GEORGIA'S

INITIAL NATIONAL COMMUNICATION

UNDER THE UNITED NATIONS

FRAMEWORK CONVENTION ON

CLIMATE CHANGE

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FOREWORD

For the end of current century the Climate Change became one of the most important problems for mankind. This is caused by those catastrophic consequences, which could take place if the global climatic system looses its equilibrium.

In 1992, when the UNFCCC was signed, the political turmoil was prevailing in Georgia. However, in 1994 Georgia already joined the Convention and since 1996 the intensive activity has begun for the fulfilment of commitments to the UNFCCC. In particular, the President approved the national Climate Change Programme, first results of which served as a basic for the preparation of Georgian's Initial National Communication to the COP, accomplished under the financial support by the UNDP and GEF.

Georgia has a sufficiently long history of meteorological observations and climatic investigations. This enabled our specialists to assess the future tendencies of climate change considering complex geographical conditions of our country, determine the level of vulnerability for different sectors of economy and natural ecosystems, work out relevant adaptation strategy.

Great attention was paid to the national inventory of greenhouse gases, the results of which have revealed important peculiarities of GHG emission dynamics. These results will be found to be useful in near future for the planed emission trading in the framework of the Clean Development Mechanism and other forms of international cooperation.

Special attention has been given in the present National Communication to the analysis of measures to mitigate greenhouse gas emissions. The results obtained were used to work out a number of project proposals, some of which are already under the realization.

The Georgian Government is paying great attention to the fulfillment of commitments under the UNFCCC. This can be proved by the fact, that in the beginning of June of this year the Presidential Order has been signed on the measures stipulating wide use of renewable sources of energy under the requirements of UN and UNESCO Sustainable Development Program. In particular, according to this order the UNFCCC National Agency has been set up, which represents a unified co-ordinating body for the activities to implement the Convention, carried out in various Governmental structures.

The accomplished National Communication represents first report in this specific field, being submitted to the Secretariat of the UNFCCC and it can be regarded as an initial share of Georgia to the achievement of the noble goals of the Convention.

Vazha Lordkipanidze,
Minister of State,
Chairman of State Commission on the promotion
to the development of renewable energy

ABBREVIATIONS

Tg	–	Teragramms (million tons)
AIJ	–	Activities Implemented Jointly
C	–	Carbon
CDM	–	Clean Development Mechanism
GDP	–	Gross Domestic Product
Gg	–	Gigagramms (thousand tons)
CH_4	–	Methane
CO	–	Carbon (II) oxide
CO_2	–	Carbon dioxide
COP	–	Conference of the Parties
EBRD	–	European Bank for Reconstruction and Development
GEF	–	Global Environment Facility
GWP	–	Global Warming Potential
ICA	–	International Co-Generation Alliance
IIEC	–	International Institute for Energy Conservation
IPCC	–	Intergovernmental Panel on Climate Change
MSW	–	Municipal Solid Waste
NCRC	-	National Climate Research Centre
NMVOC	–	Non-Methane Volatile Organic Compound
NO_X	–	Nitrogen oxides
N_2O	–	Nitrous (I) oxide
SO_2	–	Sulphur dioxide
TACIS	–	Technical Assistance for Commonwealth of Independent States
TRACECA	–	Transport Corridor Europe-Caucasus Asia
UNDP	–	United Nations Development Programme
UNEP	–	United Nations Environment Programme
UNFCCC	–	United Nations Framework Convention on Climate Change
WB	–	World Bank

Contents

1. EXECUTIVE SUMMARY

1.1. FOREWORD

Georgian Parliament ratified in 1994 the United Nations Framework Convention on Climate Change, adopted by leaders of 158 states at the Earth Summit in Rio de Janeiro in 1992. So Georgia took the obligation to the inventory of greenhouse gas emissions and their abatement, the conduction of measures, providing decrease of emission of these gases in the atmosphere

According to the rules of the Convention, within 3 years of its joining to the UNFCCC, or the beginning of relevant financial assistance, the country is to submit its National Communication to the COP. For the fulfillment of this commitments to the Convention the President of Georgia Mr. E. Shevardnadze approved in 1996 the National Climate Change Program and, in spite of financial problems standing before the country, allocated necessary financing to the year 2000. For the implementation of the Program the National Climate Research Centre (NCRC) has been set up at the Department of Hydrometeorology. Despite of the fact, that Georgia as a non-Annex 1 party, was not obliged to investigate the main trends of climate change over its territory, this Program envisaged carrying out of research in that direction for the specification on the regional level of general forecast for the global warming. The preparatory work started without delay for the composition of initial National Communication – preliminary data base has been prepared for the inventory of GHGs, the analysis has been carried out on the change of major climatic elements – air temperature and atmospheric precipitation during the 20-th century, the relevant trends were established for the different regions of Georgia, the preliminary assessments of vulnerability were made for agriculture, water resources, coastal zone and natural ecosystems. At the same time, according to the rules, established for the developing countries and economies in transition, the Government of Georgia applied to the GEF for assistance in the preparation of this communication. By this time, with the consideration of results of activities conducted in Georgia on this problem, a positive decision was adopted by GEF in September 1996. On its basis activities on 2-year project "Enabling Georgia to fulfil its commitments to the UNFCCC" started under the guidance of UNDP Country Office in Georgia since March, 1997. In April, 1997 a Steering Committee had been created headed by the State Minister. It included all leading persons of the Ministries and governmental Departments connected with the Climate Change problem.

Results, obtained at separate stages of the project implementation, have been reviewed at 3 workshops held under the project work plan. Several representatives of the Government and leading specialist of the country in this field took part in these workshops, as well as representatives of various countries and international organizations.

Results being obtained during the implementation of the project were regularly disseminated by the special Bulletin, published under the project financial support. They were also widely dealt with in periodicals, on TV and radio, were discussed in special lectures and papers.

Aiming the implementation of the project on the high level, it became possible to attract the wide range of highly professional specialists from a number of organizations, among which are to be mentioned:

- Ministry of Environment:
    - Department of Hydrometeorology;
    - National Climate Research Centre;
    - Main Administration on Atmospheric Air Protection.
- Ministry for Fuel and Energy;
- Ministry of Economy;
- Ministry of Finance;
- State Department of Statistics;
- State Department of Forestry;

- Georgian Academy of Sciences:
  - Institute of Hydrometeorology;
  - Institute of Botany;
  - Institute of Geography;
  - Institute of Paleobiology;
  - Institute of Geophysics.
- Ivane Javakhishvili Tbilisi State University;
- Centre for Agricultural Ecology of the Academy of Agricultural Science;
- Tbilisi Agrarian University.

The first national inventory of greenhouse gas emissions and sinks was carried out for 1980-1997 period in the framework of the project.

Using the vulnerability assessment for various branches of the economy and natural ecosystems to anticipated climate change, main directions of adaptation strategy have been worked out, making the basis for the creation of the National Climate Change Action Plan, the development and specification of which will be made in the Second National Communication.

For the implementation of GHG abatement activities aimed at the mitigation of climate change, along with the preparation of National Communication, over 10 project proposals were elaborated at the National Climate Research Centre. These proposals have been presented to the organizations of global cooperation, functioning in this field. These proposals consider implementation of environmentally friendly and energy-effective projects using the sources of renewable energy. 2 of them have been already approved to be carried out under the GEF financial support. In connection with indicated activity, close and prospective contacts have been established both with international organizations (GEF, UNDP, WB, EBRD, TACIS, etc.) and a number of private firms from Austria, USA, the Netherlands and other countries.

To fulfil the country's commitments to the UNFCCC, consolidation of the efforts of a number of Ministries and Departments appeared to be necessary. During the project implementation it became evident, that the solution of complicated and numerous problems connected with climate change phenomena needs creation of a unified governmental body, which will coordinate in future all activities in the field of climate change problem and will be responsible for the fulfillment of all commitments under the UNFCCC to both the Country's Government and to International organizations.

1.2. NATIONAL CIRCUMSTANCES

Georgia occupies the southeastern part of Europe, to the South of the watershed of Great Caucasian Range, in Transcaucasia, lying between the Black and Caspian Seas. Total area of the country is 69,700 km^2, 46% of which is located at the altitude of 0-1000 m a.s.l. The Likhi Range, crossing the country almost meridionally in the middle of territory, divides the country into 2 different regions that is reflected mainly in the climate.

Western Georgia is rich in rivers, the biggest of which are Rioni and Enguri. The biggest river in Eastern Georgia is Mtkvari with its several confluents flowing down from the Great Caucasus. There are tens of lakes in Georgia. The biggest of them is Paravani with the area of its water plane of 37.5 km^2. Over 20 regulating water reservoirs are constructed on a number of rivers. Swamps occupy approximately 600 km^2 of the country's territory, and glaciers occupy the area of 511 km^2.

Almost all types of climate are presented over Georgian territory except savanna and tropical forests. The Black Sea coastal zone has humid subtropical climate. Mean annual temperature here is 14-15 ^0C and annual precipitation sums range from 1500 to 2500 mm. On the Plains of Eastern Georgia the climate is dry-subtropical with average annual temperatures in the range of 11-13 ^{0} C and annual precipitation sums between 400-600 mm. In mountainous areas this value reaches 800-1200 mm.

In the cold period of the year stable snow cover does not form in both regions of Georgia up to the altitude of 400 m a.s.l. Duration of bright sunshine over the most part of the country's territory ranges from 1900 to 2200 hours. Warming period with 10 ^0C threshold value on the plains comprises 120-160 days, while in a mountainous zone it reaches 220-320 days.

In 1989 population of Georgia was 5.45 million, 56% of which lived in cities. After the breaking up of the Soviet Union, intensive migration of population has begun. Population of Georgia actually was 4.7 million by the year 1998, approximately 3 million of which lived in cities. Economically active population made 2.2 million in 1997, out of which approximately 350 thousand persons were unemployed.

Until the disintegration of the Soviet Union, the share in GDP of the main branches of economy, namely industry, agriculture and services was allocated almost evenly. By 1997 this proportion sharply changed in the direction on the decrease of industry (down to 18%) and the increase of services (up to 52%). Substantial decrease of the share of industry was mainly caused by the breaking of economic relations between former Soviet republics and catastrophic increase of the cost of energy-carriers. Due to slow, but firm course of reforms since 1996, gradual improvement of main economic indices has begun. In 1995 GDP amounted only 370 USD per capita. In 1997 this value increased up to 890 USD.

From 1997, due to the impact on the economy of various negative factors, among them the corruption, the slow-down of progress has begun. In the mean time the President and the Parliament are preparing to carry out crucial anti-corruption measures to combat the present financial and economic crisis. This would create necessary condition for the activation of country's taxation system.

Agricultural lands in Georgia occupy 35.2 thousand km^2, the most part of which is used as arable land for sowing areas under annual crops and pastures. The rest of the area is occupied by vineyards, fruit, tea crop, citrus plants, vegetables, potatoes and hayfields. Forests in Georgia occupy 29.9 thousand km^2.

Energy production is one of the greatest problems of Georgian economy. At present, the country gets only 20% of essential energy to satisfy primary needs. Energy consumption in Georgia decreased since 1988 till 1996 from 18.1 billion kWh to 7.3 kWh, respectively. In 1990, the share of hydropower plants in a total energy generation was 53%, while in 1996 this value made 83%. Due to a low level of maintenance, hydroelectric plants produce approximately 60% of their full capacity. Total energy loss in the power network reaches 25%.

Annual projected output of 60 hydroelectric plants, functioning at present in Georgia, is 10 billion kWh. The country's hydropower potential allows constructing up to 250 new hydroelectric plants of different capacity, with 30 billion kWh total output.

Out of energy resources established stock of coal over the territory of Georgia makes 432 million tons, and projected resources of crude oil are estimated up to 375 million tons. The country's demand on oil makes at present approximately 5 million tons annually. According to the results of exploration activities, conducted for the last years, there are quite a sufficient reserves of natural gas at the Black Sea shelf in Georgian sector, total output of which is estimated as 1.8 billion m^3 annually.

Among renewable energy resources Georgia is rich most of all in hydropower resources. Full energy production potential of a surface run-off reaches 219 billion kWh, out of which, it is technically feasible to generate up to 40 billion kWh of energy. Out of wind energy resources, economically reasonable part is estimated as 2-3 billion kWh, that is not practically used yet. Georgia is also rich in solar and biomass energy resources. It has sufficient reserves of geothermal waters, that may be used to satisfy the requirements of up to 1.5 million persons in hot water and heating in future, as well as to provide the functioning of a number of economically important enterprises.

The main source of CO_2 emissions in Georgia is energy production module, the share of which in the total CO_2 emission varied in 1980-1997 within 93-72%. In the 80-s total CO_2 emission from energy objects made 31-36 million tons, and by 1994 this indices decreased down to 4 million tons annually. The share of motor-transport in the total CO_2 emission in the 80-s made 8-9%. After the break up of the Soviet Union it decreased 2-3 times. Though, since 1995 sharp growth is being observed and during the recent years it reached 30-35%.

1.3. GREENHOUSE GAS INVENTORY

The first greenhouse gas inventory was carried out in Georgia according to the IPCC latest Guidelines. Along with the base 1990 year, the data for the 1980-1997 period have been considered as well, since after the disintegration of the Soviet Union the process of greenhouse gas emission underwent considerable change. Inventory covers both greenhouse gases of direct effect (CO_2, CH_4, N_2O), and indirect effect (NO_x, NMVOC, CO, SO_2). According to established rules, anthropogenic activity is being revealed in 5 modules: energy production, industrial processes, agriculture, land use change and forestry, wastes. General characteristics of main greenhouse gas emissions are presented in the Table 1.1.

Table 1.1. Characteristics of main greenhouse gas emissions during the 1980-1997 period

Greenhouse gases	1980	1985	1990	1995	1997
CO_2, Tg	34,593	39,620	36,422	5,344	9,177
CH_4, Tg	0,380	0,411	0,356	0,150	0,167
N_2O, Gg	8,435	8,598	7,895	3,273	4,366
Total in CO_2 equivalent, Tg	45,188	50,916	46,345	9,509	14,037
Total in C equivalent, Tg	12,324	13,886	12,640	2,593	3,828

Major source of the most important greenhouse gas - CO_2 emission is fossil fuel combustion, and main sink is forest. Results of CO_2 emission and sink inventory are presented in the Table 1.2.

Table 1.2. Main characteristics of CO_2 emissions and removals in Georgia (Tg)

Source categories	1980	1985	1990	1995	1997
1. Energy production, including:	30.976	35.883	33.814	3.877	7.336
Stationary sources	28.186	32.688	30.676	2.447	4.470
Motor transport	2.790	3.195	3.138	1.430	2.866
2. Industrial processes	1.200	1.259	1.042	0.136	0.207
3. Forest utilization	1.576	1.658	0.664	0.784	0.937
4. Agriculture	0.841	0.820	0.902	0.547	0.696
Total	34.593	39.620	36.422	5.344	9.176
CO_2 sink					
Forest ecosystems	-12.389	-12.389	-12.389	-12.389	-12.389
Transformation of pastures	9.836	9.836	9.836	9.836	9.836
CO_2 net emission	32.040	37.067	33.869	2.791	6.623
Share of CO_2 sink by forests (%)	27.9	25.1	27.9	82.1	65.3

In the energy production module a leading place is occupied by electricity and heat generation. Then follows residential sector, motor transport, agriculture and separate industrial branches.

Main sources of Methane emission from the territory of Georgia are wastes, agriculture and fugitive emissions from fuel production. Main characteristics of CH_4 emission are presented in the Table 1.3.

Sharp decrease of Methane emission in energy production after the collapse of the Soviet Union was caused by substantial decrease of imported fuel consumption. Main share in Methane emissions from the waste sector is attributed to solid wastes and industrial sewage, and from agricultural sector - to animal enteric fermentation and manure processing.

Table 1.4 presents data on Nitrous (I) Oxide emission from various sectors of economy.

Table 1.3. Main characteristics of Methane emission, 1980-1997 (Gg)

Source categories	1980	1985	1990	1995	1997
1. Energy production including:	103.0	121.0	106.0	6.5	7.2
Fugitive emissions from fuel	99.1	116.9	103.3	6.0	6.3
2. Industrial processes	0.4	0.3	0.2	0.0	-
3. Agriculture	107.7	113.1	90.9	65.7	74.0
4. Forest utilization	28.1	24.3	15.0	7.8	9.4
5. Waste management	140.6	152.5	144.3	71.9	72.6
Total	379.8	411.2	356.4	151.9	163.2
Total in CO_2 equivalent	7,975.8	8,635.2	7,484.4	3,189.9	3,427.2
Total in C equivalent	2,175.2	2,355.1	2,041.2	870.0	934.7

Table 1.4. N_2O emission in the atmosphere in 1980-1997 (Gg)

Source categories	1980	1985	1990	1995	1997
1. Energy production	0.280	0.320	0.293	0.048	0.096
2. Industrial processes	0.802	1.624	1.613	0.530	0.926
3. Agriculture	7.161	6.487	5.886	2.645	3.274
4. Forest ecosystems	0.193	0.167	0.103	0.050	0.066
Total	8.436	8.598	7.895	3.273	4.362
Total in CO_2 equivalent	2,615.16	2,665.38	2,447.45	1,014.63	1,352.22
Total in CO equivalent	713.23	726.92	667.49	276.72	368.79

Main share in the emission of this gas belongs to agriculture. From other branches are to be mentioned industrial processes. Use of fossil fuel and forest ecosystems play less important role.

Data on the emission of gases of indirect effect are presented in Table 1.5. Analysis of the material obtained during the inventory showed, that there was not substantial emission from the territory of Georgia of other greenhouse gases, considered by the IPCC Guidelines except indicated 7 gases.

Table 1.5. Emission of other greenhouse gases from the territory of Georgia in 1980-1997 (Gg)

	Source categories	1980	1985	1990	1995	1997
NOx	1. Energy production	112.71	133.00	124.35	23.84	51.15
	2. Industrial processes	0.31	0.40	0.40	0.08	0.14
	3. Agriculture	0.99	0.98	1.03	0.70	0.90
	4. Forest ecosystems	7.00	6.03	3.73	1.94	2.39
	Total	121.01	140.41	129.51	26.56	54.58
	Total in CO_2 equivalent	4,840.40	5,616.40	5,180.04	1,062.40	2,138.20
	Total in C equivalent	1320.11	1531.75	1412.74	289.75	595.42
CO	1. Energy production	341.00	363.90	329.00	141.70	297.22
	2. Industrial processes	1.50	1.90	2.00	0.50	0.66
	3. Agriculture	59.80	58.30	64.10	38.90	49.61
	4. Forest ecosystems	246.00	212.40	131.30	68.40	81.73
	Total	648.30	636.50	526.40	249.50	429.22
	Total in CO_2 equivalent	1,944.90	1,909.50	1,579.20	748.50	1,287.66
	Total in C equivalent	530.40	520.70	430.69	204.14	351.18
NMVOC-s	1. Energy production	36.69	40.09	37.78	1.16	1.55
	2. Industrial processes	8.82	8.25	8.58	0.38	1.05
	Total	45.51	48.34	46.36	1.54	2.60
	Total in CO_2 equivalent	500.61	531.74	509.96	16.94	28.60
	Total in C equivalent	136.53	145.02	139.08	4.62	7.80
SO_2	1. Energy production	229.03	272.01	247.36	20.24	33.08
	2. Industrial processes	1.20	0.97	1.79	0.02	0.03
	Total	230.23	272.98	249.15	20.26	33.11

Analysis of conducted inventory data makes it clear, that the greenhouse gas emissions in 1980-1997 may be characterized by three periods. In the 80-s, when Georgia was incorporated into the former Soviet Union, highest values of emission were observed. Calculated in Carbon Dioxide equivalent per capita, total emission of greenhouse gases this time was 8.6 tons annually. From 1992, due to the decline of the industrial production, emission began to decrease sharply, that continued till 1996. During this period indicated value decreased down to 2.6 tons annually. Since 1997, as a result of the gradual revitalization of the Georgian economy, certain growth of emissions is observed. The comparison of emissions during above mentioned two main periods allows to estimate unpremeditated savings of greenhouse gases, that followed economic collapse in Georgia after the break-up of the Soviet Union (Table 1.6).

Table 1.6. Characteristics of greenhouse gas emission decrease during the period of 1980-1997 (Tg)

Compounds	1980-90 mean annual	Difference comparative to average values of 1980-90 (Tg)							
		1991	1992	1993	1994	1995	1996	1997	1991-97
Carbon Dioxide (CO_2)	37.009	-8.337	-19.235	-26.496	-29.666	-31.665	-28.666	-27.833	-171.898
Methane (CH_4)	0.390	-0.081	-0.148	-0.201	-0.227	-0.238	-0.235	-0.219	-1.349
The same in CO_2 equivalent	8.190	-1.701	-3.108	-4.221	-4.767	-4.998	-4.935	-4.599	-28.329
Nitrogen (I) Oxide (N_2O)	0.009	-0.002	-0.004	-0.005	-0.006	-0.006	-0.005	-0.005	-0.033
The same in CO_2 equivalent	2.790	-0.620	-1.240	-1.550	-1.860	-1.860	-1.550	-1.550	-10.230
Carbon Oxide (CO)	0.626	-0.185	-0.497	-0.484	-0.478	-0.377	-0.236	-0.197	-2.454
The same in CO_2 equivalent	1.878	-0.555	-1.491	-1.452	-1.434	-1.131	-0.708	-0.591	-7.362
Nitrogen Oxides (NO_x)	0.132	-0.019	-0.084	-0.099	-0.111	-0.105	-0.083	-0.078	-0.579
The same in CO_2 equivalent	5.28	-0.76	-3.36	-3.96	-4.44	-4.20	-3.32	-3.120	-23.160
CO_2,CH_4 and N_2O in CO_2 equivalent, M	47.989	-10.658	-23.583	-32.267	-36.293	-38.523	-35.151	-33.982	-210.457
In Carbon equivalent M_C = 12/44 M	13.088	-2.907	-6.432	-8.800	-9.898	-10.506	-9.587	-9.268	-57.398
CO_2,CH_4, N_2O, CO, NOx Calculated in CO_2 equivalent M_{CO2}	55.147	-11.973	-28.434	-37.679	-42.167	-43.854	-39.179	-37.693	-240.979
In Carbon equivalent M_C	15.040	-0.538	-7.755	-10.276	-11.500	-11.960	-10.685	-10.280	-65.721

Considering a substantial role of aerosols in the radiation balance of the atmosphere and the Earth, dynamics of their emissions was also assessed for 1985-1996. It was established, that exhausts of solid particles from industrial and energy producing sources ranged from 89 to 239 thousand tons annually in 1985-1991 period, and then this value began to decrease from 79 to 15 thousand tons. Exhaust of soot particles from motor vehicles in the first period reached 3.9-6.3 thousand tons, annually and in the second period this value decreased and made 0.3 thousand tons (1994). Further, it reached

4.4 thousand tons. Mass of sulfates created as a result of SO_2 emission, decreased as well, respectively, from 400-600 thousand tons to 30-40 tons per annum.

1.4. POLICY AND MEASURES TO MITIGATE GREENHOUSE GAS EMISSIONS

The main essence of the Environmental Protection legislation of Georgia is reflected in the country's Constitution, and the principles of the policy and mechanisms of the realization of environmental protection are formulated in a number of laws, concerning, in general, protection of the environment, water and natural resources, getting environmental protection permissions, conducting ecological examination, etc.

Georgian Government sees the way out from a crucial situation created in the field of energy production policy, first of all, in a complete utilization of the country's own energy resources, in particular, that of hydro-power and revitalization of coal industry. Despite of the fact, that energy production by using coal will increase the GHG emissions, Georgia is forced to plan the restoration of coal industry for the provision of the production of base energy using local fuel. This will decrease Georgia's dependence on the fuel imports from other countries.

In 1997 the low on electric energy was adopted, the main purpose of which is the provision of exact reflection on expenses of effective production of electric energy, its transmission and distribution, creation of legal basis necessary for stable electric supply of consumers and promotion to investments in this field. In 1998, the Order of the President of Georgia "On the development of utilization of non-traditional energy sources in Georgia" was issued, according to which renewable energy production is acknowledged as one of the priority branches and special attention is paid to the preparation of measures to promote investments essential for the development of renewable energy resources.

The aim of a state policy in transportation branch is the decrease of the number of greenhouse gas emission sources by means of coordinated development of all types of transportation, creation of the system for the assessment and monitoring of the emissions of harmful compounds, among them greenhouse gases, by the transportation, promotion to the development of motor-highway network. Expected transit of Caspian oil via the Black Sea makes important the problem of ecological safety of marine transport and infrastructure and, in particular, maximum limitation of greenhouse gas emissions. Complicated problems arise, as well, in connection with the construction of the TRACECA motor highway, joining Europe with Asia via the territory of Georgia. One of the important directions of the development of Georgian transportation system is also the development of ecologically clean special transport for mountainous regions and places difficult of access. In 1995 the Low "On Motor transport" was adopted, determining the basis of its legal, economic and organizational activity. Nevertheless, the absence of adequate financial support is seriously hampering the implementation of those decisions.

As the way out from a critical situation, created in agriculture after the break up of the Soviet Union, accomplishment of reforms began in Georgia, the key one of which was the privatization of land. The program of agricultural development in Georgia envisages giving the priority to environmentally safe organic-biological production, the main principle of which implies minimizing the use of fossil fuel and pesticides, obtained by chemical synthesis, effective utilization of resources of organic origin, preservation of soil fertility, etc.

In forestry sector, since the middle of the recent century, activities on aforestation and reforestation were conducted successfully in Georgia, that is planned to continue in the next century. In addition, during the last 40 years due to growing urbanization of population, in many regions of the country agricultural cenoses were replaced by forests. During the same period, demands of population for fuel were completely satisfied by liquid fuel and natural gas that sharply decreased the volume of firewood production. All this substantially conditioned the preservation and further growth of the country's forest resources. Meanwhile, due to energy crisis in recent years the unlawful cutting of the trees substantially damaged forests, especially around the residential areas.

According to the law of Georgia "On the Protection of Environment" ecological requirements to wastes have been established. In particular, an acting subject is responsible for the provision of the decrease of industrial, household and other types of wastes, rendering them harmless, utilization, allocation and burial with the maintenance of environmental protection, sanitary-hygienic and epidemic regulations. Disposition of any types of wastes in the sea and other water objects is prohibited. Tax Code of Georgia envisages taxes for waste allocation.

Out of measures, aimed on the abatement of greenhouse gas emissions in energy production there are to be mentioned:

- Increase of the efficiency of electric energy generation by using fossil fuel;
- Decrease of losses in the systems of transmission and distribution of electric energy;
- Increase of energy efficiency in residential sector;
- Utilization of geothermal energy;
- Rehabilitation and modernization of existing hydro-power plants;
- Utilization of wind, solar and biomass energy.

A number of measures aimed to decrease CO_2, Methane and Nitrous Oxide emissions have been worked out as well in the field of transportation, agriculture, land use and forestry, and waste management.

1.5. EMISSION PROJECTIONS

Projection of the main greenhouse gas-CO_2 emissions in the energy production sector was conducted on the basis of existing indicating plans for the development of Georgian economy up to the year 2010. Estimations were carried out according to two scenarios, the first of which envisages, that electric power consumption per capita will reach the 1990 level and required electric energy (17.6 billion kWh) will be generated from hydro-power production (10 billion kWh), fossil fuel (7 billion kWh) and renewable sources (0.6 billion kWh). In this case CO_2 emission will be equal to 5.21 Tg per annum, that is less by 1.44 Tg than the 1990 level. The second scenario allows that the 150 MW capacity thermal power plant will be put into operation. In this case, CO_2 emission will increase by 260 Gg per annum relative to the first scenario.

In the sub-sector of heating and hot water supply, estimations were conducted also according to two scenarios, one of which provides the restoration of early existing systems, and another provides the use of energy of existing geothermal waters.

Possible emission of CO_2 has been assessed, as well, for motor transport of various capacity and type combinations from the Georgian portion of Europe-Caucasus-Asia transportation corridor within 40-200 million tons of turnover annually. It has been obtained that putting into operation of the main highway in full capacity will cause additional emission of CO_2 by the year 2010 within 1.2-2.4 Tg.

In the industry sub-sector assessments were conducted for branches of metal and building material production, machinery, food industry, production of chemicals and paper for the period till 2005 and 2010. Growing values of emissions have been obtained for various scenarios, being equal to the 1990-year level.

Projections of respective CO_2 emissions have been worked out also for residential sub-sector, agriculture, forest utilization, non-energy and other types of sources.

Forecasts of Methane emissions were worked out for the same period according to different scenarios for wastes, agriculture and fugitive emissions from fuel. In agricultural sector, the possibility of substantial growth of the number of domestic animals has been envisaged.

Projections of Nitrogen Oxide emissions were made mainly with consideration of mineral fertilizers used in agriculture. For the year 2010 approximately the same level of emissions has been obtained, as fixed in 1990. Forecast of N_2O emission has been considered also in the industrial sector and from other sources.

1.6. TRENDS OF CLIMATE CHANGE AND VULNERABILITY ASSESSMENTS IN ECONOMY AND NATURAL ECOSYSTEMS

On the basis of the data of meteorological observations conducted over the territory of Georgia since the 40-s of the last century, distribution of the annual mean temperature over Georgian territory is given. For Tbilisi, the station having the longest observational series, graphs of mean annual, minimum and maximum temperature variation are presented and trends of changes are established, according to which during the last 100 years in Tbilisi mean annual air temperature has increased by 0.7 ^{0}C. Precipitation amount has slightly changed, but at the same time, wind speed and number of cloudless days have decreased almost twice.

For the years 1906-1995 changes of mean annual air temperature and that of warm and cold periods over the territory of Georgia have been analyzed. A spotty structure of the trends of change has been revealed, on the background of which establishment of a general tendency became possible- noticeable warming (up to 0.5 ^{0}C) in Eastern Georgia and slight cooling (up to – 0.3 ^{0}C) in Western Georgia . Indicated tendency is more remarkably revealed in the cold period of the year.

The same analysis has been conducted for atmospheric precipitation, as well. The tendency of growth of precipitation sums up to 10-15% in a number of regions of the plains of Georgia and the tendency of their decrease up to 15-20% in the mountain areas of the Great Caucasus, especially in its eastern section, is established.

On the basis of investigation of the recurrence of large-scale atmospheric processes, affecting the Transcaucasia since the beginning of the recent century, substantial decrease of the influence of arctic anticyclone during the warm period of the year and in winter months was established in 1978-1998 relative to 1900-1920, certain share in which is to be attributed to the global warming.

As a result of the analysis of stratigraphic cross-sections made earlier over the territory of Western Georgia, the data on the change of the upper limit of the forest, the Black Sea level, air temperature and atmospheric precipitation sums during the last 4000 years are presented .

Using the obtained data on climate change trends and the IPCC projections, assessment of vulnerability to expected climate change in various fields of economy and natural ecosystems has been carried out.

In agriculture, the analysis was conducted for major agricultural crops. It was established that in case of temperature increase by 1 ^{0}C in Western Georgia the possibility of the expansion of tea production will be created. In Eastern Georgia, in case of temperature increase by 1-2 ^{0}C, changes in vine harvest is expected, both positive and negative. In addition, the sugar content of the crop will be increased. In main wheat growing areas of the same region decrease of the harvest by 30-60% is possible. For the considered conditions in Western Georgia growth of maize productivity is expected by 30-40%, while in Eastern Georgia, due to less humidity, it may be decreased by 20-30%.

Assessment of vulnerability of rather rich water resources of Georgia for the period of 2010-2075 revealed possibility of the increase of the run-off of main rivers by 4-13% compared with the 1980 level. In this connection, it has been obtained that by the years 2010-2030 approximately up to 600 million kWh of electric energy may be produced annually on existing hydro-power plants without any additional expenses.

As a result of the investigation of the Black Sea coastal zone vulnerability, it has been divided into three sections, out of which northern (Abkhazian) and southern (Ajarian) portions are elevating with the rate of 1.5-3.0 mm/ yr and the central portion between the rivers Enguri and Natanebi is sinking with the rate of 1.0- 5.6 mm/yr. The fastest sinking is observed on Poti-Supsa coastline of the central portion. Due to the global warming, during the last 70-80 ears the sea level is raising permanently with an average rate of 2 mm/ yr, that means that during this period, territory of Poti has sunk by 0.5 m and this process will continue in future. All this causes washing down and flooding of the coastal zone and creates danger for the functioning of existing and planned here very important economic objects. In addition, the tendency of cooling of the surface of the Black Sea has been revealed, which reached 1 ^{0}C for the last 50-70 years at the coastal zone of Georgia. This results in the decrease of the recreational and vegetation periods approximately by 10 days , that along with above-mentioned phenomena is associated with great economic losses.

In connection with the expected climate change some qualitative types of transformation tendencies in Georgian natural ecosystems have been revealed, which are conventionally classified as xerophytization, mediterranization, advantization and laurophyllization. In case of the increase of mean annual air temperature by 1.5-2 ^{0}C, the first of them will be revealed most of all in Eastern Georgia, where the aridity enduring vegetation is widely expanded. Second tendency is expressed by expected expansion of Mediterranean elements mainly in the Black Sea coastline and foothill area. Advantization implies the process of expected expansion of already penetrated or intruded species into natural ecosystems and laurophyllization implies invasion of evergreen broad-leaved species of new areas, that is expected in the mountainous part of Kolkhida, particularly, in its southern regions

Possibilities of widening or decreasing of the expansion area of separate species in the forests of Kolkhida, Eastern and Southern Georgia have been considered in detail, as well as the results of proposed shift of the upper limit of forests by 150-200m higher.

Expected evolution of vegetation, expanded above the climatic limit of snow-cover, has been also considered as the expected global warming indicator system.

Considering their importance as hay fields and pastures, ecosystems in the Alpine belt of the Central and Eastern Caucasus have been analyzed, along with supposed directions of their transformation and management possibilities.

Specific composition of Georgian forests and their present state are considered in detail. Assessments have been made to determine their vulnerability to revealed and expected regional changes of climate.

1.7. ANALYSIS OF ADAPTATION STRATEGY TO EXPECTED CLIMATE CHANGE

On the basis of the assessment of vulnerability of separate branches of economy and natural ecosystems, a plan of adaptation strategy has been worked out in relevant directions.

In agriculture, this plan envisages creation of draught-resisting, highly productive species of agricultural crops, immune to diseases and pests , complete introduction of rotation of crops, provision with moisture of agricultural fields under crops in order to get two or more high harvest of annual crops. The essential condition for this is reconstruction of existing irrigation system, introduction of sprinkling and drip irrigation, as well as an integrated system of agricultural management, full awareness of agrarian public about expected consequences related to forecasted climate change and other measures.

In the field of water resources the primary attention is paid to rational utilization of water resources. In this direction, rehabilitation and expansion of existing systems of water supply, introduction of drip irrigation systems are envisaged. Necessity of the decrease of river floods has been emphasized, that requires construction of water reservoirs in river gorges, reconstruction of existing dams, regular cleaning of river beds and accomplishment of other measures. Refilling of water resources also has a great importance, for which the carrying out of activities on precipitation enhancement from clouds both during the warm and cold periods of the year, accumulation of obtained additional water resources in water reservoirs and their highly effective utilization in agriculture and hydro-power production are recommended.

Due to the decrease of the recreational season in the Black Sea coastal zone approximately by 10 days, construction of new health resorts is recommended in the northern and southern parts of the coastline. To avoid washing down and flooding of the coastline, artificial alimentation and reinforcing of beaches with concrete constructions is necessary. Special program should be elaborated for Poti-Rioni delta and the estuary of the river Supsa, where modernization of existing dikes and creation of effective monitoring system are necessary. According to preliminary assessments, expenses required for the realization of adaptation measures are approximately 7 times less than the damage, that may be done to coastline infrastructure and natural environment in case of the neglect of indicated processes.

Due to a relatively low adaptive capacity of natural ecosystems to climate change, on the background of their expected transformation, seeding of highly nutrient grasses in natural alpine fields, expansion of well run hay-fields at the expense of pasture areas twice a year conducting hay-mowing, creation of cultivated pastures with the irrigation of arable lands, renewal of destroyed ecosystems on eroded slopes, etc. are recommended.

Among the measures, aimed to combat the desertification on the Iori Highland of Eastern Georgia, oases and individual farms should be created using underground waters, irrigation of winter pastures should be conducted and forest shelter-belts should be created. On the Black Sea coastline forest-parks should be set up using local relict species of trees. In forest ecosystems, a monitoring system should be organized to assess the resistance steadiness of plants and phytocenoses, to work out and accomplish projects on reforestation and forest growing, first of all in the neighboring areas of industrial centers.

1.8. SCIENTIFIC RESEARCH AND SYSTEMATIC OBSERVATIONS

In the 70-s of the current century, Hydrometeorological Service of Georgia incorporated up to 240 metorological stations and posts, which reflected with a sufficient accuracy the country's meteorological regime from the sea level up to 3650 m a.s.l. The network of meteorological radars was functioning, as well. At present, the Georgian Department of Hydrometeorology incorporates 60 functioning meteorological stations and 1 meteorological radar.

Using contemporary data of meteorological observations, numerous investigations were carried out on the climate of Georgia and its change, results of which are reflected in several monographs and reference books, published in 1961-1992.

At present, research on indicated problems is traditionally going on at the Institutes of Hydrometeorology and Geography of the Georgian Academy of Sciences. Investigation of resort resources of Georgia was conducted at the Institute of Health-resort and Physiotherapy of the Ministry of Health. Research on separate factors, stipulating climate change is carried out, as well, at the Institute of Geophysics of the Georgian Academy of Sciences. Problems of modelling the processes, related to the climate change are investigated at some departments of Tbilisi State University.

Investigations at the National Climate Research Center of the Department of Hydrometeorology are conducted since 1996 in the framework of the National Climate Change Program. These activities, as a result of which a number of peculiarities of recent climate change trends over the territory of Georgia have been investigated, served as a basis for the project GEO/96/G31, started in 1997 under the UNDP/GEF financial support.

During the implementation of this project a number of important investigations have been conducted. Among them some are of theoretical nature. Their aim is the forecasting of the process of global warming on the basis of the establishment of general regularities of its development, taking into account orographic and dynamic factors of a specific region. Main results of indicated investigations are presented.

1.9. EDUCATION AND PUBLIC AWARENESS

Growth of interest to Climate Change problem in Georgia started since 1996, along with the beginning of the implementation of respective program. Relevant work on the dissemination of public knowledge was carried out mainly by the National Climate Research Center through periodicals, radio and television. Indicated activity was proceeding especially intensively since the activation of the project GEO/96/G31. In 1997-1998 members of the project published over 20 articles in various magazines and newspapers, which are intended both for a wide range of readers and scientific circles. More than 10 special TV broadcasts were arranged, in which the essence of the problem and its role in the future activity of mankind was explained. After each workshop conducted under the project, wide press-conferences were organized for the representatives of mass-media, where separate aspects of climate change problem were discussed and their importance was emphasized.

Special role was given in the dissemination of information, related to the problem, to the Bulletin of the National Climate Research Center, 4 out of 8 issues of which were published in Georgian and English and were widely distributed among interested circles both in Georgia and abroad.

Over 20 lectures and presentations were delivered at various meetings and organizations, among them at international conferences and workshops, conducted by non-governmental organizations. Project members took part in the international trip of "Climate Train" which was held before COP-3 Kyoto session. Information on project activity is also prepared for the website in Internet since 1998.

In 1998, at the initiative of the project Management Team, a special Training Center on environmental management was established at Tbilisi State University, which will train highly qualified specialists in separate fields, related to the implementation of the UNFCCC. The Center will conduct also regular training cources for the education on Climate Change of specialist, working in various branches of economy.

1.10. INTERNATIONAL CO-OPERATION

During the process of preparation of the National Communication, National Climate Research Center established close relations with UNFCCC Secretariat and with such international organizations, as UNDP, UNEP,WB,EBRD, GEF, ICA, IIEC, with "Joint implementation" programs of various countries. The main purpose of these contacts is continuation of the activities in the direction of fulfilling commitments to the Convention by Georgia and attraction of investments for the implementation of projects to mitigate GHG emissions, which were elaborated during the preparation of National Communication.

Representatives of Georgia have been appointed as experts by the UNFCCC Secretariat and they are actively participating in the process of reviewing National Communications of various developing countries.

Important were relations with Dutch Joint Implementation Program, representatives of which visited Georgia several times. Some project proposals have been submitted to the US JI Program. Negotiations are going on concerning one of them with private investors from the USA.

On the basis of agreement, reached in 1998 at the COP-4 session, Georgia will participate in the World Bank Program "System of National Strategy for the Clean Development Mechanism". At the same time, under the initiative of international organizations, participation of Georgia together with the Philippines is planned in the joint protect, the aim of which is the investigation of the prospects and benefits of Clean Development Mechanism from the point view of host and donor countries.

Particularly important and fruiful is the relation of Georgia with the GEF. Along with the financing of the First National Communication, the project on technical and economic feasibility in the field of energy-efficiency is in the starting stage as well as the Project aimed on the investigation of the potential for small hydro-power plant rehabilitation.

GEF sponsored "National Communications Support Program" is holding an international workshop in Georgia, in September, 1999, which will be devoted to the working out of the policy for the mitigation of GHG emissions and the mechanisms of its implementation.

1.11. NATIONAL CLIMATE CHANGE ACTION PLAN

For the removal of barriers on the way towards the abatement of GHG emissions and the restoration of national economy on the principles of sustainable development, as well as for the fulfillment of Georgia's commitments to the UNFCCC, the draft for National Climate Change Action Plan has been elaborated, dealing with three main problems:

- Adaptation of systems, vulnerable to climate change;
- Mitigation of GHG emission sources;
- State policy.

Adaptation analysis, carried out for vulnerable systems has shown that the most vulnerable system is the Black Sea coastal zone, which has strategic importance for the rehabilitation of national economy and the development of foreign trade. The project, worked out for the adaptation of this zone, according to preliminary estimations, will cost $US 600-700 million, that is 6-7 times less than the expected loss for the year 2030. The second important vulnerable system is agriculture, where the special attention is to be given to the culture of wheat. Sufficient attention in the Action Plan is paid also to the problem of raising the efficiency of the use of water resources.

In the field of the abatement of GHG emissions the main concern is focused on the energy sector, which makes nearly 90% of country's total emission. A number of projects has been worked out, among them 6 projects in small hydroenergetics, 3 projects in heat and hot water supply using the geothermal energy, 3 projects at the use of wind and solar energy end the raise of energy efficiency. The proposals are elaborated also for the abatement of GHG emissions in transportation and industrial sectors and for the enlargement of CO_2 sinks in forestry.

In the sphere of state policy the Action Plan aims to take a number of steps for the fulfillment by Georgia commitments to the UNFCCC and under Kyoto Protocol, and for the maximum use of international aid provided by this way. In particular, the necessity is stressed for the creation of structures, which would be responsible for the implementation of UNFCCC principles inside the country and for the protection of its interests in the decision making processes on the international level. The expediency is also underlined for the adoption of legislative acts promoting the mentioned processes, for the widening of activities in the field of public awareness, education and training.

2. INTRODUCTION

At the starting point of investigations of climate in separate regions of the Earth, still in the 19-th century, substantial changes of climate were fixed in the historic past. This fact stipulated the necessity of conducting climate change forecast for the future. Very important became the determination of trends and rate of these changes. They attracted considerable attention already since the 50-s of the recent century. Until the 80-s the idea about a self-cleaning mechanism keeping a climate system of the Earth in balance and that strong anthropogenic loading on the atmosphere during the recent century could not have a significant impact upon the Earth's thermal regime, was prevailing. "Greenhouse effect", which is the result of the presence of Carbon Dioxide and other, so called " radiative gases" in the atmosphere, should not have been intensified to such an extent that to result in irreversible changes of the Earth's climate. Therefore, future climate change would be mainly stipulated by natural factors.

However, the analysis of global temperature regime, conducted in the second half of the 80-s, showed that such an optimistic approach to the problem has no ground and the Earth's climate in the second half of the 20-th century reveals quite evidently features of global warming. As the reason for this undoubtedly was named sharp increase of Carbon Dioxide and other greenhouse gas concentration in the atmosphere due to still growing human technogenic activity. In particular, increase of CO_2 concentration in the atmosphere by 30% has been fixed relative to previous centuries as a background value.

All these created an alarming situation in the international scientific community at the end of the 80-s. The Intergovernmental Panel of Climate Change was created by the United Nations specialized agency, involving world's leading meteorologists and climatologists.

The IPCC studied problem in detail and determined that in the second half of the recent century, the phenomenon of global warming is becoming quite evident and one of the reasons is the increase of greenhouse gas concentration in the atmosphere due to the action of anthropogenic sources.

Taking into account those catastrophic consequences, which will follow global warming in the next century, the Panel advised the world's leaders to carry out effective measures, aimed at the decrease of greenhouse gas emissions in the atmosphere. Due to the attention paid by politicians to the problem, the United Nations Framework Convention on Climate Change was adopted at the summit of the world's leaders, devoted to environmental protection, which was held in 1992 in Rio de Janeiro. The main purpose of the Convention is to keep greenhouse gas emissions at the 1990-year level, thus possibly providing the prevention of irreversible processes in the global climate system.

To achieve this aim during the accomplishment of Framework Convention, different forms of international cooperation (Joint Implementation, Emission Trading, Clean Development Mechanism, etc.) have been worked out. Their use is envisaged in various documents connected with the Convention, which were adopted during the years after its putting into force, and are directed to the introduction of modern environmentally friendly technologies by developed countries in the developing countries and those with economy in transition.

Formation of such cooperation between the states creates the condition for establishing new forms of relation in the world commonwealth, which serves the fulfillment of remote aims of the mankind.

Georgian Parliament ratified UNFCCC in 1994, thus taking responsibilities to fulfil commitments on recording greenhouse gas emission in the atmosphere and its limiting, conducting those measures, which provide for the abatement of emissions.

According to the articles 4 and 12 of the Convention during 3 years since the joining to it, the country should submit its initial national communication to the highest body of the Convention –

Conference of the Parties, reflecting the results of the inventory of the greenhouse gas emission sources and removals, carried out in the country, determining vulnerability of separate branches of economy and natural ecosystems to climate change and the strategy of adaptation to it, presenting the mitigation policy and setting up ways for its practical realization.

For the fulfillment of commitments to the UNFCCC in 1996, the President of Georgia Mr. E.Shevardnadze approved National Climate Change Program and despite serious financial problems existing in the country, appropriate funds have been allocated for its implementation till 2000. For this purpose, National Climate Research Centre has been created in the Department of Hydrometeorology. Despite of the fact, that as a non-Annex 1 party Georgia was not obliged to investigate main trends of climate change over its territory, this Program envisaged carrying out research in that direction to specify on a regional level general forecast of global warming. Preparatory activities have been started without delay to compose the first National Communication. Preliminary data base has been created to conduct greenhouse gas inventory, the analysis of the change of main climatic elements – air temperature and atmospheric precipitation has been conducted during the 20th century, respective trends have been established in different regions of Georgia, preliminary assessment of vulnerability in agriculture, water resources, coastal zone and natural ecosystems has been carried out.

According to international practice established for developing countries and countries in transition Georgian Government applied to GEF with the request to assist in the preparation of National Communication.

In September 1996 positive decision has been adopted on this problem taking into consideration the results of activities, already conducted in this field in Georgia. On this basis, under the guidance of Georgian Office of United Nations Development Program, activities on 2-year project GEO/96/G31 started since March 1997 under the title "Enabling Georgia to fulfil its commitments to the UNFCCC". In March, 1997 working groups were created to accomplish separate problems of the project, and in April, under the Guidance of the State Minister, the Steering Committee was established incorporating leaders of all ministries and governmental organizations, connected to the problem.

First results of working over the project were summarized at the Initiation workshop of the project, held in July, 1997 with the participation of representatives from Armenia and Azerbaijan. The second workshop was developed to problems of inventory and mitigation. It was held in December 1997 with the participation of Government experts from the Netherlands. The third workshop of the Project was held in May 1998 in the form of an international meeting of specialists, working in the field of climate change. At all these meetings, separate parts of the National Communication of Georgia were discussed in detail, that provided for its appropriate correction and bringing into accordance with international standards.

Results, obtained during the Project, were systematically published in a special Bulletin of the National Climate Research Center, which was distributed among interested organizations both in Georgia and abroad. 8 issues of the Bulletin have been published, out of which the last 4 issues – in Georgian and English. These results were also widely covered in periodicals, on radio and TV, in special lectures and presentations.

For the implementation of the project on an adequate level, the attraction of a wide range of specialists from a number of organizations become possible. In particular, the following departments and institutions took part in the fulfillment of the project:

- Ministry of Environment of Georgia:
    - Department of Hydrometeorology;
    - National Climate Research Center;
    - Main Administration on Atmospheric Air Protection.
- Ministry for Fuel and Energy ;
- Ministry of Economy;
- Ministry of Finance;
- State Department of Statistics;
- State Department on Forestry;
- Georgian Academy of Sciences :
    - Institute of Hydrometeorology;
    - Institute of Botany;
    - Vakhushti Bagrationi Institute of Geography;

- L. Davitashvili Institute of Paleobiology;
- M. Nodia Institute of Geophysics.

- Ivane Javakhishvili Tbilisi State University;
- Canter of Agricultural Ecology of the Academy of Agricultural Sciences;
- Tbilisi Agrarian University.

Within the accomplishment of the Project, the first national inventory of greenhouse gas emissions and sinks has been carried out. On the basis of these data, it became possible to carry out quantitative assessment of greenhouse gases, emitted from Georgian territory and to establish emission dynamics before and after the break up of the USSR. Taking into account the complicated nature of the process, the data of other years along with those of the base 1990 year were considered as well, reflecting both the pattern of non-deliberate decrease of the emission and possibility of its future increase in various branches of the economy.

On the basis of the assessment of vulnerability of various branches of economy and natural ecosystems to climate change, main directions of adaptation strategy have been worked out, which served as a basis, along with climate change mitigation measures, for the creation of National Climate Change Action Plan.

For the mitigation of Climate Change, the analysis of measures directed to the abatement of greenhouse gas emissions demonstrated the possibility of the implementation of a number of specific projects in Georgia. To achieve this aim and using Joint Implementation, Clean Development Mechanism and other forms of global cooperation, along with the preparation of the First National Communication, over 10 project proposals have been worked up, considering accomplishment of environmentally friendly and energy-effective projects using sources of renewable energy. Two of them, one of which deals with the increase of energy-efficiency in municipal heat-supplying systems, and the other – with the rehabilitation of small hydro-power plants, have been already approved by the GEF. Above mentioned and the following projects will stipulate foreign investments in Georgia, and their environmental protection strategy will substantially contribute to the formation and implementation of the Plan of Sustainable Development of the country's economy. In connection with this activity the close perspective contacts have established both with international organizations (GEF, UNDP, WB, EBRD, etc.) and a number of private firms from Australia, USA, the Netherlands and other countries.

During the process of conduction of inventory and working out of the strategy for the mitigation of climate change, a number of difficulties arose. They are connected with the lack of relevant statistical data, concerning the years of economic depression after the disintegration of the USSR and the lack of approved plans for future development of various branches of economy, as well. To fill the data gaps mathematical models were used in a number of cases, allowing the projection of greenhouse gas emissions in various fields of economy using different scenarios of the economic development.

To fulfil the country's commitments to the UNFCCC, concentration of the efforts of a number of Ministries and Departments has become necessary. In the first phase of the project, the function of this consolidating body was performed by the Steering Committee of the Project. In the next phase of the project fulfillment, it become evident, that such approach to the problem is not enough to solve the great number of complicated problems, which are arising in a growing scale in the country. This created a pre-requisite for the creation of the UNFCCC National Implementing Agency, which will coordinate all kinds of activities connected with climate change problem in future and will be responsible before the Government and international organizations for the fulfillment of all obligations envisaged by the Framework Convention.

Present National Communication aims to acquaint interested circles of the World Community with the first results of activities carried out in Georgia on the climate change problem and to reflect those efforts, which are to be made by Georgia in the next century to mitigate climate change and its undesirable consequences.

3. NATIONAL CIRCUMSTANCES

3.1. GEOGRAPHY

Georgia is situated on the southern slopes of the Great Caucasian Range and on the northern slopes of the Small Caucasus between 40^0 and 47^0 of the eastern altitude and 41^0 and 43^0 30' of the northern latitude. It is bordered by the Black Sea from the west, on the north its border with the Russian Federation mainly passes on the Great Caucasus watershed. On the East it borders with Azerbaijan and on the South-with Azerbaijan, Armenia and Turkey. Total area of Georgia is 69 700 km^2. 18 200 km^2 (26.1% of the whole territory) is situated at the altitude of 0-500 m above the sea level, 13 900 km^2 (19.9%) between – 500-1000 m, 24 100 km^2 (34.6%) - at the altitude between 1000-2000 m and 13 500 km^2 (19.4%) – higher than 2000 m.

The mountainous relief determines the diversity of Georgia's physical geography. The Likhi (Surami) Range, which is passing over the central part of Georgia in a meridian – like direction, in spite of its relatively low altitude (no more than 1000 m above the sea level), divides the country's territory into two different regions, that mainly is reflected in climate peculiarities.

Western Georgia is descending with slopes of the Great Caucasus, Likhi and Meskheti ranges to the Black Sea like a gigantic amphitheater and forms Kolkhida Lowland triangle in the lower part of the River Rioni.

Western sector of the Great Caucasus borders in this region the highest point of indicated system – Mt. Elbrus (5 642 m) and to the south Meskheti Range reaches 2 850 m above the sea level.

Eastern Georgia has relatively more complicated geography. Its central part is occupied by the valley of the River Mtkvari (Kura), descending uniformly from Likhi Range eastwards. From the North, southern slopes of the Great Caucasus are descending to this valley. The second highest point of the Caucasus, Mt. Kazbek (5 033 m) is erected on their northern border. Eastward up to the border with Azerbaijan, rather high (4 300-4 500 m) row of summits is stretched. From the south the valley of the River Mtkvari borders Javakheti volcanic upland. Its central part is ended by Samsari Range, the highest point of which, Mt. Didi Abuli reaches 3 301 m. a.s.l. Here, at the altitude of 2 100 m above the sea level Lake Paravani is located. Area of its water surface is 37. 5 km^2. Eastern part of indicated Region (Kakheti) is occupied by southern branch of the greater Caucasus – Tsivgombori Range and Iori upland, heights of which vary within 800-2000 m.

Western Georgia, unlike Eastern Georgia, is rich in rivers. Most of them are taking their source from the Great Caucasus and are passing through Kolkhida Lowland flowing into the Black Sea. The largest local rivers are Rioni and Enguri, rich hydro-energy potential of which is used by a number of hydropower stations. The main river of Eastern Georgia is Mtkvari, taking its source in Turkey, and passing after Georgia through Azerbaijan. The Kakheti Region is crossed only by two rivers – Alazani and Iori. They start on the southern slopes of the Great Caucasus and flow into Mingechaur Reservoir, located in Azerbaijan and fed mainly by the River Mtkvari.

There are dozens of lakes of different origin on the territory of Georgia. Some of them are remarkable for their size, such as already mentioned Lake Paravani, as well as lakes Paliastomi (surface area – 18.2 km^2), Tabatskuri (14.2 km^2) and Jandari (10.6 km^2). More than 20 regulating reservoirs are constructed on a number of rivers. Swamps are concentrated in the country mainly in the Kolkhida Lowland, occupying approximately the area of 600 km^2. As to glaciers, their total area in the central part of the Great Caucasus reaches 511 km^2.

The capital of Georgia, Tbilisi, with the population of 1.5 million, is situated in the valley of the River Mtkvari. 20 kilometers away from the capital is located Rustavi, industrial city with the population of 200 000. In Western Georgia, the main city of the Region – Kutaisi is situated in the valley of the River Rioni with the population reaching 300 000. Other large Georgian cities Batumi, Poti and Sukhumi are located on the coastline of the Black Sea.

3.2. CLIMATE

According to the diversity of physical and geographical conditions, almost all types of climate are presented over the territory of Georgia, except the climates of savannah and tropical forests. Especially sharply this variety is revealed in Western Georgia, where climatic belts comprise both humid subtropical zones and of permafrost, while direct distance between them in some cases does not exceed 70-80 km.

High mountain system of the Great Caucasus prevents the direct penetration of cold air masses from the North into the territory of Georgia. Therefore, even arctic penetrations get a mitigating impact on the water surface of the Black and Caspian Seas as a result of transformation. While passing from the West to Likhi Range, the air masses are forced to move upward, that is accompanied by intensive precipitation. Due to foehn effect such processes in Eastern Georgia are observed very often without precipitation. This type of circulation processes is the most frequent in Georgia, affecting distribution of precipitation over its territory.

The Black Sea coastal zone is characterized by humid subtropical climate, though even here is difference between its northern and southern sectors. Mean annual air temperature in Sukhumi and Batumi makes 14.7 ^{0} and 14.5 ^{0}C respectively, with an absolute minimum of -16 ^{0}C. Annual sums of precipitation make 1500 and 2500 mm respectively. In the western part of Meskheti mountain Range, in about 20 km from Batumi there is a meteorological station, where annual sum of precipitation reaches 4500 mm. The whole territory of Western Georgia is under the influence of the Black Sea. That is expressed by mild winter, hot summer and relatively abundant precipitation. In the mountain regions mean annual air temperature here makes 6 ^{0}-10 ^{0}C, and in the high mountain zone it varies within 2 ^{0} to 4^{0}C. Absolute minimum here falls respectively down to - 30 ^{0}÷ - 35 ^{0}C. In most parts of the region, annual precipitation sums fluctuate within an interval of 1200-1600 mm, while in high mountain regions it reaches 2000 mm.

Climate of Eastern Georgia is substantially of continental nature. On plains it is dry subtropical and in the mountain regions it is of alpine type. Mean air temperature on plains varies within 11 ^{0}-13 ^{0}C, in mountain regions – within an interval of 2 ^{0}-7^{0}C. Absolute minimum reaches respectively - 25 ^{0}÷ - 36^{0}C. Annual precipitation sums vary respectively from 400-600 mm to 800-1200 mm. Absolute maximum of air temperature reaches 42 ^{0} C on the valleys neighboring River Mtkvari in the southern area of Eastern Georgia and absolute minimum falls down to- 42 ^{0}C on the slope of Mt. Kazbek at the altitude of 3650 m a.s.l . (meteorological station Kazbegi-high mountain).

Mean temperature of the coldest month of the year, January, on lowlands of Western Georgia makes 5 ^{0}-7^{0}C, and on the plains of Eastern Georgia varies within - 1^{0} to +1 ^{0}C. Mean temperature of the hottest month, July, makes 22 ^{0}-24 ^{0}C in both regions.

During the cold period of the year stable snow cover does not form in both regions of Georgia up to 400 m above the sea level. In the western section of the Great Caucasus and in Western Georgia stable snow cover forms from the altitude of 500-600 m, and in the eastern section of the Great Caucasus-from the altitude of 1000m. Duration of a stable snow cover increases from 10-20 days on plains to 100-150 days in mountain regions. At some mountain stations of Western Georgia the height of snow cover reaches 4-6 m. Lower limit of the permanent snow cover in the western section of the Great Caucasus varies within the interval of 2700-3300 m, and in the eastern section-within the interval of 3300-3600 m.

Mean annual duration of solar radiati on over the territory of Georgia does not change substantially and over the most part of the territory its value varies within the range of 1900-2200 hours. In the high mountain zone, where cloudiness is frequent in some places, this value decreases down to 1500-1300 hours.

Orography of the territory stipulates peculiarities of wind regime in Georgia. In the western region, breeze circulation is considerably revealed, and in Eastern Georgia, mountain and valley winds are prevailing, especially in the valley of River Mtkvari. The most frequent and high winds are characteristic for the mountain and high mountain passes, where mean annual wind speed reaches 5.5-9.0 m/s. This value varies within the interval of 4-6 m/s in the valleys of the rivers Rioni and Mtkvari.

Average wind speed does not exceed 2-3 m/s in the valleys, covered by forests. Falling of the diurnal mean temperature below 10 ^{0}C in autumn and increasing above it in spring (heating season) on the plains of Western and Eastern Georgia makes 120-160 days. This value increases from 160 days to 220 days within the range of 500-1500 m in mountain zone, and in high mountain regions-at the altitude of 2000 m and higher duration of heating period reaches 280-320 days. Until the collapse of the USSR heating facilities in large cities functioned mainly consuming gas and oil, and in the villages wood was used. Since 1991, as a result of the lack of fossil fuel, city population mainly uses electric power for heating purposes. In summer air conditioning is used mainly only in large cities.

Great number of valleys, covered by forests, create large diversity of climatic health-resort resources. Along with the health resorts of the Black Sea coast, mountain health resorts of Georgia, such as Bakhmaro, Abastumani, Shovi, Bakuriani, Borjomi, Manglisi, Gudauri etc., are widely known, as well as the health-resorts famous for their mineral waters – Borjomi, Sairme, Java, etc. Recreational and tourist industry may become one of the most profitable branches of Georgian economy in future.

3.3. POPULATION

Population of Georgia has doubled in the current century. According to the 1913 population census its total number reached 2.60 million, 74.4% of which lived in rural places and 25.6% - in urban settlements. Before the World War II (1939) the population of the country increased to 3.55 million, 70% of which lived in the countryside, and 30% - in the cities. The 1989 figure estimated the population increase to 5.45 million, 44% of this comprised the rural population and 56% - the urban population. At this time 22.8% of the total population (1.24 million) lived in the capital, Tbilisi.

The disintegration of the USSR appeared to be a starting point for an intensive migration of population. As a result of this process, during 1990-1997, more than 218,000 people by official sources and 700,000 by non-official data left the country. The ongoing ethnic conflict in Abkhazia forced about 300,000 Georgian residents of the region to flee from their homes to the different cities of the country or even to leave the country. By the year 1998 the general picture of the population of Georgia is as follows: Tbilisi – 1.5 million, Kutaisi – 300 000, Rustavi – 200 000, Batumi - 150 000, Zugdidi – 100 000, Gori – 80 000, Poti – 60 000. The population of Sukhumi comprised 122 000 by the year 1991.

By the 1998 estimates, the total population of Georgia comprises 4.7 million, 3 million of which live in the cities. From 1980 to 1990 Carbon dioxide annual emission per capita was on the average 8.6 tons. Starting from 1991, as a result of an economic decline, CO_2 annual emission decreased to 2.6 tons per capita.

According to official data, number of economically active population in Georgia in 1997 made 2.2 million, out of which approximately 350 thousand people were unemployed. Half of the economically active population is self-employed. This refers especially to rural regions, where land privatization resulted in a sharp increase of self – employees. Number of unemployed pensioners, whose official income makes one tenth of the living minimum, reaches approximately 200 thousand.

Population increase in the 1980-s made about 1% a year. Since 1991 a reverse process started, i.e. population decreased annually approximately by 1% during 1991-1995. Birth-rate fell from 89,000 in 1989 to 57,600 in 1994. This process is still going on, that is proved by the fact that in 1997 the number of newborn children made only 53,000. According to 1990 data, duration of life made, on the average, 72.6 years (for women - 76, for men - 69). Since 1991, as a result of worsening of the social and economic conditions, and due to ethnic conflicts and military actions, this value should be decreased for some extent during the recent years. Statistical data on this problem are not available. The number of illiterates is not considerable. Their number among the population above 15 years of age makes 1%.

3.4. GENERAL FEATURES OF THE ECONOMY

Georgian economy was a constituent of the gigantic Soviet system. Economic relations be tween former Soviet republics were almost completely destroyed after the break up of the Soviet Union. Due to a high level of specialization this greatly damaged the Georgian economy. Georgian industry was considerably dependent on other republics, especially on the Russian Federation, from the point of view of raw materials, spare parts, market and fuel. 25% of electric power, consumed by Georgia in 1989 was imported, as well as almost all fuel and gas, over 80% of timber, approximately 50% of cement and almost 90% of raw materials used in the light industry. 60% of dairy products, 50% of wheat and over 30% of consumed meat were also imported from outside. In the end of the 80-s trade played considerable role in the economy. Import and export together made almost a half of gross domestic product (GDP).

Before the separation of Georgia from the Soviet Union, industrial sector was well developed. Its main branches were machinery, metallurgy, chemical industry and production of building materials, light and food industry, production of airplanes and electronic industry. By the year 1990, 40% of production belonged to food industry; next was light industry, producing consumer goods (fabric, shoes, furniture, etc.), mining industry and metallurgy decreased from 10% of the 1970 production to 4% in 1990. Since the collapse of the Soviet Union, the price of energy-carriers has catastrophically increased, due to which most branches of industry slowed down their functioning to minimum, or stopped, at all. Share of industry in GDP during the past period varied within the following limits (Table 3.4.1)

Table 3.4.1. Share of main branches of economy in the Gross Domestic Product (%)

Branch of economy	1990	1995	1997
Industry	36	13	18
Agriculture	32	44	30
Services	32	43	52
Total	100	100	100

In this table industry includes building industry and other branches of material production and the services include trade, transport, communication and other branches of non-material production.

Since 1996, due to political stability, public tranquillity and a slow, but stable course of economic reforms, gradual improvement of main economic indices began in Georgia. Particularly, if in 1995 the GDP was 370 US$ per capita, in 1996, according to official data, this value made 750 US$, in 1997 it increased up to 890 US$. The year 1994 is characterized by the lowest economic conditions when GDP per capita was 350 US$. Presented figures are based upon the State official data. But it should be noted here as well, that a considerable share of GDP, both during the Soviet period and after its break up, was made by informal sector. According to different assessments, this share varied within 40-60% for the last years. The Government of Georgia started to carry out various measures in 1998 to decrease considerably this share and to eradicate the corruption. Improvement of the economy was favored by the introduction a new monetary unit - Lari in September of 1995, characterized by significant stability. During the last 3 years it changed within interval from 1.25 to 2.30 relative to US$.

Agriculture is traditionally one of the leading sectors of Georgian economy. Out of the whole territory of Georgia – 69,700 km^2, forests occupy 29,900 km^2, 35,200 km^2 are occupied by crop fields, 700 km^2-by cities, and 3 800 km^2 are not used. The latter includes the areas covered by stones, rocks, snow and glaciers, swamps and water.

The whole area of arable land was used in 1997 as follows. Total area of ploughlands under annual crops made 10 860 km^2, 660 km^2 were under tea crops, 270 km^2 were occupied by plants. Vineyards took over 1410 km^2, orchards occupied 1430 km^2, vegetables and potatoes 420 km^2, hay-fields 1610 km^2, and 18 540 km^2 were used as pastures.

Number of domestic animals in 1997 was distributed among the groups as follows: cattle – 1.03 million, sheep and goats – 583 thousand, pigs – 330 thousand, horses – 28 thousand, poultry – 14 million and 114 thousand.

4.1 thousand km^2 of a total area, covered by forests (29.9 thousand km^2) are under coniferous species, leaf-bearing trees and bushes are expanded over 25.8 thousand km^2. Up to 60% of forests is spread on the steep slopes making their industrial utilization difficult.

3.5. ENERGY PRODUCTION

One of the greatest problems of an industrial sector and economy, as a whole, is energy production. According to various assessments, the country at present gets only 20% of necessary energy, needed to satisfy its primary needs. A vicious circle has been created-economy can not develop without sufficient energy supply; at the same time, it cannot supply energy without sufficient income from other sectors of economy. The source of this crisis lays in the Soviet system of energy supply and consumption, which was characterized by low technical and organizational level.

Due to the fact that Georgia is very rich in hydro-energetic resources, hydro-energy production historically had a primary importance. A total value of river runoff over the territory of Georgia is, on the average, 65 km^3 a year, and its hydro-energetic potential is 25 million kW in power and 219 billion kWh in output. Thermal power plants (mainly those of Tbilisi and Tkvarcheli) served for the base energy production and mostly operated on imported fuel. Dynamics of electric energy consumption and production during the last two periods (during the existence of the URSS and after its disintegration) are presented in table 3.5.1.

Table 3.5.1 Consumption and production of electric energy in Georgia (million kWh)

Years	1985	1988	1993	1994	1995	1996
Consumption	16746	18114	10771	7963	7840	7320
Production	14421	14550	10150	7045	7082	7233
Import	2325	3564	621	918	758	87

This table clearly illustrates degradation of the energy basis during the last 6-7 years, the main reason of which is a low level of maintenance on hydro-power plants and their overloading due to the deficit of fossil fuel in thermal energy production. If in 1990 hydroelectric stations produced 53% of the total energy output, in 1996 the same index made 83%. And it happened while hydroelectric stations, themselves, produced only about 60% (6.12 billion kWh) of their capacity.

Very remarkable are changes in the structure of consumption of electricity. Share of municipal consumption increased from 16% in 1990 to 52% in 1996. Respectively decreased the share of industry from 48% to 12%. Substantially increased total losses in low-and high-tension networks. In 1996 this index reached 25% instead of permissible 16-18%. Such abrupt increase of the municipal and residential share after the collapse of the USSR was conditioned by the failure of existing systems of thermal and hot water supply due to catastrophic growth of prices on imported fossil fuel. As a result, population had to use electric energy in winter for heating purposes. Substantially increased, as well, illegal cutting of forests since under the lack of electric energy wood appeared to be the only reliable source of heating.

Another reason of worsening the conditions was the fact that extraction of local oil in the Republic decreased from 3.3 million tons (1983) to 50 thousand tons (1994-1995). In the same manner was decreased coal mining from 1.8 million tons to 50 thousand tons, respectively. Consumption of natural gas fell down from 5 billion m^3 (1989) to 1 billion m^3 (1996).

At present, projected annual output of 60 hydroelectric plants, operating in Georgian energy system, is 10 billion kWh, out of which 8.4 billion kWh is produced by 28 functioning large and medium-sized stations.

In addition to that, hydro-energetic potential of the Republic allows the construction of about 250 large, medium and small hydro-stations with total output of 30 billion kWh. The most effective part to be implemented of this general direction is rehabilitation and reconstruction of existing stations that, in case of the availability of necessary investments, can produce additionally 2.0-2.5 billion kWh of energy during the nearest several years. In particular, about 80 small hydro-stations have been revealed with a total capacity of 350 MW, reconstruction of which is possible within 1-2 years. Out of 15 operating at present small hydro-stations capacity of which makes 80 MW, 7 are privatized and 3 are rented. Prospects for the development of powerful energy production system in future are directly connected with the construction of 2 large hydropower plants. Among them the first is Khudoni hydro-station on the River Enguri (capacity – 700 MW, output – 1.7 billion kWh), and the second one - Namakhvani hydro-station on the River Rioni (250 MW and 914 billion kWh, respectively).

Due to the seasonal nature of the accumulation of hydro-energetic resources, great attention is paid, at present, to basic thermal energy production, consuming fossil fuel. Out of the above-mentioned two main thermal electric plants only Tbilisi (Gardabani) plant is operating with installed capacity of 1850 MW. Tkvarcheli thermal plant with installed capacity of 220 MW has not been operating during the last years due to its overall damage. Because of an extremely low level of technical equipment, efficiency of Tbilisi thermal power plant is very small and its real capacity does not exceed, on the average, 700 MW. For instance, energy produced by Enguri hydro-station totally made 3.08 billion kWh in 1995, and that of Tbilisi thermal power plant 0.70 billion kWh. After appropriate reconstruction, the output of this plant may reach 3-4 billion kWh.

3.5.1. ENERGY RESOURCES

The problem of basic energy production development is directly connected with the problem of the availability of fossil fuel and its consumption in Georgia. Confirmed reserves of coal in Georgia make at present 432 million tons, and the potential reserves exceed 700 million tons. Tkibuli mines, which function for over 150 years, gave 3 million tons of coal in 1960. By the year of 1990 mining has decreased here to 1 million tons, and in 1997 – to 5 thousand tons. According to the Government decision, adopted in 1997, these mines are to be rehabilitated, as a result of which the coal mining level should reach 1.5-2.0 million tons annually. On this basis, construction of Tkibuli thermal power plant is planned, as well, consisting of several blocks with 100-150 MW power each.

Forecasted reserves of oil in Georgia are estimated to be 375 million tons. In 1983 oil production in Georgia reached 3.3 million tons, and by the year 1990 it decreased by 95% and made only 181 tons. This decrease was caused basically by the exhaustion of old deposits, lack of oil prospecting works and investments. Country's demand in oil, at present, makes approximately 5 million tons annually.

Batumi oil refinery, built in 1950-s, output of which in 70-s and 80-s made annually 3-4 million tons of oil products, mainly operated on imported crude oil. At present, the factory refines annually approximately 600 thousand tons of oil, transported mainly from Azerbaijan and Kazakhstan deposits. It is planned to rehabilitate and expand the factory fundamentally in future under the assistance of Japanese investors.

Until the present time it has been considered that the reserves of natural gas in Georgia are small. Production of natural gas in 1990 made only 60 million m^3, that satisfied only 1.2% of domestic demand. Prospecting works, conducted for the last period, made it clear that there is sufficient reserve of gas in the Georgian sector of the Black Sea shelf with total output estimated in 1.8 billion m^3 annually.

Georgia is very rich in renewable energy resources, especially in hydro-energy resources. As it has been noted above, total energy resource of surface run-off reaches 219 billion kWh, out of which it is technically feasible to produce 40 billion kWh of energy at about 300 electric stations of various capacity. At present, only 20-25% of this potential can be used.

Theoretical resources of wind energy in Georgia are estimated in 1 trillion kWh. In the remote future, production of 2-3 billion kWh of electricity may be considered economically reasonable. It is to be noted, that due to non-uniform nature of this energy source, its share in total production of energy system should not exceed 7-10%. On the basis of appropriate investigations, carried out in Georgia, several regions have been selected, where construction of wind plants is economically promising. Particularly, it is planned to construct a windfarm on the Likhi Range, separating western and eastern parts of Georgia, with 100 MW capacity and 500 million kWh expected annual production. Construction of 5 MW power and 7 million kWh output station is possible near the port of Poti, and near Batumi - the station of 50 MW power and 105 million kWh output. Promising sites in the environs of Kutaisi, Tbilisi, and Dedoplistskaro are also identified. According to various estimations, share of wind power in the energy balance may make 1.5-2% by the year of 2020.

Solar energy, due to a number of its advantages, attracts now an increasing attention in many countries and among them, in Georgia. 1m^2 of Georgian territory theoretically gets 1300-1800 kWh of solar energy annually , out of which practically may be used 300-500 kWh. Duration of the functioning of helio-installations under Georgian conditions may make 1700-2200 hours. The share of solar energy in total consumption, under the conditions of helio-energy production development with appropriate rate, may make 0.5% by the year 2010, and 1% - by the year 2020.

Due to great expansion of forests, Georgia is rich in the most widespread and accessible type biomass – the fire-wood. Overall resources of wood in forests make approximately 434 million m^3, that give more than 86 m^3 of value per capita. As it was indicated above, forests are predominantly expanded on steep slopes of the mountains, complicating rational usage of wood and resulting in forest cut out in easily accessible places. Average increment of wood per 1 ha makes 1.8 m^3 annually. Ecologically balanced permissible level of cutting is estimated as 3-6 million m^3 annually, i.e. 0.6-1.1-m^3 per capita.

Georgia has a sufficient reserve of geothermal waters. As a result of conducted prospecting activities it has been identified that debit of 50-110 ^{0}C thermal waters can make 220-250 million m^3 annually. Overall area of thermal waters occupies 22.4 thousand km^2, i.e. 32% of the whole territory of the country. Because of such an area of expansion and due to low level of mineralization (0.4-2.2 g/l) the consumption of thermal waters has a great perspectives in Georgia. In the nearest future, they may be used for providing about 1.5 million people with hot water and heating, as well as provision of the functioning of greenhouses, incubators, and other economically important enterprises. This branch of thermal energy production is especially promising due to the possibility of significant abatement of greenhouse gas emissions.

3.5.2. ENERGY PRODUCTION AND CONSUMPTION

As it has been noted above, break-up of the Soviet Union resulted in basic changes in energy production and consumption. This process was generally illustrated by Table 3.5.1. More detailed data on these changes are presented in Table 3.5.2. It shows that, after 1991 the sharpest changes underwent consumption of fossil fuel, though, since 1996 oil share began to increase considerably, that may not be said about natural gas and coal. Natural gas, which is imported from Russia and Turkmenistan, is supplied at present only in a limited amount to some of Rustavi enterprises and to Gardabani thermal power plant. The restoration of coal production is connected with the conduction of a number of measures, planned up to the year 2005. This Table shows as well, how intensively is functioning now Georgian hydro-energy system, output of which is featured by a sufficient stability, and its share in a total output of energy production is rather large and varies for the last years within 70-90%.

Table 3.5.2. Dinamics of energy production in Georgia (1980-1997)

Year	Production of electric ity (million kWh)	Among them hydroenergy (million kWh)	Share of hydroenergy production (%)	Oil Production (including gas condensate) (10^3 t)	Production of natural gas (10^6 m^3)	Production of coal (10^3 t)
1980	14687	6410	43.6	3186	290	1860
1985	14421	6250	43.3	552	69.6	1674
1986	14571	6057	41.6	179	41.5	1712
1987	14550	7693	52.9	183	47.4	1620
1988	14600	7748	53.1	186	51.1	1426
1989	15825	8788	55.5	185	59.4	1152
1990	14246	7600	53.4	186	59.9	956
1991	13376	7041	52.6	181	44.9	698
1992	11520	6515	56.6	125	37.9	181
1993	10150	7315	72.1	88	21.8	82
1994	7045	5101	72.4	67	11.4	44
1995	7082	6383	90.1	43	3.3	43
1996	7233	6120	84.5	128	3.3	22
1997	7172	6062	84.5	134	0	5

Change of energy output in various branches of Georgian economy is presented in Table 3.5.3. Taking into account the above-mentioned processes, this table shows averaged data for the periods of 1980-1991 and 1992-1997.

Table 3.5.3. Change of energy generation in Georgia during the period of 1980-1997 (% in total output)

No	Branches of economy and sub-branches	Average values	
		1980-1991	1992-1997
1	Production of electric energy and heat	32.4	41.1
2	Production of iron and steel	17.7	10.4
3	Municipal boilers	14.0	5.2
4	Motor transport	9.2	15.2
5	Agriculture (including forestry and fishery)	6.7	8.4
6	Production of building materials	4.4	9.0
7	Machinery and metal-working	4.4	3.0
8	Food production (including beverages and tobacco)	4.0	2.6
9	Other branches	7.2	5.1
	ALL	100.0	100.0

This Table shows that certain raising up of economy, started since 1996, considerably decreased the difference between 2 considered periods, that was especially contrasting for the period of 1992-1995. Transport share growth in total energy output is especially remarkable during recent 2 years that is considered in detail in the paragraph 3.5.4.

3.5.3. ENERGY PRODUCTION AND CO_2 EMISSION

Like other countries, the main source of CO_2 emission in Georgia is energy production module, in which the processes of energy production are mainly based upon fossil fuel consumption. Data on CO_2 total emission into the atmosphere from energy production module for the period of 1980-1997 are presented in table 3.5.4. It follows from this Table, that the share of this module in a total CO_2 emission changes within 72-93%. During the existence of the USSR, it was varying at 90% level. Since 1993 this share began to decrease, but did not fall below 72.5%. This reduction in absolute indices is very important . It decreased from 33 million tons, characteristic to the period of 1980-1991 to 4 million tons in 1995 and then began to increase gradually. Mean emission index during the period of 1992-1997 makes 8.1 million tons, that is greatly stipulated by the growth of emission from motor transport during recent 2 years.

3.5.4. TRANSPORTATION

Transportation service in Georgia (transport of passengers and goods) includes motor transport, air, railway and sea transports. The country's river transport is not developed. Railway transport practically totally (except some auxiliary operations) is operating on electric energy. Greenhouse gas emissions in the atmosphere as a result of motor- and air transport (airplanes) functioning in Georgia during 1980-1997 have been analyzed in accordance with IPCC greenhouse gas emission inventory methodology, results of which are gathered in Table 3.5.5. It shows that the share of motor transport in total CO_2 emission during the existence of the USSR was stable and made 8-9%. After 1992 (there are not data available for that year) this value decreased 2-3-times, but since 1995 it began to increase and during the recent years reached 30-35%. It can be explained by the fact that most enterprises connected with CO_2 emission have not started their functioning yet, but the motor – transport began an intensive development again.

Table 3.5.4. Overall emission of CO_2 in the atmosphere from energy production module in Georgia during 1980-1997

Years	CO_2 overall emission (million tons)	Share in total emission (%)
1980	30.98	89.6
1981	32.54	90.3
1982	33.63	90.5
1983	35.67	90.9
1984	35.48	90.4
1985	35.88	90.6
1986	33.09	90.3
1987	33.65	91.1
1988	33.22	91.5
1989	32.33	92.7
1990	33.81	92.8
1991	26.69	93.1
1992	16.09	90.5
1993	9.00	85.6
1994	5.85	79.7
1995	3.88	72.5
1996	6.67	79.9
1997	7.34	79.9

Ratio of CO_2 emitted by air-transport to the emission produced by motor-transport during the Soviet period changed within 20-24%. During the breaking up of economy this ratio fluctuated within 5-45%, and during the last 2 years its stabilization at 3-5% level is observed. The reason for this is the loss of contacts, existing between former Soviet Republics, sharp raise in air-tickets fair and availability of petrol at relatively low prices.

Table 3.5.5. GHG emissions from motor- and air-transport in Georgia during 1980-1997 (Gg)

GHG	1980	1985	1990	1991	1994	1995	1997
Motor-transport							
Carbon Dioxide	2790	3195	3137	3529	211	1430	2866
Metane	0.562	0.617	0.580	0.600	0.040	0.300	0.500
Nitrous (I) Oxide	0.046	0.057	0.058	0.080	0.004	0.030	0.060
Nitrogen Oxides, NO_x	33.54	38.53	38.09	43.30	2.40	17.30	35.00
Carbon Monoxide	289.6	314.2	291.2	275.5	21.2	138.4	257.7
NMVOCs	28.88	31.66	29.60	0.03	0.002	0.01	0.03
Air-transport							
Carbon Dioxide	664.5	675.6	696.0	193.0	96.2	127.4	162.0
Nitrogen Oxides, NO_x	2.023	2.056	2.118	0.600	0.300	0.400	0.440
Carbon Monoxide	7.334	7.456	7.681	2.100	1.100	1.400	1.760
NMVOCs	4.753	4.832	4.978	1.400	0.700	0.900	1.100
Sulphur Dioxide	0.211	0.215	0.221	0.060	0.030	0.040	0.055

Considerable share of greenhouse gas emissions from motor-transport in Georgia is explained not by a high level of motorization (overall quantity of cars by 1993 reached 642 thousand, by 1997 this figure decreased down to 349 thousand) but, first of all, by low technical and technological indices of existing motor transport, most part of which is composed by old Soviet models.

Average consumption of fuel per 100km for passenger and special cars makes 11.2 liters, and for buses and trucks 30.0 liters. This is twice as much as those for developed countries. Recent years are characterized by wide-spread import of worn-out passenger cars from European countries, even worsening the indicated situation. High level of specific emissions from motor-cars is stipulated as well by low quality of consumed fuels lack if special clearing devices, low quality of motor highways and maintenance of cars. Considering that one of the sections of “Silk Way” passes through Georgia, more attention should be paid in future to the monitoring of greenhouse gas and aerosol emissions from motor-transport over Georgian territory.

As to average annual value of fuel consumed per 1 car in various types of motor-transport, this value made 10-16 thousand liters for trucks in 1980-1991, for buses – 15-28 thousand liters, and passenger cars – 170-290 liters. During 1993-1994 this fell down to 500-800 liters (buses), to 300-600 liters (special cars) and to 20-60 liters (passenger cars). Since 1995, specific consumption of fuel began to increase rapidly and in 1996 exceeded earlier Soviet indices. Statistics on average annual run per car in each vehicle type is not reliable, though its approximate estimation is possible. This value during the existence of the USSR was 50 thousand km for trucks, 70 thousand km – for buses, 60 thousand km – for special cars and 20 thousand km – for passenger cars.

4. INVENTORY OF GREENHOUSE GAS EMISSIONS AND SINKS

The results of the first national inventory of greenhouse gas emissions and sinks in Georgia for the period of 1980-1997 are presented. Estimations were carried out according to IPCC Guidelines [5-7]. Inventory results are presented both in natural expressions and in CO_2 and C equivalents using global warming potential (GWP).

Taking into consideration the role of aerosols in solar-terrestrial radiation regime, in the last paragraph of this chapter are presented data on their emissions.

4.1. GENERAL REMARKS

Inventory of greenhouse gases, emitted in Georgia, as a result of technogenic activity, comprises both the greenhouse gases of direct effect (CO_2,CH_4,N_2O) and those of indirect effect (NO_x, CO, NMVOC, SO_2). It was undertaken according to IPCC Guidelines using official data available in Georgia. Anthropogenic activity is divided into 5 modules: energy production, industrial processes, agriculture, land use and forestry, waste management. Overall results of inventory are presented in the Table 4.1.1.

Table 4.1.1. Total GHG emissions in Georgia

GREENHOUSE GASES	1980	1985	1990	1995	1997
CO_2,Tg	34.593	39.620	36.422	5.344	9.177
CH_4,Tg	0.380	0.411	0.356	0.150	0.167
N_2O,Gg	8.435	8.598	7.895	3.273	4.366
Total in CO_2 equivalent , Tg	45.188	50.916	46.345	9.509	14.037
Total in C equivalent , Tg	12.324	13.886	12.640	2.593	3.828

1980-1991 emission high level, relative to the next period, is explained by the functioning of Soviet economy till 1991. In the next period, sharp decrease of emissions is caused by the process connected with the break-up of the USSR and the country's transition to the principles of market economy.

It should be noted, that there were no substantial emissions in Georgia of other GHGs recommended by IPCC Guidelines besides above- mentioned 7 gases.

4.2. CO_2 EMISSIONS

Main source (about 80-93%) of CO_2 emissions in Georgia is fossil fuel combustion (both from stationary and mobile sources), and the main sinks are forests. CO_2 emission inventory results are presented in the Table 4.2.1. Separate indication of motor vehicles in the table is conditioned by its large share in air pollution and considerations of its possible increase in the nearest decade.

Table 4.2.1. Total CO_2 emissions and sinks in Georgia (Tg)

Source categories	1980	1985	1990	1995	1997
1. Energy generation – incl.	30.976	35.883	33.814	3.877	7.336
stationary sources	28.186	32.688	30.676	2.447	4.470
motor transport	2.790	3.195	3.137	1.430	2.866
2. Industrial processes	1.200	1.259	1.042	0.136	0.207
3. Forest utilization	1.576	1.658	0.664	0.784	0.937
4. Agriculture	0.841	0.820	0.902	0.547	0.696
Total:	34.593	39.620	36.421	5.344	9.176
CO_2 sinks:					
Forest ecosystems	-12.389	-12.389	-12.389	-12.389	-12.389
Grassland conversion	9.836	9.836	9.836	9.836	9.836
CO_2 net emissions.	32.040	37.067	33.868	2.791	6.623
Share of CO_2 absorbed by forests, %	27.9	25.1	26.8	81.6	65.2

4.2.1. CO_2 EMISSIONS FROM ENERGY MODULE

Energy supply in Georgia is substantially based upon the fossil fuel combustion. Therefore, energy production sector is the main source of CO_2 emission. The role of different branches of this module and the role of a module, as a whole, is presented in the Table 4.2.2.

Table 4.2.2. CO_2 emissions from energy module, Gg

SECTORS OF MODULE	1980	1985	1990	1995	1997
Electric energy and heat production	9,726.5	12,774.3	12,165.3	1,092.8	1,914.0
Iron and steel production	5,575.7	5,985.0	5,576.6	232.1	234.4
Production of other metals	92.9	105.0	87.4	4.1	4.1
Production of chemicals	744.0	1,400.0	699.4	55.3	83.3
Cellulose and paper production	372.0	350.0	349.7	5.3	0.8
Food industry	1,178.0	2,100.0	1,107.3	39.2	199.1
Production of building materials	1,457.0	595.0	1,375.7	9.8	10.8
Machinery and metalworking	1,364.0	1,645.0	1,285.2	173.6	229.2
Residential sector	4,376.8	4,684.9	4,775.2	472.2	826.9
Agriculture (forestry and fishery)	2,108.0	1,925.0	2,302.2	224.2	392.4
Motor transport	2,790.0	3,195.0	3,137.0	1,430.0	2,866.0
Air transport	664.5	675.6	696.0	127.4	162.0
Use of biomass	526.6	448.2	257.1	11.2	413.1
Total:	30,976	35,883	33,814	3,877	7,336

According to data analysis, investigated period can be divided into two parts: 1980-1991 and 1992-1997. The first period reflects anthropogenic processes in the country under Soviet, so-called planned economy, the next one – controversial processes of the transition to market economy. In the second period percentage share of energy production in CO_2 total emission is decreased from 90.5% to nearly 70%. In 1995 this value was the smallest (72.5%), after which is began to rise. CO_2 emission dynamics in Georgia from energy module is presented on the Fig. 4.1.

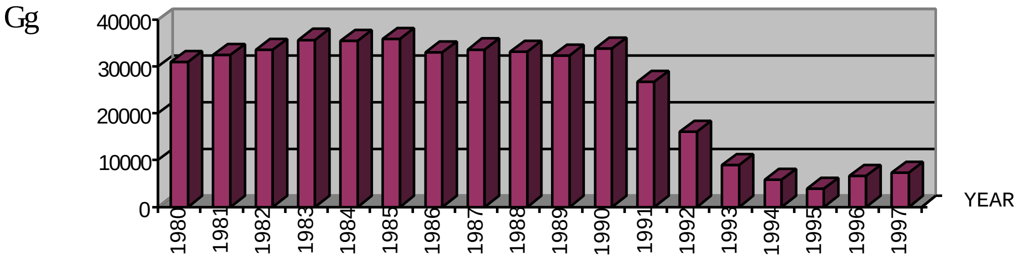


Fig. 4.1. CO_2 emission dynamics in Georgia from energy module in 1980-1997

4.2.2. CO_2 EMISSIONS FROM INDUSTRIAL PROCESSES

Industrial processes of Georgia comprise production of cement, ammonia, Nitric Acid, coke, iron and steel, ferroalloys, cellulose and paper, food and beverages. CO_2 emission from these branches is presented in the Table 4.2.3.

Table 4.2.3. CO_2 emission from industrial processes (Gg)

SOURCE CATEGORIES	1980	1985	1990	1995	1997
Cement production	833.2	785.3	642.4	30.6	46.4
Production of Ammonia	220.4	308.4	328.8	98.3	153.9
Iron and steel production	2.1	2.3	2.1	0.089	0.09
Production of Ferroalloys	141.8	160.9	67.9	6.7	6.2
Chemical recovery in ferrous metallurgy	2.2	2.0	1.1	0.031	-
Total	1199.7	1258.9	1042.3	135.72	206.59

CO_2 emission dynamics in Georgia from industrial processes is presented on the Fig. 4.2.

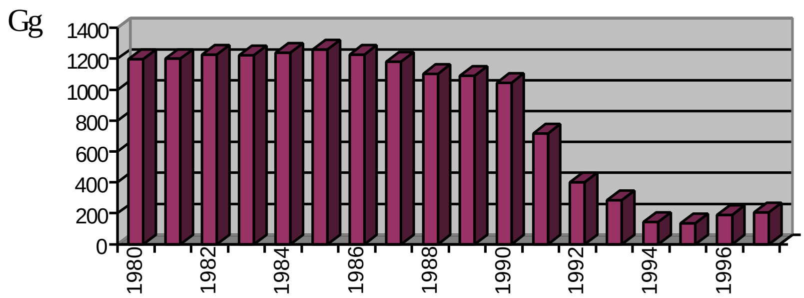


Fig. 4.2. CO_2 emission dynamics in Georgia during 1980-1997 from industrial processes

4.2.3. ROLE OF MOTOR-TRANSPORT IN CO_2 EMISSIONS

One of the important constituents of energy production sector is motor transport. It is a substantial source of air pollution in Georgia, as well as in the world, since at present:

- unlike foreign vehicles, transport functioning in Georgia is not equipped by cleaning devices for exhaust gases;
- quality of fuel, consumed by motor – vehicles in Georgia does not correspond to modern standards;
- quality of Georgian highways is very low;
- maintenance of motor vehicles is unsatisfactory.

Taking into consideration the prospects for the increase of the intensity of motor transportation in the nearest decade, CO_2 emission dynamics is presented in the Table 4.2.4.

Table 4.2.4. CO_2 emission by motor-transport during 1980-1997 in Georgia (Tg)

Types of motor-transport	Passen-ger cars	Trucks			Buses			Special cars			Total	Share of transport (%) in total annual CO_2 emission
		Petrol	Diesel	Total	Petrol	Diesel	Total	Petrol	Diesel	Total		
1980	0.168 (6.02)	1.672 (59.93)	0.302 (10.82)	1.974 (70.75)	0.319 (11.43)	0.069 (2.47)	0.388 (13.91)	0.228 (8.17)	0.032 (1.15)	0.260 (9.32)	2.790	8.07
1981	0.184 (6.31)	1.708 (58.95)	0.343 (11.36)	2.051 (70.31)	0.343 (11.76)	0.074 (2.54)	0.417 (14.30)	0.232 (7.95)	0.033 (1.13)	0.265 (9.08)	2.917	8.09
1982	0.194 (6.40)	1.729 (57.01)	0.383 (12.63)	2.112 (69.64)	0.370 (12.20)	0.080 (2.64)	0.450 (14.84)	0.243 (8.01)	0.034 (1.12)	0.277 (9.13)	3.033	8.16
1983	0.219 (6.85)	1.833 (57.37)	0.404 (12.64)	2.237 (70.01)	0.381 (11.92)	0.081 (2.53)	0.462 (14.45)	0.244 (7.63)	0.034 (1.06)	0.278 (8.70)	3.196	8.15
1984	0.210 (6.60)	1.777 (55.80)	0.434 (13.64)	2.211 (69.44)	0.379 (11.90)	0.089 (2.80)	0.468 (14.70)	0.267 (8.39)	0.028 (0.88)	0.295 (9.27)	3.184	8.11
1985	0.210 (6.57)	1.755 (54.93)	0.490 (15.34)	2.245 (70.27)	0.368 (11.32)	0.095 (2.97)	0.463 (14.49)	0.231 (7.23)	0.046 (1.44)	0.277 (8.67)	3.195	8.06
1986	0.204 (6.48)	1.670 (53.06)	0.487 (15.47)	2.157 (68.53)	0.376 (11.94)	0.102 (3.24)	0.478 (15.18)	0.262 (8.32)	0.047 (1.49)	0.309 (9.81)	3.148	8.60
1987	0.212 (6.66)	1.631 (51.25)	0.511 (16.05)	2.142 (67.30)	0.381 (11.97)	0.128 (4.02)	0.509 (15.99)	0.273 (8.58)	0.047 (1.48)	0.320 (10.1)	3.183	8.62
1988	0.205 (6.37)	1.652 (51.37)	0.569 (17.69)	2.221 (69.06)	0.384 (11.94)	0.123 (3.82)	0.507 (15.76)	0.236 (7.34)	0.047 (1.46)	0.283 (8.80)	3.216	8.86
1989	0.180 (5.82)	1.544 (49.93)	0.609 (19.70)	2.153 (69.63)	0.357 (11.55)	0.127 (4.11)	0.484 (15.65)	0.230 (7.44)	0.045 (1.46)	0.275 (8.89)	3.092	8.87
1990	0.191 (6.09)	1.596 (50.50)	0.606 (19.70)	2.202 (70.20)	0.362 (11.54)	0.129 (4.11)	0.491 (15.65)	0.211 (6.72)	0.042 (1.34)	0.253 (8.06)	3.137	8.61
1991	0.212 (6.01)	1.427 (40.44)	1.158 (32.81)	2.585 (73.25)	0.331 (9.38)	0.151 (4.28)	0.482 (13.66)	0.193 (5.49)	0.057 (1.62)	0.250 (7.08)	3.529	12.31
1992	0.097	0.071	ND	ND	0.031	ND	ND	0.004	ND	ND	ND	ND
1993	0.025 (5.15)	0.102 (21.03)	0.259 (53.40)	0.361 (74.43)	0.024 (4.95)	0.051 (10.51)	0.075 (15.46)	0.005 (1.03)	0.019 (3.92)	0.024 (4.95)	0.485	4.61
1994	0.058 (27.49)	0.069 (32.70)	0.041 (19.43)	0.110 (52.13)	0.021 (9.95)	0.012 (5.69)	0.033 (15.64)	0.004 (1.90)	0.006 (2.84)	0.010 (4.74)	0.211	2.87
1995	0.187 (13.08)	0.734 (51.33)	0.250 (17.48)	0.984 (68.81)	0.155 (10.84)	0.064 (4.47)	0.219 (15.31)	0.037 (2.59)	0.003 (0.21)	0.040 (2.80)	1.430	26.76
1996	0.325 (10.97)	1.399 (47.22)	0.659 (22.24)	2.058 (69.46)	0.295 (9.96)	0.176 (5.94)	0.471 (15.90)	0.102 (3.44)	0.007 (0.24)	0.109 (3.68)	2.963	35.51
1997	0.281 (9.81)	1.262 (44.03)	0.678 (23.66)	1.940 (67.69)	0.355 (12.39)	0.184 (6.42)	0.539 (18.81)	0.098 (3.42)	0.008 (0.28)	0.106 (3.70)	2.866	31.23

Note: In brackets is given the share (%) of types in total transport emission
ND – data are not complete, or they do not exist

Presented data consider the internal structure of motor-transport, as well. Complete characteristics of greenhouse gas emission from motor transport are presented in Table A1 of and Figs. A1 and A2 of the Appendix, demonstrating important role of motor-transport in CO_2 emissions.

4.2.4. CO_2 EMISSIONS FROM AGRICULTURAL MODULE

CO_2 emission from agricultural module is mainly connected with the field burning of agricultural waste. Crops in agriculture give large amount of waste, approximately 80% of which are removed by field-burning. Obtained results are presented on the Fig. 4.3, where CO emission is given, as well, along with CO_2 emission.

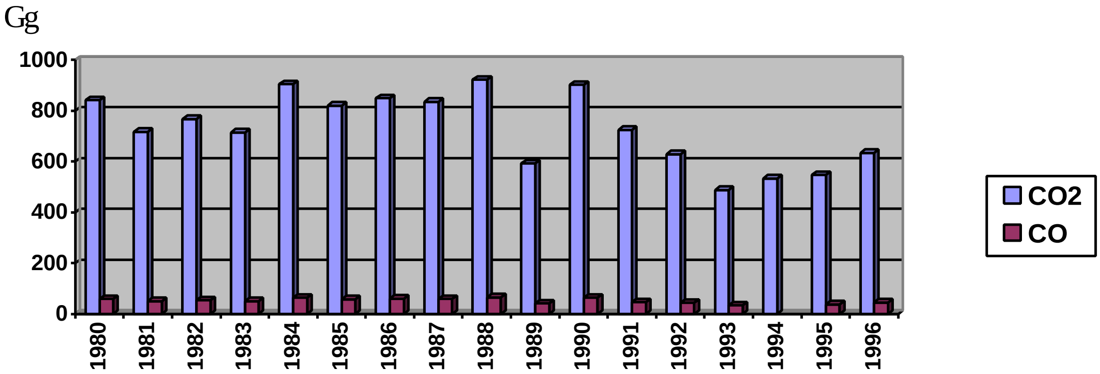


Fig. 4.3. CO_2 and CO emissions due to field-burning of agricultural waste

CO_2 emissions and removals are also stipulated by changes in land use, resulting in the Carbon amount change in separate soil types. Carbon storage is estimated in 30-cm layer of soil and to consider changes in the system of land use, a 20-year period is taken. Soil cover of Georgia is characterized by large diversity and complexity. Almost all soil types spread on the Earth are presented here. Conventional division of mineral soils in Georgia has been carried out for calculations according to IPCC Guidelines:

1. Soil of high activity;
2. Soil of low activity;
3. Aquic soils;
4. Organic soils.

Classical swamps occupy 13,000 hectares, and they are not used for agricultural production.

According to calculations, Carbon stockpile in soils of high activity for the recent 20 years in Georgia made 107.3 Tg, in soils of low activity – 16.1 Tg, and in aquic soils – 127.4 Tg, that in total makes 250.8 Tg for mineral soils.

Increment of Carbon during this period for organic soils made, on the average, 5.5 Gg, while net loss of Carbon, as a result of agricultural use of organic soils, made 9.8 Tg, that is finally reflected in the following C-CO_2 net emission:

- out of mineral soils	-	-12.54 C Tg	or	-46.0 CO_2 Tg;
- out organic soils	-	+9.85 C Tg	or	+36.1 CO_2 Tg;
- out of limestone soils	-	+0.005 C Tg	or	+0.02 CO_2 Tg.

Therefore, as a result of land use change, due to agricultural activity, C-CO_2 total emission made -2.7 C Tg or -9.8 CO_2 Tg. The internal structure of CO_2 emissions from agricultural module is presented in Table 4.2.5.

Table 4.2.5. CO_2 emission from agricultural module (Gg)

SOURCE CATEGORIES	1980	1985	1990	1995	1997
Field burning of agricultural wastes	840.8	820.1	901.5	547.4	1008.5
Agricultural soils	-480.8	-490.0	-494.8	-497.0	-500.0
Energy generation (transport)	2108.0	1925.0	2302.9	356.7	392.4
Total :	2468.0	2255.1	2709.6	407.1	900.9

Note: Sign (-) indicates CO_2 sink. Data are calculated per one year.

4.2.5. CO_2 EMISSIONS AND SINKS BY FORESTS

Vegetation cover of Georgia is rich and diverse. Both subtropical and high-mountain verdure is presented here along with desert species. They substantially stipulate the formation of the regime of surface and underground waters. Their soil protecting and climate regulating importance is remarkable, as well, and forests play a distinguished role in this direction.

Whole area of Georgia land resources makes 6949.6 thousand hectares, out of which the whole area of forest resources makes 2989.3 thousand hectares. 2753.4 thousand hectares of them are covered by forest, making 39.62% of the country's whole territory. Data on the forestation of Georgian territory are presented on the Fig. 4.4.

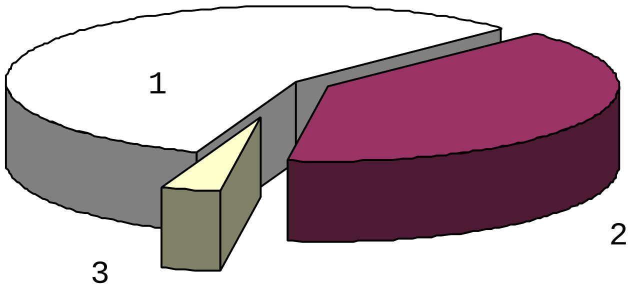


Fig. 4.4. Forestation characteristics of Georgian territory

Total reserves of wood in Georgian forests constitute 434 million m^3. Average annual increment equals to 45 thousand m^3. Approximate value of wood per capita out of its total reserves makes 86 m^3 and 0.5 hectares of the area covered by forests. Distribution of Georgian forests for the beginning of 1996, according to their species composition, is presented in the Table A2 of the Appendix.

We have not considered three processes: "Forest cutting out", "Burning in cut-out forests" and "Transformation of hayfields and pastures", incorporated in the sub-module "Changes in land use and forestry", because in early years such processes were not specified by forest management and forest utilization agencies in Georgia. Under the term of unused land we consider eroded lands. Calculations showed that annual increment of biomass (evaluated in the terms of dry mass) on unused lands during 20 years made approximately 2.5 Tg, and for the process lasting over 20 years - 1.05Tg. Amount of Carbon, accumulated by biomass in the first case makes 1.1 Tg and in the second case - 0.48 Tg.

Amount of Carbon, accumulated by soil on completely unused lands made 3.36 Tg, that makes 12.32 Tg calculated in CO_2 amount.

In the base year of 1990 as a result of anthropogenic activity, "Exploited forests" were characterized by the following balance:

- Emission – 0.664 Tg,
- Removal – 12.384 Tg, corresponding to net removal 11.725 Tg of CO_2.

During 1990-1996 maintenance and selective cutting of forests decreased in Georgia, while illegal cutting increased (Appendix, Tables A3 and A4). These processes caused the rise of CO_2 emissions. Annual amount of CO_2, emitted in this period, was increasing from 16 to 161 Gg. Maximum emission took place in 1994.

4.3. CH_4 EMISSIONS

Characteristics of Methane emissions in Georgia are presented in Table 4.3.1. The main sources of CH_4 emissions are waste management, agriculture and fugitive emissions from fuel systems (systems of natural gas and oil exploitation and coal mining, as well).

Table 4.3.1. CH_4 emissions in Georgia (Gg)

SOURCE CATEGORIES	1980	1985	1990	1995	1997
1. Energy, including	103.0	121.0	106.0	6.5	7.2
Fugitive emissions from fuels	99.1	116.9	103.3	6.0	6.3
2. Industrial processes	0.4	0.3	0.2	0.0	-
3. Agriculture	107.7	113.1	90.9	65.7	74.0
4. Forest utilization	28.1	24.3	15.0	7.8	9.4
5. Waste management	140.6	152.5	144.3	71.9	72.6
Total:	379.8	411.2	356.4	151.9	163.2
Total in CO_2 equivalent	7975.8	8635.2	7484.4	3189.9	3427.2
Total in C equivalent	2175.2	2355.1	2041.2	870.0	934.7

Emission of Methane considerably decreased in 1992-1997, namely, from 0.24 Tg (1992) to 0.15 Tg (1995). The share of different modules in Methane emission by this period is as follows: wastes 38.3-49.9%, agriculture 36.0-45.8%. Share of energy production and industrial processes has substantially decreased: from 25.1% (1992) to 4.2% (1996) and 0.04-0.003%, respectively. This can be explained by the fact that thermal energy production in Georgia was based mainly upon imported fossil fuel consumption. As a result of the destruction of earlier existing infrastructure and transition to market economy, fossil fuel import has been considerably decreased. For the detailed demonstration of the share of agriculture and wastes in CH_4 emission, data are given in Table 4.3.2, the analysis of which shows, that the main share in Methane emission from waste module belongs to solid wastes and industrial wastewater. But the share of the latter has considerably decreased during the period of 1992-1997 due to the crisis in industry. From agricultural module predominant role in CH_4 emission belongs to animal enteric fermentation and system of manure processing, share of which in this sector is approximately 97.9%.

Table 4.3.2. CH_4 emissions from waste management and agricultural modules (Gg)

	SOURCE CATEGORIES	1980	1985	1990	1995	1997
Wastes	Landfills	43.9	47.5	50.8	49.9	50.0
	Residential wastewater	12.1	13.0	14.0	13.7	13.8
	Industrial wastewater	84.5	92.1	79.4	8.1	8.9
	Total:	140.5	152.6	144.2	71.7	72.7
	Total in CO_2 equivalent	2950.5	3204.6	3028.2	1505.7	1526.7
Agriculture	Animal enteric fermentation, animal manure processing	106.0	111.4	89.0	66.3	66.1
	Field burning of agricultural wastes	1.7	1.7	1.8	1.3	2.0
	Energy production	0.15	0.14	0.16	0.03	0.03
	Total	107.85	113.24	90.96	67.63	68.13
	Total in CO_2 equivalent	2264.9	2378.0	1910.2	1420.2	1430.7

4.4. N_2O EMISSIONS

Owing to the relatively small volume of Nitrous (I) Oxide emissions in Georgia, they have been registered with possible maximum accuracy, reflecting all emission sources. The main results are presented in the Table 4.4.1.

Table 4.4.1. N_2O emissions in the atmosphere (Gg)

SOURCE CATEGORIES	1980	1985	1990	1995	1997
1. Energy generation	0.280	0.320	0.293	0.048	0.096
2. Industrial processes	0.802	1.624	1.613	0.530	0.926
3. Agriculture	7.161	6.487	5.886	2.645	3.274
4. Forest ecosystems	0.193	0.167	0.103	0.050	0.066
Total:	8.436	8.598	7.895	3.273	4.362
Total in CO_2 equivalent	2615.16	2665.38	2447.45	1014.63	1352.22
Total in C equivalent	713.23	726.92	667.49	276.72	368.79

Main share in N_2O emission belongs to agriculture. From other sectors industrial processes are important, while burning of fossil fuel and forest ecosystems play relatively less significant role. Shares of agricultural branches are presented in table 4.4.2.

Table 4.4.2. N_2O atmospheric emission from agricultural module (Gg)

SOURCE CATEGORIES	1980	1985	1990	1995	1997
Animal premises	3.128	3.328	2.804	1.665	1.832
Field burning of agricultural wastes	0.042	0.042	0.044	0.030	0.052
Energy production (transport)	0.023	0.021	0.025	0.004	0.004
Fertilizers	3.993	3.119	3.042	0.950	1.065
Total:	7.186	6.510	5.915	2.649	2.953
Total in CO_2 equivalent	2227.7	2018.1	1833.7	821.2	915.4

Data analysis shows that the main share in N_2O emission is made by the use of organic and mineral fertilizers and substantial N_2O emission by industrial processes is caused by Nitric Acid production.

4.5. EMISSIONS OF OTHER GASES

Emissions of greenhouse gases, having indirect effect (NOx, CO, NMVOCs, SO_2) are registered with possible accuracy that was feasible by the method of recording and precision of initial information. Results of inventory are presented in the Table 4.5.1, which clearly shows, that energy production sector is the main source of Nitrogen Oxides (NO_x) emission. Energy module occupies the first place in Carbon oxide (CO) emission, as well, and the next one is taken by forest ecosystems and agriculture. The role of industrial processes is insignificant (as well as in NO_x emissions). In NMVOC emissions main share also belongs to energy production. For Sulfur dioxide (SO_2) emission, energy production is responsible almost entirely.

Share in greenhouse gas emissions of branches, reflecting technogenic activity has been considerably decreased during the years of transition to market economy (from 1992). That is directly connected with the change of functioning of the country's fuel and energy complex.

Table 4.5.1. Emission of greenhouse gases, having indirect effect (Gg)

	SOURCE CATEGORIES	1980	1985	1990	1995	1997
NOx	Energy generation	112.71	133.00	124.35	23.84	51.15
	Industrial processes	0.31	0.40	0.40	0.08	0.14
	Agriculture	0.99	0.98	1.03	0.70	0.90
	Forest ecosystems	7.00	6.03	3.73	1.94	2.39
	Total:	121.01	140.41	129.51	26.56	54.58
	Total in CO_2 equivalent	4840.40	5616.40	5180.04	1062.40	2183.20
	Total in C equivalent	1320.11	1531.75	1412.74	289.75	595.42
CO	Energy generation	341.00	363.90	329.00	141.70	297.22
	Industrial processes	1.50	1.90	2.00	0.50	0.66
	Agriculture	59.80	58.30	64.10	38.90	49.61
	Forest ecosystems	246.00	212.40	131.30	68.40	81.73
	Total:	648.30	636.50	526.40	249.50	429.22
	Total in CO_2 equivalent	1944.90	1909.50	1579.20	748.50	1287.66
	Total in C equivalent	530.40	520.70	430.69	204.14	351.18
NMVOC	Energy generation	36.69	40.09	37.78	1.16	1.55
	Industrial processes	8.82	8.25	8.58	0.38	1.05
	Total:	45.51	48.34	46.36	1.54	2.60
	Total in CO_2 equivalent	500.61	531.74	509.96	16.94	28.60
	Total in C equivalent	136.53	145.02	139.08	4.62	7.80
SO_2	Energy generation	229.03	272.01	247.36	20.24	33.08
	Industrial processes	1.20	0.97	1.79	0.02	0.03
	Total:	230.23	272.98	249.15	20.26	33.11

4.6. AGGREGATED EMISSIONS

Analysis of greenhouse gas inventory represents the investigated period in two intervals: 1980-1991 and 1992-1997. The first period reflects technogenic processes of soviet economy conditions, the next period comprises processes of transition to market economy in Georgia.

Carbon dioxide emission in 1980-1991 was changing from 34.6 Tg (1980) to 28.7 Tg (1991). Percentage share of branches in this emission is expressed as follows: energy production 89.6-93.0%, forest utilization 4.6-2.0%, industrial processes 3.5-2.5%, agriculture 1.8-2.5%.

During 1992-1997 the CO_2 emission considerably decreased, namely from 17.6 Tg in 1992 to 9.2 Tg in 1997, the smallest emission (5.3 Tg) being registered in 1995. Percentage share of energy production during this period is decreased to same extent in CO_2 total emission, making 91.6-82.5%. Share of agriculture increased respectively, making 3.6-11.6%. This exceeds approximately 3.5 times the indices of this branch for a previous period.

Methane emission in 1980-1991 was changing from 0.38 Tg of 1980 to 0.30 Tg of 1991. Percentage share of branches in this emission is as follows: wastes 37.0-43.6%, agriculture 24.9-30.3%, energy generation 26.4-30.4%, forest utilization 4.2-7.4%, industrial processes 0.1%. Emissions of Methane in absolute units during 1992-1997 decreased approximately 3 times (see Annex, Table A.5).

Emission of Nitrous oxide in 1980-1991 was varying within 0.0084 and 0.0065Tg. Percentage share of sectors in this emission is reflected this way: agriculture 83.0-70.2%, industrial processes 9.5-25.9%, energy generation 3.3-4.0%, forest utilization 2.3-1.3%. Percentage share of branches did not change for the 1992-1997 interval in total N_2O emission, however amounts of total emission substantially decreased from 0.0053 of 1992 to 0.0039 Tg of 1996.

In the base year of 1990 GHG emissions in CO_2 equivalents amounted to 53.11 Tg, from which 68.6% goes to CO_2, 14.1% - to CH_4 and 4.6% - to N_2O. To the rest emissions about 3% were contributed by CO_2 and almost 10% by Nitrogen oxides NO_x.

Complete characteristics of aggregated emissions are presented in Table A.5 and on Fig. A.3 given in the Appendix.

4.7. CONCLUSIONS

Presented data are the results of the first inventory of greenhouse gas emissions in Georgia. It has been estimated that Georgia's share in greenhouse gas global emissions during 1980-1990 was approximately 0.3%. Greenhouse gas total emission calculated in CO_2 equivalent per capita for this period made approximately 8.6 tons a year (0.0086Gg/yr). At present time these respectively make 0.1% and about 2.6 tons/yr.

The dynamics of GHG emissions in 1980-1997 is shown in Table A5 and on the Fig. A3 of Appendix.

Like in almost all other countries, in Georgia energy production sector is dominant in total emission of GHGs. Analysis of data, reflecting its functioning shows, that greenhouse gas emissions are stipulated mainly by the consumption of fossil fuel (see Appendix, Figs. A4-A5).

The main conclusions of investigation may be formulated this way:

1. In 1980-1990 the tendency existed in Georgia towards the formation of fuel and energy resources predominantly by imported materials. Their share was constantly growing during the period of 1980-1990 within 63-80% (Appendix, Fig. A4);

2. Indicated period is remarkable for the tendency of local fuel production decrease in 1980-1990 respectively within 25%-4% (Fig. A4);

3. Share of primary fuel and energy resources decreased in 1980-1990 from 67% of 1980 to 59% of 1990 (Appendix, Fig.A5), namely:
    a. Oil production decreased from 54% in 1980 to 13% in 1990 (Appendix, Fig. A6);
    b. Coal percentage share in fuel and energy resources increased during the same period from 32% of 1980 to 69% of 1990 (Appendix, Fig. A6);
    c. Percentage share of fire-wood in the same period increased from 5% in 1980 to 10% in 1990 (Appendix, Fig. A6);
    d. Consumption of natural gas changed insignificantly for the same period and its share was 9% in 1980 and 8% in 1990 (Appendix, Fig. A6).

To obtain more reliable data on greenhouse gas emissions in 1990, recommended as a base year, inventory was carried out throughout 1980-1997. In 1991 the nature of functioning of economy substantially changed in Georgia due to the transition to market economy. Emission minimum coincides with the period of general depression in the country (1994-1995). Considerations of the newest prospects for the country's development indicate the further possible growth of greenhouse gas emissions.

To carry out appropriate estimation for the use of greenhouse gas emission decrease in the country in various assessments in future, appropriate analysis of the inventory data is very important. On the basis of data presented in the Tab. 4.7.1 we can make the following conclusions:

- During the period of planned economy, average annual value of emissions for CO_2 was 34-35Tg, and during the period of transition – approximately 10-12 Tg. For the last 7 years total emissions decreased by 171.9 Tg (on the average by 24.6 Tg a year).

- CH_4 emissions did not vary significantly during the first period of considered interval, and they made approximately 0.37-0.38 Tg/yr. The second period is characterized by monotonous decrease of emissions and their average value may be estimated as 0.14-0.15 Tg/ yr, that for the last 7-year period gives CH_4 emission total decrease by 1.13Tg. If we bring the value of GWP for CH_4 equal to 21, we get emission decrease in CO_2 equivalent. Hence it is equal to 23.73 Tg of CO_2, to which corresponds annual average value of decrease 3.955 Tg in CO_2 equivalent.

- N_2O emission variability dynamics is even less expressed and its average value for the first period can be estimated to be 8.4-8.5Gg/yr, while for the second period its emission on the average makes 3.5-4.0Gg/yr. For the last 7-year period the N_2O emission decreased in overall by 0.028Tg. Relative to CO_2, its GWP is 310. Due to this the corresponding amount of CO_2 will be 8.68 Tg, to which corresponds average annual rate of decrease 1.447 Tg/ yr in CO_2 equivalent.

- For CO, during the first period, emission variabilities are not considerable and make 0.63-0.64 Tg/ yr, while in the second period its average value is 0.21Tg/yr. Taking into consideration that its GWP is equal to 3, in CO_2 equivalent it gives 0.63 Tg. For the last 7-year period its total emission decreased by 2.25Tg, or in CO_2 equivalent by 6.75Tg.

- NO_x emission dynamics precisely reflects the nature of industrial development in Georgia. Its average value during 1980-1990 may be estimated to be 0.130-0.132 Tg/ yr, that accounting to its GWP, equal to 40, will give 5.20-5.28 Tg/yr. Emission average value during the second period made 0.45-0.48 Tg/yr., that gives 1.80-1.92 Tg/ yr of CO_2 equivalent. For the last 7-year period NO_x total emission decreased by 0.5Tg or 20 Tg in CO_2 equivalent.

Table 4.7.1. Characteristics of greenhouse gas emission decrease in the period of 1991-1997 (Tg)

Compound	1980-1990 average	Difference relative to 1980-1990 average value							
		1991	1992	1993	1994	1995	1996	1997	Total in 1991-97
Carbon dioxide (CO_2)	37.009	-8.337	-19.235	-26.496	-29.666	-31.665	-28.666	-27.833	-171.898
Methane (CH_4)	0.390	-0.081	-0.148	-0.201	-0.227	-0.238	-0.235	-0.219	-1.349
The same in CO_2 equivalent	8.190	-1.701	-3.108	-4.221	-4.767	-4.998	-4.935	-4.599	-28.329
Nitrous oxide (N_2O)	0.009	-0.002	-0.004	-0.005	-0.006	-0.006	-0.005	-0.005	-0.033
The same in CO_2 equivalent	2.790	-0.620	-1.240	-1.550	-1.860	-1.860	-1.550	-1.550	-10.230
Carbon oxide (CO)	0.626	-0.185	-0.497	-0.484	-0.478	-0.377	-0.236	-0.197	-2.454
The same in CO_2 equivalent	1.878	-0.555	-1.491	-1.452	-1.434	-1.131	-0.708	-0.591	-7.362
Nitrogen oxides (NO_x)	0.132	-0.019	-0.084	-0.099	-0.111	-0.105	-0.083	-0.078	-0.579
The same in CO_2 equivalent	5.28	-0.76	-3.36	-3.96	-4.44	-4.20	-3.32	-3.120	-23.160
Combined CO_2, CH_4 and N_2O in CO_2 equivalent	47.989	-10.658	-23.583	-32.267	-36.293	-38.523	-35.151	-33.982	-210.457
Combined CO_2, CH_4, N_2O in carbon equivalent,	13.088	-2.907	-6.432	-8.800	-9.898	-10.506	-9.587	-9.268	-57.398
CO_2, CH_4, N_2O, CO, NOx in CO_2 equivalent, ΣM_{CO2}	55.147	-11.973	-28.434	-37.679	-42.167	-43.854	-39.179	-37.693	-240.979
Same in Carbon equivalent ΣM_C	15.040	-0.538	-7.755	-10.276	-11.500	-11.960	-10.685	-10.280	-65.721

Therefore, emission decrease for the main contributors to the greenhouse effect (CO_2, CH_4, N_2O) during the period of depression (1991-1997) in Georgia in CO_2 equivalent, made totally 210.3 Tg, to which corresponds average annual value for indicated period 30.0 Tg of CO_2 equivalent, out of which 24.5 Tg comes directly on CO_2, and the rest 5.5 Tg of CO_2 equivalent is the result of CH_4 and N_2O emission decrease.

Interesting are the data, showing the total undeliberate saving of GHG emissions (in CO_2 equivalent) during the years of depression (1991-1996), relative to average level of emissions in 1980-es:

CO_2 - 172 Tg;
CH_4 - 28 Tg;
N_2O - 10 Tg;
CO - 7 Tg;
NO_x - 23 Tg.

These data may be useful as a reference information after the activation of GHG trading mechanism.

4.8. AEROSOL EMISSIONS

Main sources of anthropogenic aerosol emission into the atmosphere from Georgian territory are represented by residential and industrial sectors, motor transport, wastes and technological cycles, dissipation of pesticides and fertilizers, intensive ploughing of soil, etc. Determination of an aerosol constituent is associated with certain difficulties, however such assessments are in general available.

Table 4.8.1 presents the data on atmospheric aerosols, emission of soot particles from gasoline and diesel fueled motor-transport and aerosols generated from SO_2, emitted by energy producing and industrial enterprises. The Table shows that the main part of aerosols (more then 50%) is composed by Sulphates, having a substantial impact upon the decrease of solar direct radiation on the Earth's surface. It is evident from the Table, as well, that considerable decrease of aerosol emission in the atmosphere took place during the period of 1991-1996, caused by decreasing industrial production.

Table 4.8.1. Aerosol emissions by motor-transport and energy objects in Georgia during the period of 1985-1996 (thousand tons)

Years	Solid particles emitted by industrial and energy-producing enterprises	Soot particles, emitted by motor-transport	Sulphates created as a result of SO_2 emissions	Total aerosol emission
1985	186	3.9	208	398
1986	239	3.9	194	437
1987	221	4.0	196	421
1988	199	4.2	194	397
1989	171	4.3	189	364
1990	144	4.3	189	337
1991	89	6.3	147	242
1992	79	ND	103	>182
1993	47	1.3	54	102
1994	29	0.3	36	65
1995	24	1.8	15	41
1996	15	4.4	23	42
I)1985-1990	193	4.1	195	392
II) 1991-1996	47	-	63	112
II/I x100%	24	-	32	29

Note: ND - no data available

The share of soot particles in the atmosphere is not substantial (approximately 1%). Emission of there particles was still the same in 1996, as it was in 1985-1990. It is remarkable, that soot particles play a considerable role in the intensification of greenhouse effect and weakening of solar radiation on a local scale in places of motor-transport concentration in large cities.

Table 4.8.2. presents the results of measurements of solar rad iation during 1930-1990 in various regions of Georgia for cloudless conditions under the influence of an aerosol component by midday. It demonstrates the significant increase of the weakening of direct solar radiation by aerosols at all points, except Tsalka. The analysis of additional data made it clear, that a non-aerosol component

of solar radiation weakening has not changed considerably, making approximately, throughout the indicated period, in Tbilisi 465, In Telavi 419, in Anaseuli 458 in Senaki 470, in Sukhumi 465 and in Tsalka 355 W/m^2.

As a result of the solar energy weakening by aerosols during 1981-1990, intensity of solar direct radiation on the Earth's surface decreased, relative to 1931-1940 period, by 2% in Tsalka, while this indices amounted to 13-16% at other points.

Table 4.8.2. Change of solar radiant energy diffused and absorbed in the atmosphere by an aerosol component (I) and of solar direct radiation (II) on the Earth's surface at different points in Georgia (W/m^2)

Station	Altitude a.s.l (m)	Weake-ning Characte-ristics	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1981-1990 / 1931-1940 %
Tbilisi	403	I	56	86	116	146	176	206	368
		II	912	883	854	825	796	767	84
Telavi	598	I	42	68	94	120	146	172	410
		II	934	908	882	856	830	804	86
Anaseuli	158	I	59	85	111	137	163	189	320
		II	878	852	826	800	774	748	865
Senaki	40	I	73	97	121	145	169	193	264
		II	852	828	804	780	756	732	86
Sukhumi	116	I	66	91	116	141	166	191	289
		II	860	837	814	791	768	745	87
Tsalka	1457	I	22	28	34	40	46	52	236
		II	1014	1010	1006	1002	998	994	98

5. POLICY AND MEASURES TO MITIGATE GHG EMISSIONS

5.1. GENERAL POLICY CONTEXT

Georgian Climate Change Policy is based on the principles of the UNFCCC and on the reports of the IPCC, as well as on the results of scientific research at the national level.

The main principle of the Georgian Climate Change Policy is that all political decisions and measures should be thought out deeply and comprehensively and be cost effective as far as possible. Unfortunately, in Georgia, as in country with economy in transition, it is difficult and sometimes impossible to follow these principles in real value.

Georgia, as non-Annex I country, has no specific commitments connected with the reduction of GHG emissions, but it is not out of the possibility that Georgia will assume in future some specific commitments on GHG emission reduction till 2010 in the context of Kyoto Protocol. Therefore, special attention is paid to the elaboration of the policy for the period till 2010, what is in accordance with the main objective of the Convention.

Georgian Parliament ratified the Convention on 29 July 1994. Under the 1996 Order of the President of Georgia No 630 National Climate Change Programme has been approved for the years 1996-2000 and the State Commission on Climate Change Problems has been created under the chairmanship of the Minister of Environment. This commission comprised both the Ministers of different branches, connected with the Climate Change, known scientists and other representatives of society.

At the some time, in the period of 1997-1999 the UNDP/GEF-Government of Georgia joint project was implemented, the main goal of which was the preparation of Initial National Communication to the UNFCCC Conference of Parties and working out of the National Climate Change Action Plan. One of the main subjects of this project was the mitigation of GHG emissions and analysis of measures for their abatement.

5.1.1. ENVIRONMENTAL POLICY

The principles of the environmental policy and the mechanisms of its implementation in Georgia are set out in the Law on "Environment Protection in Georgia", adopted on 10 December 1996. The Article 51 of the Law concerns the Climate Change. In particular it is outlined that the subject of activities directed to the prevention of global climate change is addressed to follow the norms of GHG emissions in the atmosphere and to implement the measures for their reduction. This modern legislative framework represents a perfect basis for the national environmental policy and is focused on the following principles:

- **The Principle of limitation**
  According to this principle, all harmful or undesirable impacts must be limited to the extent relevant to the technical possibilities. At the same time this limitation also must be acceptable in economic view. This principle is in conformity with the Article 3 of the UNFCCC and provides the cost effectiveness of different measures concerning the impact on climate change ;

- **The Principle of contribution by polluter**
  According to this principle, the contribution of polluter to the measures, directed to the reduction of the impact on the environment, is established and it suggests the mechanism based on the market rules;

- **The Principle of the public awareness**
  National organizations should regularly provide the pub1ic with information on the state of the environment and the measures for its improvement.

Other laws, connected with the environmental protection, adopted as well recently in the country are: the Law on Water, the Low on the Permission for the Environmental Protection, the Law on Ecological Examination, etc.

At present, the Law on Atmospheric Air Protection is being considered by the Georgian Parliament and it will be submitted for the adoption at the autumn session of 1999. Basic principles of this Law are as follows:

- To consider and assess the impact of human activity on the atmospheric air condition while its planning and implementation, to carry out measures to avoid atmospheric air pollution;
- To compensate the damage caused by atmospheric air pollution;
- Implementation of atmospheric protection measures should not damage other environmental elements;
- Information on the state of atmospheric air must be transparent and available for the society.

5.1.2. ENERGY POLICY

Before the disintegration of the Soviet Union, policy of Georgia was ruled from the Center. Characteristic feature of this policy was the unthrifty consumption of energy resources. Georgia, in fact, imported subsidized energy carriers (natural gas, oil products, etc.) at symbolic prices from other Republics, mainly from Russia, Azerbaijan and Turkmenistan. Georgian energy system was a constituent of an united system, ruled by the Center, from which the deficit of energy was refilled without delay.

Since 1991, energy crisis has begun in the country, the main reason of which was the establishment of world market prices on energy carriers by energy supplying countries. Population began to use primitive electric, organic fuel (mainly kerosene) heating devices. Cutting out of forests sharply increased in rural areas. Economy was practically paralyzed.

Georgian government considers that the way out of the created situation is, first of all, to use completely energy resources available in Georgia, in particular, hydro power resources and coal. Despite of the fact that the use of coal in energy production will cause the significant GHG emissions, Georgia is forced to take measures directed to the rehabilitation of coal industry (the Presidential decree No. 457 dated 27 August 1997). This will ensure the production of basic energy by the use of domestic sources, what would reduce the dependence on fuel exporting countries.

Georgia is one of the richest countries in the world for its hydropower resources. Hydroenergy potential of its rivers makes 80-85 billion kWh per year. Economically effective potential is 40-50 billion kWh. By the year of 1990 overall projected output of existing hydro power plants was approximately 10 billion kWh, that made 20-25% of economically effective potential. Construction of 1,100 MW capacity hydro power plants had been started in the country, that had to produce approximately 3.3 billion kWh of electric energy. Due to the lack of financial sources, construction of these plants has been suspended. Therefore, Georgia possesses substantial reserves of the ecologically cleanest source for the development of hydro power production. There is a possibility to construct 100 MW-500MW capacity power plants in Georgia with the following conventional gradation: powerful hydro plants (>100 MW), medium size hydro power plants (10-100 MW), small hydro plants (1-10 MW) and mini and micro hydro power plants (<1 MW).

The Government of Georgia is trying to create such a legislative basis, which will stipulate the development of energy production in the above-indicated direction.

On 27 June of 1997, "The Law on Electric Energy Production in Georgia" was adopted, aiming to:

- Provision of accurate reflection of the expenses on effective production, transmission, dispatching and distribution of electric energy in the tariff system, through combining of competition mechanisms and non-competitive market regulation;

- Establishment of legislative basis, which is necessary to provide the consumers of all categories with stabile electricity;
- Promotion of local and foreign investments' attraction aiming the rehabilitation and development of electric energy sector.

On 3 March 1998, the Decree of the President of Georgia "On the Development of the Utilization of Non-traditional Energy Sources in Georgia" was signed, the main points of which are:

- Admission of renewable energy resources use as one of the primary branches of Georgian energy sector aiming the sustainable development of the country;
- Elaboration of measures promoting investments needed for the utilization of renewable resources;

According to the Renewable Energy Development Programme, the following measures are planned in the mentioned Decree:

- Provision of 10-12 % subsidy by the Government to the producers of "ecologically clean" energy;
- To guarantee by the Government the producers to purchase energy at reduced prices;
- To carry out reduced tax policy for Ecologically Clean" energy producers.

5.1.3. TRANSPORTATION POLICY

Transportation network in Georgia has been created in the Soviet Union under the conditions of complete integration. The logistics of the development of this system reflected the interests of the Union and it still preserves considerably its former state.

Privatization, carried out without any distinct strategy, caused ineffective allocation of the forms of property. Since 1990 the level of transportation and its infrastructure service has sharply decreased, resulting, in some cases, in critical distructive situation of the main facilities. Payment, statistical and management information services were broken down during the transition period.

Main features of the existing state of the country's transportation system are:

- Obsolete and significantly damaged main facilities;
- Great scarcity of investments for all types of vehicles;
- Ineffective system of the State Management of transport;
- Limited tendencies of technical innovations and improvements;
- Absence of adequate statistical base for the registration of the state of the branch;
- Lack of the information system on economic indices;
- Lack of qualified managers.

Transition to market economy under indicated conditions, formation of a private sector and decrease of economic role of the state changes completely economic structure of the country. New political and economic conditions, mainly putting into operation of TRACECA and the trend of its capacity increase, create a new potential for the development of the country's transportation system:

- The increase of the connecting role of Georgian ports with outer world and Transcaucasia -Central Asia regions, as well;
- Railway transport gets the functions of intensive carrier of international transit commodity turnover ;
- Motor-transport will have the possibility to fulfill not only the function of the commodity carrier, but effectively serve the transportation markets of the region and those of other countries as well;
- Sharply changes the role of air- transport: at present, air transport is considered as a part of service system for Euro-Asian transportation corridor.

Therefore, the country's new transport system considers not only internal transport demands, but it is intended to be used in the service of regional and transcontinental commodity transportation . This will undoubtedly have serious impact on ecological state of the environment of Georgia, in particular, on greenhouse gas emissions.

The aim of the State Policy is:

- To decrease the number of sources of greenhouse gas emissions by means of coordinated and harmonious development of all types of transport ;

- To create a system for assessment and monitoring of harmful substances emission (among them, greenhouse gases) in the transportation sector;

- Especially important is development of motor highway network. Under the 1996 Presidential decree No 338, Government commission has been set up, which prepared a Presidential program for the rehabilitation and modernization of the highways;
- Technical examination of motor vehicles, creation of GHG exhaust monitoring system, corresponding to international standards;
- Creation of a legislative basis for limits, determining GHG emissions in the aviation;
- The anticipated oil transit through the Black Sea creates the problems of ecological safety of sea transport and the infrastructure (terminals, tankers, railway and motor-transport ferries). Among them, the problem of limitation of GHG S is very important. The State ecological supervision upon Carbon dioxide emissions should be conducted by the Ministry of Environment on these routes, and the activities of the Ministry of Transport of Georgia carried out in this direction, should be supplementary but, at the same time, very important, including GHG monitoring and data statistical processing;
- Equipment of acting sea-ports with modern technologies for GHG emissions supervision;
- Training of specialists;
- Among various types of transport, railway was most integrated in the unified Soviet system. It had only narrow exploitation function. Under new conditions, when Georgian railway system has the possibility of independent development, formation and determination of its own rules of functioning, the railway system is facing the problems of quite a new nature and meaning. The system appeared to be quite unprepared for that both ideologically, conceptually, and organizationally;
- One of the important problems of the development of Georgian transport is creation for mountainous regions of ecologically clean passenger, passenger-freight and freight automatized special transport (cable, cable rail, monorail, trolley-bus, etc). The Indicating Plan of social and economic development of Georgia up to the year 2000 and the 1995 Decree of the Georgian President No 4 reflects the most important problems of the development of special transport branch in Georgia and ways of their solution. Responsible for funding the activities on the reconstruction and development and creation of normal conditions of exploitation are owners-municipal organizations, joint-stock companies and individuals (physical persons). Implementation of the complex of works is approved by the Government on the basis of Special state combined program "Spetstrans –2000".

The Law on Motor Transport was adopted in April 1995. The law defines the bases for legislative, economic and organizational activity and is relevant to all owners of motor vehicles despite of their organizational and legislative form and subordination. In October, 1995, the Decree on the prevention of atmospheric air pollution by harmfull gases, emitted by motor vehicles was adopted by the Cabinet of Ministers of Georgia.

5.1.4. AGRICULTURAL POLICY

Agricultura1 policy in Georgia was governed from the Center and till 1991 was mainly directed to satisfy the needs of the Soviet Union. In particular, priority was given to those crops, (tea, citrus p1ants, vine and fruit), cultivation of which, due to climate conditions, was limited or impossible in other Republics. In spite of great historical traditions, corn was grown in small amounts. Substantial part of meat and milk was imported from other Republics, hindering development of cattle breeding. After the break-up of the Soviet Union, situation both in agriculture and other fields of economy became critical. Establishment of world prices on products, imported from former Soviet republics, caused the necessity for the investment of considerable funds by the Government for purchasing of vital agriculture products.

In order to find the way out of the created crisis, the Government began to carry out reforms, the main of which was the land privatization. The reform in agricultural policy is based upon two main objectives; (a) sustainable production, which is in conformity with market demand and management of arable land and (b) thrifty utilization of natural resources. The main element of the concept, worked out for the achievement of these aims, is the separation of cost and income policies. In other words, prices on agricultura1 products depend upon the market situation and these prices are established, as possible, for the improvement of economic repayment, when within the scope of interests of the population, financial compensation, independent from the production, is given as a grant only in case of necessity.

The program for the development of Georgian agriculture considers the structural reorganization of the branch and changing chare proportions of agricultural crops according to the state of the world market, competitive quality of domestic products and vital interests of the population. For example, more areas will be occupied by cereals and by basic vegetables. Substantial attention will be paid to the replacement of local low-productivity cattle by high productivity breeds.

Priority will be given to environmentally sound, so called organic -biological agriculture, based upon (1) the decrease to the minimum in agricultural production and refinery of fossil fuel, pesticides and fertilizers, produced by chemical synthesis; (2) effective utilization of natural resources and materials of biological origin; (3) preservation of soil fertility; (4) production of ecologically safe foodstuff s, etc.

5.1.5. POLICY IN FORESTRY SECTOR

Utilization of forest resources has long historical traditions in Georgia. Still in the XII century Georgian kings had a chief forester at their court, which was responsible for forest protection and maintenance. In the XIV-XVII centuries numerous enemies deliberately destroyed forests of strategic importance. Unfortunately, inhabitants cut out forest pitilessly for the purpose of increasing the area for ploughlands, hayfields and pastures. Especially decreased groves of boxwood and other species of valuable wood, which were utilized and exported from Georgia long ago. Strabon mentions boxwood, as an export species in the Caucasus. The Genoans used to trade Abkhazian boxwood, as wel1.

According to the materi als of the State Archives of Georgia, status of forests in Georgia at the beginning of our century was quite poor. As a result of the intensification of timber industry during the period of 1885-1917 Georgian forest fund decreased by 654 thousand hectares, that makes approximately 25% of the present area covered by forests. Only in 1912-1916 more than l00 ,000 hectares of forests belonging to noblemen were cut out, though, it should be noted that complicated landscape and lack of highways during this period saved from destruction forests of Abkhasia, Racha-Lechkhumi and some other regions.

Until the Second World War forestry activities in Georgia were mainly directed towards the development of forest industry and intensification of timber utilization. Since that, due to excessive cutting in many regions of Georgia, mountain forests were rarified to 0.3-0.4 density. During the next period, technology and cutting intensity norms were substantially violated. The cutting out was allowed even in the forests of water-and soil-saving and recreational importance, destroying almost only valuable trees, as a result of which general state and quality of forests has been worsened. Initial density (0.7-0.9) has been lowered to 0.3-0.4 over the large areas. Since 1965 industrial cuttings in Georgia were restricted by the Government. Planned cutting has been reduced almost 4.5 times for 30-35 years and by the year of 1997 it made 500,000 m^3.

Until the 20-es of the XX century a forestation activities were not conducted regul arly and they covered only small areas. Actually, works in this direction began since 1925-1926. The Table 5.1.1 shows that they sharply decreased in 1991-1996, what was caused by heavy economic situation in the country .

Table 5.1.1. Dynamics of forest growing and protective aforestation of eroded lands during the period of 1926-1996 (ha)

Years	1926-1945	1946-1965	1966-1980	1981-1990	1991	1992	1993	1994	1995	1996
Total aforested area	3900	66288	140421	60807	2848	2001	1233	907	1023	1042
Mean annually aforested area	195	3314	9361	6081	2848	2001	1233	907	1023	1042

In the past, aforestation area in the Republic was limited only by open, woodless areas. Attention was not paid to restoration of low-density groves, because it dealt with hard labor. Since the last decades, forest fund includes rarified groves along with open, woodless areas. Since that time considerably increased the scale of growing and reconstruction of forest species under the coverage of low-density groves.

Therefore, despite of the irregular exploitation of forests in Georgia during the long period, since the middle of XX century vast reforestation activity was successfully conducted. Besides, during the last 35-40 years, as a result of growing urbanization of the population, in many regions of Georgia agricultural cenoses were replaced by forests. During the same period, fuel demands of population in the Republic have been almost satisfied by liquid fuel and natural gas that substantially decreased the volume of firewood store up. All these substantially stipulated preserving forest resources of the country and its further increase. It must be also mentioned that the energy crisis, which has occured since 1991, caused the significant increase of illegal wood cutting, that has accordingly decreased the aforested areas around the settlements. The windbreacks in eastern Georgia were especially damaged. The legal and illegal timber exporting has also intensified the situation.

5.1.6. WASTE MANAGEMENT POLICY

According to the Law of Georgia "On the Environmental Protection", ecological requirements to waste treatment have been specified. In particular, subject of the activity must ensure decrease of industrial, residential and other wastes, their safety, uti1ization, allocation and burial according to envoronmental, sanitary and hygienic standards and rules. Allocation of any kind of wastes in the sea and other water areas is restricted. Tax code of Georgia envisages taxes on their allocation.

It is necessary to prepare the State legislation on wastes, including the elaboration of the policy of waste management, their decrease and processing, to work out standards for their collection, processing and final management, among them of harmful wastes.

Responsibilities for collection and removing are different and depend upon the type of wastes. Administrations of cities are responsible for collection of solid municipal wastes and their delivery to landfills. Solid industrial wastes are within the responsibilities of each separate enterprise. Wastes are divided into hazardous and non-hazardous industrial types . The first of them should be delivered to special burial places, and at the same time, construction of a plant for their processing is planned.

At the request of the World Bank, the project "Tbilisi, General Plan of Solid Waste Management" was implemented in 1996 by the Netherlands Company "Heidemie" , in which a special attention was paid to organizational and ecological aspects, possibilities of secondary processing, existing monetary accountings and actual expenses, revealing old, useless normative documents.

5.2. MEASURES TO MITIGATE GREENHOUSE GAS EMISSIONS

5.2.1. CARBON DIOXIDE, CO_2

5.2.1.1. ENERGY MODULE

Energy efficiency almost in all sectors of Georgian economy is, in fact, very low. Tab. 5.2.1 presents data on energy efficiency in electricity generation using fossil fuel. To solve separate aspects of this problem, the implementation of the project on removing barriers to energy-efficiency in municipal heat and hot water supply in Georgia will start in 1999 under the assistance of GEF.

Table 5.2.1 Energy efficiency of electric power production (%)

Years	1987	1990	1993	1995	1996
Efficiency	27	25	23	17	22

Main measures for Carbon Dioxide emission mitigation are as follows:

- Increase of the efficiency of electric energy production using fossil fuel;
- Replacement of the fuel with high carbon consistence with more low ones;
- Reduction of losses in the system of electric transmission and distribution;
- Establishment of energy saving technologies in industry;
- Increase of energy efficiency in the municipal sector (application of energy effective lamps, refrigerators, air- conditioners and other modern devices);
- Increase of the efficiency in heat and hot water supply;
- Use of geothermal energy for heat and hot water supply;
- Reconstruction and modernization of the existing hydro power plants;
- Rehabilitation of suspended hydropower plants;
- Putting into operation of hydro power plants under construction;
- Rehabilitation and construction of small hydro power plants;
- Utilization of wind, solar and biomass energy.

5.2.1.2. TRANSPORTATION SECTOR

Measures to mitigate Carbon Dioxide emission, to be conducted at the first stage , are :

- Renewal of motor-park within the country's economic possibility;
- Establishment of the financial policy to limit the import of old, second-hand vehicles;
- Putting in order of motor-vehicle engines in accordance with technical norms and practical implementation of control system;
- Production and/or import of all necessary types of gasoline;
- Constant control of the correspondence of the fuel to technical requirements and obligatory transition to non-Ethylene gasoline;
- Improvement of highway cover in accordance with technical requirements;
- Promotion to the equipment of transport with air–cleaning devices;
- Provision of two-raw traffic on international motorways, avoiding cities;
- Provision of two-line traffic on the portion of Samtredia-Batumi of Tbilisi-Poti-Batumi railway;
- Putting in operation of Tbilisi - Akhalkalaki railway line.

5.2.1.3. AGRICULTURE

In Georgian agricultural sector emission of CO_2 mainly occurs during the field burning of vegetation waste and production of fodder grain. Amount of CO_2, emitted during the burning of waste in

1990 made 900 Gg. In 1996, due to the decline of the branch, this index fell down to 630 Gg. To decrease the emission, waste is ploughed and dug into the soil, or is to be used as fuel. This will increase the accumulation of Carbon in the soil and decrease emission of Carbon Dioxide, since utilization of waste as fuel decreases fossil fuel consumption. Partial utilization of fodder grain for energy production purpose to get biogas is favorable, as well. It will replace fossil fuel and decrease carbon dioxide emission, as well.

Accumulation of Carbon in the soil, or enhancement of agricultural soils as sinks of carbon dioxide will be promoted by the development of bio- organic technologies in agriculture.

During the energy crisis in Georgia forest shelter-belts on agricultural lands were severely cut out, causing the intensified soil erosion by wind and additional emission of Carbon dioxide into the atmosphere. So, considerable attention should be paid to the restoration and development of these forest belts in future.

5.2.1.4. LAND USE AND FORESTRY

To increase the photosynthetic activity of Georgian forests and raise the accumulation ability of removed CO_2 it is necessary:

- To preserve the existing forest cover;
- To increase specific share of young, high-productivity forests (soft-wood trees and other rapidly growing species) by means of aforestation of woodless areas;
- To carry out intensive reconstruction and rehabilitation activities in cut out forests for the increase of forest density;
- To cultivate tree plantations.

By means of the establishment of a modern style of management in 1and use, restoration of degraded soils on the basis of land-reclamation development, the substantial decrease of CO_2 emissions is possible.

5.2.2. METHANE, CH_4

5.2.2.1. WASTE MANAGEMENT

Waste processing industry does not exist, in fact, in Georgia. Earlier, there was a compost plant in Tbilisi, which produced 38,000 tons of compost annually. Since technology of the plant did not provide separation of metal, glass and plastic fractions out of waste, produced compost was useless, so, there was no demand on it and it is not expected to be in future. Due to these and other reasons, the factory does not function since 1991. Construction of a compost plant based on improved techno1ogy was started, but because of the lack of funds, it was suspended. The household garbage incinerating factory had been built, but since the technology needed enormous consumption of energy the transition to market prices on fue1 under current conditions, made operation of the factory economically unprofitable. So it does not function at present.

Methane emission from waste in Georgia made 144 Gg in 1990, or 40% of its total emission. In 1995-1996, under the conditions of economic crisis, emission was decreased down to 72-86 Gg, though, its percentage share increased up to 47%.

Waste utilization for the production of energy is considered to be very effective measure in the World practice. Energy production by burning organic mass, separated as a result of waste processing, excludes Methane emission, though it increases Carbon Dioxide emission. As a whole, it will decrease the emitted GHG amount, since generated energy will replace the energy, produced by fossil fuel. The second method is direct utilization of Methane as a fuel, that is more effective from the standpoint of climate change, though it does not solve other ecological problems.

5.2.2.2. AGRICULTURE

Emission of Methane in the agricultural sector made 91 Gg in 1990. that is approximately 25% of the whole Methane emission . It mainly occurs during the process of fermentation while digesting food by live-stock (83%). 15% of emission is caused by cattle manure decomposition . Methane emission due to burning of agricultural waste is not substantial. In spite of the fact that, during the years of depression (l992-1996) Methane annual emission decreased down to 66-67 Gg, its share increased up to 43%, that was caused by the decrease from 28-30% to 4% of the share of energy production in methane emission due to sharp limitation of the imports of natural gas into Georgia.

One of the effective ways of Methane emission decrease is the introduction of bio gas equipment ("Meth ane tanks") in farming . Their capacity will depend upon the farm scale. According to the investigations carried out by TACIS, by the state of 1990 substantial decre ase of Methane emission from agricultural waste is possible in Georgia, though it wil1 increase Carbon Dioxide emission caused by biogas burning. The wor1d practice show s, that farmers pay great interest to such equipment, since it is economically profitable for them and it increase s sanitary level on the farm, as well. There exists another way of the decrease of Methane emission by changing the fodder composition, e.g. to increase fat and other constituents, due to which the live-stock will consume less food.

5.2.3. NITROUS OXIDE, N_2O

5.2.3.1. AGRICULTURE

Nitrous Oxide emission is conditioned by cattle intestina1 fermentation and dissipation from minera1 Nitrous fertilizers. In 1990 its emission made 5.9 Gg, in 1993-1996, when agriculture was destroyed and sharply decreased the amount of fertilizers introduced into the soil, emission made only 2.6-2.7 Gg. In 1990 the country imported 22,600 tons of pesticides and 25,000 tons of mineral fertilizers. In 1994 their amount decreased to 10,000 and 12,000 tons, respectively. As a result of current economic reforms and under stabilizing conditions, intensification of agricultural production and processing industry, emissions began to increase since 1996.

The d ecreas e of emissions is possible by careful spreading of Nitrous fertilizers, especially during the time period, when growing cereals intensively absorb Nitrogen. This may both decrease required mount of fertilizers and N_2O emission. Indirect way of decreasing Nitrous Oxide emission is the utilization of waste, created during the production of biogas from live-stock manure, as a fertilizer . That is far better organic fertilizer than manure and decreases the necessity of the use of chemical, nitrous fertilizers.

Environmentally sound economic activity decreases N_2O emission, as well. Members of IF0AM from Georgia are Georgian Agroecological Society (since 1993) and association of Bio-Farmers "Elkana" (since 1996). At present there are approximately 60 ecologically safe and bio-organic acting farms in Georgia. Experimenta1 farm at Agroecological Scientific-research Center conducts works since 1992 to elaborate and disseminate systems of environmentally sound land use in Georgia.

5.2.3.2. OTHER SOURCES

Considerable emission of Nitrous Oxide took place during the production of Nitrous Acid. Its emitted amount of 1.6 Gg in 1990 decreased down to 0.4 Gg in 1994, though since l996, due to the revitalization of production, it began to increase again. Possible way of the emission decrease is complete reconstruction of the Rustavi Chemical Enterprise, that is economically profitable, for the production, though it requires rather considerable investments.

6. PROJECTIONS OF GHG EMISSIONS

6.1. CARBON DIOXIDE, CO_2

6.1.1. ENERGY MODULE

Share of energy sector in Carbon dioxide emission in Georgia is more than 90%. Table 6.1.1 presents Carbon dioxide past and prognostic emissions according to the branches of economy (sectors) and Table 6.1.2 presents emissions according to sub-sectors of energy generation sector.

Table 6.1.1 CO_2 past and forecasted emissions in various sectors of economy (Tg)

Sector	1987	1990	1995	2000	2005	2010
▪ ENERGY GENERATION (Fossil fuel)	33.65	33.81	3.88	12.74-16.94	21.77-24.60	31.41-36.37
▪ INDUSTRY	1.18	1.04	0.14	0.20-0.37	0.60-0.82	0.75-1.28
▪ AGRICULTURE	0.84	0.90	0.55	n/e	n/e	n/e
▪ FORESTRY	1.26	0.66	0.78	0.70-0.90	0.70-0.80	0.60-0.70
TOTAL	**36.09**	**36.41**	**5.35**	**13.64-18.21**	**23.07-26.22**	**32.76-38.35**

n/e - not estimated

Table 6.1.2 CO_2 past and forecasted emissions in sub-sectors of energy generation (Tg)

Sub-sector	1987	1990	1995	2000	2005	2010
▪ ELECTRICITY GENERATION	6.86	6.63	0.70	2.26	4.17-4.30	5.21-5.47
▪ HEATING AND HOT WATER	3.62	5.53	0.39	2.14	3.85-4.15	4.80-6.00
▪ TRANSPORT	3.89	3.14	1.43	4.00-4.50	4.30-5.10	5.00-6.50
▪ INDUSTRY	11.55	10.48	0.55	1.59-1.89	4.05-4.95	8.30-9.45
▪ RESIDENTIAL	4.76	4.77	0.47	1.75-1.90	3.40-3.60	5.00-5.25
▪ AGRICULTURE AND FORESTRY	2.29	2.30	0.22	0.80-1.00	1.60-1.90	2.50-2.80
▪ OTHERS	0.88	0.21	0.12	0.20-0.25	0.40-0.60	0.60-0.90

6.1.1.1. ELECTRIC ENERGY GENERATION

Some characteristics of the sub-sector for 1985 – 1995 are presented in the Table 6.1.3.

In Energy generation sector emissions are substantial during electricity generation. Table 6.1.2 presents past and pro jected emissions. Emissions for the year 2000 have been calculated according to the Action plan of the Georgian Ministry f or Fuel and Energy .

For the assessment of GHG emission level by the year 2010 two scenarios have been considered : scenario (1) su ggests that annual electricity consumption per capita will reach the 1990 level, what is approximately 3 200 kWh. Then, considering the population increase, we will get electricity amount necessary for the year of 2010 equal to l7.6 billion kWh. This amount of electric energy may be produced: from hydro power generation – 10 billion kWh, from fossil fuel -7 billion kWh, from wind, solar and biomass energy -0.6 -0.7 billion kWh .

Table 6.1.3 Some characteristics of energy generation in Georgia (TWh)

Year	Production			Consumption				Losses	Import	Export
	Total	From fuel	Hydro	Indus - try	Trans - port	Resi - dential	Others			
1985	14.4	8.2	6.2	8.3	1.0	2.2	2.7	2.5	3.3	1.0
1990	14.2	6.6	7.6	6.0	1.0	2.3	5.5	2.6	4.5	1.3
1993	10.1	2.8	7.3	1.9	0.6	3.1	2.2	3.0	1.0	0.3
1995	7.8	0.7	6.1	0.9	0.3	2.4	2.9	2.0	0.7	-

Modernization and rehabilitation of existing hydro power plants and putting into operation at least some of the plants now being under construction along with the present day trend towards the increase of the number of small hydro power plants, makes real the possibility of production of 10 billion kWh of electric energy by the year 2010.

Wind resources in Georgia are estimated to be 450-500 MW. Interest of local and foreign investors in this field and measures being taken at present allow to plan 150-170 MW capacity with the production of approximately 500-600 million kWh of electricity by the year 2010. It is supposed that utilization of solar energy for electric power generation will be of small scale due to its relatively high cost and probably will make 50-100 million kWh by the year 2010.

Capacity of Georgian thermal power plants in 1998 made approximately 550 MW. In the beginning of 1999 a 250 MW capacity power unit was additionally put in action at the Gardabani thermal plant. Rehabilitation of thermal plants in other cities will give supplementary 150-200 MW. By 2010, it is not excluded changing of old power equipment by new one. We suppose that during the generation of electricity from fossil fuel, the fuel will be consumed with the following proportion: 75% natural gas, 25% black oil. Energy efficiency will reach average world level of 30%. Carbon dioxide emission will make 5.21 Tg. Since until now Georgia has not got its own natural gas and oil, the country's Government may have to construct 150 MW capacity thermal power plant on the local coal. In this case according to the calculations made under scenario (2), it is quite clear, that GHG emissions will increase by 0.26 Tg in comparison with scenario (1).

6.1.1.2. HEAT AND HOT WATER SUPPLY

Before the disintegration of the Soviet Union, heating systems in large cities of Georgia were centralized and based upon the consumption of heat, produced as a result of combustion mainly of natural gas, and partially, black oil in district boilers. Regions, located along the gas pipeline were supplied with natural gas. Population of villages also used wood for heating, and partially hand-made stoves operating on kerosene and other fuel as well. According to the Scenario (1), energy consumption per capita by the year 2010 will reach the 1990 level. Besides, centralized heating systems will be restored in Tbilisi and other large cities, and in some districts autonomous systems will be established. In spite of the fact that Georgia has substantial resources of geothermal waters, they were used at a very small scale, mainly, to supply one of the micro-districts of Tbilisi with hot water and heating. Potentially, by the year 2010, it will be possible to supply up to 0.5 million inhabitants with hot water and heating, which would prevent consumption of 0.6 – 0.7 million tons of conventional fuel, mainly natural gas, oil and wood. According to the Scenario (2), for the supply of 0.5 million of Tbilisi inhabitants with hot water and heating, geothermal energy will be used. Results of estimations are presented in Table 6.1.2.

6.1.1.3. TRANSPORTATION

As it is known, Georgia is crossed by Transport Corridor Europe-Caucasus Asia (TRACECA), the annual freight turnover of which after the reconstruction of motor - and rail -roads, that is expected in the nearest future, will reach approximately 40 million tons. Out of this, approximately 30-40% is the share of motor transport. According to the estimations, the annual freight turnover may increase in future up to 200 million tons. It is evident that TRACECA will become the powerful source of Carbon dioxide emission. The assessments of expected emissions of Carbon dioxide over Georgian portion of TRACECA for motor vehicles of various capacity and type combinations have been conducted. According to them, Carbon dioxide emission per 1 million tons of freight appeared to be within 20,000 - 30,000 tons. By approximate assessment, putting in operation of TRACECA with its full capacity will result in the emission of Carbon dioxide within 1.2-2.4 Tg by the year 2010.

The projection of total emission of Carbon dioxide in the transportation sector of Georgia is difficult, since it is impossible to determine the state of motor park for prognostic years. At present, replacement of very obsolete motor vehicles by modern motor park, energy-efficient and ecologically relatively clean transportation means, will considerably decrease emissions, though, it is impossible to say how it will be carried out.

6.1.1.4. INDUSTRY

Carbon dioxide emission stipulated by energy consumption in the sub-sector of industry in 1987 made 34 % of emission in energy sector. Table 6.1.4 presents the share of emissions by different branches in the total emission, caused by industrial combustion of fuel in the past and projected assessments for the years 2005 and 2010.

Table 6.1.4. CO_2 emissions in branches of the industry sub-sector (Tg)

Sub-sector	1987	1990	1995	2000	2005	2010
Industry (Fuel combustion)	**11.55**	**10.48**	**0.55**	**1.59-1.89**	**4.05-4.95**	**8.3-9.45**
▪ Metal production	6.00	5.58	0.23	0.6-0.8	1.5-1.8	3.6-4.0
▪ Production of building materials	1.56	1.38	0.01	0.18	0.8-1.0	1.6-1.8
▪ Machinery	1.46	1.28	0.17	0.35	0.7-0.9	1.0-1.3
▪ Food industry	1.26	1.11	0.04	0.3-0.35	0.6-0.7	1.1-1.2
▪ Production of chemicals	0.80	0.70	0.05	0.15-0.2	0.35-0.4	0.7-0.8
▪ Paper production	0.40	0.35	0.005	0.01	0.1-0.15	0.3-0.35
▪ Others	0.07	0.08	0.04	-	-	-

Metal production

Georgia has large historical traditions of metal production. At present, the Rustavi integrated iron and Zestaponi steel works and ferroalloy plant are operating in the country. The share of cast iron and steel production in overall emissions was most substantial. In spite of the fact that Integrated steel iron works has been privatized and tendency of restoration of co-operation with former business partners (similar enterprises of CIS) exists, even according to the most optimistic assessments of economists, the Works may reach at least 50 % of the 1990 year production by the year 2010. The Ferroalloy Plant is in a better situation, since it has got 2 % segment of the World's ferroalloy production quota. So, as a whole, Carbon dioxide emissions from metal production will be still substantially less by 2010 relative to the 1990 level.

Production of building materials

Cement production is the most important in this field. There were two operating powerful plants of cement production in Georgia, but they did not meet even domestic demands of the country – considerable portion of consumed cement was imported. Under the conditions of economic crisis, cement production substantially declined, though, at present, tendencies of the revival are being observed – factories have been privatized and their owners try to make all efforts for their recovery. To make forecasts of cement production for the year 2010 is rather difficult, since they depend upon the rate of the recovery and development of building industry in the country and the competitiveness of Georgian cement at the world market. While making forecasts for 2010, we considered three scenarios: (1) production will reach the 1987 level, when approximately 1.5 million tons of cement was produced, and CO_2 non-technological emission made 0.74 million tons; (2) to meet completely the country's demand, production will increase by 25 % relative to the 1987 level, emission will increase by 0.225 million tons, respectively; (3) half of the cement, will be produced as a result of Clinker dry burning, that will decrease fuel consumption and subsequent Carbon dioxide emission by 0.25 million tons.

Making forecasts for the volume of production of other building materials and relevant Carbon dioxide emissions is difficult. We can consider that their volume will reach the 1987 per capita level, but expected increase of emissions may be compensated by replacing existing technologies with modern energy-saving ones.

Machinery

There were aircraft, automobile, car building and other factories operating in Georgia, consumers of which were mainly Republics of the former Soviet Union. Activation of these factories in future at their full capacity is doubtful, though, at present the tendency of the revival of co-operation with old partners is being observed. Emission forecast in this field may appear very rough and variable within a wide range.

Food industry

Until 1991 considerable portion of the products of Georgian food industry was exported. Breaking up of traditional links and low competitiveness of Georgian products at the World Market along with other reasons declined the production level down. According to the assessments of economists, by the year 2010, food industry should meet demands of the country's population by 80 – 85 % and manage to export certain portion of products.

Production of chemicals

Rustavi Chemical Enterprise had no problems with consumers of its products. Even today, there is a great demand for fertilizers from Armenia and Azerbaijan. So, planning of the 1990 level for its production by 2010 and relevant emissions is quite reasonable.

Paper production

There is a powerful Paper Factory in Georgia, which practically does not function today. This enterprise, located in Zugdidi, can satisfy substantial part of the country's demand for paper. Waste paper has not been collected in the country since 1991, due to which there is a rather considerable reserve of waste paper at present. It is known that production of recycled paper out of waste paper requires less energy. So, it is possible to plan the reaching of the 1990 level for paper production by 2010 with a slight decrease of emissions.

6.1.1.5. RESIDENTIAL SUB-SECTOR

Carbon dioxide emission in this sub-sector was mainly stipulated by burning natural gas in boilers and for household needs of population of large cities (cooking, laundering, etc). During the years of crisis, emissions sharply decreased in this sub-sector, though, since 1996 certain increase has been fixed. At present, due to intensive activities of the natural gas distributing private companies and great interest of the population in economically profitable natural gas, it is realistic to plan the 1990 emission level for 2010 forecast per capita.

6.1.1.6. AGRICULTURE AND FORESTRY

In 1990 emission in this sub-sector made only 6% of the sector's total emission. Program of agricultural development plans redistribution of areas occupied by various crops, considering the priorities of vitally necessary products, that may change the pattern from the point of view of energy resources, necessary for agricultural activities. Agricultural machinery in Georgia is rather out of date. Along with the improvement of the economy, it will be replaced by energy-saving, modern equipment, which will certainly reduce amount of Carbon emitted per product unit. While making the projections it was envisaged that by the year 2010 the country is to provide its population with basic agricultural products and raise the production of traditional exported goods. There is cetrain reserve for the decrease of emissions in foresty provided by the adequate management. Projections also stipulate the tendency for the increase of timber export from Georgia to neighbouring countries, mainly to Turkey.

6.1.2. NON-ENERGY AND OTHER SOURCES

Carbon dioxide technological emission in the industrial sector is mainly connected with cement production. Technological emission per one ton of cement production makes approximately 0.5 tons of Carbon dioxide. Table 6.1.5 presents past and projected emissions of Carbon dioxide in the industrial sector.

Table 6.1.5 . CO_2 technological emissions in cement and ammonia production (Tg)

Sector	1987	1990	1995	2000	2005	2010
Industrial processes	**1.18**	**1.04**	**0.14**	**0.20-0.37**	**0.60-0.82**	**0.75-1.28**
▪ Cement production	0.74	0.64	0.03	0.09	0.35-0.45	0.75-0.85
▪ Ammonia production	0.32	0.33	0.10	0.20-0.25	0.25-0.30	0.00 [1)]-0.33 [2)]
▪ Others	0.12	0.07	0.0 1	0.03	0.07	0.10

Second, very substantial source of Carbon dioxide emission is Ammonia production. At the Rustavi Ammonia producing enterprise, which mainly produces fertilizers, technological Carbon dioxide can be utilized in the production of a valuable fertilizer – the Urea. It is economically very profitable and requires substantial investment (approximately 70 million USD), that is the new owner is trying to attract at present. We can consider two scenarios to forecast Carbon dioxide emission from Ammonia production by 2010: (1) ammonia production will reach the 1990 level, created Carbon dioxide will be emitted into the atmosphere; (2) created Carbon dioxide will be completely utilized in the Urea production.

6.1.3. SINKS AND RESERVOIRS

As it is known, amount of CO_2, absorbed by young and middle aged forests exceeds the amount of CO_2, released during the combined ecosystem respiration . Both productivity and Carbon accumulation intensity for them are high.

In mature and very old forests, which are in late “successive” or “climax” stage, largest part of biomass , produced by CO_2 absorb tion as a result of photosynthesis is used in the processes of respiration of plants and heterotrophic organisms. At t his time, balance between absorbed and released CO_2 sharply falls down and sometimes is equal even to zero, as a result of which increase of biomass and of Carbon reserve is very small or does not occur at all. Such ecosystems are in relative (climactic) balance with the environment.

Activities to determine various parameters of Georgian forests, as a Carbon reservoir and removal of CO_2 from the atmosphere, were carried out mainly on the basis of the data of the Forestry Department of Georgia, according to the IPCC Guidelines. Besides, local and foreign scientific publications and methodologies have been used.

In spite of the fact that the reserves of biomass and Carbon, accumulated in Georgian forests are rather high (205.9 million tons of C), average relative increment of the biomass is small (1.3 %), that indicates old age and low productivity of the forests.

In a number of European countries, indices of the relative biomass increment are much higher: in Austria 3%, Belgium 4.6%, Denmark 5.2%, Finland 3.8%, France 3.8%, etc.

In Georgia, young forests occupy only 6.9% of the area, covered by forests. Their share in overall reserves of biomass makes 1.5%. Middle aged forests occupy 47.7% of a total area, where 37.3 % of biomass reserve is accumulated. Mature and old forests occupy 45.4% of the area, and 61% of a total biomass reserve, relative biomass increment of which or Carbon accumulation ability is quite low.

As a result of effective management in the forestry and the conduct ion of planned measures, it is possible to decrease Carbon dioxide emission, though its quantitative estimation is complicated. For the orientation, the 1990 emission level may be taken by the year 2010.

6.2. METHANE, CH_4

6.2.1. WASTE MANAGEMENT

While forecasting the Methane emissions, expected change of waste quantity and qualitative composition have been taken into account. Fore example, by the year 2010, it is expected that municipal waste will be of the following composition: organic mass 39%, cardboard/paper 34%, textile 5%, metals 5%, glass 3%, wood 3%, plastics 4% and the rest 7%. Considering that the country's economy and living standards of the population will reach the 1990 level, values presented in the Table 6.2.1 have been obtained. Two scenarios have been considered. According to the scenario (1) processing (recycling) of waste is not conducted. In this case, Methane emission will be within 150-170 Gg. According to the scenario (2), electric power plants, operating on waste, will be constructed with overall processing capacity of 400,000 tons of waste annually. Methane emission will decrease approximately by 20 Gg, though, Carbon dioxide emission will be within 350-400 Gg. This measure like all other ones, connected with waste processing, is quite expensive and its implementation is possible only by means of foreign investments.

Table 6.2. 1. CH_4 past and projected emissions (Gg)

Emission source	1987	1990	1995	2000	2005	2010
Waste	156.4	144.3	71.9	80.0-90.0	100.0-120.0	130.0-170.0
Agriculture	108.6	90.9	63.6	65.4-72.1	83.2-95.1	102.4-109.9
Volatile emissions	113.2	102.6	6.5	11.0-13.5	37.0-54.0	74.0-100.0
Other sources	35.4	20.4	11.0	15.0-20.0	20.0-25.0	30.0-35.0
Total	**413.6**	**358.2**	**153.0**	**171.4-195.6**	**240.2-294.1**	**336.4-414.9**

6.2.2. AGRICULTURE

Methane emissions from agriculture have been estimated for the years 1990-2010 according to IPCC Guidelines. Values of parameters to be introduced are presented in Table 6.2. 2. It shows that number of cattle was decreasing since 1985, as substantial amount of meat and milk was imported from other Republics. Number of cattle drasticly decreased in 1995-1996, though, relative to other branches of economy, the impact of the crisis was less here.

Table 6.2.2. Data on the number of domestic animals (in thousands) to calculate CH_4 emissions in Georgian agriculture

Emission source	1987	1990	1995	2000	2005	2010
Dairy cattle	597	552	486	500-550	600-650	650-700
Non-dairy cattle	989	746	429	450-500	700-800	950-1,000
Pigs	1,150	880	367	600-700	900-1,000	1,000-1,200
Poultry	24,342	21,759	12,290	18,000-20,000	22,000-24,000	25,000-28,000
Sheep	1,838	1,550	754	750-800	800-850	900-1,000
Goats	100	68	39	60-70	80-90	90-100
Horses	24	20	21	23-25	25-28	25-27

While determining parameters for the years, selected for the consideration, we supposed that milk and meat production will continue to grow until the year 2000 with the rate of 1995-l997 and by the year 2010 will reach the 1985 level per capita. Some indices by 2000-2010 will show the decrease. For example, use of horses, as carriers in villages will be economically ineffective. It is supposed as well that number of sheep will not reach the 1985 level, since Georgia can not use in winter the pastures, located on the southern territories of Russia.

Methane emissions estimated for selected years are presented in Table 6.2.3. Emissions will slightly, by 7-8%, exceed the 1987 level. While making estimations, it had been taken into account that local breeds of cattle will be partially replaced by high-productivity ones. The same table presents Methane emissions during the process of field burning of agricultural waste.

Table 6.2.3. Past and forecasted CH_4 emissions in agriculture (Gg)

Emission source	1987	1990	1995	2000	2005	2010
Enteric fermentation and manure decomposition	106.9	89.0	66.3	64.2-70.9	81.7-93.6	100.6-108.1
Waste burning	1.7	1.8	1.3	1.2	1.5	1.8
Total	**108.6**	**90.8**	**67.6**	**65.4-72.1**	**83.2-95.1**	**102.4-109.9**

6.2.3. OTHER SOURCES

Out of other sources very important are volatile emissions from fuel, which had a large share in Methane total emission until 1990 (approximately 25-30%). Since 1990 sharply decreased import of natural gas. Decrease of coal production and, therefore, Methane emission decrease, was connected with non-profitableness of the branch. Coal is not actually produced since 1995-1996. No substantial reserves of oil and gas have been found until now in Georgia, though, exploration works give rather hopeful results. So, the Government has to consider the problem of coal mining restoration, according to various assessments up to 0.6-1.0 million tons annually. Scale of mining will depend upon many hardly foreseeable factors, as a result of which prognostic emissions will be given within wide range. Intensification of natural gas supply is being observed today in Georgia, as well. Gas distributing organizations have been privatized. Interest of gas supplying companies in the industrial sector, increase of population solvency and economic profitability of replacing other fossil fuel with natural gas, give the grounds to plan, at least 75-100% of the 1990 level of natural gas consumption for the year 2010. Corresponding figures are given in the Table 6.2.4.

Table 6.2. 4. CH_4 volatile emissions from fuel (Gg)

Fuel	1987	1990	1995	2000	2005	2010
Coal	21.6	12.8	0.6	1.0-1.5	2.0-4.0	6.0-10.0
Natural gas	92.6	90.5	5.4	10.0-12.0	35.0-50.0	68.0-90.0
Total	**114.2**	**103.3**	**6.0**	**11.0-13.5**	**37.0-54.0**	**74.0-100.0**

Methane emission from other sources does not exceed 10% of its overall emission. Making errors in their forecasting will not be of any importance.

6.3. NITROUS OXIDE, N_2O

6.3.1. AGRICULTURE

Share of agriculture in overall Nitrous Oxide emissions makes approximately 75-80%. Emissions of Nitrous Oxide from agriculture were estimated for the period of 1987-2010 according to IPCC Guidelines. Parameters to be considered are presented in Table 6.3.1. While determining these parameters for selected years, it has been considered that as a result of conducted measures, utilization of Nitrous fertilizers will decrease relative to the 1990 level, and areas under crops will be re-distributed according to economic interests of the country. Data on the number of cattle, necessary for the estimations, are presented in Table 6.2.2. Results of calculations are summarized in the Table 6.3.2.

Table 6.3.1 . Mineral fertilizers used in agriculture and areas occupied by basic crops in Georgia

Parameter	1987	1990	1995	2000	2005	2010
Use of mineral Nitrous fertilizers , Gg	117.8	67.6	2.0	15.0-20.0	30.0-35.0	55.0-60.0
Maize , 10^3 ha	111.9	107.0	n/e	100-120	100-120	130-150
Wheat , 10^3 ha	28.9	30.0	n/e	40-45	50-60	90-120
Oat , 10^3 ha	43.1	46.8	n/e	30-35	40-45	50-60
Vegetables , 10^3 ha	70.3	63.7	n/e	50-60	60-70	80-90
Fruits , 10^3 ha	159.6	151.2	n/e	120-140	130-150	130-150
Grapes (vine) , 10^3 ha	119.2	112.8	n/e	60-70	60-70	50-60
Tea , 10^3 ha	67.3	62.3	n/e	10-12	15-20	20-25
Soybean, beans, 10^3 ha	27.2	20.6	n/e	15-20	20-25	40-50

n/e – not estimated

Table 6.3.2 Projected emissions of N_2O in Georgian agriculture (Gg)

Emission source	1987	1990	1995	2000	2005	2010
Animal	3.12	2.80	1.66	1.78-1.97	2.32-2.56	2.73-2.97
Use of fertilizers	4.60	3.05	0.95	0.72-0.94	1.43-1.67	2.62-2.85
Total	**7.78**	**5.85**	**2.61**	**2.50-2.91**	**3.75-4.23**	**5.35-5.82**

6.3.2 OTHER SOURCES

Emission of Nitrous Oxide in the industrial sector was actually caused by the production of Nitrous Acid and made 15-20% of overall emission. Large demand for this product and the trend of restoration of its production in l995-1997 makes it real to plan by the year 2010 the 1987-1990 emission level.

Out of other sources (energy generation, forestry, etc.) emission of Nitrous Oxide made only 5-7% of the total emission. Errors, made during their projection will not result in considerable changes in forecasting their total emissions.

Table 6.3.3 presents values of past and projected emissions of Nitrous Oxides. As it is seen from the table, by the year 2010, decrease of emissions relative to 1987 level is expected by 20-27% .

Table 6.3.3. N_2O past and projected emissions (Gg)

Emission source	1987	1990	1995	2000	2005	2010
Agriculture	7.78	5.84	2.61	2.50-2.91	3.75-4.23	5.35-5.82
Industry	1.62	1.61	0.53	1.20-1.30	1.50-1.60	1.50-1.60
Other sources	0.48	0.44	0.13	0.20-0.30	0.30-0.40	0.40-0.50
Total	**9.88**	**7.89**	**3.27**	**3.90-4.51**	**5.55-6.23**	**7.25-7.92**
In CO_2 equivalent	3.136	2.525	1.046	1.248-1.443	1.779-1.993	2.320-2.534

6.4. UNCERTAINTIES

Forecasting GHG emissions in countries with economy in transition, and especially in Georgia, which, from the political point of view, is situated in a rather tense region, is very difficult and in most cases, almost impossible. Basic information on projected value of country's macro-economic parameters upon which assessments should be based, does not exist not only for the year 20l0, but even for the some nearest years. This is stipulated by those numerous factors, management, planning and regulation of which are not within the country's possibilities. They are, first of all, variability of the evolution of political processes in the world and multi-version possibilities of solving economic problems of strategic importance, coming out of them. As an example, we may demonstrate so called "Big Oil" route selection, upon which determination of the priorities in the economy of Georgia will greatly depend. Development of energy production, the main sector of GHG emission, is 1argely dependent upon the hardly projectable factors: the results of oil and natural gas surveying works, scale of foreign investments, etc. There are uncertainties in the prospects for the rehabilitation and development of the industry, since, in spite of the fact that most part of the enterprises is privatized, owners are unable to reconstruct and modernize them, due to the lack of funds. They aim to make their products competitive at the world market, in most cases, they even cannot manage the rehabilitation of enterprises. Georgia, as a country having substantial transit cargo turnover potential, has quite good prospects for the development of transportation sector, forecasting of the realization of which is connected with lots of uncertainties, as well.

Proceeding from the mentioned above, calculation of GHG emission projected values are based upon certain, in frequent cases, perhaps rough approximations, and the values themselves may be considered only as position-finding ones.

We hope that in the second National Communication of Georgia information on GHG projected values will be more reliable and with less errors basing upon the following conditions: (a) Political stabilization process in the country; (b) Intensive legislative activity, (c) Activation of process of reforms; (d) Tendency to the increase of the interest of foreign investors in the economy of Georgia; (e) Support by developed countries; (f) High intellectual possibilities of Georgian population (that is frequently mentioned by foreign experts).

7. TRENDS OF CLIMATE CHANGE AND VULNERABILITY ASSESSMENTS IN ECONOMY AND NATURAL ECOSYSTEMS

7.1. CHANGES OF CLIMATIC ELEMENTS

Episodic observations on the air temperature began in Georgia in 1836. Since 1844, due to the establishment of Tbilisi Magnetic and Meteorological Observatory, these observations were carried out on a regular basis. In 1862 systematic observations started on atmospheric precipitation and other meteorological elements, as well. For the beginning of 20-th century more than 90 meteorological stations were functioning on the territory of Georgia and this makes it possible to assess quantitatively the character of changes of the main climatic elements in this country with its complex geography.

7.1.1. AIR TEMPERATURE

The distribution of mean annual air temperature is given on the Fig. 7.1.1. It follows from this map that on the territory of Georgia can be distinguished 2 warmest regions: the Kolkhida Lowland with the bordering Black Sea shore line areas in Western part the country and Kartli and Kakheti valleys in the Eastern part. The average annual temperatures here are reaching 12-14^{0}C. In the mountain regions of Great Caucasus and South Georgia this value varies between 0-2^{0}C.

On the background of these averaged temperatures different changes of air temperature took place during the current century. The longest observational series has Tbilisi, the variation of mean annual temperature for which in the period of 1845-1995 is given on the Fig. 7.1.2. The analysis of that data on the basis of linear approximation leads to the conclusion that for the last 100 years the mean annual temperature in Tbilisi has increased by 0.7^{0}C. The growth tendency is also revealed for the minimum and maximum temperatures (Fig. 7.1.3). The precipitation amounts have changed insignificantly, but wind-speed and the frequency of cloudless sky has decreased almost twice.

For the determination of the air temperature change over the whole territory of Georgia the observational data for 90 stations has been analysed for the period of 1906-1995. On the basis of linear approximation the trends of temperature change have been derived. The data gaps were filled using the correlation between neighbouring stations.

The results of the analysis are presented on the Fig. 7.1.4. It can be seen on this map, that in the current century the mean annual temperature in Western Georgia was characterised by the small decrease. The biggest decrease by -0.3-0.5^{0}C is established in the high mountain areas of Svaneti and Ajara. In other areas the temperature decrease varies in the range of -0.1-0.3^{0}C. The opposite picture has been revealed in Eastern Georgia. Here on the most part of the territory the rise of temperature has been determined in the range of 0.1÷0.5^{0}C and in some areas that value has exceeded 0.5^{0}C. The narrow strip of temperature decrease has been fixed in Inner Kartli and Javakheti regions. The contrasts between mean temperature changes are revealed more sharply in the cold period of the year (November-March). For the most regions of Western Georgia the temperature decrease in this period made -0.3^{0}C, but in the central regions of Eastern Georgia its growth exceeded 0.5^{0}C. In the warm period of the year (April-October) almost in all regions of Western Georgia the temperature change varies between -0.1÷+0.3^{0}C and more, but in Eastern Georgia a narrow zone of temperature decrease by 0.3-0.5^{0}C is stretched over the areas of Javakheti and Inner Kartli. In other regions of Eastern Georgia temperature increase by 0.3-0.7^{0}C is fixed.

FIG. 7.1.1.DISTRIBUTION OF MEAN ANNUAL AIR TEMPERATURE ON THE TERRITORY OF GEORGIA (°C)

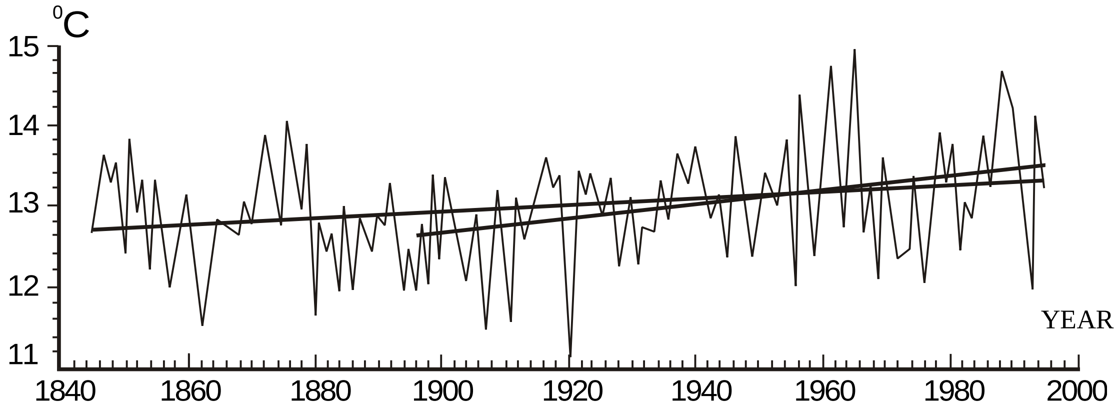


FIG. 7.1.2. CHANGE OF MEAN ANNUAL AIR TEMPERATURE IN TBILISI DURING 1845-1995

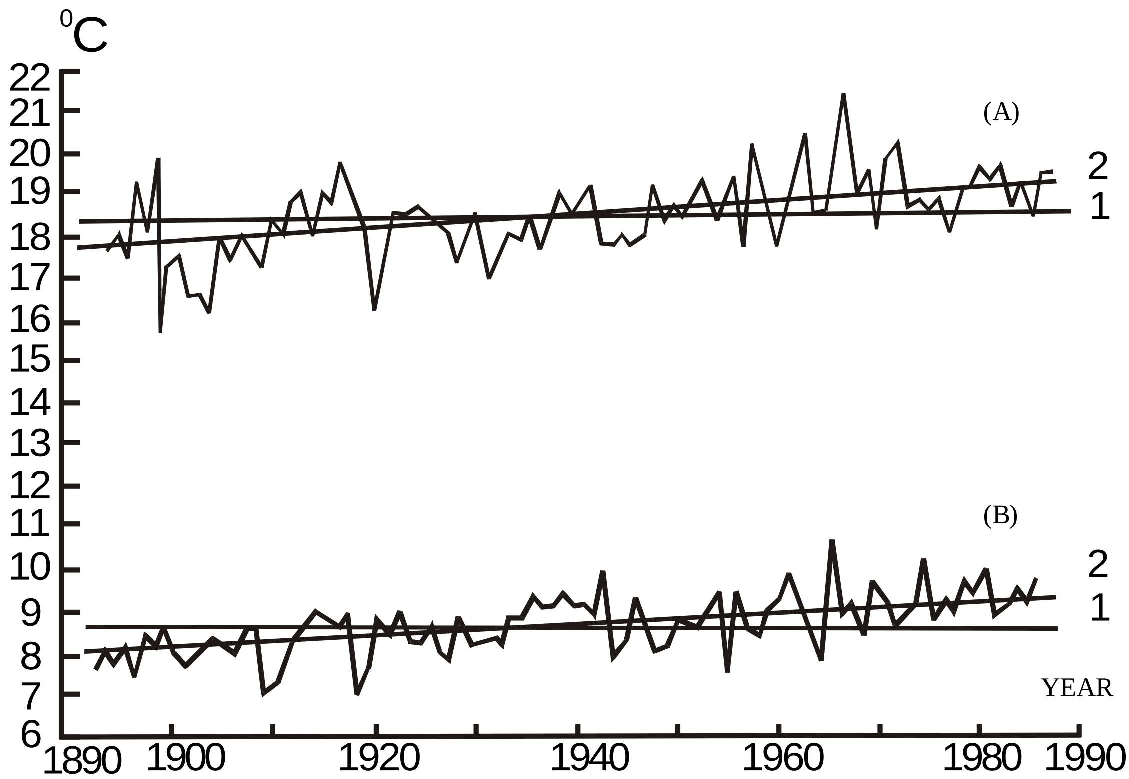


FIG. 7.1.3. CHANGE OF MEAN MINIMUM (A) AND MAXIMUM (B) AIR TEMPERATURES IN TBILISI FOR THE LAST 100 YEARS
1 – NORM, 2 – TREND

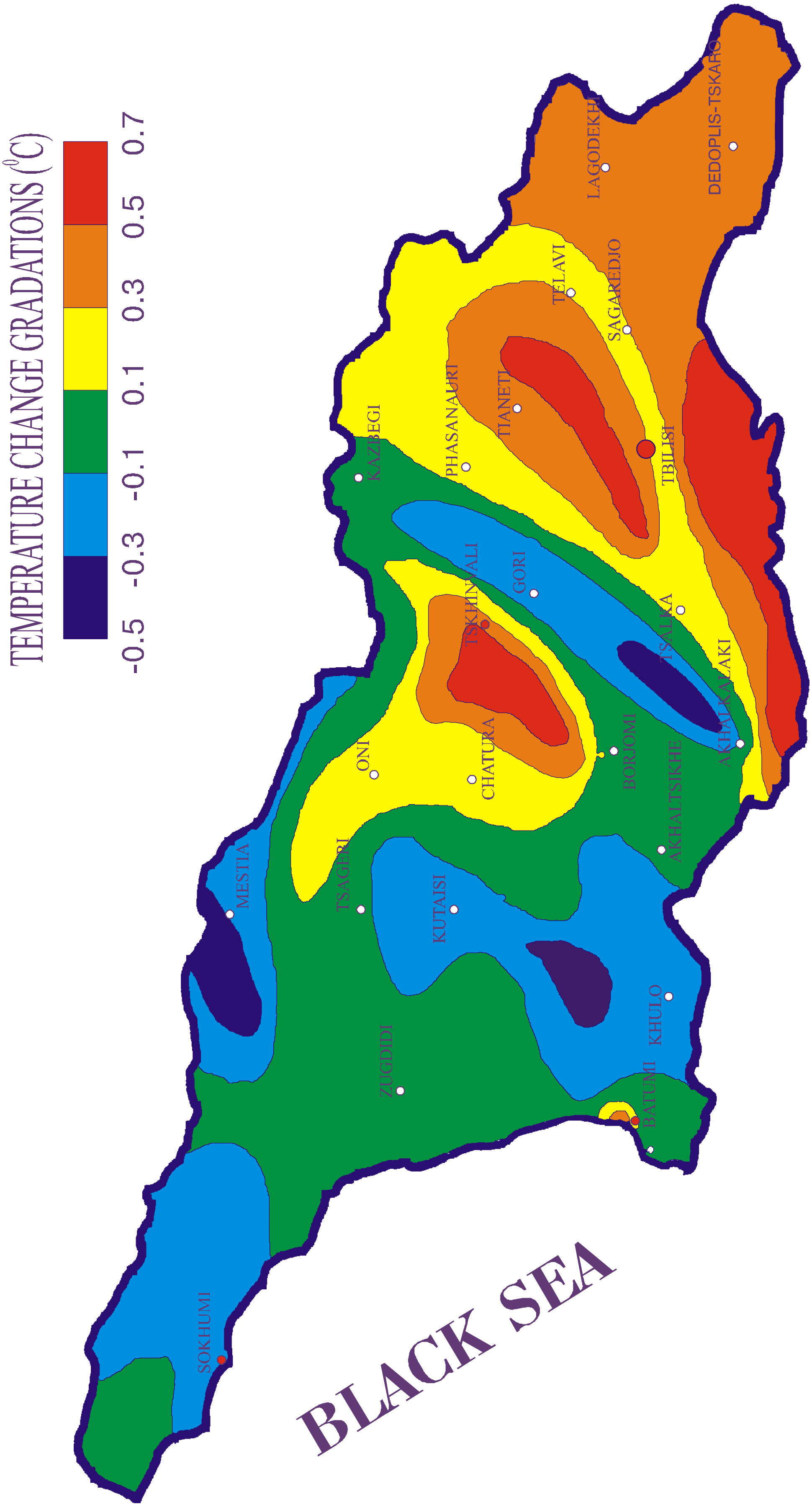


FIG. 7.1.4.CHANGE OF MEAN ANNUAL AIR TEMPERATURE FOR THE PERIOD 1906-1995

The results obtained are in good agreement with the more generalised data of the analysis, carried out by the IPCC in 1995 [4]. In particular, the decrease of temperature in Western Georgia reflects a tendency of cooling over the Black Sea and neighbouring regions, clearly revealed in this investigation by the comparison of mean air temperatures between the periods of 1995-1974 and 1975-1994. Eastern Georgia, in contrary, appeared under the influence of warming processes, spreading over the territories of Central Asia and the Caspian Sea basin. Concerning the spotty character of the distribution of temperature changes over the territory of Georgia, it can be ascribed to the complex nature of atmospheric circulation over the complicated relief of the country. The examination of this problem on the basis of mathematical modelling is one of the objectives for future research.

7.1.2. ATMOSPHERIC PRECIPITATION

The distribution of mean annual sums of precipitation on the territory of Georgia is given on the Fig. 7.1.5. It is evident from this map that this distribution has a clearly expressed regional, and within the regions – spotty structure. In most regions of Western Georgia the precipitation totals vary between 1200-2400 mm, reaching in some areas 2800 mm. In the most parts of Eastern Georgia the annual sums make 500-600 mm, varying in mountainous areas in the range of 800-1400 mm. Maximum precipitation (up to 4500mm) is registered in the mountains close to Batumi and the minimum (360 mm) in lower parts of Mtkvari Valley, south of Tbilisi.

The analysis of precipitation change patterns during the current century was not possible for such a long period of time, as it was carried out for air temperature, because in different times there were made many changes in the observational methodology. It was possible to reconstruct the uniform series only for the period of 1937-1990, which was divided into 2 parts: 1937-1963 and 1964-1990. The results of the comparison of averaged precipitation totals for these 2 periods are given on the Fig. 7.1.6.

The analysis of this map shows that tendencies of precipitation changes in the main 2 regions of Georgia are not so differing, as it was in the case of air temperature. Clear tendencies of precipitation growth are evident on the Kolkhida Lowland, in the environs of Surami Ridge (5÷10%) in eastern part of Kakheti (5÷15%). The letter, it seems, is under the influence of the Mingechaur Reservoir. The significant decrease of precipitation totals (10÷15%) are observed in the mountainous zone of Ajara and in the eastern sector of Great Caucasus. On the rest of country′s territory the changes of precipitation sums are fixed in the range of ± 5%.

Similar to the temperature, more sharp changes have been revealed in the cold period of the year. In particular, significant growth of precipitation (up to 20-30%) has been fixed in the southern part of Ajara and in Eastern Kakheti. At the same time considerable decrease has spread over the southern slopes of Great Caucasus. The increase of precipitation by 5÷10% is noted in the Kolkhida Lowland, Inner Kartli and in Javakheti.

In the warm period of the year most significant growth of precipitation (up 10÷15%) has been found in the Kolkhida Lowland. Slight increase (in the range of 5-10%) is revealed in parts of Western and Eastern Georgia except eastern sector of Great Caucasus.

The topics discussed above were analysed in the framework of the National Climate Change Program of Georgia, which was launched one year before the beginning of the project GEO/96/G31. The obtained data were used as a basis for the vulnerability assessments in different sectors of economy and in natural ecosystems and for the approximate projections of possible climate changes and relevant adaptation measures in the near future in specific regions of Georgia.

FIG. 7.1.5.DISTRIBUTION OF MEAN ANNUAL SUMS OF ATMOSPHERIC PRECIPITATION ON THE TERRITORY OF GEORGIA (MM)

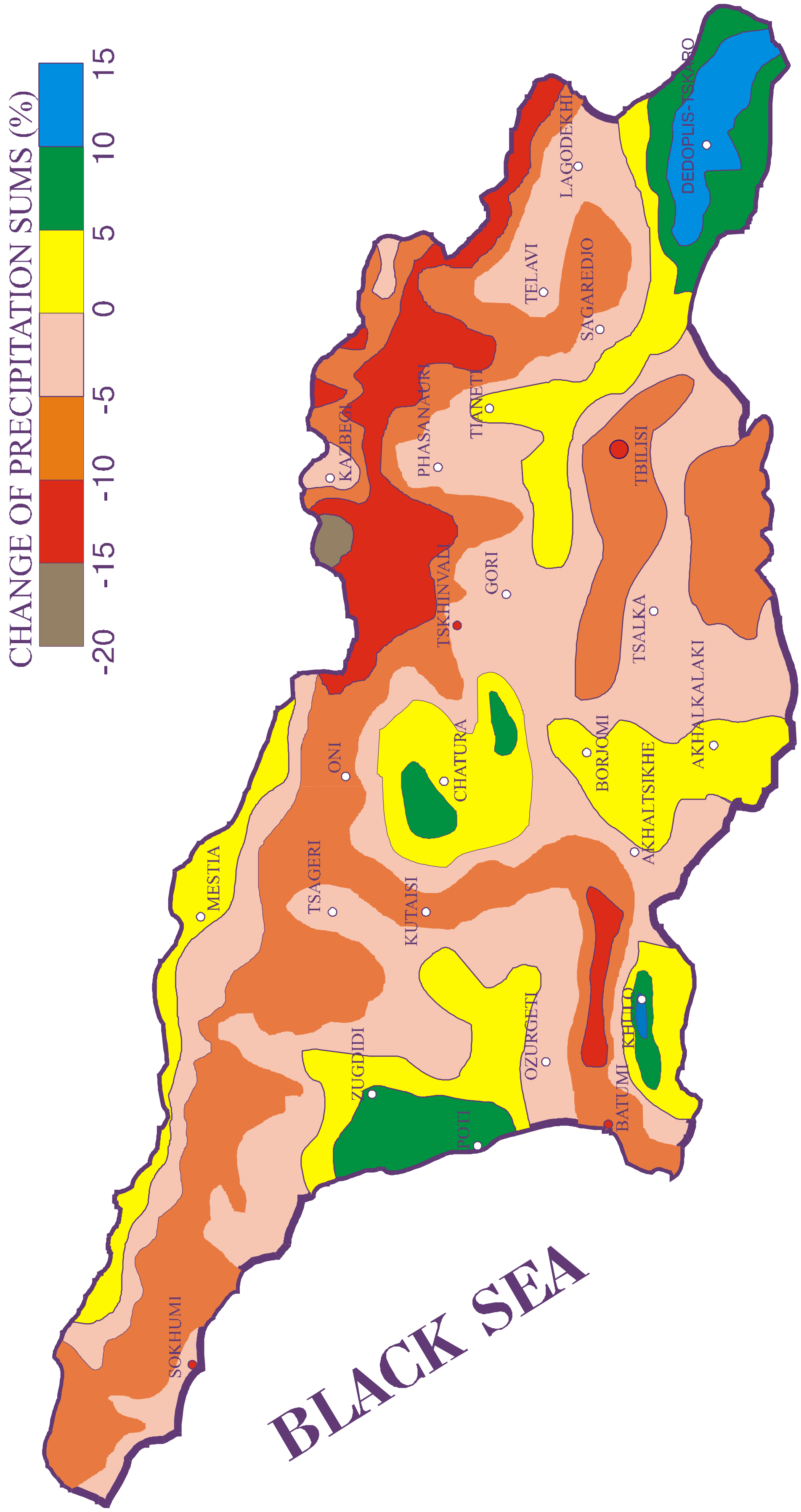


FIG. 7.1.6. ANNUAL ATMOSPHERE PRECIPITATIONSUMS FOR 1964-1990 PERIOD RELATIVE TO 1937-1964 PERIODS

7.1.3. ATMOSPHERIC CIRCULATION PROCESSES

In Transcaucasia, particularly, over the territory of Georgia, formation of weather conditions occurs as a result of intensive impact of those 1arge-scale circulation processes, which start on the Eurasian continent, in the North Atlantic and its neighbouring arctic basin (Fig. 7.1.7) Annual distribution of the recurrence of the impact of these circulation processes upon Georgian territory has been established on the basis of synoptic data. Results are presented in the Table 7.1.3.1.

Table. 7.1.3.1. Recurrence of the influence of different circulation processes upon Georgia (%) according to months

Process	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
M_L	11.8	12.9	12.3	8.6	5.8	3.0	2.0	1.1	4.4	8.0	13.8	16.3
A_H	3.8	3.3	4.5	5.1	8.2	14.7	15.9	18.7	9.9	8.9	4.7	2.3
I_L	6.9	7.3	8.5	7.1	9.9	8.9	8.7	8.2	10.1	10.5	7.6	6.3
N_H	5.3	4.2	7.6	12.1	11.0	10.1	8.7	11.8	12.9	8.4	4.8	3.1
S_H	14.2	17.0	9.2	6.9	7.9	-	-	-	6.1	7.9	13.4	17.5
A_L	-	-	-	8.5	10.9	23.0	25.1	20.3	9.4	2.8	-	-

1. Mediterranean Depression (M_L)

During the period of the influence of the depression, relative to the transport of cyclonic formations eastward, expansion of warm and humid air masses occurs over the territory of Georgia, and frequent precipitation is observed. The process often has a serial character. As it is seen from the Table 7.1.3.1, the influence is intense during a cold period of the year, the maximum value of its recurrence is observed in December (16.3%).

2. Azores High (A_H)

Relative to the expansion of the ridge of high pressure from the Atlantic Ocean eastward, in Georgia, during a warm period of the year, mainly the expansion of cool and humid air masses is observed and during the cold period – the expansion of both warm and cold, as well as humid, air masses occurs. Precipitation formation is stipulated and western winds prevail. The influence occurs during the whole yearlong (Table 7.1.3.1), but its frequency considerably increases in summer (the maximum value of the recurrence - 18.7% is observed in August).

3. Icelandic Low (I_L)

In case of the shift of cyclonic formations from northern regions of the Atlantic Ocean to south-east, in Georgia, during the whole year, intensive expansion of cold and humid air masses occurs. Abundant precipitation is observed in Western Georgia, western winds intensify (especially in Eastern Georgia). The influence has a serial nature. As it is seen from the Table 7.1.3.1, recurrence of this influence during the year is distributed relatively uniformly. The maximum is observed in October (10.5%) and the minimum – in December (6.3%).

4. Northern (Arctic) High (N_H)

In case of an anticyclone developed in the Eurasian section of the Arctic basin, or deep expansion of its ridge to the South, penetration into Georgia of very cold air masses around the Caucasian Range is observed both from the West and the East. Especially low temperature regime is created in Georgia. It is remarkable, that an average recurrence of this influence is rather high during the warm period of the year (Table 7.1.3.1), the maximum is observed in September (12.9%).

5. Siberian Anticyclone (S_H)

The influence of the Siberian (Asian) anticyclone upon Georgia is expanded from the North-East or the East, therefore dry weather conditions or with small precipitation, and cold and weak winds are mainly predominant this time in the eastern part of Georgia. Very often, relative to the development of foehn processes in the Western Georgia, rather strong eastern winds are observed on relatively high temperature background. Greatest part of the recurrence of this influence is observed in winter months (Table 7.1.3.1), the maximum being observed in December (17.5%).

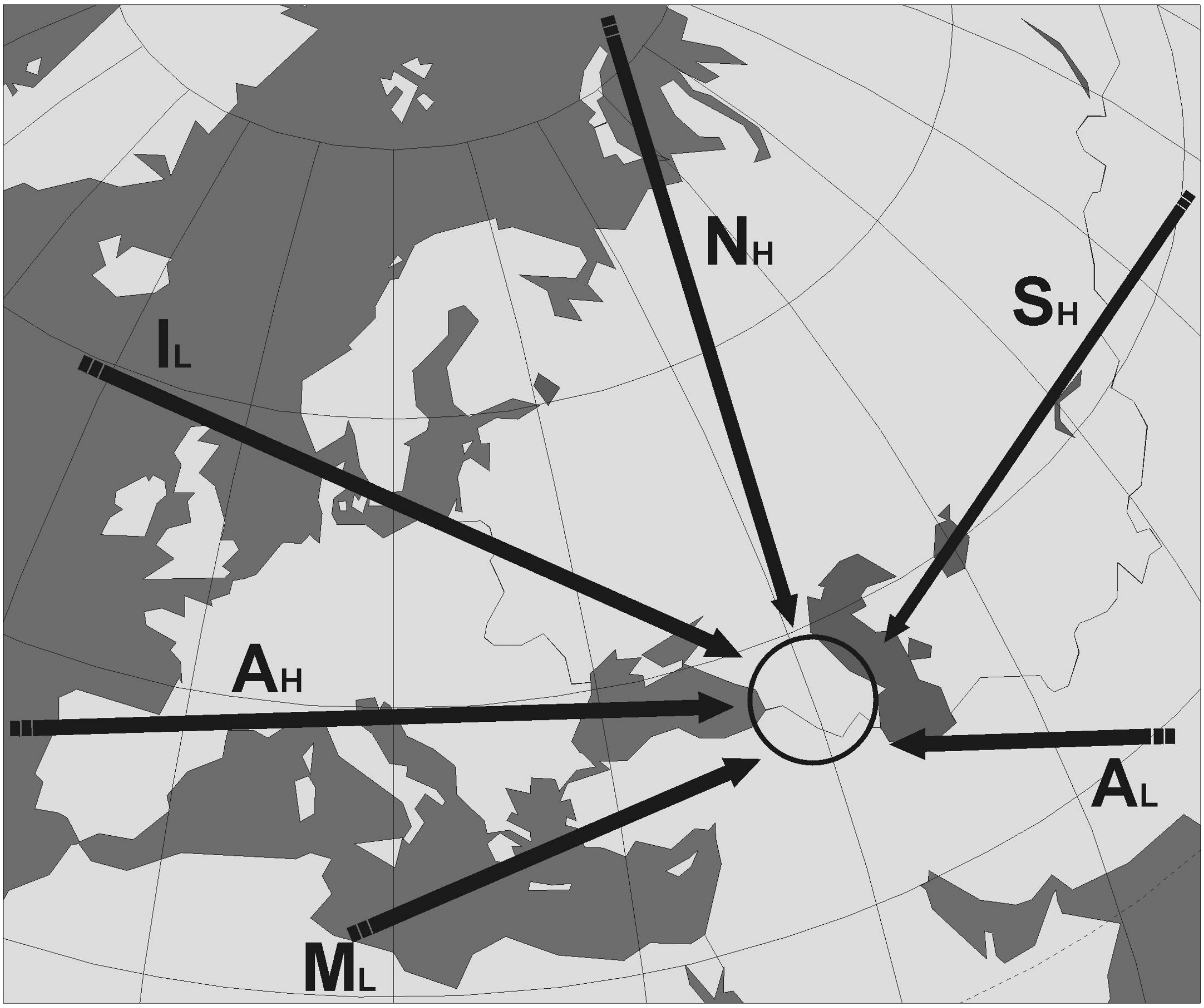


Fig. 7.1.7. Influence of circulation processes upon Transcaucasia

6. Asian Depression (A_L)

During the influence of this depression, the gully of summer thermal cyclone is expanding from the south-east, as a result of which dry and hot air masses are formed over the territory of Georgia. Minimum temperature on the lowland does not fall below +20^{0}C, and a daily maximum exceeds +35^{0}C. Recurrence of the influence is the highest in July (25.1%).

Analysis of the influence of indicated circulation processes upon Georgia shows that if recurrences of the influence fluctuate within average values, then formation of any substantial temperature anomalies does not take place in Georgia and on the contrary, in case of substantial deviation of the recurrences, temperature anomalies are created as an adequate reaction. We are presenting some examples.

<u>Cold 1907 year.</u> This year was remarkable for the activation of the influence of Siberian anticyclone (cooling factor). Deviation of the recurrence of this influence from average value in January, February, March, April and November made 16.3%, 6.8%, 78.6%, 143.9% and 60.5% respectively. Recurrence of influence of Arctic High was also substantial in September, the deviation from average value of which made 95.6%.

Cold 1949 year. During the winter months of this year, very low activity of the influence of the Mediterranean depression (warming factor) was remarkable. Deviation of its recurrence from average values in January, February and December made -65.1%, -70.8% and -62.3%, respectively. On the other hand, influence of Siberian anticyclone was rather active deviation of the recurrence of which from average values in March, April, May and November made 78.6%, 70.7%, 212.5% and 85.2%, respectively. Recurrence of the influence of Arctic High appeared to be substantial, as well, in April, when its deviation made 86.0%.

Warm 1937 year. This year was remarkable for considerable activation of the Mediterranean depression influence. Deviation of its recurrence from average values in January, February, March and April made 66.6%, 29.4%, 60.5% and 93.0%, respectively.

Warm 1966 year. This year, too, was remarkable for the activation of the influence of the Mediterranean depression, deviation of the recurrence of which from average values in January, February, April, November and December made 207.6%, 41.2%, 110.5%, 119.8% and 12.1%, respectively. At the same time, the influence of Siberian anticyclone was less active, deviation of the recurrence of which from the average values in January, February, March, April, November and December made -65.1%, -61.6%, -8.9%, -21.0%

During the recent decades, the tendency of temperature increase is being observed in Georgia, especially in its eastern part. Since formation of the temperature regime is greatly affected by the influence of the Arctic High (N_H), we present the data of deviation of the recurrence of this influence from the average values (Table 7.1.3.2) in the warm season of the year for two periods – years 1900-1920 (cold period) and years 1978-1998 (warm period), which are in a certain correlation with the periods of corresponding temperature change, derived in [1]. As it is seen from the Table 7.1.3.2, in 1900-1920 recurrence of the Arctic anticyclone influence was more than the average one (annual deviation made, on the average, 25%), that made a certain contribution into the formation of relatively low temperature regime. And during the last 21 years – vice versa, less recurrence than average values of this influence was frequently observed (annual deviation made, on the average, -32.9%), that stipulated the temperature increase for the last years. Similar conclusion has been obtained as a result of analysis made for the winter months.

Table 7.1.3.2. Deviation of the recurrence of Arctic High (N_H) influence upon Georgia from average values (%) in the warm season of the year (April-October) (1900-1920 and 1978-1998)

Year	%	Year	%
1900	101.8	1978	65.1
1901	-45.0	1979	-35.8
1902	46.8	1980	-72.4
1903	37.6	1981	-72.4
1904	19.3	1982	60.0
1905	65.1	1983	19.3
1906	46.8	1984	-63.3
1907	-63.3	1985	-35.8
1908	-45.0	1986	-72.4
1909	65.1	1987	-72.4
1910	-72.4	1988	-45.0
1911	74.3	1989	-72.4
1912	60.0	1990	-45.0
1913	-26.6	1991	-26.6
1914	46.8	1992	28.4
1915	92.7	1993	-8.3
1916	-35.8	1994	-8.3
1917	37.6	1995	-90.8
1918	-26.6	1996	-26.6
1919	111.0	1997	-45.0
1920	37.6	1998	-72.4
Average	25.1	Average	-32.9

Therefore, it may be concluded that certain changes of large-scale circulation processes played a considerable role in the formation of a positive temperature trend in Georgia, that, first of all, was revealed in the weakening of the influence of those circulation processes, which stipulate the expansion of cold air masses over Georgia (particularly, of N_H influence). It should be noted, that the weakening of the Arctic High was apparently conditioned by the evident increase of temperature to the north of Siberia during the last decades, that is fixed in recent IPCC data [4].

All these denote, that in the atmosphere there has been created such a trend of the development of global processes, that should provide preservation in near future of circulation conditions that stipulate warming. However, it can be supposed that, on the warming background, negative temperature anomalies should take place in Georgia, as well, sometimes substantial ones, since formation of temperature anomalies is the result of overall effect of the influence of various circulation processes, that is characterised by a rather complicated dynamics. Therefore, the next stage of our investigation should be devoted to specification of the peculiarities of the dynamics of an overall effect.

7.1.4. PALEOCLIMATIC DATA

Almost during the whole late Pleistocene and Holocene (Postglacial Epoch), continuos sedimentation took place in marine and land stratitypical cuts over Georgian territory and as a result, five Palynezones of Holocene has been distinguished. According to Blitt-Sernander scheme, I and II zones belong to earlier Holocene, Preboreal and Boreal periods, III-IV zones to Atlantic and Subboreal periods, V zone corresponds to later Holocene (Subatlantic)

Most of cuts investigated, are made on the Abkhazian territory. They are distributed, more or less evenly through all vertical vegetation belts. Subfossil samples have been taken as well, along the transacts, passing through present landscapes from coastal lowland to a high-mountain region. Totally, 2000 Holocene and 100 subfossil pollen spectra have been analysed. Therefore, a large amount of actual data have been collected, allowing to construct general model of vegetation and climate development both with qualitative characterisation and detailed quantitative data. Methodological basis for the reconstruction was a principle of actualisation, according to which the relation between climate and vegetation in the past was approximately similar to that observed at present. Statistical analysis made it possible to derive simple linear equation of regression, arguments of which are the most important components of pollen and pore spectrum, allowing the assessment of paleoclimatic characteristics. Method of computer analysis application in the paleogeographic reconstruction had been illustrated in detail in papers published earlier.

Climatic phenomena, their intensity and response of vegetation to climatic changes in Holocene were not uniform. At the earlier stage of Holocene, particularly in Preboreal (PB) period (10000-9000 years ago) vertical vegetation belts moved up by 700-800 m relative to late Dryas under the impact of climate warming. Area of broad-leaved forests of the Black Sea coastal foothills and piedmont plains considerably increased, but the area of fir and beech forests decreased in the mountain region.

Preboreal warming was stopped twice by cooling. Generally, the temperature regime was nearing the present one (mean annual temperature was only 0.6^0C higher than it is today). Precipitation amount on coastal lowlands reached 1400 mm, though, it was increasing during the cooling of climate.

At the beginning of Boreal (BO) period (9000-7500 years ago) heavy and short-period cooling was fixed (air temperature was 7^0C lower relative to the present one) and precipitation was 500 mm higher. Afterwards, Boreal optimum had established which was soon again replaced by heavy cooling, the heaviest one during the whole Holocene (mean annual temperature decreased almost by 10^0C), and precipitation amount reached the maximum value (2200-2400 mm). Further climatic conditions were gradually improving, but at the end of the period the cooling was observed again, being less intensive that the previous one. Such climatic fluctuations resulted in the substantial migration of vegetation associations. During the phase of maximum cooling upper boundary of forest lowered almost by 1000m.

Atlantic (AT) period (7500-4500 years ago) is characterised by three heavy warmings, divided by two rather cool phases with relatively high humidity. According to our data, climatic optimum was observed in the second part of this period when upper limit of forest was 300 m higher than the present one. Duration of Atlantic period stipulated unusual expansion of chestnut and other thermophilic elements of the forest. As to coniferous and beach-coniferous forests, their area was considerably decreased. Subalpine and Alpine vegetation underwent evident reduction.

During Subboreal period (SB), (4500-2500 years ago) climate became rigorous. Five cold and the same number of warm phases were recorded. The heaviest cooling look place 3300 years ago, when temperature lowered down to 10.5 ^{0}C. This time was characterised by the low humidity (Fig. 7.1.8). As a result of climate change all vegetation belts underwent shifting. Besides, in the high-mountain regions, distance of such a shift was considerably larger that in the lower belt of the mountains. In spite of this, the area of chestnut forests was decreased substantially, that probably should be attributed to the decrease of humidity.

Subatlantic period (SA) (beginning 2500 years ago) was characterised by most frequent and sharp climatic fluctuations, with 12 cold and 13 warm phases. Their intensity and duration were rather different. The best climatic conditions were observed in the beginning of SA_2 phase, approximately 2000 years ago, when annual temperature exceeded the present one by 2^0C, while at the boundary between Subboreal and Subatlantic periods it was 2^0C lower than the present temperature. Best climatic conditions were characteristic for the beginning of the SA phase. The largest cooling in the SA_3 phase took place 850-900 years ago, reaching SB_2 level of cooling. In the SA_3 phase, i.e. during the last 1000 years, at last 6 cooling and the same number of warmings were observed. It should be noted that these phenomena had influenced first of all the vegetation of high-mountain regions, since the amplitude of climatic fluctuation increases just with the growth of altitude.

As to the palynological data of the last century, intercomparison of the sea level fluctuation and climate changes gave very interesting results. For instance, it has been found that air temperature decreases in the lowland of Western Georgia, while this value is increasing in mountain regions and Eastern Georgia. Increase of temperature is indicated, as well, by the shift of the curve of the sea level change and that of the upper boundary of forest (Fig. 7.1.8). As to the correlation between the fluctuations of a smaller order, here too, certain regularity has been observed: during the climate cooling, phenomena have completely synchronous character in regions under observation. For example, during the years 1920-1922 maximum temperature decrease was observed both in Poti, Batumi and other districts of Georgia and also almost over the whole Europe. Generally, during the Holocene period, as well as in its separate phases, there has not been found any clear periodicity in the course of climate changes. Climate phases are not similar, neither according to their duration, nor their intensity. The similar picture is observed in the regions of Western Europe [9]. The analysis of paleoclimatic phenomena in Caucasian mountains has revealed their simultaneous occurrence in various vertical belts. In addition, it has been found, that in mountains amplitude of paleoclimatic change increased with the growth of the altitude. Most contrasting character of climatic fluctuations was observed under extreme conditions of high-mountain regions, above the forest limit. Comparison of data obtained by different methods (historical and climatological, dendrochronological, phenological, radioisotope) in various regions makes evident once again the global character of climatic changes of the past.

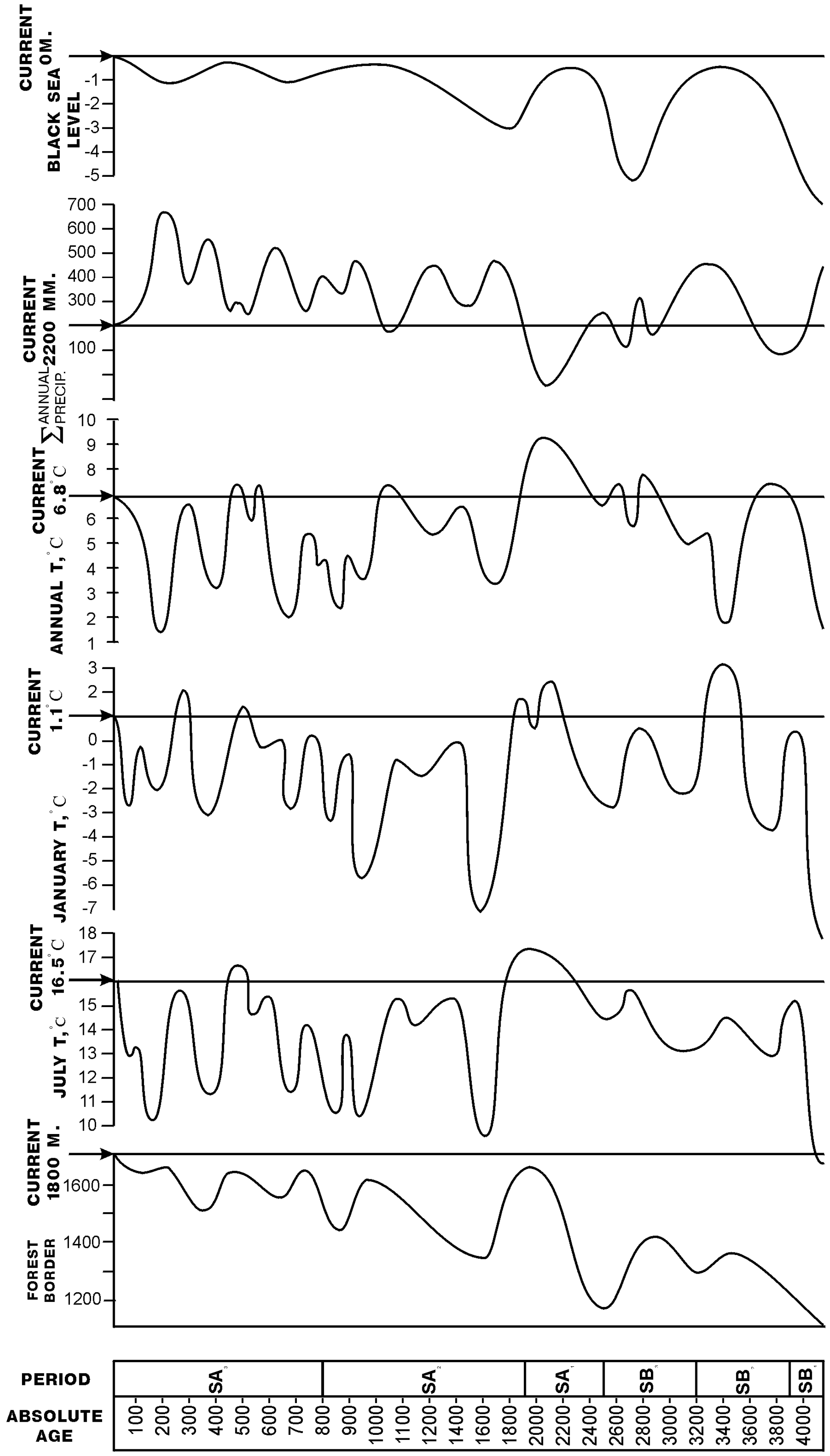


FIG. 7.1.8. CHANGE OF UPPER BORDER OF FOREST, SEA LEVEL, AIR TEMPERATURE AND PRECIPITATION DURING THE LAST 4000 YEARS IN THE BLACK SEA ABKHAZIAN SECTOR

7.2. VULNERABILITY ASSESSMENT IN AGRICULTURE

Under the conditions of transition to new economic relations, the process of worsening the qualitative state of land resources in Georgia and degradation of arable land has intensified. The main reason is the reduction of measures directed towards the increase of soil reproduction capacity, suspension of anti-erosion and land-reclamation activities. The process of applying mineral and organic fertilizers is reduced to minimum. Programs against land contamination are not being implemented. This becomes more evident with the consideration of the fact that Georgia belongs to countries with biologically productive lands, which are very vulnerable to climate change and natural disasters. So, it is necessary to answer the following three questions:

1. How substantial is the impact of global climate change upon the productivity relative to other factors?
2. Is the impact of these changes similar in all regions and for all agricultural crops or not?
3. Is it possible to forecast the impact of global climate change upon the productivity of crops?

Even the simplest calculations prove that by more intensified management of the economy in Georgia it is possible to increase twice the productivity of agriculture under present natural conditions.

The assessment of Georgia’s present soil and climatic potential from the position of market economy makes it necessary to consider in general terms the possible transformation of agricultural production for various conditions of its intensification under the impact of global warming.

Present global climate change will have quite a different impact on the development of agricultural production in Western and Eastern Georgia. One of the most substantial aspects will be its impact upon the hydrological cycle and reasonable utilization of water resources in agriculture. Frequency of extreme natural phenomena (floods, droughts) will increase resulting in the increase of the scale of natural disasters. In Eastern Georgia, under the shortage of water, desertification of the territories is expected. Therefore, to save the ploughed fields (according to the low productivity of wheat, Georgia is at one of the least places in Europe, see Table 7.2.2.), substantial financial resources should be needed. In Western Georgia, the situation will be quite opposite. So, the question arises before the country: “What concept of agricultural development should we use to enter the XXI century?”

In Georgia 43% of the country’s territory is used for agricultural purposes, that makes 0.51 ha per capita. Out of them 0.3 hectares are cultivated, 0.16 hectares of which are ploughed lands.

The country’s natural and climatic characteristics are conditioning the directions of agricultural production. Territory of Georgia is divided into 11 specialized zones and 3 subzones according to agricultural production (Fig. 7.2.1). The map presents the information on the structure of the branches of agricultural production. Division into zones is based upon the grouping of the administrative regions according to following parameters: 1. Economic conditions, 2. Natural conditions, 3. Prospects of agricultural production development.

According to the structure of branches of agriculture, Georgia is characterized by large diversity. They are represented both by main branches, such as vine-growing, tea-growing, citrus-growing, grain growing, and other branches, such as vegetable growing, livestock farming and production of technical crops. The structure of allocation of separate crops is presented in the Table 7.2.1. It clearly shows how substantially have decreased for recent years the areas under such important crops, as tea, fruit, grain, technical crops, etc. The Table also shows the prospects for their increase by the year 2000.

Current political events in Georgia caused sharp decline in the production of agricultural crops (see Table 7.2.2.), as a result of which agricultural sector could not provide the country’s population with agricultural products necessary to meet physiological norms (see Table 7.2.3.). This is mainly explained by considerable decrease of the supply of agriculture with necessary machinery, fertilizers and chemicals.

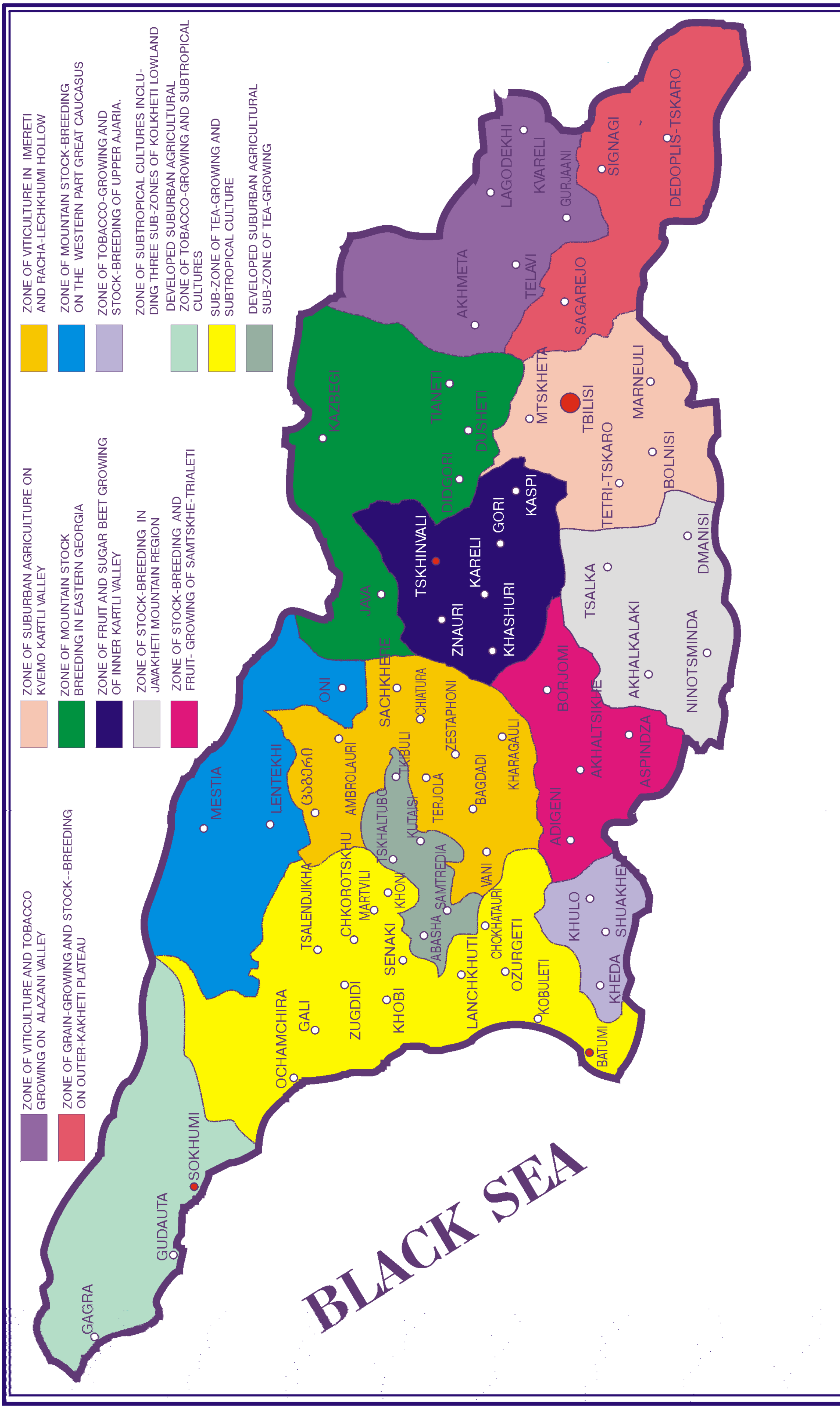


FIG. 7.2.1.SPECIALIZATION OF GEORGIAN AGRICULTURAL PRODUCTION

Table 7.2.1. Allocation of agricultural crops in Georgia (thousand hectares)

Areas under perennials

½	Cultures	1940	1960	1975	1979	1985	1989	1993	1995	1996	1997	2000
1	Vineyard	69.8	85.6	126.1	142.7	128	115.6	78.9	94.2	90.8	81.2	70.0
2	Tea	49.6	55.6	65.8	67.4	67.1	65.1	33.7	33.1	32.5	34.7	50.0
3	Citrus	24.6	9.03	18.03	20.3	26.1	26.7	16.7	13.2	11.9	11.4	20.0
4	Fruit-berries	89.2	106.0	159.1	155.3	147.6	128.2	83.5	94.9	92.6	85.3	72.0

Areas under crops

½	Crops	1940	1965	1970	1975	1979	1988	1991	1993	1995	1996	1997	2000
1	Cereals	748.4	500.8	388.5	373.0	311.6	272.0	290.6	256.0	259.0	280.7	437.2	400.0
1.1	Among them: Winter wheat	232.6	186.2	126.9	140.0	106.3	87.0	101.0	82.7	61.6	79.1	167.4	-
1.2	Spring wheat	39.5	8.5	3.1	1.0	3.4	1.0	1.0	2.1	1.3	1.3	9.2	-
1.3	Winter rye	24.5	30.4	29.7	32.1	25.2	30.0	32.0	22.9	16.3	16.2	23.1	-
1.4	Spring rye	69.1	39.0	24.5	19.7	16.6	16.0	16.0	13.0	15.6	12.9	18.8	-
1.5	Grain maize	355.3	215.8	184.0	155.8	127.7	109.0	114.6	112.0	142.4	148.8	283.2	-
1.6	Beans	19.6	15.3	7.9	9.9	13.1	16.2	12.9	12.3	13.3	13.4	10.6	-
2	Sugar-beet	5.5	4.0	1.9	3.6	3.5	1.4	1.2	0.9	0.9	0.1	-	5.0
3	Sunflower	15.5	21.1	17.2	16.2	13.3	12.0	12.6	14.0	36.2	33.3	36.3	31.1
4	Tobacco	20.9	13.9	12.4	12.4	11.5	10.5	5.7	2.6	1.2	1.1	0.2	1.5
5	Potato	24.6	24.1	24.6	28.3	31.7	30.0	23.2	21.4	23.2	23.6	27.1	35.0
6	Vegetables	14.4	24.1	29.5	32.7	36.2	39.2	31.2	25.3	28.6	28.3	32.3	-
7	Food crops	52.6	174.2	251.5	276.2	305.7	344.8	309.0	143.2	97.9	78.4	57.7	160.0

Table 7.2.2. Average productivity of leading agricultural crops in 1950-1996 (t/ha)

½	Product	1950	1960	1970	1980	1988	1990	1992	1994	1995	1996
1	Vine	3.31	2.18	6.14	2.69	5.9	6.76	4.07	3.76	4.75	3.64
2	Tea	2.08	3.19	4.75	9.04	8.05	9.04	4.16	1.76	1.26	1.04
3	Fruit	2.62	2.74	4.93	5.66	6.48	5.81	4.45	4.94	4.18	4.03
4	Citrus	1.19	7.14	17.46	12.54	26.11	16.98	10.35	7.74	9.09	6.94
5	Winter wheat	0.76	1.02	1.48	1.91	2.79	2.82	1.69	1.3	1.22	1.33
6	Maize-corn	1.3	1.63	1.81	2.45	2.98	2.52	2.32	2.48	2.71	3.3
7	Vegetables	5.5	6.9	9.5	13.5	14.7	11.06	11.36	14.3	14.0	12.1
8	Potato	5.4	9.0	12.1	11.6	10.87	10.56	9.46	12.31	15.2	13.6
9	Sunflower	0.62	0.99	0.65	0.75	1.36	0.58	0.59	0.43	0.2	0.12
10	Tobacco	0.97	1.1	1.3	1.55	1.18	1.12	1.25	0.23	0.83	0.92

Results of investigations, connected with the expected climate change, showed that agriculture development would have serious social, economic and ecological impact in Georgia both at regional and national level.

Degree of vulnerability depends upon ecological, technological and economic factors. Decisive importance here will have both the sensitivity of a separate crops to a changing environment and sensitivity and sustainability of the whole agricultural ecosystems.

Results of investigations showed that climate change in agriculture would have both positive and negative impact. Negative effects may be formulated as the following types of vulnerability:

1. Increase of the area of droughty regions, increase of moisture deficit at the expense of evaporation and the related loss of crops;
2. Intensification of soil salination processes as a result of the increase of evaporation;

Table 7.2.3. Dynamics of foodstuff consumption per capita in Georgia

½	**Foodstuff category**	1985	1990	1991	1992	1993	1994	1995	1996	1997	Physiological norm
1	Overall wheat products estimated into flour, kg	175.1	184.6	183.6	175.0	214.3	152.6	153.6	161	154.2	120.5
2	Fruit (including tinned fruit estimated into raw fruit), kg	60.1	48.3	49.3	42.5	43.9	33.2	36.7	66.3	60.2	110
3	Vegetables (including tinned vegetables estimated into raw vegetables), kg	78.7	71.1	77.2	65.2	72.3	51.5	55.8	85.6	81.2	140.3
4	Potato, kg	46.6	37.3	36.8	33.3	38.9	25.4	26.8	42	44.7	96.7
5	Meat and its products, estimated into meat, kg	41.5	36.5	26.4	19.5	22.9	9.4	12.5	14.6	15.6	70
6	Milk and dairy products estimated into milk, liters	321.0	311.3	308.9	144.1	148.0	90.6	97.9	178.4	217.6	360
7	Fish, kg	7.3	8.0	6.6	2.8	1.4	0.4	0.6	1.3	1.4	18.3
8	Eggs	149.3	140.0	12.9	89.1	75.0	63.2	66.1	105.0	107.7	260
9	Vegetable fats, kg	3.5	4.5	4.2	5.6	3.8	2.4	3.3	6.2	7.1	13.1
10	Sugar, kg	20.2	17.0	10.1	7.0	6.1	4.8	6.0	21.0	23.0	36.5

3. Rapid mineralization and exhaustion of soil organic mass;
4. Increase of the intensity and frequency of frosts in some regions as a result of humidity decrease;
5. Creation of better conditions for spreading of diseases and vermin of crops as a result of winter warming;
6. Intensification of erosion processes due to the increase of precipitation amount and frequency in some humid regions, raise of frequency of floods, hail, etc.

Positive effects may be revealed in the following way:

1. Expansion of the area under heat-loving plants and raising indices of their productivity and quality;
2. Possibility to get two and more harvests (as the after the reap crops). Increase of fodder storage for livestock farming and raise of its productivity;
3. Increased duration of the use of meadows;
4. Energy saving in greenhouse farming and further development of this branch.

To establish the degree of vulnerability in Georgian agriculture, the impact of expected climate change on main crops, grown in Georgia and possibilities of their adaptation have been studied.

Tea is the main crop in Western Georgia. Its growing, development and productivity are stipulated by sums of temperature over 10^0C. The more is this value under optimal humidity and high agricultural technology, the higher are the harvest and its qualitative indices.

The maximum growth of tea-bush is observed at 22^0C, and for its normal development the temperature should not exceed 30-32^0C. As a result of investigations (with consideration of active temperatures and precipitation sums) it has been established that according to the frequency of tealeaf harvesting, 3 zones may be distinguished: 1. Places where picking frequency is 18 or more. It comprises the part of Ajara Black Sea coastline from Khelvachauri to Kobuleti; 2. Zone, which expands over the relatively mountainous part of Ajara, including sea coastlines of Guria, Imereti, Samegrelo and Abkhazia as well, where harvesting frequency is variable within 15-17; 3. This zone covers indicated (I-II zones) mountain areas, where picking frequency is 15 or less.

In case of the increase of temperature by 1^0C, sums of active temperatures in the regions of tea crop will increase by 250-300^0C, as a result of which, increase of tea picking by one or more is expected. That implies the increase of the harvest of tealeaf up to 300-400 kg from each hectare. In addition, it will be possible to expand the area for tea production, which will be economically acceptable for Georgia, up to 50.000 hectares. It may be expanded in the southern part of Western Georgia up to the altitude of 550-600 m a.s.l. (in the mountainous parts of Ajara, Samegrelo, and Abkhazia). For the lower limit should be considered the sum of temperatures higher than 10^0C equal to 3200^0C and minimum air temperature -15^0C taking into account the presence of snow cover for the better wintering of tea crop.

Therefore, in Western Georgia, possibilities for the expansion of tea production, associated with the necessity of considerable financial investments should be created.

Vine. Viticulture and winemaking is the oldest and currently the leading branch of Georgian economy. Vine is expanded both in the Western and Eastern Georgia. Species of early ripeness are introduced up to 1100 m, and of late ripeness reach the heights of 800-820 m a.s.l.

Volume of grape production and the quality of wine substantially depend upon the climatic conditions. The quality of wine mainly forms in the phase of ripening, when mean diurnal air temperature is over 20^0C and diurnal amplitude is more than 10^0C. Under such conditions sugar content is over 20-22%, the quality of wine being high, respectively.

It has been estimated that optimal area of vineyards in Georgia should be 70 thousand hectares, average productivity of grapes should not exceed 7.5 t/ha. Keeping to of such parameters will stipulate high quality of grapes and wine. It is very important, since the fine wines represent substantial source of foreign currency inflow.

Under conditions of global warming, the assessment of vine vulnerability requires a special approach that is due to the fact that vine in Georgia is represented by numerous sorts, specific regions, variety of types of the product and qualitative indices (table, ordinary wine, champagne, etc.).

Investigations showed, that in case of expected climate change (with temperature increase by 1^0C), in main wine growing regions of Eastern Georgia humidity decreases considerably, number of draughty days increases. This period, especially according to seasonal phenomena, reaches the critical limit in the phase of ripening, when formation of qualitative indices (sugar content) occurs. Proceeding from the foregoing, qualitative indices are given in the Table 7.2.4.

Table 7.2.4. Impact of expected climate change on the indices of sugar content of grapes in the main viticulture districts of Georgia

District	$\Sigma>20^0$C ^{0}C		September t, ^{0}C		Atmosph. Precipit., mm.	Hydro-thermal coeffic. (HTC)	Sugar content c, %		
	Actual	Exp.	Actual	Exp.	Actual	Exp.	Actual	Exp.	Δc
Kvareli	2090	2200	19.2	20.0	86	1.22	20.2	21.3	1.1
Gurjaani	2050	2160	19.0	20.0	73	1.13	20.0	21.2	1.2
Akhmeta	1610	1710	18.3	19.3	62	1.06	19.0	20.0	1.0
Sagarejo	1420	1520	17.3	18.3	63	1.10	17.7	18.8	1.1
Zestaponi	2450	2570	20.3	21.3	85	1.18	21.7	22.8	1.1

As the table shows, in case of temperature increase by 1^0C, sugar content in all districts increases by 1.0-1.2% in absolute value. Preliminary investigations showed that in case of temperature increase by 2^0C, sugar content will increase by 2-2.4%. Considerable changes are expected, also in the productivity indices, presented in the table 7.2.5.

It can be seen from this table, that in case of temperature increase by 1^0C, the decrease of wine productivity is expected in Gurjaani and Kvarely districts. E.g. the decrease of productivity in Kvareli district reaches 6%, and in case of the increase by 2^0C loss of productivity will be much higher and for some regions it will reach 10-15%.

Table 7.2.5. Indices of vine productivity at the raise of air temperature by 1^0C

District	Change of air temperature ^{0}C		Many-year productivity (t/ha)	Expected changes of productivity (%)
	IV-X	IV-VIII		
Gurjaani	+0.34	+0.4	5.35	-2.2
Kvareli	+0.25	+0.4	3.76	-6.0
Telavi	+0.34	+0.4	4.47	+0.7
Akhmeta	+0.61	+0.7	4.49	+2.4
Mtskheta	+0.03	+0.5	2.91	+8.1

Proceeding from these data it is evident that the degree of vine vulnerability in Eastern Georgia is rather high and it needs the conduction of substantial adaptation measures in the future.

In case of temperature increase in viticulture regions of Western Georgia relatively better conditions will create for the development of vine, increasing the area of its expansion and, as it is very important, productivity and qualitative indices will be substantially increased.

Cereals. Winter wheat. According to 1997 data, 73% of the area under crops in Georgia was occupied by corn. 39% of them was under wheat, which is the main cereal crop in the regions of Eastern Georgia.

In connection with expected climate change and for the identification of the degree of wheat vulnerability, the base 30 year climatic data have been used. According to the scenario, created on the basis of the analysis, in case of the increase of air temperature by 2^0C, precipitation amount considerably decreases in the main wheat growing areas of Eastern Georgia, humidity decreases, amount of evaporation and number of draughty days will increase.

According to the results of investigation it has been determined that while assessing wheat vulnerability, especially important are peculiarities of individual development of the crop according to separate phases, since it responds differently to maximum temperature in different phases. Temperature change and its seasonal nature considerably stipulate development of the plant and its productivity.

In case of the increase of air temperature by 2^0C in the main wheat growing regions, substantial negative phenomena are expected in the different phases of wheat development. They are affected mainly by extreme phenomena during the spring and summer (days with temperature higher than optimal), when vegetative and generating parts are forming. In this period, such temperatures may result in delaying of wheat-ear development and respectively decrease the corn amount, formation and accumulation of organic substances is delayed or stopped at all (when $t>36^0$C). That is being reflected in the indices of productivity. It has been considered, as well, that warming by each 1^0C causes the increase of evaporation by 4-6% and during the vegetation period, it will be necessary to increase precipitation by 3-7%, or conduct corresponding irrigation measures, that will be connected with large financial investments in Eastern Georgia. Crop loss may reach 30-60% for some regions. If temperature increases by 1^0C, then degree of wheat vulnerability will be relatively low and the loss may reach 15-35%. Temperature increase may cause transfer of the zone of winter wheat growing to mountain regions, but it will result in the decrease of economic indices of wheat production, since the lack of roads and low level of mechanization of technological processes on the slopes cause substantial raising of prices on the products. That is why in foreign countries the agriculture of mountain areas is being subsidized.

Therefore, it may be concluded that wheat in the main regions of Eastern Georgia is notable for its relatively high vulnerability, and requires working out and conduction of sound adaptation measures.

Maize. Due to the variety of its use, this crop is one of the main cereals in Georgia. Areas under it make 150 thousand hectares for grain and 50 thousand hectares for silage.

According to investigations carried out, maize is highly vulnerable to expected climate change in Eastern Georgia, since the temperature increase will cause corresponding changes of the periods between phases of maize development. This will be stipulated by the increase of the number of draughty days, intensification of moisture evaporation and the decrease of precipitation resulting in the decrease of harvest by 20-30%.

In case of the raising of the temperature by 2^0C in Eastern Georgia, temperature sums will increase by 400-600^0C, that will make possible spatial replacement of maize by 300-350 m higher. In case of temperature increase by 1^0C in Western Georgia, under expected conditions of precipitation amount increase, possibilities of expanded maize production may be created. The development of maize growing on Kolkhida Lowland is quite justified in case of changed climatic conditions. On the basis of the analysis it has been determined that it will be possible to increase production of maize and raise its productivity and qualitative indices. In particular, productivity in the maize producing regions will increase by 30-40%.

According to the results of investigations, degree of vulnerability of main agricultural crops expanded in Georgia was determined and is being summarized in the Table 7.2.6.

Table 7.2.6. Indices of agricultural crop vulnerability

½	Crops	Types of vulnerability	½	Crops	Types of vulnerability
1	Vine	– (East. Georgia) 0 (West. Georgia)	8	Vegetables	+
2	Tea	0	9	Sunflower	+
3	Citrus	0	10	Tobacco	+ (East. Georgia)
4	Fruits and Berries	– (East. Georgia)	11	Sugar beet	+
5	Winter wheat	+	12	Maize for grain	+ (East. Georgia)
6	Spring wheat	+	13	Maize for silage	+ (East. Georgia)
7	Potato	+ (South. Georgia)	14	Food crops	+ (East. Georgia)

Notes: + vulnerable;
– less vulnerable;
0 not vulnerable.

As the table shows, most crops in Eastern Georgia-wheat, sunflower, tobacco, sugar beet, vegetables, maize are vulnerable to expected climate change, as well as potato, which is cultivated in regions of Southern Georgia. This kind of vulnerability of crops is stipulated by the decrease of precipitation, increase of the frequency of droughty days, reduction of soil humidity and other effects caused by the warming, which are reflected in productivity indices. Relatively less vulnerable are fruits and vine in Eastern Georgia. As to Western Georgia, the main crops, expanded in this region – tea, citrus, vine and maize are not vulnerable.

While considering the impact of temperature increase on the agricultural sector, specialist did not pay attention to negative influence of this phenomena upon the machinery, used in agriculture. However, it is known that both electric devices and capacity of tractor engines are substantially affected by environmental temperature. Particularly, when temperature increases by 1^0C, it causes the loss of 1.3% capacity of nonsynchronized engines.

Therefore, analyzing the aforesaid, we can conclude, that under the conditions of considerable climate change, basic transformation of the management of Georgian agriculture is necessary. This implies agroclimatic vertical shift, increase of vegetation period. As to productivity, due to the increase of aridity, in Eastern Georgia it will slightly decrease. However, it will be compensated by the increase of productivity in Western Georgia. At the same time, it should be noted that the improvement of soil productivity (and this measure due to irrigation, is more real) will mainly overshadow negative impact of climate change. It should be also considered here, that probability of catastrophic phenomena will increase, that is mainly associated with the increase of the recurrence of draughts and floods.

On the basis of the assessment of vulnerability degree, we have the opportunity to work out timely adaptation measures, determine correct strategy at the State level. This will provide conduction of measures, which will prevent and neutralize expected negative consequences of climate change in agriculture.

7.3. VULNERABILITY OF WATER RESOURCES

Main features of water resources in Georgia are represented by rivers, underground waters, glaciers, swamps, lakes and reservoirs. Among them the first three types of objects are important, determining all phenomena, processes connected with water resources, their course and impact on the environment.

Among the water objects rivers, in which Georgia is rich, are most important. Here, 26 thousand rivers with total length of 60,000 km are recorded. The average density of river network is 0.85 km/km^2. This is almost 3 times as much as in neighboring countries. River network is unequally distributed over Georgian territory. Their number in Western Georgia makes 18,100 with a total length of 35,000 km, that corresponds to 69% and 58% of total number and length of rivers, respectively. This Region of Georgia is distinguished as well, for large density of river network - 1.07 km/km^2. River network of the Eastern Georgia is composed by almost 8,000 (31%) rivers, with total length of 25,000 km (42%), with network density of 0.68 km/km^2 [14].

The main part of the river network is comprised by very small rivers, with the length less than 10 km. Their share is composed by 25 000 (97%) rivers, with total length of 43 000 km (72%). There are as well a lot of small rivers with the length of 10-100 km. Their share is made by 690 (2.6%) rivers with total length of 13 000 km (22%). The number of medium-sized rivers with length of 101-500 km is very small. It comprises only 14 (0.027%) though they have many tributaries. The first place belongs to the River Mtkvari (Kura), the basin of which is composed by 6434 (24.7%) rivers with total length of 13656 km (22.9%). There are 6 rivers, the network of which is composed by 1000-3000 tributaries: Kvirila (3320 rivers, with total length of 6112km), Ktsia-Khrami (2260 rivers and 6717 km), Alazani (1796 rivers and 6845 km), Ajaristskali (1511 rivers and 2115 km), Khobistskali (1038 rivers and 1635km) and Kodori (1307 rivers and 2121 km).

Density of river network is characterised by vertical distribution – it increases with the increase of the height above sea level, reaches its maximum at the average altitude of the basin, and then decreases to the heads of the rivers. Distribution of rivers according to the categories, number of which increases with the increase of river length and the area of watershed, is of the same nature. Their distribution is characterised by the increase of the number of rivers and the length from low to high categories. Rivers differ according to the area of watershed. It has great impact upon river water content and is widely used in hydrological and hydrographic calculations. Basin of the R.Mtkvari equals to 188,000 km^2 (within Georgia 19,050 km^2), Chirokhi – 22,100 km^2 (within Georgia – 1,600 km^2), Rioni – 13,400 km^2, Alazani – 10,800 km^2 (within Georgia - 5,943 km^2), Ktsia-Khrami – 8,340 km^2 (within Georgia – 4,600 km^2), Iori – 4,650 km^2 (within Georgia – 4,190 km^2), Enguri – 4,060 km^2 and others. Generally, rivers with watershed areas of less than 500 km^2 are predominant. Their share is composed by 99.8% of the total number of rivers.

Parameters of river hydrographic network change not only according to the territory, but also according to time, as well, both under the impact of anthropogenic and natural factors. Number of irrigation canals both functioning and being under construction, has considerably increased. At present, the following irrigation systems, equipped with modern hydrotechnical constructions exist in Georgia: Tashiskari, Tiriponi, Skra-Grakali, Tezi-Okami, Mukhrani, Misaktsieli, Samgori, Alazani, etc. Total length of their irrigation network reached 18000km, as a result of which network density on the irrigated area increased up to 3.5 km/km^2, that is 6-10 times more than the density of natura1 network. But there are regions, where periodica1 increase or decrease of the parameters of the river network are observed. This is characteristic for high mountain zone, where glaciation takes place. During the Wurm Ice Age density of river network was 3 times less than the density of present river network. Therefore, density of river network decreases in the zone of glaciation with its intensification and vice versa.

Among the water resources in Georgia considerable part belongs to current glaciation, which represents the remainder of the third – Wurm Ice age of Pleistocene. It began 24000 years ago and at the maximum stage of its development, that lasted for 2000 years, it covered 16-17 thousand km^2, that made 35% of the whole glaciation of the Caucasus. In this period glaciers descended very low, down to 800-1000 m. above sea level. Length of some glaciers reached 60-70 km. Basin of the River Enguri was covered by glaciers almost up to village Khaishi over approximately 2700km^2.Degradation of glaciers began 12-13 thousand years ago and by 13-th century A.D. their area considerably decreased. Heavy precipitation and low air temperature of the XIV-XVII centuries were followed by enhancement of glaciers (small glaciation), which reached maximum development in the 50-ies of the past century (the Fernau stage). Total area of glaciers increased then by 40% relative to the area of the XIII century. During the following years degradation of glaciers began again. Their area decreased down to 511 km^2, that makes 36% of the glaciation of the Caucasus and is 17% less then the area of glaciation in 1891. But degradation of glaciers was not continuous during the last 150 years: in separate years (6-7 times) glacier activation was observed. Relatively heavy was the period of small cooling in the 60-70-es of our century, which was caused by heavy precipitation in 1955-1965 (±5 years), that was followed by the glacier activation and their advancement up to 30-120 m. Since that time glacier degradation began both on global and local scales, that is continuing up to now.

The Great Caucasian Range is rich in contemporary glaciation. Prominent is basin of the R. Enguri, where glaciers cover the area of 288km^2, accumulating 22.5 km^3 of water, that makes 56 and 75% of the area and volume of the whole glaciation of Georgia, respectively. Noticeable are also basins of the R. Tergi (in Kazbegi district) - 68 km^3 (13%) and 3.34 km^3 (11%), R. Rioni-63 km^3 (12%) and 2.2km ^{3} (7%), R. Kodori-60 km^3 (11%) and 1.6 km^3 (5%). Glaciers are also expanded in the basins of the rivers Bzipi (7.8 km^2 and 0.19 km^3), Kelasuri (1.5 km^2 and0.03 km^3), Khobi (1.6 km^2 and 0.04 km^3), Didi Liakhvi (6.6 km^2 and 0.13 km^3), Aragvi (1.6 km^2 and 0.03 km^3).

Glacier regime is evidently connected with precipitation and air temperature. In case of 3400 m for the overage altitude of the firn line, the increase of air temperature by 1^0C will cause the moving up of firn line by 160 m, height of the runoff layer will increase by 500-550 mm. In case of the rise of air temperature by 2^0C, that is expected in the regions of weak expansion of glaciers, firn 1ine will move up by 320 m and many glaciers will find themselves without the alimentation field, that will cause their complete disappearance, as it is observed now in the eastern and lower regions of glaciation. As a result of glacier melting, rivers get additionally 1.5 km^3 of snow melt water, and some rivers – 0.86 km^3 (R. Enguri), i.e. almost the same amount, as it is in Jvari reservoir**.** In addition, glaciers represent the basis for creation of various types of recreational activity, functioning of national glaciation parks, that makes the source of income for the local population. Therefore, glaciers should be preserved on the basis of implementation of necessary adaptation measures.

Swamps, swamped places, boggy reservoirs represent places of the accumulation of the excess of water. 87 swamps and boggy places are recorded in Georgia, total area of which makes 1081 km^2. Number of swamps and boggy places of up to 10 km^2 area makes 39 with total area of 232 km^2. There are considerably less large swamps and boggy places the area of which is more than 10 km^2. Their number is only 11 (12%) but they are well-developed and occupy the area of almost 600 km^2, that is 55% of the whole area. Swamps expanded up to the altitude of 100 m a.s.l. are characteristic for Western Georgia. These are well-known swamps and boggy places at Kolkhida Lowland, where 17 swamps with a total area of about 600 km^2 are recorded.

Considerable attention during the current decades is paid to the utilisation of swamps and boggy places. A number of drainage measures have been conducted. They imply drainage of the eastern part of Kolkhida Lowland, other swamps and boggy places located at the altitude up to 100 m. Actions directed on the utilisation of these lands for residential purposes and as fields under agricultural crops are being conducted. It is necessary to specify water balance of swamps, quantitative characteristics of the regime of interaction between water and heat, etc. That needs declaration of some swamps as National Reserve and conduction of appropriate adaptation measures.

Lakes and reservoirs occupy 170 and 163 km^2, respectively, represented by 856 and 44 units as well. They accumulate 0.72 and 3.32 km^3 of water, respectively.

Overall water resources of Georgia make 100km^3. Share of rivers is 65 km^3, glaciers-30km^3, lakes-0.72 km^3, reservoirs -3,32 km^3, swamps-1.9 km^3. Among them, approximately 35 km^3 of water, accumulated in glaciers, lakes, reservoirs and swamps, represent secular stock of water and takes less part in the hydrological cycle of water (Fig.7.3.1)

56.5 km^3 of water out of 65 km^3 of river runoff is formed over the territory of Georgia, making 86% of the total flow. The remaining 8.74 km^3 (14%) comes from the outside territories (Armenia and Turkey). These water resources are not equally distributed, that is well seen from the Table 7.3.1.

The local (4) and transit (5) runoff in Georgia (1), in Western (2) and Eastern parts (3), river runoff (a), glacier (b), water reservoirs (c), lakes (d), marsh (e).

FIG. 7.3.1. MEAN ANNUAL RUNOFF (mm)

Table 7.3.1. Distribution of water resources over the regions by 1980 (discharge in km^3)

Region	Local	From neighbouring countries	Total
Western Georgia	43.8	6.62	50.4
Eastern Georgia	12.7	2.12	14.8
Georgia	56.5	8.74	65.2

Renewable water resources play considerable role in the country's economy-energy production, industry, municipal activity and irrigation. As a result, by the years of 1980-1990, complex utilisation of renewable water resources in the national economy reached 5.2 km^3, that makes 8% of the whole water resources. Approximately 70% (3.5 km^3) of it is utilised in agriculture for the irrigation of agricultural crops, moistening of winter pastures, for household and municipal needs of the population of villages, etc. The rest 1.7 km^3 of water is used in industry, municipal activities of the cities. Water utilisation in Eastern Georgia exceeds almost 5 times that of Western Georgia. It is planned to increase complex water utilisation up to 6-7 km^3 in future.

Out of utilised water resources only 20-25% of water returns to rivers. The rest is spent on plant vegetation, evaporation, infiltration into the soil, etc. In addition, it should be noted that to provide the areas under irrigation with renewable water resources canals of 10 000 km total length (including drainage canals) have been constructed. This fact, certainly, increases the losses of water.

Water-taking causes the decrease of river runoff and is characterised by the coefficient of water discharge decrease, which for the whole territory of Georgia makes 0.97. Increase of complex utilisation of water resources is planned for the nearest future, as a result of which the coefficient of water discharge decrease will reach 0.91. Annual water discharge decrease coefficient has been calculated for all hydrological posts. Map of geographical distribution of the coefficient of decrease is presented on the Fig. 7.3.2.

The map shows that decrease of water discharge is not observed over the most part of Georgian territory (80 %) and its coefficient is equal to 1.0 (k=1.0) Over the rest of the territory decrease of water resources as a result of water consumption is observed. In Western Georgia it is presented by the smallest areas - in the basin of R. Rioni and in the mouths of its confluents within Kolkhida Lowland and in the basin of Acharistskali. This coefficient does not come down lower than 0.95. Largest decrease of water discharge is observed in Eastern Georgia, where this coefficient falls down to 0.65 and comprises lower part of the R. Iori, left and right confluents of the R. Mtkvari within Lower Kartly Valley. Its upper limit, where k=1.0 passes at the altitude of 700-800 m. Water discharge decrease is not observed above this level, but still the basins of the rivers Paravani and Potskhovi should be noted, where the coefficient of decrease is more than 0.95 as it occurs in Western Georgia.

Low coefficients of water discharge decrease are observed in separate months. It can be seen on the case of the R. Ktsia-Khrami (vil. Imiri), in the months of maximum utilization of its waters. During the years with lack of water-1958,1960, 1961 the coefficient of water discharge decrease fell considerably (0.36-0.51) and increased with the increase of water content. During relatively water abundant years of 1951, 1955 and 1959 coefficient of decrease reached 0.58-0.62. Relation of the same nature is observed on other rivers, as well.

State of renewable water resources and connected with them other phenomena by the year 1980 were taken as a basis of probabilistic forecast of many year prognostic average water discharge for the years 2010, 2030 and 2075.

Deterministic, conceptual (SRM) and geographic-hydrological models have been used. Numerical realization of a deterministic model requires information about snow-melt water, rain-water, underground runoff intensity, snowfall starting, growth of cold storage in snow, evaporation from snow, freezing of water in snow cover, snow-melting, rainfall on the snow surface, water saturation and discharge in the snow cover, infiltration and initial layer thickness, evaporation, etc. It is accomplished according to the homogeneous landscape types, singled out in the basin of the river.

Current approach to the assessment of climate change impact on the river runoff on the basis of conceptual model comprises different models of water balance and “precipitation-runoff”. Modeling of water movement is conducted by these models since the time, when water falls in the basin in the form of precipitation up to the time, when it leaves the watershed as runoff.

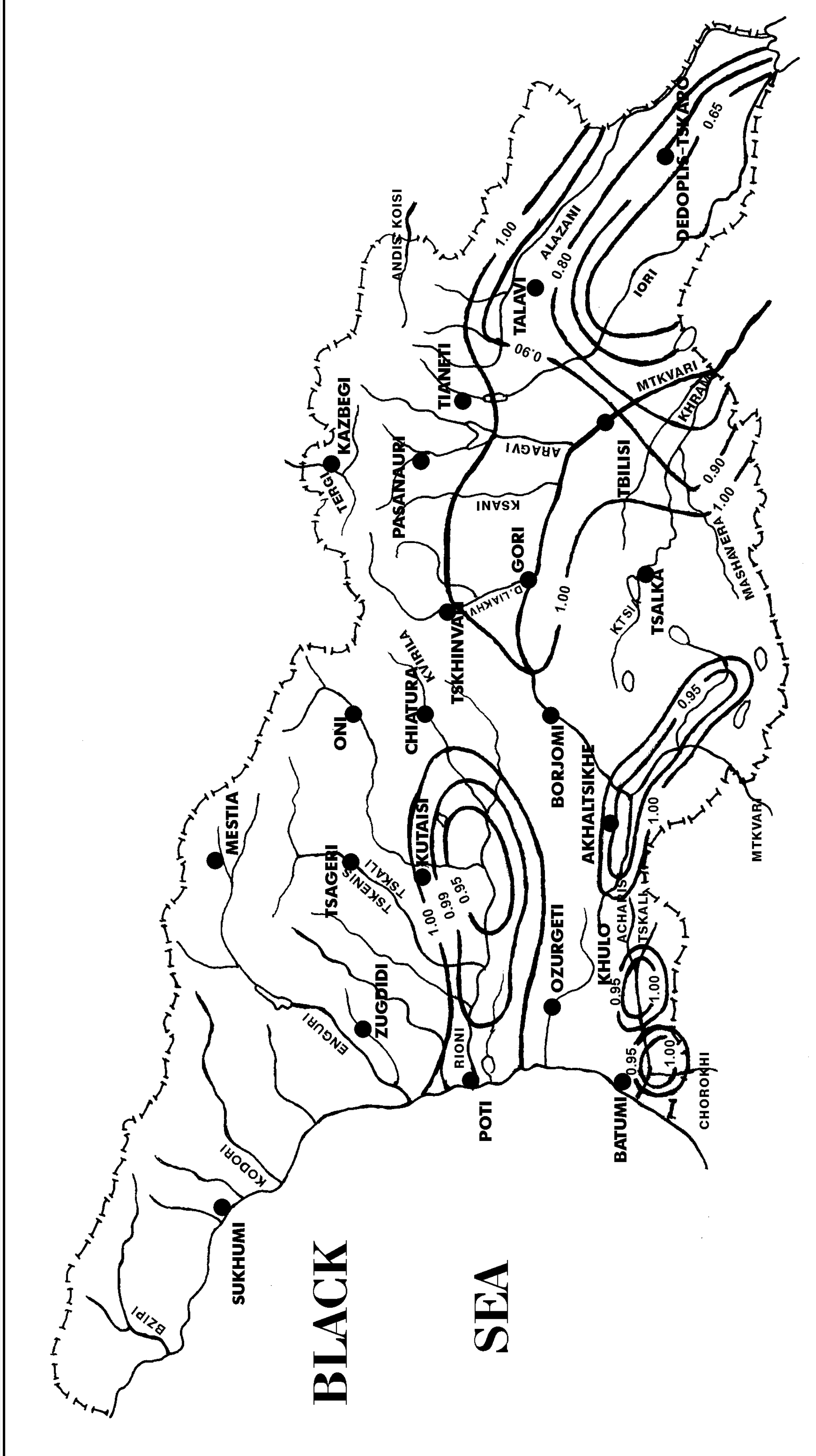


FIG. 7.3.2. DISTRIBUTION OF RUNOFF DECREASE COEFFICIENT

The geographical model is based upon empirical-statistical relations existing between the river runoff, atmospheric precipitation and air temperature.

There is good correspondence between modeled and observed annual runoffs for several rivers of Georgia. Mean error makes 15-20% in case of application of the first and second models and 5-7%, in case of the application of geographical-hydrological model.

Using of geographical model gives sufficiently good results. For example, while applying a deterministic model, we got the worst result at the River Mtkvari – Vil. Minadze. The error makes, on the average, 59%. Calculations carried out using the geographical model showed, that in case of temperature increase by 1 or 2^0C, runoff will increase on the rivers of Western Georgia (Bzipi, Enguri, Rioni), on the average, by 7-9% and 8-14%, respectively and on the river of Acharis-Tscali, it will decrease by 2 and 4%, respectively. However, obtained results are probabilistic, since for 3 years, selected in actual records when air temperature increase by 1 or 2^0C was observed really, other results were obtained.

Generally, corresponding change of run-off connected with climate change, should be reflected in average annual values of the run-off itself and the analysis of their dynamics will give more reliable results.

For the realization of this method, due to the lack of reliable prognostic values of atmospheric precipitation and air temperature for the prognostic period, average values of a long period observation, taken from the water cadastre for the years of 1962, 1970, 1975, 1980 and 1990, were used . These values have been calculated since the start of observations until the years of 1962, 1970, 1975, 1980 and 1990. On the basis of their dynamics, for the prognostic years of 2010, 2030 and 2075 calculations showed that at the level of 1980 less water discharge is expected in 28 (21%) hydrological sections, among them for the confluents of the upper parts of the rivers Kodori and Enguri, for the rivers of southern upland of Western Georgia in the portion of Khanistskali-Chakvistskali, on some rivers of the basin of the River Kvirila. In Eastern Georgia the decrease will take place on the R. Mtkvari (ZAHES and the city of Tbilisi) and on its small tributaries lower Borjomi and on the R. Duruji, as well. Generally, for Eastern Georgia, deviation of water discharges by the years of 2010 and 2030 relative to the leve1 of the year of 1980 are within $-14 \div +39$ m^3 /s and $-24 \div +52$ m^3/s respectively, and the average deviation makes +5 and+10% respectively. Trend of discharge decrease in the heads of the rivers Kodori and Enguri is caused by the trend of the increase of snow amount and as a result of the increase of albedo, which leads to the decrease of glacier melting and their hydrological efficiency. At the portion of Dzegvi-Tbilisi, on the River Mtkvari, the trend of the decrease of discharges is caused by 25 m^3/s water consumption from the River Aragvi for the water supply of Tbilisi and for the alimentation of Tbilisi Reservoir.

Indicated method was used for the calculation of total runoff for closing hydrological sections of all rivers. Number of rivers of this category appeared to be 13 in Western Georgia and 7-in Eastern Georgia. Their average many-year overall runoff for 1960, 1970, 1975, 1980, 1990 and projected values for 2010, 2030 and 2075 were calculated without (I version) and with the consideration (II version) of runoff cyclic variability. It appeared that many-year average discharge will increase by 4.7% and 13% for 2010,2030 and 2075 level relative to 1980 level. At the same time, this increase in Western Georgia will be 2-4% more than in Eastern Georgia (Table 7.3.2).

We may expect variation of annual discharge series as a result of runoff cyclic variability, particularly, in the phase of increase (1975-2015 and 2055-2075) growth will be observed, and in the phase of fall (2015-2055) - decrease will take place. In this case, many-year average discharge will increase generally by 3.8-4.4% in Georgia, particularly by 1.9-3.2% in Eastern Georgia and by 4.5-5.0% - in Western Georgia relative to 1980 level.

According to preliminary considerations, river runoff in Georgia during 2010-2030 will increase by up to 4-7%. Energy produced at hydro power stations will increase, respectively.

Georgia is rich in hydro power resources [13]. They make 229 billion kWh, large part of which – 219 billion kWh (96%) is composed by local resources. Only 10 billion kWh (4%) are due to transit water flow. These resources are not equally distributed over the Georgian territory. Their great part, 165 billion kWh (72%) comes on Western Georgia (especially on its northern part). 64 billion kWh (28%) comes on Eastern Georgia. Here, the northern part is distinguished for relatively large hydro power resources. Generally, there are 5 times as much hydro power resources in the northern part relative to southern Georgia. From the recorded 208 large, medium-size and small rivers, 19 large rivers give 72 billion kWh energy, among them remarkable for producing more than 5 billion kWh energy, are rivers Enguri (12.4 billion kWh), Rioni (10 billion kWh), Mtkvari (9.4 billion kWh), Tskhenistskali (5.65 billion kWh) and Kodori (5.4 billion kWh) (Fig. 7.3.3). According to such characteristics of hydro energetic resources Georgia takes one of the leading places in the world.

Table 7.3.2. Expected variability of the runoff of Georgian rivers for 2010, 2030 and 2075 years relative to 1980 level

Region	Years					Prognostic years		
	1960	1970	1975	1980	1990	2010	2030	2075
I Version - Runoff of the main rivers								
Western Georgia: m^3/s	897	900	898	907	930	952	979	1044
%						4.96	7.94	15.1
Eastern Georgia: m^3/s	351	364	362	365	367	375	382	399
%						2.74	4.66	9.32
Georgia: m^3/s	1248	1264	1260	1272	1297	1327	1361	1443
%						4.3	7.0	13.4
II Version - With the consideration of runoff cycling variability								
Western Georgia: m^3/s						952	948	951
%						4.96	4.52	4.85
Eastern Georgia: m^3/s						375	372	377
%						2.74	1.91	3.29
Georgia: m^3/s						1327	1320	1328
%						4.3	3.7	4.4
I Version – Total runoff of Georgian territory								
Western Georgia: m^3/s				1600		1679	1727	1842
%						4.96	7.94	15.1
Eastern Georgia: m^3/s				470		483	492	514
%						2.74	4.66	9.32
Georgia: m^3/s				2070		2162	2219	2356
%						4.3	7.0	13.4
II Version - With the consideration of runoff cyclic variability								
Western Georgia: m^3/s				1600		1679	1672	1678
%						4.94	4.52	4.85
Eastern Georgia: m^3/s				470		483	479	485
%						2.74	1.91	3.19
Georgia: m^3/s				2070		2162	2158	2163
%						4.3	3.7	4.4

At present, approximately 60 large, medium-sized and small hydro power stations are functioning in the energy system of Georgia. Their total installed capacity is 2.7 million kW, and production makes 10 billion kWh. According to present situation, the actual production of these hydro power stations is decreased by 40% and does not exceed 6 billion kWh, while in 1988 it made 8.7 billion kWh. Reason for this is that during the last 6-7 years neither major nor current repairs were conducted. We should suggest that during the nearest 2-3 years reconstruction and rehabilitation of existing hydro power stations will be carried out, that will increase energy production by 2-2.5 billion kWh and will provide the restoration of 1988 level.

Simultaneously, construction of 700 MW capacity Khudoni hydro power plant should be restarted, and Namokhvani, Twishi and Zhoneti hydro power stations should be added to the Rioni cascade. Total capacity of these four stations makes 1.14 million kW, and energy production is equal to 3.3 billion kWh. Generally, during the nearest 20-30 years approximately 300 medium-sized and small hydro power stations may be constructed with a total 40 billion kWh production. This will allow to assimilate country’s hydro energetic potential practically by 80%, while technically it is possible to produce twice as much energy.

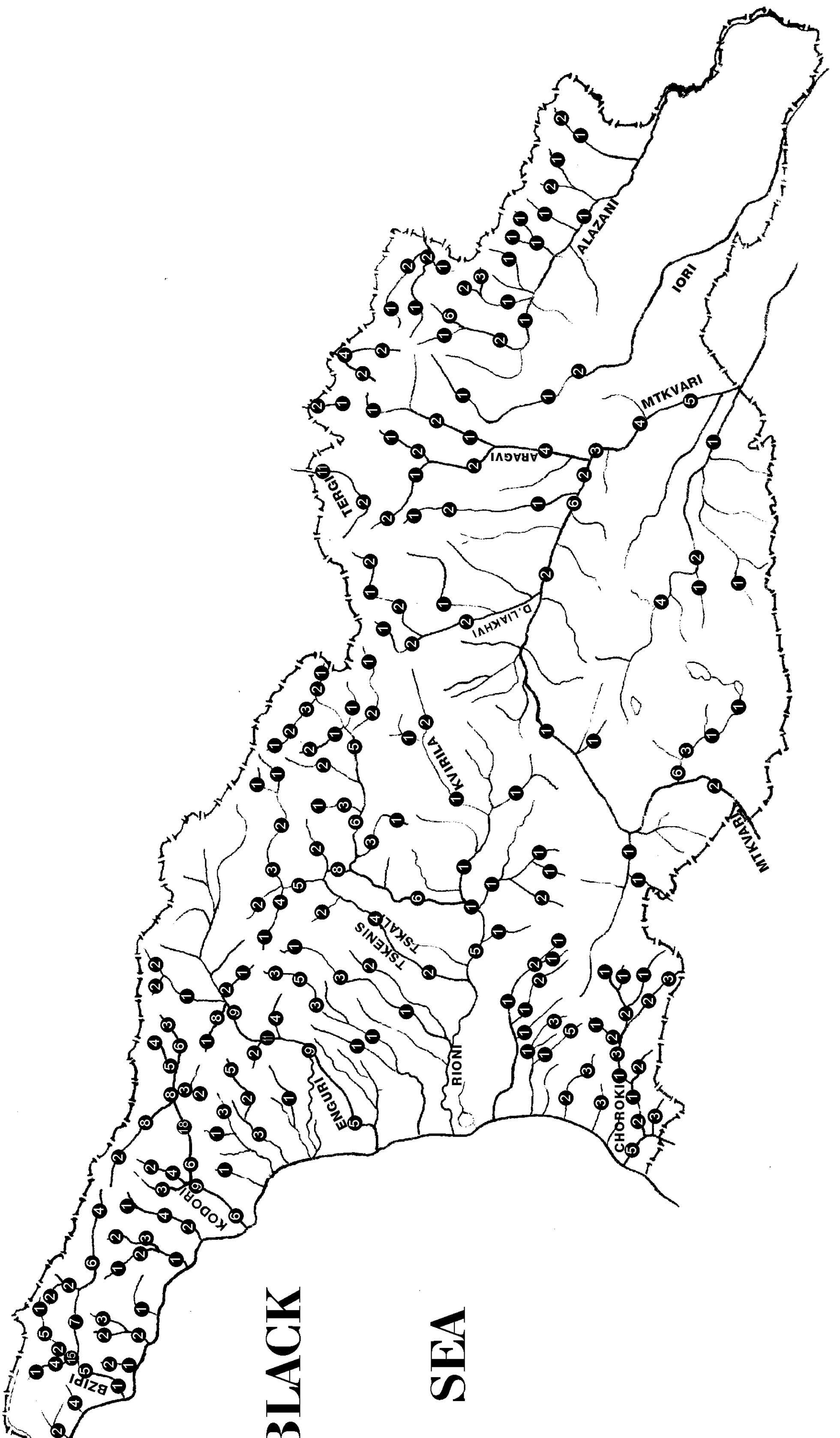


FIG. 7.3.3. DISTRIBUTION OF POTENTIAL HYDROPOWER RESOURCES ON THE MAIN RIVERS OF GEORGIA (MW/km)

On the basis of indicated data, it may be suggested that in case of staying within existing at present runoff norms, energy production will be at the present level, but if runoff increase by the years of 2010-2030 makes 4-7%, then at the same hydro power stations extra 340 million kWh will be produced by 2010 without any additional expenses, and by 2030 – 600 million kWh.

At the same time, construction of new reservoirs will considerably improve conditions of runoff regulation, lessen the danger of catastrophic floods. Here should be mentioned positive change of inter-annual distribution of runoff, caused by expected climate change, which results in the increase of winter discharge and decrease of spring-summer discharges. Such possible transformation of the runoff has been suggested by many investigations.

Therefore, climate variation expected till the middle period of the 21-st century will not worsen conditions of utilization of water resources for energy production, but, possibly, may even improve them.

7.4. VULNERABILITY OF GEORGIAN COASTAL ZONE

7.4.1. BACKGROUND FEATURES OF THE COASTAL ZONE

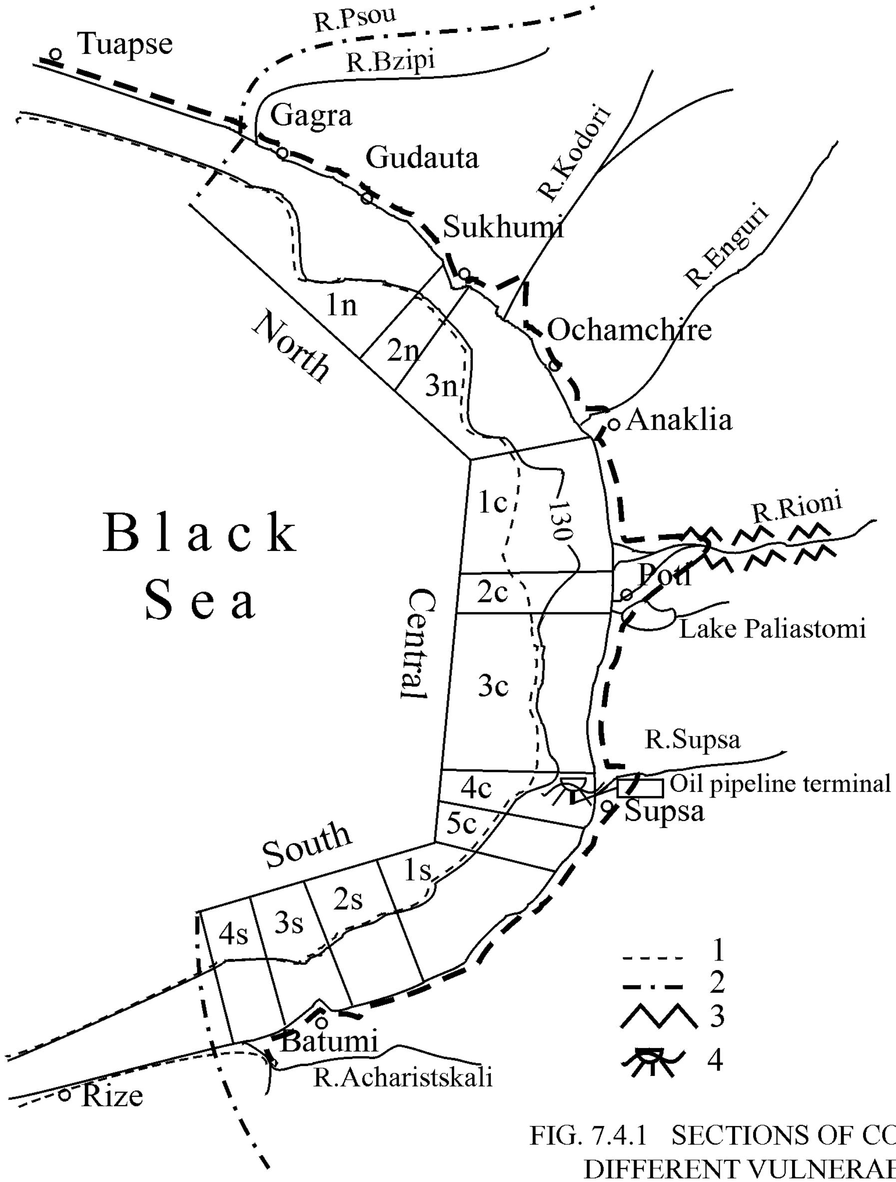
Coastal Zone of Georgia encompasses part of the eastern coast of the Black Sea on 326 km of length (Fig. 7.4.1) from the mouth of the River Psou (state border with the Russian Federation) to Kelenderi Cape (border with Turkey). Its sea boundary passes mostly along the 130-m isobath and deflects to the sea only in the mouths of large rivers. Land border represents an imaginative limit up to which the sea water action is spreading during its high activity. Area of this zone is about 2600 km^2, that of the sea portion is 2200 km^2 (85%), average width is about 8.0 km and at largest width it reaches 25km (Gudauta sand-bank).

Region under investigation is located in the tectonic zone of the Caucasus, characterised by high activity, lines of latitudinal fractures, large rates of secular fluctuations and drastic change of the trend of vertical movement along the coastal line. According to these characteristics the coastal zone is divided into three main parts, out of which marginal, i.e. northern and southern sections are elevating at a rate of 1.5-3.0 mm/yr the and central portion i.e. the area between the rivers Enguri and Natanebi is submerging at a rate of 1.0-5.6mm/yr. At the same time the coast of Poti-Supsa of the central section is sinking most rapidly (C=4.0-5.6mm/yr).

In the region under investigation, the sea horizontal circulation is created by wind-drift and river currents and vertical circulation is originated by the Black Sea central divergence and peripheral convergence. The main drift current is predominant here, passing round the sea and creating in the area of its contract with shelf descending rings of hurricane type. Such rings are originated periodically along the axis of the current and are accompanying with rotating movements the main current for a certain distance, until their complete dissipation is observed. The length of such rings is about 50 miles, the width is 30 miles. Their water volume is transported simultaneously at the same rate horizontally and in the sea depth down to 70-150m. The trajectory of these components of the main current coincides with peripheral, i.e. a coastal convergence zone and enforces it.

Divergence and convergence dynamics of the Black Sea together with wind -drift and river currents stipulate the system of vertical four-cycle water circulation, marginal cycles of which cover the coastal zone and the central cycles the rest of the sea (Fig. 7.4.2)

One of the main energy-producing sources of a sea dynamic system is wind, direction of which is defined by the sea basin orography and the trajectories of air-mass movement. On the Black Sea winds of northern` south-western and eastern rhumbs are dominant on the sea water surface. Each of them is directed to the sea with a certain angle` stipulating motion of water masses from the west east-wards` on some cyclonic closed curves, acting inside the main course. From the standpoint of sea dynamics, storms have substantial importance, causing rough sea and water inflow to the coast, resulting in the rise of the sea level by 0.6-1.0 m for 6-8 hours along the coastline, especially in bays and river mouths and the height of storm waves in the striking line reaches 4.5-5.0 m.



Conventional symbols

1 - Land and sea boundaries of coastal zone
2 - State boundary or border
3 - Dykes on River Rioni
4 - Sea module of oil terminal

Regions of different types of vulnerability

1n - Region between mouths of rivers Psou and Gumista
2n - Sukhumi Region
3n - Region between mouths of rivers Kelasuri and Enguri

1c - Region between mouth of R.Rioni and Nabada Disrict
2c - Mouth of R.Rioni including city of Poty
3c - Region of Maltakva-Lake Paliastomi
4c - Mouth of R.Supsa
5c - Region of Ureki-R.Natanebi mouth

1s - Region of Ochkhamuri-Kobuleti
2s - Region of Tsikhisdziri-Makhinjauri
3s - Batumi Region
4s - Adlia-Sarpi Region

FIG. 7.4.1 SECTIONS OF COASTAL ZONE OF GEORGIA WITH DIFFERENT VULNERABILITY TO CLIMATE CHANGE

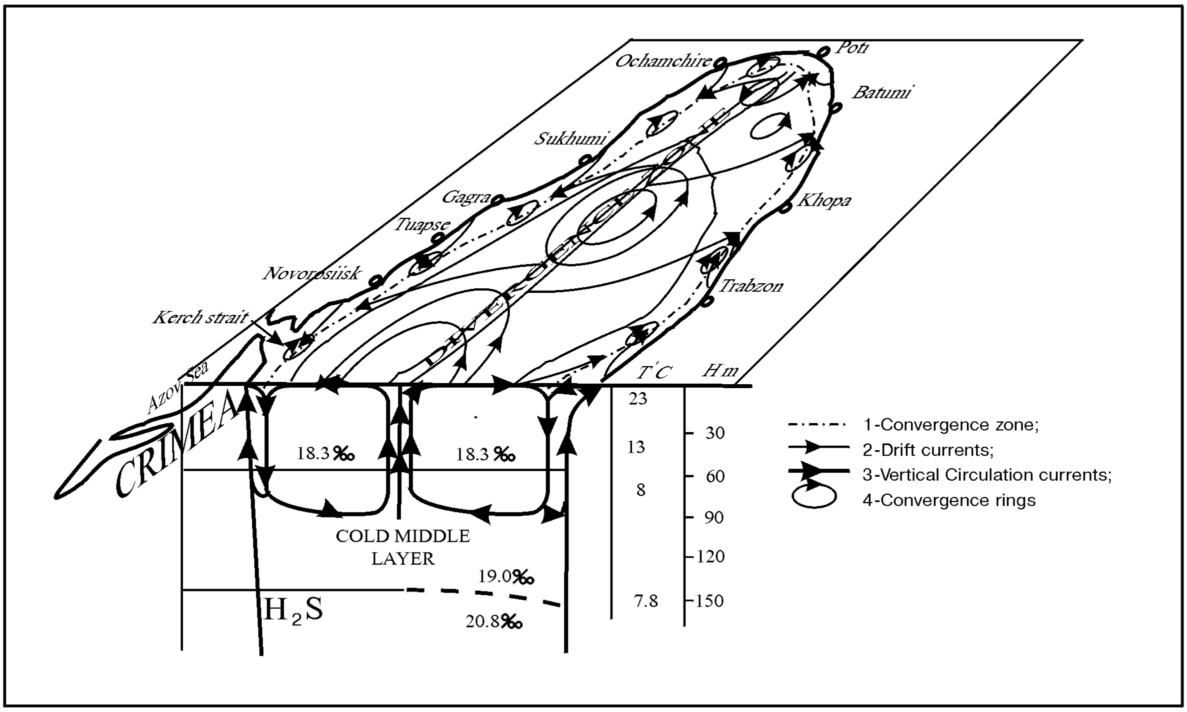


FIG. 7.4.2. SCHEME OF HORIZONTAL AND VERTICAL CIRCULATION IN THE BLACK SEA

The Black Sea tidal wave is relatively weak (h=8-10 cm), though it may become critical factor, if it coincides with stormy inflow.

Systematic hydrometeorological, geological and geodesic observations and field measurements are been conducted in the coastal zone of Georgia during many decades. Seven oceanographic stations are functioning here, conducting regular measurements of the sea level, salinity and temperature. Their data are supplementing the picture of the Black Sea temperature regime, described in the Table 7.4.1

According to the data of observations on the Black Sea level, permanent rising of the level began since 1923-1925 and is proceeding at a rate of 2.5 mm/yr. Absolute increment of the sea level made 18 cm by the year 1998 and relative one, which is elevation of the sea surface relative to the coast, exceeded 50cm in some places.

Table 7.4.1. Influence of current cycle of climate change upon the surface temperature of the Black Sea coastal waters (1923-1995)

No	Oceanographic station	Water temperature increment, ^{0}C						Duration increment, days	
		Febr.	Sept.	Annual	ΔT*	Season of recrea-tion	Season of vege-tation	of recre-ation	of vege-tation
1	Batumi	0.1	-1.6	-0.6	-1.0	-0.4	-0.8	-11	-6
2	Bichvinta	-0.6	-0.6	-0.5	-0.9	-0.5	-0.5	-8	-10
3	Tuapse	0.0	-0.8	-0.5	-0.7	-0.6	-0.8	-13	-3
4	Novorosiisk	1.6	-0.03	0.2	0.3	-0.6	-0.7	-7	13
5	Feodosia	0.7	-0.7	-0.1	0.0	-0.2	-0.3	-9	-4
6	Yealta	-0.2	-0.1	-0.1	-0.01	0.2	0.2	-5	-9
7	Sevastopol	-0.4	-0.4	-0.4	-0.9	-0.5	-0.5	-9	-5
8	Odessa	0.1	-1.3	-0.6	-0.6	-0.9	-1.2	-9	-5
Average		0.3	-0.7	-0.3	-0.5	-0.4	-0.6	-9	-4

*ΔT – Temperature increment is calculated using a regression equation

The analysis of the variability of the World Ocean level made it clear that rising of water level is a result of climate warming. Sea level rise was first fixes by instrumental measurements in the northern coast of Scotland (Aberdeen, 1898). This process was later observed at the coast of Northern France (Brest, 1908) and to the South of Portugal (Cascase, 1915). Long-period rising of the level or eustatic movement in the Mediterranean Sea and the Black Sea began since 1915-1923.

Eustatic movements of the Black Sea level created the following types of vulnerability in the coastline of Georgia:

1. Rising of the level in the river mouths has worsened the run-off transportation to the sea, resulting in the increase of catastrophic flood probability on some rivers.
2. Processes of swamping of pastures and washing out and deterioration of beaches have been enhanced.
3. Coastal communications (railway, motor-highways) and municipal facilities were seriously damaged.

According to the results of indicated vulnerability and eustatic and geological processes Georgian coastline zone should be divided into northern (up to R. Enguri), southern (to the R. Natanebi) and central sections. This division is made on the basis of relative eustatic value distribution along the coastline. Corresponding types of vulnerability are presented in the Table 7.4.2.

The heaviest types of vulnerability are observed in the central portion, as the relative eustatic movement is the highest and most important economic objects, such as the port of Poti, Supsa oil - terminal, their infrastructure and communications are located here. Therefore, five regions of especially heavy vulnerability requiring special adaptation measures have been identified in this sections.

Relative eustatic movement is the biggest and reaches 7,6 mm/yr in the first and second sections, i.e. regions of Poti and Rioni delta, meaning that the territory of Poti has receded since the beginning of this century almost by 0.52m relative to the sea, Lake Paliastomi and the R. Rioni. It is supposed that this process will develop in the nearest future. Anti-flood dykes protecting the city from the R. Rioni and Lake Paliastomi do not provide reliable protection any more. The height of these dams relative the river and the lake surface has decreased almost by 0.5m, as a result of which even p=3-5% probability floods will be catastrophic for Poti and its environs. The latter has been proved by catastrophic floods of the R. Rioni in 1987 and 1997, resulting in $13 million losses and human deaths.

Serious danger is created to the city by the sea-level rise from the side of Rioni canal. This canal divides the city into two parts and is open for sea storms. Water level in this canal, in which water-conveying capacity has decreased to 300m^3/s due to silting, will rise by 1.5m due to storm-waves and blocking-up of the river and will flood the coastal part of the city.

Therefore, it is necessary to modernise dykes, protecting the city, taking into consideration eustatic conditions and create such a monitoring system, which will permanently control the state of dykes and in case of danger will provide timely warning of the population.

Heavy form of the vulnerability of this region is washing out and flooding of Poti coastline, as a result of which the sea has advanced almost by 0.9 km and 600 hectares of the beach were eroded. This process proceeds so intensively, that a serious danger is created to the third section i.e. motor highway region, connecting Poti with Supsa terminal and passing on the crest of the coastal dune in Maltakva-Supsa region. Eustatic movements in the region have reached 32-55cm resulting in the advancement of the sea into the mainland by 50-70m and its advancement in the near future for the years 2030-2050 is expected by another 40-70m. The sea will create the danger of flooding to Poti-Supsa coast, which is planned to be occupied completely by health-resort, tourist and port complexes.

Special attention should be paid to the state of the fourth region i.e. mouth of the R.Supsa under recent eustatic conditions. Relative eustatic movement here has resulted in 32cm sinking, as a result of which the length of flooding of the R. Supsa has increased approximately by 0.5 km. In case of rising of the sea and river levels by another 20-25 cm, the length of the river flooding will grow up to 2.5-3.0 km and the decrease of the difference between the river level and its coast-line will result in its flooding in case of $p \leq 3$-5% probability water inflow. This will create serious danger to oil-terminal and its infrastructure. Especially heavy conditions will be set up for those building and the part of communications which are located in 0.7km zone between the sea and river banks, since the height of this region to the river and sea surfaces does not exceed 0.3-0.5m.

Table 7.4.2. Main sections and districts of Georgian coastal zone according to vulnerability to climate change

Coastal zone		Results of climate change 1925-1996		Area of the eroded coastal zone according to Bruni Low, km^2			Especially vulnerable elements of the infrastructure	Main types of vulnerability
Sections	Districts	Drop of sea temperature (^oC)	Eustasy relative to coast (cm)	1995	2030	2050		
Southern	Sarpi-Adlia	1.0	13	0.05		0.10	Beach, fields, fauna	1,2,6-9,11
	Batumi	1.0	14	0.04	0.10	0.14	Beach, port, recreation	1,6,7,10,11
	Makhinjauri-Tsikhisdziri	0.9	15	0.07	0.18	0.23	Beach, railway, recreation	1,2,4,6-8
	Kobuleti-Ochkhamuri	0.8	18	0.13	0.20	0.24	Beach, agr. fields, fauna	1-3,6-8,10
Central	Area of the mouth of R.Natanebi	0.7	24	0.48	0.71	0.84	Beach, agr. fields, fauna	1-3,6-9
	Area of the mouth of R.Supsa	0.7	32	0.10	0.14	0.20	Oil pipeline terminal, beach	1,2,6-11
	Maltakva-Lake Paliastomi	0.7	53	0.20	0.27	0.30	Beach, motor-highway, “Ramsaar” territory	1-3,5-10
	Poti	0.7	53	0.24	0.28	0.30	Security, port, beach, sewage	1,2,6-11
	Area of the mouth of R.Rioni	0.7	53	Dynamic equilibrium (washing down is compensated by sediments)			Security, “ Ramsaar” territory, agricultural fields	6-10
	Area of the Nabada-mouth of R.Enguri	0.7	35	0.10	0.11	0.13	Highway, beach, agricultural fields	5-9
Northern	Area between the mouths of R.Enguri-Kelasuri	0.8	-6	Sea regresses			Recreation, fauna	6,7
	Sukhumi	1.0	15	0.04	0.06	0.07	Safety, beach, port, recreation	1,2,6,7,11
	Area between the mouths of R.Gumista-Psow	1.0	-3	Sea regresses			Recreation, fauna	6,7

1. Erosion of beaches and swamping; 2. Decrease of living and agricultural field areas; 3. Salination of ground waters; 4,5. worsening of exploitation conditions for railway and highways, respectively; 6. Worsening of recreational conditions; 7. Change of living conditions for fauna; 8. Worsening of feeding by the beach sediments; 9. Sharp increase of probability of catastrophic water rise on rivers; 10. Worsening of conditions for public utility in populated areas; 11. Sharp increase of probability of catastrophic storm flooding.

The second heavy type of vulnerability in this region is washing out of the coastline as a result of the intensification of eustatic processes. At present due to them the coastline has already been removed into the depth of the land by 1.0-3.0m, destroying 0.1km of the beach of high recreational capacity. In the nearest future, advancement of the sea by another 2.0m is expected, causing additional loss of a considerable part of coastal area (0.2 km^2). The fifth region of this section, i.e. Ureki–R. Natanebi, is known for its magnetite beach of unique recreational features. It has lost already 0.6km^2 of a coastal zone due to eustatic processes. This loss will increase in future by another 1.0km^2, but if beach constructing sand flow, coming from the mouth of the R.Supsa is dammed, 30-40% of these beaches will be destroyed.

Land is emerging at a rate of approximately 1.0 mm/yr in the southern section of the coast, therefore the eustatic relative movement is so low here ($\Delta H \leq 1.5$mm/yr) that comparatively heavy eustatic types of vulnerability, such as erosion of beaches, complications of railway exploitation conditions and considerable increase of the probability of destroying populated settlements due to eustatic flooding, are observed only in its second and fourth regions. Serious complications are observed in railway communication on Chakvi-Makhinjauri coastline, where due to eustatic raising of the sea level, the bottom of the railway bed appears in the zone of increased impact of water during storm water inflows. Degradation of the coast is so considerable here, that it became necessary to create artificial beaches protecting the bed by filling it with additional sediments. Degradation of beaches has especially intensified in the extreme southern Adlia-Sarpi region of this section. The sea has already occupied the 13m wide coastal part and since the coast degradation process is going on intensively here, the loss of the area of 0.2km^2 is expected in the nearest future. This assumption is even more reliable because R. Chorokhi will be dammed in near future by the cascade of weirs. As a result of that most part of the southern coast (from Batumi to Sarpi) will completely lose the source of alimentation by sediments of the R. Chorokhi.

The land is rising in the northern section of the Coastal Zone at a rate considerably exceeding the sea eustatic movement. Therefore relative eustasy is negative here, meaning that the sea level along this portion is lowering at a rate of 1.0 – 1.5 mm/yr. So, the main type of vulnerability here is the decreasing of the depth of the seaports of Gagra and Gudauta, causing the necessity of corresponding deepening of their fairway in the nearest future.

The coast of Sukhumi represents exception, receding at a rate of 2.0 mm/yr due to local landslide movement. As a result, relative eustasy here reaches 3.9 mm/yr and seriously accelerates washing out and degradation of beaches. According to this, part of the second region – Sukhumi coast, between Sukhumi cape and the port is under dangerous conditions here, where due to the deficit of beach-constructing sediment the coast retreated by 1,2m. Advancement of the sea by another 0.6m is expected here in the nearest future, resulting in the worsening of state of beaches in this region.

7.4.2. COOLING OF THE SEA SURFACE AND RESPECTIVE TYPES OF VULNERABILITY

On the background of global climate warming, temperature decrease is observed in some regions of the Earth and among them-on some seas and parts of the World Ocean. According to observations in the period of 1923-1995, sea surface temperature at Batumi has decreased by 1^0C. At Bichvinta this process is observed more clearly since the sea has cooled by 0.9^0C here for the last 45 years. Sea surface cooling process is clearly presented at almost every oceanographic station, located on its perimeter. Observations were conducted here in 1923-1995 (Table 7.4.1). According to the comprehensive analysis of the information from these stations, water surface layer along the Black Sea coast has been cooled on the average by 0.6^0C. Besides, this process is much stronger at the southern i.e. steep coast, having narrow shelf and is relatively weakly revealed in the environs of Kerch strait, where shelf is wide and water exchange with Azov Sea has an essential impact on thermal and hydrologic regime of the sea.

Cooling of the sea creates a serious problem to its whole coastal zone, especially in those parts, where recreation and tourism has a leading role for the economy. This process is painful for zones where subtropical plants are cultivated, since the cooling of the sea takes place in the second half of the worm period of the year i.e. during the ripening and harvesting of crops.

Cooling of the Black Sea is caused by intensification of its vertical circulation, as a result of which heat redistribution between surface layer and so called "cold intermediate layer", located at the depth of 80-120 m has been accelerated. The reason of such acceleration is the activation of atmospheric processes due to climatic warming in Georgian coastline created the following types of heavy vulnerability:

1. Sea surface temperature has fallen approximately by 1^0C and it happened mainly due to the decrease of summer-autumn seasonal temperatures, causing the worsening of the sea comfort conditions.
2. Recreational season has shortened almost by 10 days i.e. approximately by 7%.
3. Vegetation period has decreased almost by 8 days i.e. by 5%, worsening the conditions for subtropical planting.
4. Thermal conditions of the sea environment have been changed substantially, that may result in the migration of marketable fish to warmer waters to the south.
5. In the coastal regions, especially in such mountain regions as Georgia, two-layer climate has been created, in the lower part of which or in the zone of breeze circulation air temperature is falling and in the higher layer climate warming is clearly observed, reflected in glacier retreat and air temperature rise. Such type of climate will be preserved in the sea coastline until sea response to the global warming is observed.

7.4.3. VULNERABILITY FORECAST FOR THE NEAREST FUTURE (2030- 2050)

The Black Sea, as a highly inertial system, will preserve, in the near future and intensively develop the factors, determining coastal zone vulnerability-eustasy and falling of water surface temperature.

Under the conditions of projected development of climate warming, further stable cooling of the sea surface by another $0.5\text{-}0.7^0$C is expected in Georgian coastal zone. Due to above-mrntioned processes of heat redistribution in the depth of the sea, this will accelerate thermal expansion of upper biologically active 150 m layer of the sea and the rate of the sea level rising will be increased, respectively up to 2.6-2.7 mm/yr.

Absolute eustatic increment will reach 10-13 cm and relative increment in the central section will be 30-41 cm, while in the southern part it will be 4-6 cm and in the northern-it will decrease by 2-3 cm. Exception in the latter will be Sukhumi coast, where eustatic movement will increase by 10-12 cm. Further intensification of vulnerability of the coastal zone will involve health-resort and recreational economy and subtropical plant growing, being especially vulnerable to sea temperature change.

The increase of types of vulnerability, connected with the change of ecological conditions is also expected, since it is impossible to forecast the state of flora and fauna of the coastal zone in advance under the conditions of changing characteristics of the sea biological layer. It is difficult to assess accurately in advance the volume of degradation of Batumi-Adlia coast and importance of its results for the city, as well, since this type of vulnerability will be sharply aggravated in case of damming of the R. Chorokhi, resulting in the loss of the main source of sediment alimentation.

Therefore, further intensive investigation of the vulnerability of Georgian coastal zone to climate change is necessary, furthermore that the results of this investigation will be extremely useful for the countries of the Black sea and Mediterranean Sea basin, which may appear in the zone of climate regional cooling.

7.5. VULNERABILITY OF NATURAL ECOSYSTEMS

7.5.1. MAIN TENDENCIES OF EXPECTED TRANSFORMATION OF NATURAL ECOSYSTEMS OF GEORGIA

Natural ecosystems of Georgia are especially diverse, that is stipulated, first of all, by the country's geographical, and particularly, climatic peculiarities, its location on the crossroads of Europe and Asia, landscapes of quite different origin, etc.

Long anthropogenic impact substantially changed ecosystems of Georgia. Area of natural vegetation of forests and steppes considerably decreased. Well expressed tendency of gradual degradation of natural ecosystems has been identified. That is the reason of the anxiety caused by expected global climate change and its possible ecological consequences.

It is supposed that while increasing mean annua1 temperature by 1,5-2^{0}C, transformation of natural ecosystems of Georgia will develop in two main directions:

- Scheme of vertical zonality of ecosystems will substantially transform;
- Considerable changes of the types of natural ecosystem structure are expected.

Relative to expected climate change, revealing some tendencies of transformation of Georgian ecosystems is supposed. They may be named conditionally as follows (see Fig. 7.5.1):

- Xerophytization;
- Mediterranization;
- Adventization;
- Laurophilization

Xerophytization

This process will be most revealed in Eastern Georgia. Besides, it should be most evident on the north-east Caucasus, in Akhaltsikhe Hollow and Javakheti and Iori Highlands. Xerophyte vegetation preferring arid conditions will expand widely.

However, this process may change radically, if temperature increase will be accompanied by the increase of atmospheric precipitation: while increasing of mean annual sums of atmospheric precipitation by 20-25% (if it does not take place only during the late autumn-winter months) complete domination of savannah ecosystems, arid rare forests and steppes is supposed accompanied by almost complete elimination of semi-deserts and deserts (except very saline biotypes).

Mediterranization

This term denotes the process of expected expansion of Mediterranean Sea elements mainly in the Black Sea coastal zone and foothills. According to botanical and geographical division into districts, considerable part of this portion, even at present, belongs to Mediterranean district. Mediterranization is especially evident in Northern Kolkhida (particularly, in the central part of Abkhazian coast), where annual distribution of climatic indices is similar to Mediterranean one.

Adventization

This term is used to denote the process of expected expansion of invaded or introduced species, which have already penetrated into natural ecosystems. As it is evident by present tendencies of dynamics of these species and the cenoses created by them, advantization should be particularly revealed in the passage of Transcaucasian depression – most of all, in Kolkhida Lowland and relatively elevated portions of the depression (200-1000 m a.s.l.).

Laurophilization

The term denotes a process of invasion of new areas by evergreen broad-leaved species. Sharp intensification of this process is expected in the mountain portion of Kolkhida, especially, in South Kolkhida, where the laurophilous species are widely expanded.

FIG. 7.5.1. THE MAIN TRENDS OF EXPECTED TRANSFORMATION OF NATURAL ECOSYSTEMS

7.5.1.1. EXPECTED SPATIAL AND TYPOLOGICAL TRANSFORMATION OF NATURAL ECOSYSTEMS RELATIVE TO POSSIBLE CLIMATE CHANGE IN WESTERN GEORGIA

Expected transformation of natural ecosystems of Western Georgia is considered at present in the context of a single scenario, in particular – in case of mean annual air temperature increase by 1.5^{0}C. This is optimally clear scenario, revealing main tendencies of expected spatial and typological and structural transformation of natural ecosystems of Western Georgia.

While considering expected transformation of natural ecosystems in connection with possible global climatic change, it is most important to realise clearly their main regional peculiarities, which determine stable originality of these ecosystems, i.e. to reveal those characteristics, which substantially stipulate the balance of a given regional system in space and time.

Present distribution of natural ecosystems in Western Georgia is connected quite clearly with peculiarities of the process of historical evolution of local ecosystems. It is known that Western Georgia – the main part of Kolkhida bio-geographical region, was a shelter for representatives of Tertiary flora during the glaciation periods. A number of vegetation species, which, even at present, have a stable phytocenic position or pronounced ecological niche, are relics. At the same time, considerable part of relics are of local origin, and a number of species represent local endemic forms, i.e. they are most unique. From the point of view of contemporary ecological and phytocenic structure, special role here belongs to the group of semi-sprawling relict forms, mostly shrubs, which give quite an original appearance to Kolkhida Region. The main part of this group is composed by evergreen relicts, such as: Rhododendron ponticum, Rhododendron ungernii (local endemic), Rh. Smirnowii (local endemic), Lauroceracus officinalis, Ilex colchica, Ruscus ponticus, Epigaea (the most rare local endemic), etc. Existence of this group substantially defines present tendencies or stability of Kolkhida ecosystem dynamics.

Another very important feature of the region is the abundance of Mediterranean elements in the coastal zone.

It is expected that just these two elements – evergreen Kolkhida and Mediterranean elements will appear to be most sensitive to possible climate change. Substantial changes are expected, as well, on Kolkhida Lowland; though, this transformation will be less connected with direct response of a biological part of ecosystems to climate change. Decisive factors here will be the change of the sea level and the level of underground waters, connected with it.

7.5.1.2. KOLKHIDA ECOSYSTEMS AND EXPECTED GLOBAL CLIMATE CHANGE

Kolkhida ecosystems take a special place in biological diversity of the world, that, first of all, is explained by the fact, that it represents one of the largest refuge for relic Tertiary hydrophilous and thermophilous plants, needing special care and protection.

Expected global climate change will create particular danger to coastal vegetation. It will be revealed in the elevation of the sea level on the one hand, and on the other-in the invasion of arid vegetation.

POSSIBLE IMPACT OF EXPECTED CLIMATE CHANGE ON KOLKHIDA COASTAL ZONE VEGETATION

The transformation of vegetation of Kolkhida province coastline, foothills, lower, middle and upper belts of mountain forest and high mountains are considered in case of expected temperature increase. The already worked out scenario for outlying districts of Alps in Europe has been taken as a model, i.e. the raise of temperature by 1.5-2^{0}C..

The width of the Black Sea coastline, composed of sand and gravel, does not exceed 100-300 m. The part of this coast is expected to be flooded. It is suggested that a similar event took place during the earlier stage of formation of the continents, i.e. when first mountain ranges elevated above the water and stormy rivers began to carry rocks into the sea. All these make scientists to suggest that coastal sands and gravel represent the oldest and “relic” substrate.

Expected climate change will not have sharp impact on coastal vegetation, if we don’t take into consideration the raise of the sea level and substantial degradation of sandy vegetation of the first line (littoral), and in some cases, elimination of a number of interesting species. This danger threatens the following species: Pancratium maritimum, Glaucium corniculatum, Euphorbia paralias, Eryhgium maritimum. All these species are plants of Mediterranean Sea coast and need special protection, which should be conducted by replanting them in botanical gardens and conserving their seeds in genetic banks.

In case of temperature increase, expansion of xerophilous plants (mainly representatives of steppes) is expected from bordering territories of the Black Sea coast (e.g. from the Crimean coast).

POSSIBLE IMPACT OF EXPECTED CLIMATE CHANGE ON KOLKHIDA LOWLAND AND FOOTHILL FORESTS

Lowland and foothill forests in Kolkhida are characterised by a number of common formations. These are: 1.Alnetum, 2.Quercetum iberici, 3.Querceto-Zelkovetum, 4.Carpinetum orientalae, 5.Carpinetum caucasici, 6.Castanetum sativae, 7.Fagetum orientalae, 8.Mixed valley forests, and 9.Mountain pines. These forests have their ecotopological area, or the region of their expansion, which is characterised by particular (unlike other parts of forest) ecological conditions, stipulated by landscape peculiarities.

In case of the raise of temperature the Alnetum forests will be competed by more arid verdure, that will bring the further decrease of already small area of this forests.

In case of climate warming, the area of Quercetum iberici will expand, as a rule, only in rocky and limestone places, i.e. where Mesophilous and Sciophilous plants will not be able to penetrate.

It should be supposed that as a result of climate warming on the Black Sea coast Zelkovetum will expand here again. Expected climate change will not cause any radical change in Carpinetum orientalae community. Expected temperature increase will cause shifting of Carpinetum caucasici from moist slopes. It is natural that expected increase of temperature will result in sharp decrease of the expansion of a very valuable species - Castanetum sativae. Expansion of Fagetum orientalae, as a hydrophilous plant, will decrease in case of expected temperature rise. Therefore, all above-indicated shows that substantial increase of temperature will sharply change the pattern of the variety of plants of mixed forests – many species will disappear at all, and many will be removed from this territory. Temperature increase will result in considerable expansion of pine forests.

Perhaps, Castanetum sativae will not change at all on the coastal slopes of Meskheti Range, where condensed precipitation will probably always be abundant. In other places, everywhere – on the slopes of Samegrelo, Svaneti and Racha-Lechkumi ranges, as a result of temperature increase, mainly Mediterranean vegetation will penetrate and will be mixed with these forests. Similar picture will be observed for Abietum and Fagetum orientalae – Abietum forests expanded above Fagetum orientalae forests. Border of their expansion will rise approximately by 150-200 m (if temperature increases by 1.5^0C). Here also substantial area will be occupied by representatives of arid Mediterranean flora. Migration from the Mediterranean Sea coast will increase, as it took place in Quaternary geological period.

EASILY VULNERABLE (SENSITIVE) ECOSYSTEMS OF KOLKHIDA HIGH MOUNTAINS

Sensitive ecosystems of Kolkhida high mountains are: 1.Crooked birch, 2.Fagetum orientalae, 3.Betuletum, 4.Fagetum orientalae, 5.Abietum, 6.Piceetum, 7.Subalpine altherbosa, 8.Rhododendretum, 9.Salicetum (bushes), 10.Alpine forbs, 11.Carpet-Like Alpine meadows, 12.Schneetalchen, 13.All ecosystems of subnival belt.

Existence and development of listed ecosystems are stipulated by thick snow cover in winter and by abundant precipitation in summer. In connection with the temperature increase, change of the snow cover regime will result in sharp change of spatial distribution of these ecosystems. Particularly, they will shift by 150-200 higher and their bio-system relationship will substantially degrade for a long time. They will be replaced by less hydrophilous vegetation, among them are many adventing species and cultivated plants.

7.5.1.3. EASTERN GEORGIA

All vertical belts of vegetation are presented here beginning with sub-arid steppes, semideserts and hemixerophilous rare forests, and ending with humid Alpine and nival belts. Forest belt in Eastern Georgia begins from 500-600 m a.s.l., while in Western Georgia this belt is present immediately from the seacoast.

In case of temperature increase, desertification of semideserts and related transformation of vegetation on saline soils is expected. Especially sharply this process will develop in the ecosystems, degraded under anthropogenic influence, as a result of intensive pasture of domestic animals or recreational activity. Degradation of steppe vegetation and at its replacement by semidesert vegetation is expected as well. In case of precipitation increase along with temperature rise (according to the forecast of Georgian climatologists) savannah (or semisavannah) type of vegetation will develop. Besides, in case of the increase of temperature by 1.5^0 C, all above mentioned ecosystems will shift upward by about 100-200 m.

Share of Carpinetum orientalae, Quercetum iberici, pine forests will substantially increase, while the share of Carpinetum caucasici, Fagetum orientalae and Castanetum sativae in forests of lower and upper belts of mountain forest will largely decrease. Substantially will decrease, as well, the area occupied by Taxus baccata and Zelkova carpinifolia. Upper border of the forest will rise by 150-180 m and replace ecosystems of Alpine shrubs, particularly Rhododendretum. The belt of alpine vegetation will be narrowed significantly.

Sharp shift of vegetation will take place in subnival and nival belts. If at present, upper border of expansion of these plants is 3700-3800 m, then, in future, the altitude will be 3900-4000 m.

7.5.1.4. SOUTHERN GEORGIA

In this relatively continental region, in case of temperature rise by 1.5^0C, ecosystems will shift above on the average, by 150-200 m. Lower belt of mountain verdure in this region is presented by xerothermic vegetation (Qiercetum iberici, mountain hemixerophilous ecosystems). In the middle belt of mountain forests, Fagetum orientalae, Pinus and again mountain hemixerophilous ecosystems are developed. Decrease of the expansion of Fagetum orientalae ecosystems is expected at the expense of the expansion of Pinus and mountain hemixerophilous vegetation. Steppes of the upper belt of mountain, Quercetum iberici and Pine forests will invade small areas, occupied by mesophilous forests. Especially large areas will be occupied by the components of steppe ecosystems, but the formation of steppe ecosystem itself will need, certainly, rather a long time. In the Subalpine belt, where the most easily vulnerable species are represented by crooked Betuletum and Rhododendretum forests, having very narrow expansion, these ecosystems will decrease even more and will shift into the Alpine belt. Most sensitive ecosystem in the Alpine belt is represented by so called carpet-like Alpine lichen, which develops under hidden glacial landform conditions and its existence is connected with snow cover. It is natural that this ecosystem will be degraded and some of its components lichen start expanding in the subnival belt. The latter, which is represented as a narrow strip in this region, is undergoing intensive transformation and a number of typical subnival plants, connected with glacier and snow cover, will be actually eliminated.

7.5.2. VEGETATION EXPANDED ABOVE SNOW CLIMATIC BORDER IN THE CONDITIONS OF EXPECTED GLOBAL CLIMATE CHANGE

Available models of climate change in European Alps have been considered and they were used for high mountain conditions of Georgia.

1. According to the hypothesis of temperature largest increase, the mean annual temperature will rise throughout Europe, on the average, by 3.8±1.0 ^{0}C. Precipitation amount will increase slightly: 0.22 mm daily and 70 mm annually (Regularity of their annual redistribution is not known). According to this hypothesis, belts should be shifted in European mountains by 700 m higher and each lower belt will replace the upper one.

    According to our forecast, the Caucasian high mountain region will change as follows:

    - Reduction of snow cover will take place and abundant water will be observed in the lower belt;
    - Glaciers will retreat, friable and labile snow mass will melt;
    - In lakes and mountain valleys changes of a total storage of water runoff will be observed Regularities of their drainage will change, as well.

2. According to the hypothesis of relatively moderate increase of temperature, rising of belts will take place by 150-180 m, i.e. approximately, by one quarter of a belt. Precipitation change gradient is not known.

    Let's consider changes, expected in the subnival belt of the Caucasus, according to these two hypotheses.

    According to the first hypothesis, nival belt in Georgia will be preserved only on Shkhara, Kazbek, Ushba and some other mountain summits. Subnival belt will rise, respectively (and in some cases, will completely disappear). Decrease of the expansion area and in some cases, elimination, threaten those vegetation species, which are expanded above the snowline and are relatively stenotopic. These are:

    - On the Western Caucasus, particularly, in Svaneti: Saxifraga scleropoda (4000 m), Colpodium versicolor (3900 m), Primula bayernii (3900 m), Minuartia trautvetteriana (3900 m), Tephroseris karjaginii 3900 m), etc.
    - On the Central Caucasus, particularly, in Racha – glacier Chanchakhi: Cerastium kazbek (3600 m), Eunomia rotundifolia (3500 m), Cerastium cerastoides (3500 m), etc.
    - Near Gergeti glacier, Kazbek: Cerastium kazbek (3900 m), Alopecurus dasyanthus (3750 m), Saxifraga moschata (3750 m), Saxifraga sibirica (3750 m), Colpodium versicolor (3700 m), etc.
    - Heads of the River Didi Liakhvi: Cerastium polymorphum (3500 m), Cerastium kazbek (3500 m), Saxifraga sibirica (3500 m), Veronica schistosa (3500 m), Ranunculus lojkae (3450 m), Saxifraga pontica (3450 m).

Therefore, we have dealt with plants, which are expanded above the snow border and more than other species, are connected with glaciers and snow cover.

According to the other hypothesis, temperature should increase by 1.0-1.2^{0}C, that will result in the shifting of vertical belts by 100-150 m. This hypothesis seems more real and judging according to this scenario, lower border of subnival belt on the Caucasus will not pass at the altitude of 2900-3000m, but at 3000-3150 m a.s.l. Upper border of a subnival belt will change respectively and it will not pass at the height of 3500-3650 m, but at 3650-3800 m a.s.l.

In our opinion, relatively sharp changes should take place in the lower zone of subnival belt, where fragments of Alpine meadows, connected with snow cover, are presented. Degradation of the vegetation of this portion is inevitable as a result of intensive snowmelt.

As it is known, in this zone of subnival belt, many chionophilous plants of the Alpine belt and of subnival belt itself, are expanded, among them: Antennaria caucasica, Anthemis iberica, Gnaphalium supinum, Potentilla gelida, Tephroseris karjaginii, Sibbaldia semiglabra, species of Pedicularis, Taraxacum stevenii, Viola minuta, etc. In connection with temperature increase they will have to change their place of expansion or, be eliminated at all, since, as it is known, chionophilous plants are less resistant to a temperature factor and find shelter under snow cover.

Besides, as it is known, plants of subnival belt are characterised by so called “Xeromorphycity”, that first of all is expressed in excessive fluffiness of some species (Anthemis marschalliana, Aetheopappus caucasicus, etc.), in development of succulent leaves (Tripleurospermum subnivale, Eunomia rotundifolia, etc.). Sharp increase of temperature and growth of its diurnal fluctuation will result in the intensification of “Xeromorphycity”.

7.5.3. NATURAL GRASSLANDS RELATIVE TO EXPECTED GLOBAL CLIMATE CHANGE

7.5.3.1. SUBALPINE BELT OF THE CENTRAL CAUCASUS (KHEVI REGION)

According to the forecast, in the high-mountain Caucasus, temperature increase approximately by 1.5^{0}C and precipitation decrease is expected in connection with the global climate change. As a result, ecological loading will grow shapely, first of all, on the feeding lands of subalpine belt, particularly, on natural hay-fields and pastures. We have considered expected ecological circumstances for them and proposed some measures for the preservation of heir stable state.

Khevi region is the highest part of high-mountain central Caucasus, where average altitude of mountain ridges is over 3500 m a.s.l. The relief is very rugged by longitudinal and transverse deep and steep slopes. Khevi Subalpine belt represents an old perigloeval of Quaternary Age. Morphological forms, caused by processes of glacial erosion and glaciation processes of that period have been preserved here. Main current geomorphological processes are presented by erosion, denudation, weathering, accumulation, actions of collapses, avalanches, landslides, midstreams and glacial exaration. Out of microrelief forms, alluvial material and their cones are dominated.

The Khevi Region is especially rich in glaciers, the area of which here takes about 116 km^2. Most of them are located on the slopes of Mt.Kazbek and they actually are the gorge glaciers. It is to be considered, that the raise of temperature and aridity will cause melting of this glaciers and the increase of river runoff.

Cold air, having reached Khevi Region, warms due to foehn effect. The Khevi Region is especially rich in glaciers, the are of which here takes about 116 Km^2. Most of them are located on the slopes of Mt. Kazbek and they actually are the gorge glaciers. It is to be considered that the raise of temperature and aridity will cause melting of this glaciers and the increase of river runoff. It must be noted also that in summer the dry and hot air-masses from the deserts of Central Asia are reaching that part of Great Caucasus. During the warm period, mean monthly temperature in subalpine areas equals to 12.9-15.2^{0}C. Air temperature absolute maximum in July-August in the vill. Kazbegi is 32^{0}C, and on Gudauri and Jvari mountain passes it equals to 27^{0}C (July-September).

Average annual precipitation amount in Kazbegi region (Valley of the R.Tergi) does not exceed 652 mm. This indicates, that some 20-30 years later the conditions on Kazbegi feeding-lands will be critical. This circumstance is even complicated by the regularity, implying that from the second half of July this ravine faces drought and intensification of southern warm winds.

Vegetation. The climate in Kazbegi subalpine belt is dry and continental in comparison with other mountain regions of Georgia. Therefore, according to the forecasts, available expected climate global change impact upon the vegetation, mainly, will not be as sharp, as in the western part of Caucasus. In Kazbegi Region temperature increase and precipitation decrease will have an impact, first of all, upon the groups of medium humidity feeding land types.

Meadows of one of these main groups are widely expanded in the region up to 2600 m a.s.l. They are mainly used as pastures and, partially, as hay-fields.

7.5.3.2. ALPINE BELT OF THE CENTRAL AND EASTERN CAUCASUS

Ecosystems of Alpine belt are especially vulnerable to high temperature and aridity, since their development is connected with snow cover. Such ecosystems are carpet-like alpine lichen, grass meadows, Rhododendretum, the line of birch upper belt, etc.

Vegetation of alpine belt, unlike subalpine vegetation, is used only for pastures.

Most vulnerable to expected temperature increase and precipitation decrease will be mesophillic alpine grass lands. General description of this type of fields is presented below on the case of central and eastern Caucasus alpine belt (Khevi, Samachablo, Tusheti and Khevsureti).

Alpine pastures are characterised by low-productivity grass vegetation. Their main components are cereals and representatives of Carex: Nardus stricta, Festuca varia, Koeleria species, Phleum alpinum, etc. Carum caucasium, Taraxakum, Sibbaldia semiglarbia, etc. are also expanded here.

Southern slopes of Alpine belt are mainly covered by Bromopsis variegata and Agrostis tenuis, forming highly nutrient pastures. Festuca varia cenoses are dominant on strongly steepy slopes of the same exposition. Their nutrient importance for domestic animals is average.

Relatively even relief creates the condition for meadows useless for pastures with the domination of Naralus stricta.

Substantial area is occupied in Alpine belt by so-called alpine carpet-like lichen, spreading mainly on snow-edge areas and are used as pastures.

As it is known, the development of grass vegetation is connected with the zonal distribution of precipitation and temperature. E.g. during the whole summer, in regions, rich in atmospheric precipitation (Ajara, Guria, Svaneti, Racha-Lechkhumi) storage of grass during the summer continuously increases. However in Central and Eastern Caucasus-in Khevi, Samachablo, Tusheti and Khevsureti regions, as a rule, droughts are observed from the second half of July. This time grass-vegetation undergos strongly stressing phenomena-diffusion resistance of stoma to water vapour and carbon dioxide increases, intensities of transpiration and photosynthesis decrease and frequency and duration of depression of these processes decrease, water deficiency in the plant increases, photosynthetic productivity decreases 8-12 times in various species, diurnal balance of carbon dioxide gas exchange is breaking. All these stipulate the suspension of vegetation growth during the drought and sharp decrease of its productivity. Development of shoots is being stopped in this period, as well.

Content of Provitamin A in grasses of pastures, provided with moisture, in much higher, then on dry pastures. Besides, it is remarkable that vitamin content during summer is higher in rainy months than in droughty months. Vitamin content is higher, as well in grasses, growing on the northern slopes than in the verdure of the southern slopes.

During the vegetation period the most humid are northern slopes of Alpine belt. Slopes of southern exposition are not sufficiently provided with moisture from the second half of July. Valley bottoms have transitional state. Particular water deficit is observed on the crests, where during the droughts especially hard ecological situation is created (wind factor should be considered here, as well).

So, expected precipitation decrease and temperature growth on central and Eastern Caucasus may cause substantial degradation of agricultural lands, particularly, that of Alpine pastures.

7.5.4. CURRENT STATE OF GEORGIAN FORESTS AND THE NATURE OF THEIR ALLOCATION

Forests cover more than the third (36.7%) of the territory of Georgia, that is approximately 2.70 million hectares, half a million from which are occupied by rare and degraded forests.

Diversity of the physical geography of Georgia, particularly that of climate and complicated history of formation of its vegetation cover, condition the variety of the content of its forests. Currently, over 350 species of trees have been registered over the country's territory – especially interesting are the derivatives of old mesophytic dendroflora (so called "tertiary relics"). This type of vegetation seems to be quite unusual for forest landscapes of Western Eurasia, particularly for Georgia and does not inscribe naturally in a general scheme of floristic mosaic.

Forest formations of Georgia contain about 51% of Fagus orientalis, 10% of Abies nordmanniana, 6.3% of Picea orientalis, 9.3% of various types of Oak (mainly Quercus iberica, rather less – Q. macranthera, Q. pedunculiflora, etc), 3.6% of Pinus kochiana 3.0% Alnus barbata, 2.1% Castanea sativa, 2.0% of various species of Betula, mainly Betula litwinowii. Relatively small areas are occupied by forests of Carpinus caucasica, Tilia begoniifolia, Alnus incana, Acer platanoides, Fraxinus excelsior, etc. Other species are: Acer velutinum, Taxus beccata, Zelkova carpinifolia, Quercus hartwissiana, Q. imeretina, Pretocarya pretocarpa, Populus canescens, P. nigra, P. hybrida, Salix excelsa, S. alba, etc., Ulmus suberosa, U. foliacea, U. elliptica, Pistacia mutica, Celtis caucasica, Juniperus foetidissima, J. rufescens, J. policarpos, J. oblonga, etc.

On Kolkhida Lowland forests expand just from the sea level. These are Alnetum incahae and Pterocarya prerocarpa. In the areas of less forestation Quercetum iberici, Carpinetum caucasici, Castanetum sativare are expanded. In Abkhazia, Pinus pityusa is growing on the seacoast.

In the past, Kolkhida foothills were covered by forests. At present, they do not exist almost at all. In the lower part of the forest belt (up to 500-600 m) Quercusiberica, Q. hertwissiana. Castenetum sativae, Carpinetum caucasici have been preserved in some places; higher – mainly Fagetum orientalia, and at 1000 m above sea level – Fagetum orientalea and Abiltum and Fagetum orientalea and Betulltum are expanded.

For forests of Western Georgia relic creeping shrubs – among them evergreens – Rhododendron ponticum, Laurocerasus officinalis, Jlex colchica, Rhododendron luteum, Vaccinium arctostaphylos, etc., are characteristic. They form undergrowth at all levels of the forests of Kolkhida and its neighbouring mountains. In the subalpine belt Rhododendron caucasicum grows, as well. In some places, especially in Abkhazia and Samegrelo mountains, Ruxus colchica is still expanded on the second forest layer.

On lowlands and foothills of Eastern Georgia forests grow only along the lower part of the rivers. Among them predominant are Quercus pedunculiflora, species of Rhododendretum, etc. Very characteristic for the forests of Alazani valley is Pterocarya; higher – within 150-600 m above sea level light forests have been preserved in some places. Shrubs of Paliurus spina – christi, Rhamnus pallasii, Spiraea hypericifolia, etc. are expanded as well in the same belt.

In the lower part (600-900 m) of a forest belt, Quercus iberica is expanded, which is replaced higher by Querceto – Carpinetum caucasici, Carpinetum caucasici, Carpineto castanetum sativae. In the middle and upper parts of the forest belt Fagetum orientalea, as well as Abietum are predominant and on the elucidated slopes - forests of Pinus are growing.

In the lower part of a subalpine belt of high mountains, rare forests of Betula litwinowii, B. medwedewii, B. megrelica, Acer trautvetteri, etc. are developed. For subalpine forests Elfin woodland is characteristic, less expanded are (Western Georgia) Fegetum orientalea.

In subalpine belt, higher than 2100-2200 m, especially in the Western part of the Caucasus, Altherbosa is developed. It is observed in the alpine belt, as well. On well elucidated southern slopes shrubs are formed by Juniperus sabina, J. depressa.

7.5.4.1. REVEALED AND EXPECTED (UNTIL 2050) REGIONAL CHANGES OF CLIMATE AND VULNERABILITY OF GEORGIAN FORESTS

Until recently data on possible consequences of expected climate change in Georgia were not available. Investigations carried out under the National Climate Change Program, have revealed the dynamics and territorial variations in the 20-th century of separate elements of climate, such as air temperature and atmospheric precipitation.

The established rate of temperature change considerably falls behind a limiting value ($0.1^{O}C/10$ yr) of temperature adaptation of vegetation (according to the assessment of IPCC). Proceeding from this, it may be noted, that indicated change of mean air temperature should not have any impact upon ecological state of forests in Georgia.

The nature of atmospheric precipitation change during the 54 years (1937-1990) is rather non-homogeneous. The range of the change of precipitation sums during the warm period of the year is quite high: from -25% to +15% (i.e. -5%/10 yr +3%/10 yr). This factor might have a certain impact on forests. Particularly, in dry regions on the background of mean air temperature increase, substantial increase of atmospheric precipitation (especially in northern and north-eastern parts of Eastern Georgia) might result in xerophytisation of forest vegetation.

In those regions, where small increase of temperature is observed ($+0.1^{0}C \div +0.3^{0}C$ in century), as well as high rate of precipitation increase (+15% in 50 years), favourable conditions for vegetation (forests) expansion should be created.

According to available data, in the next 50 years in Transcaucasia, particularly in Georgia, increase of mean air temperature from $1^{0}C$ to $1.5^{0}C$ is expected. This will have a substantial impact on the ecological condition of forests. In those regions, where temperature increase and precipitation decrease are projected, frequency and duration of droughts will grow. As a result, the area of forests will decrease, regularities of the allocation of forest formations will change, dendroflora will become poorer, specific share of relatively drought resisting verdure will increase. Especially great danger will be created for relics of old, mesophytic flora.

At the same time, in some regions (e.g. in the district of Dedoplis-Tskaro), if a positive trend of climate change, existing at present (precipitation increase) will increase in the next 50 years, expansion of a forest area is expected. However, number of such regions is very small .

To decrease the impact of negative consequences of expected climate change, it is necessary to work out a special strategy and conduct preventive measures. Otherwise, forest degradation process will become irreversible.

8. ANALYSIS AND THE STRATEGY OF ADAPTATION MEASURES TO EXPECTED CLIMATE CHANGE

The assessment of the trends of change of main elements of the climate in the past century and the investigation of vulnerability of different branches of economy and natural ecosystems made it possibl e to work out the plan of adaptation measures in relevant directions to expected climate change.

8.1. AGRICULTURE

Due to the impact of expected climate change, the working out of suitable adaptation strategy in agriculture includes adaptation to changing biological, technical, economic, social and regulatory conditions, so that to respond correctly to expected consequences , caused by climate change.

Proceeding from the biology of agricultural crops, the increase of temperature over the most pa rt of the territory of Georgia will result in the considerable change of conditions.

In case of the raise of temperature (in Western Georgia – by 1 ^{0}C and in Eastern Georgia – by 2^{0}C) the structure of industrial branches will change slightly, that will be stipulated by a spatial shift of crops. In Western Georgia they will shift upwards, on an average, by 170-200 m and in Eastern Georgia – by 350-400 m, that will be caused by the increase of sums of active temperatures. This value will reach 4300 ^{0}C and even more, in subtropical zone, and in Eastern Georgia (Lower Kartli, Alazani valley) – more than 4600 ^{0}C. In Western Georgia temperature sums will increase by 300 ^{0}C, and in Eastern Georgia – by 600 ^{0}C. In case of the realization of indicated conditions the following adaptation measures should be conducted.

A. Drought-resisting, highly productive species of agricultural crops such as wheat , oat , maize, vine, sunflower, tobacco, etc ., immune to diseases and pests should be created for Georgian conditions.
   To reveal such qualities , genetic potential of local species should be studied. On the basis of revealing desirable features, it will be possible to determine the ability of any species to adapt to climate change;
B. To introduce completely rotation of crops, that will settle the following important problems:
   a) Preservation and increase of soil fertility at the expense of the fixing of biological Nitrogen by decreasing the use of mineral fertilizers and additional utilization of artificial cultures of Nitrogen fixing organisms, improving biophysical features of soil. Thus, eduction of Nitrogen Oxides (NO_x) will substantially decrease, resulting in considerable lowering of greenhouse gas emission;
   b) Reasonable consumption of water resources by improving soil water -consuming properties (moisture content, resistance to erosion), that will provide decrease of drought impact to some ext ent;
   c) Considerable decrease of spreading of plant diseases, pasts and weeds, that will substantially lessen the use of Herbicides and Pesticides
C. Spring crops (wheat, oat) should be substituted by winter crops;
D. With the purpose of getting two or more high and qualitative yield of crops, moisture supply will be needed, the necessary condition of which is the reconstruction of existing irrigation system, its expansion and complete utilization, introduction of sprinkling and drip irrigation to provide lesser water consumption.

E. Adoption of an integrated system of agricultural management, providing the development of new technologies and its wide introduction and utilization, that will stipulate the raise of efficiency of agriculture.

F. Provision of the part of population, engaged in agriculture with full, scientifically proved information, for making them familiar with the problems, concerning vulnerability, adaptation and mitigation measures as a result of expected climate change. Since in case of temperature increase up to 38 ^{0}C, the thermal regime of a human organism is violated and human ecological balance is strained, the public should be ready for the conduction of protective measures.

Therefore, agriculture in Georgia has a high adaptation potential, which may be effectively used in case of appropriate financial investments.

8.2. WATER RESOURCES

Abundant water resources of Georgia are quite sufficient to satisfy demands of its population and national economy at present, as well as in the next century. Annual volume of water per capita is equal to 12 thousand m^3, representing one of the best indices in the world. However, these resources are not distributed unevenly over the territory. Almost three quarters of water resources come on Western Georgia, and one quarter – on Eastern Georgia.

In addition, in a number of regions, there is already sharp shortage of water that should be eliminated in time. Besides, situation is grave in some part of the rivers (Kvirila, etc.) concerning water contamination, making the situation even harder.

Expected climate change will cause aggrevation of dangerous hydrometeorological phenomena. Frequency of droughts and floods will increase, resulting in water shortage during frequent droughts on the one hand, and the increase of damage done by floods, on the other. Under such conditions a number of obstacles are to be expected in different branches of national economy and therefore, scale of adaptation increases for projected years. It should be carried out mainly in three directions: by water regulation, saving and refilling of water resources.

A. Ways of efficient utilization of water resources. Conservation of water resources demands the rehabilitation and expansion of existing water – utilization systems, building of new constructions (dams, canals, dikes, aqueducts, etc.), improvement of existing systems of water-consumption and water-supply.

A1. It is necessary to put in order these systems, improve their technical condition, timely carry out maintenance and repair works, equip them with modern water-saving devices. This category mainly includes the systems of drip irrigation, providing effective and rational use of irrigational water and its minimum loss, since systems are closed and water-supply and maintenance is conducted through metal or polyethelene pipes;

A2. Some marshes of the Black Sea coast of Kolkhida Lowland should be converted into a reverse zone, that will stipulate the saving of available water resources, provide recreational activity and protection of ecological conditions of a whole territory;

A3. It is necessary to slow-down the processes of secondary swamping, that could be achieved by increase the efficiency of existing water-draining systems and rational use of water resources in the 5-30 m eminent zone of Kolkhida lowland.

B. Ways of river flood decrease. Floods due to water tides of different categories cause catastrophic dangerous phenomena. For the protection from the following system of measures should accomplished:

B1. Planned water reservoirs should be constructed in the gorges of rivers (Bzipi, Kodori, Enguri, Rioni, Tskhenistskali, Mtkvari and its tributaries) in the nearest 15-30 years as the most reliable and effective measure of protection against water tides;

B2. Flooding limit on populated banks of rivers and areas of economic activity should be determined with the consideration of all categories of water tides;

B3. Dangerous parts of dikes on the banks of the River Rioni, caused by the processes of long-term river meandering and water side erosion, should be revealed, which may be broken during new water tides. Their maintenance should be conducted;

B4. After each water tide passage river beds are to be systematically cleaned of stones and rocks on the riverside populated areas to increase water conductivity of the river bed;

B5. Control graphs of emergency emptying during the passage of water tide are to be constructed for some reservoirs to prevent the intensification of the tide, passing on the river and to provide more effective accumulation of tidal water as a result of emptying;

B6. Timely emptying of reservoirs, located near the epicentre of an earthquake should be provided, since the first shock may be followed by new strong tremors;

B7. Periodic and stationary observational network should be created on the lakes, formed in river gorges as a result of blocking rivers by rocks and landslides caused by seismic phenomena, because this lakes are presenting potentially dangerous objects;

B8. The catalogue of catastrophic water tides and a map of catastrophic water tide dangerousity are to be worked out.

C. Ways of refilling water resources. To avoid expected shortage of water resources during the droughty months, the possibility should be expanded for the increase of water resources using the cloud seeding methods, applied to specific natural conditions of the region. To achieve this goal the following measuring should be conducted:

C1. To recommence in Eastern Georgia research and operational works on precipitation enhancement by cloud seeding. Practice has shown that in the basins of River Iori and Lake Paravani it is possible to increase the seasonal sums of precipitation in the warm period by 10-15% and the subsequent river runoff by the same value;

C2. Cloud seeding could be also conducted in the cold period of the year on the forestless south-eastern highland, snow-abundant coastal mountains and in the regions of high snow-avalanche dangerousity. This will cause the redistribution of snow cover in the form of avalanches and storing of great volumes of snow in gorges. As a result of this the losses of snow on evaporation will decrease, that could prolong the melting of snow cover by 2-4 months and intensify the moisture condensation processes. This will result in the increase of river runoff by 10-15% in the hot periods of summer;

C3. The water resources, got as a result of floods and cloud seeding, are to be timely accumulated in reservoirs. their network should be widened by constructing new ones.

Part of indicated measures of artificial increase of river runoff and its saving, has been introduced in practice, part is at the stage of research, but the present level of their utilization and research is quite unsatisfactory. Moreover, it can be said, that they are completely suspended due to existing economic difficulties.

Economic development of the country needs renewal and intensification of the research activities aiming the improvement of measures for the increase, saving and protection of water resources as a vital source of water supply and hydropower generation. To achieve this aim, first of all it is necessary to create a special testing ground where experimental field study will be carried out. On the basis of a deep analysis of obtained data a perfect scientific basis will be created for technical and economic grounding of measures directed towards saving, protection and artificial increase of water resources.

To conduct indicated activities it is necessary to create an appropriate system of state bodies, which will accomplish scientific, practical and operational activities of saving, protection and increase of water resources.

8.3. THE BLACK SEA COASTAL ZONE

To avoid or mitigate possible heavy consequences of vulnerability caused by the change of climate in the coastal zone of Georgia, it is necessary to create adaptation programme for its infrastructure in nearest future. The basis for such a programme should be a scheme of division of the coast into districts according to types of vulnerability (Fig. 7.4.1). The most widely covered kind of vulnerability in this scheme is the decrease of efficiency of health-resort and tourist complexes due to the shortening of a recreational season approximately by 10 days. Health-resort and tourist industry of Georgian coastline will lose annually 7% (60 million USD) of its income annually due to this type of vulnerability. Measures of avoiding this loss imply intensification of loading on existing complexes and construction of new health-resorts. The first of them is ecologically unacceptable, since recreational complexes of Georgia are functioning at full loading and their further intensification will make the sea useless due to its contamination. Construction of new health-resorts is possible in those districts of northern and southern parts of the coast, where ecologically clean, free areas are available (Kindgi, Gantiadi and Shekvetili). Construction of such health-resorts will cost approximately 300 million USD at recent market prices and if this measure of adaptation will be neglected the loss by the year 2030 will reach 1.8 billion USD.

The next widely expanded type of vulnerability is washing down and flooding of the coastline, to avoid of which it is necessary to carry out artificial refilling and reinforcing by concrete constructions. These measures are especially necessary to be conducted on Poti, Maltakia-Supsa, Chakvi-Makhinjauri, and Batumi-Adlia coastlines, since this type of vulnerability is particularly heavy here.

A special subprogramme of adaptation and mitigation should be worked out for Rioni delta and the mouth of the river Supsa. The city of Poti and its port with its umland are within the first district, representing the main port of TRACECA and its wide expansion to the shores of the R.Rioni is planned in future.

Dikes protecting this area from flooding have lost their efficiency due to their age and deformation and lowering. That is why under current eustatic conditions modernization and creation of an effective monitoring system are necessary that will cost approximately 40 million USD. Otherwise, the loss 3 times exceeding the project cost and human deaths are expected.

Supsa oil terminal with its infrastructure will also appear under the danger, for the protection of which construction of dikes of approximately 3 million USD in value is necessary. Without these measures the loss will exceed 20 million USD, accompanied by ecological loss resulted from pouring out of oil.

Finally, for effective accomplishment of the programme for the adaptation of the coastline of Georgia to the consequences of anticipated climate change 600 million USD will be necessary, plus approximately 10 million USD to create scientific and working versions and fragments of the programme and operative consultations.

Neglection of the accomplishment of this project will have very heavy consequences for Georgian population, coastal infrastructure and natural environment. The loss is evaluated approximately in 4 billion USD, human deaths and substantial moral loss. Therefore accomplishment of the adaptation programme of the coastal zone has a vital importance for the whole country.

8.4. NATURAL ECOSYSTEMS

Climate change will go faster than the adaptation period of ecosystems to new ecological environment. So, complete degradation of existing ecosystems will occur. Economic damage will be quite substantial. Situation will worsen for fodder fields, forest will become rare.

Mitigation measures for any kind of climate change will be: seeding of fodder grasses (leguminous plants, cereals) of high nutritive value in natural meadows. While seeding, a mixture of cereals and leguminium plants with the proportion 1:1 or 1:2 should be used. In the fields of a forest belt (hay-fields and pastures) the following grasses should be seeded: Trifolium pratensis, Hibride Clover, Phleum pratense, Poa pratensis. In Alpine meadows species of Agrostis, Festuca ovina, Trifolium repens, Lotus, etc. should be seeded.

Areas of pastures should be decreased and replaced by well maintained hay-fields. Hay-mowing should be conducted twice a year. Considerable attention should be paid to the creation of cultivated pastures using fodder crops.

In Georgia there was a tradition of watering grass lands during droughty periods (the second half of plant vegetational period is implied). As a result of these measures, increase of the productivity of alpine pastures and substantial growth of grass yield (2-4 times) are possible. Much better effect will be obtained if both organic and mineral fertilizers (keeping to ecological norms) would be introduced in natural grass fields.

Introduction of fertilizers is necessary, as well, in cultivated fodder fields. Systematic seeding of perenninal crops is also necessary here, as well as frequent hay mowing of uneatable grasses and weeds.

The line of an upper limit of forest representing one of the main buffer zones against avalanches, mud-streams and for the protection of water resources should be declared as a strictly reserved territory.

Degraded ecosystems should be renewed, that needs the conduction of bio-engineering activities on eroded slopes. Reconstruction should be carried out by means of renaturation of vegetation, characteristic only for this ecosystems.

Concerning desertification, the following measures should be carried out: on Iori Highland, everywhere, where there is the possibility of underground water utilization, oasises should be created and farming activities should be established.

Irrigation of winter pastures should be conducted keeping to all measures, that excludes soil salination. Artificial (cultivated) hay-fields and pastures should be created as well as forest shelter-belts.

Sea coastline is mainly a health-resort area. Consequently forest-parks should be arranged here, using remarkable local kinds of trees, particularly Pinus pithyusa, which successfully grows on sandy and pebby vegetation-free substratum and occupies coastal areas, washed by the sea.

8.4.1. ADAPTATION STRATEGY FOR GEORGIAN FORESTS

This strategy should be based on the following main principles:

1) Creation of forest ecosystems' monitoring system with the aim of assessment of plant and phytocenoses resistance to expected climate change:
2) In this connection, standard portions of forests should be separated in different parts of Georgia for the following features:
   a) Genetic diversity;
   b) High endemic level;
   c) Sensitivity;
   d) Soil-protecting and water-regulating functions;
   e) Recreational importance.
3) Conservation in situ and ex situ of species being under especially high danger.
4) Revealing of genetic resources of drought-resisting trees and shrubs for their further use in selection.
5) Elaboration of reforestation and forest-growing projects.
6) Reforestation activities should be carried out first of all in the vicinity of industrial centres, where anthropogenic emissions in the atmosphere are especially substantial. At present, two projects have been worked out at the National Climate Research Centre considering the reconstruction of Tbilisi dendrological park and aforestation of the areas located near the capital on the territory of Ksani forestry area.
7) Creation of regional scenarios of the impact of expected climate change upon forest ecosystems.

9. SCIENTIFIC RESEARCH AND SYSTEMATIC OBSERVATIONS

Systematic observations on meteorological elements in Georgia started in 1844 along with the foundation of Magnetic – Meteorological Observatory in Tbilisi. Since 1867 it was transformed into the Main Physical Observatory of Caucasus and geophysical observations, carried out over the whole territory of the indicated Region were conducted under its guidance. By the end of the 19-th century, over 70 meteorological stations were already operating in Georgia. On the basis of their observational data, some monographs, devoted to the investigation of climate of Georgia were published by the beginning of the 20-th century. The data of meteorological observations, carried out in Georgia were regularly sent to Potsdam Observatory until the First World War and were published in corresponding reference-books.

By the 70-s of the current century Georgian Hydrometeorological Service comprised up to 240 meteorological stations and posts, rather comprehensively reflecting the meteorological regime of the country's territory from the sea level up to 3650m (st. Kazbegi – high mountain). Observations on clouds and precipitation were conducted by means of the network of meteorological radars, located at the airports and over the areas protected by the Hail-Suppression Service. Since the disintegration of the Soviet Union observations were suspended at most meteorological stations, but at present 60 meteorological stations and posts are functioning at the Georgian Department of Hydrometeorology along with a meteorological radar located at Tbilisi airport.

Since the 50-s of the current century considerable attention was paid to the research of climate of Georgia and its change using recent data of meteorological observations. A number of investigations were carried out on the problem. Obtained results are reflected in several monographs published in 1961-1992 [2,3,8,12].

At present problems of the climate of Georgia and its change are studied in several academic and departmental centres.

Research in the field of mentioned problems is carried out traditionally at the Institute of Hydrometeorology of the Georgian Academy of Sciences. Since the 50-s of our century a group of scientists has been set up here, the scientific interests of which covered both climatology itself and a number of relevant fields (aerology, agricultural meteorology, radiation investigations, atmospheric precipitation, wind, dangerous meteorological phenomena, etc.). Characteristic features of climate and its change have been studied not only over the territory of Georgia, but over the whole Transcaucasia. About 40 monographs and over 100 volumes of transactions have been published as a result of these activities, contributing substantially to recent investigations in the field of climate change. At present the Atlas of climatic and agroclimatic resources of Georgia is being prepared at the Institute.

Considerable traditions in climate research has also the Institute of Geography of Georgian Academy of Sciences. During the last half a century a number of original ideas connected with the problem of climate change have been proposed and worked out here. Atlases, scientific papers and separate monographs of great scientific value have been published. An energy – balance model of climate change is being elaborated at present at the Institute. It will serve as a basis for climate change projections, considering impacts of various anthropogenic admixtures in the atmosphere over the Region.

Investigations of climatic resources of Georgian resorts were carried out at the Institute of Health-Resort and Physiotherapy of the Ministry of Health. Microclimatic conditions of separate resorts have been studied, recommendations for their rational use were worked out. Over 20 volumes of scientific papers and some monographs have been published, among them – " Climatography of Georgian Resorts" (1980) and the "Atlas of Georgian resorts and resort resources" (1989).

Investigation of specific factors stipulating climate change are conducted at the Institute of Geophysics of the Georgian Academy of Sciences as well. During the years, the Institute carries out research in the field of atmospheric aerosols, that will play an important role in solving the problems, connected with greenhouse effect.

A number of problems of modeling atmospheric processes connected with climate change are being worked out at some departments of Tbilisi State University.

Investigations at the National Climate Research Centre of the Department of Hydrometeorology are conducted in the framework of the National Climate Change Programme approved by the President of Georgia. These activities started in 1996 and were put since 1997 as a basis for the project GEO/96/G31. While preparing the National Communication, a number of peculiarities of climate change over Georgian territory have been studied on the basis of National Programme. Appropriate theoretical activities have been conducted as well. Main results of the research carried out at the Centre are regularly published in special Bulletins in Georgian and English languages.

Summary of theoretical work recently conducted at the National Climate Research Centre is presented below.

In paper [10], climate global warming and greenhouse effect have been considered first as a nonlinear problem of atmospheric thermal conductivity, when in the Earth's atmosphere, as in a physical system, nonlinear thermal sources, induced by anthropogenic factors are acting. It has been demonstrated that greenhouse effect – the global phenomenon of the atmosphere, should represent an organized structure limited in space and time on the background of stochastic processes - result of the actions of nonlinear thermal anthropogenic sources in the atmosphere. While meeting I. Prigozhin's four necessary conditions, it will preserve its individual features for a certain time period in the same way as they are kept by other organized phenomena of the atmosphere (cyclones and anticyclones, fronts, clouds of various types, etc.).

It has been demonstrated that the development in time of climate warming or cooling should be proceeded on the background of two opposite cooperative processes. First of them stipulates the increase of greenhouse effect in time (radiative gases) and the second one prevents it and causes the decrease of greenhouse effect (anthropogenic aerosols, atmospheric natural impeding factors - advection, absorption, dispersion), to which the factor of radiative gas atmospheric concentration decrease should be added, stipulated by measures of international control.

The obtained analytical nonlinear solutions simply reveal the main features of greenhouse effect: course in time of warming or cooling and heat localization in a limited area of space.

It has been shown theoretically that global climate warming, proceeding at present in the atmosphere, is in its initial phase and therefore in theoretical considerations we may be limited by small time intervals, easily deriving analytical formulae which describe well the regularities of recent climate warming (cooling) linear dependence on time. The obtained results also demonstrate, that when at a certain height the density of greenhouse gases exceeds the density of aerosols, the process of climatic warming takes place in the atmosphere, otherwise the cooling will be developed and in case of their equality the average climatic temperature will not change in time. Quantitative analysis of obtained nonlinear solutions demonstrates that global climatic warming should develop in future according to the following scenario.

Until the time, when the impact of heat inflow source, created as a result of impact of radiative gases upon the temperature field will exceed the action of heat loss source, induced by anthropogenic aerosols and natural retarding factors, global warming process will continue in the atmosphere. It will last until the time when these two opposite processes will balance each other and warming process will reach a certain maximum value. Since characteristic parameters of heat loss source are able to accumulate in time, their action, having exceeded the effect of heat inflow source, will induce decrease of average climatic temperature and its gradual transfer to a new stationary state will start. The process proceeding up to the maximum may be called "global warming" and after the maximum – "global cooling". Conventionality of these two processes is caused by the fact that energetic level of the atmosphere in a new stationary state will be higher than the energetic level, existing at the beginning of warming (average content of greenhouse gases and aerosols will be more at the end of greenhouse effect than at the beginning of warming), that in principle justifies a general title "Climatic warming of the atmosphere". By theoretical assessment relaxation time of climate warming duration covers approximately 30-40 years. However, substantial decrease of this time interval will be possible if actions will be conducted at the international level, aimed at the abatement of greenhouse gas emissions in the atmosphere. Presented analytical results and obtained exact nonlinear solutions will be used in future to create a general numerical model of climate warming.

Statistical analysis of trends of change of climatic air temperature in the period of 1906-1995 has revealed the regularity of climate cooling in Western Georgia and its warming in Eastern Georgia.

To interpret indicated cooling process, permanent thermal and advection dynamic sources, characteristic for Western Georgia have been found, time periodicity of which is by order of year and the horizontal and vertical scales of closed circulation make about 200-300 km and 3-4 km, respectively. It has been shown that indicated circulation has a monsoon nature and it is caused by irregular warming of the Black Sea and Kolkhida Lowland during the year. This circulation, which does not exist in Eastern Georgia, should be stipulated by the influence of two permanent heating mechanisms, acting in Western Georgia. The heater in summer should be Kolkhida Lowland and the refrigerator – the Black Sea. In winter the pattern is opposite. Substitution of indicated sources over Kolkhida Lowland results in temperature change during the year.

Existence of anthropogenic layer in high layers of troposphere actually stipulates breaking of radiation balance in the atmosphere and occurrence of greenhouse effect. We have theoretically elaborated physical mechanism of the creation of this layer considering main factors of free atmosphere. In particular, it has been demonstrated that western seasonal winds dominating at indicated altitudes, diffusive processes and advection and diffusive flows cause formation of a layer structure of small admixtures (greenhouse gases, aerosols) at indicated altitudes with concentration maximum at a certain height.

Further generalization of obtained theoretical results and deriving on their bases of important conclusions concerning the action of small admixtures in the atmosphere represents the subject of our future research.

10. EDUCATION AND PUBLIC AWARENESS

Rising of the interest to the problems of climate change in Georgia began since 1996 along with the starting of the execution of the National Programme in this field. Public was mainly informed through the activities of the National Climate Research Centre by periodic press, radio and television, emphasizing global nature of these problems and their importance for Georgian conditions.

Especially intensively the indicated activity was conducted after the activation of the Project GEO/96/G31. To intensify the public interest to climate change problem the Management Team of the project published over 20 articles during the 1997-1998 year period in various journals and newspapers, which were intended both for a wide range of readers and the scientific circles as well. Up to 10 special TV programmes have been broadcasted, giving the explanation of the problem and its importance for the future activity of mankind. After each workshop, held under the Project, wide press-conferences were arranged for mass-media representatives, where leading specialists of the Ministry of Environment, project members and foreign guests widely covered separate aspects of climate change problem and emphasized their importance.

Especially substantial role has been given to the Bulletin of the National Climate Research Centre in distribution of information dealing with the problem. Its first issues were dedicated to the review of those activities, which were conducted in developed countries of the world to fulfill the commitments under the UN Framework Convention on Climate Change. The next issues presented the results of investigations carried out in the framework of the National Climate Change Programme and the Project, various information concerning the project fulfillment, giving the possibility to inform readers on the problem, set before the project and those wide opportunities which expose before the country along with participation in the activity, envisaged by the Framework Convention – in particular, substantial attention was paid to the analysis of such mechanisms of international cooperation as “Joint Implementation” and “Clean Development Mechanism”, prospects of their use for the rehabilitation of Georgian economy. The bulletin was widely distributed in Georgia and abroad, as well.

The Management Team of the Project paid great attention to arranging lectures and presentations on Climate Change problem at various meetings and organizations. In particular, over 20 papers have been presented, among them at the conference, devoted to energy efficiency problems, organized by TACIS, at the National Conference on the Black Sea problems, organized by a non-governmental “Caucasian House”, at the joint meeting of the Committees on Sectoral economy and Environmental protection of the Georgian Parliament, at various meetings, organized by “Movement of Freens” of Georgia, at the special workshop, held at Kaspi Cement Plant, etc.

Participants of the project took part at the international event “Climate Train”, which was held in November, 1997 before the COP-3 Kyoto Session.

Taking into account the scale of Climate Change problem and aiming to provide participation of Georgia in future activity in this field, the project Management Team initiated a special Training Centre on environmental management at Tbilisi State University in 1998, which will train highly qualified specialists in separate directions, connected with the fulfillment of Framework Convention – mathematical modeling of economy development, projection of greenhouse gas emissions, strategy of climate change mitigation, methodology of adaptation, etc. Systematic training courses will be arranged, as well at the Training Centre to rise the awareness on Climate Change of specialists, working in various branches of economy.

In future, in connection with the creation of the UNFCCC National Agency, all above mentioned public awareness raising activities will be concentrated in this organization, which will supervise appropriate work and will intensify and deepen it by means of cooperation with relevant international organizations.

11. INTERNATIONAL COOPERATION

During the preparation of the National Communication, National Climate Research Centre established close contracts with UNFCCC Secretariat and such international organizations as UNDP, UNEP, WB, EBRD, GEF, ICA, IIEC, with representatives of JI/AIJ Programmes of various countries.

The main purpose of these contacts along with the preparation of the National Communication, is to continue without delay, activities in the directions of the fulfillment of commitments to the Convention and attraction of investments to carry out the projects aimed at the abatement of greenhouse gas emissions.

Contacts with the UNFCCC Secretariat were very important since the starting point, as the Secretariat was providing us regularly with most important information and documentation on the current processes. These contacts have been much intensified since the reelection of Mr. T.Gzirishvili, UNFCCC National Focal Point in Georgia, as a member and the Vice-President of the Bureau of COP. Georgia is actively participating in the process of preparation of new proposals and their working out at the meetings of the Bureau, at the Conferences and various assemblies. The activity, conducted by the country in this direction, is reflected in full in appropriate reports, official documents and Bulletins, published by the Secretariat. Representatives from Georgia, named by our Government, have been appointed as experts by the Secretariat and they take an active part in the process of discussion of National Communications of various developing countries. Under the recommendation of the Secretariat, a special WEB-page has been prepared for Georgia, where the activities, being conducted in the country within the UNFCCC and short descriptions is presented of those projects, which are aimed at the promotion of sustainable development and are needing the investments.

The sufficient contacts have been established with the Dutch Joint Implementation Programme. Representatives of this Programme visited the National Climate Research Centre several times, taking part in two workshops, held under the project. Negotiations are conducted with Canadian Joint Implementation Programme to prepare Memorandum of Understanding on the cooperation between Canada and Georgia within the Clean Development Mechanism.

Several projects were presented to the United States Joint Implementation Programme. Negotiations on one of them - “The geothermal heat supply for Tbilisi” are being conducted with private Americans investors. Georgia was visited by Mr. Karl Mitchell (USAID Environmental Protection Bureau), who assessed the situation, created in Georgia, reviewed those potential projects in various branches of economy and first of all in energy production, which are connected with the mitigation of climate change process. The list of those measures and specific projects, which have been selected by Mr. Mitchell, is hoped to be approved at the end of 1999.

In the beginning of November 1998, the meeting with Mr. Peter Kalas, representative of the World Bank, Manager of the Programme “National Strategy System” was held in Buenos Aires, Argentina, at the 4th session of the COP. On the basis of these negotiations, Georgia will participate in the World Bank Programme “National Strategy System for Clean Development Mechanism”. According to this Programme, the trends of the development of Georgian economy and its various sectors should be studied and projections of expected greenhouse gas emissions from large enterprises should be conducted. As a result of this work the potential of greenhouse gas emission decrease, its impact upon the country’s economy, cost of the decrease of greenhouse gas emission, methodology of certification and other important problems will be solved. This is the investigation, which was not been planned within the first National Communication.

At the same session of COP, representatives of International Co-generation Alliance and International Institute for Energy Conservation offered Georgia to participate (as a country with economy in transition) along with the Philippines (as a developing country) in the joint project (in energy sector), the aim of which is to study Clean Development Mechanism prospects and benefits. As the Project managers informed us, they took into account our remarks and will soon present a revised version of the Project Document which will be put into action to get investments in case of governmental review and positive evaluation.

At the sessions of the Conference of Parties and at local workshops, business meetings with representatives of European Bank for Reconstruction and Development are very frequent, especially with specialists of its Environmental Department.

Close contact with representatives of TACIS have been established, especially with those who are engaged in energy production (renewable energy resources and increase of energy efficiency). Under the request of TACIS, the report of the National Climate Research Centre on the financial mechanisms of the UNFCCC will be presented in September 1999 at the workshop, arranged by TACIS for the Georgian Parliament.

Especially important and fruitful may be considered the cooperation of Georgia with GEF in the field of Climate Change. Preparation of the Initial National Communication was financed by GEF. Recently two projects "Removing Barriers to Energy Efficiency in Municipal Heat and Hot Water Supply in Georgia" (PDF-B block) and "Removing Barriers to the Development of the Small Hydro Power Sector for the Mitigation of Greenhouse Gas Emissions in Georgia" (PDF-A block) have been approved. According to the results of these projects, specific demonstration projects will be stipulated. First of all, fulfillment of the projects, selected by this approach, will be planned on the basis of Clean Development Mechanism. In April 1999, the members of the Climate Change Project took part at the GHG Inventory International Workshop in Baku, where it was planned to hold another workshop under the "National Communications Support Programme" in September 1999 in Tbilisi. The workshop will be devoted to the elaboration of policy of greenhouse gas emission decrease and the mechanism of its fulfillment. This meeting will be attended by the delegations from Azerbaijan, Armenia, Moldova, Kazakhstan, Uzbekistan, etc. Georgia has close contacts with these countries – foundation of a Regional Center is planned with Armenia and Azerbaijan to import Clean Technologies in Transcaucasian Region, as well as the investigation of the potential of renewable energy resources, available in Transcaucasia.

Georgia actively participates in the preparation of those proposals for GEF, which will assist this financial mechanism to become even more active and effective for those countries, on the assistance of which it is aimed. Currently, Georgia is working out proposals on the preparation of the Second National Communication for non-Annex 1 countries. In particular, what subjects are to be stressed in the Second National Communication, when the proposal may be made to get financial assistance and what the optimal time will be required for its preparation. Georgia used to take an active part, along with other countries, in these processes which stipulated decision-making on the financial support to prepare Second National Communications for non-Annex I countries.

12. NATIONAL CLIMATE CHANGE ACTION PLAN

(DRAFT)

During the process of implementation of the national communication, the barriers, preventing mitigation of greenhouse gas emissions in Georgia and rehabilitation and development of the country's economy, have been distinguished, proceeding from the "Rio Resolution", i.e. considering principles of sustainable development. To remove these barriers and to fulfill the country's commitments to the Convention, a draft of National Climate Change Action Plan has been worked out, consisting of three main directions:

1. Adaptation of the systems, vulnerable to climate change;
2. Mitigation of greenhouse gas emission sources;
3. State policy.

12.1. ADAPTATION OF VULNERABLE SYSTEMS

As a result of activities, conducted within the first national communication, the systems, most vulnerable to climate change in Georgia have been singled out and project of for their adaptation has been elaborated. Scenarios of expected climate change have been considered, based upon climate change trends, forecasted by IPCC and revealed as a result of statistical processing of historically existing series of temperature and precipitation observations over the territory of Georgia. As a result of conducted investigations, it has been established that the most vulnerable system is the Black Sea coastline, which has a strategic importance for the rehabilitation of the country's economy and development of foreign trade. Its role will much increase in future, since the growth of transport corridor, passing through Georgia, oil pipeline capacity, functioning of ports and oil terminals in optimal regime will be greatly depended upon the infrastructure of the coastal zone. Therefore, working out of adaptation measures for the Black Sea coastline and their implementation are considered to be important for the country.

The most vulnerable region in the coastline is the estuary of the River Rioni, where one of the most important ports of Georgia, city of Poti is situated. For the adaptation of this portion of the coastal zone, the project has been worked out, according to which the following main measures are planned: artificial fortification of this portion of the sea coastline, refilling of beaches, reconstruction of the buildings of the port of Poti and generally, that of the infrastructure of the whole city. The cost of carrying out indicated measures, according to preliminary assessment, makes 600-700 million $US, that is 6-7 times less than the loss, expected by the year 2030.

The second important vulnerable system in Georgia is agriculture, where special attention is paid to wheat in Eastern Georgia, though, during the last 2-3 years, processes related to the sharp decrease of precipitation in this region and substantial rising of mean winter temperature threaten other agricultural crops as well to decrease their harvest or eliminate, at all. Within the first national communication it was not possible to prepare project of adaptation for agriculture, in particular, preparation of a project for the adaptation of wheat in Eastern Georgia, but it is to be considered one of the most important for the next stage. A project on the use of agricultural wastes to produce biogas and organic fertilizers is also under consideration.

In spite of a sufficient supply of water resources, appropriate attention in the Action Plan is being paid to the problem of the increase of the efficiency of their utilization. Particularly, construction of water reservoirs on a number of rivers is planned to increase the capacity of water storage and its further rational use in agriculture and energy production. Introduction of modern technologies for water resources utilization and creation of surface water monitoring system is considered, as well.

12.2. MITIGATION OF GREENHOUSE GAS EMISSION SOURCES

At this stage, in Georgia, as in other countries with economy in transition, due to rapid decline of economy, the 1evel of greenhouse gas emissions is quite low, though, it is certain that along with the revitalization of economy, appropriate increase of emissions is expected. The value of increase will depend upon the strategy of rehabilitation and development of economy and the rate of these processes. Hence, the main principle in the field of greenhouse gas emission mitigation will be the restoration of the economy and its further development on the basis of the principles of sustainable development. Because of the break-up of socialist principles and transition to the principles of market economy, taking place at present in the country, creation of new governing structures and infrastructures is necessary, respectively. Industry is not activated yet in Georgia, energy production is in crisis. Actually, forecasting of greenhouse gas emissions, expected at present stage from various branches, is connected with lots of complications and inaccuracies. Due to this fact, the National Action Plan, aims to conduct main measures of greenhouse gas emission mitigation in the sectors, where rapid increase of greenhouse gas emissions is expected proceeding from the pattern, obtained as a result of greenhouse gas emission inventory conducted within the initial National Communication. Results of inventory demonstrated that in 1980-1990-es greenhouse gas emission from energy sector made approximately 90% of the whole emission from the territory of Georgia. Along with the fact that this sector was largest emitter of greenhouse gases in Georgia, its rehabilitation and development is considered to have the priority in the country both from the point of view of further development of its economy and the solution of social problems of the population. Consequently, one of the central places in the draft of the National Climate Change Action Plan is occupied just by this sector. Majority of projects is aimed on the rehabilitation and development of this sector according to principles of sustainable development. List of those projects, activation of which is planned during 1999-2001 in energy production sector, is presented below. In case of the implementation of these projects in the whole capacity, that requires approximately 90 million USD, decrease of CO_2 emission into the atmosphere by 22.3 million tons will be possible.

SMALL HYDRO-ENERGETICS

According to the data, obtained as a result of academic investigations, corresponding hydro-power potential of small hydro-electric plants makes approximately 10 billion kWh, while, according to various assessments, economically effective potential is about 5-6 billion kWh.

1. ***Removing barriers to develop small hydro energy sector for the mitigation of greenhouse gas emission in Georgia;***

2. Project of STORI hydropower plant. Decrease of CO_2 emission during the whole period of the hydro-power plant operation (25years) makes 730 thousand tons, approximate amount of necessary investments equals to 8.4 million US$.

3. ***Project of Misaktsieli hydro-power plant rehabilitation***. Decrease of CO_2 emission during the whole period of hydro power plant operation (25 years) is estimated to be 506 thousand tons, approximate amount of necessary investments makes 2.3 million US$.

4. ***Project of Intsoba hydro power plant rehabilitation***. Decrease of CO_2 emission during the whole period of hydro-power plant operation (25 years) makes 160 thousand tons, approximate amount of investments is 850 thousand US$.

5. ***Project of Abasha hydro power plant rehabilitation***. Decrease of CO_2 emission during the whole period of hydro-power plant operation (25 years) is 247 thousand tons, required approximate amount of investments makes 1 million US$;

6. ***Project of Martkopi hydro power plant rehabilitation***. Decrease of CO_2 during the whole period of the plant operation (25 years) is 140 thousand tons, needed investments make approximately 750 thousand US$;

GEOTHERMAL HOT WATER SUPPLY

Output of low mineralization geothermal waters of 50-110 ^{0}C is estimated as 220-250 million cubic meters annually, and the area occupied by these waters is 32% of the country's territory.

1. ***Project of Tbilisi geothermal hot water supply.*** Decrease of CO_2 emission during the whole period of the project functioning (25years) is estimated by 4.5 million tons, approximate amount of investments is 30.8 million US$.

2. ***Project of Zugdidi geothermal heat supply***. Decrease of CO_2 emission is by 2.3 million tons during the whole period of the project functioning (25 years), approximate amount of investments makes 15 million US$;

3. ***Project of the Hippodrome district geothermal hot water supply***. Decrease of CO_2 emission is estimated by 350 thousand tons during the whole period (25 years) of the project functioning, approximate of required investments makes 860 thousand US$.

WIND POWER

"Karenergo" – the project of wind power plant. Decrease of CO_2 during the whole period of the project functioning (25 years) will be 825 thousand tons, approximate investment amount is 5 million US$;

SOLAR ENERGY

Georgia has a substantial potential for the use of solar energy. According to academic investigations, utilization of 30% of this potential will make it possible to prevent burning of about 1.5 million tons of conventional fuel and to decrease CO_2 emission approximately by 2.4-3.0 million tons.

Batumi heat supply with solar energy. Decrease of CO_2 during the whole period of the project functioning (30 years) is estimated by 12 million tons, approximate investment amount makes 21.8 million US$;

INCREASE OF ENERGY EFFICIENCY

Removing Barriers to Energy Efficiency in Municipal Heat and Hot Water Supply in Georgia. The project aims creation of those main demonstrating or pilot projects, for which attraction of investments should be carried out in this phase of investigation. UNDP/GEF Government of Georgia. Cost - 211 thousand US$.

TRANSPORTATION

Substantial place in energy sector is occupied by a transportation sub-sector, the share of which in total emission makes approximately 10%. In 1992-1994 number of motor transport sharply decreased in Georgia. Situation has changed since 1996, when intensive process of importing second hand cars started, resulting in the creation of alarming from the environmental point of view situation. It has been worsened by the following circumstances: (1) Existing motor transport depot became out of date. (2) Extremely declined the quality of motor highways due to the lack of funds, as a result of which movement of the transport became slow, consumption of the fuel and greenhouse gas emission increased, respectively; (3) Due to the low quality of consumed petrol and other types of fuel, consumption of fuel and greenhouse gas emission per a unit of fuel increased, respectively; (4)

Infrastructure of transportation service has been completely destroyed; (5) Increase of cargo turnover through the Europe-Caucasus-Asia Transportation Corridor has overloaded existing highways, the capacity of which has been remained practically unchanged. According to the present situation, conduction of the following activities planned aiming the decrease of greenhouse gas emissions:

(a) Decrease of greenhouse gas emission by means of harmonic development of transportation types;
(b) Renovation of motor transport depot;
(c) Creation of the system of assessment and monitoring of the exhausts from motor transport, among them-greenhouse gas emissions;
(d) Development of motor highways, especially their rehabilitation and modernization;
(e) Improvement of the system of technical control of the functioning of motor transport engines;
(f) Formation of the basis for legislative standards, determining greenhouse gas emissions in aviation;
(g) Provision of Sea-ports with necessary modern equipment for ecological supervision over greenhouse gas emissions;
(h) Training of the staff;
(i) Development of ecologically clean, passenger and freight automated special means of transportation (cable cars, cable and railway cars, monorail transportation, trolleybuses, etc).

INDUSTRY

As to the industrial sector, emission from it was not too high and at this stage only the project on the equipment of Kaspi Cement Plant with electric filters is planned. However, along with the rehabilitation of the industrial sector, increase of emission is expected from such large enterprises, as Zestaponi Ferroalloy Plant, Rustavi Metallurgical Plant. Preparation of projects, mitigating greenhouse gas emission from these enterprises is planned during the process of the implementation of Second National Communication, hoping that by this time these enterprises will be activated at most.

Project on energy efficiency increase in Kaspi Cement Plant. Decrease of CO_2 emission during the whole period of project operation (25 years) is estimated by 230 thousand tons, approximate amount of investments makes 1 million US$.

FORESTRY

According to the present situation in this sector (weakening of forest management system due to the lack of financial resources, intensive illegal cutting of forests, tendency of the increase for the process of uncontrolled export of timber), the following activities are planned, respectively:

(a) Preservation of existing forests;
(b) Stipulation of the regeneration of natural forests;
(c) Growing of new plantations of trees;
(d) Slowing down of the process of illegal cutting down of forests and limiting of wood export;
(e) Shearing of the experience of other countries in the management of forest and introduction of contemporary methods in forestry.

1. ***Project on Tbilisi dendrologycal park restoration***. Sequestration of CO_2 during the whole period of the project functioning (50 years) is estimated by 90 thousand tons, approximate amount of required investments makes 230 thousand US$;

2. ***Project on reforestation of Kaspi district***. Sequestration of CO_2 for the whole period of project functioning (50 years) is estimated by 98 thousand tons, approximate amount of the investment required is 350 thousand US$.
3. ***Project on aforestation of the "Red Bridge" environs***. Sequestration of CO_2 for the whole period of the project (50 years) is estimated by 75 thousand tons, approximate amount of required investments makes 250 thousand US$;

4. ***Project on "Nabadkhevi" forest rehabilitation***. Sequestration of CO_2 for the whole period of the project functioning (50 years) is estimated by 85 thousand tons, amount of investment funds is approximately 270 thousand US$.

LIST OF TECHNOLOGIES, REQUIRED FOR THE CONDUCTION OF MITIGATION POLICY

1. Approximate cost of electric filters, necessary for the Kaspi cement Plant and their import - 500 thousand US$;
2. Electric and mechanic equipment for small hydro-and wind power plants (turbines, generators, etc.) - approximately 11 million US$.

12.3. STATE POLICY

The state policy is one of the main constituents of the Action Plan, which creates the bases for the national strategy for the development and environmental protection, the main purpose of which is to provide the formation of the policy of sustainable development of Georgia and its implementation.

The conduction of greenhouse gas emission mitigation activities and measures directed to the adaptation of vulnerable systems will be possible only in case of the right state policy. This implies that the process of restoration and development of the economy should be based upon the principle of sustainable development, according to which solution of economic, environmental protection and social problems should be carried out integrally. The Action Plan aims taking a number of steps in the state policy, directed towards the implementation the country's commitments to the UNFCCC and the Kyoto Protocol and the maximum use of international assistance:

1. Creation in the country of those structures, which will be directly responsible for the implementation of the UNFCCC principles inside the country and protect the country's interests, while adopting decisions on international processes.

   On the background of present fruitful relation of Georgia with other countries, the problemarises, areas that this policy should have an adequate continuation inside the country. Very important is to determine what kind of policy we shall carry out in the country, replying to goodwill of international organizations, just now , when Georgia has been unanimously acknowledged by the Council of Europe as its full member. Though somehow late, but the actions have been already started in this direction. Formation under the President of Georgia, of non-budgetary structures, implementing the state policy, will be the first substantial step made in this direction.

   Taking into account the experience of other countries, the problem arose for the creation a structural unit, capable to coordinate activities, conducted in respective governmental bodies in the context of climate change and to avoid the bureaucratic barriers. [Ω]
2. Adoption of legislative acts, favorable for above-mentioned processes.
   - 2.1. The draft for easing taxes has been prepared and presented to the Parliament for those projects, the aim of which is maximum utilization of renewable energy resources in Georgia;
   - 2.2. The draft is being prepared on the easing of taxes on those projects, that will be implemented within the Clean Development Mechanism and will stipulate sustainable development of the country's economy;
3. Rising of public awareness
   - 3.1. Issuing of quarterly Bulletins on UNFCCC implementation process in Georgian and English;
   - 3.2. Preparation of TV programs and films for a wide audience;
   - 3.3. Wide dissemination of brief adapted version of initial national communication in the country;

[Ω] ***Note:*** According to the Decree of the President of Georgia No. 349 dated 3 June 1999, the UNFCCC National Agency has been created along with the International Agency on Sustainable Development and formation of the State Commission for the promotion to efficient use of possibilities of new investment mechanisms in energy Sustainable Development under the UNFCCC, the UNESCO World Solar Programme and for the facilitation of the utilization of renewable sources of energy.

3.4. Participation in meetings of respective committees of the Parliament and workshops, arranged by international organizations;

3.5. Organization of an international workshop on "The Policy of greenhouse gas emission mitigation for non Annex I countries of the Convention". UNDP/GEF and Climate Research National Center. September, 1999 Tbilisi, Georgia;

3.6. Holding of initiation and summary workshops within the project on energy efficiency.

4. Education and Training system.
   A Training Center on Ecology and Environmental management has been established at Ivane Javakhishvili Tbilisi State University, which will train highly qualified specialists for the UNFCCC National Agency in future.
5. Preparation of the Second National Communication for presentation to the Conference of the Parties. This implies implementation of those activities, which were not conducted within the First National Communication. Projections of expected emissions and correction of the National Climate Change Action Plan, that will be based upon the assessments of future emissions.

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APPENDIX

Table A1. Quantitative characteristics of harmful substances emitted by motor-transport in Georgia during 1980-96

Years	Substances					
	Carbon dioxide, million tons	Methane, tons	Nitrous oxide (N_2O), tons	Nitrogen oxides (NOx), thousand tons	Carbon monoxide, thousand tons	NMVOCs, thousand tons
1980	2.790	562.298	46.381	33.537	289.663	28.883
1981	2.917	583.556	49.039	35.092	300.521	30.005
1982	3.033	602.174	51.554	36.473	309.521	31.014
1983	3.197	635.538	54.204	38.458	326.784	32.743
1984	3.184	628.677	54.590	38.330	323.346	32.530
1985	3.195	616.495	56.632	38.528	314.232	31.678
1986	3.149	606.092	56.273	37.812	310.274	31.393
1987	3.183	606.377	57.791	38.201	310.324	31.543
1988	3.216	604.217	58.982	38.858	306.062	31.063
1989	3.092	569.493	57.977	37.478	286.517	29.200
1990	3.138	579.746	58.261	38.086	291.206	29.596
1991	3.529	573.159	75.176	43.339	275.494	29.122
1992	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1993	0.485	55.339	13.165	6.076	22.107	2.670
1994	0.211	39.097	4.442	2.398	21.183	2.288
1995	1.430	272.156	25.636	17.294	138.365	14.184
1996	2.962	533.363	56.495	36.114	265.723	27.628

Note: N.D. - no data available, uncomplete data

Table A2. Typological and age composition of forests under the Department of Forestry for January 1991

Types	Area, 10^3 ha	Age structure, 10^3 ha					% of total
		Young	Middle aged	Riping	Ripe	Aged ripe	
Coniferous:	410.6	28.1	167.1	63.3	102.1	50.0	19.2
Pinus	102.3	26.7	47.8	17.3	9.6	0.9	4.8
Abies	126.0	1.2	76.9	20.4	20.9	6.6	5.9
Picea	182.3	0.2	42.4	25.6	71.6	42.5	8.5
Hard-wood:	1416.4	67.1	719.0	210.0	309.9	110.4	66.2
Fagus	1051.4	22.8	504.4	167.5	269.4	87.3	49.1
Quecus	220.9	41.4	147.2	18.7	12.6	1.0	10.3
Carpinus	144.1	2.9	67.4	23.8	27.9	22.1	6.7
Soft-wood:	157.3	16.1	72.3	26.5	31.3	11.2	7.4
Alnus	69.1	11.9	18.4	14.3	16.8	7.7	3.2
Castanea	54.4	4.4	22.5	9.3	14.7	3.5	2.5
Others	33.8	2.4	9.8	11.0	8.0	2.6	1.6
Other kinds	103.9	13.2	51.4	16.5	18.3	4.5	4.9
Bushes	51.3	2.0	28.5	9.8	10.5	0.5	2.3
TOTAL:	2139.5	126.5	1038.3	326.1	472.1	176.6	100.0
%	100	5.9	48.5	15.2	22.1	8.3	

Table A3. Registered illegal cuttings of forests in Georgia during 1990-1996

Years	Volume of illegal cuttings, m^3	Volume of revealed cuttings, m^3	Share of revealed cuttings, %
1990	5006	3276	65.4
1991	5593	3594	64.3
1992	18041	11406	63.2
1993	42018	22051	52.5
1994	51420	23840	46.4
1995	47252	16939	35.8
1996	44238	15227	34.4

Table A4. Increase of CO_2 emissions due to illegal cuttings of forests in Georgia

Years	Volume of illegal cuttings, $10^3 m^3$	Total biomass, in 10^3 tons of dry mass	Carbon fraction	Annulal increment of carbon emission, Gg of C	Annulal increment of CO_2 emission, Gg
1990	5.006	9.511	0.45	4.280	15.69
1991	5.593	10.627	0.45	4.782	17.53
1992	18.041	34.287	0.45	15.429	56.57
1993	42.018	79.834	0.45	35.925	131.73
1994	51.420	97.698	0.45	43.964	161.20
1995	47.252	89.779	0.45	40.400	148.14
1996	44.238	84.052	0.45	37.823	138.69

Table A5. Aggregated emissions of GHG in Georgia in 1980-1997 (Tg/%) according to the sectors of economy

GHG	Sector	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Carbon dioxide, CO_2	Energy	30.976 89.6	32.537 90.3	33.631 90.5	35.670 90.9	35.479 90.4	35.883 90.6	33.090 90.3	33.650 91.1	33.225 91.5	32.333 92.7	33.814 92.8	26.691 93.1	16.089* 90.5	9.000 85.6	5.849 79.7	3.877 72.5	6.669 79.9	7.336 79.9
	Industr. processes	1.200 3.5	1.200 3.3	1.226 3.3	1.224 3.1	1.241 3.2	1.259 3.2	1.228 3.4	1.182 3.2	1.102 3.0	1.089 3.1	1.042 2.9	0.716 2.5	0.401* 2.3	0.287 2.7	0.144 2.0	0.136 2.5	0.188 2.3	0.207 2.3
	Forestry	1.576 4.6	1.592 4.4	1.547 4.2	1.624 4.1	1.640 4.2	1.658 4.2	1.460 4.0	1.262 3.4	1.069 2.9	0.865 2.5	0.664 1.8	0.540 1.9	0.655* 3.7	0.738 7.0	0.817 11.1	0.784 14.7	0.852 10.2	0.937 10.2
	Agriculture	0.8408 2.4	0.7174 2.0	0.7676 2.1	0.7137 1.8	0.9031 2.3	0.8201 2.1	0.849 2.3	0.8352 2.3	0.9215 2.5	0.5920 1.7	0.9015 2.5	0.7248 2.5	0.6294* 3.5	0.4883 4.6	0.5328 7.3	0.5474 10.2	0.6341 7.6	0.696 7.6
	Total	34.5928	36.0464	37.1716	39.2317	39.2631	39.6201	36.6270	36.9292	36.3175	34.879	36.4215	28.6718	17.7744	10.5133	7.3428	5.3444	8.3431	9.176
Methane, CH_4	Energy	0.103 27.1	0.099 26.7	0.101 26.7	0.103 26.8	0.110 28.1	0.121 29.4	0.121 29.1	0.118 28.9	0.120 30.4	0.110 28.7	0.106 29.7	0.0778 25.4	0.06017 25.1	0.0357 19.1	0.0172 10.7	0.0065 4.4	0.0065 4.2	0.0072 4.3
	Industr. processes	0.0004 0.1	0.0004 0.1	0.0004 0.1	0.0004 0.1	0.0004 0.1	0.0003 0.07	0.0003 0.07	0.0003 0.07	0.0002 0.05	0.0002 0.05	0.0002 0.06	0.00014 0.05	0.000094 0.04	0.000036 0.02	0.00001 0.01	0.000005 0.003		
	Forestry	0.0281 7.4	0.0247 6.6	0.0249 6.6	0.0248 6.5	0.0240 6.1	0.0243 5.9	0.0279 6.7	0.0250 6.1	0.0256 6.5	0.0252 6.6	0.0150 4.2	0.0107 3.5	0.0080 3.3	0.0089 4.8	0.0095 5.9	0.0078 5.2	0.0085 5.5	0.0094 5.6
	Agriculture	0.1077 28.4	0.1042 28.1	0.1061 28.0	0.1076 28.0	0.1088 27.7	0.1131 27.5	0.1122 27.0	0.1087 26.6	0.0982 24.9	0.0995 26.0	0.0909 25.5	0.0877 28.6	0.0818 34.1	0.0682 36.4	0.0627 38.9	0.0635 42.5	0.0653 42.1	0.0782 46.7
	Wastes	0.1406 37.0	0.1430 38.5	0.1463 38.6	0.1482 38.6	0.1494 38.1	0.1525 37.1	0.1549 37.2	0.1564 38.3	0.1506 38.2	0.1484 38.7	0.1443 40.5	0.1300 42.4	0.0899 37.5	0.0745 39.8	0.0716 44.5	0.0719 47.3	0.0732 47.2	0.0726 43.4
	Total	0.3798	0.3713	0.3787	0.3840	0.3926	0.4112	0.4163	0.4084	0.3946	0.3833	0.3564	0.30634	0.239964	0.187336	0.16101	0.149705	0.1551	0.1674
Nitrous oxide, N_2O	Energy	0.00028 3.3	0.000293 3.5	0.000302 3.5	0.000322 3.6	0.000322 3.2	0.00032 3.7	0.000313 3.2	0.000318 3.2	0.000318 3.4	0.000308 3.6	0.000293 3.7	0.000257 3.9	0.000117* 2.2*	0.000069 2.0	0.000041 1.3	0.000048 1.5	0.000087 2.2	0.000096 2.2
	Industr. processes	0.000802 9.5	0.0009663 11.5	0.0011307 13.0	0.001295 14.4	0.0014595 14.7	0.0016241 18.9	0.001622 16.7	0.00162 16.4	0.001618 17.3	0.001616 18.8	0.001613 20.4	0.001675 25.6	0.00095* 17.9	0.000727 20.6	0.000422 13.0	0.00053 16.2	0.000842 21.2	0.00093 21.3
	Forestry	0.0001933 2.3	0.0001699 2.0	0.0001714 2.0	0.0001704 1.9	0.0001651 1.7	0.0001669 1.9	0.0001917 2.0	0.0001716 1.7	0.0001759 1.9	0.000173 2.0	0.0001032 1.3	0.00007 1.1	0.00005* 0.9	0.00006 1.7	0.00007 2.2	0.00005 1.5	0.00006 1.5	0.000066 1.5
	Agriculture	0.007161 84.9	0.007009 83.0	0.007077 81.5	0.007202 80.1	0.007985 80.4	0.006487 75.5	0.007579 78.1	0.007778 78.7	0.007255 77.5	0.00652 75.7	0.005886 74.6	0.004542 69.4	0.004197* 79.0	0.002681 75.8	0.002706 83.5	0.002645 80.8	0.002976 75.1	0.003274 75.0
	Total	0.0084362	0.0084382	0.0086811	0.0089894	0.0099316	0.008598	0.0097057	0.0098876	0.0093669	0.008617	0.0078952	0.006544	0.005314	0.003537	0.003239	0.003273	0.003965	0.004366
Carbon monoxide, CO	Energy	0.341 52.6	0.3484 56.4	0.3577 56.6	0.3785 58.4	0.3751 57.6	0.3639 57.2	0.3565 55.5	0.3594 56.3	0.3564 55.0	0.3331 55.8	0.329 62.5	0.2994 67.8	0.014* 10.8	0.029 20.4	0.027 18.2	0.1417 56.8	0.2702 69.2	0.2972 69.2
	Industr. processes	0.0015 0.2	0.0016 0.26	0.0017 0.27	0.0018 0.28	0.0018 0.28	0.0019 0.3	0.0019 0.3	0.0019 0.3	0.0019 0.3	0.0019 0.3	0.002 0.4	0.0014 0.3	0.0008* 0.6	0.0006 0.4	0.0004 0.3	0.0005 0.2	0.0006 0.2	0.00066 0.15
	Forestry	0.246 37.9	0.2163 35.0	0.2182 34.5	0.2169 33.5	0.2102 32.3	0.2124 33.4	0.2241 34.9	0.2184 34.2	0.2239 34.6	0.2202 36.9	0.1313 24.9	0.0937 21.2	0.0699* 54.0	0.0782 54.9	0.0832 56.0	0.0684 27.4	0.0743 19.0	0.08173 19.0
	Agriculture	0.0598 9.2	0.051 8.3	0.0546 8.6	0.0506 7.8	0.0642 9.9	0.0583 9.2	0.0604 9.4	0.0592 9.3	0.0655 10.1	0.0421 7.0	0.0641 12.2	0.0469 10.6	0.0448* 34.6	0.0347 24.4	0.0379 25.5	0.0389 15.6	0.0451 11.6	0.04961 11.6
	Total	0.6483	0.6173	0.6322	0.6478	0.6513	0.6365	0.6429	0.6389	0.6477	0.5973	0.5264	0.4414	0.1295	0.1425	0.1485	0.2495	0.3902	0.4292
Nitrogen oxides, NOx	Energy	0.11271 93.1	0.118229 94.2	0.122622 94.3	0.13024 94.6	0.129894 94.6	0.133003 94.7	0.125493 93.8	0.126461 94.3	0.126743 94.2	0.123156 94.3	0.124347 96.0	0.108714 96.6	0.0449* 94.0	0.0296 91.0	0.017715 85.1	0.023838 89.7	0.04650 93.8	0.05115 93.8
	Industr. processes	0.000306 0.3	0.0003246 0.3	0.0003432 0.3	0.0003608 0.3	0.0003794 0.3	0.000397 0.3	0.000399 0.3	0.0004 0.3	0.000402 0.3	0.0004 0.3	0.000397 0.3	0.000309 0.3	0.000164* 0.3*	0.000117 0.4	0.000068 0.3	0.000083 0.3	0.000128 0.3	0.000141 0.26
	Forestry	0.006999 5.8	0.0061443 4.9	0.006195 4.8	0.0061443 4.5	0.005968 4.4	0.006031 4.3	0.00693 5.2	0.006202 4.6	0.006357 4.7	0.006254 4.8	0.0037292 2.9	0.00266 2.4	0.00198* 4.1	0.00222 6.8	0.00236 11.3	0.00194 7.3	0.00211 4.3	0.00239 4.26
	Agriculture	0.00099 0.8	0.000850 0.7	0.000930 0.7	0.000860 0.6	0.0011 0.8	0.0009823 0.7	0.001003 0.8	0.00101 0.8	0.00109 0.8	0.00074 0.6	0.001029 0.8	0.00083 0.7	0.00072* 1.5	0.00059 1.8	0.00067 3.2	0.0007 2.6	0.00082 1.7	0.00090 1.65
	Total	0.12101	0.125548	0.130091	0.1376051	0.1373413	0.14041	0.1338246	0.1340731	0.1345922	0.130548	0.12950	0.112513	0.047767	0.032523	0.020813	0.026561	0.04956	0.05451

Note: * - Uncomplete data due to lack of initial information

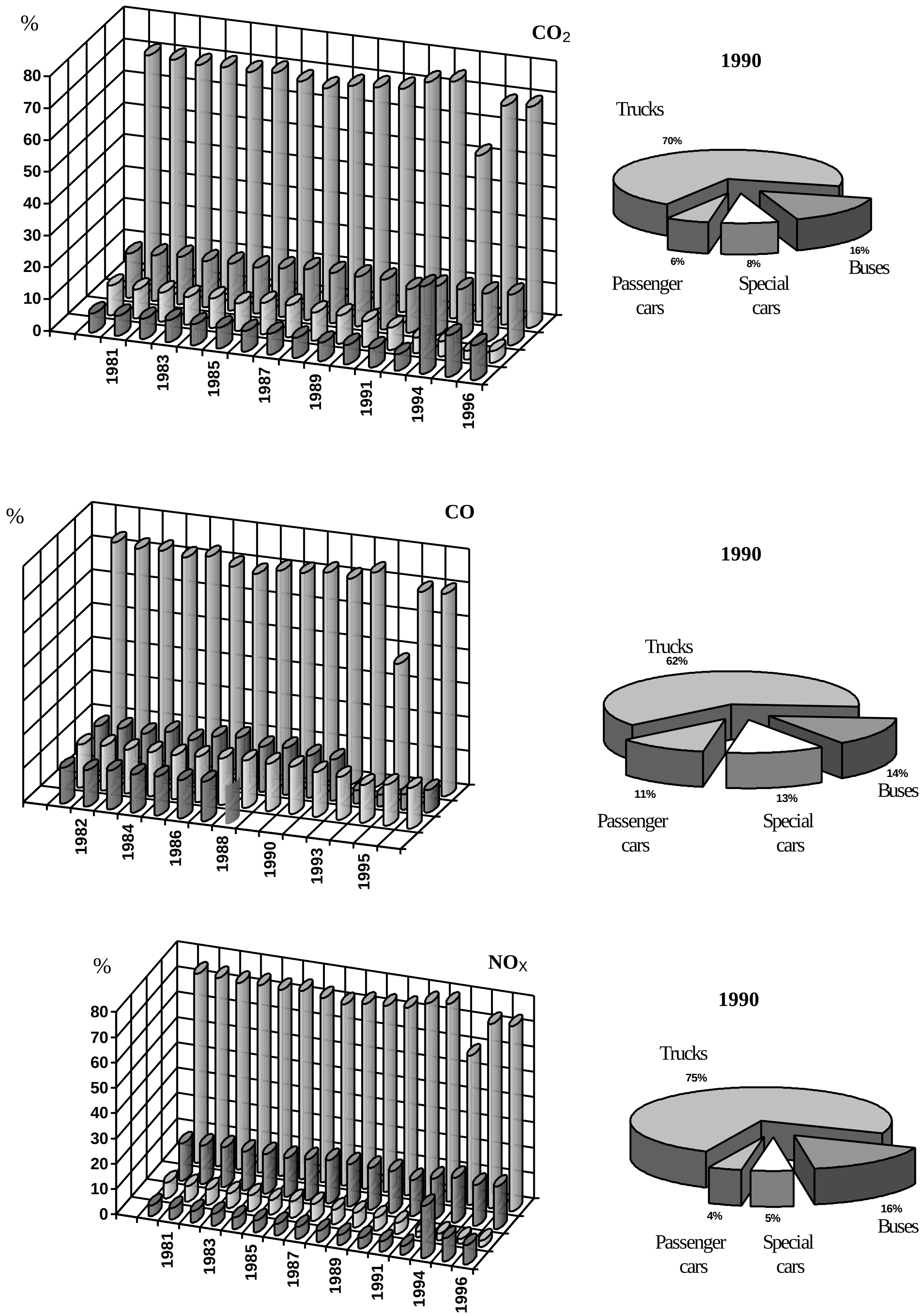

Fig. A1. Emission of CO_2, CO and NO_x by specific types of motor-transport in Georgia for 1980-96 relative to the total emission (%)

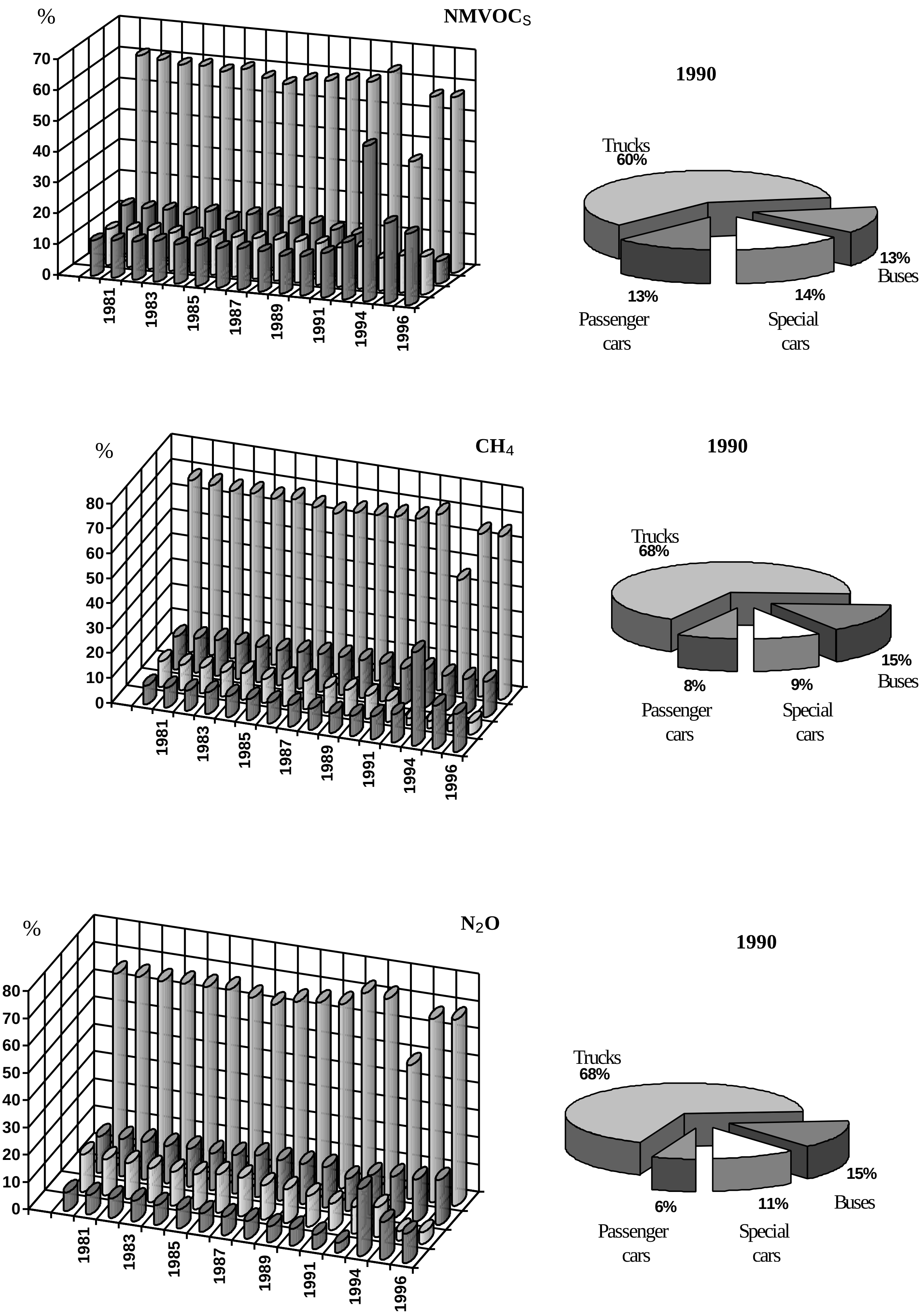

Fig. A2. Emission of NMVOCs, CH_4 and N_2O by specific types of motor-transport in Georgia for 1980-96 relative to the total emission (%)

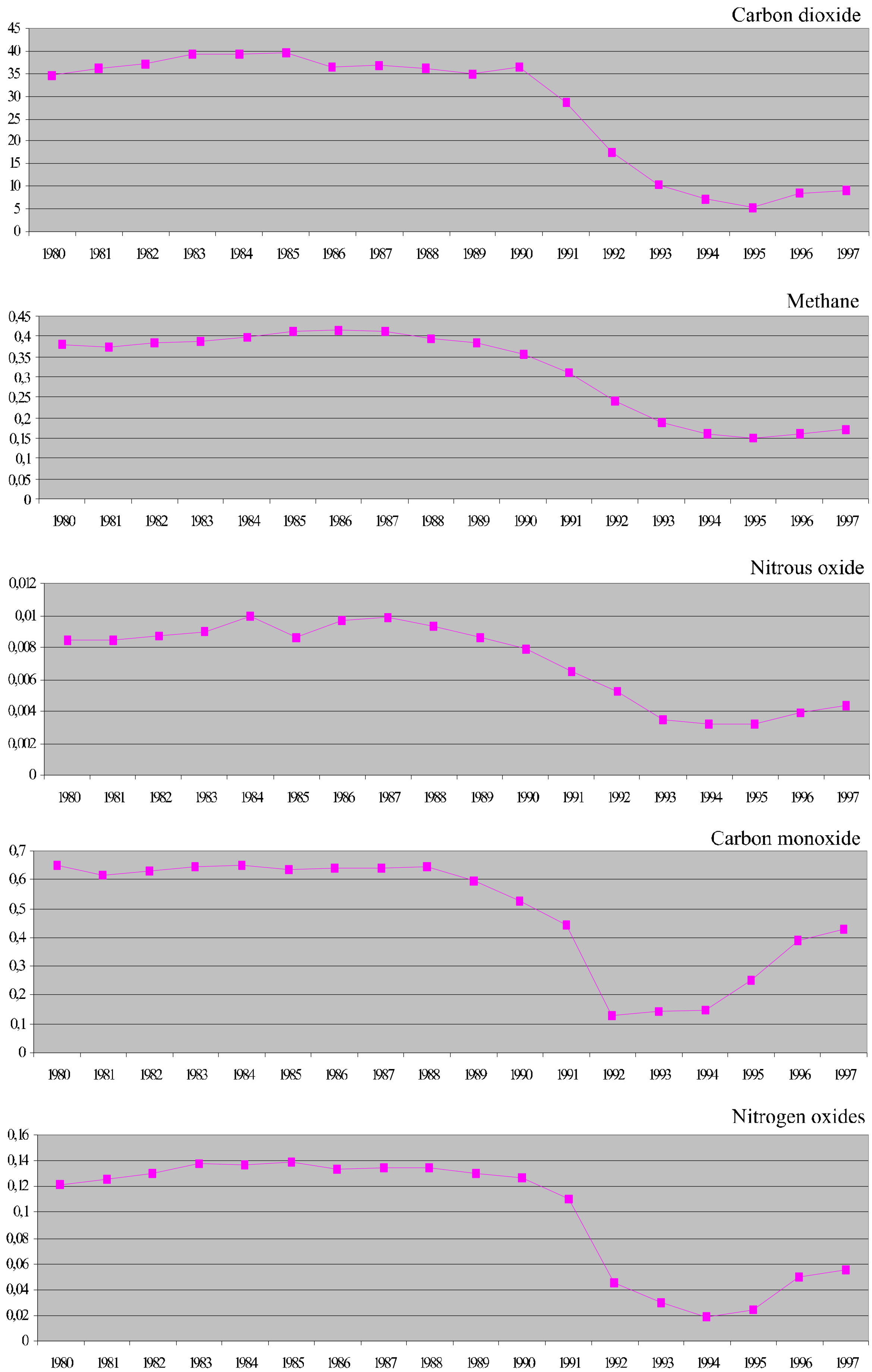

Fig. A3. Emission dynamics of GHGS in 1980-1997 (Tg)

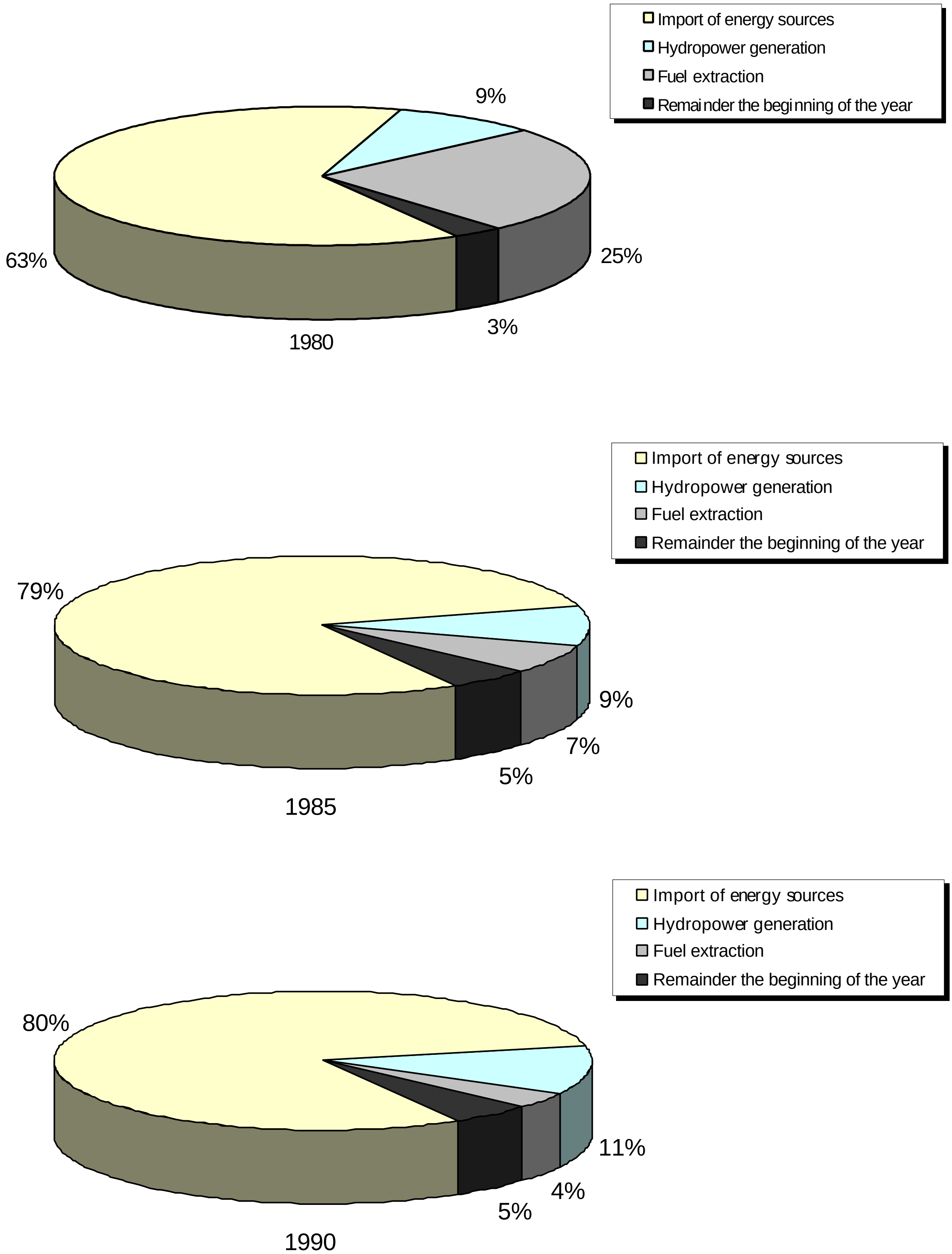

Fig. A4. Percentage share of various sources in energy resources

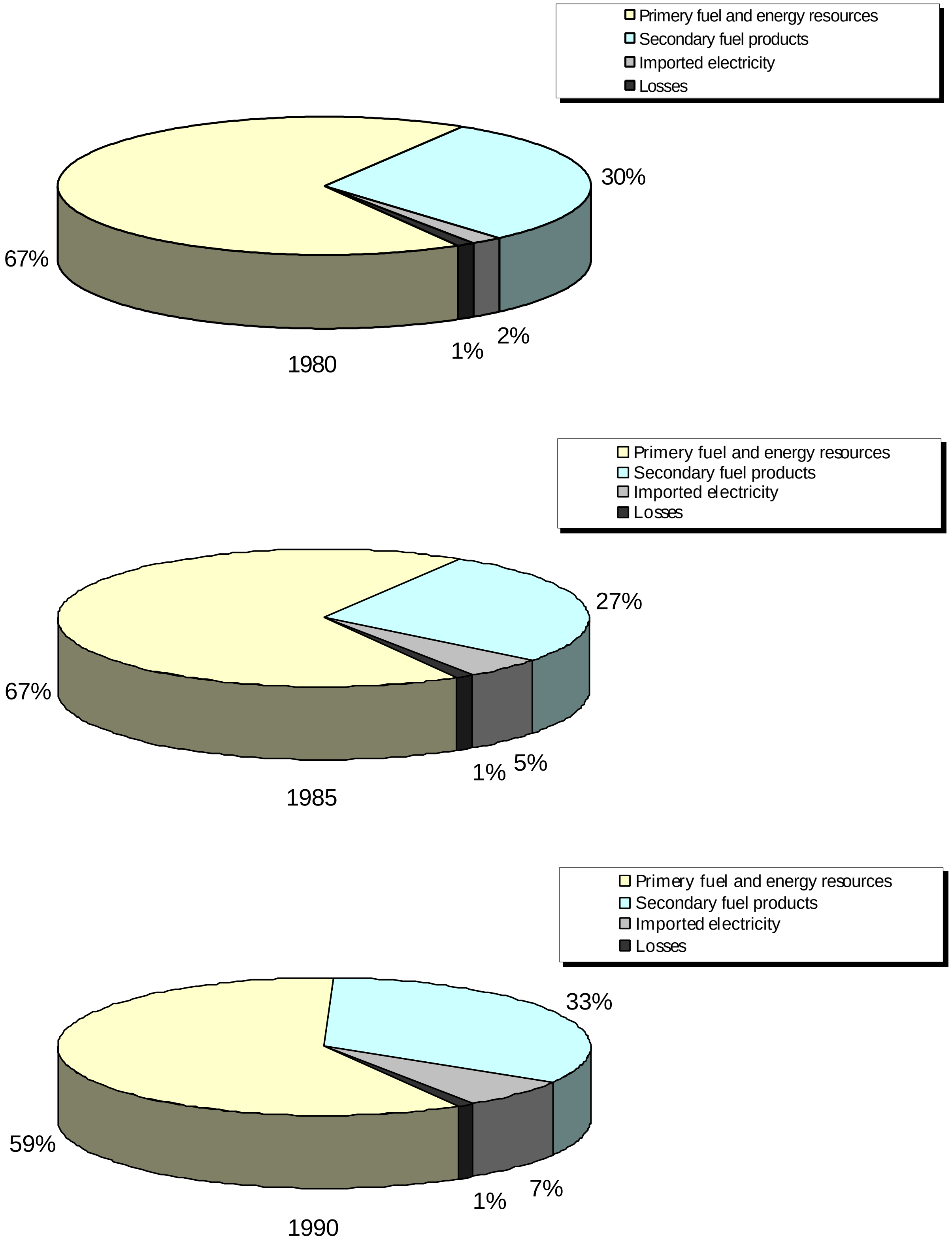

Fig. A5. Structure of energy resources (%)

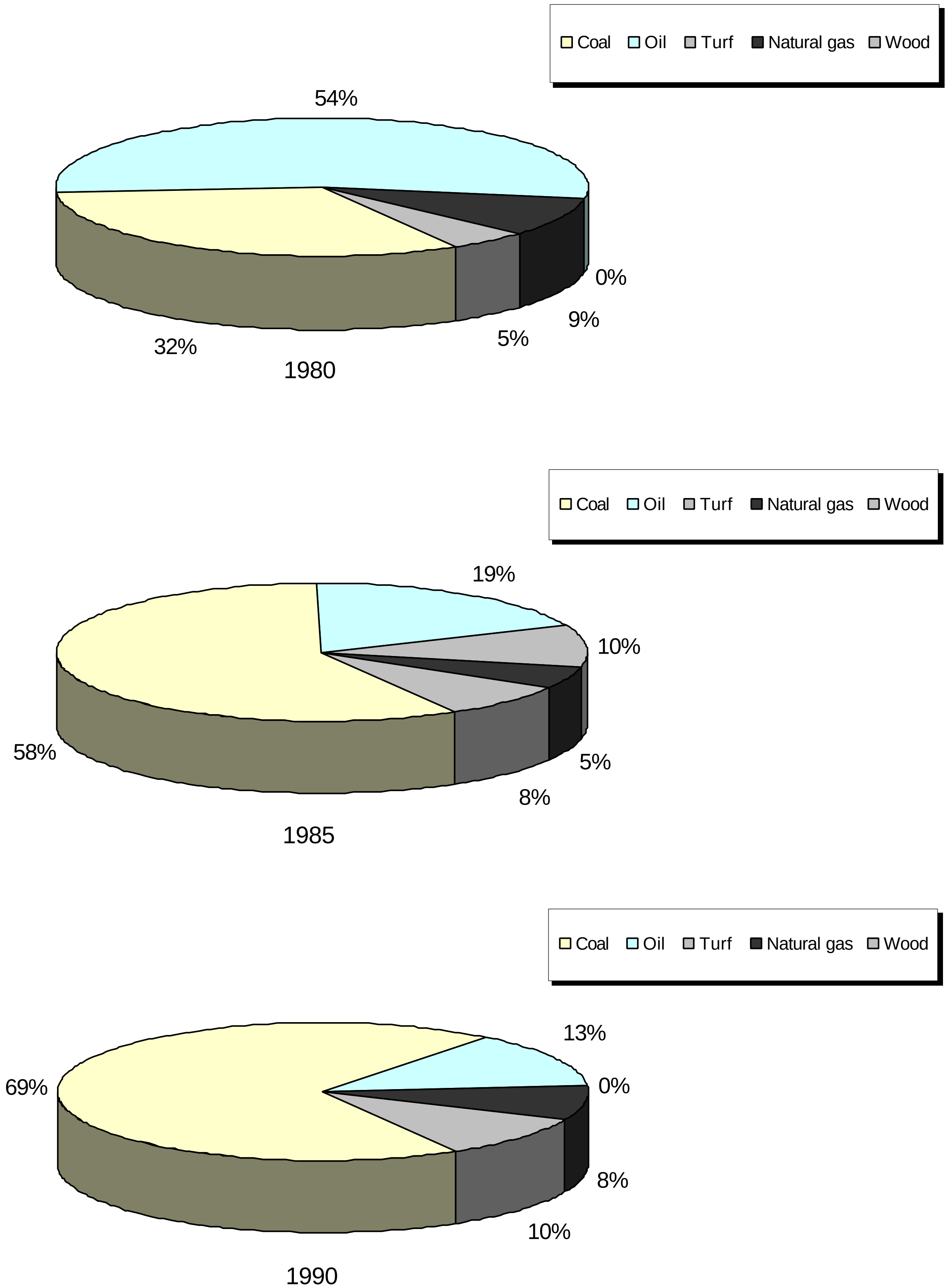

Fig. A6. Change in the structure of natural fuel extraction (%)