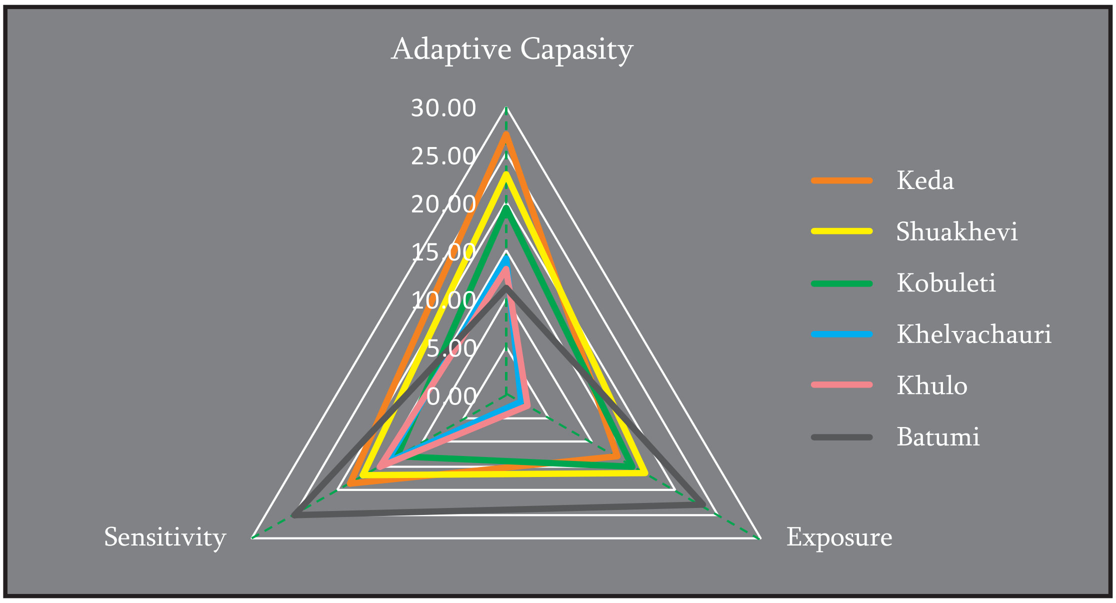


Fig. 4.5.4. Vulnerability of healthcare sector in Ajara by municipalities assessed through multi-criteria analysis (1961-2010)

Based on current climate change data the most vulnerable proved to be Batumi, which is basically preconditioned by high risks and sensitivities, caused by climate change (59.33). Keda municipality is on the second position (58.45), which compared to Batumi has higher adaptation capacity, but is more sensitive to climate impact than Batumi (Fig. 4.54).

As a result of assessment of future conditions it was revealed that Batumi will remain the most vulnerable, which could be explained by the increase of negative impact of climate. According to future forecast the risks caused by climate change in Batumi are growing compared to current period and the indicator of total vulnerability rises from 59.33 to 61.13. While in Keda such impact is being significantly reduced. In future Khelvachauri will be on the second position, where the value of negative impact of climate is also being increased (Fig. 4.5.5).

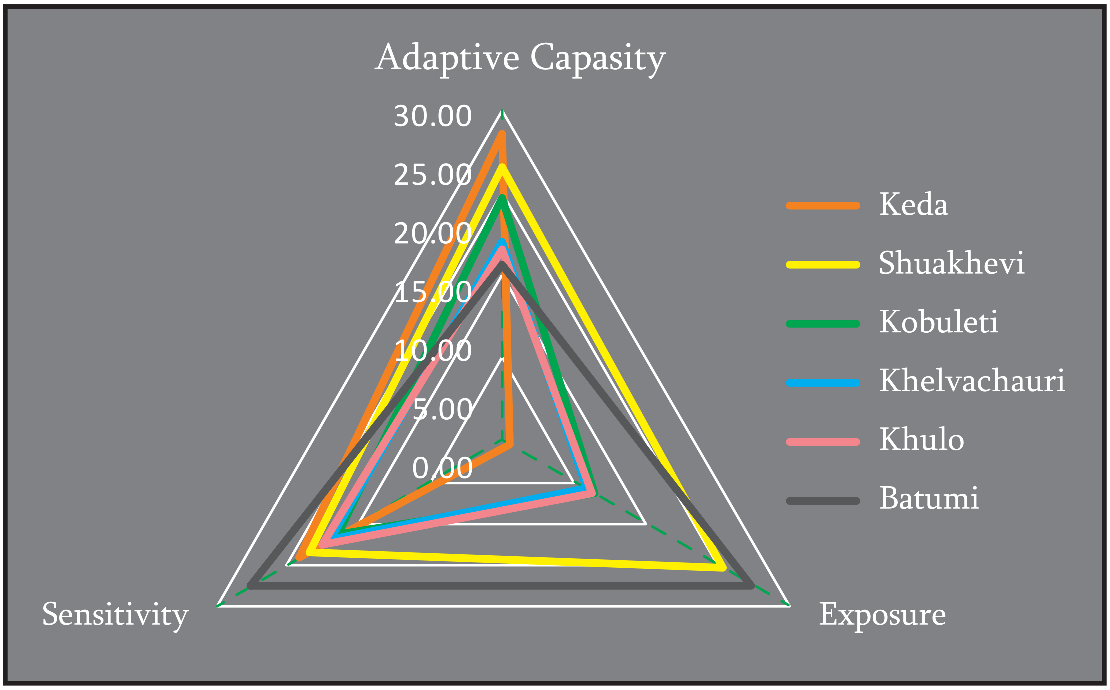


Fig. 4.5.5. Future vulnerability of healthcare sector in Ajara assessed through multi-criteria analysis (2020-2050)

In order to assess vulnerability of healthcare sector in **Upper Svaneti**, along with the study of climate-related diseases the access to healthcare was assessed. As demonstrated by primary analysis of situation, in Upper Svaneti access to healthcare service is quite law, due to inefficient medical infrastructure and lack of respective staff. Mestia municipality is lacking medical professionals, such as: cardiologist, physician, psychotherapist, neonatologists, allergist, surgeon and so on. Above listed staff is essential for the reduction of climate based diseases risks[95]. At the same time, above mentioned specialists as well as well operating healthcare system are essential for tourism development.

For assessment of vulnerability of healthcare system to climate change, the risks were identified, which increase vulnerability indicators. The first risk caused by geographic location of Upper Svaneti is existence of natural disasters. Based on the survey, conducted by CENN and Earth Sciences Faculty of the Twente University (ITC), according to revealed risks Samegrelo-Upper Svaneti is on the second position among nine regions, after Ajara[96]. According to total threats and risk level analysis (the highest risk indicator is 12, the lowest – 1), which is assessed by multi criteria spatial analysis[44], Samegrelo -Upper Svaneti got total indicator 11, which indicates to very high risk.

Connecting natural disasters with climate-related diseases is a bit difficult in Georgia, since there is no system for accurate recording of disasters and long term medical statistics of Mestia municipality is not available as well. Proper recording is available just from 2000. Based on available statistical data the following relation was identified: during last 12 years maximum number of traumas was recorded in 2004. Just this year mudflows and landslides were especially intensive, as a result of which 180 buildings were destroyed (including residential houses) and more than 50 families became eco migrants[97].

Landslides and mudflows were too active in 2010, when landslips destroyed 67 buildings. Unfortunately, number of eco-migrants is not known for this year. As for trauma statistics, incidence and prevalence of traumas is increased in 2010 (prevalence and incidence indicators compiled about 5 000).

Similar to Ajara, the multi-criteria analysis was used to assess vulnerability of healthcare system in **Kakheti**. In 2011, according to referrals per capita, Kakheti was on forth position with 1.3% among the regions of Georgia and this is the lowest indicator during last 6 years. Primary healthcare infrastructure is not adequate, majority of facilities of this system do not meet international standards[98]. Besides, medium level medical staff is lacking. According to the Ministry of Labor, Health and Social Affairs provision of beds in inpatient facility of Kakheti is 95.4 per 100 000 persons, which is the lowest in Georgia, after Mtskheta-Mtianeti[99] region.

According to the survey conducted by USAID in February-June of 2011 in Kakheti specialist doctors were lacking in inpatient sector. Other problems in healthcare sector are as following: low salaries of inpatient sector doctors, delays in paying salaries, high level of self treatment and self medication of population.

As for connection of diseases with climate change, the trend of increase in the frequency of cardio vascular diseases as well as in average and extreme temperature is clearly revealed in Kakheti. In order to highlight connection between cardio vascular diseases and climate change two 5 year periods were compared - 2001-2005 and 2006-2010. For comparison three municipalities of Kakheti were selected: Telavi – regional center of Kakheti, where the highest indicators of cardiovascular diseases and hypertension are recorded; Kvareli – also distinguished by high indicator of cardio vascular diseases and Dedoplistskaro, where climate change is more demonstrated than in other municipalities (Table 4.5.7).

[95] Interviews with representatives of the local health system
[96] Atlas of Natural Hazards and Risks in Georgia. CENN, ITC; 2012
[97] Report: "Natural geological processes in Upper Svaneti", Ilia Chkheidze, 2013
[98] Information provided during working meetings
[99] Statistict of the Ministry of Labor, Health and Social Affairs, National Center of Disease Control and Public Health, 2011

Table 4.5.7. Changes observed in statistics of arterial hypertension and climate parameters in three municipalities of Kakheti, 2001-2010

Municipality	Increase of arterial hypertension (%)	Increase of average annual tmperature (° C)	SU25 (Increase of day/yr.)	SU30 (Increase of day/yr.)
Telavi	188	0.3	6	21
Kvareli	173	0.5	5	33
Dedoplistskaro	155	0.6	28	57

From climate parameters average annual temperature and number of especially hot days (when temperature is more than 25 ^{0}C and 30 ^{0}C) are taken. As demonstrated by the table, the rate of arterial hypertension has sharply increased in all three municipalities, while the biggest change of climate parameters is recorded in Dedoplistskaro district. Since Dedoplistskaro is prone inclined to draughts and the increase of draughts and hot days is projected, this probably will cause the increase of frequency of cardio vascular and respiratory diseases.

As a result of assessing future vulnerability of healthcare sector of Kakheti, it was identified that in future the most vulnerable will be Telavi, which could be explained by the negative impact of climate. In fact, the indicator of climate impact is being increased compared to current value and the consequently increases the indicator of general vulnerability from 0.66 to 0.70. Kvareli will be on second position, where the value of climate impact indicator is also increasing (Fig. 4.5.6).

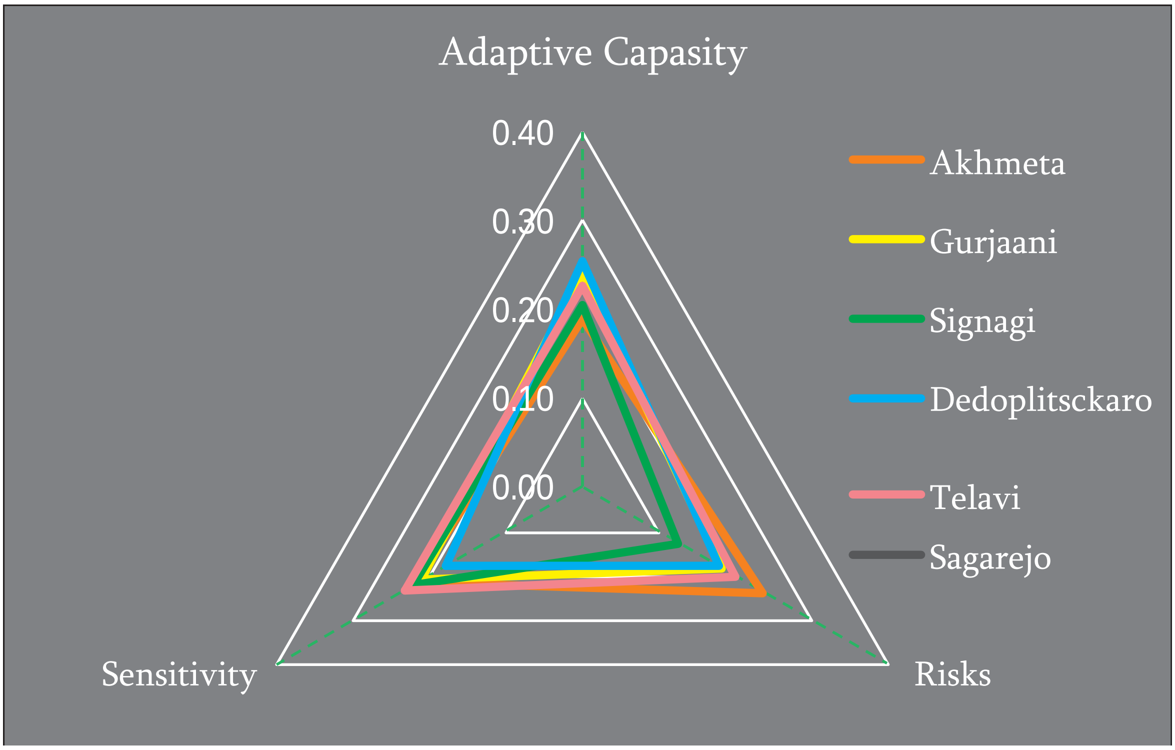


Fig. 4.5.6. Healthcare vulnerability indicators for Kakheti municipalities revealed through multi-criteria analysis, 2020 –2050

Within the frame of Red Cross Georgia project "Climate Forum – East", HI values were calculated for **Tbilisi**, similar to Ajara, in order to assess climate change impact on the recurrence of heat waves. The tables below demonstrate the change in HIs within two periods (1961-1985 and 1986-2010). Change in the number of hot/dangerous days was also calculated (Table 4.5.8). "Dangerous" days include "very warm" and "hot" days.

Table 4.5.8. Number of dangerous days and HI average value in Tbilisi (present)

a) HI, number of days

HI Category	Tbilisi		
	1961-1985	1986-2010	Difference
Standard	87.36	75.76	-11.6
Warm	47.52	45.08	-2.44
Very warm	17.92	31.28	13.36
Hot	0.2	0.88	0.68
Very hot	0	0	0
Extremly hot	0	0	0
Total number of "dangerous" days	18	32	14

b) HI, average value

HI Category	Tbilisi		
	1961-1985	1986-2010	Difference
Standard	18.64	18.40	-0.24
Warm	25.35	25.43	0.08
Very warm	27.99	28.31	0.32
Hot	33.34	33.10	-0.24
Very hot			
Extremly hot			
Total number of "dangerous" days	30.66	30.70	0.04

As Table 4.5.8 shows the number of dangerous days has increased by 14 days in second period, compared to first period. As given in this Table HI values are being increased on the average by 0.04 to 2010. Similarly, the increase of extremely hot days and temperature values is observed for two compared periods (1961-1985 and 1986-2010), which probably could be associated with the increase of number of climate-related diseases. As demonstrated by future trend (Table 4.5.9) number of dangerous days has been increased by 28 days, while the value of HI might be increased by 0.68 in future (Table 4.5.9 a and b).

Table 4.5.9. Number of dangerous days and HI average value in Tbilisi (future)

a) HI, number of days

HI Category	Tbilisi		
	1986-2010	2025-2049	Difference
Standard	76	50	-26
Warm	45	40	-5
Very warm	31	50	19
Hot	1	10	9
Very hot	0	0	0
Extremly hot	0	0	0
Total number of "dangerous" days	32	60	28

b) HI, average value

HI Category	Tbilisi		
	1986-2010	2025-2049	Difference
Standard	18.40	18.67	0.27
Warm	25.43	25.47	0.05
Very warm	28.31	28.82	0.51
Hot	33.10	33.95	0.85
Very hot			
Extremly hot			
Total number of "dangerous" days	30.70	31.38	0.68

Comparison of heat index change between the periods of 1986-2010 and 2025-2049, to the changes between 1961-1985 and 1986-2010 in the past, demonstrates that in future number of hot days and heat index values will be more altered than before. In particular if number of hot days increased by 14 between the periods 1961-1985 and 1986-2010, doubling of this number is expected (increase by 28) between 1986-2010 and 2025-2049.

HI value will grow sharply in future: in 1961-1985 and 1986-2010 the change compiled 0.04, while in future heat index values of 2025-2049 will increase by 0.68 compared to 1986-2010.

Such change gives a possibility to make following conclusion: increase of extremely high temperature value might be accompanied by higher frequency of climate based diseases, which are more sensitive to climate change and increasing trend of incidence and prevalence of which is still maintained. Besides the increase in the frequency of non transitive diseases, which is a challenge for Tbilisi and Georgia in general, cases of non infection diseases might also get increased, in particular of vector-borne diseases (for example malaria), the risk of spread of which is still existing (frequency of its dissemination is high in bordering countries).

- Reduction of distribution of climate-related diseases by implementing special measures for the region:

    - Negative impact of heat waves is especially manifested in Tbilisi and the Black Sea coastal zone – Batumi and Kobuleti. Consequently, it is necessary to reduce heat wave associated risk – mobilize healthcare sector in summer during the days "dangerous" for health. In particular, during the heat wave period Heat Action Plan shall be elaborated and implemented that should be started from large city – Tbilisi. Besides, it is reasonable to train qualified medical personnel for tourism sector in Ajara region, providing that staff will have sufficient knowledge and skills necessary for the reduction of risks associated with "heat waves" and climate based diseases;
    - High rate of traumas is observed in Upper Svaneti, which is conditioned by complex local terrain and natural disasters to which the region is inclined, as well as by low awareness of the representatives of tourism sector on the risks associated with traumatism. Thus, it is important to elaborate adaptation measures directed to maximal mobilization of healthcare sector in period of natural disasters; rising awareness of tourism sector employees, concerning the risks associated with traumas is also important;
    - Lack of medical staff, including orthopedist is a challenge in Upper Svaneti. Thus provision of respective personnel is essential for better trauma management in this region;
    - The rate of diarrheal diseases is quite high in Ajara, which develops risk for the health of local population as well as for the development of tourism sector. Thus, it is important to inform people operating in tourism sector, about climate change and climate-related diseases, and improve the knowledge of medical personnel on the prevention and management of climate based diseases;
    - Single cases of anthropozoonotic diseases, not existed before, were recorded in Georgia and in particular in Ajara, which indicates that increase of cases of this climate-related diseases is expected, unless controlled by healthcare sector;
    - Cases of climate-related infectious disease – malaria were recorded in the past in Georgia, especially in Kakheti. Mobilization of public healthcare system fully eliminated the cases of this so called tropical disease, which is good example for the control of such diseases;
    - Cardiovascular diseases are considered as the most widespread in Georgia, especially in Tbilisi, Kakheti and Upper Svaneti. It is necessary to improve awareness of medical staff on cardio vascular pathologies and the management of climate-related diseases.

- Promoting the healthcare sector in regions, by providing respective infrastructure (establishing healthcare units) and medical personnel (orthopedist, psychotherapist, cardiologist, neonatologists, etc.), who will be focused on controlling and prevention of climate-related diseases: for example provision of specially trained medical personnel in highland Ajara and Upper Svaneti, in tourism complexes of Kakheti (Lopota, Kvareli Lake), who will manage climate based diseases effectively and care for the health of locals as well as of tourists.
- Elaboration of adaptation measures directed to maximal mobilization of healthcare sector in period of natural disasters. The health sector shall by all means be engaged in disaster management process in general and of each phase, for which elaboration of medical plan for disaster management is essential. Medical management component is especially necessary for Upper Svaneti and highland Ajara municipalities. Traumatism level is high in Upper Svaneti, while post trauma mental disorders are widespread in Ajara region. One of the key components of post trauma mental disorders is rehabilitation.
- **Promoting tourism development** by providing comfortable healthy environment for tourists: rising awareness of tourism personnel on climate-related diseases and providing medical personnel for tourism complexes (for example in Mestia, Batumi, Kobuleti, Lopota, Kvareli Lake and so on), including emergency care staff, to ensure care for the health of tourists.

- **Development of early warning system**, which will serve healthcare system and local population and make easier management of climate-related diseases. The system is essential in regions and cities, where the risk of climate-related diseases is high. For example in mountain Ajara and Upper Svaneti, which are distinguished by frequency of natural disasters, the risk of traumas is high; in Tbilisi as in Batumi and Kobuleti the trend of intensifying “heat waves” is identified, readiness to which is especially important for the health of population; early warning system could easily provide information about the distribution of new diseases in the region, like this happened in Ajara, where cases of anthropozoonotic diseases were recorded. Besides mentioned system gives opportunity to provide medical monitoring in the regions where cases of climate-related diseases were eliminated (e.g. malaria in Kakheti), however the risk of spread still exists.
- **Promoting medical surveys**, which will study climate impact on human health and with this, facilitate the development of particular adaptation measures, programs and projects.
- **Rising public awareness** about climate based diseases by means of TV programs, information materials and other social activities.

4.6 Climate change impact on tourism sector

Envisaging climate in tourism industry

Reliable climate data are key determining factor for proper management and planning economic sectors, such as agriculture, construction, water resources management, tourism, recreation and human health. Thus it could be said that climate is not just natural but social economic factor as well, consequently the interest to its study is not surprising.

Climate and weather together with people and surrounding environment represent natural resource which is essential for the development of tourism and recreation of any country or region. Functioning of tourism market is seasonal, influenced by different factor. Primary factor is natural climate and secondary – economic, demographic, psychological and technological and so on.

World Tourism Organization (WTO) considers that climate forecasts became extremely important for sustainable development of tourism all over the world.

Among key components of tourism recreation potential are climate resources. In 2003 WMO and WTO adopted first resolution on the need for assessment of tourism recreation potential in tourism regions of member countries. Georgia is full member of both organizations since 1990, which preconditions the need for the assessment of its tourism recreation potential.

Georgia, with its complex physical geographic conditions, due to high hypsometric location and complexity of climate originating factors is characterized by special diversity. All climate types are met on the territory of Georgia, except for desert, Savana and tropical rainforest. It could be said that it is classical example of poly-climatic country, in which climate variations undergo more painfully than in some other countries with vast territory, characterized by just some types of climate. Consequently, the issue “human and climate” is real challenge in Georgia.

Climate indexes are used for the assessment of tourism and recreation resources. These indexes are accepted in applied climatology and biometeorology. There are more than 200 climate indexes. Bioclimatic and tourism climate indexes represent complex of different weather elements and well describe combined effect of their values.

One of such indexes is Complex Climate parameter - K, which can be used for the assessment of annual potential of tourism recreation resources and is determined by combination of 4 weather elements:

$$K = \frac{Hf}{S\sqrt{A}}$$

where
H is precipitation in warm period of the year (mm),
F – Relative humidity of the hottest month (%),
S – Average duration of sunshine on horizontal surface (hours),
A – Annual amplitude of air temperatures (January and July) (^{0}C).

According to complex parameter territory of Georgia is divided by zones according to following variations:

- Excellent (K>90)
- Very good (K= 80÷89)
- Good (K= 70÷79)
- Pleasant (K= 60÷69)
- Acceptable (K= 50÷59)
- Unfavorable (K=40÷49)
- Extremely unfavorable (K<40).

The values of ***K*** parameter were calculated using the data of 54 weather stations in different climate zones of Georgia for the period of 1957-2006. General distribution of complex parameter is given on Fig. 4.6.1.

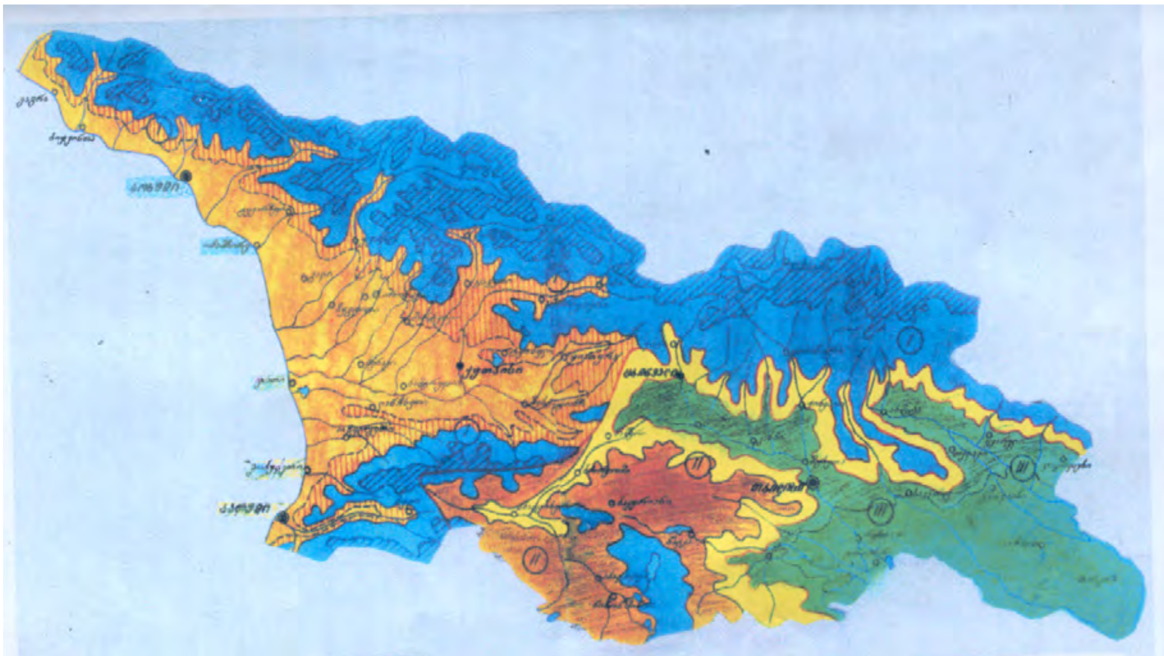


Fig. 4.6.1[100] Distribution of Complex Climate Parameter on the territory of Georgia

[100] Kartvelishvili L, Rokva K., Tourism and Climate Change. Contemporary problems of Geography., “Geoidi” Tbilisi 2011, p. 213-220. (in Georgian)

The analysis of obtained data demonstrated that the highest values of complex climate parameter comply with the Black Sea coastal regions, where it reaches more than 90.

Identification of tourism potential by seasons and months is essential for the development of tourism industry, while just annual values could be calculated by means of given index (***K***). Besides, this index does not include thermo physiological component, which is necessary for assessing tourism and recreation resources. Consequently, Tourism Climate Index (TCI) elaborated by WMO was used for more accurate assessment of tourism resources in certain regions of Georgia (Ajara, Kakheti, Upper Svaneti). The index includes combination of seven parameters, out of which five are independent and two represent bio climatic combination:

$$TCI = 8 \cdot Cld + 2 \cdot Cla + 4 \cdot R + 4 \cdot S + 2 \cdot W,$$

where Cld is daily comfort index, which includes average maximum of air temperature- Tmax (°C) and relative humidity minimum - Fmin (%), Cla is daily comfort index, which includes average air temperature- T(°C) and average relative humidity -f (%), R is total precipitation (mm) in examined period, S is sunshine duration (hours) and W – average speed of wind (m/s).

Tourism climate index is assessed in scores from 100 to 30 and includes following categories (Table 4.6.1).

Table 4.6.1. Tourism climate index

TCI	Category
90 ÷ 100	Ideal
80 ÷ 89	Excellent
70 ÷ 79	Very good
60 ÷ 69	Good
50 ÷ 59	Pleasant
40 ÷ 49	Acceptable
30 ÷ 39	Unfavorable
20 ÷ 29	Very unfavorable
10 ÷ 19	Extremely unfavorable
- 30 ÷ 9	Unacceptable

The calculations demonstrated that TCI categories suitable for conditions of Georgia in three selected regions vary from “very good” to “unfavorable”. More details on the current and projected changes of TCI will be provided below.

Ajara

Photo 4.6.1. Ajara coastal zone (Kvariati)[101]

Climate change impact on tourism potential of Ajara

In recent years tourism became the most dynamically developing sector of economy of Ajara. In 2004 total number of visitors compiled 83 thousand, while by 2011 this number reached 913 thousand and exceeded 1 million in 2012.

Tourism friendly climate conditions start in May in coastal zone of Ajara, where the most visitors come, and it lasts till October-November. In spring some delay of tourism season is caused by huge thermal inertia of the Black Sea, due to which the sea cannot get warm sufficiently in March and April after cooling in winter months. Change of number of tourists by months according to 2007-2010 data is given in Fig. 4.6.2.

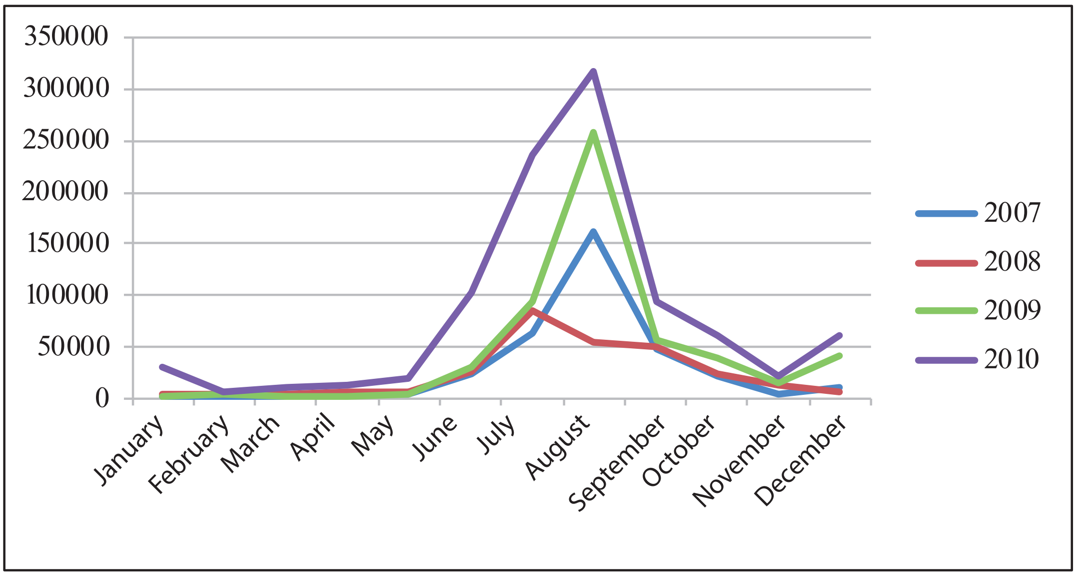


Fig. 4.6.2. Number of tourists in Ajara by months (2007-2010)[102]

[101] Archil Guchmanidze's photo
[102] Department of Tourism and Resorts of the Autonomous Republic of Ajara

Resorts and recreation sites of Ajara to which the most of tourists come are developed in coastal zone and along it, however more than half of recreation places are in highland Ajara. Detailed information on the resorts of Ajara is provided in Ajara Climate Change Strategy[103].

Climate zone in which sea resorts are located, is characterized by humid climate, mild winter and hot summer. Key treatment factors of this recreation and tourism district are as follows: warm sea, chemical microelements of marine origin in the air, high value of radiation balance, significant portion of oxygen in air composition, low contamination of air. Such climate is useful for the treatment of cardiovascular, neurological, pulmonary and arthrological patients and development of recreation tourism. Duration of sunshine per year in Batumi on the average compiles 1 958 hours, while on upper weather station of Green Cape - 1 815 hours. Number of sunny days varies within 300 – 295 respectively. In July continuous duration of high discomfort temperature – above 33 ^{0}C could be 8 hours in middle part of the river Acharistskali, while in the sea coast zone this value is not more than 4-6 hours, and in mountain zone compiles 0-2 hours.

Climate change impact on tourism in Ajara basically was assessed by the indicators of change of TCI, as well as of HI. The TCI[104] contains more climate information compared with HI.

In order to assess change of TCI due to global warming in 1961-2010, two equal periods were studied and average values of TCI were calculated according to data of four weather stations of Ajara (Batumi, Kobuleti, Khulo and Goderdzi Pass).

According to obtained data, in coastal zone of Ajara (Batumi, Kobuleti) tourism friendly climate conditions (category 1 and 2) were observed from May to October, and in second period April was added to these months, due to climate warming. Besides, worsening of conditions were observed in August (Kobuleti) and November (Batumi). Such changes did not take place in mountain Ajara zone (Khulo) and “very good” conditions were observed from May to September during both periods of time. As for weather station located in alpine zone (Goderdzi Pass), tourism climate conditions were improved here in second period: July-August (“pleasant” was substituted by “good”) and in April and October (“unfavorable” was substituted by “acceptable”).

Thus, it could be said that during the last half-a-century, under the impact of climate warming tourism climate conditions were improved in spring in Ajara coastal zone, while in summer and autumn some worsening took place. Besides, tourism conditions were improved in alpine zone, during all three examined seasons. It is to be mentioned that climate index values were steadily maintained in May-September in mountainous Ajara (Khulo), which indicated to great potential of tourism development in this zone.

Convergence of high temperature and humidity impose hazard to human and consequently tourist health. This condition is reflected by HI, which expresses severity of the body’s sense of temperature for different values of air humidity. The same temperature in conditions of different humidity is perceived with different severity and has different impact on human condition. Number and frequency of days with high heat index has noticeably increased in all regions of the world during the last 20 years, due to global warming. The days with high heat index as a rule continue for different periods and produce “heat waves”, which for several times went over European continent. The strongest wave was observed in France in 2003. In the process of preparing this document heat index change in past was assessed for some recreation zites in Ajara (Batumi, Kobuleti).

Data of weather stations of Batumi and Kobuleti were used for assessing climate change impact on the recurrence of HI in Ajara. Heat index values were calculated in 2 equal periods of time: 1961-1985 and 1986-2010.

[103] http://www.ge.undp.org/content/georgia/en/home/operations/projects/environment_and_energy/enabling-activities-for-the-preparation-of-georgias-third-nation.html
[104] Tourism climate index was elaborated by World Meteorological Organization (WMO) for characterizing and comparing tourism climate conditions of different countries and regions

The results demonstrated that in Batumi number of hot days has significantly increased during last 25 years, while this was not the case in Kobuleti. Number of warm and hot days was significantly increased in cities, due to warming process and increase of the number of comfortable days. Assessment of heat index demonstrated that in 1986 -2010 the trend of repetition of warm days mostly increases in August and approximates to very warm days zone (light yellow), which is characterized by particular hazards, but this index yet does not reach this zone (Fig. 4.6.3).

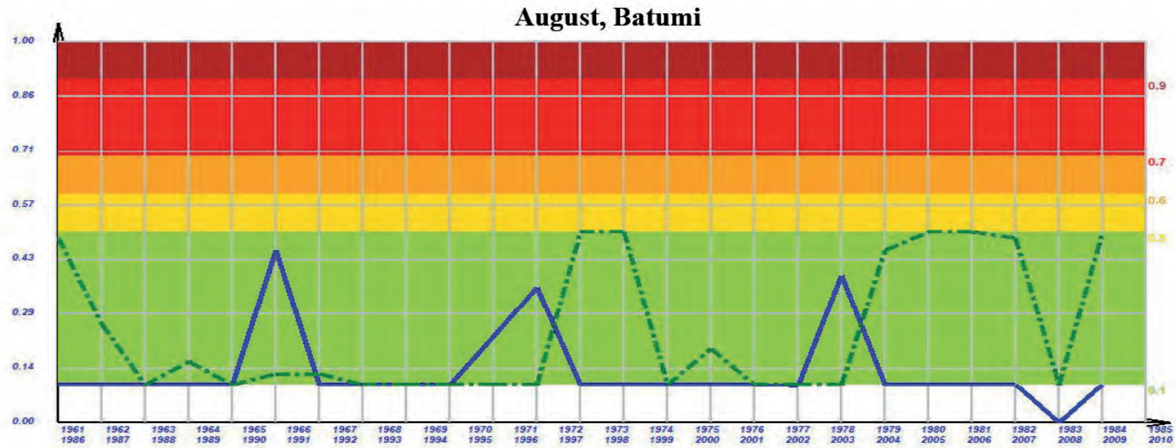


Fig. 4.6.3.[105] Intensity of HI and occurrence probability in two assessed periods (August, Batumi)

Impact of expected climate change on tourism sector in Ajara

Expected change of CTI between above mentioned second time period and 2026-2050 was assessed using climate change forecast data up to the middle of current century.

According to obtained data, as a result of climate warming, in the first half of the century in Batumi worsening of tourism climate conditions is expected by one step decrease of respective categories in all three months of summer. However, some improvements in climate conditions are expected in November, when category "acceptable" moves to "pleasant". Changes are not expected in Kobuleti, however forecasted move from "pleasant" to "good" conditions in April and October is added to already wonderful conditions in May-September in Khulo. Improvement of tourism conditions in alpine zone is expected in September as a result of changing "pleasant" category with "good".

The results demonstrate that projected warming by 2050 probably will cause worsening of climate conditions in summer in Batumi, and improvement of these conditions in mountain and high mountain zones. Stability of climate conditions in Kobuleti points to yet indefinite advantage of northern part of coastal zone, compared to southern part.

Expected change in the number of high HI was assessed for Batumi, Kobuleti and Goderdzi Pass between the periods of 2020-2050 and 2070-2099 (Fig. 4.6.4). The calculations showed that in 2020-2050 in Batumi number of the days with "very warm" heat index increases minimum by 22 days per year. The same is in Kobuleti, the difference is just that hot days were not recorded in Batumi before, while in Kobuleti such cases took place. As for Goderdzi Pass and resort of Beshumi, number of warm days is increasing here.

105 ——— 1961-1985.
– · – · – · – 1986 -2010

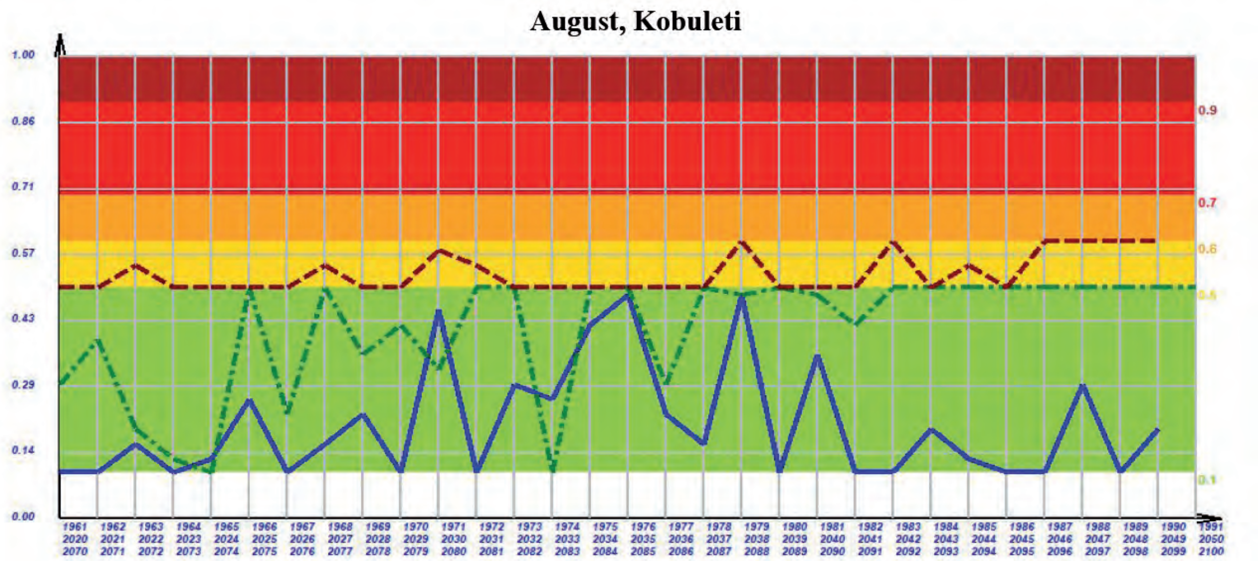


Fig. 4.6.4. Intensity and occurrence probability of HI in three periods (August, Kobuleti)

Besides number of days, the trends of ocurrence of HI in different months were assessed for three different periods (1961-1990; 2020-2050 and 2070-2099). Consequently it was identified that Kobuleti will become hotter than Batumi and the threat of heat index is being increased. In fact in 2070-2100 in July and August this index is within hazard zone, however warming is underway in Batumi and Kobuleti but it does not reach the threat level. The conditions are quite comfortable for population and tourists.

According to assessments conducted in other countries with tourism potential, climate warming in geographic and climate conditions such as in Ajara, could cause both positive and negative results for tourism sector. Expected positive results are as follows:

- Prolongation of tourist season will be followed by the expansion of services and infrastructure as well as respective improvement of income of local population and living standards. As mentioned above, in case of Ajara this increase in coastal zone by middle period of current century might compile one month and tourism season might be continued in November as well. Similarly, in mountain zone improvement of climate comfort conditions will be expected in May, while in highland zone - tourism season will be continued in September.

Expected negative results are as follows:

- Abundance of extremely hot weather in coastal zone (prolongation of heat waves) in July – August, which will develop discomfort for tourists. However, in case of Ajara this is expected only in the end of the century and just on the territory of Kobuleti;
- As a result of the increase of frequency of severe storms in sea coastal zone, worsening of tourism conditions, increase of threats associated with storms, intensive washing down of beaches and flooding the bank are expected along the seashore;
- Increase of the risk of flash floods and mudflows in coastal zone, as a result of abundance of rainfall in summer, is the factor especially dangerous for tourism sites located in mountain zone, basically settled along the river banks;
- In conditions of Ajara, increase of temperature during tourist season could cause increase of diarrhea cases and intensification of infection diseases as well as the increase of frequency of heat waves, which

will make essential establishment of early warning service. It is expected that climate associated health problems – traumas and mental disorders will become more frequent. To combat these problems it is reasonable to involve healthcare sector in disaster management system. Within the frame of current project the proposal was prepared, which is included in the Climate Change Strategy of Ajara;

- In case of increase of average winter temperature by almost 2 ^{0}C in highland zone to 2050, the skiing season might be reduced by 1 – 1.5 month. However according to forecasts precipitation amount will get increased almost by 30%[106], which will compensate negative results of warming.
- As a result of increase of sea surface temperature together with air temperature (≥30 ^{0}C) mass destruction of mollusks and other species, inhabitants of coastal strip, that took place in 2011-2012 might be repeated and consequently make negative impact on the development of specific tourism sector – diving. At the same time, the overheating of water recently caused dissatisfaction of tourists in Ajara coastal zone.

Thus, conducted analysis makes it possible to conclude that tourism friendly climate conditions are provided in all three climate zones of Ajara. Based on TCI and HI projected data, it could be said that for the middle period of current century even more improvement of these conditions is expected. However it will be necessary to make particular amendments to current strategy for tourism development in Ajara.

[106] These signs are already clearly manifested especially in winters with much snow.

Mestia (Upper Svaneti)

Photo 4.6.2. Village Ushguli, Upper Svaneti[107]

Climate change impact on tourism potential of Upper Svaneti

According to adopted classification, four tourism recreation zones were identified at the territory of Upper Svaneti by 1980.

Highland alpinism and mountain sport and tourism zone occupies main position among others. It includes famous peaks such as: Shkhara, Ushba Shkhelda, Tetnuldi, Laila and others. Due to abundance of glaciers and peaks with difficult access, Upper Svaneti attracts many alpinists and tourists from different countries. Another zone, acknowledged as historical sanctuary is not less popular. it includes the most highland community in Europe – Ushguli, with villages Zhibiani, Chazhashi and others. Recreation zone located on the terraces in the of middle part of the river Enguri Gorge and mountain slopes includes the settlements with rich historical past (Mestia, Lemsia, Ushkhvnari, Svipi, Tvebishi, Lakhamula and etc.), as well as forested recreation areas of inimitable beauty, where more than 30 mineral water springs are located, including Lakhamula, Etseri, Svipi, Lasili, Khalde, Adishi and other springs. Due to lack of adequate infrastructure these sites are not used properly. Short term relaxation zone basically includes places with steep slopes and deep forests.

Climate characteristics of Upper Svaneti are available using the data of weather stations Mestia and Khaishi. For calculating TCI values Mestia weather station was selected, which is more representative for territory of this region. Peculiarity of this station is its location in the Mestia depression surrounded with mountains, where the hollow specific microclimate is developed with hard frosts in winter and high heat of summer.

CTI monthly values were calculated based on averaged climate data of 1961-2010. The calculation demonstrated that in so called “middle zone” of Upper Svaneti June, July, August and September had “very good” CTI values, May – “good”, April and October had “pleasant”, March and November – “marginal” and all three

[107] Photo by Koba Chiburdanidze.

months of winter had "unfavorable". It is to be mentioned that TCI index does not envisage assessment of favorable conditions for winter skiing sport, for which different index should be used.

Analysis of TCI projected values for 2071-2100 demonstrated that in this forecasting period "very good" conditions will be transferred to May, September and October and as a result of presumable increase of temperature by 4 ^{0}C in all three months of summer, TCI category "very good" will be shifted to "good", while in December, February and March it will be increased and shifted up in one category.

Taking into consideration expected results of global warming, in the second half of current century in Upper Svaneti tourism friendly ("pleasant" and better) climate conditions are expected from March to November. Thus, all links of tourism infrastructure (hotels, roads, transport and so on) shall be ready for the extension of tourism season (up to 9 months), preparation for which should be started right now.

Taking into consideration worsening of climate conditions in summer months, attention should be paid to the development of recreation areas (resorts) on terraces around mineral sources close to alpine meadows, where expected increase of temperature will have less impact on worsening of tourism climate conditions, due to high location above sea level.

Kakheti

Photo 4.6.3 Vashlovani reserve [108]

Climate change impact on tourism-recreation potential of Kakheti region

Diverse climate zones and terrain as well as rich cultural heritage precondition high tourist and recreation potential of Kakheti region, which was just partially used in the past. Mtatusheti is distinguished among recreation areas, huge tourism potential which in fact was not used previously, due to non availability of road. Recreation areas are in single localities of Tsiv-Gombori Ridge and southern slopes of Greater Caucasus (Gombori, Tsivi, Koda, Tetri Tsklebi, Akhalsopeli, Torghvas Abano, Arkhiloskalo, Ujarma, Akhtala and others), out of which two latter are famous with mud cures. Highland area of Caucasus Range contains broad possibilities for the development of sport tourism. Kakheti territory is covered with historical monuments, which makes the entire region zone of cognitive tourism.

High tourism potential of Kakheti is significantly determined by great number of protected areas (Lagodekhi, Vashlovani, Mtatusheti, Batsara, Babaneuri, Mariamjvari protected areas, Ilto, Iori and Chachuna reserves, Alaznis Chala, Artsivis Kheoba and Takhti-Tepa natural monuments, etc.).

Under the impact of global warming, the climate in Kakheti has significantly changed, which is proved by the results obtained in the TNC of Georgia. Consequently, the assessment of possible change in climate recreation potential of Kakheti became necessary taking into consideration already started and expected changes of climate elements. The assessment should be done with the same methods and criteria as those which were used for Ajara and Upper Svaneti.

At the first stage changes in TCI were assessed between two equal 25-year periods (1961-1985 and 1986-2010) for following stations: Sagarejo, Telavi, Kvareli, Sighnagi and Dedoplistskaro. At the second stage possible change of potential in current century was assessed, in connection with forecasted change of climate elements.

TCI categories have not changed between two studied periods at all examined weather stations. This certifies that global warming which started since 1970 has not yet impacted significantly tourism climate conditiones of Kakheti. Detailed analysis of parameters included in TCI (daily and day/night comfort indexes, total precipi-

[108] Photo by Amiran Kodiashvili

tation, duration of sunshine and wind speed) demonstrated that monthly values of these parameters undergo insignificant variation between viewed periods, however change might be visible on particular weather station.

It is to be mentioned that obtained result differs from characteristics revealed for Ajara region, by similar approach, where TCI categories underwent in three seasons of the year (except winter) between the same periods, both recorded on seashore and highland stations.

In Gare (Southern) Kakheti TCI values belong to "very good" category from May to September, while in Kvareli and Sighnagi TCI categories shift one step lower.

The fact that in winter months TCI average value does not fall below "acceptable" category on all examined weather stations could be explained by the following: in Kakheti in winter average minimal temperature does not drop below -3, -5 ^{0}C except for highland zone, precipitation is not too much (monthly totals vary within 20-40 mm, which is about 5% of annual norm), duration of sunshine compiles 100 – 150 hours per month, average relative humidity of air is not more than 70-80%, and average wind speed changes within 2-3 m/s. All mentioned provide comfortable climate conditions even in winter.

As for extreme values of categories, they rarely fall below "acceptable" (less than 40 points) at all stations in winter and spring months. However, from April to October TCI values often move to "excellent" and "ideal" categories (more than 80 points).

In addition to two mentioned periods TCI projected values were also calculated for 2071-2100, using climate change forecasting model. The results demonstrated that by the end of current century TCI will move to higher categories at all five weather stations of Kakheti, due to global warming and its accompanying processes, providing that tourism climate conditions will be improved. Besides, in warm/hot period of the year (from May to September) we should expect inverse process, when discomfort able conditions associated with the increase of temperature cause transfer of TCI values to lower category.

This trend is especially clearly manifested in July – August, when indexes for Telavi and Kvareli moved to 5 "unfavorable" category.

Thus, in terms of global warming the improvement of tourism friendly climate conditions in winter and transition periods and worsening - in summer months is expected in both Kakheti and Ajara regions.

Availability of tourism and agriculture friendly climate conditions in Kakheti makes possible dynamic development of agro-tourism in this region. For this purpose it is necessary to provide adequate infrastructure (roads, hotels and so on). Together with agro tourism the development of cognitive tourism should also be supported, which could be unified in one complex able to function all-year-round.

Highland part of the region - Mtatusheti has high tourism potential as in summer (chilly recreation areas of unique beauty), so in winter (mountain ski sport). Taking this into consideration the construction of access road to Omalo and development of infrastructure in this area should be speeded up.

The mud-bath potential of Akhtala and Ujarma should be revived and used on modern level.

4.7 Climate change impact on melting of glaciers and Enguri river runoff

Caucasus is one of the most important mountain regions in the world. 1 640 km^2 (0.37%) of its territory is covered by glaciers – dynamic geographic system, moving under the impact of natural factors (moving forward, back). However, the glaciers are intensively retreating for last decades, due to well known modern climate change – global warming.

As a result of analyses of satellite images obtained in 1985- 2000, it was derived that in the central part of Greater Caucasus, which includes R. Enguri basin, average rate of glaciers retreat is 8 meters per year. Besides, relation of the speed of stepping back of the glacier with its size was identified. In particular, the speed of retreat of the glaciers size of which is more than 10 km^2 is 12 meters per year, while in case of the glaciers of less than - 10 km^2 size, this speed is not more than 6 km per year. Stepping back of the glaciers is followed by the increase of the surface covered with moraine debris. According to the studies[109], if in 1985 for all selected glaciers total area of ice, free of debris on the average compiled 1 260 km^2, by 2000 this value decreased to about 1 136 km^2, that is in compliance with 6-9% increase of the area covered by clastic, taking into consideration reduction of total area of glaciers. On the background of climate change in the mentioned region, number and size of the lakes originated as a result of melting of the glaciers has also changed. The comparison of satellite images of 1985 and 2000 provided that number of pro-glacial lakes has increased by 50% and their area by 57% to 2000. Glacial lakes are surrounded by moraine materials, which facilitate water stagnation in the lakes. As a result of field observations in 2002-2004 it was identified that 2 lakes existed in 1985 near the tongue of glacier Bashkara (River Adil Sus Valley) were consolidated. As a result of melting glaciers the level of water is being increased in lakes that could in future cause moraine debris material breakthrough and disastrous flash flood in the lower part of river beginning from the glacier. That will damage the settlements and economic facilities located there[110].

Following factors provide physical and geographic conditions for the development of glaciers: 1) General features of climate and their change in glacial districts (solar radiation, air temperature, atmospheric precipitation, atmospheric circulation, etc.); 2) Absolute heights of ranges; 3) Location of ranges and gorges, between which local climate changes are developed; 4) Exposition of slopes against sun and prevailing winds; 5) Fragmentation of slopes and forms of terrain. Glaciation is caused not just by single factor but their complex, and impact on one another in particular geographic conditions.

Despite of the mechanism of complex inter relation, essential for the development of glacier, from the point of view of climate two meteorological factors can be identified: solid atmospheric precipitation during winter or the whole year and low temperatures of air, especially in summer, in order to maintain snow cover accumulated during the winter. If this equilibrium is broken, the glacier starts moving – it moves forward or back, depending on the degree of accumulation or ablation of snow on the surface of glacier or its neve.[111]

The process of accumulation, maintenance or ablation of snow on the surface of glacier depends on certain weather conditions and synoptic processes. Georgia is located under the impact of circulation of air masses of moderate and subtropical latitudes. It is situated between Black and Caspian seas, that preconditions the development of four main synoptic processes, according to air mass invasion: western, eastern, bilateral (from east and west) and wave disturbance from the south. All four processes in accordance with seasons and locations develop particular weather conditions. Svaneti – especially Upper Svaneti is protected from invasion of cold air masses from north by the peaks of 4 000 – 5 000 meters height (Svaneti Caucasus), and from south by Svaneti and Lechkhumi ranges. The only way from which cold air masses intrude from the west to this territory is the gorge of River Enguri.

The longest glacier in South Caucasus is Lekhziri – 12 km (Photo 4.7.1) which is located in Svaneti in the basin of Enguri River.

[109] Beritashvili – Evolution of Caucasus Glaciers in second half of 20th century, . United Nations Framework Convention on Climate Change, Results received in Second National Communication in 2007, Tbilisi 2008, pp 136-155 (in Georgian)
[110] Such event took place in 2014 in areas of Devdoraki Glacier.
[111] Neve - granular ice.

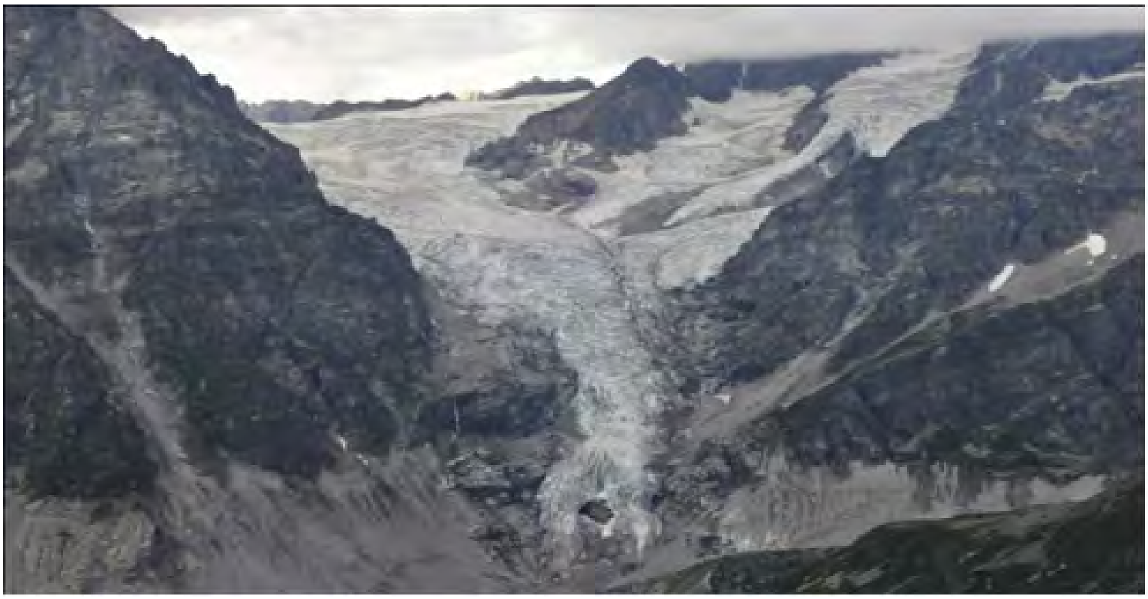


Photo 4.7.1. Glacier Lekhziri (Svaneti, Caucasus)

Favorable synoptic conditions for the existence of glaciers in Upper Svaneti and in particular in R. Enguri basin (basically distribution of air temperature and atmospheric precipitation) are preconditioned by **western processes**, during which humid air masses giving precipitation are invading from the Black Sea.

During **eastern synoptic process** atmospheric pressure gradient is directed from the east (Caspian Sea) to the west (Black Sea). In this process eastern currents impact is weakly revealed in West Georgia, especially in Upper Svaneti. This time dry and weak cloudy weather is observed in whole West Georgia. In winter, in time of eastern incursions hard frosty days are not observed in Upper Svaneti, except for the cases when incursion is very strong, due to the intensification of Siberian High.

As for **bilateral synoptic process**, when cold air masses invade simultaneously from the west and the east on the territory of Georgia, the possibility of its recurrence is relatively low. During this process the weather is cloudy and rainy on whole territory of the country and air temperature falls sharply. During wave disturbances from the east, the conditions of weather worsening in Upper Svaneti are not observed.

In Upper Svaneti region the most favorable conditions for the existence of glaciers in the R. Enguri basin - abundant atmospheric precipitation and low temperature - are developed during western synoptic process.

4.7.1 Glaciers of R. Enguri basin

Glaciers are not equally distributed in the Enguri basin, according to their number and areas occupied in basins of particular rivers. According to 1965[112] data 250 glaciers were presented here – with total area of 288 km^2 (Table 4.7.1). According to their number, small glaciers with area about 0.5 km^2 were prevailing. They compiled 73% of total number of glaciers in the basin. However, it is to be mentioned that they occupied just 13% of total area of glaciers. According to the area, large glaciers (>10 km^2) had leading position, covering 48% of total area of glaciers. The glaciers of this size compiled 3% of total number. Medium size glaciers occupy 39% of area and compile 24% of total number (Table 4.7.1.).

[112] Svanidze G., Tsomaia V. Water Resources of Transcaucasia. Gidrometeoizdat, 1988 (in Russian)

Table 4.7.1. Distribution of Enguri river basin glaciers[(112)]

Glacier's type	Number	%	Area km^2	%
Small <0.5 km^2	173	73	38	13
Medium 0.5-10 km^2	70	24	113	39
Big >10 km^2	7	3	137	48
Total	250	100	288	100

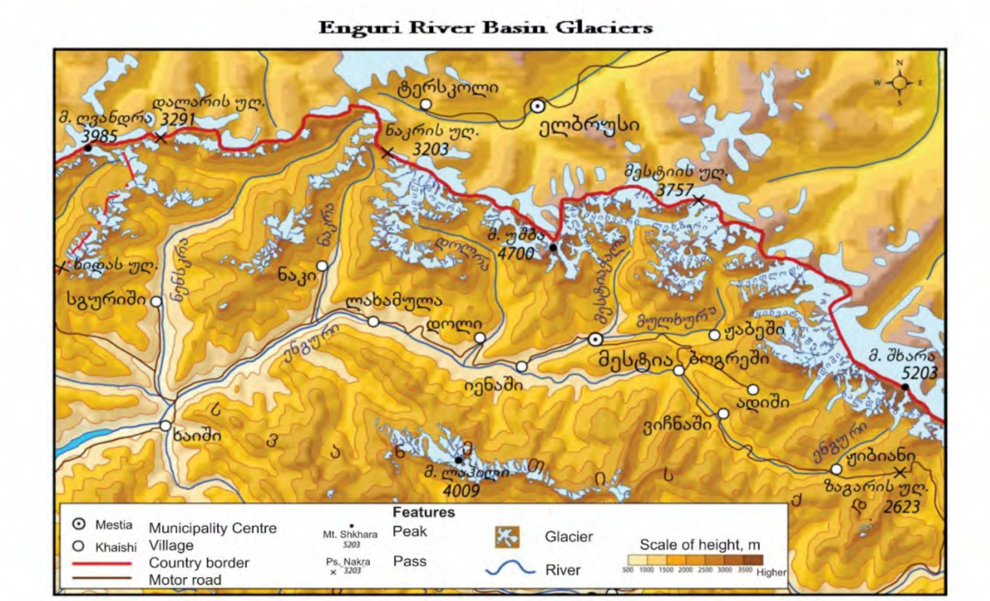


Figure 4.7.1. Distribution of glaciers in Enguri river basin[(112)]

Due to complex and fragmented terrain, the glaciers of different morphological type and exposition are developed in River Enguri basin (Fig. 4.7.1), number and percentage distribution of which is given in the Table 4.7.2.

Table 4.7.2. Distribution of glaciers of River Enguri basin by morphological types[113]

Morphological type	Number	%	Area, km^2	%
Cirque	123	48	8	2.5
Gorge	40	16	40	14
Hanging	34	14	4	1.5
Cirque-gorge	30	12	9	3
Gorge-complex	6	3	136	47
Cirque-hanging	17	7	93	32

Characteristics of certain part of complex glaciers of Enguri river basin are provided in Table 4.7.3. Their distribution by basins and areas as well as years of observation and step retreat, are given in mentioned Table. However, it is to be noticed that information on all glaciers is not complete, since due to complexity of glaciological studies (human and material-technical resources) simultaneous observation of several glaciers is impossible. The glaciers given in this Table of course together with other morphological type glaciers existing in the basin are forming the glacial runoff of Enguri basin, average of which up to village Khaishi compiled 0.908 km^3/year[(112)]. Glacial rivers participate in R. Enguri runoff formation up to the village Khaishi, after which R. Enguri runoff is regulated by the Jvari Reservoir.

[113] Gobejishvili, Kotliakov – Glaciology, Tbilisi 2006. P. 226 (in Georgian)

Table 4.7.3. Characteristics of the glaciers of River Enguri basin (113)

Glacier	River Basin	Length km	Area km^2	Height of the end of tongue	Morphology	Exposition	Years of retreat of tongue length/ in km
Shdavleri	Neskra	3.35	2.28	2 690	Gorge	Northern	
Kharikhra	Neskra	2.7	2.6	2 300	Gorge	Northern-East	
Nakra	Nakra	2.8	1.76	2 750	Gorge	West	
Leadashti	Nakra	2.7	1.72	2 740	Gorge	Northern-West	
Dolra	Dolra	5.9	8.0	2 600	Gorge	Northern-East	
Ushba	Dolra	5.75	9.4	2 430	Gorge-complex	West	
Qvishi	Dolra	8.4	19.14	2 460	Gorge-complex	Southern-East	
Tsaneri	Mulkhra	10.55	28.70	2 520	Gorge-complex	West	
Tviberi	Tkviberi	7.8	23.0	2 200	Gorge-complex	Southern	1889-1987. 4.340
Kvitlodi	Tkviberi	7.0	11.9	2 340	Gorge		
Lekhziri	Mestia Chala	12.0	35.6	2 020	Gorge-complex	Southern	
Chalaati	Mestia Chala	7.8	9.7	1 800	Gorge	Southern	1974-2011. 0.436
Adishi	Enguri	7.4	10.0	2 420	Gorge	Southern-West	
Khalde	Enguri	7.8	10.3	2 550	Gorge	Southern-West	
Shkhara	Enguri	4.7	5.4	2 540	Gorge	Southern	

Characteristics of glaciers given in Table 4.7.3 (length, area, height of the end of tongue), are got as a result of processing the LANDSAT satellite images of 2005. Following global warming all glaciers of southern slopes of Greater Caucasus are retreating, however the rate of retreat due to this process is differently revealed on each of them.

Good example of degradation of glaciers due to global warming, are glaciers of the **River Tviberi basin**. From the beginning of XIX century until second half of XX century, the glaciers in this basin were connected and used to develop complex glacier of the gorge. Their entire tongue was down to 2 030 m (Fig. 4.7.2[114]). On the topographic map of 1890 glacier Tviberi is represented as an entire system (its area was 43.1 km^2, length - 10.24 km). Decoding of aerial photography images of 1959-1960 and analyses of topographic maps of the same period, demonstrated that glacier Tviberi has changed a lot. In 1890-1960 its length was reduced by 2.14 km and area by 3.0 km^2. From the left side of glacier developed its biggest branch – Kvitlodi, which became independent glacier. To date the tongue of Glacier Kvitlodi is in 800 – 900 meters from the Glacier Tviberi and ends at 2 290 m. 5 small glaciers are also separated from Glacier Tviberi system – Seri (Fig. 4.7.2), Asmashi, Toti, Iriti, Lichati. Distance between the tongues of glaciers is 200–500 m.

[114] Tielidze L. Glaciers of Georgia 2014, p 171 (in Georgian)

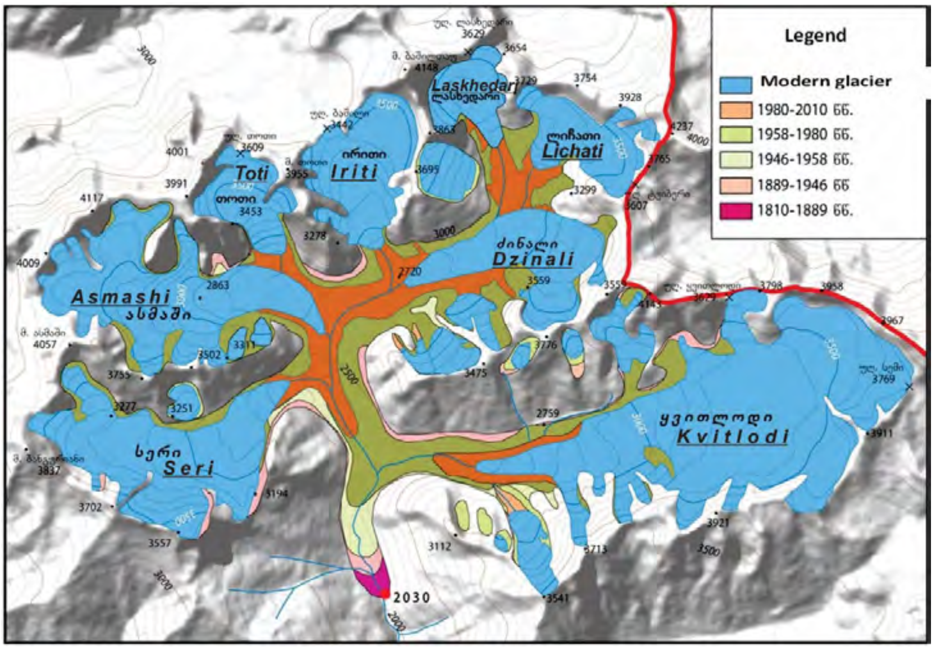


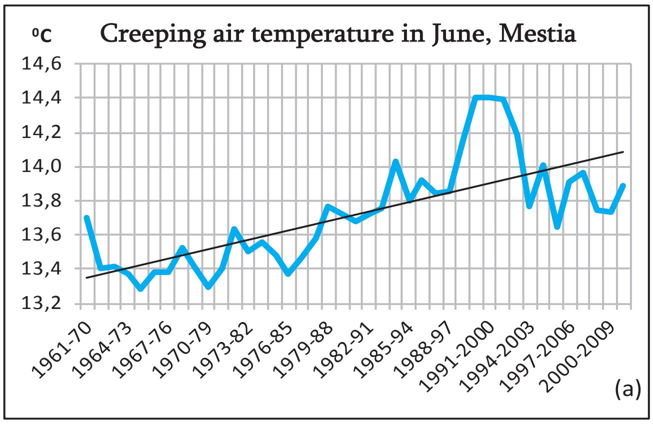
Fig. 4.7.2. The retreat of Glacier Tviberi in 1810-2010

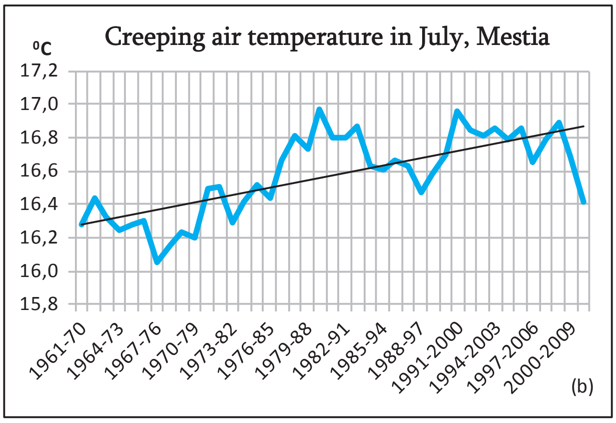
Elevation of neve line gives interesting picture. From 1889 to 1960 glacier snow line moved by 100 m on glacier Tviberi, and from 1960 to 1987 - by 50 m, in 1987-2010 by additional 50 m.

Photo 4.7.2 Glacier Seri, 2011

The retreat of glaciers (because of ablation) is conditioned by high temperature, mainly in summer. Since there are no series of continuous meteorological observations on any of the glaciers of R. Enguri basin, study of air temperature regime is possible only based on the data of Mestia weather station.

For this purpose a chart was developed, providing information of temperature changes on Mestia weather station in 1961-2010 (Fig. 4.7.3), which in all three months of summer showed rising trend. In July this was especially sharply revealed in form of two rising cycles in 1976-1985 and 1982-1991 as well as in 1990-1999 and 2001-2010.





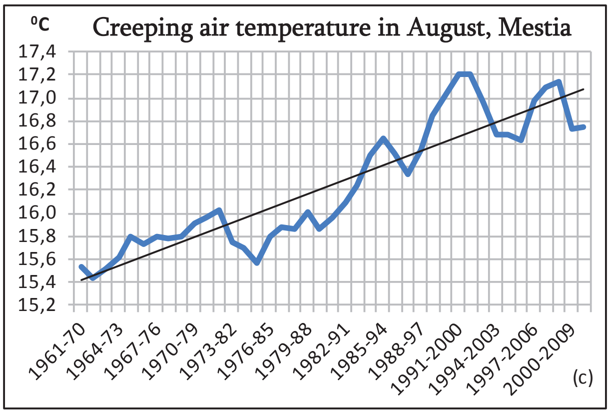


Fig. 4.7.3. Shifting decadal of air temperature in Mestia in June (a), July (b) and August (c)

Presumably in this period air temperature regime had similar trend in glacial district of Enguri River basin, that is proved by the data of glacier Chalaati: the retreat recorded in 1974-1988, which compiled 182 m, corresponds to decades from 1976-1985 to 1985-1994; and step back by 69.0 m recorded in 2004-2011 – to decade 2001-2010; and the results of observations on glacier Tviberi in the same period: retreat by 50m in 1987-2010.

River Enguri basin is distinguished by morphological diversity of glaciers, however implementation of glacial hydrometeorological studies is more reasonable on gorge type glaciers, due to which the glacier of river Mestiachala basin – Chalaati was selected.

Glacier Chalaati

The only representative glacier in the Enguri river basin, on which in different years (1959, 1960, 2000, 2011) complex glacial hydrometeorological studies were conducted – is Chalaati. It is representative due to following factors:

1. It is only glacier in South Caucasus, which is penetrated in forest zone and is relatively easily accessible;
2. It is easier to implement glacial hydrometeorological studies on this glacier due to its favorable morphological and morphometric characteristics;
3. Glacier Chalaati with its geomorphological, meteorological, glacial conditions and dynamics is representative for glaciers in the R. Enguri basin.

Glacier Chalaati – is complex glacier of gorge and consists of two flows. It is located in R. Mestiachala basin and is fed from the slopes of more than 4 000m peaks: Ushba, Chatini, Cavkasi and Bzjeduki. It comes to the lowest point among the glaciers on Greater Caucasus slope, and penetrates to the forest. The area of glacier is 9.7 km^2, length - 7.8 km. On its left flow (Photo 4.7.3) icefall is developed, which points to existence of cross-bars under glacier terrain. The height of the strongest icefall is 300 meters, width – 600 meters (Photo 4.7.4). Lower two icefalls are relatively small. In the area of icefalls the tongue of glacier is covered by trenches of different direction.

Photo 4.7.3. Left flow of the Glacier Chalaati, 2011 Photo 4.7.4. Upper icefall of Glacier Chalaati, 2011

During the last stage of glaciation (XVI-XIX) the tongue of the glacier Chalaati in 1 810 descended down to 1 620 meters (Photo 4.7.5), as evidenced by erratic boulders and stage moraines existing in the gorge. In 1 810-1 960 the length of glacier was reduced by 1 500 meters, and area- by 2.3 km^2. (In 1960 area of glacier was 12.3 km^2, length - 8.0 km) In 1970-1973 the glacier was stable and slight step forward was observed (1-2 meters). In this period many glaciers of Caucasus were stable, to which is associated formation of stage moraines.

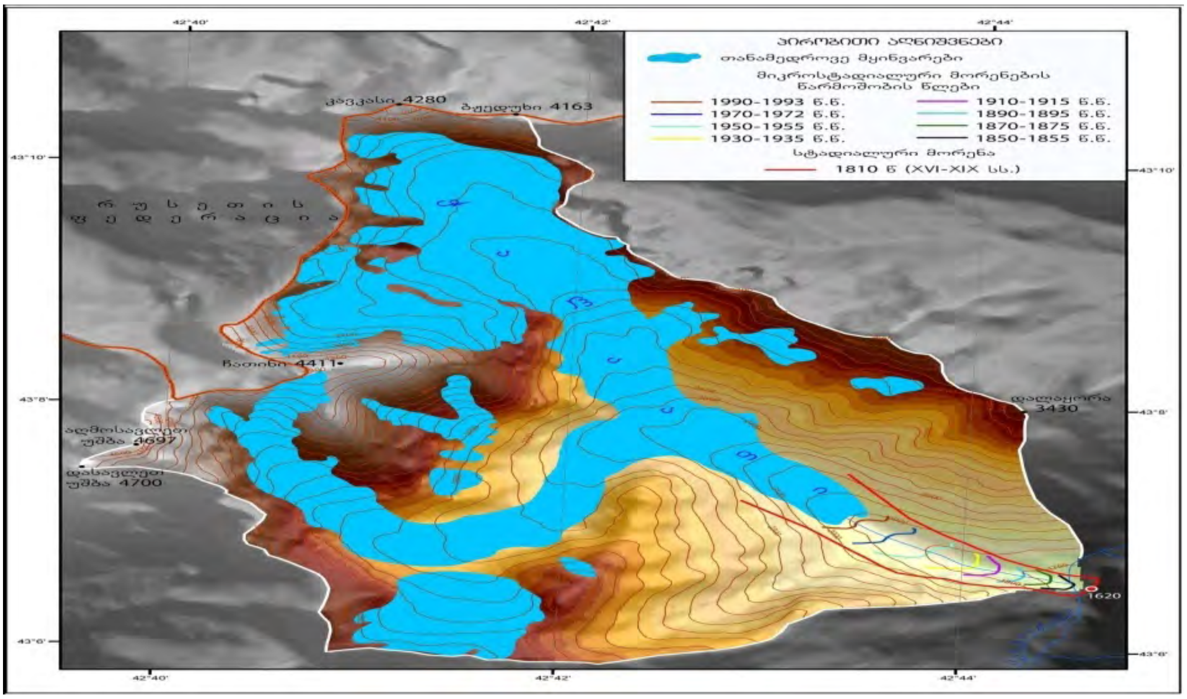


Photo 4.7.5. Dynamics of Glacier Chalaati in 1810-2011

As a result of measuring receding of glacier by labeling method, it was revealed that since 1974 to 2011 tongue of the glacier retreated by 436 meters (11.8 m/yr). Receding by single parts is shown in the Table 4.7.4.

Table 4.7.4. Dynamics of Glacier Chalaati tongue according to labeling method

Years	Glacier's movement
1970-1973	Stationery and insignificant increase (1-2m)
1974-2011	Retreat by 436 m i.e. 11.8 m/yr
1974-1988	Retreat by 183 m i.e. 13.0 m/yr
1988-2004	Retreat by 184 m i.e. 11.5 m/yr
1989-1995	Advancing in total 15 m i.e. 2.5 m/yr
2004-2011	Retreat 69.0 m i.e. 9.0 m/yr

In 2011 comparison of the surveys conducted by the Institute of Geography at Tbilisi State University and satellite images of 2010 (Photo 4.7.7) to topographic map of 1960 demonstrated that Chalaati has significantly changed during this period. Satellite image clearly shows that both flows of the glacier are still interacting. Right flow has visibly changed, two glaciers were separated from it, one located on Chatini slope of 1.0 km^2 and another from right side of 1.5 km^2 (Photo 4.7.6). In this period the tongue of glacier has reduced by 0.15 km^2, in total the area of glacier was reduced by 2.6 km^2. Number of glaciers is reduced by two.

Photo 4.7.6 Right flow of Glacier Chalati - 2011 Photo

4.7.7 Satellite image of Glacier Chalaati, 2010

Ablation processes on the surface of glacier and under it provide main source for glacial river runoff. Thus, levels and streamflow of such rivers depend on regime of the glacier, which is reflected on seven years distribution. Basic runoff of such rivers take place in summer months, special abundance of water is common in spring, when snow accumulated during the winter in gorge starts to melt. Later, from July ice starts to melt, and this process continues until October.

Basic part of seven years runoff of river Chalaati is originated namely from glacial flow. Hydrological observations demonstrated that in 2011 1 mm ablation of glacier developed 12 100 m^3 water. The results of observation in 1959 showed 9 100 m^3 water per 1-mm melting. As made out, during 50 years from 1959 to 2011 area of Glacier Chalaati was reduced by 2 km^2 and runoff has increased by 3 000 m^3 per 1 mm of ablation.

At the background of global warming, it is difficult to assess degradation of glaciers based on the data of one particular glacio-hydrometeorological study. Consequently, for assessment of dynamics of the glaciers of River Enguri basin for upcoming 100 years, the results of the studies of previous period should be used.

4.7.2 Assessment of global warming impact on R. Enguri runoff

Under the impact of global warming, which became significantly intensive after 1980s in all regions of the world, including central part of the Caucasus Range, degradation of glaciers is obvious[(109)]. In conditions of melting and retreating of glaciers runoff of the rivers of glacial feeding is being increased[115]. At the same time, this process causes decrease of runoff, due to the reduction of glaciers areas and ice supply, which after total melting of glaciers will be transformed into runoff of atmospheric precipitation and underground nourishment. Besides, change of the latter is possible together with disappearing of the last glaciers. According to the latest assessments[116], in conditions of projected increase of current pace and temperature this mountain system will be released of ice cover by 2150 – 2160.

River Enguri occupies distinguished place in hydro energy development plans of Georgia that is conditioned by the existence on this river of the biggest hydro power plant in the Caucasus region – the Enguri HPP and possibilities of using its water resources in future. All typical components of runoff: underground, glacial, snow and rain participate in the formation of total annual runoff in River Enguri basin. According to data provided in the paper[117], their contribution to full runoff of the river is distributed as follows (Table 4.7.5).

Table 4.7.5. Distribution (rates) of components of total annual river runoff in Enguri River Basin

River-post	Watershed area, km^2	Average height of basin, m	Annual Runoff Rate, %				Annual Runoff million m^3
			Underground	Glacial	Snowy	Rainy	
Engury-Latali	1 000	2 570	23.7	39.5	28.7	8.1	1 415
Enguri-Lakhamula	1 370	2 520	23.6	33.0	27.4	16.0	1 920
Enguri-Dizi	1 620	2 490	21.8	25.7	38.3	14.2	2 250
Enguri-Jvari	3 170	2 220	30.0	21.0	32.0	17.0	4 670
Enguri-Darcheli	3 660	2 020	34.7	16.8	25.9	22.6	5 300
Mulkhra-Latali	435	2 680	19.0	53.0	13.0	15.0	672
Nenskra-Lakhami	468	2 270	26.2	19.3	40.2	14.3	959

***** Data provided in the table are based on measurements made in 1931 – 1968***

As demonstrated by this Table, underground runoff along the River Enguri flow is being increased from about 24% to 35%, and the share of glacial runoff is being decreased from almost 40% to 17%. The Table shows that in Upper Svaneti including hydrological checkpoint Jvari, snow (on the average 32%) and underground (30%) components are dominating in runoff.

Since, during the last decades glaciers in Enguri River basin are significantly transformed due to global warming[118], assessment of forecasted changes impact on Enguri runoff became really interesting. According to the data [(119)] of 1931 - 1968 share of glacier runoff on different hydrological checkpoints in the middle of Enguri River and its tributaries was changing within 20.0-47.2% and on the average compiled 27.3% (table 4.7.6). According to other data[(112)], based on measurements done on Khaishi hydrological post on R. Enguri (at this point the area of watershed is 2 780 km^2, average height - 2 320 m, glaciation 288 km^2), share of glacial runoff in annual runoff compiles 26.2%. Providing that this last number describes data for longer period on the checkpoint where all glacial runoffs of the rivers in Enguri basin are collected, the value characterizing 80s of the last century could be considered as 26.2%. The data on glacial runoff of the River Enguri are obtained in 1958-1976, as a result of expedition works of the Institute of Hydrometeorology, the Institute of Geography and Hydrometeorological Department of the NEA, and are provided in the papers.[119,120,121]

[115] Climate Change 2007. Impacts, Adaptation and Vulnerability, IPCC, 2007, p.44.
[116] Tsomaia V. et al. Dynamics of glaciations in Caucasus and forecasts for dissapearing of glaciers . Transactions of Institute of Hudrometeorology. 2013, volume 119, pp. 197-203. (in Georgian)
[117] Vladimirov L., Shakarashvili D., Gabrichidze T. Water Balance of Georgia. "Metsniereba" , Tbilisi, I974, p. 144 (in Russian).
[118] Janelidze P. Assessment of the role of glaciers in Georgia's river runoff formation. National Agency of Climate Change, Tbilisi, 2000 (in Georgian)
[119] Tsomaia V.Sh. Calculation of Glacial Runoff Rate in Glacial Feeded Rivers of Georgia. IZV. Academy of Science of USSR, Geography, № 5, 1963. (in Russian)
[120] Vladimirov L.A., Glacial Feeding of Georgia's Rivers. Academy of Science of USSR, Geography, № 5, 1963. (in Russian)
[121] Tsomaia V. Sh. Consideration of Glacial Rate in Calculation of Liquid Runoff of Glaciers. Proceeding of Glaciological Research, issue 25, 1976, p. 77-83. (in Russian)

Since 90-es of last century, systematic observations on R. Engury runoff were terminated on the checkpoint Khaishi, due to which assessment of the change as a result of global warming is possible only with indirect data. In particular, in 2000, under the support of USAID the National Agency on Climate Change conducted complex measurements on 4 glaciers of Enguri River (Chalaati, Lekhziri, Kvishi and Dolra(118)). However share of this runoff in seasonal runoff of the river was not determined due to technical reasons. Despite of this, in four (4) months period of ablation certain important regularities, which together with the data obtained last year give possibility to assess in the first approximation expected correlation of Enguri River water resources with forecasted process of global warming.

Table 4.7.6. Glacial runoff * in Enguri river basin [122]

River –Check Point	Watershed area, km ^{2}	Glaciations, km^2	Glacial runoff	
			Million m^3 per year	Total annual %
Enguri-Lakhamula	1 370	232	614	33.0
Enguri-Dizi	1 620	250	741	28.9
Enguri-Purashi	3 170	302	942	20.0
Mulkhra-Latali	435	141	278	47.2
Neskra-Lakhami	468	32.9	177	20.2
			Average	27.3

**** Glacial runoff consists of 2 components. First is so called "grotto water" coming out from the end of glacier during the year, to which in summer – ablation period is added second component produced as a result of melting the surface of glacier. In summer the latter is significantly dominating the first component.***

According to the results obtained within the frame of Third National Communication of Georgia on Climate Change, it is expected that average annual temperature will be increased to 2 100 by 3.7 ^{0}C in Upper Svaneti region, which includes upper part of Enguri river basin, compared to average of the period 1986-2010. This will undoubtedly impact geometrical sizes of the basin glaciers and glacial runoff. For approximate assessment of this impact, available data on degradation of the basin glaciers and measured and projected changes in the region are used.

According to data provided in above mentioned paper(112), 250 glaciers were recorded in Enguri basin by second half of 20th century, total area of which compiled 288.3 km$^{3.}$ Majority of glaciers (73%) were of small size and their area was not more than 0.5 km^2. Among relatively big glaciers were distinguished the following: Lekhziri (38.1 km^2), Kvishi (13.8 km^2), Chalaati (13.2 km^2) and Dolra (8.8 km^2). Glacial runoff of the rivers: Nenskra, Nakra, Dolra, Mestiachala, Mulkhra and others is collected in checkpoint of Khaishi, where according to 1937-1980 data average annual runoff of Enguri compiled 110 m^3/s, and full annual runoff - 3.465 km^3. Taking into consideration glacial runoff share (26.2%), average annual glacial runoff of Enguri River in this period was equal to 0.908 km^3, or 908 million m^3.

According to the same paper (112) in the period of 1890-1965 total area of glaciers in Enguri river basin was reduced from 332 km^2 to 288 km^2, which compiles 13% reduction. This process is in compliance with degradation observed globally, which from 1890 continues with increasing pace in different regions of the world[123].

Since in Mestia the observations started just in 1936, for assessing relation of reduction of glaciers area with increase of temperature in this period, the data of Kutaisi – the closest weather station in the region, with long term series of observation, were reviewed. According to mentioned data, average annual temperature between 1906-1913 and 1954-1963 sub periods has increased by 0.3 ^{0}C[124]. Analyses of the data available in the De-

[122] Vladimirov L.A. Water Balance of Great Caucasus."Metsniereba" Tbilisi:, I970. (in Russian)
[123] Climate Change 1995.The Science of Climate Change. IPCC, 1996, p. 371
[124] Beritashvili B. Kapanadze N. Chogovadze I. Assessment of climate response to global warming. Institute of Hydrometeorology, Tbilisi, 2010, p 59. (in Georgian)

partment of Hydrometeorology demonstrated that in 33 years period from 1959 to 1991 value of correlation coefficient between annual temperatures on Kutaisi and Mestia weather stations complies 0.882. This makes it possible to consider that in the first half of 20th century annual air temperature in Upper Svaneti also has risen by 0.3 ^{0}C, causing the relevant reduction of area of glaciers in Enguri River basin.

In the first half of 20th century the trend of stable increase of temperature was observed, in general on the whole territory of the continent of Europe. According to fourth report of IPCC[125], in the period of 1906-1950 the increase compiled 0.4 ^{0}C. Taking into consideration that Georgia is located on bordering territory of Asia, where in the same period increase was 0.2 ^{0}C, it could be said that our assessment is in compliance with the results got on international level.

Thus, reduction of the area of glaciers in Enguri river basin as a result of warming, could be based on the circumstance that in the period of 1890-1965 total area of glaciers in the basin was reduced by 13%, followed by the increase of average annual temperature by 0.3 ^{0}C in Upper Svaneti region.

Analyses conducted in the Third National Communication, demonstrated that in half-a-century period of 1961-2010 average annual temperature has increased by 0.3 ^{0}C at weather station Mestia. If we assume that duration of this period is nearly the same as above mentioned 1906-1963 period and in both cases increase of temperature is 0.3 ^{0}C, we can assume that 13% reduction of glacier area recorded in the first period was with the same pace continued in the second period of 1961-2010. In this case value of last century - 288 km^2 will be reduced to current probable-251 km^2, while glacier runoff will be proportionally decreased from 908 million m^{3}to 790 million m^3 annually.

As for future assessment by 2100, according to climate forecasts increase of average annual temperature by 3.7 ^{0}C compared to average of 1986-2010 is expected by 2100 in Upper Svaneti. According to forecast increase of temperature is expected to be slower by 2050 (1.2 ^{0}C), and by the end of century in higher (2.5 ^{0}C). In case of such increase of temperature in the period of 2010 -2100, for this term we could take about half of projected increase - 1.8 ^{0}C as average value of increase of temperature. This value in mentioned period of time (2010-2100) contains six 0.3 ^{0}C increases and if we assume that 0.3 ^{0}C increase of temperature at each stage is followed by 13% reduction of the area of existing glaciers, we'll get that by 2100 current probable area of glaciers in Enguri basin (251 km^2) will be reduced down to 108 km^2 (57%) (Fig. 4.7.5). Consequently, annual glacial runoff in the basin will be reduced from probable 790 million m^3 to 340 million^3 without taking into consideration additional ablation of glaciers.

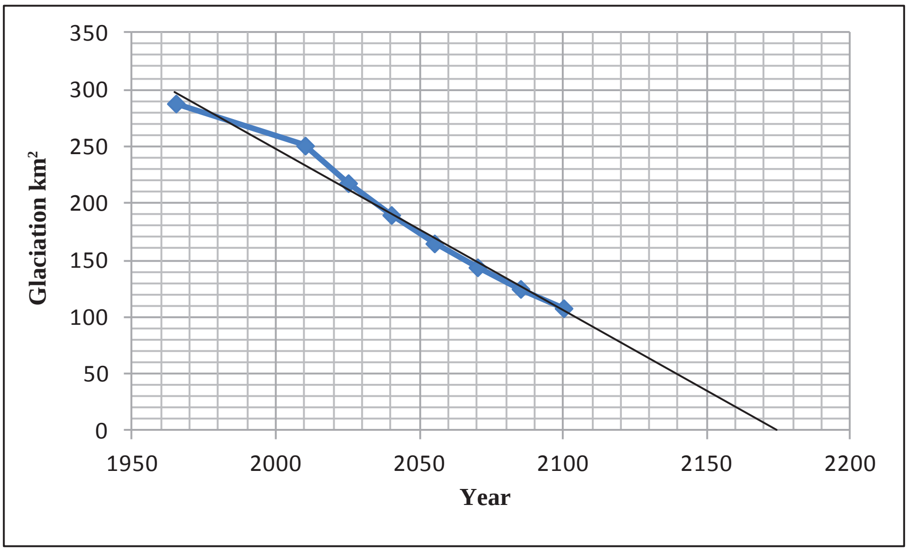


Fig. 4.7.4. Presumable dynamics of glaciation decrease in the R. Enguri basin based on accepted assumptions

125 Climate Change 2007.The Physical Science Basis. IPCC, 2007, p.11

Given drawing demonstrates that in conditions of adopted assumption, which mean increase of temperature on the average by 0.3 ^{0}C every 15 years and consequent reduction of glaciers' area by 13% compared to every previous period, the extrapolation of developed curve brings expected disappearance of glacial cover in R. Enguri basin by 2170-2180. This result is close to the forecasts provided in above cited paper[116].

While studying dependence of glacial runoff on temperature, one of the key issues is connection between ablation of glacier cover with air temperature. This process is normally characterized by the change of the height of glacier surface, due to the change of average daily temperature by 1 ^{0}C. Besides temperature the process is significantly influenced by the condition of the glacier surface (whether it is covered by moraine debris) and its exposition, solar radiation, wind, precipitation and so on. Average rate of ablation[119] per 1 ^{0}C increase is 6.5 mm in conditions of the Caucasus. The results of measurements[126], done on the Chalaati glacier in 1959 actually coincide with this value, (see Table 4.7.7)

Table 4.7.7. Correlation between melting and average daily temperature on the Chalaati glacier, 1959

Mean air temperature at the glacier, ^{0}C	3	4	5	6	7	8	9	10	11	12
Daily melting, mm	7	11	16	22	29	37	45	55	62	80

In 1960s extreme heights of Chalaati glacier compiled 1 890 and 4 330 m. The weather station characterizing these heights is Mamisoni Pass located in neighboring region (2 854 m), where in 1932 – 1960 average temperature of the warmest months – July and August was 7.3 and 7.6 ^{0}C, and average maximum - 11.7 and 12.1 ^{0}C respectively. Thus, if we consider that temperature range of ablation period on the Chalaati is 4-12 ^{0}C, then 7 mm increase of ablation will correspond to the increase of temperature by 1 ^{0}C. Obtained result was confirmed by further measurements conducted on the Chalaati by the Institute of Geography in 1960[127].

Following connection[127] between ablation period on Chalaati glacier and glacial runoff (Table 4.7.8) has been derived.

Table 4.7.8. Correlation between surface ablation and glacial runoff, Chalaati glacier, 1960 [127]

Period	Surface melting, cm	Average rate of melting, cm/day	Glacier runoff, Million m^3	Runoff 1 mm melting, thous. m^3/mm	Avg. temp. deviation from the norm in Mestia, ^{0}C
09.07 – 01.08	186.2	8.4	18.417	9.9	+0.8
01.08 – 01.09	229.4	7.4	19.094	8.3	-1.6
Total	415.6		37.511		
Average		7.9		9.1	-0.4

Runoff was measured on 300m lower from the tongue of glacier.

The Table demonstrates that on the Chalaati glacier in ablation season of 1960, on the average 9 100 m^3 of runoff was formed per 1mm ablation, naturally this includes runoff of glacial grotto water as well.

It is to be mentioned that average monthly temperature of July and August in 1960 was 17.2 and 14.7 ^{0}C respectively, that was by 0.8 ^{0}C less than climate norm of July, and by 1.6 ^{0}C less than norm of August. So it could be explained 16% less runoff per 1mm ablation in August compared to July.

Next series of glacial and hydrometeorological observations on Chalaati glacier was conducted in 2000. Measurements were underway during 4 months period of ablation from 16 June to 15 October. The results associated with glacial runoff are demonstrated in Table 4.7.9.

[126] Tsereteli D. and others. Glaciological observations on Chalaati and Lekhziri glaciers (Upper Svaneti) in spring of 1959; Vakhushti Institute of Geography; Papers volume XVII, 1962, p. 223-255 (in Georgian).
[127] Shengelia R., Chijavadze M. Regime of Chalaati glacilal river in summer 1960. Vakhushti Institute of Geography; Papers volume XVIII, 1963, p. 245-253 (in Georgian).

Table 4.7.9. Features of ablation period on Chalaati glacier in 2000

Period	Total average ablation , cm	Average rate of ablation, cm/day	Average glacial runoff, m3/s	Glacier runoff, million m^3	Runoff per 1 mm ablation, thousand m^3/mm	Mean temperature deviation from norm in Mesria, ^0C
16.06 – 05.07	138	6.9	7.1	12.269	8.9	+3.8
05.07 – 01.08	218	8.7	8.4	18.144	8.3	+4.9
01.08 – 01.09	188	6.1	10.9	29.194	15.5	+1.6
01.09 – 15.10	218	4.8	5.8	22.550	10.3	+0.4
Total	762			82.100		
Average		6.6	8.0		10.7	+2.7

The runoff was measured 1.5km down from the tongue of glacier.

Data provided in the Table demonstrate that ablation season 2000 in Upper Svaneti was characterized by abnormally high deviations in temperature, average value of which compiled +2.7 ^0C. For comparison it could be said that temperature anomaly of July- August in 1960 equaled to 0.4 ^0C, and in 2011 to +1.4 ^0C as given below. This could explain the fact that in 2000 runoff of Chalaati glacier in ablation period on the average compiled 10 700 m^3 per 1mm, which is by 18% higher than indicator of 1960. It is important that in July – September of 2000, average stream flow on water of the river Mestiachala (running from the glacier Chalaati) (38.2 m^3/s) by 26% exceeded the norm of the same period.

Based on the results of observations conducted in 2000 on the glaciers in Enguri basin, according to the conclusion made in the report[118], in ablation period water flow and air temperature correlate in the basins of single rivers, while role of precipitation is less important. Besides, far from glacial feeding source the role of precipitation increases (river Mestiachala – borough Mestia). According to the IPCC[125], flow of water on the rivers with glacial feeding mainly is determined by air temperature.

Last glacial and hydrometeorological expedition on glacier Chalaati was conducted in 2011, by the Institute of Geography of Tbilisi State University. Measurements of ablation, glacial runoff and meteorological elements took place in July – Augist and the results are provided in Table 4.7.10.

Table 4.7.10. Chalaati glacial runoff measurements results, 2011

Period	Total average ablation cm	Average rate of ablation, cm/day	Average glacial runoff, m3/s	Glacier runoff, million m^3	Runoff per 1 mm ablation, thousand m^3/mm	Mean temperature deviation from norm in Mesria, ^0C
08.07-14.07	74	12.3	15.5	8.035	10.8	
14.07 – 20.07	56	9.3	14.6	7.569	13.5	+2.1
20.07 – 28.07	71	8.9	14.7	10.161	14.3	
28.07-04.08	73	10.4	15.1	9.132	12.5	
04.08 -14.08	97	9.7	9.7	8.381	9.6	+0.6
14.08-23.08	56	5.6	8.4	7.258	13.0	
Total	427			50.536		
Average		9.4	13.0		12.1	+1.4

The runoff was measured 500m below the tongue of glacier

Comparison of obtained data with the results of two previous expeditions, demonstrates that characteristics of ablation on the Chalaati Glacier have increased. In particular, if in the previous seasons average rate of ablation ranged 7-8 cm/day, in the last season this value exceeded 9 centimeters a day. The same could be said about glacial runoff per 1mm, which has increased from 9 100 m^3/mm in 1960 to 12 100 m^3/mm in 2011. It seems that this circumstance is associated with the increase of the glacier degradation rate, that is reflected in the reduction of its size and increase of moraine cover on its surface.

The results of field studies conducted on Chalaati glacier during last half-a-century give a possibility to assess expected impact of climate warming on the runoff of Enguri River. This assessment will be based on the same assumptions which were used above for the assessment of expected changes of glaciers' area.

In particular, if the increase of ablation on the glacier by 7 mm corresponds to 1 ^{0}C increase of daily air temperature, consistent increase of temperature by 1.8 ^{0}C in 2010-2100 will cause increase of ablation from Chalaati glacier to 12.6 mm per day. During 4 months period (120 days) this will give 120x12.6 mm = 1 510 mm ablation increase. For average ablation of 7 620 mm recorded on Chalaati in 2000, this value will give 20% increase. If we assume that in the Enguri basin this result could be spread on all glaciers, then in 2010-2100 the rise of temperature by 3.7 ^{0}C could increase runoff by about 20% as a result of ablation. Finally, this result will cause compensation of almost 60% decrease of glacial runoff by 2100, compared to 2010, not by 60 but by 40%. With this respect, instead of 908 million m^3 existed by the middle of 20th century and 790 million m^3 assessed for 2010, the reduction of glacial runoff by about 790x0.4=320 million m^3 will be expected for 2100 and respectively its reduction to about 470 million m^3 per year. This will correspond to almost 14% decrease of average annual runoff on checkpoint Khaishi on the river Enguri compared to the last century and 52% decrease of glacial runoff.

In the middle of last century total annual runoff determined for hydrological post of Khaishi was 3.465 km^3 which without glacial runoff compiled 2.557 km^3 of atmospheric precipitation and underground feed runoff. According to above assessment, glacial runoff will be about 0.470 km^3 by 2100. Taking this into consideration, full runoff of the river Enguri to 2 100 might be reduced up to 2.557+0.470 =3.027 (km^3/year), which compiles 87% of runoff existing by the middle of 20th century.

Thus, as a result of global warming 40% reduction of glacial runoff is expected by 2100, compared to the level of 2010, which will be reflected in 13% decrease of annual runoff characterizing the river Enguri for the middle of last century on checkpoint Khaishi.

Assumptions made in assessment

Assessments of changes of glaciers' areas and glacial runoff in the basin of River Enguri are approximate and are based on certain assumptions, which are the source of uncertainty. First assumption refers to proportional reduction of total area of glaciers with the same value after 1961 as a result of global warming, which was recorded in 1890-1965. Basis for this assumption is an opinion that due to invariability of physical and geographic conditions in glaciers area, response of glaciers to warming in following periods might be similar to previous periods. However, together with gradual reduction of areas occupied by glaciers and change of radiation features of terrain this opinion becomes less realistic, but we still have to use it since there is no other data.

Second assumption refers to proportional relation between glaciers area and glacial runoff in the basin of River Enguri. Due to lack of data of observations on glaciers balance, this assumption might be considered as reasonable, however in detailed studies relation of this proportion to height, size, exposition, genetic type, terrain and other factors for each glacier should be taken into consideration. For determining annual change of glacier mass balance, weather station should function near the glacier, hydrological observations should be conducted on the runoff and glaciological observations should be provided on the glacier.

According to third assumption the results obtained for glacier Chalaati on the connection between the volume of ablation and volume of runoff were disseminated to whole territory of glaciations in Enguri river basin. Obviously, this assumption is quite arbitrary, since Chalaati glacier is third by size in Enguri basin, while majority of glaciers are much smaller and consequently transfer of regularities adopted for Chalaati is disputable.

Despite of this we have to admit this assumption due to the lack of observations on other glaciers, as well as the assumption on reasonability of connection between increase of ablation by 7 mm and the increase of air temperature by 1^0C during whole period of ablation.

It is to be mentioned that in the reports of studies conducted on Chalaati glacier in 2000 and 2011, term “ablation” is similar to surface melting, which is related to ignoring of evaporation from the surface of glacier. In ablation period in conditions of strong winds this assumption could cause big error, however in Upper Svaneti according to climate data this event is not frequent. At the same time ignoring evaporation is somehow compensated by inclusion of “grotto water” flow in glacial runoff.

For significant reduction of uncertainties caused by mentioned and other more important assumptions similar assessments should be conducted by means of model calculations, which will be based on satellite data on the number and size of glaciers in Enguri basin, experimental data on ablation of glaciers and formation of glacial runoff and relevant mathematical models.

4.8 Assessment of climate change impact on protected areas of Georgia

The status of protected areas excludes serious anthropogenic impact on natural ecosystems locally, due to which these territories represent the best indicator for determining climate change impact on the processes underway in these ecosystems including, their species and habitats.

In Georgia’s TNC climate change impact on protected areas was assessed on the example of protected areas of Ajara, while for Kakheti this issue was earlier studied in the SNC.

Table 4.8.1. Protected Areas of Ajara

<table>
<tr><th colspan="2">Protected Area</th><th>Year of Establishment</th><th>Category (IUCN)</th><th colspan="2">Area (ha)</th><th>Location</th></tr>
<tr><td rowspan="2">Kobuleti (Ispani) Protected Areas</td><td>Kobuleti Natural Reserve</td><td>1999</td><td>I</td><td>238.03</td><td rowspan="2">603.47</td><td rowspan="2">Kobulrty municipality, near town Kobulety</td></tr>
<tr><td>Kobuleti Managed Reserve</td><td>1999</td><td>IV</td><td>365.44</td></tr>
<tr><td rowspan="2">Kintrishi Reserve</td><td>Kintrishi Natural Reserve</td><td>1959</td><td>I</td><td>10 703</td><td rowspan="2">13 893</td><td rowspan="2">Kobuleti municipality, in the gorge of River Kintrishi, in 20-25 km from Kobuleti, amidst the village Tskhemlovani and Khino mountain. Lower border lies on 250-300 meters from the sea level, and upper zone is bordering high alpine meadows (2 600 m above sea level).</td></tr>
<tr><td>Kintrishi Protected Terrian</td><td>2007</td><td>V</td><td>3 190</td></tr>
<tr><td colspan="2">Mtirala National Park</td><td>2006</td><td>II</td><td colspan="2">15 806</td><td>Kobuleti-Chakvi Range newr the Black Sea (distance from the sea to the nearest point of the park is 12 km).
Territory of Kobuleti, Khelvachauri and Keda (small part) municipalities.</td></tr>
<tr><td colspan="2">Machakhela National Park</td><td>2012</td><td>II</td><td colspan="2">8 733</td><td>Basin of River machakhela; Territory of Khelvachauri and Keda (small part) municipalities.</td></tr>
</table>

Protected areas of Ajara, except for Kintrishi Reserve have short term history of functioning, which is not more than 12 years. Besides, “strict” status of Kintrishi Reserve, established more than half-a-century ago was too restrictive and in some cases even excluded implementation of monitoring or scientific research activities on its territory. Thus, scarce information available about biodiversity of protected areas does not give possibility for full identification of particular forms of climate change impact.

Temperature, precipitation and humidity changes underway during last two decades in the forests of Ajara, due to global climate change impact, were reflected on the sanitary ecological condition of forests. In recent time, increase of the areas of spread of old diseases and appearing of new diseases is observed in protected areas. Out of old diseases should be mentioned the following: chestnut cortex cancer, great spruce bark beetle, European spruce bark beetle, engraver beetle and bacterial wilt-causing fungi. Relatively new diseases are as following: horse chestnut leaf miner, Cameraria ohridella Deschka and most importantly, the box-fungal disease - leaf burn. During last 2-3 years mentioned box disease covered almost 60% of box-tree population of Kintrishi protected areas and Mtirala and Machakhela National Parks. More details on this issue are provided in the chapter discussing Ajara forests (4.4).

Historically, spring trout (together with its Black Sea salmon form) is the most widespread fish species in the rivers of Ajara – Kintrishi, Chakvistskali, Korolistskali, Machakhelis Tskali, etc. and consequently it is the most valuable object of local fishery. This was preconditioned by ideal hydrological characteristics of the rivers of Ajara for reproduction and growth of trout salmons. Recently reduction of these charismatic species is observed in the rivers of Ajara. According to experts this is due to illegal fishery. According to their assessments population of spring trout is almost 3 times reduced in the rivers of Ajara during last 20 years. Reduction is especially evident on the sections located up to 600 meters above the sea level. Majority of trout sections in the rivers of Machakhelas-Tskali, Kintrishi, Chakvis-Tskali and Korolis-Tskali are within the boundaries of protected areas (Mtirala and Machakhela Naitonal Parks, Kintrishi protected area).

Spring trout prefers cold water. Optimal temperature for it is 8-16 ^{0}C. For fry this value is even lower. This temperature regime preconditions concentration of oxygen in water, prependum of which corresponds to the interval 9.5-12.5mg/l.

Increase of temperature causes reduction of concentration of oxygen diluted in water, due to which in summer hot months (July – September) fish population in the rivers of Ajara moves to cooler places in upper parts of the rivers. As a result of this the space and food for population become limited, which the most of all damages young fish, due to particular behavior and cannibalism of this species. This is key factor causing the reduction of spring trout as a result of climate warming.

On the other hand, strong ecosystems developed on protected areas can well protect embankments and other territories from degradation and loosing as it was mentioned earlier.

Above mentioned data demonstrate that climate change can make significant impact on natural ecosystems of protected areas. According to the data given in Georgia's TNC, by the end of this century increase of average temperature by 2-4 ^{0}C and increase of precipitation by 5-10% are expected on the whole territory of Ajara. This change might significantly impact flora and fauna of protected areas of Ajara. In particular, areas the dissemination of diseases will be increased, which is especially dangerous for chestnut and box-tree populations. Presumably, climate warming will facilitate change of species composition, due to spreading of more heat-loving species as well as the change of upper boundary of forest in hundreds of meters could impose threat to trout populations. Taking into consideration mentioned danger, several project proposals were elaborated within the frame of the present report, aimed at the implementation of measures for restoring spring trout in big rivers of Ajara and for combating distribution of pest diseases in forests of Ajara.

At the same time, planning of the measures for mitigation of climate change impact and adaptation on protected areas of Ajara, should be preceded by the monitoring of biodiversity (species and habitats) and climate-induced processes in natural ecosystems on these territories, including: provision of joint observations on diseases of tree plants in close cooperation with forestry facilities of bordering regions (Guria, Samtskhe-Javakheti) and neighboring countries (Turkey); implementation of measures against plant diseases (biological and integrated) either on protected areas and nearby forests; establishment/extension of protected areas in localities with bio conservative value in Ajara (Tikery forestry district of Kobuleti municipality, Chirukhi areas of Shuakhevi municipality, basin of the rivers Londari and Didgele in Keda municipality, basin of the rivers Acharistskali and Kinkisha in Kintrishi protected area).

4.9 Impact of Climate Change on Historical Monuments of Upper Svaneti

General Overview

Natural conditions facilitate virtual isolation of Upper Svaneti from other regions of Georgia and neighbors from the North. This created the ground for the formation of original culture, which at the same time was developing under the influence of processes going on in Kolkheti. In V-VI centuries, after Christian religion was introduced in Svaneti, active process of building churches and other religious constructions started. The process has continued through the Middle Ages. During this period, due to difficult accessibility of the region, temples constructed in Upper Svaneti were used to rescue the national treasure from the invaders, attacking other regions of the country. This preconditioned accumulation of the samples of cultural heritage in the region, which, together with the original architectural monuments, gives Upper Svaneti the status of historical and architectural reserve.

Studying cultural heritage of Upper Svaneti started in the 1940-50s. However, there are also photos taken by Georgian and foreign travelers in XIX c. These photos provide important information about the condition of the monuments in those times. The photos made by Vittorio Sella in 1889-90, show the condition of churches, houses and towers. The covers of the towers are mostly not repaired. The roofs of the houses are in better condition and the domes of the churches are damaged.

Like in other regions with rich historical past (Egypt, Greece, Italy, India, China, etc.), in Upper Svaneti climate factors and extreme weather events (avalanche, landslide, abundant precipitation) negatively affect the condition of historical monuments, causing their damage and destruction.

If this is accompanied by anthropogenic loading (increase of rain acidity, construction of reservoirs, cutting forests, road construction, numerous tourists, etc.), the condition of the monuments worsens. In addition to religious buildings, Upper Svaneti is also rich in civil architectural monuments (towers) characteristic for this part of Georgia. Due to their identity, these towers are ethnographically very valuable. Naturally, climate factors negatively affect the towers too.

Due to diversity of the relief, the populated territory of Upper Svaneti is featured by different climate peculiarities. In terms of the influence of climate and its changes on the state of the monuments in the region, Mestia municipality is presently divided into three zones, which are situated on different altitude and distance from the sea and Enguri HPP reservoir.

First, the highest zone is located at 1 500-2 180 m from the sea level at the distance of 165-210 km from the sea shore. It includes four communities – Ushguli, Kala, Ipari and Tsvirmi. There are 385 monuments registered within this zone, among them 42 are religious, 330 – civil and protective, 13 – archaeological. Part of the villages in this zone is characterized by relatively warm and dry climate, which can be explained by well-chosen place in the gorges. Apart from the monuments, destroyed due to their age and lack of maintenance, their condition in the zone is assessed as medium; however, absence of roofs on the towers has caused damage and destruction of many of them. Situation is different with churches – they are well- groomed and majority of them even have well retained frescos. In this zone, the biggest impact on the poor condition of the towers was caused by impossibility of maintenance, which was conditioned by the lack of timber wood due to the fact that forests are quite far from the alpine zone.

Second, medium height zone, is disposed at 1 350-2 020 m from sea level and in 150-180 km from the seashore. This zone has the densest population and it includes 8 communities: Mulakhi, Mestia, Lenjeri, Latali, Tskhumari, Becho, Etseri and Pari communities. 573 monuments are registered within the zone, out of which 153 are religious, 404 – protective and civil and 16 – archaeological monuments. The condition of the monuments is diverse in different communities. Namely, in Mulakhi, Mestia, Lenjeri and Latali communities, majority of churches have roofs and are well maintained as well as towers. However, for integrity of the Svan complexes it is necessary to rehabilitate and maintain the Svan houses in the vicinity of many of the towers. In Chkhumari and Becho communities, churches are less preserved, majority of towers are not covered and are damaged. In Etseri and Pari communities, churches are in even worse condition, in Pari community many churches have turned into ruins. Situation is similar concerning the towers, majority of which require restoration.

Third, lower zone is at 500-1 500m from the sea level and in 80-150 km from the seashore and 0-55 km from Jvari reservoir. This zone includes 5 communities: Lakhamula, Nakra, Chuberi, Khaishi and Idliani communities. This is the poorest zone in terms of monuments: 62 monuments are registered here, out of which 18 are religious, 19 – protective and civil, 25 – archaeological monuments. The main part of material-culture monuments over the whole territory have turned into ruins or archaeological monuments. Samples of tower architecture have remained mainly in the relatively high part of the zone. No frescos have been preserved in churches. The situation within the zone seemingly has been caused by 2 reasons: it was easily accessible for invaders, who did not mercy historical monuments. In addition to that, its vicinity to the sea and in the last decades – to the large reservoir, conditioned high air humidity, which hastens deterioration of the monuments. Majority of the historical buildings in the third zone are fortification constructions and remains of antique metallurgical plants.

Thus, in total 1 020 material monuments of culture are registered in Upper Svaneti out of which 213 are religious and 753 – protective and civil monuments. In the higher and medium zones, majority of churches are well maintained but they still require restoration. This can be explained by the fact that during the last decades, majority of the population has moved into more comfortable houses, towers have lost their main function and are lacking attention. The main problem of the monuments is roofing, due to which rain and snow are damaging the interior of churches and walls of the towers. It is also important to mention that only an insignificant part of the monuments are damaged as a result of natural disasters (avalanche, landslide, heavy snow, etc.), since the population used to choose places for them with minimum risk. At the same time, the design of the monuments, particularly of the Svan Towers, is resistible to heavy snow and avalanches.

The area of the impact of extreme geological processes fully includes the territory of Upper Svaneti and it is natural that disastrous processes developing in the historical period have to certain extent touched the monuments of material culture like Svan Towers and houses – machvibs (machubs).

Among geological processes, in terms of negative impact on historical monuments of Upper Svaneti, the most wide-scale were expressions of the internal – endogenous forces of the earth – seismicity in the form of earthquakes. In the past, Svaneti several times has been in the epicenter of earthquakes. Historical monuments of cultural heritage have been affected by transit earthquakes, which are normally expressed in Svaneti in the form of 5-6-point earthquakes. Although the epicenters of the earthquakes were mostly in adjacent regions of Upper Svaneti, like in case of the 1991 earthquake in Racha, they have left significant trace on historical monuments of Svaneti. Apart from direct damage, constructions damaged by seismic shocks have become exposed to exogenic geological and hydrometeorological processes – snow avalanches. Widening of cracks on the walls of towers and houses, caused by seismic shocks and, as a result, further weakening of the constructions to destruction of the walls is the result of exogenic geological process – the weathering.

Many examples of Svan Towers and houses damaged by natural geological processes could be listed. Virtually, there is no historical settlement without a tower or a traditional house damaged to some extent. Sometimes towers are orientated on the slopes in such a way that they can avoid frontal hit of avalanche.

The reason for tower damage mostly is erosion processes on the slopes caused by water streams resulting from rain and melting snow. During heavy rains, water streams often grow into mudflow like it happened, for instance, in Mestia borough Lekhtagi district with a family tower (of Chartolanis). In 2008, study conducted within the framework of Mestia Tower Rehabilitation Project revealed the fact that for many centuries of existence, as a result of erosion and accumulative processes on the slopes, the walls of the towers were covered to the height of three meters from the foundation with clay and mud brought down the slope by mudflow. This fact illustrates the pace of accumulative processes in the anthropogenically transformed environment. Based on the artifacts found in the cultural stratum, the layer has been dated, based on which more than a half of the general thickness of the layer was considered to be created in the 20th century. Processes similar to the above take place in Seti, Lanchvali and Laghami areas of Mestia. Possibly the reason for destruction of one of the towers here was also a mudflow process. Besides Mestia borough, similar processes developed and are developing in Latali, Etseri, Lenjeri, Mulakhi, Kala-Ushguli and other settlements.

In the last decades, under the conditions of intensification of disastrous geological processes caused by climate change, which were illustrated by the natural disasters of 1987, 1997-98 and 2004, the risk of damage to historical monuments has increased.

In winter 1987, an unprecedented snowfall has been recorded in Svaneti. Practically in all gorges, there were avalanches, which damaged towers and old traditional houses – machvibs. Particular damage was inflicted to Ushguli and Mulakhi communities, where almost all the houses were damaged. Towers in Murkhmeli and Zhamushi were damaged and destroyed.

In the conditions of global climate change, which, according to forecast, in Upper Svaneti by 2050, will be distinguished by average annual and daily maximum, the increase of the scale of negative impact of mudflows and erosion processes on the slopes is expected. Due to that, the risk of damage of towers and other constructions has increased, which conditions the necessity of more responsible approach to the solution of these problems and urgency of preventive action plan development.

The rigorous climate of Upper Svaneti forced local architects to take maximum account of the impact of climate factors on architectural monuments. The fact that in the region churches of IX-X centuries have been preserved, points out those architects of the past fulfilled their task properly.

Churches

In the churches of Upper Svaneti, as well as in other buildings, walls are made of well-processed pumice and bladder stone, fixed with lime. Change of climate, frequent winds and rains affect lime first, washing it out and destroying with increased humidity. Humidity also badly damages frescos in the temples. That is why, while restoring the monuments, special attention should be paid to the enrichment of lime solution with modern admixtures to increase its resistance to humidity, application of modern technologies of roofing without breaking the monuments' authenticity and arrangement of drainage systems around the monuments to decrease humidity in the ground under the walls.

It must be noted here that in Svaneti, for roofing of churches and machubs, architects used shingle, however, in Ushguli community, they widely use also slate. Both shingle and slate are one of the oldest materials used in mountain regions of Georgia for roofing. This kind of roofing is very practical for heavy snowfalls – its surface is flat and slippery that prevents snow from retaining on the roof. If normal tiles were used here, it would make the construction heavier, snow would not slip from the roof and it wouldn't be even possible to clean the roof from snow.

Examples of churches typical for Upper Svaneti are given on the Photo 4.9.1.

The earliest churches in Svaneti are Nezguni Church in Lenjeri community (IX c), Chvabiani Church in Mulakhi community (IX-X centuries) and Matkhvarishi Church (X c). The churches are built of well-processed pumice. The construction of the churches is quite firm, that is why they have been preserved almost unchanged. Only their roofing has been substituted. Chvabiani Church has been recently restored – new floor was laid and drainage was arranged around the building that removed water from the ground around the walls.

Photo 4.9.1. Church Monuments of Upper Svaneti

The analysis of the condition of existing temples showed that in Svaneti, there are not much functioning churches, requiring significant constructional reinforcement. Restoration works in 1970-80s, as well as several years ago, involved rehabilitation of roofing and arrangement of drainage system to protect the building from moisture. These measures significantly improved preservation of the churches, but weather conditions and climate change still noticeably influenced the constructions, their frescos and items and icons kept in the churches. For instance, Iprali façade frescos were much better preserved in 1940-50s, than they are now. Same is the situation with Laghami Church facade.

Interior wall paintings are seriously damaged in Ienashi, Ipkhi, Chvabiani and Taringzeli churches. Frescos are darkened and exfoliated because of humidity.

It must also be noted that many easel painted and embossed icons are kept in Svaneti churches. Due to absence of microclimate regulating equipment in the churches, there are many cases of metal corrosion. Sharp changes in climate damage metal, as well as paint of frescos and icons. When it becomes colder and then warmer again, paint contracts and delates back, which results in exfoliation of paint.

Thus, it could be said that the condition of art pieces kept in Svaneti has deteriorated compared to the last century. However, restoration works that have intensified recently are directed towards termination of these processes and preservation of cultural heritage.

In the current century, in relation to global warming, due to expected acceleration of extreme climatic conditions and increase of the level of humidity over the whole territory of Georgia, the work for conservation of historical monuments in Upper Svaneti should be intensified, taking into consideration the experience of other countries with similar geographic conditions.

Towers

Towers play important role in creation of artistic and architectural image of Svaneti. By now, about 250 towers are registered in Svaneti, majority of which are situated within I and II zones.

Svan Tower represents a rectangular, firm, vertically developed monumental construction, narrowing on the top. Towers are mainly 4-5-storied buildings. Mostly, the top story is covered by arched crown (Photo. 4.9.2).

Photo 4.9.2. Examples of Svan Towers

Despite of clearly protective function, in case of emergency, these towers served as a residence and, sometimes, shelter for cattle. Presently, they are mainly used for subsidiary household industrial purposes, however, they haven’t lost their symbolic meaning, representing the pride of each family.

The walls of the towers are built of rock bladder stone and mortar, with cobble-stones and broken-stones reinforcing the lower part. This kind of construction material is quite resistant to climate change. The foundation of the tower represents a 3-4m high integral monolith volume, which ensures its seismic stability and resistance to avalanches.

Two-sided roofing of the tower is fixed to roof timber. Traditionally, wooden construction was covered by birchmat and then shingle or slate. Presently, under the roof, which preserves the authenticity of the tower, tin sheets are laid. If shingle is damaged, the latter protects the construction from water getting in and significantly increases the lifetime of the roof.

Despite of this, presently, restoration methods give preference to monument authenticity and use of traditional materials for restoration.

As a result of lack of maintenance and frequent rains, shingle and timber rot quickly, which leads to wetting of the tower walls and their destruction. There have been cases when towers were damaged by moisture getting into the walls not from the top but from the foundation.

Recent investigations have shown that foundations of many towers are quite wet. In such cases it becomes necessary to conduct geological study of the tower and by means of drainage or other method remove water from the foundation.

Machubi and Castle-house

Machubi is a two-story, usually right-angled house built of stone, used for dwelling and in winter as a stall. Nowadays, machubi has lost its residential function and is used only for keeping cattle stalled.

Another type of Svan residential house is a castle-house, or a tower house, which is encountered only in Ushguli. Castle-house is a three or four-story residential building, usually wider than a tower. Ground floor is a normal machubi with fire-place and stall. Middle floors are residential and the top floor combines protective and residential functions representing a very compact and effective construction. Like towers, this type of building reveals the impact of climate change in wetting and destruction of the walls in case of damage of the roof, which may also result from wetting of the foundation.

Recommendations for protection of historical monuments of Upper Svaneti and Georgia in general from negative impact of climate change are given in the Climate Change Strategy of Georgia (Chapter 3), and more detailed information is given in the Report on Adaptation of Upper Svaneti to Climate Change[128].

[128] http://www.ge.undp.org/content/georgia/en/home/operations/projects/environment_and_energy/enabling-activities-for-the-preparation-of-georgias-third-nation. html

5 Policy and measures for mitigation of greenhouse gas emissions

Introduction

Georgia is non-annex 1 country to the UNFCCC (United Nations Framework Convention on Climate Change). Thus, yet it doesn't have the quantified obligation to reduce greenhouse gas emissions from its territory. Nevertheless, in sight of ongoing international negotiations and expectations of the quantified mitigation obligation that the country has to pledge in 2015, GHGs mitigation has received the unexpected importance for the country. There are several ongoing processes of major importance in this direction:

- The Government of Georgia (GOG) develops a Low Emission Development Strategy (**LEDS**). The LEDS is intended to represent a long-term, whole-of-economy plan to reduce the growth of greenhouse gas (GHG) emissions while promoting economic prosperity. In December 2012 GOG signed memorandum of understanding with the Government of United States on collaboration on **LEDS**. Under this process USAID has funded the "Enhancing Capacity for Low Emission Development Strategies (EC-LEDS)" project which aims to support GoG in this process.
- Georgia is actively involved in preparation and implementation of projects for Nationally Appropriate Mitigation Actions (**NAMAs**). In the framework of this initiative the first project started in Georgia concerns the sustainable management of forests in sight of ongoing climate change. Within this projects 40ha forest should be planted, which will annually absorb 8 706 Tons of CO_2. This project is already registered by the governments of Georgia and Austria. The second NAMA project will install 10 000 solar water heaters and 10 000 energy-effective wood stoves, and establish mechanisms for MRV (Measurement, Reporting and Verification). The demonstration part, which will install 50 solar water heaters and 50 energy effective stoves is financed by EU, remaining investment is yet to be sought. The project is implemented by "Green movement of Georgia – Friends of earth – Georgia", in collaboration of several Georgian organizations and "Women of Europe for Collective Future – WECE". Solar water heaters will save annually 10 050 tons of CO_2. With the support of German government the preparation of the third NAMA project has been started which concerns the improvement of energy efficiency of buildings sector in Georgia.
- In June 2014, the Association Agreement has been signed with EU which explicitly points out collaboration on preparation of **LEDS**, as well as Nationally Appropriate Mitigation Actions (NAMAs).
- Government of Germany intensively works with Georgia on setting up the system for MRV through the Partnership Programme leading by the Society for International Collaboration of Germany - GiZ.
- In 2008, the EU launched the **Covenant of Mayors (COM)** process where signatory cities pledge to decrease emissions by 20% from the territory of city by 2020. The cities have to develop a Sustainable Energy Action Plans (SEAP), and monitor their implementation to report reduced emissions. Nine cities are currently signatories in Georgia—Tbilisi, Kutaisi, Batumi, Rustavi, Gori, Zugdidi, Poti, Telavi and most recently Akhaltsikhe — and are in different stages of the process. Several donors, including EU and USAID are providing the cities with support to draft SEAPs and implement mitigation measures identified in these action plans.
- Other initiatives, like preparation of **INDC** (Intended Nationally Determined Contribution) and preparation of Biennial Update Reports to the UNFCCC have been already launched.
- From the very start Georgia has been involved in Clean Development Mechanism (CDM) and has registered seven project, although one of them was not implemented. These projects annually reduce 1 768 639 tons of CO_2 eq. emissions. Nowadays, due to the uncertainty of perspectives of CDM globally, activities in this direction in the country are weakened.

The Third National Communication project has from its side contributed to these processes by preparing the disaggregated GHG inventory and mitigation strategy for Ajara Autonomous Republic (AR) and simplified SEAPs for Batumi and Poti. It also closely collaborates with GoG and other donors in preparation of LEDS.

The analysis of mitigation measures presented in TNC is derived from above listed activities and is based on the work done under TNC, EC-LEDS and CoM processes as of July 2014. It covers the sectors of energy, waste, greening (LULUCF) and agriculture. All but energy sector measures don't represent the whole territory of country. They are extracted from cities Sustainable Energy Action Plans (SEAPs) and Ajara AR mitigation strategy.

5.1. Analysis of Energy Sector

The greenhouse gases inventory prepared for 2006-2011 years in the framework of the Third National Communication of Georgia to the UNFCCC demonstrated that the leading sector in greenhouse gases emissions is energy sector (including transport sector). That is why the main accent was placed on this sector in planning of mitigation measures.

The analysis is based on national MARKAL (MARKet ALlocation) integrated energy system model, MARKAL-Georgia, and examines the role of mitigation in meeting future energy requirements through 2036 to support sustained economic growth while considering LEDS goals.

MARKAL[129]-Georgia was initially developed under US Agency for International Development (USAID) Regional Energy Security and Market Development (RESMD) project and in conjunction with the joint SYNENERGY Strategic Planning (SSP) effort undertaken with Greece Hellenic Aid. In this project MARKAL models[130] were developed for 10 Energy Community Contracting Parties and Observer Countries, including Georgia. The Ministry of Energy and Natural Resources was actively involved in the process. At the end of the project a Policy Brief was prepared, which described the Reference (Business As Usual) scenario along with policy scenarios to examine energy efficiency and renewable energy opportunities in Georgia. By the end of 2013 USAID's regional project "Low Emissions Strategies and Clean Energy Development in Europe&Eurasia" supported an update of the MARKAL-Georgia database and trained the Analytical Department of Ministry of Energy in the use of MARKAL-Georgia. DecisionWare Group (DWG), working under IRG and Tetratech, lead the model development and capacity building undertakings for these projects mentioned. The update and training continued under the Hydro Power and Energy Planning Project (HPEP) project by Deloitte and Word Experience Georgia (WEG). Currently the model is being further improved and enhanced by adding Greenhouse Gas accounting for the non-energy sectors under USAID's EC-LEDS Clean Energy Program in Georgia led by DWG working under Winrock International and supported by the Sustainable Development Centre Remissia. Thus the model used is the result of joint work of the Ministry of Energy of Georgia, Winrock International, DecisionWare Group, Deloitte, World Experience for Georgia (WEG) and the Sustainable Development Centre Remissia. The analysis discussed in this chapter is based on the MARKAL-Georgia version from the end of July 2014 as conducted by the Third National Communication team. The MARKAL-Georgia analysis undertaken uses a cross-sectoral, least cost optimization approach to identify the most economic efficient set of measures for mitigation.

This mitigation strategy focuses on assessing the energy sector costs and benefits for the entire energy system of meeting energy demand throughout 2030. It also examines the effects of potential mitigation targets in Georgia for 2030, as possible commitment values. It considers how meeting the targets impacts key issues facing energy sector decision-makers – namely, how to foster energy security and diversification at low emission level, and ensure competitiveness and affordability, as part of promoting cost-effectiveness in energy planning.

The following analyses have therefore been undertaken:

- Reference (or Business-as-Usual (BAU)) Development: The likely supply and investment require-

[129] MARKAL was developed and supported under the auspices of the International Energy Agency's Energy Technology Systems Analysis Program (IEA-ETSAP), www.iea-etsap.org.
[130] The initial model structure was developed under the USAID Regional Energy Demand Planning (REDP) project.

ments to support the evolution of the national energy system in the absence of policies and programs aimed at altering current trends to low emission pathway.

- Mitigation targets: These scenarios examine the requirements to successfully achieve a mitigation target by 2030 and maintain it afterwards. 15%, 20% and 25% mitigation targets against BAU scenario are applied and analyzed.

It should be underlined, that the official BAU scenario is being developed under the LEDS process, which will be discussed and approved by the country. For the moment that TNC analysis was performed, the BAU scenario hasn't yet been approved, thus BAU scenario presented here cannot be considered as official BAU scenario for the country. The analysis here doesn't aim to give preference to any presented scenario, but rather to show the possibilities of mitigation in different sectors together with associated costs. The purpose of reference scenario is only to set a reference level against which mitigation targets are evaluated.

5.2. Georgia's Business-as-Usual (BAU) Energy Pathway

To assess the impact of different policies and programs on the evolution of the energy system in Georgia, a Reference (BAU) scenario was developed, taking into account specific characteristics of the national energy system, such as existing technology stock, domestic resource availability and import options, and near-term policy interventions. The Reference scenario is aligned with the government plans of developing Georgia's abundant hydropower potential. Once established, the Reference scenario can also produce baseline estimates of energy consumption and carbon emissions to measure trends with respect to achieving low emission development goals in future.

All available national data sources (State Statistical Office, Ministry of Energy, etc.) were utilized to establish BAU scenario. The full list of information sources is provided in Appendix 5.1.

BAU scenario, presented in this document relies on the growth projections from the summer of 2014, according to which final energy consumption will increase significantly – by 76.6%[131], driven by Gross Domestic Product (GDP) growth and increased per capita energy consumption. This will require higher import levels of energy carriers. The growth of domestic consumption as well as export to Turkey will require expanding the electricity generation system from 3,260 MW to 5,731 MW. As a consequence the GHG emissions from fuel combustion category of Georgia's power sector will increase and reach 11 179 Gg[132] by 2030. Key indicators from the Reference scenario are shown in Table 5.1 and summarized subsequently.

Table 5.1. Key Indicators for the Reference (BAU) Scenario

Indicator	2012	2030	Average Annual Growth Rate (%)	Overall Growth (%)
Primary Energy (Ktoe)	4 174	7 189	3.07%	72.22%
Final Energy (Ktoe)	3 416	6 035	3.21%	76.64%
Power plant capacity (MW)	3.260	5.731	3.18%	75.79%
Imports (Ktoe)	2 658	4 548	3.03%	71.09%
CO2 emissions (Kt)	6 488	11 179	3.07%	72.30%
GDP (€M)	12 323	28 805	4.83%	133.75%
Population (000s)	4 498	4 846	0.42%	7.76%
Final Energy intensity (toe/€000 GDP)	0.28	0.21	-1.54%	-24.43%
Final Energy intensity (toe/Capita)	0.76	1.25	2.78%	63.92%

[131] According to the latest information by the beginning of 2015 this forecast is much higher – the scenarios of increasing of energy consumption and GHG emissions are still being developed under LEDS process.

[132] According to the latest estimations before the publication of this document this number is close to 16 000 Gg.

Primary energy consumption in 2030 is projected to be 7 189 k/toe[133], increasing from 2012 levels by 72.2%. While growing GDP and increasing household energy intensity are driving up energy demand, it is also important to note that energy intensity per unit of economic output is much lower than observed in 2012 – estimated to be 0.21 toe/1 000 €, a reduction of around 24.4%. This is due to the fact that economy grows faster than energy consumption.

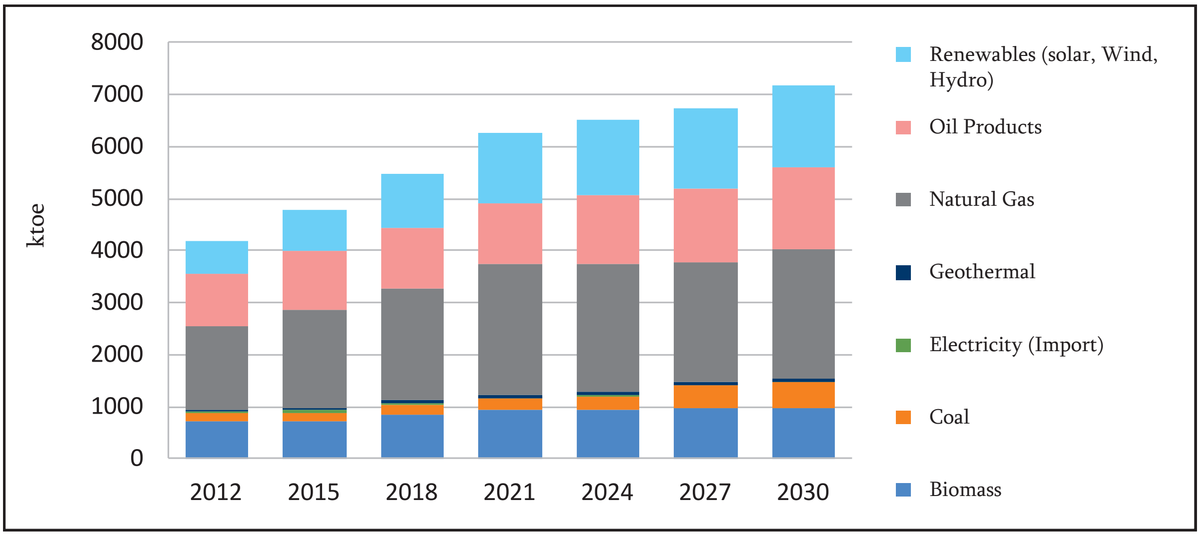


Fig. 5.1. Primary Energy Supply for BAU

Observed growth in primary energy does not lead to significant changes in supply mix. As shown in Figure 5.1, the imported natural gas has highest share in primary energy supply in 2012, as well as 2030 – around one third. The growth in transport demand is reflected in the increase in oil products (imported), although the share in primary energy is similar. The contribution of renewable energy sources (including hydro and excluding biomass) to total primary energy increases from 16% to 23% over the years 2015-2030. The biomass share drops from 17% to 14% in total primary energy although it increases in absolute volume.

Total final energy consumption grows by over 76.6% over the planning horizon, as shown in Figure 5.2, remaining proportionally similar with the exception of the increasing role for gas and coal and introduction of biofuels.

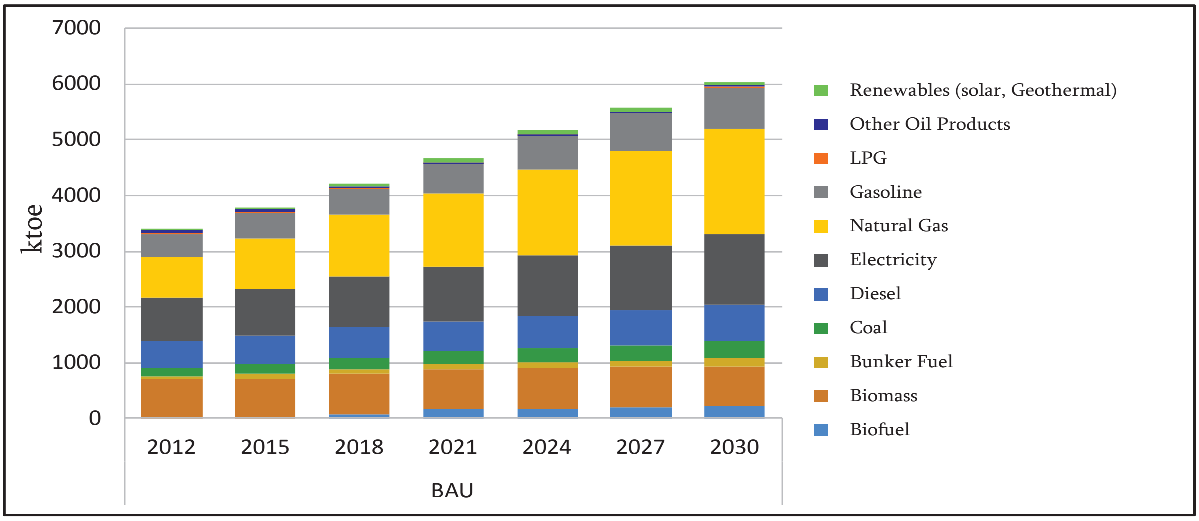


Fig. 5.2. Final Energy Consumption by Energy Type for BAU

[133] toe-tons of oil equivalent.

A more detailed view of **gas consumption** by sector is shown in Fig. 5.3. It shows that the majority of gas is used in the residential, commercial, and industry sectors with significant reduction in gas for power generation after 2014. This is caused by decommissioning of two major thermal plants – “Mtkvary Energy” with installed capacity of 300 MWh (in 2021) and “Tbilsresi” – 270 MW (in 2025), after which only exiting Gardabani Power Plant (110 MW) and new Gardabani Power Plant (230 MW), both working on natural gas. Thus the installed capacity of power plants working on natural gas reduces almost three times, resulting in corresponding reduction of gas consumption. In the residential and commercial sectors, gas is used for space/water heating and cooking. Gas is used across most industry sectors for the production of high temperature heat for a number of different processes[134]. Gas consumption increases most rapidly in the residential sector due to ongoing gasification as well as in transport sector with people switching to CNG from gasoline.

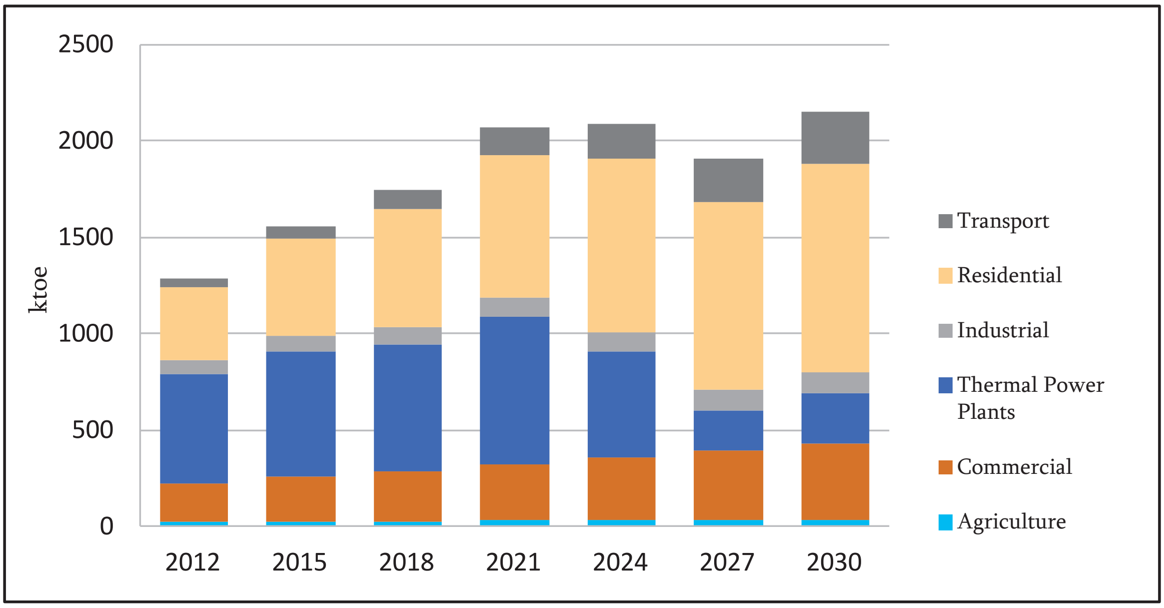


Fig. 5.3. Gas Consumption by Sector

The majority of Georgia’s fossil energy requirements are imported. In 2012 64% of primary energy supply was imported and this share remains almost constant during whole period of analysis. But demand for energy overall increases import dependency, resulting in an increase of imports by 2030 by 70% (relative to 2012 levels, Fig. 5.4.). The high consumption of gas in the end-use sectors reflects the criticality of the need for energy diversification and shows the vulnerability of economic and social development to external factors. Natural gas is major fuel imported and its import increases by 57% in 2030 compared to 2012 levels. The high consumption of gas in the end-use sectors reflects the criticality of the need for energy diversification and shows the vulnerability of economic and social development to external factors.

[134] In industry natural gas is also used as feedstock but this use is not considered and presented in this analysis.

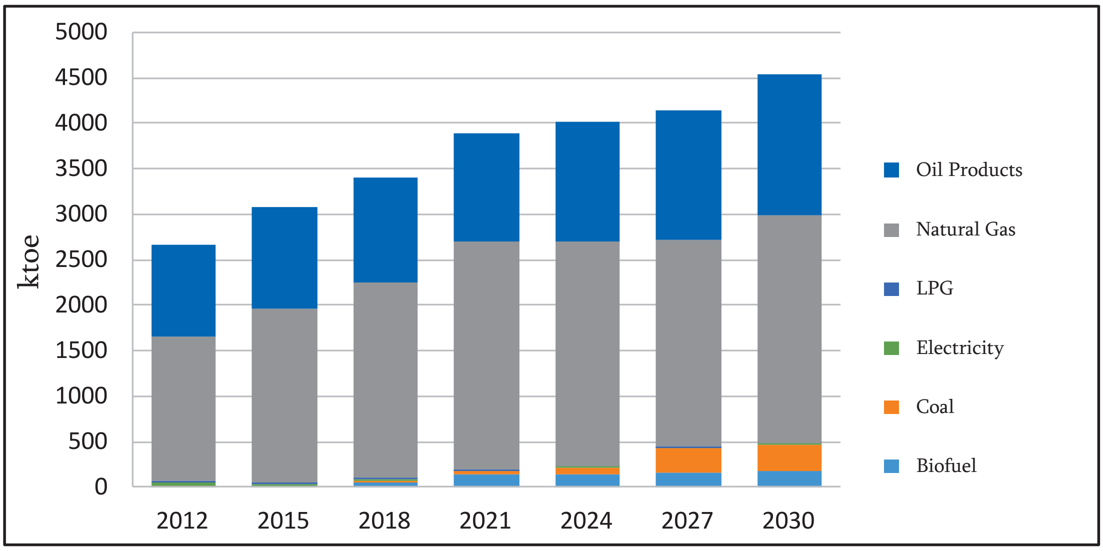


Fig 5.4. . Imports by Type of Energy

In BAU scenario the **new power generation capacity** additions in each three-year period are shown in Table 5.2, with the corresponding costs shown in Figure 5.5. Continued expansion of hydro power is the most prevalent trend with a cumulative additional capacity of 2 601 MW by 2030. In addition, coal plant (160 MW) and natural gas plants (230 GW) are built, as well as 50 MW wind plant. Capacity additions and the retirement of old power plants results in 5 731 MW of total installed generation capacity in place in 2030.

Table 5.2. Additional Power Plant Capacity by Fuel Type (MW)

Plant Type	2015	2018	2021	2024	2027	2030	Total additions
Coal-fired power plants	0	0	0	0	160	0	160
Gas-fired power plants	0	230	0	0	0	0	230
Hydroelectric power plants	364.0	760.0	721.0	355.6	300.0	100.0	2 601.0
Renewable and Other power plants	50	0	0	0	0	0	50
Total	414	990	721	356	460	100	3 041

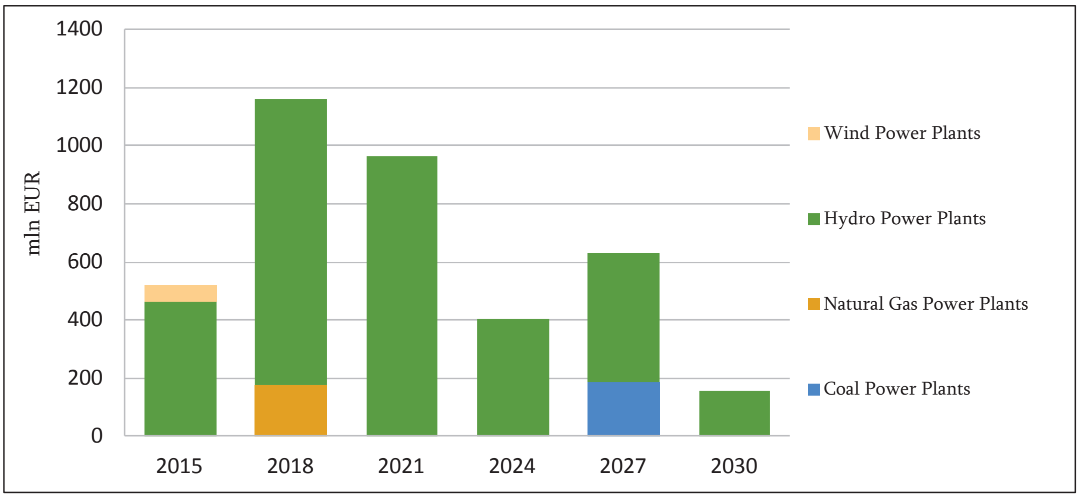


Fig. 5.5. Total Investment Cost of New Power Plants [135]

[135] Investment levels are not annual but cumulative for a three-year period.

This significant additions are due to the increase of electricity demand as well as higher levels of export, which are in line with the investor interest to export Georgian electricity to Turkey. According to model it is beneficial to add capacity of power plants and export the electricity – from 2018 on around 25-30% of generated electricity is exported.

Growth in the energy system will require significant levels of new investment, for both the power sector and demand devices, and increased payments for fuel. However, energy system expenditures are generally expected to absorb a smaller percentage of GDP in 2030 due to the reduced energy intensity per unit of economic output, shown in Table 5.3. A breakdown of the energy system cost components is presented in showing the growth in expenditure for fuel (extraction, import, and sector differential charges), operating and maintenance (O&M) costs (fixed and variables), investments in new power plants, and the purchase of new end-use devices.

Table 5.3. Annual Energy System Expenditure (M€)[136]

Expenditure Type	2012	2015	2018	2021	2024	2027	2030
Fuel Supply Costs	1 167	1 295	1 509	1 531	1 714	1 920	2 180
Delivery Costs (All Sectors)	406	469	532	602	666	717	817
O&M Costs (Demand)	362	408	476	543	623	703	797
O&M Costs (Electricity Generation)	312	328	366	403	416	438	461
Annualized Investment (Demand)	0	651	1 403	2 154	2 975	3 590	4 086
Annualized Investment (Electricity generation)	0	39	128	200	230	279	290
Total	2 248	3 190	4 413	5 434	6 624	7 647	8 631

Under the Reference scenario assumptions 3 041 MW of new generation capacity is needed, requiring a total investment of 3 831 € million, which translates to average annual payments in the order of 290 € million by 2036. At the same time, over 4 000 € million annually will be required to cover the cost of new demand devices, with the majority of this investment made by the private sector, including household vehicle purchases. Fuel supply costs will also increase significantly, driven by growing demand and increasing prices, from 1 167 € million per year today to 2 180 € million in 2030. This will have a significant impact on country's foreign trade balance.

As already mentioned above, the CO_2 emissions form energy sector fuel combustion will grow by 72.3% in 2030 compared to 2012 and reach around 11.2 mln tons based on this analysis dated from August 2014 (Fig. 5.6). In 2015 the analysis was revised based on which emissions reach 16 mln Tons[137]. The most growth will be observed in residential sector (113%) which is due to gasification of this sector. Significantly increase emissions also in industry, commercial and transport sectors (each around 90%). Emissions from power sector don't change significantly. Despite the decommissioning of 570 MW of gas thermal plants, which reduce emissions by 2024, new gas plant 9 260 MW) and coal plant (160 MW) compensate these reductions by 2030.

[136] For power plants and end-use devices, the upfront capital cost is amortized over the lifetime of the unit with annualized payments calculated according to the lifetime and cost of capital. These annualized payments, along with associated operating and maintenance costs and fuel expenditures constitute the overall energy system cost. The annualized investment costs associated with existing power plants and demand devices are not included.
[137] Strategy was developed based on the MARKAL results from August 2014.

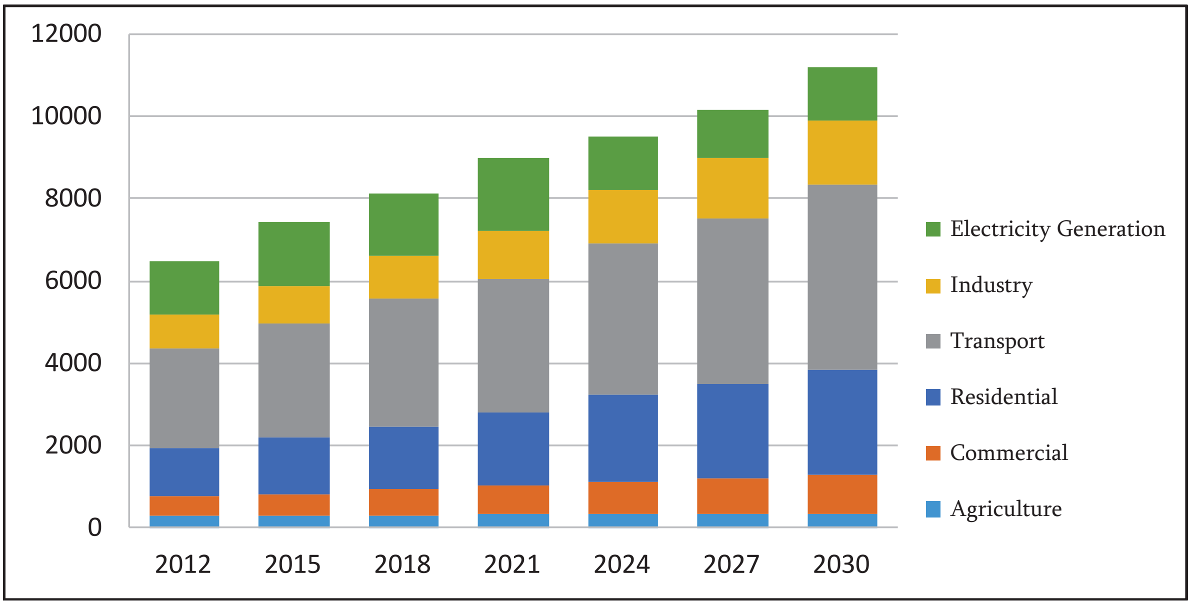


Fig 5.6. CO_2 emissions from fuel combustion in BAU (2012-2030, 10^3 tons)

5.3. Examination of the Promotion of Low Emission Development in Georgia

As mentioned already, the Government of Georgia (GOG) is developing a Low Emission Development Strategy (LEDS). The **LEDS** is intended to represent a long-term, whole-of-economy plan to reduce the growth of greenhouse gas (GHG) emissions while promoting economic prosperity.

Since at the time of preparation of this report, there is no ready LEDS for Georgia, which would set targets for mitigation, nor does the country have any mitigation target as non-annex 1 country of Convention, this analysis examines three possible targets – 15%, 20% and 25% by 2030 relative to BAU scenario. This analysis can be used as a first step to set the target, by identifying costs and cost-effective policies and measures for each target.

Policies that promote GHG emissions mitigation have significant benefits, as described below. This is the increase of energy security, decrease of energy consumption, increase of share of renewable energy and decrease of payments for imported fuels.

The GHG emissions can be reduced by increase of energy efficiency in demand sector, increase of share of renewables in demand sector as well as for electricity generation and fuel switching. The later covers measures like switching from gasoline to CNG, which may not result in the decrease of final energy consumption, but nevertheless cause the decrease of emissions.

As said, there is strong synergy between energy efficiency and mitigation. The final energy consumption is enough to be reduced by 5% in case of 15% target, by 7% for 20% and 9.5% for 25% target, supported by relevant EE strategy.

For renewable energy sources, their share in electricity generation (hydro and wind generation) has to increase from 90% in BAU to 93-94%. Less impact has the increase of renewables (including biomass) in demand sector – their share increases insignificantly in 2030 compared to BAU (BAU- 16.7%, 15% target- 17.7%, 20% target -18.2%, 25% target - 18.8%).

Just 15% emission reduction target (with measures of energy efficiency, renewable energy and fuel switching) will result in over 13% reduction in imports in 2030, enhancing energy security goals. In case of 20%

the reduction of required import reaches 18% and 23% in case of 25% emission reductions. In later case the import independence of Georgia improves significantly. As already mentioned in 2012 64% of primary energy is imported and this share is maintained through whole time period in BAU. In 25% emission reduction target the share of imported fuels reduces to 54% by 2030.

The overall savings of 7.4% or around 161 € million arises due to reductions in payments for fuel in case of 25% mitigation target (850 € million over while period) that are offset by increased expenditures for better performing demand devices, which, despite policies and programs, still command a premium over conventional devices.

Table 5.4 shows the key results and comparison between the Reference and mitigation scenarios. The total discounted energy system cost is the net present value of all the investments, device purchases, fuel expenditures and operating and maintenance costs throughout the entire energy system over the 18 years planning horizon. For the 15% mitigation target the total system cost increases by 0.60% (EUR 336 million) over the Reference benchmark , by 1.06% (EUR 589 million) in case of 20% emission reduction target, and 1.68% (EUR 930 million) in case of 25% target, indicating that achieving mitigation targets for Georgia is not very expensive.

Table 5.4. Impacts of mitigation targets

Indicator	Units	BAU	15% Emission reduction target		20% Emission reduction target		25% Emission reduction target	
			Value	Change, %	Value	Change, %	Value	Change, %
Total Discounted Energy System Cost	M€	55 514	55 850	0.60	56 103	1.06	56 445	1.68
Primary Energy Supply -2030	Ktoe	7 189	6 708	-6.69	6 600	-8.19	6 424	-10.64
Imports -2030	Ktoe	6 035	5 737	-4.93	5 603	-7.16	5 464	-9.45
Fuel Expenditure - 2030	M€	4 548	3 944	-13.28	3 711	-18.40	3 494	-23.17
Power Plant New Capacity (over all planning horizon)	MW	2 180	2 153	-1.22	2 055	-5.71	2 018	-7.40
Power Plant Investment Cost (over all planning horizon)	M€	3 041	3 251	6.91	3 761	23.68	3 761	23.68
Demand Technology Investments (over all planning horizon)	M€	3 831	4 400	14.83	5 353	39.70	5 353	39.70
Final Energy - 2030	Ktoe	11 179	9 502	-15.00	8 944	-20.00	8 385	-25.00

As already stated above, in achieving the emission mitigation targets both power sector and demand sectors play significant role. Figure 5.7 shows emission reductions in different sectors for three emission reduction targets.

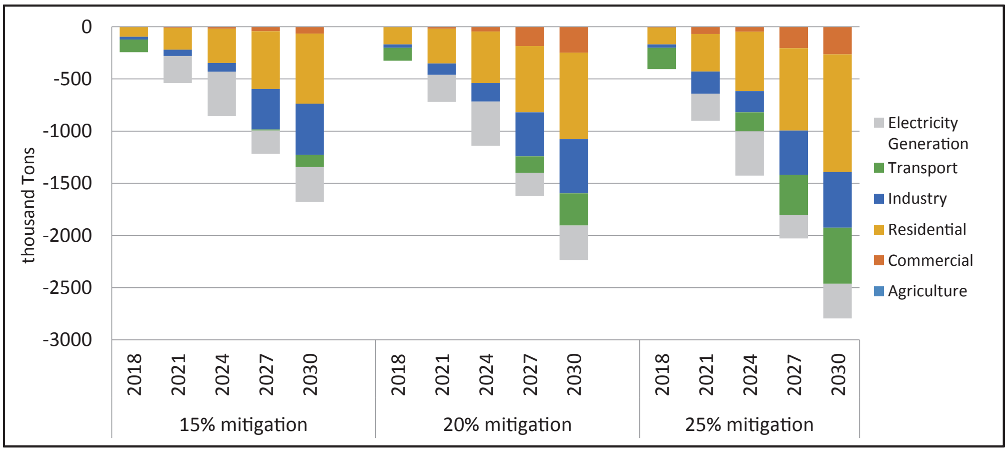


Fig. 5.7. Reduction of CO_2 emissions in different sectors for considered three mitigation targets

Demand sectors contribute significantly to emission reduction targets in addition to electricity generation sector. Under the 20% target, the residential sector provides the largest savings (37% of total savings), followed by industry (23%), transport[138] (15%), and commercial (11%). Remaining 14% is attributed to electricity generation[139] sector.

The analysis showed that rich hydro resources of Georgia can play significant role in reducing emissions. This doesn't only include the substitution of thermal generation by cleaner hydro generation, but also substitution of fossil fuels by clean electricity in demand sectors, which also requires capacity additions. One of the most cost-effective mitigation measures is the substitution of thermal generation by hydro generation. This first of all concerns coal plant and secondly gas plants. Although from the point of view of system stability and energy security, this analysis assumes that both types of thermal plants should exist and generate with some minimal capacity factor. Thus there is no reduction of thermal capacity in any of the scenarios, but the decrease of their load is observed and hydro generation is increases to satisfy export needs and substitute fossil fuels in demand sectors wherever possible.

The Reference scenario showed an increase in new hydro and wind power generation capacity of about 2 650 MW out of a total of 3 041 MW new capacity additions. In other words, renewable electricity generation is playing a crucial part in meeting future demand even without an established mitigation target. However, to further enhance energy security and address climate change, pursuing an even more aggressive renewables strategy has additional merit, though at a cost.

Under the 15% mitigation target, additional 200 MW hydro capacity is needed. For 20% and 25% targets the additional requirement for renewable electricity is 480 MW hydro and 240 MW wind. This suggests that meeting the targets and sustaining it beyond 2030 will require attracting higher levels of capital for expanding the power generation sector. This additional capital required under the 15% target in the 2030 is estimated at 568€ million over the planning horizon, and 1.5 € billion for 20% and 25% targets.

A summary of the change in renewable energy use for electricity generation is provided in Figure 5.8. As the figure demonstrates the generation of electricity from renewable sources has to increase by approximately 3 000 GWh annually, and the generation of electricity from thermal plants have to reduce by around 800 GWh. Electricity export is also reduced and imports[140] increased. Added electricity is used to substitute fossil fuels in demand sectors.

[138] It should be noted that many important measures in transport sector, such as avoidance of travel and mode shifting, is not modeled in this version of MARKAL. Thus potentially transport sector has higher potential for reducing emissions, than presented here.
[139] This share can be much higher if more thermal generation is assumed in BAU, or if less thermal generation is allowed in mitigation scenarios.
[140] The costs of electricity import and capital costs of new capacity has significant influence on such decisions. In this version the system pays less for imported energy in winter in later years, than for construction of new capacity. In addition export decreases due to increase of internal consumption. This assumptions can be changed by adding constraints on import for energy security purposes or changing costs.

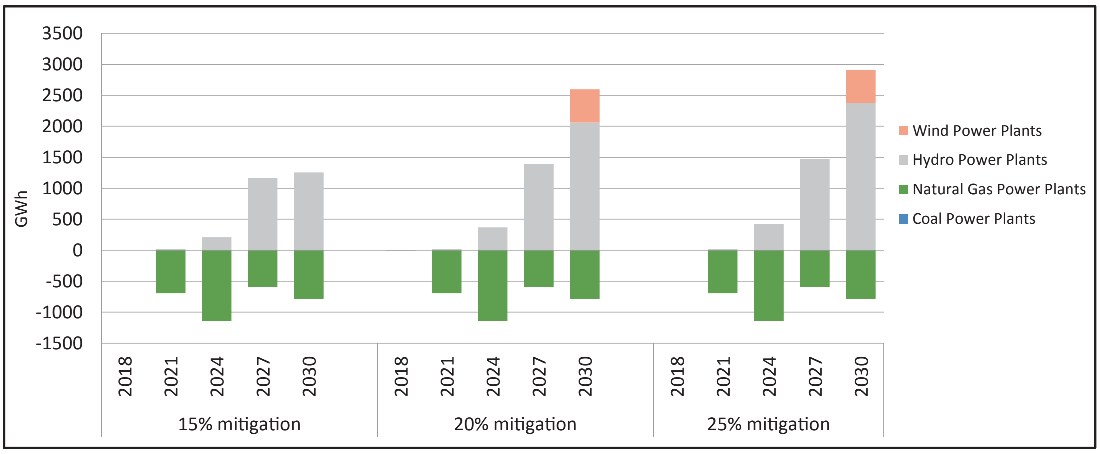


Fig. 5.8. Changes[141] in electricity generation under mitigation targets, compared to the BAU scenario

The Figure 5.9 shows changes in final energy consumption for all three scenarios. As already explained we are dealing with two processes: 1. Less energy effective technologies are substituted by energy efficient ones and 2. Technologies working on gas, coal and diesel are substituted by technologies working on electricity, which from one hand are more clean, and on the other hand – more effective. As a result, more electricity is needed. Figure 5.10 shows changes in electricity generation due to the increase of electricity consumption on demand side. The use of solar and geothermal energy also increases but with less effect, since their potential is limited.

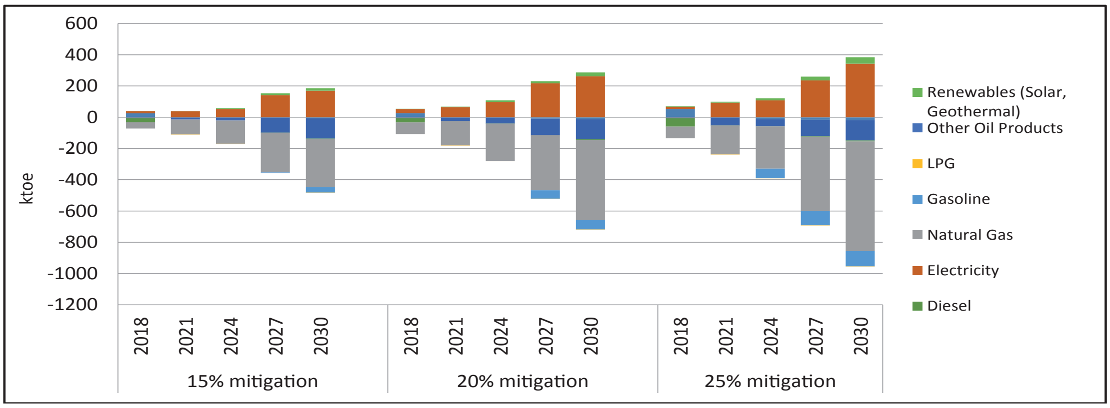


Fig. 5.9. Changes in the final energy consumption under mitigation targets compared to BAU

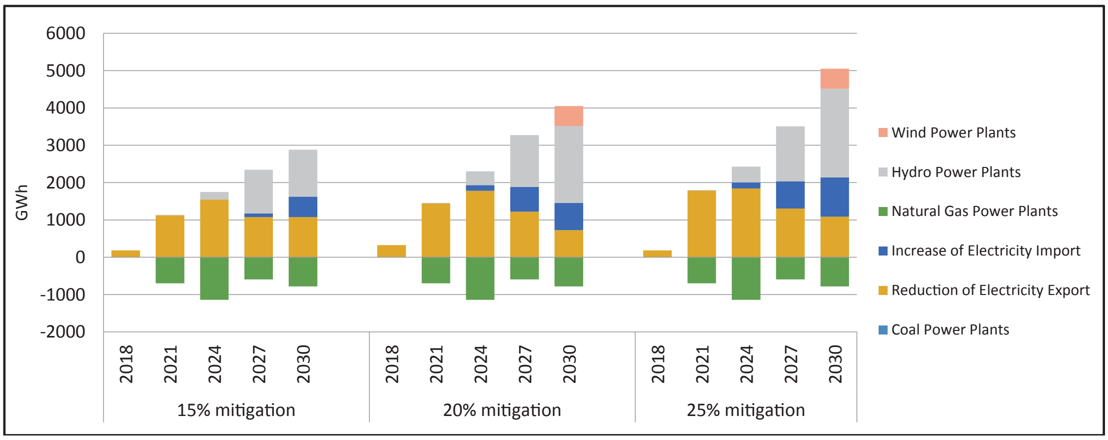


Fig. 5.10. Changes in electricity generation, imports and exports under mitigation targets compared to BAU

[141] The assumption is made that there is no change in the generation of coal plant.

A more detailed overview of fuel savings by energy service demands are shown in Fig. 5.11. As said before the most cost-effective reductions occur from residential sector, which includes more efficient space and water heating, with a strong uptake of heat pumps (using electricity) and more efficient residential lighting and other appliances. This leads to a fairly strong reduction in gas consumption and increase in electricity consumption. For the transport sector, the bus fleet moves towards more advanced Internal Combustion Engine (ICE) technology. Also there is an increasing uptake of efficient Light Commercial Vehicles (LCV)s.

In industry, savings are most prevalent in non-metallic mineral industries, where efficiency savings from process heat are realized. Savings from industry also include saving in construction and food industries. Much of the commercial[142] savings are in building insulation, followed by heating and hot water, including increased penetration of heat pumps.

If three targets are compared, it is obvious that all three affect same end-uses but at different extent. For example, the measures targeting Light Duty Vehicles should start earlier and effect wider audience in case of 25% target than in case of 15% target.

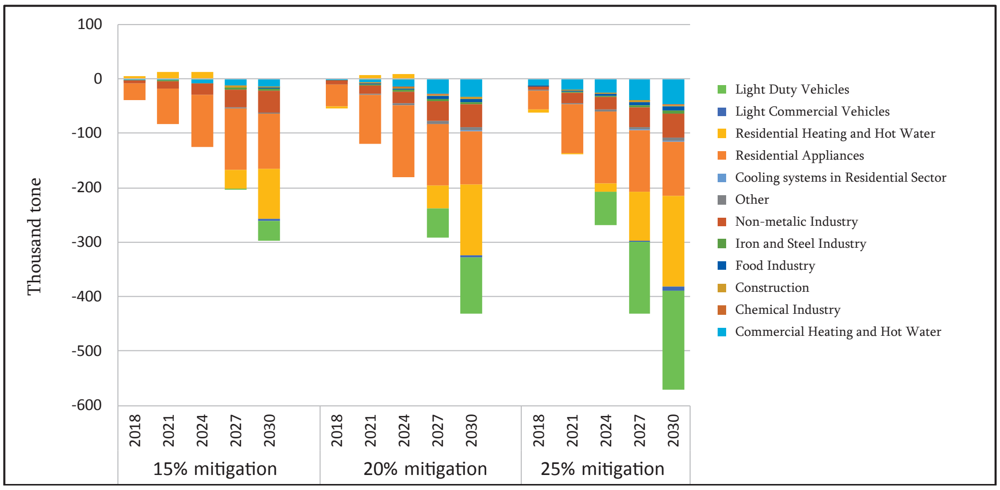


Fig. 5.11. Final energy reduction by energy service type under mitigation targets

The measures for mitigation to achieve 20% emission reduction[143] in 2030 are listed in the following Table.

[142] Commercial sector includes all non-residential buildings, where energy is consumed for services of heating, cooling, lighting, etc. Mainly these are offices, education organizations, hospitals, stores, etc.
[143] 20% reduction scenario is chosen as example.

Table 5.5. Mitigation measures for energy sector

Measure	Description of measure	Anticipated emission reduction (20% reduction target), t CO_2 by 2030 compared to BAU
1. Higher share of renewable power plants in electricity generation system	Measure includes 4 800MW more hydro plants and 240MW of wind plants.	**332**
2. Improvement of energy efficiency and promotion of renewable energy in residential sector	Measure should target the improvement of insulation, which will reduce fuel consumption both for heating and cooling, and promotion of heat pumps. These can be achieved by new building code and public outreach activities. Other targeted areas include residential lighting and electric appliances which can be achieved by introducing labeling system and stricter legislation on the use of incandescence bulbs. Existing "EnergyCredit" system should become more active and cover wider audience. Use of geothermal water and solar energy for water heating shall be promoted in areas with corresponding potential.	**829**
3. Increase of energy efficiency in commercial building and promotion of renewable energy sources	Measure should target the improvement of insulation in existing and new commercial buildings, which will reduce fuel consumption both for heating and cooling, and promotion of heat pumps. Initially the targeted buildings will be municipal and state owned buildings, where national and local governments can take direct action. Commercial buildings should be targeted through appropriate outreach activities.	**246**
4. Increase of energy efficiency in industry	Promotion of energy efficiency for process heat technologies should be targeted mostly in non-metallic mineral industries and food industries. Reduction of the use of oil products for construction transport can have additional benefits.	**519**
5. Increase of energy efficiency in agriculture	Promotion of energy efficiency for oil products for agricultural transport and in irrigation systems.	**2**
6. Improving public transport services and transition to more energy efficient technologies in transport fleet	Measures include moving bus fleet towards more advanced internal combustion engine (ICE) technology. Also there is there is an increasing uptake of efficient light commercial vehicles (LCV)s.	**309**
Total		**2 236**

It is important to highlight that there are significant uncertainties concerning the potential of opportunities for energy efficiency including the overhead costs of policies and measures for their implementation. Therefore, it is important to continually review the data in the model for use in future analyses, assessing new data available in Georgia to further improve the robustness of the analysis.

5.4. Ongoing and Planned Mitigation Measures

Covenant of Mayors

Total Emissions: The Emission inventories and emission reductions by 2020 from Sustainable Energy Action Plans of five[144] Georgian cities, that are signatories of the Covenant of Mayors are given in Table 5.6.

[144] City Gori has submitted SEAP but it is being updated recently and therefore Gori is not included in assessments.

Table 5.6. The emission inventories and emission reductions from SEAPs

City	Base year	Base year emissions (tons CO_2eq)	2020 Emissions from BAU (tons CO_2eq)	Emission Reductions (tons CO_2eq)
Batumi	2012	261 098	437 717	100 128
Zugdidi	2012	46 666	65 264	15 723
Tbilisi	2009	3 012 277	5 153 512	1 238 699
Rustavi[145]	2012	389 391	---	108 313
Kutaisi	2012	201 588	297 263	83 982

It has to be noted that the SEAPs of different cities cover different sectors. In addition the methodologies of calculating electricity grid emission factors are different as well as methodologies for developing BAU scenario. Rustavi SEAP does not use BAU scenario at all and calculates emission reductions against base year instead.

Below the non-energy sectors considered in SEAPs are discussed.

Solid Waste. As stated above, there are nine CoM signatory cities, four of them (Tbilisi, Batumi, Kutaisi, Zugdidi) target waste sector in their Sustainable Energy Action Plans. Current versions of Gori and Rustavi SEAPs don't consider these sectors. In addition the mitigation strategy of Ajara region developed under TNC project covered waste sector. This analysis is based on the SEAPs and mitigation measures identified in them for solid waste sector.

All four SEAPs indicate the mitigation measure of collecting methane from their corresponding landfills and utilizing it in one way or another. Tbilisi and Batumi SEAPs also cover wastewater, since they have operating wastewater treatment plants, whereas Kutaisi and Zugdidi don't.

Table 5.7. presents methane emission from all landfills in mentioned cities in 2012 and 2030. The table practically represents the BAU scenario for solid waste sectors for these cities. According to it methane emission in 2012 accounted approximately 418 Tons of CO_2eq and will reach 418 Tons of CO_2eq by 2030. The reduction is temporary and is caused by fact that from old closed landfills emissions will gradually reduce and new landfills will need around 3-5 years to start generating significant amounts of methane.
146

Table 5.7. CH_4 emissions from landfills in considered cities

City	Landfill	2012 Emissions (thousand tons of CO_2eq)	2030 Emissions (thousand tons of CO_2eq)
Tbilisi	Gldani	227.95	30.64
Tbilisi	Iagluja	113.02	13.43
Tbilisi	Lilo	23.26	3.78
Tbilisi	Norio	27.33	243.79
Batumi	Old	14.91	2.31
Batumi	New	0.00	36.96
Kutaisi	Nikea functioning	36.96	77.70[146]
Zugdidi	Old	2.52	0.42
Zugdidi	New	1.05	9.24
Total:		**483.96**	**418.26**

The Table below represents the measures for mitigating methane emissions from landfills and their potential, which by 2030 comprises around 292 thousand Tons of CO_2 eq.

[145] Rustavi doesn't consider BAU scenario
[146] If Nikea landfill is closed, the emissions from this landfill will equal to 7.94 thousand Tons of CO2 eq.

Table 5.8. Mitigation measures from landfills

City	Landfill	Description of measure	Emission reductions in 2030 (thousand Tons of CO_2eq)
Tbilisi	Gldani	Collection and flaring of methane	21.30
Tbilisi	Iagluja	Collection and flaring of methane	9.33
Tbilisi	Lilo	Collection and flaring of methane	2.63
Tbilisi	Norio	Collection and flaring of methane	169.49
Batumi	Old	Collection and flaring of methane	1.61
Batumi	New	Collection and flaring of methane	25.70
Kutaisi	Nikea functioning	Collection and flaring of methane	54.02
Zugdidi	Old	Collection and flaring of methane	0.29
Zugdidi	New	Collection and flaring of methane	7.39
		Total	**291.76**

It should be mentioned that for some landfills (Gldani, Iagluja, Lilo, old Zugdidi landfill) this is only theoretical potential, since for them even the cost of flaring can be very high.

Wastewater. From the wastewater sector, methane[147] emissions from only Tbilisi and Batumi plants are considered, namely Gardabani and Adlia wastewater treatment plants.

Table 5.9. CH_4 Emission from wastewater

City	2012 Emissions (thousand Tons of CO_2eq)	2030 Emissions (thousand Tons of CO_2eq)
Tbilisi (Gardabani)	146.2	239.5
Batumi (Adlia)	0.0	52.0
Total	**146.2**	**291.5**

Table 5.10 presents mitigation measures for wastewater sector, which can reduce 233.25 thousand tons of methane in CO_2 equivalent by 2030.

Table 5.10. Mitigation measures form Tbilisi and Batumi wastewater treatment plants

City	Description of measure	Emission reductions in 2030 (thousand Tons of CO_2eq)
Tbilisi (Gardabani)	Capturing and utilization	191.63
Batumi (Adlia)	Capturing and utilization	41.62
Total		**233.25**

Green zones (LULUCF). The SEAPs of Tbilisi, Batumi, Kutaisi and Zugdidi consider the green zones as sectors where GHG emissions can be mitigated. Table 5.11 presents the amount of stored carbon in green zones of these cities and volumes of their annual removal.

[147] N_20 emission is relatively smaller and the mitigation measures for it haven't been considered.

Table 5.11. The amount of stored carbon in green zones of cities and volumes of their annual removal

City (base year)	The area covered by plants, ha	Carbon stored on 1ha, tC	Carbon stored in green zones, tC	Annual removal of carbon/carbon dioxide		
				Annual increase of carbon stock in 1ha, tC	Annual increase of carbon stock in considered terriotries, tC	Annually Removed Carbon Dioxide, t CO_2
Tbilisi (2009)	7 079.50	20	141 590	0.58	4 106	15 056
Batumi (2012)	720.0	30	21 600	0.60	432	1 584
Kutaisi (2012)	212.0	26	5 396	0.59	125	458
Zugdidi (2012)	64.0	58	3 690	0.71	46	167

The measures planned in SEAPs and carbon dioxide mitigated (removed) in the case of their implementation is given in Table 5.12.

Table 5.12. Greening of cities as mitigation measures

year	Planned measure and greened area	Increase of carbon stock in 1ha, tC	Annual increase of carbon stock in project terriotries, tC	Annually Removed Carbon Dioxide, t CO_2
Tbilisi				
2015	Greening activities in and around the city, 10 ha	1.6	16.0	58.7
2016		3.4	34.0	124.7
2017		6.2	62.0	227.3
2018		9.2	92.0	337.3
2019		12.3	123.0	451.0
2020		16.5	165.0	605.0
2025		38.0	380.0	1 393.3
2030		62.3	623.0	2 284.3
Batumi				
2015	Greening activities in and around the city, 1 ha	4.47	4.5	16.4
2016		10.1	10.1	37.0
2017		16.9	16.9	62.1
2018		24.7	24.7	90.7
2019		33.4	33.4	122.5
2020		43.0	43.0	157.7
2025		89.5	89.5	328.4
2030		127.7	127.7	468.3
Kutaisi				
2015	Greening activities in the city, reconstruction of botanical garden, establishment of plant nursery , total greening – 5ha	2.7	13.5	49.5
2016		6.4	32.0	117.3
2017		11.1	55.5	203.5
2018		16.1	80.5	295.2
2019		21.1	105.5	386.8
2020		26.2	131.0	480.3
2025		52.2	261.0	957.0
2030		80.8	404.0	1 481.3

Zugdidi				
2015	Reconstruction and greening of botanical garden, 1ha	2.3	2.3	8.4
2016		5.3	5.3	19.3
2017		8.9	8.9	32.6
2018		12.4	12.4	45.6
2019		15.8	15.8	58.0
2020		19.0	19.0	69.9
2025		36.8	36.8	134.9
2030		59.4	59.4	217.6

Biogas production. It can be quite beneficial for the mountainous regions of Georgia, such as Ajara, Zemo Svaneti and others, to produce and use biogas by families or farms. Although the technological base is not fully developed in Georgia, that hinders the wider development in this direction. At present, a total of 89 biogas digesters are installed in Ajara AR with annual capacity of 96.79 thousand m^3, but only 50% of them are operational.

The conservative assumption has been made that in case of use of 50% of potential of biogas in Ajara, 7276 tons of CO_2eq. emission will not be emitted annually to atmosphere, which will cumulatively reduce 36 380 tons of CO_2 equivalent by 2020 and 109 140 tons of CO_2eq. by 2030.

Such theoretical estimation have been made for the municipality of Mestia as well, but here more difficulties are connected with the application of technologies, since the thermophilic digesters are required because of cold climate. It is much more difficult to operate them by families and requires professional technical service on places. According to theoretical estimation, 117 t methane can be reduced annually which after combustion will reduce 2 134 tons of CO_2eq. annually. If by 2020 technological problems are solved, by 2030 32 000 tons of CO_2eq. will be reduced. In addition the population will get clean energy and fertilizer of high quality.

The projects carried out by Clean Development Mechanism (CDM) and NAMA and emissions reduced in these projects are given in the tables 5.13 and 5.14.

Table 5.13. Clean Development Mechanism (CDM)

N	Project title	Registration N	Annual emission reductions tCO_2eq	Timeframe (years)
1	Leak Reduction in Above Ground Gas Distribution Equipment in the KazTransgaz-Tbilisi Gas Distribution System	2 404	339 197	10
2	Leak Reduction in Above Ground Gas Distribution Equipment in 'Socar Georgia Gas' gas distribution system,	5 213	173 651	10
3	Refurbishment of Enguri Hydro Power Plant	7 756	581 715	10
4	Dariali Hydroelectric Power Project	8 491	259 229	10
5	Acharistskali Hydroelectric Power Project	7 983	391 956	10
6	Gudauri Small Hydropower Project	9 079	22 891	7 (and renewable)
	Total		1 768 639	

Table 5.14. Nationally Appropriate Mitigation Actions (NAMA)

N	Project title	Annual emission reductions tCO_2eq	Description	Donor
1	Adaptive Sustainable Forest Management in Borjomi-Bakuriani Forest District	8 706 annually by 2030	40ha of forests should are planted	Austria
2	Promotion of solar water heaters and efficient wood stoves	10 050 annually/solar	10 050 solar heaters and 10 050 efficient wood stoves are installed. Each solar heater reduces around 1 t CO_2eq annually.	EU sponsors demonstration part for 50 solar and 50 efficient stoves in 2014-2015
3	Low carbon buildings	Has not been calculated yet	Project proposal is being developed.	Germany

For the moment really financed, monitored and mitigating are CDM projects, the annual emission reductions of which comprise around 1 768 639 t CO_2eq.

6 Other information

6.1. Systematic observations

As stated in Georgia's Second National Communication (SNC) on Climate Change by 2009 there were 40 hydrometeorological stations and posts, including 22 automated weather stations (AWS). During the last 6 years the number of stations and posts under subordination of the Hydrometeorological Department of the National Environmental Agency increased up to 116, and by the end of 2014 there were 21 weather and 95 hydrometeorological posts. The number of automated meteostations increased up to 30.

In 2009-2014 and particularly after 2011, the National Environmental Agency systematically gets the international assistance for strengthening the observation network and most importantly, for introducing the full electronic base. Within this period about 4.2 million USD of foreign grants and 1.7 million GEL from the state have been allocated for this purpose. It also includes arrangement of monitoring system over the underground fresh water that has been considered as a state priority since 2013.

6.2. Review of foreign investments for climate change activities

The SNC included the strategies and action plans up to 2025 that were based on the current and expected climate changes. They encompassed inventory of greenhouse gases, building the of local capacities to implement the Climate Change Convention, vulnerability assessment and adaptation, mitigation activities, and education and awareness-raising in the climate change field. On the basis of those sectoral strategies the SNC included 2009 strategy of Georgia on the actions related to the climate change.

Following the recommendations provided for in this strategic document in 2009-2014 Georgia implemented about 70 projects supported by the foreign grants provided by the key donor organizations: Global Environment Fund (GEF), European Union (EU), USAID, GIZ, also the governments of Austria, the Netherlands, Norway, Sweden, Switzerland and Czech Republic. The principal implementing organizations are: United Nations Development Program (UNDP); the Ministry of Environment and Natural Resources Protection; Caucasus Environmental NGO Network (CENN), Caucasus Regional Environment Center (REC Caucasus); Energy Efficiency Center; World Experience to Georgia (WEG) and others. Most of the problems are of regional character and they are being implemented simultaneously in a group of countries.

Implemented and ongoing projects can be divided into 2 parts:

- Vulnerability evaluation and adaptation to climate change;
- Mitigation of greenhouse gas emissions. Energy efficiency is a key component in the mitigation group.

Within the first domain the projects mostly reflect the following principal issues: evaluation of vulnerability to climate change; adaptation to climate change; strengthening of local potential; elaboration of strategic documents; assistance to the legislative improvements; disaster risk management; forest and water resources management; biodiversity and conservation; education and awareness-raising on the climate change, etc. The issues covered within the second domain are as follows: climate change policy; legislative and institutional issues; harmonization of legislative basis and institutional arrangement to the EU requirements; building of local capacity and awareness raising; energy and transport; forest and pasture rehabilitation (fostering the carbon sinks); waste management. This list illustrates that creation of local potential and raising of awareness are included in both groups of topics and, in addition, they accompany every project.

In these two domains (vulnerability/adaptation and mitigation) the proportion of implemented projects is 42% to 58%, and the grants in money terms for mitigation activities are three times more (27% and 73%) (Fig. 6.1).

It should be mentioned that at the current stage assessment of a number of analyzed projects within the frame of the Third National Communication and of their cumulative funding is not complete, although it reflects the distribution of grants among the sectors. The results are shown in Figures 6.2 and 6.3. According to this incomplete evaluation the total funding through the foreign grants made about 176 mln USD.

In addition to the vulnerability-adaptation and mitigation categories, the projects also have been evaluated against the specific sectors, according to their belonging.

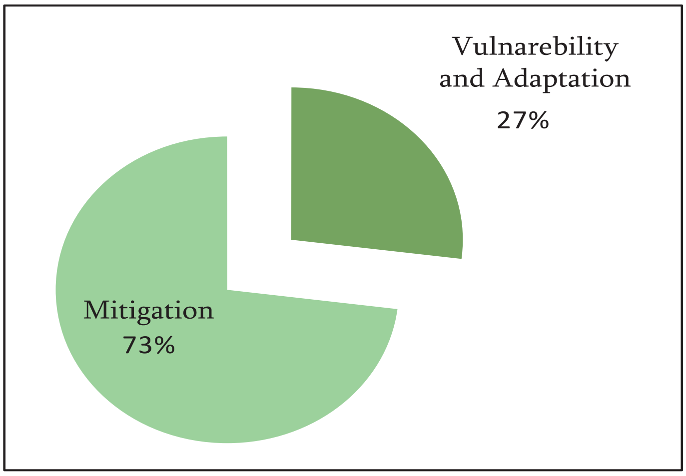


Fig. 6.1. Tentative shares of grants allocated in the vulnerability/adaptation and mitigation sectors

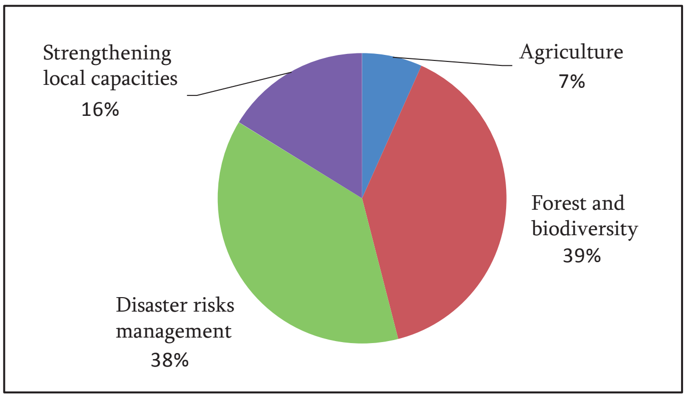


Fig.6.2 Distribution of grants allocated in the vulnerability and adaptation by sub-sectors

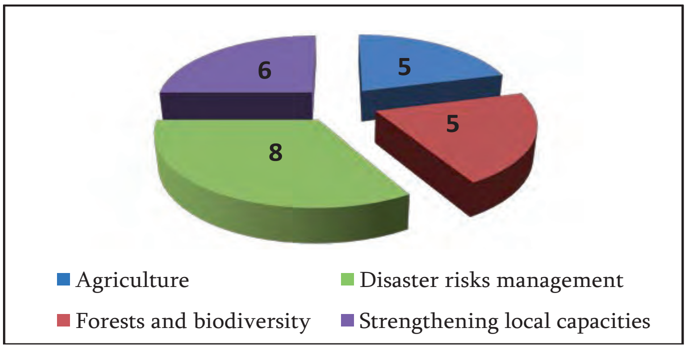


Fig. 6.3. Number of projects implemented within the vulnerability and adaptation sub-sector

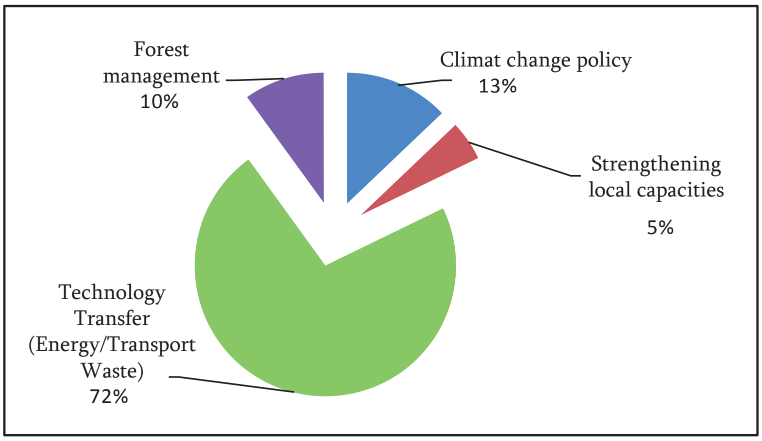


Fig.6.4. Distribution of grants allocated for mitigation by sub-sector

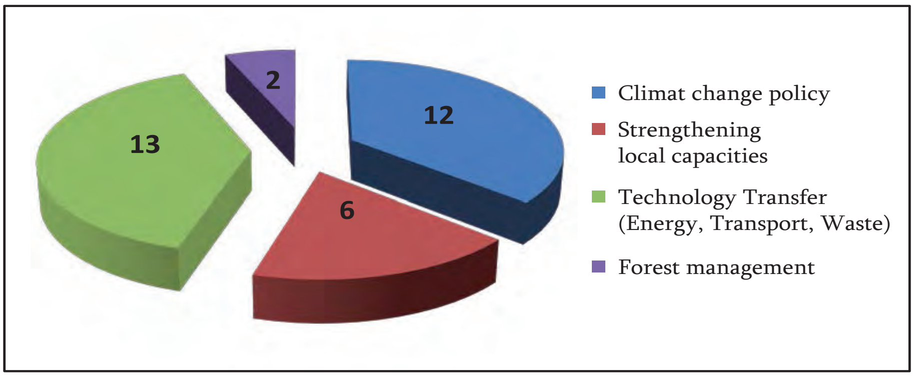


Fig.6.5. Number of projects implemented within the mitigation sub-sectors

Here it must be mentioned that such grouping of projects is rather conditional as many of them cover multiple sectors. It is especially true regarding the sub-sectors for management of natural disasters and for strengthening of local potential.

Incomplete number and partial financing of climate change projects by sectors implemented in Georgia in 2009-2014 through the foreign investments are displayed in Figures 6.6 and 6.7.

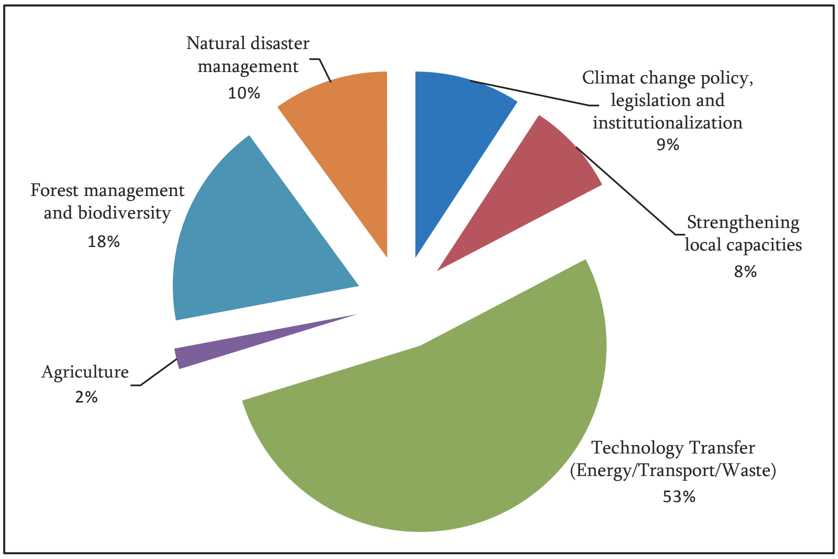


Fig.6.6. Tentative assessment of climate change sectors financing in Georgia

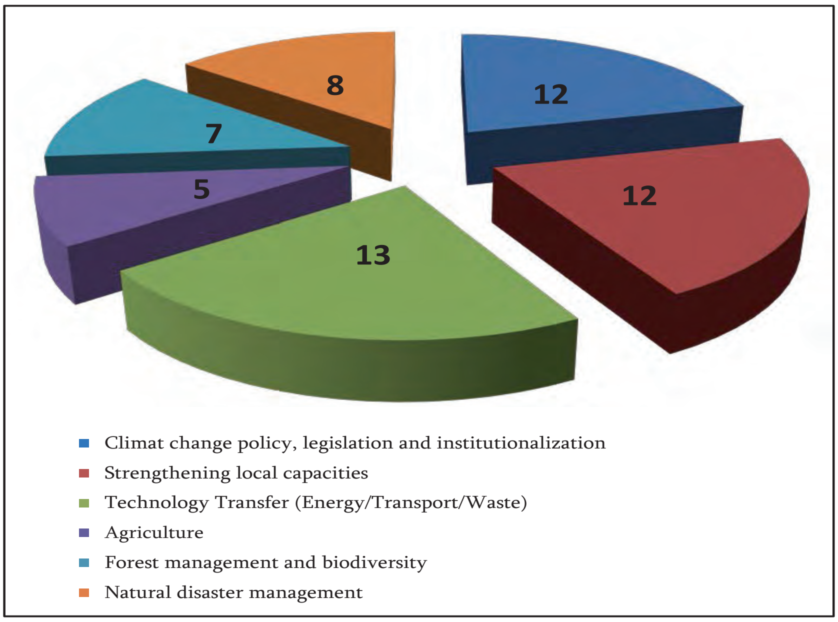


Fig. 6.7. Number of climate change related projects implemented in Georgia by sectors

The figures show that over the recent 6 years the projects implemented or initiated in the field of mitigation have exceeded the number of projects for vulnerability/adaptation by 16%, while the difference in funding is about 46%.

- With the number of implemented projects and volume of funding two sectors are among the sole leaders: energy and transport; and forest and biodiversity. As the figures show about 60% of total funds has been allocated within these two sectors. The sectors of climate change policy and natural disaster management received considerable amount of funds, while the agriculture sector takes the last position in this list.
- No projects related to the health and tourism sectors are found among the implemented projects, thus indicating to the need for more active approach to these activities. More attention requires agriculture that is identified as priority field of Georgia's economy since it greatly depends on climate change. In the Second and Third National Communications of Georgia about 20 proposals on adaptation have been elaborated with the aim to fill this gap. At the current stage some of them are in progress. Implementation of designed projects would have contributed to the reduction of vulnerability of Georgia's agriculture sector to the climate change.
- Given the incompleteness of data on implemented projects and their funding it could be assumed that about 70-80 projects on climate change have been implemented in Georgia, with the total funding of nearly 180 million USD.

Furthermore, the support was found towards such sectors that had been abandoned for a long period of time and now they are financed through the local funds. These are: observations on glaciers and monitoring of underground water. In 2009-2014, together with other projects in the climate change field four projects of total 383 000 GEL (about 225 000 USD) in glaciology were implemented through the national funding. About 1.7 million GEL (950 000 USD) were allocated for improving the meteorological and hydrological observation system and for rehabilitation of monitoring system for fresh water. Sh. Rustaveli National Science Foundation is the principal donor organization for these projects and the Institute of Geography of Tbilisi State University is the major implementing agency.

The special consideration should be given to the investments for the **National Inventory of Greenhouse** Gases. As a rule, National inventory of greenhouse gases mostly is implemented in the course of preparation of national communication. However since 2010 when Tbilisi and then other cities of Georgia signed the Covenant of Mayor they committed to prepare the plans for sustainable energy development, which includes inventory at a city level. The countries and cities received additional funds in a form of grant, mostly from the USAID, GIZ and the EU. Currently in Georgia there are 9 signatory cities to the Covenant of Mayor; among them four cities have already elaborated the Action Plan for sustainable energy development and the greenhouse emission inventory is in progress in other cities. GHGs emission inventory serves to the collection of valuable and reliable data, determination of emission factors, and elaboration of methodologies and development of skills at a local level. According to some calculations about 7-8 million USD are allocated in this direction, but the funds have been distributed within the analyzed mitigation sector.

In 2015 Georgia starts preparing the biannual updating report (BUR) in which the greenhouse emission inventory is the leading sector.

At a project level inventory and monitoring over the reduction of greenhouse gas emissions is carried out in the projects of Clean Development Mechanism (CDM). In Georgia there are 5 projects in progress relating to the greenhouse emission monitoring. These projects serve to the identification of activity data and emission ratio and help to improve the calculation methodology.

Evaluation of effectiveness of implemented projects

After questioning of those involved in the project implementation and evaluation of effectiveness of completed and ongoing projects under the 2009 strategy, also based on analysis provided in section 6.2 it was determined that the abovementioned projects made a considerable contribution to the implementation of climate change strategy of 2009 and include nearly all recommendations. However, most of them are not completed. This situation is preconditioned by several reasons, including the lack of comprehensiveness of recommendations, as well as the change of priorities by both national and international donors. This evaluation depicted the following picture:

- Majority of projects meet the requirements of the same items of strategic document thus providing the ground for conclusion that the both implemented and ongoing projects serve to the similar objectives and there can be content overlapping. Therefore, the better coordination between the donor and implementing organizations is required to have effective and efficient implementation of each project;
- The project concept shall be based on the deep and comprehensive analysis of situation in the country and on justification of feasibility of strictly identified problem. At the same time priority of the problem addressed in the project shall be well developed. Project sustainability requires serious works/measures to be carried out at different levels (regional, local). The measures must be long-term and adapted to Georgia's reality;
- Effective planning and implementation of projects related to climate change require inter-sectoral co-operation, as well as the cooperation within the sector and between the agencies. At the current stage such cooperation is rather week and requires the further strengthening. This need comes from the fact that the most of projects cover several sectors and also require different levels of involvement within the frame of one sector;
- For implementing the international principles of the UNFCCC at a national level it is important to secure active involvement of civil society. Therefore it is important to strengthen communication and ensure experience sharing between the state and civic organizations, also between the organizations of such type and academic sector;
- Analysis demonstrates that not every sector identified as vulnerable in the strategy was included in the adaptation projects. Healthcare is one of such fields, which is especially vulnerable to the climate change (to the certain extent the vulnerability assessment has already been implemented) and there is a need to plan and introduce the projects encouraging adaptation of this field to climate change;
- The fewest number of adaptation projects to climate change comes to the agriculture sector, which also received the least funding, while it is the priority sector in the country along the whole reporting period. However, to the certain extent, the agriculture issues are included in biodiversity and risk management projects, but in those projects the agriculture component is very modest and it cannot change the whole picture;
- Most of the projects in mitigation sector are implemented without holistic plan on mitigation and other plans of sectoral strategies. Due to this gap the process of implementation lacks the consistency and application of results is also ineffective;
- Tools for regional and international project management are often inflexible and impede the effective working process;
- The local political and financial environment calls for additional measures to ensure introduction of sustainable energy and energy saving technologies.

Annexes

Annex 1.1. Distribution of the territory of Georgia according to land-use categories

(Data provided by FAOSTAT, National Statistics Office of Georgia[135] and the Ministry of Environment and Natural Resources Protection[136]), thousand ha

Land categories	Year																			
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agricultural arable land (including areas belonging to the Forest Funds) Among them:	3229.0	3128.0	3097.0	3048.0	3035.0	3037.0	3045.0	2999.0	3000.0	3003.0	3004.0	3006.0	2512.0	2539.0	2535.9	2526.6	2523.3	2527.0	2468.5	2469.0
1. Arable land and perennials	1129.0	1128.0	1127.0	1078.0	1066.0	1063.0	1062.0	1060.0	1062.0	1063.0	1064.0	1066.0	572.0	599.0	595.9	586.6	583.3	587.0	528.5	529.0
2. Pastures and hay -fields	2100	2000	1970	1970	1969	1974	1983	1939	1938	1940	1940	1940	1940	1940	1940	1940	1940	1940	1940	1940
Forest areas Among them:	2777.0	2775.6	2774.7	2773.6	2772.4	2771.3	2770.1	2769.0	2767.8	2765.3	2762.7	2760.2	2757.6	2755.1	2752.5	2749.9	2747.4	2744.8	2742.3	2739.7
1. Managed forests	2691.3	2689,9	2689.0	2687.9	2686.7	2685.6	2684.4	2636.1	2634.9	2632.4	2629.8	2627.3	2624.7	2622.2	2619.6	2542.5	2440.0	2437.4	2434.9	2428.2
2. Forest areas at protected territories	85.7	85.7	85.7	85.7	85.7	85.7	85.7	132.9	132.9	132.9	132.9	132.9	132.9	132.9	132.9	207.4	307.4	307.4	307.4	311.5
Wetlands (water resource, marshes) Among them:	215.1	215.1	215.1	215.1	215.1	215.1	215.1	215.1	215.1	215.1	893.6	893.6	893.6	893.6	893.6	893.6	893.6	893.6	893.6	893.6
1.Territorial waters area (the Black Sea)	-	-	-	-	-	-	-	-	-	-	679	679	679	679	679	679	679	679	679	679
2. Internal waters	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
3. Marshes	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1
Settlements	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Other lands (including areas belonged to the Forest Fund)	639.9	742.3	774.2	824.3	838.5	837.6	830.8	877.9	878.1	877.6	879.7	880.2	1376.8	1352.3	1358.0	1369.9	1375.7	1374.6	1435.6	1437.7
Total	6949.4	6949.4	6949.4	6949.4	6949.4	6949.4	6949.4	6949.4	6949.4	6949.4	7628.4	7628.4	7628.4	7628.4	7628.4	7628.4	7628.4	7628.4	7628.4	7628.4

[148] http://www.fao.org/statistics/en/
[149] http://moe.gov.ge/index.php?lang_id=GEO&sec_id=43

Annex 2.1 Activity Data and Emission Factor Sources

IPCC source-category	Gas	Sources of activity data	Sources of Emission factors
1A Fuel combustion	CO_2, CH_4,N_2O	Annual Energy Balances specially developed for this inventory[150] were used in GHGs National Nnventory of 2006-2011. Information sources for these balances are as follows: Export-import of oil products and coal - Georgia's National Statistics office on (GNSO); Extraction of coal and natural gas, also export-import of natural gas -import - Georgia's Oil and Gas Corporation (GOGC)[151]; Shares of different sectors in final consumption – International Energy Agency (IEA)[13] Energy Balances; Natural gas consumption in power generation sector (in 2006-2011) and in residential sector (in 2009-2011) – Georgian Oil and Gas corporation (GOGC); Fuel wood consumption and International Bunkers - International Energy Agency (IEA) Energy Balances.	IPCC 1996 Default values
1B1 Fugitive emissions from solid fuel	CH_4	2007-2011 years - GNSO 2006 year - International Energy Agency (IEA) Energy Balances.	IPCC 1996 Average value of default range
1B2 Fugitive emissions from oil production	CH_4	Georgian Oil and Gas corporation (GOGC)	IPCC 1996 Average value of default range
1B2 Fugitive emissions from gas production	CH_4	Georgian Nationa Statistics Office (GNSO)	IPCC 1996 Average value of default range
1B2 Fugitive emissions from gas transportation and distribution	CH_4	Georgian Gas Transportation Company, annual reports from Georgian National Energy and Water Regulatory Commission[1]	Clean Development Mechanism (CDM) Methodology
2A1 Cement production	CO_2	GNSS; Ministry of Environment and Natural Resources Protection (MoENRP); JSC Heidelbergcement	IPCC 1996
2A2 Lime production	CO_2	GNSO; Ministry of Environment and Natural Resources Protection (MoENRP)	IPCC 1996
2A3 Limestone and Dolomite use	CO_2	GNSO	IPCC 1996
2A4 Glass production	CO_2	JSC "Mina"	IPCC 2006
2B1 Ammonia production	CO_2	GNSO; JSC "AZOTI" (Rustavi)	IPCC 1996
2C1 Iron and Steel production	CO_2	GNSO; JSC "AZOTI" (Rustavi)	IPCC 1996
2C2 Ferroalloys production	CO_2	GNSO; Georgian National Academi of Science (GNAS)	IPCC 1996
2B2 Nitric Acid production	N_2O	GNSO; GNAS	IPCC 1996
2D2 Food and Drink production	NMVOCs	Ministry of Environment and Natural Resources Protection (MoENRP)	EMEP/EEA Emission Inventory Guidbook-96
2F Halocarbons use	HFC	Ministry of Environment and Natural Resources Protection (MoENRP); GNSO	IPCC 1996
2E Sulfur Hexafluoride use	SF_6	JSC "Georgian State Electrosystem"	IPCC 1996
3 Solvent and other product use	N_2O	Ministry of Environment and Natural Resources Protection (MoENRP); GNSO	EMEP/CORINAIR (EEA, 2005)
4. Agriculture, all sub-categories	CH_4, N_2O	Statistical Publication "Georgia's Agriculture-2011". GNSO Tbilisi, 2012	IPCC 1996 Default values (Asia region, developing countries, temperate climate)

[150] After 2000 year Energy Balance the next Balance was developed in 2014 and became available for users only in the beginning of 2015 when Georgia's third inventory was already complished. According to the information from the GNSO ir is planned to prepare and issue Energy Balances every year in future. This process significantly will improve the GHGs inventory of Georgia's energy sector.

[151] Activity Data were provided in response to the official request/query from the Ministry of Envirobment and Natural Resources Protection.
http://www.iea.org/statistics/every year in future. This process significantly will improve the GHGs inventory of Georgia's energy sector.

5.A Forests and Forest covered areas	CO_2	Georgian office of UN FAO statistics for 1992-2011[152]; Forest Resources, FAO, Department of Forest management, 2006; Ministry of Environment and Natural Resources Protection (MoENRP[153]) Georgia's national Statistics Office (GNSO), http://geostat.ge/; Georgia's Second National Inventory 2008.	V. Mirzashvili, G. Kuparadze. Forest inventory reference book; S.E. Makhviladze Timber management, Tbilisi 1962; A.M. Borovikov, B.N. Ugolyev. Timber management gide. "Forestry", Moscaw, 1989; Good Practice Guidance for Land Use, Land-Use Change and Forestry.
5.B Arable lands	CO_2	Statistical data of UN FAO for 1992-2011 years (faostat3.fao.org);	" Soils in Imereti rregion and agriculture", Rosa Lordkipanidze, Tbilisi 1997; Good Practice Guidance for Land Use, Land-Use Change and Forestry.
5.C Pastures	CO_2	Statistical data of UN FAO for 1992-2011 years (faostat3.fao.org);	Good Practice Guidance for Land Use, Land-Use Change and Forestry.
6A Disposal of solid waste	CH_4	Number of population whose waste is dumped in landills - GNSO; Waste generation and dumping parameters - studies performed for closing old and constructing new landfill in Batumi ("MATRA"- social behaviour changes programme facilitating the public involvement in local waste management processes which was supported by the government of the Netherlands. Poti –Batumi coastal region) and „2003, GIZ" and "GEO-Cities Tbilisi: Integrated Environmental Assessment of trends in state of Georgian capital Tbilisi" "GEO- cities[154]". In case of Tbilisi the share of collected and dumped waste considered as 100%; Annual load and waste amount stocked were provided by local municipalities for some landfills in Georgia; and by municipal services of the Ministry of Regional Development and Infrastructure; Waste composition - studies performed for closing old and constructing new landfill in Batumi ("MATRA"- social behaviour changes programme facilitating the public involvement in local waste management processes which was supported by the government of the Netherlands. Poti –Batumi coastal region) and „2003, GIZ" and "GEO-Cities Tbilisi: Integrated Environmental Assessment of trends in state of Georgian capital Tbilisi" "GEO- cities[155]". In case of Tbilisi the share of collected and dumped waste considered as 100%;	MCF-Methane Correction Factor Revised 2006 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual; Conversion of C to CH4 - 2006 IPCC; Fraction of DOC (Degradable Organic Carbon Dissimilated DOC_F) -2006 IPCC;
6B1 Industrial wastewater treatment	CH_4	Activity Data of Georgia's Industry Sector; GNSO	(Maximum Methane Producing Capacity) - IPCC GPG ; (Methane Conversion Factor for the Handling)- 2006 IPCC; DOC - 2006 IPCC; Wastewater Produced (m3/tonne product)- 1996 IPCC;
6B2 Domestic and Commercial Wastewater Handling	CH_4	Urban population in Georgia -GNSO; Share of population which is connected to the wastewater treatment plants in Georgia - Municipalities; Types and capacities of wastewater treatment plants - Municipal Servicies; BOD (Biological Oxigen demand) for Batumi wastewater treatment plant – Municipal service of Batumi city;	(Maximum Methane Producing Capacity) Bo=0,6 kgCH4 /kgBOD; IPCC GPG 2000; (Methane Conversion Factor for the Handling)-2006 IPCC; DOC- from 1996 IPCC
6B2 Domestic and Commercial Wastewater Handling	N_2O	Urban population in Georgia -GNSO; Protein consumption in Georgia -http://chartsbin.com/view/1155	$Frac_{NPR}$-share of nitrogen in protein (kg N/kg protein): –IPCC 1996; EF6 (kg N2O-N/kg sewage-N produced)- IPCC 1996.

[152] http://www.faostat3.fao.org
[153] http://www.moe.gov.ge
[154] http://geocities-tbilisi.ge/failebi/2388-Introduction.pdf
[155] http://geocities-tbilisi.ge/failebi/2388-Introduction.pdf

Annex 2.2. Emission trends in LULUCF sector

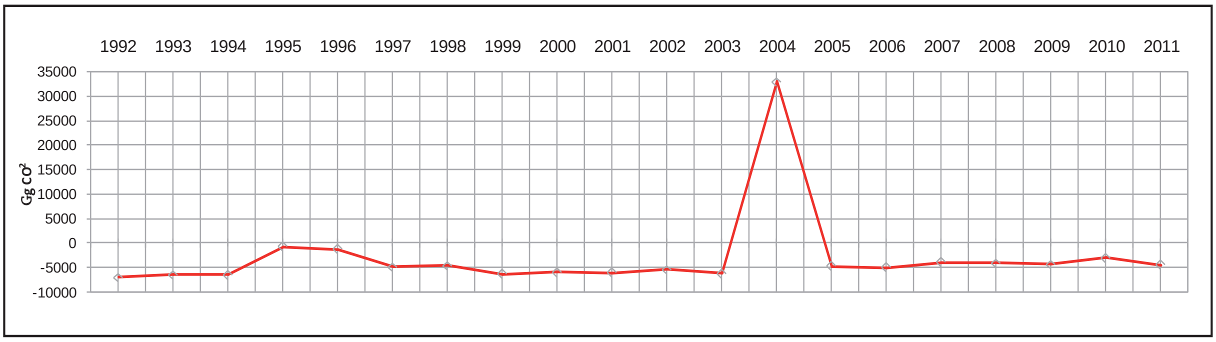


Fig.1. Aggregated emissions in LULUCF sector, calculated for 1992-2011

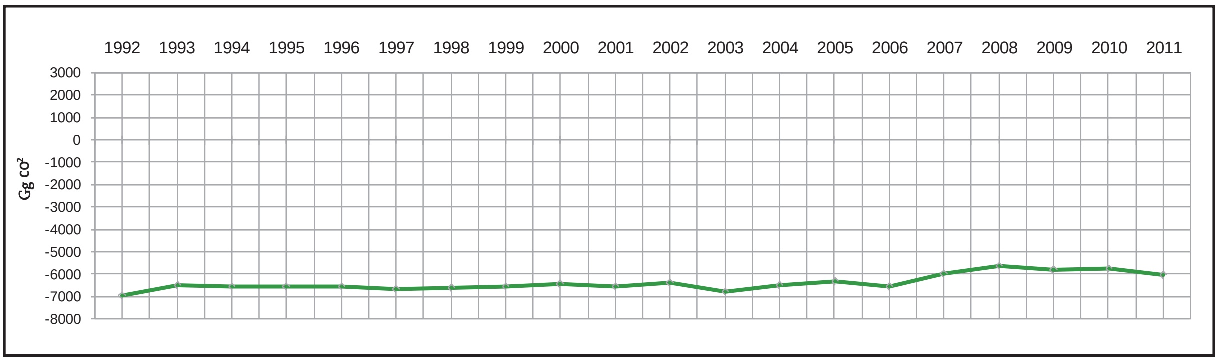


Fig.2. Trend of CO_2 uptake in Forest Land subsector calculated for 1992-2011

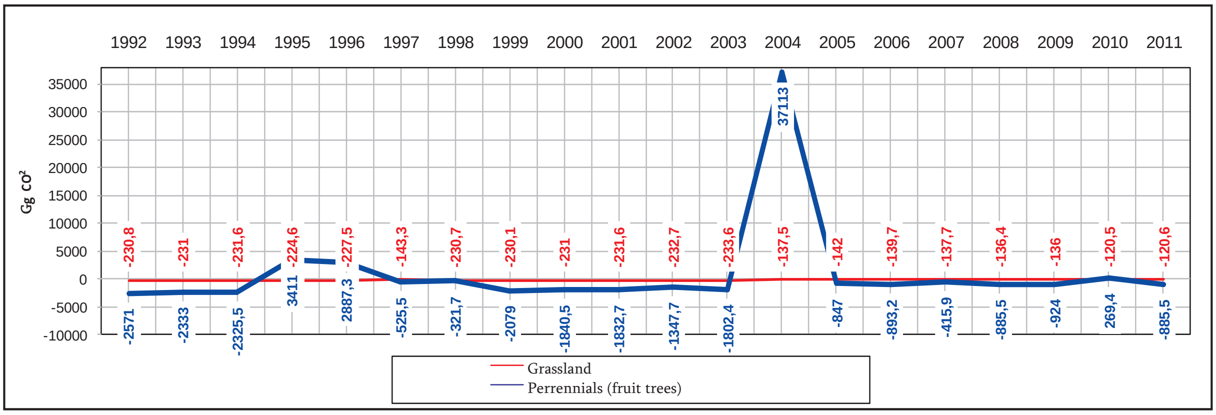


Fig.3. Trend Dynamics of CO_2 removal/emissions in Arable lands (including perennials) subsector

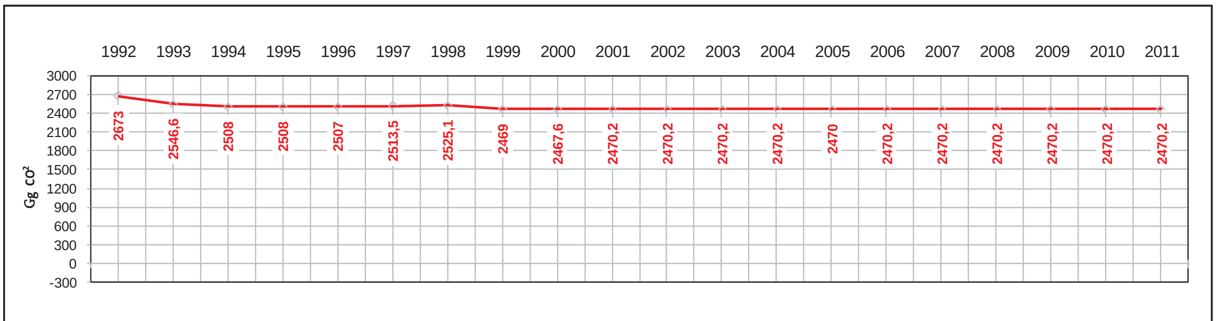


Fig.4. Dynamics of CO_2 emissions from "Hayfields-pastures" subsector

Annex 4.1. Climate Change Assessment Methodology

Assessment of current climate change (till 2010) has been conducted based on observation data of 33 meteorological stations[156] of Georgia's hydrometeorlogical network, future scenarios for 2021-2050 and 2071-2100 periods were constructed using Regional Climate Model RegCM4[157].

Based on the data of mentioned 33 meteorological stations current changes in climate parameters have been assessed for the main three periods: I period – since the station establishment till 1960; II period – 1961-1985 and III period – 1986-2010. Among each successive periods for the variety of climate parameters calculated mean values have been compared, tendencies of revealed changes and patterns of spatial distribution have been defined. For the last 50-year period (1961-2010) seasonal and annual trends have been revealed and their statistical significance has been assessed (by Mann-Kendall test). Essential climate parameters which changes character has been studied are: mean annual and seasonal temperature, annual and seasonal precipitation amount, average wind speed and relative humidity.

For increasing the reliability of obtained results, the time series of these parameters were checked on ***homogeneity***[158] as far as both statistical and dynamical methods used for climate change study are highly depended on investigated time series quality and homogeneity. The question is very topical, since frequent changes that are caused by these effects are climate change order and distort significance of long-term trends and dynamical characteristics. Thus, prior to any analyses, the need to homogenize the data and check their quality arises. Testing for consistency or "homogeneity" has been conducted using the two-phased regression models (RHtestV4 and RHtests_dlyPrcp[159]) for detection of change points. The tests divide time series on two parts and calculate linear trends with the relevant statistical parameters. When this statistics exceeds critical value test detects "change point" for which station metafile should be checked.

Changes in time series of climate parameters have been estimated using two methods: for each parameter the average values for three abovementioned periods were compared as well as for the last 50-years period the seasonal and annual trends were identified and their statistical significance were assessed. ***Trend analysis*** has been carried out using non-parametric Mann-Kendall test method[160]. This is a statistical method which is being used for studying the spatial variation and temporal trends of hydroclimatic series. Throughout the study, we consider a trend as being reliable if it is statistically significant at the 90% level. The magnitude of trend is predicted by the ***Sen's Slope Estimator Test***[161]. It can be computed efficiently, and is insensitive to outliers; it can be significantly more accurate than simple linear regression for skewed and heteroskedastic (when in a collection of random variables there are sub-populations that have different variabilities, i.e. statistical dispersions) data, and competes well against simple least squares even for normally distributed data. This more robust approach for trend estimation was adopted because the extreme climate indices have mostly non-Gaussian distribution and also because daily data could contain large real outliers that could compromise the results returned by the non-resistant least squares method.

As far as under a climatic change, a small variation in the mean values can be associated with large changes in the frequency of extreme events. For the assessment of climate change a variety of ***extreme climatic characteristics (indices)*** is used, calculation methodology of which has been developed under IPCC recommendations[6]. Indices have been computed using RClimDex[162], a software package developed at the Climate Research Branch of Meteorological Service of Canada on behalf of the ETCCDMI (WMO CCl/CLIVAR Expert Team (ET) on Climate Change Detection, Monitoring and Indices). By means of them regularities of possible changes in the magnitude, frequency and/or severity of temperature and precipitation extremes have been investigated.

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[156] Names of stations and values of climate parameters are given in the annexes 4.2-4.5.
[157] Regional Climate Model of the International Centre for Theoretical Physics (ICTP) http://www.ictp.it/research/esp/models/regcm4.aspx
[158] http://www.wmo.int/datastat/documents/WCDMP_72_TD_1500_en_1_1.pdf
[159] http://etccdi.pacificclimate.org/homogenization.shtml
[160] http://www.stats.uwo.ca/faculty/mcleod/2003/DBeirness/MannKendall.pdf
[161] Sen, P.K. 1968. Estimates of the regression coefficient based on Kendall's tau. Journal of the American Statistical Association 63:1379-1389.
[162] http://etccdi.pacificclimate.org/indices.shtml

From known drought indexes ***Standardized Precipitation Index*** (SPI)[163] has been selected that is the difference of precipitation from the mean for a specified time period divided by the standard deviation where the mean and standard deviation are determined for different i time steps (i=1, 3, 6, 9, 12 months). Time steps characterize influence of deficiency of precipitation on all five types of the usable water resources (soil moisture, ground water, snowpack, streamflow and reservoir storage). The standardized precipitation is linearly proportional to precipitation deficit and allows specification of drought probability, percent of average and accumulated precipitation deficit.

To estimate future projection of climate in Georgia for 2050-ies and the end of 21st sentury sevaral studies were analsed:

In the frame of TNC of Georgia climate change scenarios for 33 above mentioned meteorological stations have been constructed according to regional climate model's RegCM4[164] result. Global prediction of ECHAM5/MPI-OM[165] model with **A1B[166]** SRES scenario was dinamically downscaled using RegCM4 for South Caucasus domain with 20 km resolution. Mean seasonal and annual values of main climate parameters (temperature, precipitation, wind, relative humidity) as well as extreme climate indices (SU25, SU30, TR20, ID0, FD0,CCD, etc.) have been analysed in this study. Results (absolute values and differences) for 33 Georgia's meteorological stations are presented in Annexes 4.2-4.5; Future changes are estimeted for the periods 2021-50 and 2071-2100 (reference period is 1986-2010).

For the TNC future climate changes have been calculated using Climate Wizard4[167]. This program helps to downscale prediction of different Global models (16 Coupled atmosphere-ocean general circulation models (AOGCMs)[168] from CMIP3 project and SRES[5)] for the territory of Georgia with 50 km resolution and create ensemble. **According to Climate Wizard4** future scenarios for East and West Georgia have been constructed only for temperature and precipitation. Results from this study are presented in Table 4.1.1., where Increments for different SRES scenarios (A2, A1B and B1) have been taken as 16 member encembel's median[169]. Future periods when the changes have been calculated are the following: 2021-50 and 2071-2100 (reference period is 1986-2010).

[163] http://ulysses.atmos.colostate.edu/SPI.html
[164] http://www.ictp.it/research/esp/models/regcm4.aspx
[165] http://www.mpimet.mpg.de/en/science/models/echam.html
[166] There are 40 different scenarios, each making different assumptions for future greenhouse gas pollution, land-use and other driving forces. These emissions scenarios are organized into families, which contain scenarios that are similar to each other in some respects. The following are the major families of SRES emissions scenarios: The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B). The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines. The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels. http://ipcc.ch/ipccreports/tar/wg1/029.htm#storya1
[167] http://www.climatewizard.org, Nature Concercancy. The Washington University and South Mississippi University Joint Project .
[168] http://climatewizard.org/documentation.html
[169] http://en.wikipedia.org/wiki/Median

Table 4.1.1. Projection of main climate parameters for East and West Georgia using Climate Wizard4

	Winter			Spring			Summer			Autumn			Year		
	A2	A1B	B1	A2	A1B	B1	A2	A1B	B1	A2	A1B	B1	A2	A1B	B1
	2021-2050														
Eas.ΔT(⁰C)	0.2	0.0	0.4	2.2	2.5	0.6	1.7	2.7	0.4	1.4	0.7	0.3	1.2	1.4	0.6
Wes. ΔT(⁰C)	0.3	-0.5	0.4	2.1	2.1	0.5	1.6	2.2	0.6	2.0	2.4	0.5	1.6	1.1	0.9
Eas /ΔP (%)	22.9	-3.1	10.2	9.3	-6.0	8.8	-8.8	-5.4	6.5	-16.4	-17.4	-17.0	1.8	-8.0	2.1
Wes. ΔP(%)	16.9	14.6	10.4	-13.6	0.6	-1.9	-13.6	-15.6	1.2	-12.7	-18.9	-11.4	-5.8	-4.8	-0.4
	2071-2100														
Eas /ΔT(⁰C)	3.3	2.5	1.8	3.5	3.2	2.2	5.0	4.6	3.4	3.5	3.2	1.2	3.8	3.4	2.2
Wes. ΔT(⁰C)	3.2	2.2	1.8	3.3	3.0	2.4	4,7	4.3	3.2	3.6	3.2	1.1	3.7	3.2	2.1
Eas /ΔP (%)	2.4	12.6	8.0	-3.4	-2.7	5.0	-23.7	-19.1	-12.0	3.1	-4.9	-4.0	-3.9	-3.1	-0.8
Wes /ΔP(%)	10.5	14.2	-2.4	-4.6	10.0	8.0	-25.5	-18.5	-12.0	2.0	-3.6	-6.0	-5.4	-3.5	-0.3

- In 2012-13 special research was conducted by German climate-service-center to estimate future climate change on Georgia's territory (granted by KFW and BMZ) and its results was published as "Cimate Fact-Sheet Georgia". In this study results of ensemble with 24 Coupled atmosphere-ocean general circulation models (AOGCMs)[170] member from CMIP3[171] project have been analysed. This results have been taken without downscaling and for the whole territory of Georgia[172]. The range of possible changes have been determined for the following characteristics: Mean annual temperature, heatwaves, cold spells, dry spells, heavy rains, wind speed, evaporation, sea level. Based on mentioned study it's easy to obtain difference between future predictions generated from different models and scenarios and to estimate range of posible changes, with corresponding probabilities, but it does not include local pattern of changes, what is necessary for assessing climate change local impact and adaptation planning. Results from this study are presented in Table 4.1.2. Future changes are estimated for 2071-2100 period with reference period 1961-1990;
- All above mentioned results have been compared with values presented in IPCC 5th assesment report[173]. This report was published in 2013, where climate processes on the territory of Georgia have been analysed, also more exact future trends have been obtained for the Europian domain with extended mediterranian countries. In the report results of CMIP5 project (Coupled Models Intercomparision Project) are presented, where muli-model ensemble's prediction, with 39 AOGCMs members was summarised by regions. In the frame of CMIP5[174] project next development of AOGCMs has been aheived. In the 5th Assesment Report results of comparision of CMIP5 project multi-model ensemble prediction based on RCP4.5 (Representative Consentration Pathway[175]) senario with prediction generated by 24 AOGCMs from CMIP3 project based on A1B scenario are published. Future prediction has been estimated for 2086-2099 with reference period 1986-2005. In this study changes of mean annual temperature and precipitation sums, also temperatures in winter and summer, as well as changes of precipitation sums in cold (November-March) and warm (April-October) periods are discussed. All results are presented in Table 4.1.2.

[170] http://climatewizard.org/documentation.html
[171] http://cmip-pcmdi.llnl.gov/cmip3_overview.html?submenuheader=1
[172] From the different resolution (resolution identifies number of points on some area) AOGCMs output only one value available for entire Georgia territory.
[173] http://www.ipcc.ch/report/ar5/wg1/
[174] http://cmip-pcmdi.llnl.gov/cmip5/availability.html
[175] The RCPs are not fully integrated scenarios (i.e., they are not a complete package of socioeconomic, emissions, and climate projections). They are consistent sets of projections of only the components of radiative forcing (the change in the balance between incoming and outgoing radiation to the atmosphere caused primarily by changes in atmospheric composition) that are meant to serve as input for climate modelling. Conceptually, the process begins with pathways of radiative forcing, not detailed socioeconomic narratives or scenarios. Central to the process is the concept that any single radiative forcing pathway can result from a diverse range of socioeconomic and technological development scenarios. Within RCPs also exists three main categorry of high(RCP 8.5W/m² 2100 year), medium (RCP 4.5W/m²) and low (RCP 3-PD23 W/m²) scenarios, corresponding to SRES A2, A1B and B1 ones.

High resolution future climate change scenarios for Georgia have been constructed based on RegCM4 results for 33 meteorological stations using A1B scenario. Station based values have been averaged for Eastern and Western parts, as well as the whole country, to compare them with other above mentioned results. The comparison revealed that for temperature all results are too close with RegCM4 based prediction for 2100. Only temperature increment is lower in 5th Assessment Report. Comparison results are presented in Table 4.1.2. For 2050 period RegCM4 results have been compared with ClimateWizard4's results.

Future changes of climate extrems

Future climate change scenarios for 2050-ies and up to the end of 21st sentury were constructed for extreme climate indices. Scenarios have been constructed based on RegCM4 results. These results have been compared with corresponding ones from German Climate Service Center study- "Cimate Fact-Sheet Georgia" for 2071-2100 period, where two temperature indices (heat waves, cold spels) and two precipitation indices (dry spell, number of heavy rainy days) are presented. Future changes tendencies, also its rate are in good agreement with RegCM4 results for temperature indices. As for number of heavy rainy days according to German Climate Servce Center number of such days increases by 8% for 2100 period, when by RegCM4 only extremely heavy rainy days (90 mm) number will very likely to increase.

Table 4.1.2. Annual and seasonal increaments of mean temperature and precipitation for 2021-2050 and 2071-2100 periods Compared to 1986-2010 period mean.

	Winter		**Spring**		**Summer**		**Autumn**		**Year**		**Winter**		**Spring**		**Summer**		**Autumn**		**Year**	
	2021-2050										**2071-2100**									
Models	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
RegCM4/ Δ**T**(^{0}C)	1.2	1.4	1.1	1.1	1.0	1.1	1.3	1.6	1.1	1.3	2.9	3.3	3.5	2.9	3.9	3.7	3.6	3.8	3.5	3.4
RegCM4 /Δ**P (%)**	28.0	13.0	-13.3	-13.7	9.8	22.4	3.8	3.0	3.4	5.4	-6.1	-5.1	-22.6	-11.5	19.5	-15.0	-4.8	-11.8	-6.9	-10.9
ClimateWizard4 Δ**T**(^{0}C)	0.0	-0.5	2.5	2.1	2.7	2.2	0.7	2.4	1.4	1.1	2.5	2.2	3.2	3.0	4.6	4.3	3.2	3.2	3.4	3.2
ClimateWizard4 Δ**P (%)**	-3.1	14.6	-6.0	0.6	-5.4	-15.6	-17.4	-18.9	-8.0	-4.8	12.6	14.2	-2.7	10	-19.1	-18.5	-4.9	-3.6	-3.1	-3.5
Cimate Fact-Sheet Georgia Δ**T**(^{0}C)	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	3.5 [1.8 ÷ 4.9]	
Cimate Fact-Sheet Georgia Δ**P (%)**	-	-	-	-	-	-	-	-	-	-	10%		-	-	[-35÷ -20]		-	-	7 [-19÷ +8]	
The Fifth Assessment Report (AR5)/ΔT(^{0}C)	1.2	1.2	-	-	-	-	-	-	-	-	2-3	2-3	-	-	3-4		-	-	3.0	
The Fifth Assessment Report (AR5)/Δ**P (%)**	-3 ÷ +22.9	1 0 ÷ 17	-	-	-	-	-	-	-	-	+2.4÷ +12.6	-2.4 ÷ +14.2	-	-	-10÷-20		-	-	±5	
Précis (HadCM)/ Δ**T**(^{0}C)	-	-	-	-	-	-	-	-	-	-	2.5	2.0	2.5	-1	6.5	4	2.5	2.0	3.5	1.8
Précis (HadCM)/ Δ**P (%)**	-	-	-	-	-	-	-	-	-	-	50	100	50	50	-125	-180	-50	-100	-75	-130
Précis (ECHAM)/ Δ**T**(^{0}C)	-	-	-	-	-	-	-	-	-	-	5.0	4.5	4.2	3.5	6.0	5.0	4.0	4.0	3.9	3.4
Précis (ECHAM)/ Δ**P (%)**	-	-	-	-	-	-	-	-	-	-	-45	108.0	-72.0	-9.0	0	-54.0	45.0	-9.0	-72.0	36.0
Magicscengen/ Δ**T**(^{0}C)	-	-	-	-	-	-	-	-	-	-	6.1	4.3	7.1	5.6	5.2	7.7	5.8	4.1	4.9	5.2
Magicscengen/ Δ**P**(%)	-	-	-	-	-	-	-	-	-	-	9.0	-27	-72	-72	-90	-36	-81	-99	-106	110

Annex 4.2 Current changes of Main climate parameters

Mean Temperature and precipitation seasonal and annual values for three periods: till 1960 year-from station opening; 1961-1985 and 1986-2010 and their changes between mentioned periods

Stations	T_1(⁰C)	T_2(⁰C)	T_3(⁰C)	Δ_1(⁰C)	Δ_2(⁰C)	P_1 mm	P_2 mm	P_3 mm	Δ_1 %	Δ_2 %
					Winter					
Dedoplistskaro	-0.1	0.6	1.0	0.7	0.4	84.0	75.9	83.1	-9.6	9.5
Kvareli	2.2	2.6	3.1	0.4	0.5	132.0	121.6	130.6	-7.9	7.4
Lagodekhi	2.1	2.8	3.2	0.7	0.4	137.0	123.4	139.0	-9.9	12.6
Gurjaani	2.0	2.5	2.8	0.5	0.3	109.0	97.8	106.5	-10.3	8.9
Telavi	1.6	2.1	2.4	0.5	0.3	111.0	88.9	93.8	-19.9	5.5
Tsnori	1.4	1.9	2.6	0.5	0.7	79.0	78.6	89.7	-0.5	14.1
Akhmeta	1.6	2.4	2.8	0.8	0.4	132.0	97.6	104.6	-26.1	7.2
Sagarejo	1.0	1.5	1.9	0.5	0.4	126.0	102.8	93.9	-18.4	-8.7
Bolnisi	1.5	2.2	2.6	0.7	0.4	76.0	70.6	66.0	-7.1	-6.5
Tbilisi	2.1	2.7	3.1	0.6	0.4	72.0	61.7	61.6	-14.3	-0.2
Gori	0.0	0.4	0.7	0.4	0.3	134.0	94.6	102.0	-29.4	7.8
Tskhinvali	-0.8	0.1	0.4	0.9	0.3	170.0	137.3	145.2	-19.2	5.8
Akhaltsikhe	-2.2	-2.2	-2.0	0.0	0.2	97.0	77.1	81.2	-20.5	5.3
Tsalka	-3.7	-3.3	-3.2	0.4	0.1	85.0	72.8	73.9	-14.4	1.5
Pasanauri	-2.8	-2.2	-2.0	0.6	0.2	161.0	147.2	160.9	-8.6	9.3
Mta-Sabueti	-2.8	-2.4	-2.2	0.4	0.2		384.3	425.1		10.6
Kutaisi	6.2	6.5	6.3	0.3	-0.2	508.0	415.6	448.6	-18.2	7.9
Zugdidi	5.7	6.1	5.9	0.4	-0.2	442.0	427.3	458.2	-3.3	7.2
Gali	5.5	6.3	6.0	0.8	-0.3 ↓	415.0	368.0	416.7	-11.3	13.2
Sokhumi	6.4	7.0	7.2	0.6	0.2	431.0	398.0	407.4	-7.7	2.4
Poti	6.0	6.8	6.9	0.8	0.1	500.0	419.7	453.2	-16.1	8.0
Kobuleti	5.7	6.4	6.3	0.7	-0.1	715.0	616.9	655.1	-13.7	6.2
Chaqvi	7.0	7.3	6.9	0.3	-0.4	786.0	733.1	756.7	-6.7	3.2
Batumi	7.4	7.8	7.5	0.4	-0.3		716.3	698.2		-2.5 ↓
Keda	4.1	4.5	4.8	0.4	0.3	515.0	575.1	633.2	11.7	10.1
Khulo	2.1	2.2	1.9	0.1	-0.3	429.0	440.2	498.0	2.6	13.1
Sachkhere	1.2	1.7	1.6	0.5	-0.1	284.0	219.8	252.8	-22.6	15.0
Ambrolauri	0.7	1.1	0.9	0.4	-0.2	258.0	258.1	289.1	0.0	12.0
Pskhu	-0.5	-0.1	0.0	0.4	0.1	774.0	687.9	670.0	-11.1	-2.6
Lentekhi	-0.8	-0.8	-0.8	0.0	0.0	313.0	335.3	359.9	7.1	7.3
Khaishi	0.7	0.8	0.8	0.1	0.0	429.0	329.9	369.7	-23.1	12.1
Mestia	-4.9	-4.3	-4.4	0.6	-0.1 ↓	226.0	185.4	241.8	-0.2	30.4
Goderdzi Pass	-	-6.9	-6.8	-	0.1	589.0	350.0	354.9	-0.4	1.4
					Spring					
Dedoplistskaro	8.9	9.8	9.9	0.9	0.1	215.0	191.6	211.6	-10.9	10.4
Kvareli	11.8	12.2	12.4	0.4	0.2	356.0	306.2	296.8	-14.0	-3.1
Lagodekhi	11.8	12.7	12.6	0.9	-0.1	332.0	300.1	331.8	-9.6	10.6
Gurjaani	11.7	12.3	12.3	0.6	0.0	270.0	253.3	261.6	-6.2	3.3
Telavi	10.9	11.6	11.7	0.7	0.1	288.0	244.5	250.6	-15.1	2.5
Tsnori	12.2	12.8	12.6	0.6	-0.2	207.0	200.5	198.9	-3.1	-0.8
Akhmeta	10.8	11.7	12.0	0.9	0.3	273.0	240.5	231.0	-11.9	-4.0

Sagarejo	10.0	10.3	10.6	0.3	0.3	291.0	264.7	244.5	-9.0	-7.6
Bolnisi	11.2	11.7	11.7	0.5	0.0	196.0	180.8	181.6	-7.8	0.4
Tbilisi	11.9	12.4	12.4	0.5	0.0	186.0	164.4	164.1	-11.6	-0.2
Gori	10.3	10.6	10.4	0.3	-0.2	173.0	142.7	146.1	-17.5	2.4
Tskhinvali	8.6	9.4	9.7	0.8	0.3	198.0	169.0	180.3	-14.6	6.7
Akhaltsikhe	8.7	8.6	8.7	-0.1	0.1	155.0	163.7	148.6	5.6	-9.2
Tsalka	4.9	5.3	5.3	0.4	0.0	252.0	237.4	219.5	-5.8	-7.5
Pasanauri	7.2	7.6	8.1	0.4	0.5 ↑	317.0	313.1	299.9	-1.2	-4.2
Mta-Sabueti	4.9	5.6	5.6	0.7	0.0		301.0	270.5		-10.1
Kutaisi	13.1	13.6	13.6	0.5	0.0	340.0	279.1	307.4	-17.9	10.1 ↑
Zugdidi	12.5	13.0	12.9	0.5	-0.1	361.0	397.4	450.6	10.1	13.4 ↑
Gali	12.6	13.1	13.1	0.5	0.0	344.0	381.9	404.9	11.0	6.0
Sokhumi	12.4	12.9	13.0	0.5	0.1	374.0	373.8	362.0	-0.1	-3.2
Poti	12.4	12.7	12.7	0.3	0.0	271.0	251.9	295.3	-7.0	17.2 ↑
Kobuleti	11.3	11.9	11.9	0.6	0.0	362.0	348.4	330.8	-3.8	-5.1
Chaqvi	11.8	12.1	11.9	0.3	-0.2	438.0	413.8	394.3	-5.5	-4.7
Batumi	12.1	12.5	12.5	0.4	0.0	404.0	355.8	326.7	-11.9	-8.2
Keda	11.9	12.2	12.2	0.3	0.0	282.0	292.7	374.3	3.8	27.9 ↑
Khulo	9.4	9.5	9.3	0.1	-0.2	259.0	265.7	279.2	2.6	5.1 ↑
Sachkhere	11.1	11.2	10.9	0.1	-0.3	205.0	223.7	243.4	9.1	8.8
Ambrolauri	10.7	11.1	10.9	0.4	-0.2	277.0	241.0	258.0	-13.0	7.1
Pskhu	8.6	9.0	9.3	0.4	0.3	538.0	514.9	520.0	-4.3	1.0
Lentekhi	8.9	9.5	9.7	0.6	0.2	318.0	315.3	356.6	-0.8	13.1 ↑
Khaishi	10.2	10.5	10.6	0.3	0.1	304.0	263.5	320.3	-13.3	21.6
Mestia	5.2	5.5	5.6	0.3	0.1	253.0	235.5	277.6	-6.9	17.9
Goderdzi Pass	-	1.2	1.1	-	-0.1	361.0	316.2	234.6	-12.4	-25.8 ↓
Summer										
Dedoplistskaro	20.6	20.7	22.1	0.1	1.4 ↑	206.0	211.6	165.6	2.7	-21.7
Kvareli	22.6	22.6	23.4	0.0	0.8 ↑	343.0	311.3	289.6	-9.2	-7.0
Lagodekhi	23.0	23.2	23.8	0.2	0.6	297.0	298.7	318.5	0.6	6.6
Gurjaani	22.6	22.7	23.3	0.1	0.6 ↑	224.0	259.3	206.5	15.8	-20.4
Telavi	21.8	21.9	22.7	0.1	0.8 ↑	270.0	282.2	232.9	4.5	-17.5
Tsnori	23.3	23.5	24.1	0.2	0.6	176.0	188.5	159.9	7.1	-15.2
Akhmeta	21.4	21.9	22.9	0.5	1.0↑	249.0	261.2	213.4	4.9	-18.3
Sagarejo	20.9	20.8	21.7	-0.1	0.9 ↑	241.0	265.7	198.1	10.2	-25.4
Bolnisi	22.4	22.5	23.4	0.1	0.9	162.0	160.6	126.9	-0.9	-21.0 ↓
Tbilisi	23.2	23.0	23.9	-0.2	0.9 ↑	169.0	172.8	155.4	2.2	-10.1
Gori	21.2	20.7	21.3	-0.5	0.6 ↑	140.0	151.1	141.5	7.9	-6.4
Tskhinvali	19.4	19.5	20.2	0.1	0.7	156.0	171.0	167.1	9.6	-2.3
Akhaltsikhe	19.4	18.7	19.6	-0.7	0.9 ↑	179.0	187.4	190.1	4.7	1.4
Tsalka	15.1	15.2	15.7	0.1	0.5 ↑	237.0	259.3	236.7	9.4	-8.7
Pasanauri	17.5	17.3	18.3	-0.2	1.0 ↑	317.0	315.9	322.3	-0.3	2.0
Mta-Sabueti	15.0	15.1	16.0	0.1	0.9 ↑	253.0	267.8	192.5	5.8	-28.1 ↓
Kutaisi	22.6	22.2	23.2	-0.4	1.0 ↑	315.0	285.3	296.1	-9.4	3.8
Zugdidi	21.9	21.6	22.7	-0.3	1.1 ↑	463.0	567.1	510.4	22.5	-10.0
Gali	21.9	22.0	22.7	0.1	0.7	450.0	476.7	448.1	5.9	-6.0
Sokhumi	21.8	21.9	22.8	0.1	0.9	335.0	364.1	348.0	8.7	-4.4

Poti	22.1	21.9	23.0	-0.2	1.1 ↑	539.0	582.1	605.5	8.0	4.0
Kobuleti	21.5	21.5	22.3	0.0	0.8 ↑	547.0	565.8	564.3	3.4	-0.3
Chaqvi	21.5	21.3	21.9	-0.2	0.6 ↑	613.0	607.7	599.2	-0.9	-1.4
Batumi	21.4	21.4	22.3	0.0	0.9 ↑	599.0	537.5	512.0	-10.3	-4.7
Keda	20.6	20.5	21.1	-0.1	0.6 ↑	275.0	286.5	326.0	4.2	13.8
Khulo	18.2	17.7	18.5	-0.5	0.8 ↑	219.0	216.0	246.6	-1.4	14.2
Sachkhere	21.5	20.8	21.5	-0.7	0.7	172.0	241.5	238.5	40.4	-1.2
Ambrolauri	21.1	20.6	21.3	-0.5	0.7 ↑	260.0	259.7	262.1	-0.1	0.9
Pskhu	18.5	18.3	18.8	-0.2	0.5	409.0	386.3	373.0	-5.6	-3.4
Lentekhi	19.1	19.2	20.2	0.1	1.0 ↑	287.0	321.5	345.8	12.0	7.6
Khaishi	20.0	19.6	20.0	-0.4	0.4	307.0	292.3	300.8	-4.8	2.9
Mestia	15.6	15.2	15.9	-0.4	0.7	243.0	295.7	270.8	21.7	-8.4
Goderdzi Pass	-	11.0	11.8	-	0.8 ↑	303.0	349.3	278.2	15.3	-20.4 ↓
Autumn										
Dedoplistskaro	11.1	11.4	12.2	0.3	0.8 ↑	143.0	127.9	152.9	-10.6	19.5
Kvareli	13.5	13.5	14.0	0.0	0.5 ↑	239.0	237.1	246.2	-0.8	3.8
Lagodekhi	13.6	13.9	14.3	0.3	0.4	310.0	257.2	273.3	-17.0	6.3
Gurjaani	13.4	13.4	13.8	0.0	0.4	201.0	181.4	200.5	-9.8	10.5
Telavi	12.9	12.9	13.2	0.0	0.3 ↑	191.0	163.6	184.0	-14.3	12.5 ↑
Tsnori	13.6	13.5	14.2	-0.1	0.7	149.0	132.6	148.0	-11.0	11.6
Akhmeta	12.8	13.2	13.6	0.4	0.4	203.0	167.1	177.3	-17.7	6.1
Sagarejo	11.9	12.0	12.5	0.1	0.5	207.0	175.6	191.4	-15.2	9.0
Bolnisi	13.0	13.3	13.6	0.3	0.3	138.0	106.0	127.9	-23.2	20.7 ↑
Tbilisi	13.7	13.7	14.1	0.0	0.4 ↑	132.0	104.2	118.6	-21.1	13.8 ↑
Gori	12.1	11.6	12.1	-0.5	0.5 ↑	138.0	127.4	120.2	-7.7	-5.7
Tskhinvali	10.8	11.0	11.4	0.2	0.4	172.0	157.7	153.0	-8.3	-3.0
Akhaltsikhe	10.3	9.7	10.2	-0.6	0.5 ↑	123.0	111.0	111.9	-9.8	0.8
Tsalka	7.2	7.3	7.2	0.1	-0.1	162.0	139.0	136.7	-14.2	-1.7
Pasanauri	9.2	9.1	9.7	-0.1	0.6 ↑	204.0	194.6	219.1	-4.6	12.6
Mta-Sabueti	8.0	7.9	8.3	-0.1	0.4 ↑		311.1	288.3		-7.3
Kutaisi	16.1	15.9	16.5	-0.2	0.6 ↑	423.0	378.9	405.0	-10.4	6.9
Zugdidi	14.9	14.9	15.5	0.0	0.6 ↑	457.0	454.1	493.9	-0.6	8.8 ↑
Gali	14.8	15.1	15.6	0.3	0.5	437.0	409.7	436.9	-6.2	6.6
Sokhumi	15.6	15.8	16.1	0.2	0.3	415.0	383.1	390.0	-7.7	1.8
Poti	15.8	15.6	16.2	-0.2	0.6 ↑	652.0	611.2	683.2	-6.3	11.8
Kobuleti	15.2	15.1	15.7	-0.1	0.6 ↑	890.0	784.7	856.5	-11.8	9.1 ↑
Chaqvi	15.9	15.7	15.8	-0.2	0.1	951.0	859.8	995.3	-9.6	15.8
Batumi	16.2	16.0	16.4	-0.2	0.4 ↑	998.0	894.3	974.9	-10.4	9.0
Keda	14.1	13.8	14.6	-0.3	0.8 ↑	580.0	546.2	639.2	-5.8	17.0
Khulo	12.1	11.8	12.0	-0.3	0.2	414.0	397.3	453.7	-4.0	14.2
Sachkhere	13.0	12.4	12.5	-0.6	0.1	243.0	239.4	280.7	-1.5	17.3
Ambrolauri	12.4	11.9	12.4	-0.5	0.5 ↑	280.0	282.3	309.8	0.8	9.7 ↑
Pskhu	9.8	9.6	9.8	-0.2	0.2	563.0	563.9	540.0	0.2	-4.2
Lentekhi	10.5	10.0	10.4	-0.5	0.4	326.0	326.2	342.3	0.1	4.9
Khaishi	11.4	11.1	11.9	-0.3	0.8	381.0	332.6	380.2	-12.7	14.3
Mestia	6.9	6.7	7.2	-0.2	0.5	270.0	247.3	271.1	-8.4	9.6
Goderdzi Pass	-	4.2	4.4	-	0.2	569.0	373.8	315.7	-34.3	-15.5 ↓

				Year						
Dedoplistskaro	**10.1**	**10.6**	**11.3**	**0.5**	**0.7 ↑**	**585**	**607.1**	**612.2**	**3.8**	**0.8**
Kvareli	**12.5**	**12.7**	**13.2**	**0.2**	**0.5 ↑**	**991**	**978.1**	**961**	**-1.3**	**-1.8**
Lagodekhi	**12.6**	**13.1**	**13.5**	**0.5**	**0.4 ↑**	**1004**	**979.6**	**1060.5**	**-2.4**	**7.6**
Gurjaani	**12.4**	**12.7**	**13.1**	**0.3**	**0.4 ↑**	**741**	**792.1**	**773.6**	**6.9**	**-2.4**
Telavi	**11.8**	**12.1**	**12.5**	**0.3**	**0.4 ↑**	**770**	**781**	**759.7**	**1.4**	**-2.8**
Tsnori	**12.6**	**12.9**	**13.4**	**0.3**	**0.5 ↑**	**568**	**600.2**	**595.4**	**5.7**	**-0.8**
Akhmeta	**11.6**	**12.3**	**12.8**	**0.7**	**0.5 ↑**	**788**	**767.2**	**725.6**	**-2.6**	**-5.7**
Sagarejo	**11**	**11.2**	**11.7**	**0.2**	**0.5 ↑**	**768**	**808.9**	**726.7**	**5.3**	**-11.3**
Bolnisi	**12**	**12.5**	**12.8**	**0.5**	**0.3 ↑**	**512**	**518.2**	**495.2**	**1.2**	**-4.6**
Tbilisi	**12.7**	**13**	**13.4**	**0.3**	**0.4 ↑**	**505**	**504.1**	**499**	**-0.2**	**-1**
Gori	**10.9**	**10.8**	**11.2**	**-0.1**	**0.4 ↑**	**498**	**516.1**	**511.9**	**3.6**	**-0.8**
Tskhinvali	**9.5**	**10**	**10.5**	**0.5**	**0.5**	**598**	**632.9**	**650.5**	**5.8**	**2.7**
Akhaltsikhe	**9**	**8.7**	**9.1**	**-0.3**	**0.4 ↑**	**508**	**537.4**	**531.7**	**5.8**	**-1.1**
Tsalka	**5.9**	**6.1**	**6.3**	**0.2**	**0.2**	**653**	**709.2**	**667.1**	**8.6**	**-6.3**
Pasanauri	**7.8**	**8**	**8.5**	**0.2**	**0.5 ↑**	**932**	**969.5**	**984.1**	**4**	**1.5**
Mta-Sabueti	**6.3**	**6.6**	**6.9**	**0.3**	**0.3 ↑**	**1101**	**1263.1**	**1171.1**	**14.7**	**-7.9 ↓**
Kutaisi	14.5	14.6	14.9	0.1	0.3 ↑	1380	1357.8	1451.1	-1.6	6.4
Zugdidi	13.8	13.9	14.3	0.1	0.4 ↑	1616	1839.2	1930	13.8	4.7 ↑
Gali	13.7	14.1	14.4	0.4	0.3	1569	1630.3	1705	3.9	4.4 ↑
Sokhumi	14.1	14.4	14.8	0.3	0.4	1478	1510.9	1507.4	2.2	-0.2
Poti	14.1	14.2	14.8	0.1	0.6 ↑	1768	1860.7	2061.3	5.2	9.7
Kobuleti	13.4	13.7	14.1	0.3	0.4 ↑	2320	2314.7	2399.3	-0.2	3.5
Chaqvi	14.1	14.1	14.1	0	0	2621	2619.7	2740.3	0	4.4
Batumi	14.3	14.4	14.7	0.1	0.3 ↑	2532	2511.7	2501.4	-0.8	-0.4
Keda	12.7	12.7	13.2	0	0.5 ↑	1558	1696.4	1965.4	8.9	13.7 ↑
Khulo	10.4	10.3	10.4	-0.1	0.1	1177	1320.3	1468.6	12.2	10.1 ↑
Sachkhere	11.7	11.5	11.7	-0.2	0.2	830	917.7	1011.9	10.6	9.3
Ambrolauri	11.2	11.2	11.4	0	0.2	983	1036.7	1129.9	5.5	8.2 ↑
Pskhu	9.1	9.2	9.5	0.1	0.3	2142	2138.9	2103	-0.1	-1.7
Lentekhi	9.4	9.5	9.9	0.1	0.4 ↑	1193	1290.9	1393.1	8.2	7.3 ↑
Khaishi	10.6	10.5	10.9	-0.1	0.4 ↑	1301	1213.9	1399.2	-6.7	13.2 ↑
Mestia	5.7	5.8	6.1	0.1	0.3	918	961.8	1058.4	4.8	9.1
Goderdzi Pass	2.4	2.4	2.6	0	0.2 ↑	1350	1389	1182.7	2.9	-17.4 ↓

Mean annual relative humidity and wind speed values for three periods: till 1960 year-from station opening; 1961-1985 and 1986-2010 and changes between mentioned periods

Stations	RH1%	RH_2%	RH_3%	Δ_1%	Δ_2%	V_1, m/sec	V_2, m/sec	V_3, m/sec	Δ_1, m/sec	Δ_2, m/sec
Year										
Dedoplistskaro	76	76.5	79.2	0.5	2.7 ↑	2.1	1.6	1.3	-0.5	-0.3 ↓
Kvareli	72	73.3	78.9	1.3	5.6 ↑	1.2	1.1	0.7	-0.1	-0.4
Lagodekhi	72	72.3	75.2	0.3	2.9 ↑	1.1	1.1	0.4	0.0	-0.7 ↓
Gurjaani	72	74.7	72.9	2.7	-1.8 ↓	1.7	1.1	0.8	-0.6	-0.3
Telavi	69	70	70.2	1.0	0.2	2.4	1.7	1.1	-0.7	-0.6 ↓
Tsnori	76	75.6	75.4	-0.4	-0.2	1.0	1.0	0.8	0.0	-0.2 ↓
Akhmeta	69	69.1	68.3	0.1	-0.8	1.1	1.7	2.5	0.6	0.8
Sagarejo	69	68.5	65.7	-0.5	-2.8 ↓	2.2	1.8	1.3	-0.4	-0.5 ↓
Bolnisi	67	69.1	67.7	2.1	-1.4	2.1	1.4	0.6	-0.7	-0.8 ↓
Tbilisi	66	66.9	69.3	0.9	2.4 ↑	2.4	1.6	1.6	-0.8	0.0
Gori	74	73	73.9	-1.0	0.9 ↑	4.1	2.8	1.4	-1.3	-1.4 ↓
Tskhinvali	70	72.4	70.7	2.4	-1.7	4.0	4.0	2.2	0.0	-1.8 ↓
Akhaltsikhe	69	71.6	76.1	2.6	4.5 ↑	1.6	1.4	0.6	-0.2	-0.8 ↓
Tsalka	74	78.2	75.6	4.2	-2.6 ↓	2.0	1.4	1.1	-0.6	-0.3 ↓
Pasanauri	74	74.8	76.7	0.8	1.9 ↑	1.2	1.5	0.8	0.3	-0.7 ↓
Mta-Sabueti	83	84.3	85.7	1.3	1.4 ↑	9.2	6.4	5	-2.8	-1.4 ↓
Kutaisi	70	72	72.1	2.0	0.1	5	5.8	4.8	0.8	-1 ↓
Zugdidi	76	76.6	78.6	0.6	2.0 ↑	1.3	1.2	1.0	-0.1	-0.2 ↓
Gali	79	79.4	78.2	0.4	-1.2	1.0	1.0	0.7	0.0	-0.3 ↓
Sokhumi	70	70.4	71	0.4	0.6 ↑	1.7	1.1	0.8	-0.6	-0.3 ↓
Poti	79	78.4	83.8	-0.6	5.4 ↑	3.4	3.2	1.7	-0.2	-1.5 ↓
Kobuleti	81	82.6	82.7	1.6	0.1	2.6	3.1	3.0	0.5	-0.1
Chaqvi	78	78.8	81.3	0.8	2.5	1.7	1.7	1.8	0.0	0.1
Batumi	75	75.7	74.6	0.7	-1.1	4.6	4.5	4.3	-0.1	-0.2 ↓
Keda	77	77.3	80.4	0.3	3.1 ↑	1.2	1.2	1.3	0.0	0.1
Khulo	70	72	71.9	2.0	-0.1	2.6	2.2	1.5	-0.4	-0.7 ↓
Sachkhere	76	75.9	73.9	-0.1	-2.0 ↓	1.8	1.5	1.2	-0.3	-0.3 ↓
Ambrolauri	75	75.2	76.7	0.2	1.5 ↑	2.3	2.0	1.1	-0.3	-0.9 ↓
Pskhu	83	83.2	84	0.2	0.8	0.9	0.9	0.5	0.0	-0.4 ↓
Lentekhi	78	80.2	83.5	2.2	3.3 ↑	_	0.4	0.1	_	-0.3 ↓
Khaishi	76	76.4	77.3	0.4	0.9	2.3	2.3	1.1	0.0	-1.2 ↓
Mestia	75	74.7	76.8	-0.3	2.1 ↑	1.1	1.1	0.7	0.0	-0.4
Goderdzi Pass	80	85.4	88.7	5.4	3.3 ↑	5.5	5.1	4.5	-0.4	-0.6 ↓

Designations:

T- mean air temperature (seasonal and annual respectively);

P- sums of precipitation (seasonal and annual respectively);

RH-annual relative humidity

V – mean annual wind speed;

Subscript 1 – from station opening-till **1960** year**.**

Subscript 2 – **1961-1985** period**;**

Subscript 3- **1986-2010** period**;**

Δ1 – difference between periods **1961-1985** and from station opening-till **1960** year**;**

Δ2 - difference between periods **1986-2010** and **1961-1985;**

↑ - ascending trend ↓ - descending trend;

Annex 4.3 Future changes of Main climate parameters

Mean Temperature and precipitation seasonal and annual values for three periods: 1986-2010; 2021-2050 and 2071-2100 and changes between mentioned periods;

Stations	T3(0C)	T4(0C)	T5(0C)	Δ3(0C)	Δ4(0C)	P3, mm	P4,mm	P5, mm	Δ3,%	Δ4%
Winter										
Dedoplistskaro	1.0	2.1	3.6	1.1	2.6	83	97	94	16.1	13.5
Kvareli	3.1	4.2	6.1	1.1	3	131	181	107	38.7	-17.9
Lagodekhi	3.2	4.4	6.1	1.2	2.9	139	179	105	28.6	-24.7
Gurjaani	2.8	4.1	5.7	1.3	2.9	107	141	94	32.4	-11.4
Telavi	2.4	3.7	5.5	1.3	3.1	94	134	80	43.1	-14.6
Tsnori	2.6	3.5	4.9	0.9	2.3	90	95	80	6.4	-10.7
Akhmeta	2.8	3.9	5.7	1.1	2.9	105	137	90	31.2	-14.1
Sagarejo	1.9	3	4.6	1.1	2.7	94	135	104	44.1	10.5
Bolnisi	2.6	3.7	5.4	1.1	2.8	66	93	71	41.5	8.0
Tbilisi	3.1	4.2	5.9	1.1	2.8	62	76	64	24.0	4.4
Gori	0.7	2.0	3.7	1.3	3	102	135	97	32.6	-5
Tskhinvali	0.4	1.6	3.5	1.2	3.1	145	202	139	38.8	-4.5
Akhaltsikhe	-2.0	-0.8	1.2	1.2	3.2	81	110	85	35.0	4.6
Tsalka	-3.2	-1.7	0.0	1.5	3.2	74	81	74	9.9	0.4
Pasanauri	-2.0	-0.7	1.2	1.3	3.2	161	182	153	13.0	-5.1
Mta-Sabueti	-2.2	-0.9	0.3	1.3	2.5	425	477	297	12.1	-30.2
Kutaisi	6.3	7.8	9.8	1.5	3.5	449	552	428	22.9	-4.6
Zugdidi	5.9	7.4	9.3	1.5	3.4	458	609	437	33	-4.6
Gali	6.0	7.7	9.6	1.7	3.6	417	502	371	20.4	-10.9
Sokhumi	7.2	8.2	10.2	1.0	3.0	407	561	420	37.7	3.1
Poti	6.9	8.2	10	1.3	3.1	453	668	424	47.4	-6.4
Kobuleti	6.3	7.6	9.3	1.3	3	655	644	471	-1.7	-28.1
Chaqvi	6.9	8.2	10	1.3	3.1	757	878	701	15.9	-7.4
Batumi	7.5	8.9	10.8	1.4	3.3	698	876	765	25.5	9.7
Keda	4.8	6.1	7.9	1.3	3.1	633	624	658	-1.5	4.0
Khulo	1.9	3.2	4.9	1.3	3.0	498	495	433	-0.7	-13.0
Sachkhere	1.6	3.2	5	1.6	3.4	253	142	228	-43.7	-10.0
Ambrolauri	0.9	2.4	4.4	1.5	3.5	289	327	271	13.2	-6.4
Pskhu	0.0	1.2	3.3	1.2	3.3	670	814	740	21.6	10.5
Lentekhi	-0.8	0.5	2.9	1.3	3.7	360	407	384	13.2	6.6
Khaishi	0.8	2.1	4.3	1.3	3.5	370	421	362	13.8	-2.0
Mestia	-4.4	-3.1	-0.7	1.3	3.7	242	240	215	-0.8	-11.0
Goderdzi Pass	-6.8	-5.4	-3.6	1.4	3.0	355	373	298	5.0	-16.0
Spring										
Dedoplistskaro	9.9	11.1	13.6	1.2	3.7	212	160	96	-24.6	-54.9
Kvareli	12.4	13.5	15.9	1.1	3.5	297	263	226	-11.4	-23.8
Lagodekhi	12.6	13.8	16.3	1.2	3.7	332	260	228	-21.7	-31.3
Gurjaani	12.3	13.6	16	1.3	3.7	262	209	175	-20.3	-33.1
Telavi	11.7	12.9	15.2	1.2	3.5	251	216	178	-13.8	-28.9
Tsnori	12.6	14.0	16.6	1.4	4.0	199	152	136	-23.6	-31.8
Akhmeta	12.0	13.0	15.3	1.0	3.3	231	200	166	-13.2	-28.2

Sagarejo	10.6	11.6	14.0	1.0	3.4	245	221	169	-9.8	-31.0
Bolnisi	11.7	13	15.4	1.3	3.7	182	151	115	-17.1	-36.7
Tbilisi	12.4	13.5	15.8	1.1	3.4	164	133	106	-18.7	-35.2
Gori	10.4	11.6	14.0	1.2	3.6	146	122	103	-16.7	-29.4
Tskhinvali	9.7	10.5	13.0	0.8	3.3	180	150	135	-16.7	-25.2
Akhaltsikhe	8.7	9.7	12.0	1.0	3.3	149	154	143	3.3	-3.8
Tsalka	5.3	6.3	8.6	1.0	3.3	220	211	-7177	-3.7	-19.3
Pasanauri	8.1	8.6	11.1	0.5	3.0	300	291	280	-3.1	-6.7
Mta-Sabueti	5.6	6.7	9.1	1.1	3.5	271	265	425	-2.1	57.1
Kutaisi	13.6	14.7	16.8	1.1	3.2	307	250	240	-18.6	-21.9
Zugdidi	12.9	13.9	15.7	1.0	2.8	451	354	405	-21.4	-10.1
Gali	13.1	14	15.7	0.9	2.6	405	356	364	-12.0	-10.1
Sokhumi	13.0	13.9	15.7	0.9	2.7	362	334	356	-7.8	-1.7
Poti	12.7	13.6	15.4	0.9	2.7	295	225	261	-23.7	-11.5
Kobuleti	11.9	12.8	14.4	0.9	2.5	331	199	231	-39.9	-30.1
Chaqvi	11.9	12.9	14.6	1.0	2.7	394	349	353	-11.5	-10.5
Batumi	12.5	13.8	16	1.3	3.5	327	332	342	1.5	4.6
Keda	12.2	13.1	14.8	0.9	2.6	374	318	359	-15.0	-4.0
Khulo	9.3	10.4	12.1	1.1	2.8	279	246	246	-12.0	-12.0
Sachkhere	10.9	13.5	14.7	2.6	3.8	243	264	197	8.5	-19.0
Ambrolauri	10.9	12.2	14.5	1.3	3.6	258	221	227	-14.5	-12.0
Pskhu	9.3	9.8	11.7	0.5	2.4	520	482	533	-7.3	2.5
Lentekhi	9.7	10.4	12.7	0.7	3.0	357	312	338	-12.4	-5.4
Khaishi	10.6	11.4	13.5	0.8	2.9	320	246	265	-23.2	-17.4
Mestia	5.6	6.4	8.7	0.8	3.1	278	234	251	-15.9	-9.6
Goderdzi Pass	1.1	2.3	4.0	1.2	2.9	235	219	172	-7.0	-27.0
Summer										
Dedoplistskaro	22.1	22.8	25.6	0.7	3.5	166	188	186	13.5	12.2
Kvareli	23.4	24.5	27.2	1.1	3.8	290	273	235	-5.8	-19
Lagodekhi	23.8	25	27.9	1.2	4.1	319	268	240	-15.9	-24.7
Gurjaani	23.3	24.6	27.5	1.3	4.2	207	236	197	14.2	-4.7
Telavi	22.7	23.8	26.6	1.1	3.9	233	247	211	6.1	-9.5
Tsnori	24.1	25.4	28.3	1.3	4.2	160	174	161	8.9	0.8
Akhmeta	22.9	23.8	26.7	0.9	3.8	213	228	195	6.6	-8.7
Sagarejo	21.7	22.9	25.8	1.2	4.1	198	226	198	14.1	-0.1
Bolnisi	23.4	24.5	27.4	1.1	4.0	127	140	124	10.2	-2.5
Tbilisi	23.9	24.9	27.8	1.0	3.9	155	165	166	6.4	6.9
Gori	21.3	22.3	25.2	1.0	3.9	142	162	137	14.7	-2.9
Tskhinvali	20.2	21.2	24.2	1.0	4.0	167	178	132	6.3	-20.8
Akhaltsikhe	19.6	20.4	23.5	0.8	3.9	190	194	135	1.8	-28.9
Tsalka	15.7	16.9	19.7	1.2	4.0	237	280	252	18.1	6.4
Pasanauri	18.3	19.0	21.8	0.7	3.5	322	331	234	2.8	-27.3
Mta-Sabueti	16.0	16.7	20.2	0.7	4.2	193	298	780	55.0	304,1
Kutaisi	23.2	23.7	26.4	0.5	3.2	296	323	204	9.2	-31.1
Zugdidi	22.7	22.9	25.2	0.2	2.5	510	736	472	44.2	-7.5
Gali	22.7	23.4	25.6	0.7	2.9	448	549	328	22.5	-26.9
Sokhumi	22.8	23.2	25.6	0.4	2.8	348	508	313	46.1	-10.0

Poti	23.0	23.2	25.5	0.2	2.5	606	757	512	25.0	-15.5
Kobuleti	22.3	23.7	25.6	1.4	3.3	564	536	337	-5.0	-40.3
Chaqvi	21.9	23.4	25.5	1.5	3.6	599	599	501	-0.1	-16.4
Batumi	22.3	24.1	27.0	1.8	4.7	512	543	492	6.0	-3.9
Keda	21.1	22.5	25.1	1.4	4.0	326	320	284	-2.0	-13
Khulo	18.5	20.0	22.7	1.5	4.2	247	252	178	2.0	-28
Sachkhere	21.5	24.1	25.4	2.6	3.9	239	618	169	159.1	-29.3
Ambrolauri	21.3	22.2	25.2	0.9	3.9	262	269	182	2.5	-30.6
Pskhu	18.8	19.9	23.2	1.1	4.4	373	435	374	16.6	0.2
Lentekhi	20.2	20.8	23.9	0.6	3.7	346	393	349	13.7	1.0
Khaishi	20.0	21.2	24.4	1.2	4.4	301	330	258	9.8	-14.2
Mestia	15.9	16.9	20.0	1.0	4.1	271	353	315	30.2	16.1
Goderdzi Pass	11.8	13.2	15.8	1.4	4.0	278	279	261	0.5	-6.0
Autumn										
Dedoplistskaro	12.2	13.2	15.6	1.0	3.4	153	146	145	-4.6	-5.5
Kvareli	14.0	15.1	17.5	1.1	3.5	246	254	224	3.2	-8.9
Lagodekhi	14.3	15.7	17.9	1.4	3.6	273	288	242	5.2	-11.5
Gurjaani	13.8	15.1	17.6	1.3	3.8	201	201	173	0.4	-13.7
Telavi	13.2	14.5	16.9	1.3	3.7	184	175	159	-4.9	-13.7
Tsnori	14.2	15.5	17.7	1.3	3.5	148	145	120	-2.2	-19.1
Akhmeta	13.6	14.8	17.3	1.2	3.7	177	198	163	11.4	-8.2
Sagarejo	12.5	13.7	16.2	1.2	3.7	191	201	171	4.8	-10.8
Bolnisi	13.6	15.0	17.5	1.4	3.9	128	122	106	-4.3	-17.3
Tbilisi	14.1	15.5	17.8	1.4	3.7	119	127	105	7.1	-11.8
Gori	12.1	13.4	15.6	1.3	3.5	120	135	123	12.4	2.0
Tskhinvali	11.4	12.8	15.1	1.4	3.7	153	164	144	7.3	-5.9
Akhaltsikhe	10.2	11.7	14.3	1.5	4.1	112	116	107	3.8	-4.7
Tsalka	7.2	8.9	11.0	1.7	3.8	137	164	149	19.8	9.2
Pasanauri	9.7	10.8	12.9	1.1	3.2	219	199	169	-9.2	-22.8
Mta-Sabueti	8.3	9.8	11.6	1.5	3.3	288	319	481	10.6	66.7
Kutaisi	16.5	17.9	20.1	1.4	3.6	405	391	339	-3.4	-16.2
Zugdidi	15.5	16.9	19.1	1.4	3.6	494	483	395	-2.1	-20.0
Gali	15.6	17.1	19.1	1.5	3.5	437	404	335	-7.5	-23.3
Sokhumi	16.1	17.7	19.9	1.6	3.8	390	405	363	3.8	-7.0
Poti	16.2	17.7	19.8	1.5	3.6	683	625	510	-8.5	-25.3
Kobuleti	15.7	17.3	19.4	1.6	3.7	857	904	684	5.5	-20.1
Chaqvi	15.8	17.5	19.7	1.7	3.9	995	1128	944	13.4	-5.1
Batumi	16.4	18.3	20.9	1.9	4.5	975	1275	1104	7.0	13.3
Keda	14.6	16.2	18.0	1.6	3.4	639	665	684	4.0	7.0
Khulo	12.0	13.7	15.4	1.7	3.4	454	499	499	10.0	10.0
Sachkhere	12.5	14.4	16.6	1.9	4.1	281	262	201	-6.8	-28.4
Ambrolauri	12.4	13.7	16.2	1.3	3.8	310	278	234	-10.2	-24.5
Pskhu	9.8	11.7	14.1	1.9	4.3	540	622	507	15.2	-6.0
Lentekhi	10.4	12.1	14.6	1.7	4.2	342	341	292	-0.3	-14.7
Khaishi	11.9	13.2	15.7	1.3	3.8	380	344	298	-9.7	-21.6
Mestia	7.2	8.7	11.3	1.5	4.1	271	251	215	-7.5	-20.7
Goderdzi Pass	4.4	6.2	8.4	1.8	4.0	316	395	321	25.0	1.5

					Year					
Dedoplistskaro	11.3	12.3	14.6	1.0	3.3	612	589	525	-3.8	-14.2
Kvareli	13.2	14.3	16.7	1.1	3.5	961	970	804	0.9	-16.4
Lagodekhi	13.5	14.7	17.0	1.2	3.5	1061	994	829	-6.3	-21.9
Gurjaani	13.1	14.3	16.7	1.2	3.6	774	786	647	1.6	-16.3
Telavi	12.5	13.7	16.0	1.2	3.5	760	771	636	1.5	-16.2
Tsnori	13.4	14.6	16.9	1.2	3.5	595	566	501	-4.9	-15.8
Akhmeta	12.8	13.9	16.2	1.1	3.4	726	762	606	5.0	-16.5
Sagarejo	11.7	12.8	15.2	1.1	3.5	727	781	655	7.5	-9.9
Bolnisi	12.8	14.1	16.4	1.3	3.6	495	506	411	2.1	-17.0
Tbilisi	13.4	14.5	16.8	1.1	3.4	499	503	447	0.7	-10.4
Gori	11.2	12.3	14.6	1.1	3.4	512	555	466	8.5	-8.9
Tskhinvali	10.5	11.5	13.9	1.0	3.4	651	693	556	6.5	-14.5
Akhaltsikhe	9.1	10.2	12.7	1.1	3.6	532	571	477	7.5	-10.4
Tsalka	6.3	7.6	9.8	1.3	3.5	667	735	663	10.2	-0.6
Pasanauri	8.5	9.4	11.7	0.9	3.2	984	1002	846	1.8	-14.0
Mta-Sabueti	6.9	8.1	10.3	1.2	3.4	1171	1355	2265	15.7	93.4
Kutaisi	14.9	16.0	18.3	1.1	3.4	1451	1511	1222	4.2	-15.8
Zugdidi	14.3	15.3	17.3	1.0	3.0	1930	2176	1701	12.7	-11.9
Gali	14.4	15.5	17.5	1.1	3.1	1705	1807	1422	6.0	-16.6
Sokhumi	14.8	15.8	17.9	1.0	3.1	1507	1803	1475	19.6	-2.1
Poti	14.8	15.7	17.7	0.9	2.9	2061	2269	1699	10.1	-17.6
Kobuleti	14.1	15.4	17.3	1.3	3.2	2399	2084	1515	-13.1	-36.9
Chaqvi	14.1	15.5	17.5	1.4	3.4	2740	2756	2448	0.6	-10.7
Batumi	14.7	16.4	18.9	1.7	4.2	2501	2820	2618	12.8	4.7
Keda	13.2	14.5	16.5	1.3	3.3	1965	1894	1936	-3.6	-1.5
Khulo	10.4	11.8	13.8	1.4	3.4	1469	1466	1404	-0.2	-4.4
Sachkhere	11.7	13.8	15.4	2.1	3.7	1012	1285	804	27.0	-20.6
Ambrolauri	11.4	12.6	15.1	1.2	3.7	1130	1095	922	-3.1	-18.4
Pskhu	9.5	10.7	13.1	1.2	3.6	2103	2348	2169	11.6	3.1
Lentekhi	9.9	10.9	13.5	1.0	3.6	1393	1451	1353	4.1	-2.8
Khaishi	10.9	12.0	14.5	1.1	3.6	1399	1336	1174	-4.5	-16.1
Mestia	6.1	7.3	9.8	1.2	3.7	1058	1075	991	1.5	-6.4
Goderdzi Pass	2.6	4.1	6.1	1.5	3.5	1183	1253	1043	5.9	-11.9

Mean annual relative humidity and wind speed values for three periods: 1986-2010; 2021-2050 and 2071-2100 and changes between mentioned periods;

Stations	RH3%	RH4%	RH5%	Δ3%	Δ4%	V3, m/sec	V4, m/sec	V5, m/sec	Δ3, m/sec	Δ4, m/sec
					Year					
Dedoplistskaro	79.2	75	76	-4.2	-3.2	2.1	1.3	1.2	-0.8	-0.9
Kvareli	78.9	77	76	-1.9	-2.9	1.2	0.8	0.8	-0.4	-0.4
Lagodekhi	75.2	75	75	-0.2	-0.2	1.1	0.6	0.7	-0.5	-0.4
Gurjaani	72.9	70	69	-2.9	-3.9	1.7	0.8	0.7	-0.9	-1.0
Telavi	70.2	67	66	-3.2	-4.2	2.4	1.1	1.2	-1.3	-1.2
Tsnori	75.4	71	69	-4.4	-6.4	1.0	0.8	0.7	-0.2	-0.3
Akhmeta	68.3	66	63	-2.3	-5.3	1.1	2.6	2.4	1.5	1.3
Sagarejo	65.7	65	63	-0.7	-2.7	2.2	1.4	1.2	-0.8	-1
Bolnisi	67.7	68	69	0.3	1.3	2.1	1.3	1.1	-0.8	-1
Tbilisi	69.3	65	65	-4.3	-4.3	2.4	1.5	1.3	-0.9	-1.1
Gori	73.9	72	70	-1.9	-3.9	4.1	1.6	1.4	-2.5	-2.7
Tskhinvali	70.7	70	71	-0.7	0.3	4.0	2.5	2.1	-1.5	-1.9
Akhaltsikhe	76.1	71	69	-5.1	-7.1	1.6	0.8	0.8	-0.8	-0.8
Tsalka	75.6	76	76	0.4	0.4	2.0	1.5	1.3	-0.5	-0.7
Pasanauri	76.7	74	73	-2.7	-3.7	1.2	0.9	1.0	-0.3	-0.2
Mta-Sabueti	85.7	82	79	-3.7	-6.7	9.2	4.6	4.3	-4.6	-4.9
Kutaisi	72.1	71	71	-1.1	-1.1	5.0	5.3	5.1	0.3	0.1
Zugdidi	78.6	76	77	-2.6	-1.6	1.3	0.9	1.0	-0.4	-0.3
Gali	78.2	79	78	0.8	-0.2	1.0	1.0	0.9	0.0	-0.1
Sokhumi	71	72	72	1.0	1.0	1.7	1.9	1.8	0.2	0.1
Poti	83.8	78	77	-5.8	-6.8	3.4	3.0	2.8	-0.4	-0.6
Kobuleti	82.7	82	83	-0.7	0.3	2.6	3.2	3.0	0.6	0.4
Chaqvi	81.3	79	80	-2.3	-1.3	1.7	1.7	1.6	0.0	-0.1
Batumi	74.6	75	74	0.4	-0.6	4.6	4.3	5.1	-0.3	0.5
Keda	80.4	81	85	0.6	4.6	1.2	0.9	0.7	-0.3	-0.5
Khulo	71.9	71	69	-0.9	-2.9	2.6	2.1	2.3	-0.5	-0.3
Sachkhere	73.9	75	74	1.1	0.1	1.8	1.1	1.0	-0.7	-0.8
Ambrolauri	76.7	73	73	-3.7	-3.7	2.3	1.1	0.9	-1.2	-1.4
Pskhu	84	81	81	-3.0	-3.0	0.9	0.4	0.3	-0.5	-0.6
Lentekhi	83.5	80	79	-3.5	-4.5	0.1	0.5	0.4	0.4	0.3
Khaishi	77.3	80	82	2.7	4.7	2.3	1.1	0.9	-1.2	-1.4
Mestia	76.8	79	79	2.2	2.2	1.1	1.5	1.1	0.4	0.0
Goderdzi Pass	88.7	86	84	-2.7	-4.7	5.5	5.1	5.1	-0.4	-0.4

Designations:

T- mean air temperature (seasonal and annual respectively); Subscript 5 - 2071-2100 period;
P- sums of precipitation (seasonal and annual respectively);
Δ3 – difference between periods 2021-2050 and 1986-2010;
RH-annual relative humidity
Δ4 - difference between periods 2071-2100 and 1986-2010;
V – mean annual wind speed;
Subscript 3 – 1986-2010 period.
Subscript 4 – 2021-2050 period;

Annex 4.4. Seasonal values of extreme climate indeces (daily) for 1961-1985 and 1986-2010 periods and changes between mentioned periods

Stations	$ID0_2$	$ID0_3$	Δ_2	$FD0_2$	$FD0_3$	Δ_2	$SU25_2$	$SU25_3$	Δ_2	$TR20_2$	$TR20_3$	Δ_2	$Rx1day_2$	$Rx1day_3$	Δ_2	$Rx5day^2$	$Rx5day_3$	Δ_2	$R50_2$	$R50_3$	Δ_2	$R90_2$	$R90_3$	Δ_2
Winter																								
Dedoplistskaro	12	11	-1	68	66	-1.9	-	-	-	-	-	-	28	35	6.8	56	62	5.6	-	-	-	-	-	-
Kvareli	5.1	1.8	-3.3	50	47	-3.1	-	-	-	-	-	-	41	50	9.9	92	79	-12.8	-	-	-	-	-	-
Lagodekhi	4.8	2.9	-1.9	46	40	-6.1	-	-	-	-	-	-	43	45	2.2	95	71	-24.7	-	-	-	-	-	-
Gurjaani	6	3.5	-2.5	45	48	2.6	-	-	-	-	-	-	33	39	6.1	75	62	-13	-	-	-	-	-	-
Telavi	7.4	4.2	-3.2	53	54	0.8	-	-	-	-	-	-	44	41	-2.4	82	80	-2.4	-	-	-	-	-	-
Tsnori	5	2.2	-2.8	62	59	-2.7	-	-	-	-	-	-	40	29	-11.4	71	52	-19.2	-	-	-	-	-	-
Akhmeta	5.8	2.7	-3.1	50	49	-0.9	-	-	-	-	-	-	26	36	9.9	81	66	-15.2	-	-	-	-	-	-
Sagarejo	9.9	7.3	-2.6	59	56	-2.8	-	-	-	-	-	-	25	42	16.2	59	73	13.7	-	-	-	-	-	-
Bolnisi	5.3	3.6	-1.7	55	55	0.5	-	-	-	-	-	-	23	42	19.3	55	45	-10.3	-	-	-	-	-	-
Tbilisi	3.8	2	-1.8	45	42	-2.7	-	-	-	-	-	-	26	37	10.4	51	54	2.3	-	-	-	-	-	-
Gori	8.3	6.3	-2	66	68	1.9	-	-	-	-	-	-	35	50	15.1	64	84	20	-	-	-	-	-	-
Tskhinvali	12	9.8	-2	68	67	-0.5	-	-	-	-	-	-	42	49	7.3	77	123	46.4 ↑	-	-	-	-	-	-
Akhaltsikhe	18	15	-2.2	82	81	-1.2	-	-	-	-	-	-	29	32	3.5	56	68	12.3	-	-	-	-	-	-
Tsalka	29	27	-1.2 ↓	84	86	2 ↑	-	-	-	-	-	-	25	29	4.1	53	43	-10.8	-	-	-	-	-	-
Pasanauri	18	17	-0.9	81	81	0.7	-	-	-	-	-	-	43	67	23.5	103	192	88.9	-	0.1	0.1	-	-	-
Mta-Sabueti	41	44	3	79	78	-1.4	-	-	-	-	-	-	84	60	-24.2	183	154	-29	0.2	-	-0.2	-	-	-
Kutaisi	0.8	0.6	-0.2	13	12	-0.9	-	-	-	-	-	-	60	84	24.7	148	206	57.9	0.4	0.5	0.1	-	-	-
Zugdidi	0.4	0.2	-0.2	27	29	1.3	-	0.1	0.1	-	-	-	83	84	1	158	203	44.8	0.3	0.3	0	-	-	-
Gali	0.4	-	-0.4	25	24	-0.7	0.2	0.1	-0.1	-	-	-	76	76	0	122	122	0	0.1	0.3	0.2	-	-	-
Sokhumi	0.3	0.2	-0.1	10	7.9	-2.2	-	-	-	-	-	-	64	71	7	146	135	-10.9	0.4	0.4	0	-	-	-
Poti	0.3	-	-0.3	14	9.2	-4.3	-	-	-	-	-	-	59	73	14.3	183	154	-28.8	0.3	0.4	0.1	-	-	-
Kobuleti	0	-	-	21	19	-1.8	-	-	-	-	-	-	95	125	29.9	217	290	73.1	1	1.5	0.5	0	0.1	0.1
Chaqvi	0.1	-	-0.1	11	11	0	0.2	0.1	-0.1	-	-	-	112	95	-17.4 ↓	206	183	-23.6	2.4	2.4	0	0.3	0.1	-0.2
Batumi	0.3	0.1	-0.2	6.2	6.9	0.7	0.3	-	-0.3	-	-	-	114	99	-14.7 ↓	193	292	99.6	2.1	2	-0.1	-	0.1	0.1
Keda	1.6	1.1	-0.5	28	27	-1.6	-	0.2	0.2	-	-	-	113	139	26.5 ↑	263	322	59.1	1.4	2.3	0.9 ↑	0.2	0.3	0.1
Khulo	8.9	13	4.5	51	51	0.4	-	-	-	-	-	-	75	88	13.7	225	202	-22.6	0.6	1.1	0.5	-	-	-
Sachkhere	2.5	3	0.5	59	60	0.6	-	-	-	-	-	-	82	94	12.5	128	245	117.6	-	0.2	0.2	-	-	-
Ambrolauri	5.4	5.5	0.1	65	69	4.1	-	-	-	-	-	-	65	106	41.7	115	289	173.9	0.2	0.4	0.2	-	0.1	0.1
Pskhu	5.1	4.8	-0.3	68	65	-2.7	-	-	-	-	-	-	155	184	29	417	385	-31.5	2.9	2.5	-0.4	0.4	0.4	0
Lentekhi	14	18	3.4 ↑	69	67	-2.1	-	-	-	-	-	-	75	108	33.3	210	278	67.6	0.6	0.6	0	-	0.1	0.1
Khaishi	11	11	0.1	54	57	3.7	-	-	-	-	-	-	79	118	39.8	192	314	122.4	0.4	0.3	-0.1	-	0.1	0.1
Mestia	27	34	7.1 ↑	88	88	-0.2	-	-	-	-	-	-	38	55	17	126	135	9.4	-	0.1	0.1	-	-	-
Goderdzi Pass	69	73	4	90	89	-0.1	-	-	-	-	-	-	60	96	36	150	173	22.4	0.2	0.2	0	-	-	-

Spring																								
Dedoplistskaro	1.1	0.3	-0.8	16	14	-2.1	4.6	6.3	1.7	-	-	-	59	93	33.9	84	101	16.3 ↑	0	0.1	0.1	-	-	-
Kvareli	0.2	-	-0.2	6.2	5.7	-0.5	13	15	1.7	-	-	-	71	85	14.4	105	123	18.3	0.3	0.2	-0.1	-	-	-
Lagodekhi	0.1	-	-0.1	5.3	3.6	-1.7	16	14	-1.9	-	0.1	0.1	88	83	-5.2	119	138	19.4	0.3	0.4	0.1	-	-	-
Gurjaani	0.2	-	-0.2	6	6.1	0.1	14	14	-0.2	-	-	-	69	93	23.7	103	135	32.2	0.2	0.2	0.1	-	-	-
Telavi	0.5	0.1	-0.4	8.4	8.2	-0.2	8.6	9.7	1.1	-	-	-	62	58	-3.4	97	97	0.1 ↑	0.2	0.2	0.1	-	-	-
Tsnori	0.1	-	-0.1	8.8	8.6	-0.2	20	20	0.2	-	-	-	65	56	-9.1	122	105	-17.5	0.1	0	0	-	-	-
Akhmeta	0.2	-	-0.2	6.4	5.5	-0.9	9.7	11	1.5	-	-	-	63	47	-15.3	107	95	-11.6	0.1	-	-	-	-	-
Sagarejo	1	0.2	-0.8	12	10	-1.5	6.8	7.3	0.5	-	-	-	82	104	21.9	111	185	73.7	0.2	0.2	0	-	-	-
Bolnisi	0.2	-	-0.2	8.5	8.7	0.2	9.2	9.5	0.3	-	-	-	93	56	-37.2	129	89	-39.7 ↑	0.1	-	-	-	-	-
Tbilisi	-	-	-	5.7	4.9	-0.8	15	14	-1.2	-	-	-	97	82	-15.2	109	103	-6.6	0.2	0.1	-0.1	-	-	-
Gori	0.2	0	-0.2	16	16	0.7	9.2	9.3	0.1	-	-	-	35	37	2.1	61	65	4.5	-	-	-	-	-	-
Tskhinvali	0.9	0.2	-0.7	16	15	-1.2 ↓	4.7	5.4	0.7	-	-	-	41	45	4.1	76	70	-6.4	-	-	-	-	-	-
Akhaltsikhe	0.8	0.4	-0.4	31	29	-1.5 ↓	8.6	11	2.5	-	-	-	38	47	9.7	55	55	0.2	-	-	-	-	-	-
Tsalka	4.9	3.2	-1.7	40	42	1.8	0.1	0.2	0.1 ↑	-	-	-	59	49	-10.2 ↓	87	72	-14.5	0.1	-	-0.1	-	-	-
Pasanauri	0.9	0.3	-0.6	23	21	-1.5	1.2	2.8	1.6 ↑	-	-	-	58	59	0.4	101	108	6.6	0.1	0	-0.1	-	-	-
Mta-Sabueti	7.7	7.6	-0.1	30	30	-0.6	0.1	0.4	0.3 ↑	-	-	-	55	54	-0.2 ↓	106	96	-10.3	-	-	-	-	-	-
Kutaisi	0	-	-	2.2	1.3	-0.9	23	20	-2.4	1.9	1.6	-0.3	100	82	-17.6	154	161	6.7	0.1	0.1	0	-	-	-
Zugdidi	-	-	-	4.8	4.1	-0.7	20	19	-0.8	0.5	0.3	-0.2	123	148	24.6	146	222	76.2	0.7	0.9	0.2 ↑	-	0.2	0.2 ↑
Gali	-	-	-	3.8	3.6	-0.2	20	22	1.7	0.3	0.5	0.2	89	165	76.6	132	217	85.5 ↑	0.6	0.4	-0.2	-	-	-
Sokhumi	-	-	-	1.7	1.5	-0.2	12	14	1.9	0.5	0.7	0.2	127	109	-18.2	203	216	13.2	0.6	0.5	-0.1	-	-	-
Poti	-	-	-	1.8	1.2	-0.6	12	13	0.9	0.1	0.3	0.2 ↑	65	72	6.3	137	103	-33.9 ↑	-	0.1	0.1	-	-	-
Kobuleti	0	-	-	3.4	3	-0.4	8.6	9	0.4	0	-	-	94	83	-11.6	203	127	-76.2	0.3	0.2	-0.1	-	-	-
Chaqvi	0.1	-	-0.1	2.3	3.3	1	11	8.7	-1.9	-	-	-	80	76	-3.6	341	368	27.4	0.9	0.6	-0.3	-	-	-
Batumi	0.1	-	-0.1	1.4	1.3	-0.1	9.2	8	-1.2	0.2	0.8	0.6 ↑	65	71	5.3	160	135	-25.1	0.6	0.2	-0.4	-	-	-
Keda	0.1	-	-0.1	3.8	4.4	0.6	20	21	1.9 ↑	-	0.3	0.3	100	104	4.5 ↑	163	197	34.2	0.3	0.4	0.1 ↑	-	-	-
Khulo	1.2	1.4	0.2	15	16	0.6	9.1	9.4	0.3	-	0.1	0.1	133	66	-67	192	122	-69.7	0.2	0.1	-0.1	-	-	-
Sachkhere	0.1	-	-0.1	13	12	-1.1	18	15	-3.5 ↓	0.1	0.5	0.4	98	75	-22.2	124	90	-33.7	0.1	0.1	0	-	-	-
Ambrolauri	0.1	-	-0.1	12	13	1.1	1.8	2.5	0.7	-	-	-	73	65	-7.9 ↑	103	139	36	0.1	0.1	0	-	-	-
Pskhu	0.3	0.3	0	21	19	-2.2	12	13	1.2	-	-	-	102	102	0	200	210	10.1	1.2	1.1	-0.1	-	-	-
Lentekhi	0.4	-	-0.4	15	13	-1.8	11	11	-0.4	-	-	-	64	83	18.6	128	207	79	0.2	0.6	0.4 ↓	-	-	-
Khaishi	0.1	0.1	0	9.1	8.4	-0.7	13	12	-1.8	-	-	-	64	72	8.2	113	160	46.5	0.2	0.2	0	-	-	-
Mestia	2	2.6	0.6	39	43	4	0.9	4.1	3.2	-	-	-	55	67	12.1	92	127	35.5	-	-	-	-	-	-
Goderdzi Pass	18	19	1.9	56	54	-2.4	0	0	0	-	-	-	47	44	-3.7 ↓	118	95	-23	-	-	-	-	-	-

Summer																								
Dedoplistskaro	-	-	-	-	-	-	62	73	11 ↑	3.4	7.8	4.4 ↑	97	72	-25	168	137	-31.1	0.4	0.4	0	0	-	-
Kvareli	-	-	-	-	-	-	78	83	5.5 ↑	9.8	16	5.8	131	119	-11.7	161	221	60.1	0.7	0.8	0.1 ↑	0.1	0	-0.1
Lagodekhi	-	-	-	-	-	-	81	82	1.3	18	33	15	132	114	-17.6	223	288	64.9	0.8	0.8	0	0.2	0	-0.1
Gurjaani	-	-	-	-	-	-	78	82	4.7 ↑	15	18	3.5	123	69	-54.5	211	123	-88.2	0.6	0.3	-0.3	0	-	-
Telavi	-	-	-	-	-	-	71	78	6.9 ↑	12	17	4.8 ↑	100	85	-14.6	115	146	30.6	0.6	0.4	-0.2	0	-	-
Tsnori	-	-	-	-	-	-	84	88	3.8	14	20	6.6	61	70	9	122	114	-7.8	0.3	0.3	0	-	-	-
Akhmeta	-	-	-	-	-	-	71	80	9.4 ↑	12	20	7.9 ↑	79	71	-8.5	101	129	27.9	0.4	0.2	-0.2	-	-	-
Sagarejo	-	-	-	-	-	-	66	71	5.6 ↑	4.9	9.3	4.4 ↑	80	88	8	144	109	-35.7	0.6	0.3	-0.3	-	-	-
Bolnisi	-	-	-	-	-	-	77	82	5.6 ↑	17	20	3.4	86	53	-33	94	73	-21.1	0.1	-	-	-	-	-
Tbilisi	-	-	-	-	-	-	80	83	3.6 ↑	19	30	10 ↑	130	118	-12.4 ↑	144	124	-20.3 ↑	0.2	0.2	0	0.1	0	-0.04
Gori	-	-	-	-	-	-	65	70	5.3 ↑	4.6	6	1.4	82	79	-3	96	85	-10.4	0.1	0.1	0	-	-	-
Tskhinvali	-	-	-	-	-	-	55	62	7.3	1.1	1.3	0.2	89	82	-7.4	109	89	-20.4	0.2	0.1	-0.1 ↓	-	-	-
Akhaltsikhe	-	-	-	-	-	-	63	72	8.7 ↑	0.3	0.3	0	75	51	-24	86	96	10.5	0	0	0	-	-	-
Tsalka	-	-	-	0.1	0.2	0.1	12	19	7 ↑	-	-	-	63	69	5.3	100	100	-0.6	0.1	0.2	0.1	-	-	-
Pasanauri	-	-	-	-	-	-	39	48	9.6 ↑	-	0	0	88	85	-3	191	123	-67.5	0.2	0.3	0.1	-	-	-
Mta-Sabueti	-	-	-	-	-	-	9.4	17	7.7 ↑	-	0.1	0.1	88	58	-29.6 ↓	153	90	-63.2 ↓	0.3	0.2	-0.1 ↓	-	-	-
Kutaisi	-	-	-	-	-	-	72	75	3	20	36	16 ↑	127	125	-1.5	280	166	-114	0.6	0.7	0.1	0.2	0	-0.1
Zugdidi	-	-	-	-	-	-	63	76	13 ↑	16	30	14 ↑	174	205	30.8	283	281	-2	2.7	2.3	-0.4	0.9	0.4	-0.5
Gali	-	-	-	-	-	-	69	78	9.2	20	27	6.6	174	154	-19.8	261	261	0	2.1	1.6	-0.5	0.5	0.2	-0.3
Sokhumi	-	-	-	-	-	-	57	63	6.4	27	28	1.1	169	178	8.7 ↑	180	197	17 ↑	1.6	1.5	-0.1	0.4	0.4	0
Poti	-	-	-	-	-	-	54	72	19 ↑	26	43	17 ↑	223	191	-31.8	305	259	-46.1	2.8	3.2	0.4	0.6	0.9	0.3
Kobuleti	-	-	-	-	-	-	50	66	16 ↑	19	31	12 ↑	164	261	97.3	263	317	54.4	2.6	2.7	0.1	0.6	0.6	0
Chaqvi	-	-	-	-	-	-	53	60	6.6	18	28	10 ↑	235	156	-78.5	341	297	-44.4	2.8	2.9	0.1	0.8	0.7	-0.1
Batumi	-	-	-	-	-	-	50	58	8.1 ↑	22	38	15 ↑	162	150	-11.7	242	209	-32.8	2.8	2.6	-0.2	0.4	0.6	0.2
Keda	-	-	-	-	-	-	61	70	8.7 ↑	4.9	13	8.2 ↑	107	83	-24.4	163	169	5.6	0.6	0.6	0	0.1	0	-0.1
Khulo	-	-	-	-	-	-	36	46	10 ↑	1.1	1.6	0.5	68	86	18.1 ↑	124	124	0.8	-	0.1	0.1	-	-	-
Sachkhere	-	-	-	-	-	-	65	71	5.9	4.8	15	10 ↑	59	63	3.5	110	114	3.6	0.1	0.1	0	-	-	-
Ambrolauri	-	-	-	-	-	-	29	39	9.9 ↑	3	2.3	-0.7	77	81	3.8	100	119	19	0.4	0.5	0.1	-	-	-
Pskhu	-	-	-	-	-	-	57	60	2.3	0.3	0.4	0.1	121	125	4.2	252	290	37.9 ↑	1.1	1.2	0.1	0.1	0.1	0 ↑
Lentekhi	-	-	-	-	-	-	56	64	7.5 ↑	0.4	0.8	0.4 ↑	123	111	-12.2	147	166	19.2 ↑	0.6	0.9	0.3 ↑	0.1	0.1	0
Khaishi	-	-	-	-	-	-	54	61	7.1	0.8	1	0.2	87	73	-14.6	105	116	11.4	0.4	0.3	-0.1	-	-	-
Mestia	-	-	-	0.1	-	-	37	46	9.2	-	-	-	145	68	-77.7	168	125	-42.1	0.3	0.1	-0.2	0.1	-	-
Goderdzi Pass	0.1	-	-0.1	1.2	0.7	-0.5	1.2	2	0.8	-	-	-	69	55	-14.6 ↓	116	94	-21.9	0.2	-	-	-	-	-

	Autumn																							
Dedoplistskaro	0.1	0.3	0.2	7.3	7.2	-0.1	9.2	15	5.8 ↑	-	0.2	0.2	55	64	9	79	119	40.3 ↑	0	0.1	0	-	-	-
Kvareli	-	-	-	2.9	2.9	0	18	22	4.2 ↑	0.2	0.8	0.6	88	89	1.9	170	148	-22.4 ↓	0.8	0.5	-0.3 ↓	-	-	-
Lagodekhi	-	-	-	2.5	1.4	-1.1	20	22	2.1	0.2	1.8	1.6	82	88	5.6	177	193	15.6	0.6	0.8	0.2	-	-	-
Gurjaani	-	-	-	1.7	2.9	1.2	17	21	3.6 ↑	0.2	0.4	0.2 ↑	59	66	7	99	122	23	0.1	0.2	0	-	-	-
Telavi	-	-	-	3.8	3.7	-0.1	14	18	4.5 ↑	0.1	0.5	0.4 ↑	67	109	42.4	100	124	23.8	0.1	0.4	0.2 ↑	-	-	-
Tsnori	-	-	-	9.3	6.2	-3.1	23	29	5.3	0.4	0.7	0.3	50	54	3.6	85	100	14.9	-	0.1	0.1	-	-	-
Akhmeta	-	-	-	2.6	2.9	0.3	15	20	4.8	0.2	0.8	0.6	97	89	-7.8	110	106	-3.9	0.2	0.2	0	0	-	-
Sagarejo	-	0.3	0.3	4.6	5	0.4	13	14	1.9	-	0.4	0.4 ↑	55	73	17.9	136	97	-39.2	0.1	0.3	0.2	-	-	-
Bolnisi	-	0.1	0.1	3.5	4.8	1.3	16	20	3.5 ↑	0.1	1	0.9 ↑	54	33	-21.5	80	70	-10.1	-	-	-	-	-	-
Tbilisi	-	-	-	3.2	3.2	0	21	23	2.4	0.4	1.9	1.5 ↑	62	53	-8.6	92	69	-23.2	0.1	0	0	-	-	-
Gori	0	-	-	12	13	1.2	13	16	3.1 ↑	-	0.5	0.5 ↑	60	43	-17	70	79	9.6	0	-	-	-	-	-
Tskhinvali	-	0.1	0.1	7.8	12	3.7	9.2	11	2.2	-	0.1	0.1	46	44	-2.7	78	85	7	-	-	-	-	-	-
Akhaltsikhe	0.2	0.2	0	25	21	-4.2 ↓	15	19	3.5 ↑	-	-	-	63	40	-22.9	130	87	-43.6	0	-	-	-	-	-
Tsalka	1	1.8	0.8	30	30	0.7	1.3	3	1.7 ↑	-	-	-	55	45	-10.1	78	79	0.4	-	-	-	-	-	-
Telavi	0.3	0.5	0.2	17	15	-1.5	4.6	7.6	3 ↑	-	-	-	73	74	1.3 ↑	107	159	52.5 ↑	0.1	0.3	0.2 ↑	-	-	-
Mta-Sabueti	1.8	4.1	2.3	15	15	0.1	0.4	1.4	1 ↑	-	-	-	81	58	-22.6	125	166	41	0.2	-	-0.2	-	-	-
Kutaisi	-	-	-	0.1	-	-0.1	27	28	0.4	3.5	6.4	2.9 ↑	90	83	-6.7	156	201	44.5	0.7	0.8	0.1	-	-	-
Zugdidi	-	-	-	1.3	0.9	-0.4	25	30	5.2 ↑	0.4	2.6	2.2 ↑	131	144	13.5 ↑	202	223	21.5	1.4	1.6	0.2	0.2	0.3	0.1
Gali	-	-	-	1	0.7	-0.3	27	31	4.6	0.8	2.6	1.8	121	118	-3.7	198	198	0	1	0.9	-0.1	0.1	0.1	0
Sokhumi	-	-	-	0.1	-	-0.1	18	21	2.9	2.3	3.3	1	90	78	-12.3	180	185	5.3 ↑	1.2	1.3	0.1	-	-	-
Poti	-	-	-	-	-	-	16	23	6.6 ↑	1.7	4.3	2.6 ↑	170	157	-13.7	375	332	-43	2.6	3	0.4	0.6	0.7	0.1
Kobuleti	-	-	-	0.4	0.3	-0.1	12	21	8.4 ↑	1.4	3.3	1.9 ↑	194	165	-28.7	407	264	-143	4.6	4.5	-0.1	0.8	1.1	0.3
Chakvi	-	-	-	-	0.2	0.2	15	18	3.7	1.6	2	0.4	163	198	35.1	210	275	65.1	5.4	6.3	0.9	1.2	1.3	0.1
Batumi	-	-	-	-	-	-	13	17	4.1 ↑	1.7	4.4	2.7 ↑	239	207	-31.8	339	381	41.1	5.6	6.3	0.7	1	1.5	0.5 ↑
Qeda	-	-	-	1.1	1.3	0.2	19	27	8.2 ↑	0.1	1.5	1.4 ↑	124	171	46.9	239	358	119.1	1.8	2.6	0.8	0.2	0.6	0.4
Khulo	0.2	0.7	0.5	5.3	5.8	0.5	11	14	2.6	0.1	0.3	0.2	107	112	5.4	214	256	42.3	1	1.3	0.3	0.1	0.1	-0.04
Sachkhere	-	-	-	9.9	8.7	-1.2	22	25	2.2	0.2	1.2	1 ↑	63	65	1.8 ↑	98	143	45.3	-	0.2	0.2 ↑	-	-	-
Ambrilauri	-	-	-	10	10	0	4.1	6.2	2.1 ↑	-	0.1	0.1	56	72	16.2	122	147	24.5	0.2	0.3	0.1	-	-	-
Ptskhu	-	-	-	16	16	-0.4	12	13	1.8	-	-	-	138	156	18	214	337	122.9	2.1	2.2	0.1	0.3	-	-0.3
Lentekhi	0.2	0.3	0.1	11	9.5	-1.1	11	11	-0.1	-	-	-	79	107	27.9	141	178	37	0.3	0.3	0	-	-	-
Khaishi	0.1	0.2	0.1	4.4	4.7	0.3	11	14	2.6	-	0.1	0.1	53	88	34.5	140	209	69.2	0.2	0.3	0.1	-	-	-
Mestia	1.1	2.2	1.1	33	31	-2	5.9	8.3	2.4	-	-	-	72	70	-1.6	98	160	62.3	0.1	0.1	0	-	-	-
Goderdzi Pass	9.9	12	1.7	36	34	-2.7	-	-	-	-	-	-	81	64	-16.4	232	169	-62.2	0.2	0.3	0.1	-	-	-

Annual values of extreme climate indeces (daily) for 1961-1985 and 1986-2010 period and changes between mentioned periods

Stations	$ID0_2$	$ID0_3$	Δ_2	$FD0_2$	$FD0_3$	Δ_2	$SU25_2$	$SU25_3$	Δ_2	$TR20_2$	$TR20_3$	Δ_2	Rx1day2	$Rx1day_3$	Δ_2	$Rx5day_2$	$Rx5day_3$	Δ_2	$R50_2$	$R50_3$	Δ_2	$R90_2$	$R90_3$	Δ_2	CDD_2	CDD_3	Δ_2	CWD_2	CWD_3	Δ_2
Year																														
Dedoplistskaro	**13**	**11**	**-1.4**	**91**	**86**	**-4.9**	**76**	**94**	**18.4↑**	**3.4**	**8**	**4.6↑**	**97**	**93**	**-3.4**	**168**	**137**	**-31.1**	**0.4**	**0.5**	**0.1**	**0**	**0**	**0**	**30**	**30**	**0.6**	**5.6**	**5.7**	**0. 1**
Kvareli	**5.1**	**1.8**	**-3.3**	**59**	**55**	**-4.2**	**109**	**120**	**11.4↑**	**10**	**17**	**6.5↑**	**131**	**119**	**-11.7**	**170**	**221**	**50.4**	**1.8**	**1.6**	**-0.2**	**0.1**	**0**	**-0.08**	**26**	**28**	**1.2**	**7**	**7**	**0**
Lagodekhi	**4.8**	**2.9**	**-1.9**	**54**	**44**	**-9.9**	**117**	**118**	**1.6**	**18**	**35**	**16.8**	**132**	**114**	**-17.6**	**223**	**288**	**64.9**	**1.7**	**2**	**0.3**	**0.2**	**0**	**-0.12**	**26**	**26**	**0**	**6.5**	**7**	**0. 5**
Gurjaani	**6**	**3.5**	**-2.5**	**53**	**56**	**3.2**	**109**	**117**	**8.1**	**15**	**19**	**3.7**	**123**	**93**	**-30.3**	**211**	**135**	**-76.7**	**0.9**	**0.7**	**-0.2**	**0**	**0**	**0**	**29**	**30**	**0.9**	**7**	**6.5**	**-0.5**
Telavi	**7.7**	**4.2**	**-3.5**	**64**	**66**	**1.4**	**93**	**106**	**12.4↑**	**12**	**18**	**5.3↑**	**100**	**109**	**9.3**	**115**	**146**	**30.6↑**	**0.9**	**1**	**0.1**	**0**	**0**	**0**	**31**	**32**	**1.5**	**5.4**	**6.9**	**1.5 ↑**
Tsnori	**5**	**2.2**	**-2.8**	**80**	**73**	**-6.6**	**127**	**136**	**9.4 ↑**	**14**	**21**	**6.9**	**65**	**70**	**4.9**	**122**	**114**	**-8.5**	**0.4**	**0.4**	**0**	**-**	**-**	**-**	**31**	**31**	**-0.6**	**5.2**	**6.1**	**0.9**
Akhmeta	**5.9**	**2.8**	**-3.1**	**59**	**56**	**-2.2**	**96**	**112**	**15.8**	**12**	**21**	**8.5↑**	**97**	**89**	**-7.8↓**	**110**	**129**	**19**	**0.7**	**0.3**	**-0.4**	**0**	**-**	**-**	**30**	**29**	**-0.7**	**5.8**	**7.1**	**1.3**
Sagarejo	**11**	**7.8**	**-2.8**	**75**	**70**	**-4.6**	**85**	**93**	**8 ↑**	**4.9**	**9.7**	**4.8↑**	**82**	**104**	**21.9**	**144**	**185**	**40.2**	**0.9**	**0.8**	**-0.1**	**-**	**0**	**0.04**	**29**	**30**	**0.9**	**7**	**6.5**	**-0.5**
Bolnisi	**5.3**	**3.7**	**-1.6**	**67**	**67**	**0.7**	**102**	**111**	**9.2↑**	**17**	**21**	**4.5**	**93**	**56**	**-37.2**	**129**	**89**	**-39.7**	**0.2**	**0**	**-0.2**	**-**	**-**	**-**	**33**	**32**	**-0.4**	**5.4**	**5.7**	**0.3**
Tbilisi	**3.8**	**2**	**-1.8**	**54**	**50**	**-4.1**	**115**	**120**	**4.8**	**20**	**32**	**11.9↑**	**130**	**118**	**-12.4**	**144**	**124**	**-20.3↑**	**0.4**	**0.4**	**-0.08**	**0.1**	**0**	**-0.08**	**34**	**35**	**0.3**	**5.6**	**5.4**	**-0.2**
Gori	**8.5**	**5.6**	**-2.9**	**94**	**95**	**1.1**	**87**	**97**	**10.2↑**	**4.6**	**6.5**	**1.9↑**	**82**	**79**	**-3**	**96**	**85**	**-10.4**	**0.1**	**0.1**	**0**	**-**	**-**	**-**	**28**	**30**	**1.7**	**5.2**	**5.5**	**0.3**
Tskhinvali	**13**	**9.2**	**-3.5**	**92**	**92**	**-0.4**	**69**	**80**	**11.5**	**1.1**	**1.3**	**0.2**	**89**	**82**	**-7.4**	**109**	**123**	**14**	**0.2**	**0.1**	**-0.1↓**	**-**	**-**	**-**	**25**	**25**	**-0.3**	**5.7**	**6.9**	**1.2 ↑**
Akhaltsikhe	**18**	**16**	**-2.2**	**138**	**131**	**-7 ↓**	**87**	**102**	**14.8↑**	**0.3**	**0.3**	**0**	**75**	**51**	**-24**	**130**	**96**	**-34.4**	**0.1**	**0**	**-0.04**	**-**	**-**	**-**	**27**	**25**	**-2.2**	**5.8**	**5.8**	**0**
Tsalka	**34**	**32**	**-1.9**	**154**	**158**	**4.3**	**13**	**22**	**9 ↑**	**-**	**-**	**-**	**63**	**69**	**5.3**	**100**	**100**	**-0.6**	**0.2**	**0.2**	**0**	**-**	**-**	**-**	**28**	**24**	**-4.4**	**7.3**	**7**	**-0.3**
Pasanauri	**19**	**18**	**-1.4**	**120**	**117**	**-3.6**	**44**	**58**	**13.6↑**	**-**	**-**	**-**	**88**	**85**	**-3**	**191**	**192**	**1.3**	**0.4**	**0.7**	**0.3**	**-**	**-**	**-**	**25**	**26**	**0.6**	**7.4**	**7.5**	**0.1**
Mta-Sabueti	**50**	**55**	**5**	**124**	**121**	**-2.8**	**9.8**	**19**	**9 ↑**	**-**	**0.1**	**0.1**	**88**	**60**	**-27.8↓**	**183**	**166**	**-16.3**	**0.7**	**0.3**	**-0.4↓**	**-**	**-**	**-**	**17**	**18**	**1**	**8.6**	**11**	**2.2**
Kutaisi	0.8	0.6	-0.2	16	14	-2	121	122	1	25	44	18.4↑	127	125	-1.5	280	206	-74.2	1.8	2.1	0.3	0.2	0	-0.16	19	19	0.5	8	8.6	0.6
Zugdidi	0.4	0.1	-0.3	34	33	-1	108	124	16.7↑	16	33	16.5↑	174	205	30.8	283	281	-2	5	5.3	0.3	1.2	1	-0.2	19	18	-1	7.6	8.2	0.6
Gali	0.4	-	-0.4	30	28	-2	115	131	15.5	21	30	8.6	174	165	-8.6	261	261	0	3.8	3.2	-0.6	0.6	0.4	-0.2	18	18	0	6.4	9	2.6
Sokhumi	0.3	0.2	0.2	12	9.4	-2.5	87	98	11.1	30	32	2.3	169	178	8.7	203	216	13.2↑	3.8	3.7	-0.1	0.4	0	-0.4	18	18	0	6.2	6.2	0
Poti	0.3	-	-0.3↓	15	11	-4.6	82	110	28.3↑	28	48	20.2↑	223	191	-31.8	375	332	-43	5.7	7.2	1.5↑	1.2	1.6	0.4	18	17	-0.9	8.6	9.2	0.6
Kobuleti	0.1	-	-0.1	25	22	-2.8	71	96	24.7↑	21	35	13.7↑	194	317	123.5	407	212	-194.6	8.4	8.8	0.4	1.4	1.8	0.4	18	17	-1.2	9.7	9.9	0.2
Chaqvi	0.2	-	-0.2	13	15	1.3	79	87	8.3 ↑	20	31	10.5↑	235	368	133.2	341	238	-103.4	12	12	0.6	2.2	2.1	-0.1	17	16	-1.8	8.6	10	1.4
Batumi	0.4	0.1	-0.3	7.8	8.1	0.3	7 2	83	10.9↑	24	43	18.6↑	239	381	141.8	339	230	-109.4	11	11	-0.1	1.5	2.2	0.7	20	17	-3.1	8.4	8.5	0.1
Keda	1.7	1.1	-0.6	33	32	-1.6	99	118	18.9↑	5	15	9.9↑	124	358	233.9↑	263	204	-58.8	4	6	2↑	0.6	1	0.4	19	17	-1.2	8.3	11	2.5
Khulo	11	15	4.9	71	72	0.9	56	69	13.2↑	1.2	2	0.8↑	133	256	123.4	225	256	31.2	1.8	2.5	0.7	0.2	0.1	-0.1	20	17	-3	8.8	11	2
Sachkhere	2.7	2.8	0.1	82	78	-3.9	106	113	6.3	5.2	17	11.4↑	98	94	-3.2	128	245	117.6	0.3	0.6	0.3	0	0	0	20	19	-0.4	6.3	7.2	0.9
Ambrolauri	5.5	5.4	-0.1	87	90	2.7	35	46	11.6↑	3	2.3	-0.7	77	106	29	122	289	167.1↑	0.8	1.4	0.6 ↑	-	0.1	0.1	21	22	1	6.9	8.5	1.6
Pskhu	5.5	4.8	-0.7	105	100	-5.5	80	86	5.3	0.3	0.4	0.1	155	184	29	417	385	-31.5	7.3	7	-0.3	0.9	0.4	-0.5	17	17	0	6.6	6.6	0
Lentekhi	15	18	3.3 ↑	95	89	-6 ↓	78	85	6.5 ↑	0.4	0.8	0.4↑	123	111	-12.2	210	278	67.6	1.6	2.2	0.6	0.1	0.3	0.2	21	20	-0.3	7.6	8.8	1.2
Khaishi	11	10	-1	67	68	1	78	86	8.1	0.8	1.1	0.3	87	118	31	192	314	122.4	1.1	1.2	0.1	-	0.1	0.1	21	21	-0.5	7.1	8	0.9
Mestia	30	38	8.4 ↑	160	160	0	43	57	14 ↑	-	-	-	145	70	-75.4	168	160	-7.2	0.4	0.2	-0.2	0.1	-	-0.1	19	18	-0.4	7.6	10	2.7
Goderdzi Pass	97	105	7.7	184	179	-4.9↓	1.2	2	0.8	-	-	-	81	173	92.3	232	108	-123.9	0.6	0.5	-0.1	-	0.1	0.1	16	16	0	9.7	11	1.2

Designations:ID0 – Annual/seasonal count of days when daily maximum temperature Tmax<00C;
FD0 - Annual/seasonal count of days when daily minimum temperature Tmin < 0 ^{0}C;
SU25 - Annual/seasonal count of days when daily maximum temperature Tmax>25 ^{0}C;
TR20 - Annual/seasonal count of days when daily minimum temperature Tmin>20 ^{0}C;
R50 - Annual/seasonal count of heavily rainy days (≥50 mm) ;
R90 - Annual/seasonal count of heavily rainy days (≥90 mm);
Rx1day Monthly maximum 1-day precipitation
Rx5day - Monthly maximum consecutive 5-day precipitation:
CDD - Maximum length of dry spell, maximum number of consecutive days with RR < 1 mm:
CWD - Maximum length of wet spell, maximum number of consecutive days with RR ≥ 1 mm:
Subscript 2 – **1961-1985** period**;**
Subscript 3- **1986-2010** period**;**
Δ_2 **-** difference between periods **1986-2010** and **1961-1985;**

Annex 4.5. Seasonal values of extreme climate indeces (daily) for 2021-2050 and 2071-2100 periods and changes against 1986-2010 period's corresponding averages.

Stations	$ID0_4$	$ID0_5$	Δ3	Δ4	$FD0_4$	$FD0_5$	Δ3	Δ4	$SU25_4$	$SU25_5$	Δ3	Δ4	$TR20_4$	$TR20_5$	Δ3	Δ4	$Rx1day_4$	$Rx1day_5$	Δ3	Δ4	$R50_4$	$R50_5$	Δ3	Δ4	$R90_4$	$R90_5$	Δ3	Δ4
Winter																												
Dedoplistskaro	2.6	3.0	-8.0	-7.6	60.9	47.9	-4.9	-17.9	-	-	-	-	-	-	-	-	27	31	-7.8	-4.2	-	-	-	-	-	-	-	-
Kvareli	1.0	0.7	-0.8	-1.1	33.8	22.5	-13.2	-24.5	-	-	-	-	-	-	-	-	21	23	-29.6	-27.0	-	-	-	-	-	-	-	-
Lagodekhi	1.2	1.2	-1.7	-1.7	32.4	23.8	-7.1	-15.7	-	0.1	-	0.1	-	-	-	-	24	29	-20.9	-16.1	-	-	-	-	-	-	-	-
Gurjaani	0.8	0.7	-2.7	-2.8	33.0	24.3	-14.9	-23.6	-	-	-	-	-	-	-	-	23	30	-15.6	-9.1	-	-	-	-	-	-	-	-
Telavi	1.3	1.2	-2.9	-3.0	36.4	25.4	-17.6	-28.6	-	-	-	-	-	-	-	-	18	19	-23.1	-22.6	-	-	-	-	-	-	-	-
Tsnori	0.6	0.5	-1.6	-1.7	52.0	40.5	-6.9	-18.4	-	0.1	-	0.1	-	-	-	-	25	27	-3.6	-1.8	-	-	-	-	-	-	-	-
Akhmeta	0.7	0.6	-2.0	-2.1	32.9	22.2	-15.8	-26.5	-	-	-	-	-	-	-	-	20	24	-16.0	-11.8	-	-	-	-	-	-	-	-
Sagarejo	1.2	1.3	-6.1	-6.0	46.5	33.7	-9.2	-22.0	-	-	-	-	-	-	-	-	32	53	-9.9	11.4	-	-	-	-	-	-	-	-
Bolnisi	0.6	0.5	-3.0	-3.1	42.4	29.0	-12.6	-26.0	-	0.1	-	0.1	-	-	-	-	22	37	-20.4	-5.6	-	-	-	-	-	-	-	-
Tbilisi	0.3	0.4	-1.7	-1.6	29.6	18.7	-12.7	-23.6	-	0.1	-	0.1	-	-	-	-	18	21	-18.4	-16.0	-	-	-	-	-	-	-	-
Gori	1.8	1.4	-4.5	-4.9	53.7	37.6	-14.1	-30.2	-	-	-	-	-	-	-	-	19	20	-30.9	-30.2	-	-	-	-	-	-	-	-
Tskhinvali	2.8	1.9	-7.0	-7.9	36.6	24.6	-30.4	-42.4	-	-	-	-	-	-	-	-	24	22	-24.7	-26.6	-	-	-	-	-	-	-	-
Akhaltsikhe	13.8	7.2	-1.6	-8.2	80.8	71.0	0.2	-9.6	-	0.1	-	0.1	-	-	-	-	17	18	-15.0	-14.2	-	-	-	-	-	-	-	-
Tsalka	17.2	11.2	-10.1	-16.1	87.0	79.8	1.3	-5.9	-	-	-	-	-	-	-	-	20	26	-8.9	-3.8	-	-	-	-	-	-	-	-
Pasanauri	10.8	5.3	-6.2	-11.7	70.2	48.2	-11.1	-33.1	-	-	-	-	-	-	-	-	36	26	-30.4	-40.3	-	-	-0.1	-0.1	-	-	-	-
Mta-Sabueti	27.8	16.9	-16.0	-26.9	69.7	54.6	-8.0	-23.1	-	-	-	-	-	-	-	-	56	61	-4.1	0.6	0.1	0.1	0.1	0.1	-	-	-	-
Kutaisi	0.1	-	-0.5	-0.6	8.7	4.0	-3.6	-8.3	0.1	0.1	0.1	0.1	-	-	-	-	72	63	-12.0	-21.6	0.1	0.3	-0.4	-0.2	-	-	-	-
Zugdidi	-	-	-0.2	-0.2	16.5	7.8	-12.2	-20.9	0.3	0.3	0.2	0.2	-	-	-	-	95	89	11.3	5.4	0.7	0.8	0.4	0.5	-	-	-	-
Gali	-	-	-	-	15.9	7.3	-7.9	-16.5	1.1	1.1	1.0	1.0	-	-	-	-	47	47	-28.4	-29.1	0.0	0.0	-0.3	-0.3	-	-	-	-
Sokhumi	-	-	-0.2	-0.2	1.5	0.8	-6.4	-7.1	12.8	12.8	12.8	12.8	5.4	-	5.4	-	70	67	-0.9	-3.6	0.5	0.4	0.1	-	-	-	-	-
Poti	-	-	-	-	5.7	3.0	-3.5	-6.2	-	-	-	-	-	0.1	-	0.1	92	69	18.9	-4.5	0.5	0.4	0.1	-	-	-	-	-
Kobuleti	-	-	-	-	15.0	-	-4.0	-	0.6	-	0.6	-	-	-	-	-	88	-	-37.3	-	1.1	-	-1.5	-	-	-	-0.1	-
Chaqvi	-	-	-	-	8.0	-	-2.9	-	4.1	-	4.0	-	-	-	-	-	143	-	47.9	-	3.1	-	-2.4	-	-	0.3	-0.1	-
Batumi	0.3	-	0.2	-	4.5	-	-2.4	-	0.4	-	0.4	-	-	-	-	-	64	-	-35.0	-	0.4	-	-2.0	-	-	-	-0.1	-
Keda	0.4	-	-0.7	-	17.2	-	-9.5	-	0.6	-	0.4	-	-	-	-	-	110	-	-29.3	-	1.5	-	-2.3	-	-	0.1	-0.3	-
Khulo	2.7	-	-10.7	-	32.1	-	-18.8	-	-	-	-	-	-	-	-	-	125	-	37.0	-	1.0	-	-1.1	-	-	0.1	-	-
Sachkhere	0.4	0.4	-2.6	-2.6	48.8	34.1	-11.1	-25.8	-	-	-	-	-	-	-	-	35	29	-59.5	-65.7	-	-	-0.2	-0.2	-	-	-	-
Ambrolauri	1.9	0.8	-3.6	-4.7	52.0	38.2	-16.8	-30.6	-	-	-	-	-	-	-	-	45	33	-61.4	-73.6	-	-	-0.4	-0.4	-	-	-0.1	-0.1
Pskhu	4.8	2.0	-	-2.8	57.2	42.9	-7.9	-22.2	-	-	-	-	-	-	-	-	108	96	-75.8	-87.8	2.1	1.8	-0.4	-0.7	0.1	0.1	-0.3	-0.3
Lentekhi	14.3	6.7	-3.5	-11.1	58.2	43.8	-8.8	-23.2	-	-	-	-	-	-	-	-	71	51	-37.0	-57.3	0.1	-	-0.5	-0.6	-	-	-0.1	-0.1
Khaishi	11.7	4.8	0.6	-6.3	43.4	31.5	-14.0	-25.9	-	-	-	-	-	-	-	-	76	45	-42.4	-73.4	0.1	-	-0.2	-0.3	-	-	-0.1	-0.1

Mestia	22.4	13.0	-11.3	-20.7	85.6	74.8	-2.2	-13.0	-	-	-	-	-	-	-	-	40	28	-15.7	-27.1	-	-	-0.1	-0.1	-	-	-	-
Goderdzi Pass	60.8	-	-12.6	-	86.0	-	-3.4	-	-	-	-	-	-	-	-	-	91	-	-95.5	-	0.4	-	-0.2	-	-	-	-	-
Spring																												
Dedoplistskaro	0.7	0.1	0.4	-0.2	15.8	8.5	2.3	-5.0	15.0	25.1	8.7	18.8	-	1.5	-	1.5	62	59	-31.7	-34.5	0.1	-	-	-0.1	-	-	-	-
Kvareli	0.1	-	0.1	-	6.8	2.5	1.1	-3.2	20.7	33.2	6.0	18.5	0.2	4.3	0.2	4.3	69	63	-15.5	-21.9	0.1	0.1	-0.1	-0.1	-	-	-	-
Lagodekhi	0.2	-	0.2	-	5.7	2.5	2.1	-1.1	23.4	34.8	9.4	20.8	1.0	5.9	0.9	5.8	101	103	18.3	20.2	0.2	0.2	-0.2	-0.2	-	-	-	-
Gurjaani	0.1	-	0.1	-	6.7	2.7	0.6	-3.4	22.4	33.9	8.8	20.3	0.7	5.8	0.7	5.8	51	58	-41.6	-34.5	0.1	-	-0.1	-0.2	-	-	-	-
Telavi	0.2	-	0.1	-0.1	7.8	3.4	-0.4	-4.8	18.2	29.0	8.5	19.3	0.3	4.7	0.3	4.7	33	50	-25.2	-7.8	-	-	-0.2	-0.2	-	-	-	-
Tsnori	-	-	-	-	9.4	3.9	0.8	-4.7	29.5	40.8	9.7	21.0	0.5	4.6	0.5	4.6	49	56	-7.1	-0.3	-	-	0.0	-	-	-	-	-
Akhmeta	0.1	-	0.1	-	6.4	2.6	0.9	-2.9	19.2	30.0	8.0	18.8	0.3	4.2	0.3	4.2	39	68	-8.1	21.0	-	-	0.0	-	-	-	-	-
Sagarejo	0.4	0.1	0.2	-0.1	12.4	5.5	2.4	-4.5	17.0	27.3	9.7	20.0	-	1.8	-	1.8	91	92	-12.8	-11.7	0.2	0.2	-	-	-	-	-	-
Bolnisi	0.1	-	0.1	-	7.9	3.1	-0.8	-5.6	20.7	31.9	11.2	22.4	0.2	3.5	0.2	3.5	66	59	10.4	3.2	0.1	0.0	0.1	-	-	-	-	-
Tbilisi	-	-	-	-	3.7	1.6	-1.2	-3.3	22.6	34.3	8.6	20.3	0.2	2.8	0.2	2.8	135	57	53.2	-25.5	0.1	0.1	-	-	-	-	-	-
Gori	-	-	-	-	10.9	4.8	-5.3	-11.4	17.4	28.0	8.1	18.7	-	0.7	-	0.7	26	34	-10.6	-2.7	-	-	-	-	-	-	-	-
Tskhinvali	0.1	-	-0.1	-0.2	10.0	6.8	-5.2	-8.4	12.0	22.1	6.6	16.7	-	0.3	-	0.3	55	40	10.4	-4.7	-	-	-	-	-	-	-	-
Akhaltsikhe	0.5	0.1	0.1	-0.3	28.1	19.2	-1.0	-9.9	15.8	29.5	4.7	18.4	-	0.5	-	0.5	32	27	-15.1	-20.3	-	-	-	-	-	-	-	-
Tsalka	3.8	1.2	0.6	-2.0	39.1	28.8	-2.9	-13.2	2.6	9.3	2.4	9.1	-	-	-	-	57	55	7.5	5.8	0.1	0.0	0.1	-	-	-	-	-
Pasanauri	0.8	0.1	0.5	-0.2	22.8	9.8	1.7	-11.3	7.1	13.2	4.3	10.4	-	-	-	-	71	79	12.3	20.0	0.1	0.3	0.1	0.2	-	-	-	-
Mta-Sabueti	4.9	2.0	-2.7	-5.6	28.4	16.5	-1.4	-13.3	3.2	9.3	2.8	8.9	-	-	-	0.2	60	79	5.2	24.1	0.1	-	0.1	-	-	-	-	-
Kutaisi	-	-	-	-	1.6	0.5	0.3	-0.8	28.6	36.9	8.5	16.8	1.9	5.9	0.3	4.3	50	54	-31.8	-27.5	0.0	0.0	-0.1	-0.1	-	-	-	-
Zugdidi	-	-	-	-	3.9	1.4	-0.2	-2.7	24.5	30.0	5.5	11.0	1.2	3.3	0.9	3.0	127	148	-20.6	0.3	0.7	0.9	-0.2	-	0.1	0.1	-0.1	-0.1
Gali	-	-	-	-	3.6	1.4	0.0	-2.2	25.0	31.8	3.3	10.1	1.5	4.4	1.0	3.9	87	75	-78.3	-90.6	0.5	0.4	0.1	-	-	-	-	-
Sokhumi	-	-	-	-	1.8	0.2	0.3	-1.3	3.5	20.8	-10.5	6.8	0.8	5.7	0.1	5.0	183	139	74.3	29.5	3.1	0.8	2.6	0.3	0.7	0.1	0.7	0.1
Poti	-	-	-	-	0.9	0.8	-0.3	-0.4	17.2	24.1	4.6	11.5	1.4	3.9	1.1	3.6	110	95	37.9	23.2	0.2	0.3	0.1	0.2	-	-	-	-
Kobuleti	-	-	-	-	4.0	-	1.0	-	14.9	-	5.9	-	2.4	-	2.4	-	95	-	12.5	-	0.5	-	0.3	-	-	-	-	-
Chaqvi	-	-	-	-	2.2	-	-1.1	-	20.1	-	11.4	-	1.9	-	1.9	-	122	-	45.8	-	1.0	-	0.4	-	0.2	-	0.2	-
Batumi	0.1	-	0.1	-	1.3	-	-	-	8.6	-	0.6	-	0.3	-	-0.5	-	70	-	-0.7	-	0.1	-	-0.1	-	-	-	-	-
Keda	0.1	-	0.1	-	3.4	-	-1.0	-	20.8	-	-0.6	-	0.8	-	0.5	-	116	-	11.9	-	0.5	-	0.1	-	0.1	-	0.1	-
Khulo	-	-	-1.4	-	12.4	-	-3.4	-	16.6	-	7.2	-	0.1	-	-	-	76	-	10.2	-	0.2	-	0.1	-	-	-	-	-
Sachkhere	-	-	-	-	11.7	5.0	0.1	-6.6	24.2	34.5	9.3	19.6	0.2	2.1	-0.3	1.6	42	41	-33.3	-34.3	-	-	-0.1	-0.1	-	-	-	-
Ambrolauri	0.1	-	0.1	-	12.9	6.0	-0.1	-7.0	24.8	33.2	22.3	30.7	0.1	2.1	0.1	2.1	37	41	-28.0	-24.8	-	-	-0.1	-0.1	-	-	-	-
Pskhu	0.3	0.1	-	-0.2	20.8	11.2	2.2	-7.4	19.9	17.9	7.2	5.2	-	0.9	-	0.9	105	93	3.3	-9.2	0.5	0.8	-0.6	-0.3	-	-	-	-
Lentekhi	0.4	0.1	0.4	0.1	19.1	11.1	6.2	-1.8	16.4	25.1	5.8	14.5	-	0.6	-	0.6	84	69	0.9	-13.8	0.1	0.1	-0.5	-0.5	-	-	-	-
Khaishi	0.3	0.1	0.2	0.0	13.9	7.4	5.5	-1.0	20.8	27.9	9.3	16.4	-	1.7	-	1.7	46	37	-26.1	-35.1	-	-	-0.2	-0.2	-	-	-	-
Mestia	1.9	0.9	-0.7	-1.7	37.9	27.1	-5.1	-15.9	6.5	12.7	2.4	8.6	-	0.1	-	0.1	76	56	8.9	-11.4	-	0.1	-	0.1	-	-	-	-
Goderdzi Pass	12.4	-	-7.0	-	51.1	-	-2.9	-	0.2	-	0.2	-	-	-	-	-	63	-	19.1	-	0.1	-	0.1	-	-	-	-	-

	Summer																											
Dedoplistskaro	-	-	-	-	-	-	-	-	74.5	83.5	1.4	10.4	21.3	48.4	13.5	40.6	96	100	24.1	28.0	0.2	0.2	-0.2	-0.2	-	-	-	-
Kvareli	-	-	-	-	-	-	-	-	81.2	87.5	-2.0	4.3	34.4	60.0	18.8	44.4	64	52	-54.6	-66.5	0.1	0.1	-0.7	-0.7	-	-	-	-
Lagodekhi	-	-	-	-	-	-	-	-	81.7	87.6	-0.7	5.2	43.5	67.5	10.3	34.3	86	144	-28.2	29.6	0.3	0.2	-0.5	-0.6	-	-	-	0.1
Gurjaani	-	-	-	-	-	-	-	-	81.1	87.4	-1.2	5.1	39.9	67.5	21.8	49.4	80	65	11.4	-3.6	0.1	0.1	-0.2	-0.2	-	-	-	-
Telavi	-	-	-	-	-	-	-	-	75.7	84.5	-2.0	6.8	35.1	61.3	18.1	44.3	34	76	-51.5	-9.9	-	0.1	-0.4	-0.3	-	-	-	-
Tsnori	-	-	-	-	-	-	-	-	85.8	89.4	-1.9	1.7	40.5	67.6	20.3	47.4	63	78	-7.3	7.6	0.2	0.1	-0.1	-0.2	-	-	-	-
Akhmeta	-	-	-	-	-	-	-	-	77.1	85.0	-3.2	4.7	37.6	65.3	17.6	45.3	46	74	-24.6	3.5	-	0.1	-0.2	-0.1	-	-	-	-
Sagarejo	-	-	-	-	-	-	-	-	74.9	84.7	3.7	13.5	27.9	55.2	18.6	45.9	65	82	-23.5	-6.1	0.2	0.2	-0.1	-0.1	-	-	-	-
Bolnisi	-	-	-	-	-	-	-	-	80.7	87.0	-1.4	4.9	39.0	65.8	18.8	45.6	43	55	-9.7	2.0	-	-	-	-	-	-	-	-
Tbilisi	-	-	-	-	-	-	-	-	82.4	88.2	-0.8	5.0	44.5	68.7	14.8	39.0	64	74	-53.3	-43.9	-	0.1	-0.2	-0.1	-	-	-	-
Gori	-	-	-	-	-	-	-	-	72.5	83.9	2.6	14.0	16.6	43.0	10.6	37.0	51	48	-28.0	-31.4	-	0.0	-0.1	-0.1	-	-	-	-
Tskhinvali	-	-	-	-	-	-	-	-	68.8	79.2	7.0	17.4	3.9	32.0	2.6	30.7	77	60	-4.4	-21.4	-	0.1	-0.1	-	-	-	-	-
Akhaltsikhe	-	-	-	-	-	-	-	-	74.2	79.5	2.4	7.7	3.8	16.3	3.5	16.0	41	53	-10.2	2.1	-	-	-	-	-	-	-	-
Tsalka	-	-	-	-	0.0	0.0	-0.2	-0.2	34.2	55.1	15.3	36.2	-	0.9	-	0.9	72	123	3.7	54.1	0.1	0.2	-0.1	-	-	-	-	-
Pasanauri	-	-	-	-	-	-	-	-	54.3	63.0	6.2	14.9	0.9	7.4	0.9	7.4	83	40	-2.1	-45.1	0.1	0.0	-0.2	-0.3	-	-	-	-
Mta-Sabueti	-	-	-	-	-	-	-	-	28.0	47.9	10.9	30.8	0.8	9.5	0.7	9.4	106	92	47.7	34.0	0.4	0.2	0.2	0.0	-	-	-	-
Kutaisi	-	-	-	-	-	-	-	-	68.1	78.8	-6.4	4.3	39.8	64.1	4.2	28.5	106	109	-19.3	-15.6	0.4	0.2	-0.3	-0.5	0.1	-	-	-
Zugdidi	-	-	-	-	-	-	-	-	62.3	77.6	-13.6	1.7	30.2	57.9	0.3	28.0	248	295	43.3	90.2	3.9	2.3	1.6	0.0	2.1	1.2	1.7	0.8
Gali	-	-	-	-	-	-	-	-	69.7	82.0	-8.1	4.2	35.9	60.6	9.0	33.7	264	271	110.1	116.7	2.7	1.3	1.1	-0.3	1.0	0.4	0.8	0.2
Sokhumi	-	-	-	-	-	-	-	-	29.5	77.4	-33.9	14.0	11.8	66.6	-16.1	38.7	192	229	13.5	51.1	4.8	1.6	3.3	0.1	2.3	0.6	1.9	0.2
Poti	-	-	-	-	-	-	-	-	70.2	71.2	-2.2	-1.2	51.6	66.8	8.2	23.4	138	229	-53.6	37.6	2.9	2.6	-0.3	-0.6	0.9	1.2	0.0	0.3
Kobuleti	-	-	-	-	-	-	-	-	63.7	-	-2.4	-	49.3	-	18.0	-	273	-	12.0	-	2.1	-	-0.6	-	0.7	-	0.1	-
Chaqvi	-	-	-	-	-	-	-	-	61.1	-	1.1	-	52.0	-	23.6	-	226	-	69.6	-	2.9	-	0.0	-	0.8	-	0.1	-
Batumi	-	-	-	-	-	-	-	-	64.1	-	6.4	-	57.0	-	19.5	-	206	-	55.9	-	0.7	-	-1.9	-	0.2	-	-0.4	-
Keda	-	-	-	-	-	-	-	-	64.4	-	-5.1	-	28.3	-	15.2	-	101	-	18.5	-	0.5	-	-0.1	-	-	-	-	-
Khulo	-	-	-	-	-	-	-	-	58.1	-	12.3	-	4.5	-	2.9	-	57	-	-29.3	-	-	-	-0.1	-	-	-	-	-
Sachkhere	-	-	-	-	-	-	-	-	72.5	82.0	1.6	11.1	22.0	46.1	7.2	31.3	59	44	-4.0	-18.9	0.1	-	-	-0.1	-	-	-	-
Ambrolauri	-	-	-	-	-	-	-	-	71.2	81.6	32.5	42.9	19.2	42.1	16.9	39.8	99	60	18.0	-20.6	-	-	-0.5	-0.5	-	-	-	-
Pskhu	-	-	-	-	-	-	-	-	59.8	70.0	0.1	10.3	6.7	25.5	6.3	25.1	107	62	-18.5	-62.7	0.6	0.3	-0.6	-0.9	0.1	-	-	-0.1
Lentekhi	-	-	-	-	-	-	-	-	67.5	81.3	4.0	17.8	11.6	32.2	10.8	31.4	86	53	-24.5	-57.3	0.1	0.1	-0.8	-0.8	-	-	-0.1	-0.1
Khaishi	-	-	-	-	-	-	-	-	62.6	75.8	2.0	15.2	18.7	42.2	17.7	41.2	67	52	-5.3	-20.8	0.1	-	-0.2	-0.3	-	-	-	-
Mestia	-	-	-	-	0.2	-	0.2	-	52.8	71.4	7.1	25.7	-	2.3	-	2.3	78	49	10.7	-19.1	0.1	-	-	-0.1	-	-	-	-
Goderdzi Pass	-	-	-	-	0.7	-	-0.7	-	2.6	-	0.6	-	-	-	-	-	52	-	-2.1	-	-	-	-	-	-	-	-	-

	Autumn																											
Dedoplistskaro	-	-	-0.3	-0.3	6.4	2.6	-0.8	-4.6	20.3	30.1	5.3	15.1	0.4	5.6	0.2	5.4	60	68	-4.0	4.2	0.1	0.1	-	-	-	-	-	-
Kvareli	-	-	-	-	3.4	1.6	0.5	-1.3	28.3	39.1	6.0	16.8	3.0	10.5	2.2	9.7	104	86	14.7	-3.4	0.1	0.1	-0.4	-0.4	-	-	-	-
Lagodekhi	-	-	-	-	3.0	1.4	1.6	-	29.1	39.9	7.3	18.1	4.7	14.7	2.9	12.9	158	98	70.5	10.1	0.6	0.4	-0.2	-0.4	-	0.1	-	0.1
Gurjaani	-	-	-	-	3.0	1.2	0.1	-1.7	26.7	37.8	5.9	17.0	4.7	14.3	4.3	13.9	62	60	-4.4	-6.4	0.1	0.1	-0.1	-0.1	-	-	-	-
Telavi	-	-	-	-	3.9	2.1	0.2	-1.6	23.2	33.9	5.1	15.8	3.2	10.9	2.7	10.4	34	71	-75.7	-38.8	-	0.1	-0.4	-0.3	-	-	-	-
Tsnori	-	-	-	-	5.7	2.2	-0.5	-4.0	33.7	43.9	5.2	15.4	2.9	11.8	2.2	11.1	88	52	34.0	-2.0	0.1	-	0.0	-0.1	-	-	-	-
Akhmeta	-	-	-	-	3.0	1.3	0.1	-1.6	24.5	36.0	4.3	15.8	3.5	13.3	2.7	12.5	113	53	23.5	-36.2	0.1	-	-0.1	-0.2	-	-	-	-
Sagarejo	-	-	-0.3	-0.3	3.9	1.5	-1.1	-3.5	22.4	33.0	8.0	18.6	1.4	9.1	1.0	8.7	97	84	23.7	10.8	0.2	0.1	-0.1	-0.2	0.1	-	0.1	-
Bolnisi	-	-	-0.1	-0.1	3.3	1.2	-1.5	-3.6	26.2	36.9	6.3	17.0	3.0	13.0	2.0	12.0	66	49	32.9	15.9	0.1	-	0.1	-	-	-	-	-
Tbilisi	-	-	-	-	2.4	0.7	-0.8	-2.5	28.5	38.8	5.5	15.8	3.3	14.3	1.4	12.4	59	48	5.7	-5.5	0.1	-	0.1	-	-	-	-	-
Gori	0.1	-	0.1	-	7.4	3.0	-5.9	-10.3	21.9	31.3	6.0	15.4	0.1	3.5	-0.4	3.0	39	46	-4.0	3.2	-	-	-	-	-	-	-	-
Tskhinvali	0.0	-	-0.1	-0.1	2.7	2.2	-8.8	-9.3	27.2	28.8	15.8	17.4	4.5	6.8	4.5	6.8	87	105	43.5	61.3	-	0.1	-	-	-	-	-	-
Akhaltsikhe	0.5	0.1	0.3	-0.1	17.6	11.3	-3.3	-9.6	26.8	38.7	8.1	20.0	0.3	1.6	0.3	1.6	25	29	-14.7	-10.5	-	-	-	-	-	-	-	-
Tsalka	0.5	0.2	-1.3	-1.6	23.0	14.6	-7.4	-15.8	5.6	13.9	2.6	10.9	-	-	-	-	46	42	0.9	-2.9	-	-	-	-	-	-	-	-
Pasanauri	0.3	0.0	-0.2	-0.5	11.6	5.5	-3.7	-9.8	12.9	17.0	5.3	9.4	-	0.5	-	0.5	50	89	-24.2	15.0	-	0.1	-0.3	-0.2	-	-	-	-
Mta-Sabueti	1.3	0.5	-2.8	-3.6	10.2	4.4	-4.4	-10.2	4.8	12.2	3.4	10.8	-	0.5	-	0.5	105	138	46.7	80.2	0.3	0.3	0.3	0.3	-	0.1	-	0.1
Kutaisi	-	-	-	-	0.6	0.1	0.6	0.1	35.5	46.9	7.9	19.3	10.7	23.1	4.3	16.7	94	83	10.7	0.3	0.8	0.8	0.0	-	-	-	-	-
Zugdidi	-	-	-	-	1.5	0.4	0.6	-0.5	34.6	47.6	4.8	17.8	4.3	12.8	1.7	10.2	200	158	55.1	13.3	1.9	1.6	0.3	-	0.3	0.3	-	-
Gali	-	-	-	-	1.2	0.3	0.5	-0.4	37.7	49.9	6.5	18.7	5.6	14.0	3.0	11.4	106	99	-11.9	-18.7	1.1	0.7	0.2	-0.2	0.1	0.1	-	-0.1
Sokhumi	-	-	-	-	0.1	-	0.1	-	44.7	43.5	24.2	23.0	14.9	22.2	11.6	18.9	168	164	90.0	86.2	0.9	1.3	-0.4	-	0.2	0.2	0.2	0.2
Poti	-	-	-	-	-	-	-	-	36.1	44.5	13.1	21.5	10.0	22.0	5.7	17.7	104	152	-52.5	-4.5	2.9	2.5	-0.1	-0.5	0.8	0.8	0.1	0.1
Kobuleti	-	-	-	-	0.6	-	0.3	-	29.2	-	8.4	-	6.2	-	2.9	-	300	-	135.4	-	5.0	-	0.5	-	1.6	-	0.5	-
Chaqvi	-	-	-	-	-	-	-0.2	-	29.0	-	10.8	-	9.0	-	7.0	-	294	-	96.2	-	5.5	-	-0.8	-	1.9	-	0.6	-
Batumi	-	-	-	-	-	-	0.0	-	22.5	-	5.1	-	8.9	-	4.5	-	82	-	-125.4	-	0.6	-	-5.7	-	-	-	-1.5	-
Keda	-	-	-	-	0.8	-	-0.5	-	18.3	-	-8.6	-	1.4	-	-0.1	-	277	-	106.1	-	6.9	-	4.3	-	3.4	-	2.8	-
Khulo	-	-	-0.7	-0.7	2.1	-	-3.7	-	20.3	-	6.7	-	0.6	-	0.3	-	116	-	3.7	-	0.5	-	-0.8	-	-	-	-	-
Sachkhere	-	-	-	-	7.2	3.5	-1.5	-5.2	31.3	42.4	6.8	17.9	1.6	6.7	0.4	5.5	65	54	0.1	-10.3	0.1	-	-0.1	-0.2	-	-	-	-
Ambrolauri	-	-	-	-	7.1	3.6	-2.9	-6.4	30.0	41.4	23.8	35.2	1.0	5.2	0.9	5.1	51	48	-20.9	-23.9	-	-	-0.3	-0.3	-	-	-	-
Pskhu	0.3	-	0.3	-	10.5	5.7	-5.3	-10.1	24.1	34.6	10.8	21.3	0.3	2.1	0.3	2.1	125	170	-31.4	14.4	1.9	1.7	-0.3	-0.5	0.2	0.1	0.2	0.1
Lentekhi	0.8	0.2	0.5	-0.1	10.1	5.3	0.6	-4.2	23.5	35.7	12.6	24.8	0.3	3.2	0.3	3.2	84	85	-23.4	-22.4	0.2	0.2	-0.1	-0.1	-	-	-	-
Khaishi	0.7	0.2	0.5	-	6.5	3.0	1.8	-1.7	24.2	34.5	10.2	20.5	1.9	7.5	1.8	7.4	78	65	-9.3	-22.8	0.1	0.2	-0.2	-0.1	-	-	-	-
Mestia	1.6	0.5	-0.6	-1.7	21.3	13.2	-10.0	-18.1	16.7	28.1	8.4	19.8	-	0.1	-	0.1	60	68	-9.7	-1.9	0.1	0.1	-	-	-	-	-	-
Goderdzi Pass	8.5	-	-3.1	-	27.6	-	-6.0	-	0.3	-	0.3	-	-	-	-	-	105	-	40.7	-	0.2	-	-0.1	-	-	-	-	-

Annual values of extreme climate indeces (daily) for 2021-2050 and 2071-2100 periods and changes against 1986-2010 period's corresponding averages

Stations	ID0 (IV)	ID0 (V)	Δ_3	Δ_4	FD0(IV)	FD0(V)	Δ_3	Δ_4	SU25(IV)	SU25(V)	Δ_3	Δ_4	TR20(IV)	TR20(V)	Δ_3	Δ_4	Rx1days(IV)	Rx1days(V)	Δ_3	Δ_4	Rx5days(IV)	Rx5days(V)	Δ_3	Δ_4	CDD(IV)	CDD(V)	Δ_3	Δ_4	CWD(IV)	CWD(V)	Δ_3	Δ_4
	Annual																															
Dedoplistskaro	3.3	3.2	-7.7	-7.8	83.1	58.9	-2.9	-27.1	110	139	15.9	44.7	21.7	55.5	13.7	47.5	96	100	2.7	6.6	147	162	10	15	32.7	22.6	2.7	-10	7.5	2.5	1.8	5
Kvareli	1.1	0.7	-0.7	-1.1	44	26.6	-11	-28.4	130	160	10.3	39.8	37.6	74.8	20.6	57.8	104	86	-15	-33	161	127	-59.8	-34.7	20.6	25.4	-7.4	4.8	10	10	3	0
Lagodekhi	1.4	1.2	-1.5	-1.7	41.2	27.7	-2.8	-16.3	134	163	16.1	44.5	49.1	88.1	14.1	53.1	158	144	44	29.6	169	205	-119	36	22	26	-4	4	9.4	9	2.4	-1.4
Gurjaani	0.9	0.7	-2.6	-2.8	42.6	28.1	-13.4	-27.9	130	159	13.3	42.1	45.3	87.5	26.3	68.5	80	65	-13.1	-28.1	145	119	10	-26	23.8	28.3	-6.2	4.5	8.9	8.9	2.4	0
Telavi	1.5	1.2	-2.7	-3	48.1	30.9	-17.9	-35.1	117	148	11.1	41.5	38.7	77	20.7	59	34	76	-75.1	-33.5	87	102	-59.5	15.5	20.3	25.7	-12	5.4	15	6	8.1	9
Tsnori	0.6	0.5	-1.6	-1.7	67	46.7	-6	-26.3	149	174	13	38.2	43.9	84	22.9	63	88	78	17.5	7.6	148	168	34	20	29.6	36.1	-1.4	6.5	7.5	7.5	1.4	0
Akhmeta	0.8	0.6	-2	-2.2	42.4	26.1	-13.6	-29.9	121	151	8.9	39.1	41.4	82.8	20.4	61.8	113	74	23.5	-14.8	136	124	6.6	-12.1	21.3	27.1	-7.7	5.8	9.5	8.8	2.4	-1.7
Sagarejo	1.5	1.4	-6.3	-6.4	62.8	40.7	-7.2	-29.3	114	145	21.3	52	29.4	66.1	19.7	56.4	97	92	-7.5	-11.8	163	123	-22	-40	24.5	21	-5.5	-3.5	8.5	7.9	2	-1.6
Bolnisi	0.7	0.5	-3	-3.2	53.6	33.4	-13.4	-33.6	128	156	16.6	45	42.2	82.3	21.2	61.3	66	59	10.4	3.2	113	121	24	8	31	35	-1	4	7.9	8.2	2.2	0.5
Tbilisi	0.3	0.4	-1.7	-1.6	35.7	21	-14.3	-29	134	161	13.5	41.4	48.1	85.8	16.1	53.8	135	74	17.2	-44.2	129	142	5	13	42	45	7	3	6.6	6.7	1.2	0.1
Gori	1.8	1.4	-3.8	-4.2	72	45.4	-23	-49.6	112	143	14.8	46.2	16.7	47.2	10.2	40.7	51	48	-27.9	-31.3	79	73	-6	-6	38	37.5	8	-0.5	6.1	5.9	0.6	-1.2
Tskhinvali	2.9	1.9	-6.3	-7.3	49.3	33.6	-42.7	-58.4	108	130	28	50.1	8.4	39.1	7.1	37.8	87	105	5.2	23	116	123	-7	7	29	31	4	2	6.3	6.8	-0.6	0.5
Akhaltsikhe	14.7	7.4	-1.3	-8.6	127	102	-4.4	-29.5	117	148	14.8	45.8	8.1	18.4	3.8	18.1	41	53	-10.2	2.1	87	90	-9.5	3.5	25	29	0	4	8.3	7.8	2.5	-1.5
Tsalka	21.5	12.6	-10.5	-19.4	149	123	-8.8	-34.9	42.4	78.3	20.4	56.3	-	0.9	-	0.9	72	123	3.4	53.8	89	117	-11	28	24.8	27	0.8	2.2	7.7	8.1	0.7	0.4
Pasanauri	11.8	5.4	-6.2	-12.6	105	63.5	-12.5	-53.5	74.3	93.3	16.3	35.3	0.9	7.9	0.9	7.9	83	89	-2.4	4.4	200	184	8	-16	25.5	28	-0.5	2.5	7.9	7.9	0.4	0
Mta-sabueti	34	19.3	-21	-35.7	108	75.5	-12.7	-45.5	36.1	69.4	17.1	50.4	0.9	10.2	0.8	10.1	106	138	45.9	78.2	186	157	20	-29	18	18.6	0	0.6	12	12	0.7	0.3
Kutaisi	0.1	-	-0.5	-0.6	10.9	4.6	-3.1	-9.4	132	164	10.2	41.6	52.4	93.2	8.4	49.2	106	109	-19.3	-15.6	190	203	-16	13	22	23.7	3	1.7	9	8.8	0.4	-0.2
Zugdidi	-	-	-0.1	-0.1	21.9	9.7	-11.1	-23.3	122	156	-2.3	32.4	35.6	74.1	2.6	41.1	248	295	43.1	90	455	418	174	-37	19.8	21.7	1.8	1.9	8.9	9	0.7	0.1
Gali	-	-	-	-	20.7	9	-7.3	-19	134	168	2.5	36.5	42.9	79.1	12.9	49.1	264	271	99.3	106	277	286	16	9	18.2	19.4	0.2	1.2	9	9.3	0	0.3
Sokhumi	-	-	-0.2	-0.2	3.5	1	-5.9	-8.4	90.4	142	-7.6	44.4	32.9	94.6	0.9	62.6	192	229	13.5	51.1	220	185	4	-35	18.4	18.8	0.4	0.4	6.3	5.5	0.1	-0.8
Poti	-	-	-	-	6.6	3.9	-4.4	-7.1	87.4	141	-22.6	30.8	63	92.8	15	44.8	138	229	-53.2	38	297	310	-35	13	19	19.6	2	0.6	9.5	9.9	0.3	0.4
Kobuleti	-	-	-	-	19.1	9.9	-2.9	-12.1	108	139	12.4	43	57.9	87	22.9	52	300	278	39.1	-39	237	225	25	13	17.8	18	0.8	18	9.3	9.5	-0.6	-0.4
Chaqvi		-	-	-	10	10.4	-5	-4.6	115	138	27.6	51	62.9	90	31.9	59	294	228	96.2	-140	265	284	27	46	16.4	17.1	0.4	17.1	11	11	1	1
Batumi	0.3	0	0.2	-0.1	6.5	3	-1.6	-5.1	95	131	12	48	66	93	23	50	206	287	-0.8	-94	157	200	-72.7	-30	20.4	20.1	3.4	20.1	9.3	9.1	0.8	0.6
Qeda	0.5	0.3	-0.6	-0.8	21.4	3.5	-10.6	-28.5	104	140	-13.8	22	30.6	60	15.6	45	277	285	106	-73	198	186	-6	-18	18.2	18.4	1.2	18.4	11	10.6	-0.2	-0.4
Khulo	2.7	1	-12.3	-14	46.6	28.4	-25.4	-43.6	95.1	132	26.1	63	5.2	37	3.2	35	125	148	13.3	-108	270	262	14	6	17	17.6	0	17.6	11	10.7	0.4	-0.3
Sachkhere	0.4	0.4	-2.4	-2.4	67.6	42.6	-10.4	-35.4	128	159	15	46.2	23.8	55	6.8	38	65	54.3	-29.3	-39.7	260	214	15	-46	21.3	22.8	2.3	1.5	6.8	6.6	-0.4	-0.2
Ambrolauri	2	0.8	-3.4	-4.6	72	47.8	-18	-42.2	126	156	79.9	110	20.3	49.5	18	47.2	99	60.4	-7	-45.6	280	254	-9	-26	22.4	21.3	0.4	-1.1	11	14.2	2.5	1.2
Pskhu	5.4	2.2	0.6	-2.6	88.4	59.8	-11.6	-40.2	104	123	17.7	36.5	7	28.6	6.6	28.2	125	170	-59.4	-13.6	340	302	-45	-38	17.8	18	0.8	0.2	8	10.5	1.4	1.5
Lentekhi	15.5	7	-2.5	-11	87.3	60.2	-1.7	-28.8	107	142	22.4	57.3	11.9	36	11.1	35.2	86	84.5	-24.9	-26.5	291	266	13	-25	18	17.3	-2	-0.7	9.4	10.6	0.6	.2
Khaishi	12.6	5.1	2.6	-4.9	63.9	41.8	-4.1	-26.2	108	139	21.6	52.5	20.7	51.4	19.6	50.3	78	75.9	-39.7	-42.1	170	175	-145	5.5	16	15	-5	-1	14	12.6	6.4	-1.8
Mestia	25.9	14.4	-12.1	-23.6	145	115	-15	-44.9	76	112	19	55.2	-	2.4	-	2.4	78	68	8.3	-2	126	131	-34	5	16.4	15.5	-1.6	-0.9	14	11.8	3.6	-1.8
Goderdzi pass	81.4	67.3	-23.6	-37.7	165	142	-13.6	-37	3.1	15.9	1.1	13.9	-	-	-	-	105	89	-68.2	-84	119	126	11	18	15	15	-1	15	12	11.7	1.2	0.7

Designations:

ID0 – Annual/seasonal count of days when daily maximum temperature Tmax<0 ^{0}C;
FD0 - Annual/seasonal count of days when daily minimum temperature Tmin < 0 ^{o}C;

SU25 - Annual/seasonal count of days when daily maximum temperature Tmax>25 ^{0}C;
TR20 - Annual/seasonal count of days when daily minimum temperature Tmin>20 ^{0}C;
R50 - Annual/seasonal count of heavily rainy days (≥50 mm) ;
R90 - Annual/seasonal count of heavily rainy days (≥90 mm);
Rx1day Monthly maximum 1-day precipitation
Rx5day - Monthly maximum consecutive 5-day precipitation:
CDD - Maximum length of dry spell, maximum number of consecutive days with RR < 1 mm:
CWD - Maximum length of wet spell, maximum number of consecutive days with RR ≥ 1 mm:
Subscript 4 – 2021-2050 period**;**
Subscript 5 - 2071-2100 period**;**
Δ_3 **-** difference between periods 2021-2050 and 1986-2010;
Δ_4 **-** difference between periods 2071-2100 and 1986-2010 ;

Annex 4.6. Climate parameters and extreme geological phenomena

Table 4.6.1. Seasonal values of climatic parameters in the years of intensiication of extreme geological processes, 1996-1995 (Mestia)

1996 (1995)					
	Winter	**Spring**	**Summer**	**Autumn**	**Year**
Mean Temperature (^{0}C)	-3.4 (-1.50*)	7.1 (5.10)	15.5 (14.70)	5.8 (7.97)	6.30
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sums of precipitation (mm)	136.5 (144)	184.0 (239)	206.0 (276)	246.0 (228)	776.0 (876)
1986-2010 Average (mm)	241.8	277.6	270.8	271.1	1 058.0

Table 4.6.4. Seasonal values of climatic parameters in the years of intensification of extreme geological processes, 1997 (Mestia)

1997					
	Winter	**Spring**	**Summer**	**Autumn**	**Year**
Mean Temperature (^{0}C)	-3.7	4.5	15.7	NA	NA
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sums of precipitation (mm)	324.0	248.4	221.0	218.4	1 022.0
1986-2010 Average (mm)	241.8	277.6	270.8	271.1	1 058.0

Table 4.6.3. Seasonal values of climatic parameters in the years of intensification of extreme geological processes, 1998 (Mestia)

1998					
	Winter	**Spring**	**Summer**	**Autumn**	**Year**
Mean Temperature (^{0}C)	NA	7.1	17.8	8.2	NA
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sums of precipitation (mm)	288	304	138	209	949
1986-2010 Average (mm)	241.8	277.6	270.8	271.0	1 058.0

Table 4.6..4. Seasonal values of climatic parameters in the years of intensification of extreme geological processes, 2004 (Mestia)

2004					
	Winter	**Spring**	**Summer**	**Autumn**	**Year**
Mean Temperature (^{0}C)	-2.9	5.3	15.2	7.1	6.2
1986-2010 Average (^{0}C)	-4.4	5.6	15.9	7.2	6.1
Sums of precipitation (mm)	191	322	285	258	1 061 (1207)
1986-2010 Average (mm)	241.8	277.6	270.8	271.0	1 058.0

Note: Data in brackes refer to 2003.

Annex 5.1. Data sources for MARKAL- Georgia

The MARKAL Georgia analysis is based upon different sources and assumptions. These sources are presented in the Table.

Table 5.1. Main data sources for MARKAL- Georgia

Sector	Source
Natural gas balance and prices	• Georgian Oil and Gas Corporation (GOGC); Natural gas distribution companies • National Comission on Energy and Water supply of Georgia • Georgian Natural Gas Transportation Company
Oil products balance and prices	• Georgian Oil and Gas Corporation • Ministry of Finance • International Energy Agency
Coal balance and prices	• Saknakhshiri LTD • National Statistics Service of Georgia
Timber balance and prices	• National Forestry Agency at the Ministry of Environment and Natural Resources Protection • USAID publication "The Potential of Bio-forests in Georgia and Its Efficient use"
Geothermal energy balance and prices	• National Environmental Agency
Electric energy balance and prices	• Distribution companies • Electric energy market operator
Activity data for various sectors	• National Statistics Service of Georgia • Ministry of Economy and Sustainable Development • Ministry of Internal Affairs • Electric energy and gas distribution companies
Energy sector	• Ministry of Energy
Demand Determining factors (e.g. GDP, population)	• "Country's basic data and direction for 2013-2016". Ministry of Finance • International Monetary Fund, GDP Forecasts • World Banks, GDP Forecasts • National Statistics Service of Georgia

The data are collected and prepared mainly by the Analytical Department of Ministry of Energy.

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