INITIAL COMMUNICATION OF THE REPUBLIC OF UZBEKISTAN

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Contents

Summary 5

Introduction 14

1. National Circumstances 15
1.1 Geographic Situation and Climate 17
1.2 Natural Resources 18
1.2.1. The Land and Agricultural Resources 18
1.2.2. Water Resources 18
1.2.3. The Aral Sea and Amudarya River Basin 20
1.2.4. Biological Resources 21
1.2.5. Natural Ecosystems 22
1.3. The Socio-Economic Description of Uzbekistsan 23
1.3.1. Population 23
1.3.2. Economy Structure 23
1.3.3. Development of the Power Sector in Uzbekistan 25
1.3.4. Transport 27
1.4. Protection of Environment 28

2. National Inventory of Greenhouse Gas Emissions 30
2.1. Methodology 30
2.2. Total GHG Emissions 31
2.3. Carbon Dioxide Emissions 34
2.4. Methane Emissions 35
2.5. Nitrous Oxide Emissions 35
2.6. Changes in Land Use and Forestry 35
2.7. International Cargo 36
2.8. GHG Emissions from 1990 to 1997 36
2.9. GHG Emissions with Indirect Greenhouse Effect 37
2.10. Estimation of Uncertainty 39

3. Development Forecast 41
3.1. Economic Development Forecast 41
3.1.1. Macroeconomic Forecast 41
3.1.2. Social Development 42
3.2. Economic Restructuring 43
3.2.1. Industry 43
3.2.2. Agriculture 44
3.2.3. Transport 44
3.3. Energy Sector Development Forecast 45
3.3.1. Energy Consumption 46
3.3.2. Development of the Energy Sector of the Economy 47

4. GHG Emissions Forecast 50
4.1. Development Possibilities: Main Characteristics 50
4.2. Emission Forecast by Sector 51
4.2.1. Energy Sector 51
4.2.2. Industrial Processes 52
4.2.3. Agriculture 53
4.2.4. Wastes 54
4.3. Combined Scenarios of GHG Emissions 54

5.	**Potential Evaluation and Measures to Reduce GHG Emissions……**	59
5.1.	Energy Sector……………………………………………………………………	60
5.2.	Industrial Processes……….………….…………………………………………..	65
5.3.	Agriculture ………………..…………….………………………………………	66
5.4.	Forestry …………………………………………………………………………	66
6.	**Climate System Research**………………..…………………….…………..	67
6.1.	Data Collection of Systematic Monitoring, Database…………..………………………………………………………….….	67
6.2.	Developmenet of Research……………………………………..……...………..	67
6.3.	The National Climate Program (NCP)…….……………………………….………..	68
6.4.	Study of Paleoclimatic Situation in the Aral Sea Basin in Late Pleistocene and Holocene Periods…………….…………………………..	68
6.4.1.	Ancient Rivers' Flow…………………………………………………………...	68
6.4.2.	The Aral Sea during the Last 20,000 Years………………………………………	69
6.4.3.	Paleo-Glaciation in the Aral Sea Basin………..……………………………….	70
6.5.	The Changes in Glaciation of the Pamir-Alay Range in the Second Half of the 20th Century……………………………………….…..	71
6.5.1.	Analysis of the Changes in Area and Volume of Glaciers of the Pamir-Alay Range ….….…………………………………………………….	71
6.5.2.	Evaluation of Tendencies of Changes in Present Glaciation ……………..……...	71
6.6.	Observed Climate Changes in Uzbekistan………..…………………………………	74
6.7.	Expected Climate Changes and Climate Scenarios…………….. ………..………	75
7.	**Consequences of Climate Change: Vulnerability Assessment and Ways of Adaptation**…………………..	80
7.1.	Approaches to Vulnerability Assessment..…………………………..…………	80
7.2.	Agro-Climatic Resources and Agriculture…………..……………….…..………	80
7.2.1.	Estimation of Probable Changes in Agro-climatic Resources……..……………….	80
7.2.2.	The Climate Change Impact on Agricultural Production ……………...………...	82
7.2.3.	Vulnerability of Natural Pastures………..…………………………………….	84
7.2.4.	Adaptation Measures in Agriculture…………………………...…………..….	84
7.3.	Water Resources, Changes and Adaptation Measures…….………………….….	86
7.3.1.	Vulnerability of Surface Water………………………………………………...	86
7.3.2.	Prospective Assessment of Water Resources..………………………………....	87
7.3.3.	Adaptation Measures……… ……………………….………….………….…..	88
7.4.	Consequences of Climate Change. Mitigation Measures for Some Ecosystems………………………………………	90
7.4.1.	Problems of the Aral Sea and Amudarya Delta…………………………………..…	90
7.4.2.	Measures for Mitigation of Negative Effects of the Drying up of the Aral Sea ……………………………………………….	91
7.4.3.	Vulnerability of Forest Resources…………………………………………….	92
8.	**Education and Popularization** … ……………………….……………	94
9.	**Problems and Directions of Subsequent Activities**…….. …………	95
10.	**Proposals for Institutional Structure for Implementation of the UNFCCC in Uzbekistan**	99
	Annex…………………………………………..	107

Summary

Introduction

Acknowledging the significance of the climate change problem and the necessity to take effective steps to mitigate its impacts, in 1993 Uzbekistan signed the United Nations Framework Convention on Climate Change (UNFCCC) and in November 1998 – the Kyoto Protocol, which was ratified on August 20, 1999.

As a first step in meeting the commitments specified in the UNFCCC, a project entitled "Uzbekistan Country Study on Climate Change" was conducted and the First National Communication of the Republic of Uzbekistan on Climate Change was developed. This Report includes a description of national conditions, greenhouse gas inventories (inventory data of 1990 and 1994), forecasts of greenhouse gas emissions for the period until 2010, a general description of GHG mitigation measures, an assessment of vulnerability to climate change and possible adaptation to climate changes.

National Circumstances

The Republic of Uzbekistan is situated in the central part of the Eurasian continent between the 37° and 45° N. latitude and 56° and 73° W. longitude at the northern boundary of the subtropical and temperate climate zones. The area of the Republic makes up 447.4 thous. km^2 ; 78.8% (the Western part) of this territory falls on the plains, and the rest (21.2%) - on the mountains and foothills.

The Climate of Uzbekistan is arid-continental. The average July temperature on the plains' territory varies from 26° C in the North to 30° C in the South, and the maximum temperature reaches 45 – 47° C. The average January temperature falls to as low as 0° C in the South and to -8° C in the North; the minimum temperature during some years reaches -38° C (the Ustyurt Plateau). Precipitation primarily occurs during the winter-spring period. Annual precipitation amounts to 80 – 200 mm on the plains, 300 – 400 mm in the foothills area and 600 – 800 mm on the eastern and south-eastern slopes of the mountain ridges.

The territory of Uzbekistan contains five ***natural ecosystem*** types: the desert ecosystem of the plains; the piedmont semideserts and steppes; the rivers and coastal ecosystems; the ecosystems of wetlands and deltas; and the mountain ecosystem. The majority of Uzbekistan's territory is occupied by desert ecosystems (70% of the territory). Sandy deserts make up 27% of the flat part of the country.

The Land Reserves. Natural pastures occupy 50.1% of the total area of Uzbekistan, and 9.7% of irrigated lands. High salinity and small humus content characterize all types of soils in Uzbekistan. Irrigated land is cultivated for cotton, spiked cereals, rice and potato. Cotton plants occupy 36.5% of the cultivated areas and grain crops 39.5%. The vast desert and semidesert territories of the Republic serve as the base for Karakul sheep breeding.

Given the abundance of solar radiation and heat, the major factor limiting the use of agroclimatic and land resources is a deficit of water.

Surface Waters. The territory of the Republic houses part of the closed Aral Sea Basin, to which all rivers and lakes flowing through Uzbekistan belong. The water resources of the Basin are jointly used by the Central Asian states. The river flow is concentrated in the two largest transboundary rivers: the Amudarya and Syrdarya Rivers, which run down from the mountains to the plains, cross the deserts and flow into the Aral Sea.

Uzbekistan is the major water consumer in the Aral Sea Basin. In accordance with interstate agreements, on average 43 – 52 km^2 of water per year is allotted for use by Uzbekistan from the boundary rivers. About 90% of river flow is formed beyond Uzbekistan's boundaries.

Intensive irrigation has lead to the drying up of the Aral Sea. Salt marshes and salty, traveling sands are forming on the dried up bottom of the sea. Eolian transfer carries these salty sands to surrounding territories.

Population. In 1997, the population of Uzbekistan reached 23.7 mln. people. The rural population makes up 62%. A special feature of the Republic is a high level of population growth. The highest population density can be found in large, inter-mountain valleys. The capital of Uzbekistan is the city of Tashkent, where more than 2,200,000 people reside. The territory of Uzbekistan includes the Republic of Karakalpakstan and twelve oblasts. In 1997, the mean average life expectancy in the Republic was 70.3 years. The literacy rate and education level in Uzbekistan is among the highest in world.

National Economy. During the period from 1990 to 1997 the economy in Uzbekistan developed. The non-governmental sector made up 64% of GDP in 1997 and accounted for 71% of the employment in the economy.

Uzbekistan is an agrarian-industrial country, in which agriculture occupies the prevailing share in the economy. The agricultural sector accounts for 70% of the internal trade turnover and 50% of the foreign currency earnings; its share of GDP amounts to 28.2%. Irrigated farming is the basis of agriculture in Uzbekistan and the major crop is cotton. Uzbekistan ranks 4th in the world in cotton-fiber production. The agricultural sector makes it possible to produce up to 80% of the foodstuffs required for the country's population. During the period 1990-1997, grain production was nearly doubled thanks to the expansion of cultivated areas.

Light industry, food processing, machine building, chemistry, metallurgy, electric power, transport, communication and service sectors are being developed with attracted foreign capital. Unlike in other CIS countries, Uzbekistan did not experience a slump in production after the collapse of the former Soviet Union. Since 1996, GDP has steadily grown.

The Power Sector. The power sector (electric power and fuels industry) makes up 24.3% of the total volume of industrial production. Electric power output in 1997 equaled 46.1 billion kWh, oil production increased from 2.8 mln. t in 1991 to 7.9 mln. t in 1997, and natural gas production rose from 41.9 to 54.8 billion m^3.

The largest fuel and electric power consumers are the public-service sector and the power sector, with a share equaling almost 75% of the power consumption of the fuel/power resources. Therewith, the population is the largest consumer, accounting for 37.8% of fuel and electric power consumption in 1997 (as compared with 17.7% in 1990). The principal features of power sector development in the Uzbekistan since 1990 are as follows:

- The volume of power consumption has not significantly changed;
- A considerable growth in primary energy production has taken place;
- Substitution of natural gas for other types of fuel and power occurred (the share of natural gas made up 80.8% of total consumption in 1997 as compared with 63% in 1990);
- From 1990 through 1996, GDP decreased but power intensity increased by 18.0% (a decrease in energy efficiency).

Transport. Road vehicles provide the main form of transport of passengers and goods in Uzbekistan: passenger turnover is 78% and freight turnover is 83%. The total number of the motor vehicles in Uzbekistan exceeds 1.1 mln. Motor transport is the major consumer of liquid hydrocarbon; a very low percentage of vehicles operate on diesel fuel (6.1%), and on compressed and condensed gas (2.3%).

National Inventory of Greenhouse Gas Emissions

The National Inventory of Greenhouse Gas emissions presents data for 1990 and 1994 on emissions of gases with a direct greenhouse effect (carbon dioxide, methane and nitrous oxide) and of gases with an indirect greenhouse effect (carbon monoxide, nitric oxide, sulfur dioxide and non-methane hydrocarbons).

Development of the Inventory is based on 1996 IPCC methodology and on official statistical data. In estimations of greenhouse gas emissions, both the IPCC and local coefficients were used.

Five categories of GHG emission sources were considered: *Power Sector*, *Industrial Processes*, *Agriculture*, *Land Use Change and Forestry and Wastes*.

Overall GHG emissions in Uzbekistan: 1994 GHG emissions levels were 94.5% of 1990 levels (a 5.5% decrease).

Table

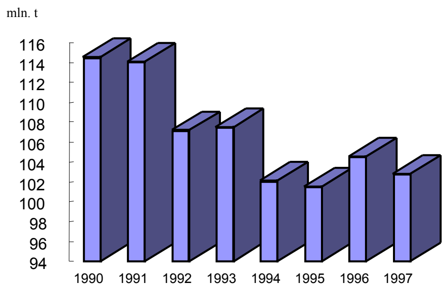
Greenhouse Gases Emission in Uzbekistan (mln. t CO_2equivalent)

Gas	1990	1994	% by 1990
CO_2	114.6	102.2	89.2
CH_4	37.7	41.8	110.8
N_2O	10.9	10.2	93.5
Total	163.2	154.2	94.5

This reduction in emissions occurred because of specific features of the social and economic development of Uzbekistan: the power delivery volume to all consumers during the 4 years between 1990-1994 decreased by 6.3%, but natural gas deliveries to the population more than doubled. In Uzbekistan, specific emission of greenhouse gas emissions in CO_2equivalent made up 8.0 t per capita in 1990 and in 6.9 t per capita in 1994; of this amount CO_2 accounted for 5,6 t and 4.6 t respectively.

In 1990, carbon dioxide accounted for 70.2% of total emissions, methane 23.1% and nitrous oxides 6.7%. In 1994, carbon dioxide emissions decreased to 66.3% of total emissions, methane increased to 27.1% and the amount of nitrous oxide in aggregate GHG emissions did not significantly change. The major source of greenhouse gases is the power sector, which accounted for about 83.0% of the overall emissions in 1990 and 1994.

Carbon Dioxide. From 1990 through 1994, carbon dioxide emissions decreased by more than 12.4 mln. t (10.8%). In view of this reduction in fuel consumption by the production spheres of the economy, the overall GHG emissions from the *Power Sector* decreased by 10.0% but an increase in emissions from the *Population* and *Municipal Household Service* sectors of 84.5% and 46.0% respectively took place.



Dynamics of Carbon Dioxide Emissions

The processes related to fuel combustion are the major sources of CO_2 emissions. In 1990, they accounted for 94.3% of emissions, and industrial processes accounted for 5.7%. In 1994, under reductions in production of industrial products, emissions from the power sector reached 95.2% of GHG emissions, and emissions from production processes were decreased to 4.8% of overall GHG emissions.

According to inventories of forested areas, forest sinks were estimated to house 421 thous. t of CO_2 in 1990 and 399 thous. t of CO_2 in 1994.

Methane. The major source of methane emissions is the power sector (oil and gas industry). In 1990, the *Power Sector* accounted for 73.5% of the overall volume of methane emissions, *Agriculture* – 18.3%, and *Waste* – 8.2%. In 1994, the structure of the sources hadn't significantly changed, but methane emissions increased by 10.7%.

Growth of methane emissions is the result of an increase in natural gas production and consumption, an increase in rice production, and population growth.

Nitrous Oxide. Cultivated soils are the principal sources of nitrous oxide emissions, and they accounted for 96.8% of the overall nitrous oxide emissions in 1994. In 1994, total emissions of nitrous oxides decreased by 5% as compared with 1990, therewith, the reduction in the *Agriculture* sector made up only 3.8% of this reduction, while emissions from *Industrial Processes* decreased by 5 times, as a result of reduced nitric acid production.

International Bunker Fuel. Due to a lack of official data on the use of fuel for international air transportation, an estimate of carbon dioxide emissions from jet fuel was conducted, which showed an emissions reduction from 2.0 mln. t in 1990 to 0.6 mln. t in 1997. This reduction in emissions is the result of a reduction in air passenger traffic.

Emissions of Gases with an Indirect Greenhouse Effect. From 1990 to 1994, the emission volumes of gases with an indirect greenhouse effect considerably decreased: carbon oxide by 31.5%, sulfur dioxide gas by 50.2%, nitric oxide by 29.2% and non-methane hydrocarbons by 16.4%. The reason for this reduction in emissions is change in the structure of consumption: a reduction in the use of liquid and solid fuels and an increase in the consumption of gaseous fuel.

Assessment of Uncertainties. Error in the estimations of greenhouse gases emissions associated with possible errors in the initial statistical data for nearly all sectors is calculated to be 5 to 10%. General uncertainty relating to the emission factors and the accuracy of the data on economic activities by various sectors is estimated to be 9 – 80%, and, in the most significant sector, the *Power Sector,* uncertainty is estimated to be 9%. General uncertainty by type of GHG gases was estimated as follows for 1990: CO_2 – 8.5%, CH_4 – 42.7%, N_2O – 77.4%; and for 1994: CO_2 – 8.6%, CH_4 – 42.6% and N_2O – 79.5%.

Development Forecast

A number of conditions influence the economic development of Uzbekistan:

- Maintenance of relatively high population growth level (by 2010 population will reach 28.2 mln. people at an average annual growth rate of 1.5%);
- An increasing deficit in water resources, reduction in irrigated lands productivity and the need to solve a number of ecological challenges;
- Production of mostly raw (as opposed to finished) goods in the economy.

Under the current conditions of economic transition, the main instrument of economic development forecast will be the scenario approach supplemented by econometric modeling methods and by estimates of the development of the branches and sectors of the economy.

The ***inertia scenario*** presumes that by the year of 2000, GDP will grow by only 2 – 3%, and that subsequently, a decline in economic development will take place.

To ensure sustainable development of the country, GDP growth rates should be higher than the population growth rates by at least 1.5 – 2.0 times and increase by 5-6% in 2001-2005. The ***mobilization scenario*** assumes GDP growth of 6-8% for the period 2001-2005. This scenario assumes economic stimulation and new sources of sustainable economic growth (improvement in tax, budget and monetary policies, liberalization of the currency market, development of financial and banking systems, enhancement in development of manufacturing and high-technology industrial productions oriented for export, etc.).

Industrial output is forecasted to increase 2.5 – 3.0 times by 2010. The following sectors of the economy are expected to develop at the quickest pace: the engineering industry (growth of 3.0 – 3.5 times expected), light industry (growth of 2.5 – 3.0 times expected), food processing industry (growth of 3.0 – 3.5 times expected) and the chemical industry (growth of 2.5 – 3.0 times expected). By the year of 2010, sustainable incremental growth of agricultural production of at least 5 – 6% is expected. Freight turnover of all types of transport will increase by 1.4 times, and passenger traffic by 1.2 times. An increase in the average per capita consumption of goods and services of 1.6 – 1.7 times is anticipated during the period from 1999 to 2010.

The Power Sector. The power sector and the population are expected to remain the major power consumers. The principal type of the fuel used in the Republic will remain natural gas, although the share of natural gas consumption (in comparison with consumption of other fuels) will slightly decrease. The strategy in the power sector development will be oriented at:

- Further extraction of brown coal through open-pit mining;
- Development of underground gasification of coal;
- Maintenance liquid hydrocarbons production at current levels;
- Growth and stabilization of natural gas production;
- Improvement in the processing of hydrocarbons raw materials;
- Improvement in product quality to a world standard level;
- Maintenance of a balanced electric power structure.

By 2010, the volume of the electric power output may equal 73.6 billion kWh and thermal power may equal 67.1 million Gcal.

In accordance with economic development scenarios, three power demand scenarios were developed:

- ***1st scenario -*** assumes the inertia scenario of economic development and an absence of consumer-energy efficiency measures;
- ***2nd scenario*** – assumes the mobilization scenario of economic development without consideration of any energy-efficiency measures;
- ***3rd scenario*** – assumes the mobilization scenario of economic development, development of new oil deposits and implementation of the energy-efficiency measures.

The three power demand scenarios presume growth in aggregate energy demand by the year 2010 of 58.5 mln. t, 64.3 mln. t and 56.2 mln. t in oil equivalent respectively.

Greenhouse Gases Emission Forecast

On the basis of the two scenarios of economic development (the inertia scenario and the mobilization scenario) and the three power-demand scenarios, three versions of major greenhouse gases (CO_2, CH_4 and N_2O) emission forecasts have been developed for the period until 2010.

The developed forecasts for GHG emissions by separate categories have been aggregated and principal indicators are given in the Table below.

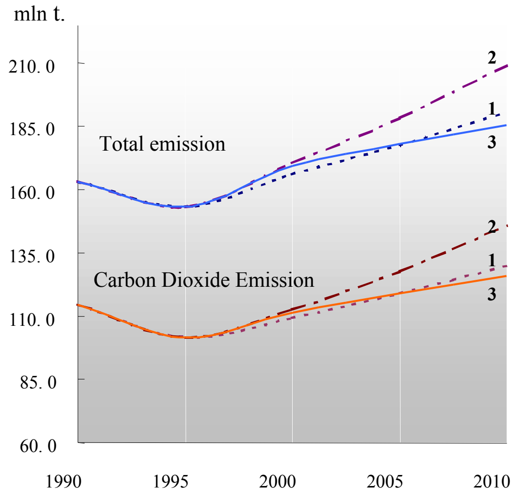
Table

The Greenhouse Gases Emission Forecast by 2010 (% to the base year of 1990)

Emissions	1990 (*mln. t CO_2 equivalent*)	Development Scenarios		
		1	2	3
Total	**163.2**	**116.7**	**128.0**	**113.7**
__2	114.6	113.4	127.2	109.8
__4	37.7	131.8	138.7	129.7
N_2O	10.9	100.0	100.0	100.0
GHG emissions per capita, t	8.0	6.8	7.5	6.6

These estimates demonstrate that even under conditions where all planned GHG mitigation measures are implemented, GHG levels in 2010 will still exceed 1990 levels by 13.7%.

GHG Emission Forecast by Categories of GHG Emission Source. GHG emissions estimates have been made for four separate categories of GHG emission sources: the *Power Sector*, *Industry*, *Agriculture* and *Wastes*.



Greenhouse Gases Emission Forecast
(1st ,2nd ,3rd – version of GHG emissions)

Due to the forecasted economic growth under all scenarios of development, aggregate levels of GHG emission from the *Power Sector* in the year 2000 are expected to be higher than 1990 levels. Aggregate emissions by the year 2010 are expected to equal 158.3 mln. t in CO_2 equivalent (under the third version of GHG emissions forcast), or in other words, be 16.6% higher than the of 1990 levels.

The *Industrial Processes* sector is expected to account for the highest level of GHG emissions' reduction. GHG emissions from industrial processes are not expected to reach 1990 levels by the year 2010 under any of the GHG emissions forecast versions. Processes associated with the output of mineral products and chemicals are expected to remain the major GHG emission source in this sector for the period until 2010 and CO_2 is expected to be the principal GHG emission, accounting for 98.0 – 99.0% of the emissions in this sector by 2010.

In the *Agriculture* sector, the soils used in farming and domestic animals are expected be the main sources of the GHG. Expected growth in farm animal stock and poultry, as well as an increase in rice production for the period until 2010 will result in insignificant growth of the GHG emissions in this sector.

In the *Waste* sector, only methane emissions have been considered. Inasmuch as the principal GHG sources in this sector are solid waste sites and household effluents, emissions growth rates under this sector are expected to correspond to the growth rates of the urban and rural population of the Republic.

Potential Evaluation and Measures to Reduce GHG Emissions

The total technical potential of CO_2 emissions mitigation resulting from energy-efficiency measures (*Power Sector*) which may be actually realized through available investments is estimated to be 25.0 mln. t. By the year 2010, it is expected that only a part of this potential will be realized, equaling around 7.0 mln. t in oil equivalent and a subsequent CO_2 emissions reduction of 17.1 mln. t.

Other sectors of GHG emission sources have considerably less potential for reduction. The aggregate technical potential of GHG emissions reduction for the sectors *Industrial Processes*, *Agriculture* and *Waste* are estimated at 2.2 mln. t of CO_2 equivalent.

The main sources of GHG mitigation in Uzbekistan are as follows:

- Reducing fuel and power losses and improving fuel and power efficiency in all sectors of the economy;
- Introducing advanced technologies in production processes and equipment of the power sector and in other sectors of the economy;
- Enhancing farming productivity; improving the power structure balance of the country;
- Further research and development of renewable energy sources.

Using renewable energy sources, it will be possible to reduce GHG emissions by 1.3 mln. t of CO_2 equivalent for the period until 2010.

The main foci in realizing energy-saving and energy efficiency potential are as follows:

- Pursuing appropriate tariff policies;
- Improving industrial production technology;
- Developing combined production of electric and thermal power on the basis of steam-gas and gas-turbine plants;
- Installing meters for natural gas, thermal power and water at all stages of the resources flow;
- Reducing fuel and power losses and improving fuel and power use technologies.

Climate System Research

The first meteorological observations in Uzbekistan were made more than 100 years ago. Currently, there are 87 meteorological stations, 94 posts and 120 hydrological stations in Uzbekistan; 18 stations are included in the Global Observing System and 3 stations are included in the Global Climate Observing System.

Study of the paleo-climatic conditions in the Aral Sea Basin revealed considerable fluctuations in the climate of the Pleistocene period. The traces of seven sea levels were found in the Aral Sea depression. At the end of the late Pleistocene period, extremely high levels of the Aral Sea were observed. During the beginning of the AD era, a dramatic reduction in levels of the Aral Sea occurred, to dimensions even lower than present-day Aral Sea levels, due to changes in the flow of the Amudarya river (runoff to the Caspian Sea).

Observation study has shown that changes in various components of the climate system are already underway in the region. Positive trends in the temperature and a climate warming tendency during both the cold and warm halves of the year have been observed.

Observation data in the mountain river basins demonstrate a stable decrease in the reserves of snow. The degradation of glaciers is evident, as well as a reduction in over-all glacial areas. Over the 31 years of measurement and observation, the Abramov Glacier alone has lost 18% of its water reserves. For the period 1957 through 1980, the glaciers of the Pamir-Alay mountain system lost 126 km^3 of ice (about 113 km^3 of the water), equaling up 19% of their total ice reserves in 1957. In the future, glaciation reduction is expected to have a detrimental impact on the volume, flow and quality of fresh water in Uzbekistan.

Climate Scenarios. In order to assess vulnerability of the environment and separate sectors of the economy to potential climate changes and to develop adaptation strategies, a series of climate scenarios for Uzbekistan and the adjacent mountain territory were developed, applying empirical-statistical and analog approaches as well as the data of a general circulation model.

The first approach constructs a composite scenario on the basis of integrating the outcomes of the atmosphere and ocean general circulation models (GCM) and historical analogs. The estimates of possible climate changes using this approach if emissions in CO_2 equivalent were doubled equal 2.0 – 3.0°C in winter and 1.5°C in summer. Possible annual temperature changes are estimated at 1.0 – 3.0°C.

The second approach constructs regional scenarios on the basis of statistical dependence between the average annual air temperature observed in Uzbekistan and the adjacent mountain territory and the global temperature. Global temperature forecast were made by using the results of the Model for Assessing the Greenhouse Gases Impacts and Climate Change (MAGICC) for a wide variety of greenhouse gases emissions (IPCC, IS92a-IS92f). Under emissions scenarios IS92a-IS92b, a rise in the average annual temperature of 1.0 –2.5°C is anticipated in Uzbekistan by 2030.

The annual precipitation volume for Uzbekistan and the adjacent mountain territory is expected to be 100% to 120% of the base standard value.

Climate change scenarios were developed from GCM data assuming that CO_2 concentration in the atmosphere doubles. According to the CCCM and UKMO models, annual temperature increases of 5.2 – 6.9°C relative to the base norm are anticipated and under the GFDL and GISS models: 3.4 – 4.6°C temperature increases are expected. Comparison of the simulated temperature forecasts (the control model runs) with real temperatures indicates that these scenarios somewhat overestimate the anticipated climate warming. The expected amount of precipitation in Uzbekistan and on the adjacent mountain territory under the CCCM model equals 89 – 100% of the base norm, under the UKMO model: 90 – 106% of the base norm, under the GFDL model: 104 – 114% of the base norm, and under the GISS model: 113 – 140% of the base norm.

Consequences of Climate Change: Vulnerability Assessment and Ways of Adaptation

The assessment of climate change on such natural resources as the water and agroclimatic ecosystems, separate natural ecosystems, and the search to identify possible strategies adaptations are based on the IPCC recommendations, regional policies and expert estimates.

As a result of climate warming, the boundary between the arid tropical and temperate climatic zones will shift to the North by 150 – 200 km, and the altitudinal climatic zones will shift upwards by 150 – 200 m. Duration of the frost-free period will increase by 8 – 15 days. Temperatures will increase by 5 – 10%. Expected temperature increases in the Central Kyzylkum region of 1.5 – 2.0°C will lead to a "vegetation" winter regime replacing the current winter regime.

Agr*iculture*. The increase in the carbon dioxide concentration, all other factors being favorable, will have a beneficial effect on the growth and yield of most of the cultivated crops. Under optimal conditions of water availability, cotton yield is expected to increase by 11% in nearly all oblasts of the Republic. Yield from spiked cereals on irrigated and non-irrigated lands is expected to increase by 7-15%. Pasture vegetation yield capacity in the mountain zone may increase by 15-20%.

However, an increase in the number of the days during the spring-summer period with high temperatures unfavorable for the crops and pasture vegetation productivity is also expected. If there is a water deficit and high temperatures, yield losses may amount to 10 – 50% for vegetable crops; 9 – 15% for cotton crops; 10 – 20% for rice crops; and 10 – 30% for melon crops. As for the desert pastures, green fodder reserves may be decreased by 20 – 40%.

Adverse climate change impacts (increases in the summer temperatures and increases in the rate of evaporation) add to the impacts of all types of natural and anthropogenic soil erosion.

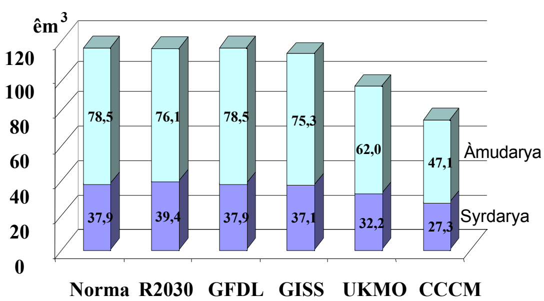
A decrease in desert pasture productivity and an increase in the number of days with high temperatures will worsen grazing conditions for livestock on plains territories. Unfavorable hot conditions will decrease livestock productivity. Mountain pastures are expected to shift their boundaries to higher altitudes.

Actions in response to climate change in agriculture should be coordinated with socio-economic measures to ensure the sustainable and secure development of the Republic as well as with anti-desertification and drought control measures.

Recommendations on adaptation to climate change are primarily focused on the necessity of restructuring agriculture in order to increase productivity. Adaptation measures include: optimizing land reserve use, applying the water-saving technologies, land reclamation, optimization of the cropping structure, introducing drought-resistant varieties, increasing effectiveness of fertilizer application and plant protecting agents, recovery of the natural vegetative cover, phytoreclamation of pastures and artificially increasing rainfall.

For the nearest future (the next 10 –20 years) dramatic changes in the agriculture sector are not required.

Water Resources. Indicators of the vulnerability of water resources to climate change (river flows, glaciers, snow cover in the mountains) were determined using mathematical models for the mountain river flow formation (SANIGMI – Central Asian Scientific Research Hydrometeorological Institute).



The Annual Flow of the Amudarya and Syrdarya Rivers under Various Climate Change Scenarios

Estimations of the Amudarya and Syrdarya Rivers' flow has been carried out under varying climatic scenarios. The CCCM scenario predicts the most arid outcome of climate conditions in the flow formation zone, anticipating a decrease in the Syrdarya River flow of 28% and in the Amudarya River flow of 21%.

According to the GFDL and GISS scenarios and to the scenarios constructed on from the empirical-statistical approach, no considerable reduction in the Amudarya and Syrdarya Rivers' flow is expected.

Model estimates of snow and ice reserves in the mountains under various climate scenarios anticipate a general decline in these reserves. A decrease of up to 15 – 30%, in the contribution that melting snow feeds into the rivers is expected, especially for the snow-fed rivers. The contribution of the snow-fed inflows may increase from 12 – 15% to 25 – 35%, which will influence the characteristics of flow as well as multiyear and intra-annual variability.

Along with the rainfall increase, a general growth in rainfall intensity is expected, which will cause the flash floods, increase in soil erosion and flow turbidity. The entire foothill belt may become an intensive mudslide zone. The intra-annual river runoffs of the snow-rainfall will take place about a month earlier, shifting spring floods, which in turn will affect the operation of hydro-technical structures.

According to the climate scenarios, reduction in the snow and ice reserves in the mountains, an increase in evaporation during the growing season of 15 – 20%, and subsequent flow reduction can be expected. The anticipated flow reduction during the vegetation period is especially unfavorable for irrigated farming and regional ecosystems (coastal and delta ecosystems, etc.). The increase in evaporation will respectively increase water losses in irrigated zones and increase irrigation intensity.

Under current conditions, water resource shortages in Uzbekistan, even a small but stable reduction of these resources presents a drastic problem.

During the course of the last third of the 20th century, intensive irrigation from the flows of the Central Asian rivers caused the regrettable Aral Sea crisis: the drying-up of the Aral Sea level, a reduction of the lake's delta system and drastic aggravation of the ecological situation in the Aral Sea Region. The anticipated climate change will cause additional adverse impacts: increasing evaporation and salt migration; depleting ground water reserves; reduction of humid landscapes; salinity growth in the closed lakes; accelerated development of the water bodies' eutrophy. In addition, not a single climate scenario predicts increases in the flow of the Amudarya and Syrdarya Rivers; rather, considerable reduction in the flow is anticipated in the future. This will worsen the Aral Sea crisis.

The mitigation measures in response to climate change in the Aral Sea Region will also alleviate the Aral Sea crisis. Mitigation measures include adequate water delivery to the delta; formation of buffer protection zones of a chain of local water bodies; development of systems for regulating the water exchange in the lake system; phyto-reclamation; development of protected natural reserves; application of water-saving technologies in agriculture; further development of the infrastructure for drinking water supply.

To mitigate the adverse impacts of the water resources change, it will be necessary to establish reliable hydrometeorological monitoring in the flow formation zone and to use the available water resources carefully and effectively. Particular attention should be given to construction of reservoirs on mountain rivers, allowing for regulation of river regimes in accordance with the requirements of the water consumers.

Education and Popularization

Much attention is given to issues of ecological education in the Republic of Uzbekistan. Training in «Ecology and Nature Use» is being carried out in most the country's Universities. Education of specialists in hydro-meteorology is conducted at Tashkent State University in the geography and physical sciences departments and at the Tashkent Hydrometeorological Technical College. A developed system of general and specialized education in Uzbekistan and Uzbek scientific research institutions ensure wide dissemination of knowledge on climate change issues.

Within the framework of the project *Uzbekistan Country Study on Climate Change,* a series of seminars were held on the results of study of climate change, assessment of climate change impacts, GHG mitigation measures, and the development of adaptation strategies to potential climate change. Articles were published in newspapers and periodicals and special broadcasts on national radio and TV stations were made. Popular publications and three information bulletins on Uzbekistan's commitments under the UNFCCC have been completed.

Problems and Directions in Subsequent Activities

During the preparation of Uzbekistan's First National Communication, a series of problems arose. Some of these problems were solved during the process of work on the Communication, while additional work and support is needed to solve several of these problems.

Inventorying of Greenhouse Gases. During the course of work on the national inventory of greenhouse gases, it became apparent that study of local factors of emissions, in particular specifying emission coefficients by certain types of fuels, is necessary. In addition, improvement of the existing database of greenhouse gases and of the inventory software is also needed.

Climate Studies. Currently**,** the assessment of the vulnerability of water resources in the Aral Sea Basin has been performed considering climate factors only. A complex assessment of vulnerability is required, one which will consider the development of agriculture and water management in the Basin as the whole. It is necessary to develop a procedure for statistical interpretation of the results of global climate models for assessing alterations in the regional climate characteristics and to conduct research on the impacts of aerosol emissions on regional climate systems.

Development and Improvement of Regional Climate Monitoring and Information Dissemination System. Support to maintain and develop the observation network in the regions is needed, especially for those observation stations that measure anthropogenic effects on the climate. A common climate database needs to be developed and a system of upkeep and data-input for this database should be developed. Support to regularly issue a Regional Bulletin on the Climate Monitoring is also necessary.

Since the Pamir and Tien Shan mountains are zones of flow formation in Central Asia (the process of flow formation is especially intense in glacier-regions), monitoring of glacier mountains and snow and ice cover is needed.

A ***unified system of information exchange among the Republics*** for assessing water resources for the whole Central Asian region is critical.

Work on ***inventories of potential sources of renewable energy*** based on observation data of solar radiation and wind speed should be continued.

Central Asia has one of the highest aerosols pollution rates in the world. This situation is aggravated by the physical-geographical and climatic conditions of the region: the climate aridity, vast areas of sand deserts and solonchaks, and loess soil of irrigated areas. Therefore, an ***aerosol monitoring system*** should be developed.

Scientific research and information on the problems associated with climate change will aid in solving a series of social, economic and ecological problems.

Proposals for Institutional Structure for Implementation of the UNFCCC in Uzbekistan

To solve problems associated with climate change and to take effective measures to mitigate potential adverse impacts, the Government of Uzbekistan founded the National Commission of the Republic of Uzbekistan on Climate Change in 1995. This Commission is an inter-ministerial entity, made up of representatives from 34 governmental Ministries, Departments and Institutions. The Coordination Committee functions within the body of National Commission on Climate Change.

The Main Administration of Hydrometeorology (the Glavgidromet) is responsible for providing the state management authorities of the Republic and economic entities with information about the climate, the environment pollution levels and for keeping centralized information records. The Glavgidromet performs analysis on the influence of anthropogenic activities on hydrometeorological processes, the climate and environment, and develops recommendations for elevation of adverse impacts. The Glavgidromet organizes international cooperation on issues of hydrometeorology, climate and climate change, monitoring of environmental pollution and the state of the ozone layer.

When implementing the project *Uzbekistan Country Study on Climate Change,* the Glavgidromet set up the Information and Analytical Center for data analysis, developing the National Communication and on the mechanisms of the Kyoto Protocol. Working groups of national experts have been formed on the following subject areas: greenhouse gases inventory; study of the climate system and development of climate change scenarios; assessment of vulnerability and developing adaptation strategies; economic and power analysis; and development and assessment of GHG mitigation measures.

Maintaining the developed organizational structure is required for subsequent fulfillment of national commitments of the Republic of Uzbekistan under the FCCC Convention on the long-term basis.

Introduction

At the World Conference on Environment and Development, which took place in Rio-de Janeiro in 1992, 155 countries signed the UN Framework Convention on Climate Change (UNFCCC). This outstanding international agreement intends to stabilize atmospheric concentrations of greenhouse gases (GHG), thereby alleviating the dangerous degree of anthropogenic interference with the natural global climate. These levels would be achieved within a sufficient timeframe to allow for ecosystems to naturally adapt to climate change, and for countries to adequately respond to climate change related threats to food security, economic and sustainable development.

The main commitments of member states under the UNFCCC are as follows:

- To provide information on emissions and sinks of the six greenhouse gases;
- To analyze climate changes;
- To assess environmental and economic vulnerability to those climate changes;
- To develop mitigation and adaptation measures to respond to the effects of climate change;
- To undertake steps to reduce greenhouse gas emissions.

Acknowledging the importance of the issue of global climate change, and the necessity to undertake effective measures to mitigate its impacts, Uzbekistan acceded to the UNFCCC in 1993, thereby making a definitive commitment to the international community.

In November 1998, the Republic of Uzbekistan signed the Kyoto protocol, which was ratified on the 20^{th} of August, 1999.

A National Commission on Climate Change was established to implement activities under the commitments of the Framework Convention, and to coordinate actions among all relevant ministries and governmental agencies. Some 30 ministries and agencies participate in the work of this commission. Additionally, the country's premier scientists and some NGOs are involved in solving particular problems.

The Republic of Uzbekistan's First National Communication to the UNFCCC includes GHG inventory data for the period 1990 to 1994, emission trends, a summary of the current and planned mitigation measures, an assessment of Uzbekistan's vulnerability to climate change, as well as planned adaptation measures. The results of the greenhouse gas inventory represented in the given report (Methodology of the IPCC, 1996) exceed the results of the first inventory undertaken in Uzbekistan beforehand by 20%.

1. National Circumstances

The territory of the Republic of Uzbekistan is located in an arid zone of Asia. Desert and semi-desert land, especially vulnerable to likely climate changes, comprise more than 70% of its territory. A significant characteristic of the country is water scarcity. Uzbekistan is a major water consumer in the region of Central Asia, because irrigated farming is a major element of its economy. Some 90% of water resources used in the Republic originate from the territories of contiguous countries situated in the mountainous part of Central Asia.

Intensive water use for irrigation has led to the shrinking of the Aral Sea and its subsequent shoaling, provoking a number of economic and social problems.

Global warming will proceed alongside an increase in aberrations of natural phenomena, (i.e. longer periods of drought, higher summer temperatures, changed conditions of water resource formation) all of which may result in negative consequences for the country.

Table 1.1 provides some basic national data on the Republic of Uzbekistan for 1990, 1994, and 1997, based on official statistics and expert judgements.

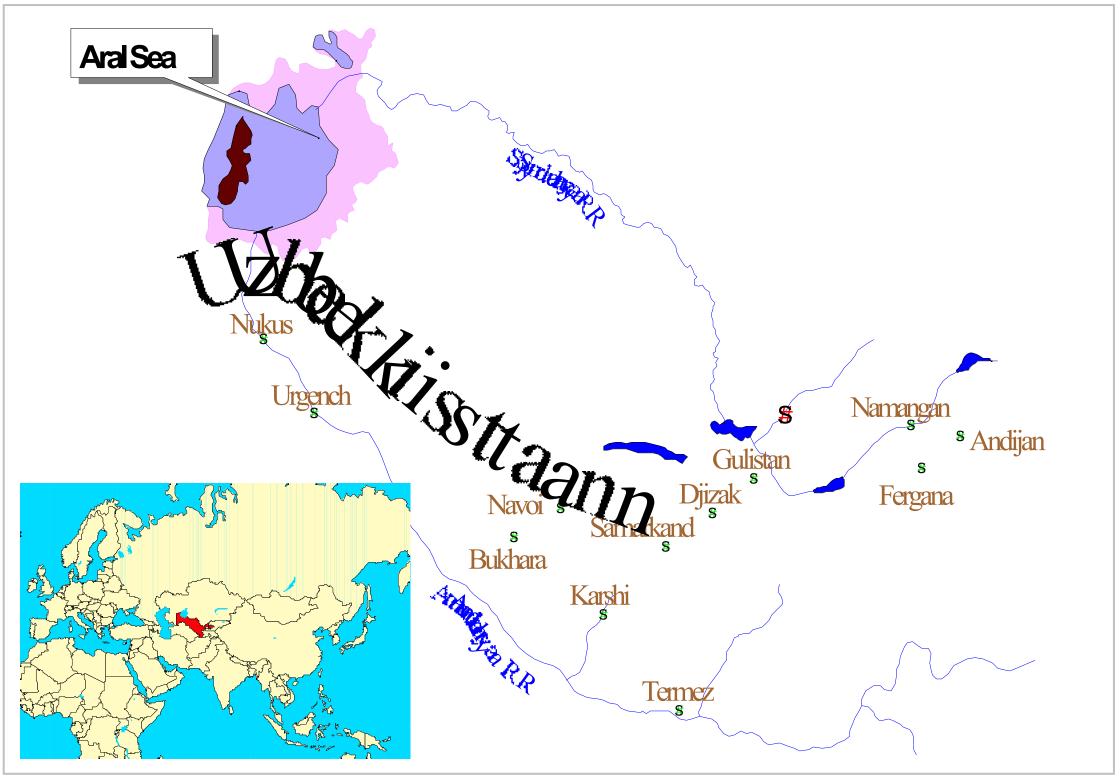


Fig. 1.1 Geographical Data on the Republic of Uzbekistan.

Table 1.1

National Circumstances

Criteria	1990	1994	1997
Total territory (in 000.0 km^2)	447.4	447.4	447,4
Population (000000.0 people)	20.5	22.4	23.7
Population growth rate (% since 1990)	100.0	109.1	115.3
Urban population (% of the total population)	40.8	38.7	38.0
Average life expectancy (years)	69.3	70.1	70.3
Literacy (%)	97.7	99.0	99.3
GDP in PPP per capita (US $)	3250**	2438*	2670*
GDP growth rate (% since 1990)	100.0	81.9	86.8
Industry and construction as percentage of GDP (%)	33.3	24.2	22.9
Agriculture as percentage of GDP (%)	33.4	34.5	28.2
Services as percentage of GDP (%)	34.4	33.1	36.5
Net taxes	-1.1	8.2	12.4
State-owned sector as percentage of GDP (%)	-	38.2	63.5
Area of State Forest Reserves (000.0 km^2)	14.1	14.3	14.4
Land for agricultural purposes (000.0 km^2)	280.8	276.0	269.2
Irrigated land (000.0 km^2)	42.2	42.8	43.0
Natural pastures (000.0 km^2)	234.7	229.9	222.9
Cattle (000.0 heads)	4580.8	5483.3	5196.4
Cows (000.0 heads)	1856.4	2336.9	2281.3
Sheep and goats (000.0 heads)	9229.6	10059.3	8586.7
Horses (000.0 heads)	105.2	144.8	148.8

Source: Ministry of Macroeconomics and Statistics of the Republic of Uzbekistan

* “Human Resources Development”, UNDP Report, Uzbekistan, 1998;
** Evaluation with regard to growth of GDP and population;
.

1.1. Geographic Situation and Climate

The Republic of Uzbekistan is situated in the central part of the Eurasian continent, between the 37° and 45° North latitudes, and the 56° and 73° East longitudes. Its total surface area is 447.4 thousand square kilometers. Uzbekistan borders Kazakhstan to the North and West, Turkmenistan and Afghanistan to the South, and Tadjikistan and Kyrgyzstan in the East (Fig. 1.1).

Uzbekistan is unequally divided into two parts: plains occupy about three quarters (78.8%) of its territory, while mountains and mountainous valleys constitute the rest (21.2%). The plains, which stretch out from the Northwest to the Southeast, comprise the larger part of the Turan Lowland. This area mainly contains deserts and semi-deserts, including the Karakum Desert—the largest in Central Asia—stretching from the Zeravshan river valley to the Aral Sea. Small mountainous ridges and elevations cross its central part, closed inland drainage basins characterize the landscape in the South.

In the South and Southeast of the country the plains gradually transform themselves into ridges and reliefs of the Tien-Shan and Gissar-Allay mountain systems. Between these ridges lie vast valleys having plain-like surfaces (e.g. Tashkent-Golodnosteppe Valley, Fergana and Zeravshan Valleys).

Significant variations in altitude characterize the territory of the Republic. The lowest spot is at the bottom of the Mingbulak depression (12 meters under sea level). Khazret Sultan peak of the Gissar Chain is the highest point, at 4643 m. above sea level.

Climate. Uzbekistan's climate is strongly influenced by its location in the northern band between the subtropical and temperate zones. High solar radiation, coupled with the unique features of its surface and air circulation patterns, form a continental-type climate. This climate is characterized by seasonal and day-to-night fluctuations in temperature, long, hot, and dry summers, humid springs, and irregular winters. Depending on the location, average July temperatures vary from 26^{o} C in the North, to 30^{o} C in the South, with the peak temperature around 45-47^{o} C. Average January temperatures are –8^{o} C in the North, and 0^{o} C in the South, with the lowest temperature being –38^{o} (on the Usturt Plateau).

Uzbekistan's territory is penetrated by diverse air masses. Transformed Atlantic and Arctic air masses penetrate the vast plains from the North and Northwest. Penetration by tropical air masses and warm southern cyclones can occur across Central Asia, particularly during the cold half of the year, provoking intensive warming and abrupt changes in the weather.

Precipitation occurs year-round, peaking between April and May, or between March and April in higher altitudes. However, precipitation is most common in winter and spring. In spring, snow avalanches are likely and intense rainfall can lead to mudslides. Highly arid, continental, tropical air forms in the summer months, intensely heating the deserts. On the whole, precipitation is minimal (within the range of 80-200 mm a year), yet very unstable, with an annual precipitation variation factor of 0.5. Precipitation can be as much as 300-400 mm a year in the foothills, and 600-800 mm a year on the western and southwestern slopes of mountain ranges, which are subject to wet air masses. Conspicuously, the Aral Sea does not affect the quantity of precipitation very much, only contributing to slight increases in humidity in the narrow coastal areas.

1.2. Natural Resources

1.2.1. The Land and Agricultural Resources

Agrarian land can be divided into three categories: irrigated land, dry land, and natural pasture. The structure of land use in 1997 is shown in Figure 1.2..

The Republic's State Forest Reserve accounts for about 3.2% of its total surface area (444.6 thousand square km). Uzbekistan's forests can be divided into sand-desert, wetland and valley, and mountainous forests; bushes and shrubs also occupy a significant area. The Republic's State Forest Reserve accounts for about 80 thousand square kilometers, some 85% of which lies in the sand zone, 13% in the mountainous zone, and only 2% in wetland and valleys.

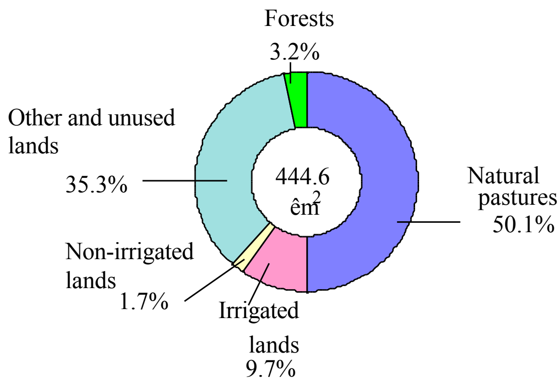


Figure 1.2 Use of land resources.

As solar radiation is abundant, the only factor inhibiting utilization of agrarian land is a shortage of water resources. Thus, irrigated farming is the basis of agricultural production. Most arable land is irrigated, and only a minor portion of this land is non-irrigated land (Fig.1.2). The climate in Uzbekistan is favorable for growing crops that thrive in temperate or tropical zones, particularly cotton.

Indeed, cotton is its major crop, and. However grains, rice and potatoes are also cultivated on irrigated land. Sometimes insufficient warmth in the northern areas can hinder crop ripening. Harsh weather (i.e. late-spring and early-fall frosts, draughts, high temperatures) and pollution in a number of regions have limited the full use of agrarian land resources.

Besides cotton, cereals, gardens, and vineyards are planted in the foothills. Astrakhan sheep and camels are bred on vast desert and semi-desert areas. Only 20% of the total area for natural pasture lie in the foothills and the mountains.

In the republic saline lands occupy 1748 thousand km^2, 241 thousand hectares of which are extremely saline. The processes of salinization are progressing in Karakalpakstan and in Bukhara and Syrdarya regions. The territories subject to irrigation and wind errosion also take place. During last 20-30 years the humus content in soil (the main indicator of soil fertility) reduced by 30-50%. The soils with very low humus content occupy about 40% of the whole irrigated territory.

1.2.2 Water Resources

The territory of Uzbekistan is an inland basin of the Aral Sea, to which all its rivers and lakes drain. Water resources include natural surface and ground water as well as recycled water**.**

All countries in Central Asia jointly use the surface water of the Aral Sea basin. Water reserves in the lakes of the mountainous area of the Amudarya River make up 46 km^3, while reserves from the Syrdarya River total 4 km^3. Excluding the Aral Sea, the total volume of water from the plains is approximately 70 km^3. The volume of ice in the glaciers of the Gissar-Alay area is estimated at 88 km^3, and the glaciers of Pamir-Alay at 465 km^3.

River runoff primarily collects in the largest of Central Asia's rivers—the Amudarya and Syrdarya, which flow into the Aral Sea. The annual volume of river runoff to these rivers is shown in Table 1.2. Uzbekistan is subject to international agreements allocating water use. Uzbekistan is entitled to an average of 43-52 km^3 of water per year. In any given year, water allocations are calculated and adjusted subject to the agreed ratio.

Table 1.2

Water Resources (km^3/year) of the Rivers of the Aral Sea Basin

River	Average long-term volume of runoff	Volume of Runoff corresponding to 5% cumulative probability	Volume of Runoff corresponding to 95% cumulative probability
Amudarya	78.5	108.4	46.9
Syrdarya	37.9	54.1	21.4

Much like the Aral Sea basin, Uzbekistan on the whole features an unequal distribution of water resources. The plains contribute very little to river flows. In irrigated zones, these flows are mainly from irrigation canals. But in the upper watershed, the zone of flow formation, there is a well-developed river network.

Six percent of the river runoff directly formed on Uzbekistan's territory emanate from the Amudarya River basin and fifteen percent come from the Syrdarya River basin. However, less than 10% of total runoff are formed on Uzbekistan's territory; the bulk of water resources used in Uzbekistan originate beyond its borders. The natural course of river flow from the Amudarya and Syrdarya Rivers is greatly distorted by reservoirs, water withdrawal for irrigation, and the discharge of drainage water. All of these break up their hydro-dynamic and hydro-chemical regimes**.**

The ground water of the Aral Sea basin, including the territory of Uzbekistan, is formed from precipitation as well as filtration from water reservoirs, riverbeds, canals, lakes, and irrigated areas. Presently, there are 95 deposits of ground water in the Republic.

Recycled water resources include collected drainage and wastewater. While constituting a large share of water resources, it is at the same time a serious source of pollution.

Lakes are located mainly in river valleys, but their origin differs. Mountainous lakes usually originate from **obstruction and glacier-moraine**, while lakes located in the plains form from drainage water. The Aral Sea is the largest lake.

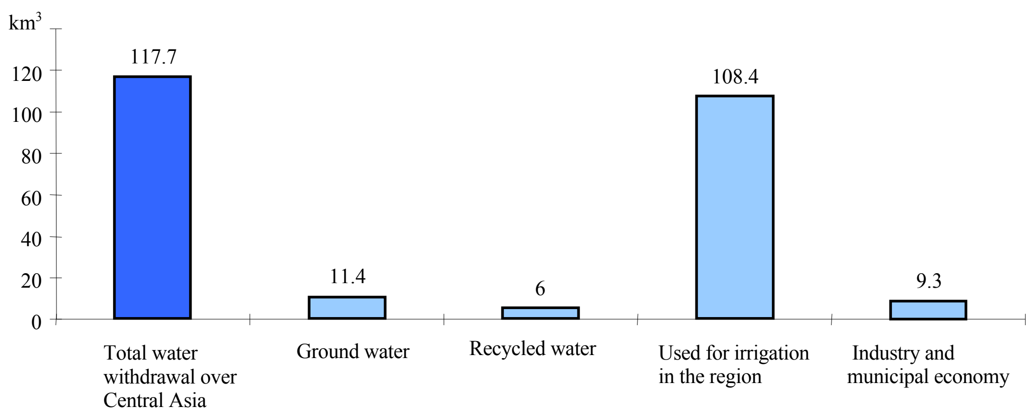


Fig. 1.3 Annual water allocation (km^3) and use in the Aral Sea basin.

The Tuyamuyun, Chardara, Karakum, Charvak, and Andijan reservoirs are the largest artificial water facilities in Uzbekistan. They were built to regulate seasonal river runoff, accumulate water for irrigation periods, as well as to prevent flooding. At the edge of irrigated areas, in natural depressions and reliefs, lakes are formed from water overflow. The lakes of the Arnasay and Sarykamish systems, in their current dimensions, were formed from water drainage from reservoirs.

Irrigated farming utilizes more than 90% of the region's available water resources. Figure 1.3 depicts the annual structure of water resource allocation and average annual uses in the Aral Sea basin.

1.2.3. The Aral Sea and Amudarya River Basin

The Amudarya River and Syrdarya River drain into the Aral Sea, which until recently was the fourth largest inland water reservoir in the world. The Aral Sea has been subjected to an unprecedented degree of negative anthropogenic impacts. In fact, the very existence of the sea as a geographic entity is in doubt.

The Aral crisis is one of the most significant ecological disasters. About 35 million people including a considerable part of the Uzbekistan's population experience its impact. This largest zone of ecological disaster of the Central-Asian region appeared due to the intensive drying of the Aral sea.

Prior to the drying of the Aral Sea, its area was 66.1 km^2 and volume was 1064 km^3. It played a pivotal role in the economy of the region. Annual fish harvesting was approximately 400-500 thousand metric centners, and the volume of cargo turnover was 200-250 thousand tons. Some 1 million muskrat pelts were produced in the Amudarya and Syrdarya river deltas each year.

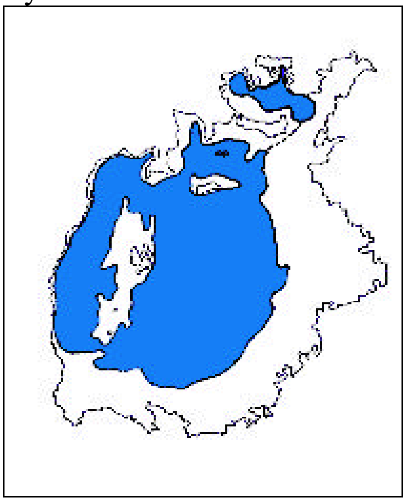


Fig. 1.4 Coastal outlay of the Aral Sea..

Irrigation resulted in a sharp decline of water in-flow to the Aral Sea, and, consequently, a drop in the Sea's water level, shrinking of its surface area, and an increase in salinity. By 1994, the Sea's total surface dropped to 31.7 thousand km^2. Salt marsh and salty shifting sand areas formed and became sources of eolian transfer of sand and salt onto the contiguous territories. Prior to 1992, salinity averaged 9-11%; but by 1992, salinity increased to 35%, on par with the salinity of the World's Oceans. Under such conditions, the Sea's ability to remain a bio-productive water reservoir is increasingly in doubt. The outline of the coastal outlay of the Aral Sea in 1961 and 1994 are shown in Figure 1.4.

The Amudarya River forms a vast delta to the northeast of the Republic. Downstream areas are some of the driest in Uzbekistan: annual precipitation ranges between 90-100 mm. Increased water scarcity in the region has created social problems in Karakalpakstan and the Khorezm Province. The present ecological situation has negatively affected 1.5 million people.

The present, triangular-shaped delta of the Amudarya River lies between the 42°30' and 44°00' North latitudes, having as its apex the town of Takhiatash. Along the length of its western boundary is the edge of Usturt Plateau, and in the East-- the ancient riverbed network that abuts a desert, with the Aral Sea as its northern boundary.

Average annual water discharge into the delta was 1060-2090 m^3 before the drying of the Aral Sea. In the 1970s, it declined to 850-1200 m^3 per second, and by the 1980s, to just 50-500 m^3 per second. After the 1980s, the existence of any flow from the Amudarya River to the Aral Sea became unpredictable. In the 1990s, water flow to the delta increased by 10-15%.

Prior to the drying of the Aral Sea, natural sedimentation of alluvium expanded the delta at an annual protraction rate of 1-1.5 km^2. As the Aral Sea began to shrink in size, the delta expanded further due to the drying of sea bottom. An analysis of satellite information and maps from different years reveals that the total area of the delta has grown from 14,000 to 21,000 km^2 during last 35 years.

Wetlands and lakes are important indicators of water outflow to the delta. At the beginning of the 1960s, approximately 2600 lakes existed within the delta. By 1995, this number had decreased to 400, due to water scarcity and reduced soil erosion. In natural depressions, salt marshes took the place of lakes. Low drainage and worsening drainage system quality on the delta plain have led to an increase in salinity.

Despite higher water availability of late, satellite information confirms that water flow patterns to the delta have worsened. The Sea's rapid ebb and drying of its bottom have lead to local climate changes in the region. Global warming that has already occurred has only aggravated the complex ecological situation in this region.

1.2.4. Biological Resources.

Biological natural resources include vegetable and animal life. Uzbekistan is home to 27,000 specific species of flora and fauna.

Vegetation. Natural flora are represented by almost 4,800 species of vascular plants, which belong to 115 families, the most common of which are compositae (570 species); legumes (almost 440 species), and cereals (260 species). This complex and diverse system of vegetation is specific feature of Uzbekistan's climatic and soil.

On the plains, desert types of vegetation are formed: saxaul (haloxylon), sand acacia, saltwort, 'kandym', wormwood (absinthe), and sand sedge. The total amount of biomass in the deserts is estimated at 50-60 metric centners per hectare. Biological productivity in the desert is rather low, confined mostly to cattle breeding. Along the riverbanks are tugais and wetland forests where hygrophilous trees, bushes and grass grow, as well as turanga, loeaster, tamarisk, willow, malt, cane, reed, and dog-bane.

Some 500 species of wild plants for medicinal, food and raw materials are cultivated in the Republic. However, only 45 of these are commercially used, including dog-rose, rhubarb, St. John's wort, cumin, oregano, bayberry, sage, and malt. In the forests, the main species include: saxaul, kamdym, saltwort (deserts); almond tree eltas, turanga, loeaster, tamarisk (wetlands and river); juniper and pistachio trees (mountains). Forests are of great value and fulfill protective, sanitary and hygienic functions. As such, they belong to and are protected by the State.

The animal world. Of 15,000 species of wild animals, the vertebrates are represented by 5 classes, which include 664 different species: birds (424); mammals (97); fish (83); reptiles (59); and amphibians (3). Some 53 of these species are endemic to the Republic.

The fauna in the desert belt is diverse. Reptiles include lizards (toad agama, monitor lizard, gecko) and snakes (viper, 'gourza', Central Asian cobra, 'shitomnordnik'). Of the large mammals, goitred gazelle (Middle asian gazel) and 'saigak' are particularly important to protect. Jackals, wild boar, honey badger, wolves, foxes, porcupines, badgers, and hedgehogs dwell in the plains and foothill areas. The rich diversity of bird life includes eagles, jackdaws, and kites. Many species common to mountainous areas of Central Asia also dwell in Uzbekistan's Alpine zones: the Siberian goat, snow leopard, 'ular' (mountian turkey) and others.

1.2.5. Natural Ecosystems

Given these natural and climatic conditions, a number of different natural ecosystems have evolved on the territory of Uzbekistan: the desert ecosystems of the plains; ecosystems in the foothill semi-deserts and steppes; river and coastal ecosystems; wetland and delta zone ecosystems, and mountainous ecosystems. Each contains a complex system of natural elements that shape the development and health of the above specified flora and fauna.

The desert ecosystems of the plains are found in the Kyzylkum Desert, Ust'urt plateau, Karshinsky Steppe, in the south of the Republic and the Ferghana Valley. Geologically, desert territories are divided into sand, brackish, clay and rocky (gypsum) soils. Desert ecosystems are the main dwelling area of rare and endangered animal species in the Republic.

Sand deserts occupy 27% of the plains. The Kyzylkum, Sundukli, and Kattakum are the largest areas of sand tracts. Rocky desert is typical of the Ust'urt plateau, part of the Kyzylkum Desert, as well as along the southern foothills. Saline soil deserts are found in the Ust'urt plateau and its slopes, in the inland hollows and present delta of the Amudarya River. The characteristics of these deserts are high salt concentrations in the upper soil layers, a constant humidity level and temporary water reservoirs. Clay deserts are located in the clay and **loess** deposits in the basin of the Kashradarya River, in Dalverzin and in the Golodnaya Steppes.

Foothill semi-deserts and steppes are found in the foothill zone 800-1200 m above sea level, and a 30-50 km strip that encompasses the mountainous ranges. They account for around two-thirds of the mountainous territory of the Republic.

River and coastal ecosystems are in the plains of the Amudarya and Syrdarya River valleys and downstream areas of the Zeravshan River and the Surkhandarya River. Here, there are three main types of ecosystems: tugai, weed thickets, and rivers and open shoals.

Tugai tracts are preserved in narrow strips or islands in the Amudarya River and its delta. They can also be found in the Syrdarya, Surkhandarya, Zeravshan, and Chirchik River valleys. The rivers and open shoals are home to many rare and endangered animal species.

Wetland areas (inland waterways and marshes) can be divided into natural and anthropogenic ecosystems. They are similar to river and coastal ecosystems, except for their larger water surface area and higherhumidification. Natural wetland areas are located in the Amudarya River delta, occupying approximately 700 thousand hectares. As water in-flow to the delta declined, shifting the coastal outlay of the Aral Sea, numerous natural freshwater lakes disappeared, tugai areas decreased two-fold, and reed areas decreased 6-fold. Only in recent years, as inflow of collected drainage water has slowly increased, have some lake ecosystems recovered. Anthropogenic wetlands are artificial water reservoirs and overflow lakes. The Aydar-Arnasai lake system, Dengizkul, Karakir, and Solyonoe Lakes are the most vast of these.

Mountain ecosystems occupy areas of certain inclines, soil, moisture, and slope conditions. Mountainous steppes are found at heights of 2000-2600 meters above sea level. Deciduous forests grow at the heights between 1000 and 2500-2800 meters above sea level. The largest tracts of deciduous forest are concentrated in the of the Western Tian-Shan (Ugam, Pskem, Chatkal, and Fergana mountain ranges), and the Pamir-Alay (Gissar mountain range). Walnut, plane, and persimmon trees grow in relict forests.

In mountainous areas, at heights of 1400-3000 meters above sea level, juniper forests grow. Sub-alpine and alpine meadows are found at heights between 2700 and 3700 meters above sea level.

1.3. The Socio-Economic Description of Uzbekistan

1.3.1. Population

Uzbekistan is the most populous of all the Central Asian Republics. Population in 1997 totaled 23.7 million people. Average life expectancy in Uzbekistan rose to 70.3 years in 1997 from 69 years in 1990.

Uzbekistan comprises the Republic of Karakalpakstan and 12 provinces. Tashkent, the capital city of Uzbekistan, enjoys the status of an independent, administrative entity. Some 2 million, 200 thousand people live in Tashkent.

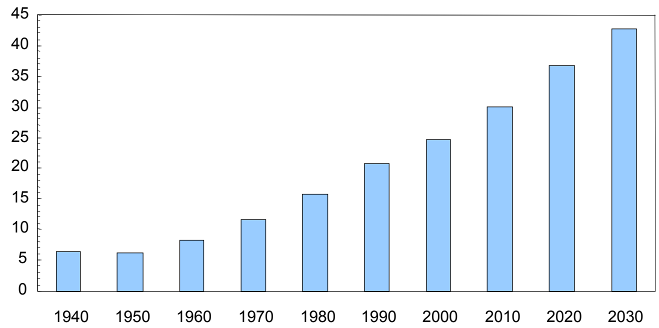


Fig. 1.5 Dynamics of population growth (forecast of the Ministry of Macroeconomics and Statistics)

The bulk of the population is concentrated in large mountainous valleys, along rivers, and in irrigated areas. Population density is highest in the Fergana and Zeravshan valleys, and in Tashkent Province, while vast desert areas are practically uninhabited. Uzbekistan has a high population growth rate (Figure 1.5). Recently, there have been steady incremental reductions in the population growth rate, from 2.38% in 1992, to 1.87% in 1997.

Emigration from the Republic slowed from 363 thousand people in the 1991-94 period, to only 186 thousand people in the 1995-97 period.

Rural areas account for almost four-fifths of population increase . By 1997, 62% of Uzbekistan's inhabitants lived in rural areas. Similarly, more than three-fourths of the increase in the workforce came from rural areas. Presently, 43.5% of the population is engaged in agricultural production, 21.1% in industry, and the remaining 35.4% in services or other sectors of the economy.

Economic reforms, increased foreign investment, enterprise restructuring, and the development of small and medium-sized businesses all resulted in improved economic performance and higher employment rates in the Republic .

The level of education in Uzbekistan is among the most advanced in the world. In spite of the difficulties of the economic transition period, the country succeeded in preserving its state system of education. Universal, nine-year compulsory education provides equal access to all, regardless of class, income level, domicile, or nationality. The literacy level approached 99.3% in 1997.

1.3.2. Economy Structure

The economy of Uzbekistan is agrarian-industrial, but the agricultural sector predominates. Agriculture accounts for 28% of gross domestic product (GDP), and provides 70% of domestic trade and 50% of foreign currency revenues. More than 44% of the workforce is engaged in the agricultural sector. Local agricultural production meets 80% of the national demand for food products.

Uzbekistan is the fourth largest producer of cotton fibers; more that one third of irrigated land (or 1.5 million hectares) is cultivated for cotton.

The goal of grain self-reliance has been reached. Between 1990 and 1997, cereal production doubled as the area cultivated for cereals increased (Table 1.3). Uzbekistan is also a large producer of vegetables, fruits, and grapes.

Pasture used for the breeding of astrakhan and woolen sheep accounts for more than 80% of agricultural land. There are more than 5 million heads of livestock and approximately 10 million heads of sheep and goats in the Republic.

Industrial production is developing steadily. Since the country's independence, more than 600 new items began to be produced, including cars, hi-tech domestic appliances and electronics, and various oil products. Light industry and food packaging, machinery, chemicals products, metallurgy, power production, transport, telecommunications, and the service sector are all developing with the participation of foreign investors. Unlike in other countries of C.I.S., Uzbekistan did not experience a decline in industrial production.

Table 1.3

Composition of Agricultural Production: Crop Area (%)

Crop	1990	1994	1997
Cereals	24.0	36.3	39.5
Cotton	43.6	37.2	36.5
Potatoes, vegetables, melons and gourds	6.4	6.1	5.5
Fodder	24.8	20.4	12.3
Other	1.2	-	6.2

(Data of the Ministry of Macroeconomics and Statistics)

Within a short period after independence, Uzbekistan developed a multi-faceted economy. The private sector plays a more significant role in this economy than the state-owned sector, now accounting for 64% of GDP and 71% of employment.

Table 1.4

The Structure of Gross Domestic Product (%)

Sector of economy	1990	1994	1997
Industry	22.7	17.0	15.6
Agriculture	33.4	34.5	28.2
Construction	10.6	7.2	7.3
Services	34.4	33.1	36.5
Net taxes	-1.1	8.2	12.4

(Data of the Ministry of Macroeconomics and Statistics)

After 1996, GDP growth stabilized. In 1997, GDP increased by 4.4%, closely paralleling the population growth rate. The structure of GDP is outlined in Table 1.4.

The power sector (electric and fuel power) accounts for much of industrial development and represents 24.3% of the increase in industrial output. Rapid development of the fuel and energy sector (FES) helped Uzbekistan achieve its goal of energy autonomy. Oil production rose from 2.8 million tons in 1991 to 7.9 million tons in 1997, while natural gas increased from 41.9 BCM to 54.8 BCM during the same period. In 1997, electric power production totaled 46.1 billion kWh.

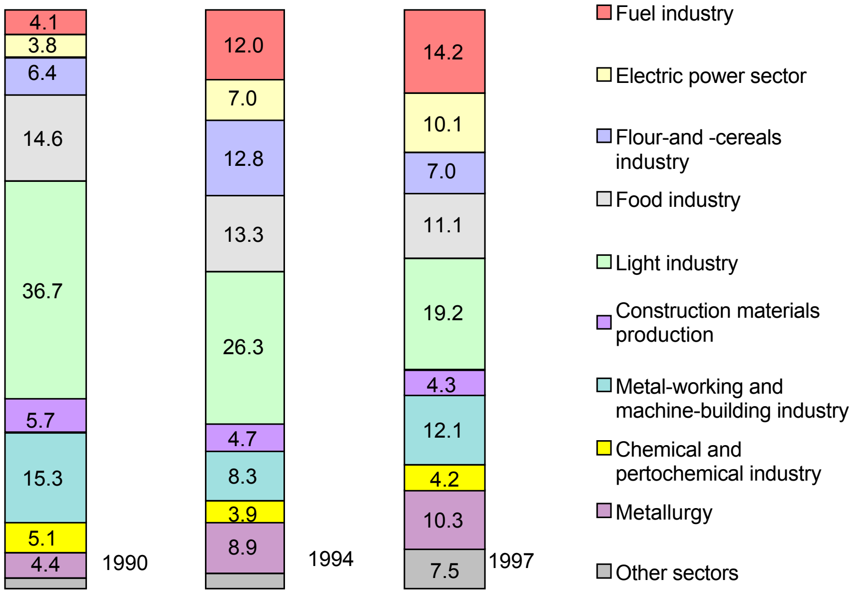


Fig. 1.7 Composition of industrial output by Sector (%)

Between 1994 and 1997, the machine-building industry grew almost 1.5-fold, accounting for 12.1% of industrial output. Light industry (19.2%), food packaging (11.1%), and metallurgy (10.3%) account for the other significant shares of industrial production.

1.3.3. Development of the Power Sector in Uzbekistan

A steady and uninterrupted supply of fuel and energy after 1990 made a successful economic and social transformation in Uzbekistan possible. This was accomplished by accelerating the development of the Republic's oil and gas industry and its hydrocarbon deposits. Total hydrocarbon reserves are estimated at more than 7 billion tons in oil equivalent, including proven natural gas reserves in excess of 3 trillion cubic meters.

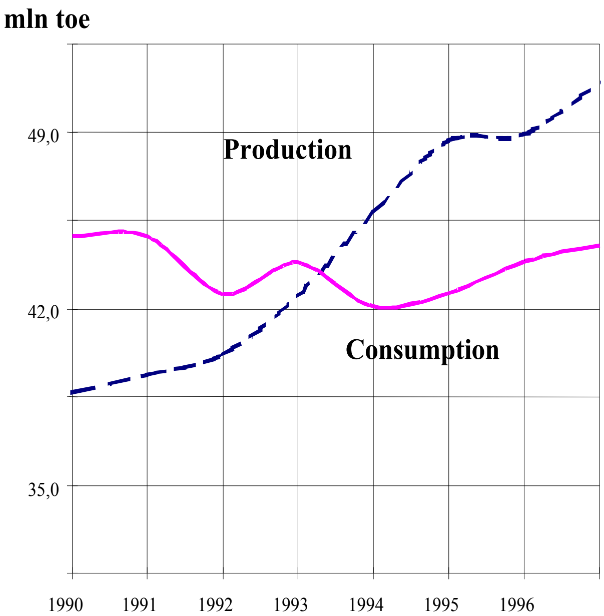
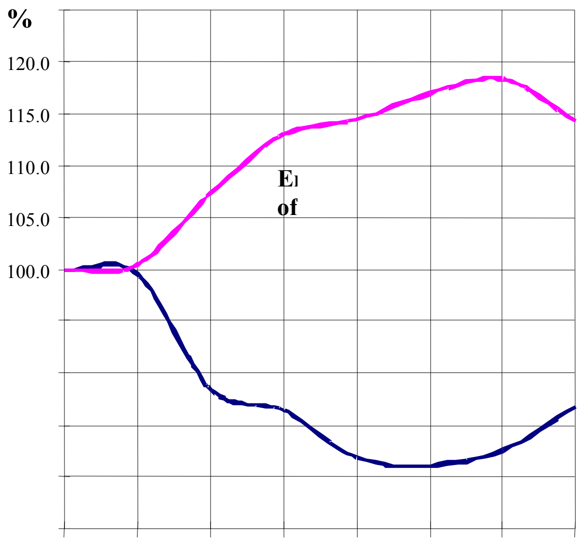


Fig. 1.7 Production and consumption of energy (mln.tc

The development of the energy and power sector in the 1990-97 period has significantly shaped not only perceptions of national development, but also perceptions of the ability to reduce greenhouse gas emissions. Notably, after 1990, energy consumption **did not change substantially** from before (Figure. 1.7). Total consumption in 1990 was 44.9 milliontoe, and in 1997 total consumption decreased by only 0.8% to 44.5 milliontoe. On the other hand, production growth in oil and gas condensates induced a 31.9% growth in primary energy production in this same period. (Figure 1.7)

Due to the decrease in energy consumption and GDP between 1990 and 1996, energy consumption as a percentage of GDP actually increased by 18.0% from 1990 levels (Figure 1.8). This also suggests that a remarkable **decrease in the efficiency of energy use occurred** during the period in question.



The main factors triggering this reduction in energy efficiency include:

- Decreased economic activity in Uzbekistan and contiguous countries;
- Deterioration of fixed assets in the economy;
- Obsolete machinery and technology at the enterprise level in a majority of sectors;
- Lack of devices to measure energy consumption trends; Spendthrift and wasteful mentalities on the part of consumers toward energy use.

A shift in energy consumption, both in type of energy used and consumption by sector, has been another major development (Figure 1.10). Natural gas has effectively been substituted for other types of energy and fuel. Natural gas accounted for 80.8% of total energy consumption in 1997, compared to 63.6% in 1990.

Meanwhile, coal consumption decreased 3.5-fold, and oil products decreased 1.8-fold. As a result of these changes, coal now accounts for only 2.1% of total fuel consumption, and oil products for 15.8%.

Energy consumption in the productive sectors, particularly in industry, declined by 42.7% from 1990. On the other hand, energy consumption in the municipal and service sectors grew by 44.3% and 116.8% respectively in this period.

As before, electrical energy, thermal energy, and gas fuel are mainly used in industry, while oil products are mainly used in construction. In the transport sector, use of gas increased, and in the agricultural sector, consumption of electricity grew. In the municipal and consumer service sectors, the share of gas increased considerably. Natural gas use in daily activities increased from 48.3% in 1990, to 82.1% in 1997; natural gas use in the municipal sector similarly increased to account for 56.8% of all energy use by 1997.

Industry's share of in consumption of FER declined from 18.3% in 1990 to 10.7% in 1997; the transport sector's decreased from 17.7% to 9.0%; the agricultural sector's from 7.3% to 6.0%; and construction's share from 1.6% to 0.8%. During the same period, household consumption of FER increased from 16.1% to 37.8%; the municipal sector's FER consumption also increased, from 7.7% to 11.4%. Thus, at present, the municipal and service sectors are the largest consumers of fuel and energy resources, while households are the largest consumers of electric power (75%).

These energy activity features have significantly affected the dynamics and composition of greenhouse gas emissions within the period 1990-97.

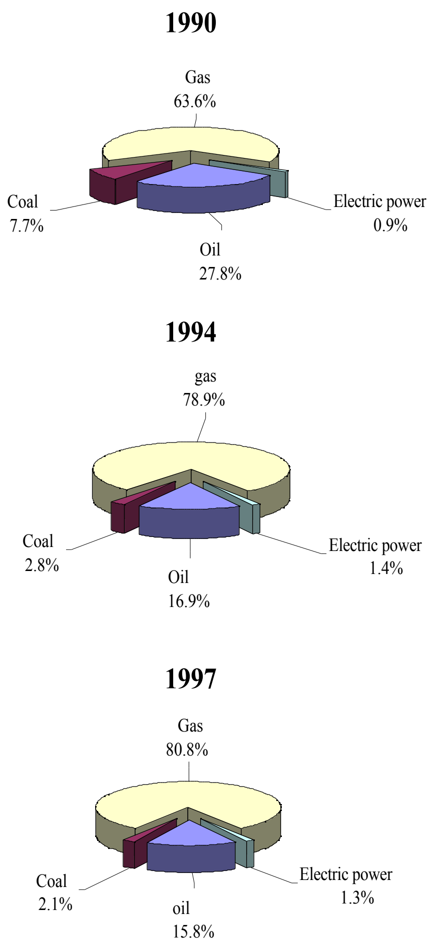


Fig.1.10 Primary Energy Consumption

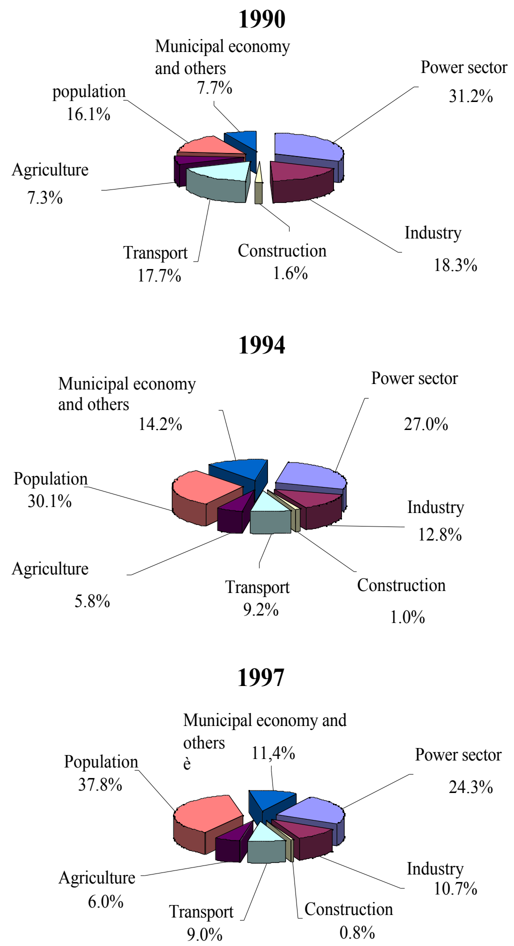


Fig. 1.10 Energy consumption by economic sector

1.3.4. Transport

Motorized transport carrying passengers and cargo is the main consumer of liquid hydrocarbons, with 91.6% using gasoline, 6.1% using Diesel fuel, and 2.3% using compressed or liquified gas. Passenger turnover at an average carrying distance of 6 kilometers is 78.0%, while the turnover rate of goods at an average carrying distance of 11 kilometers is 83%. Uzbekistan's total number of automobiles exceeds 1.1 million, with an average fuel economy of 95 grams per ton-kilometer. Currently, 74% of motorized transport is in private sector hands.

The relatively high emissions of greenhouse gases in the transport sector can be explained by the following factors:

· Truck models available do not correspond to consumers demands, especially under urban conditions, where modified, low-tonnage vehicles are required; this discrepancy between supply and demand leads to higher fuel consumption.

· Only 30% of all trucks operate on Diesel fuel and 7% operate on natural gas, **passenger carriers – 20.2% and 4.1%, respectively.** These indicators are significantly lower on average than those in Europe.

· Cargo and passenger fleets consist of standardized vehicles manufactured in Russia or other C.I.S. countries. Their average fuel economy is 15-20% lower than comparable European models operating on high-octane gasoline.

· Many vehicles were imported in the early 1980s. By 2000, 91% of the truck fleet will be at the end of their useful life; by 2002, 97% of the fleet will need to be retired. Motorized transport consumes 25-35% more fuel than necessary because of underdeveloped maintenance and repair infrastructure for engines and transmissions.

The automobile manufacturing industry has just started to develop in Uzbekistan. Joint ventures with Mercedes-Benz, Tatra, and IVECO are currently unable to cope with the demand for new vehicles. For this reason, steps must be taken to refurbish the existing motor fleet, reduce its energy consumption, and enforce European emissions standards.

Railroad transport carries 16.7% of all goods an average distance of 122.7 km, and some 8.3% of all passengers at an average distance of 153.7 km. Approximately 120 thousand tons of Diesel fuel are consumed for rail transport each year. Yet, railroad transport is the most efficient in terms of energy consumption, at 4.1g/t.km for a Diesel locomotive, 4.6 g/t. km for a yard locomotive, and 18-30 g/t. km for an electric locomotive. Uzbekistan's locomotive fleet has operated for over 20 years with hardly any replacements (the average life of a locomotive being 30 years).

Air transport consumes about 300 thousand tons of fuel annually.

1.4. Protection of Environment

Currently, the following system of environmental protection and management exists in the Republic. The *Oliy Majlis* of the Republic (Parliament) makes policy and adopts laws on environmental and ecological protection, as well as coordinates the activities of the State Committee for Environmental Protection and other related agencies. The President of the Republic of Uzbekistan makes strategic decisions on environmental questions, and is in charge of developing measures for international cooperation in the sphere of environment protection. The Cabinet of Ministers implements the Republic's Environmental Protection Policy, approves and implements federal environment-related programs, and undertakes an inventory and evaluation of natural resources.

The State Committee for Environmental Protection *(Goskompriroda)* is the main executing body for laws on environmental protection in Uzbekistan, reporting to the *Oliy Majlis*. It regulates the environmental activities of ministries, governmental agencies, enterprises and organizations, monitors compliance to environmental quality norms and standards, conducts state environmental appraisals, issues or annuls permits for emissions and discharges of pollutants and wastes, and prepares state environmental programs. *Goskompriroda*'*s* organizational structural is regional, with committees of environmental in each of the provinces and the Republic of Karakalpakstan.

The Ministry of the Interior, the State Committee for Worker and Industrial Safety, the Ministry of Agriculture and Water, the State Land Committee, and the Chief Administration of Meteorology execute selected environmental protection laws.

The Ministry of Macroeconomics and Statistics is responsible for developing of short- and long-term forecast on the environment, as well as summarizing the costs and benefits of environmental protection measures.

Individual standards for marginal permissible emissions and pollution discharges have been established for all industrial enterprises. Emissions and discharges in excess of standards set by applicable laws are subject to fines collected by national and regional entities of *Goskompriroda*. A portion of these fines is spent on environmental protection projects.

Uzbekistan is a co-founder of the Interstate Council for Addressing the Aral Sea Crisis and the Interstate Commission for Water Coordination.

The Aral Sea Crisis is the largest ecological disaster, which is of interstate importance nowadays. In January, 1994, the heads of the Central Asian states and Kazakhstan adopted

"The Program of Concrete Actions to Improve Ecological Situation in the Aral Sea basin". The Program comprises a number of projects aimed at mitigation of the Aral Sea Crisis. Since 1997 the realization of these projects was started. "The Environment and Water Resources Management in the Aral Sea Basin" project of the GEF is one of the most important. The projects intend to improve water supply to the Aral Sea region, restore lake ecosystems, and to better the inventory of quality and quantity of thransboundary waters. The realization of these projects will facilitate the recovery of the ecological and socioeconomic situation in the Aral Sea region. Uzbekistan contributes the implementation of the above projects considerably.Environmental and ecological protection is an integral part of the Republic's policies. Uzbekistan has committed to fulfill the conditions and requirements of the 10 Conventions it has acceded to and the 12 international environmental cooperation agreements it has signed. This has rendered it essential to develop a national strategy and plan of action on various aspects (environment protection, combat with desertification, biodiversity protection). The above has been executed within the framework of corresponding projects including The Transboundary Project on Biodiversity Protection in the Western Tyan-Shan.

A process of legislative reform is also underway, which will review outmoded laws and develop new ones. The Constitution of the Republic guarantees all citizens environmental security. Legislation on environmental protection has established economic and social conditions for public environmental safety on the basis of universally accepted principles.

Some 100 legal acts, directly or indirectly related to environmental protection, the use of natural resources and energy use (The Law of the Republic of Uzbekistan "On the Rational Energy Use" dated Aprli 25,1997), have been adopted, encompassing this legal framework:

The Law of the Republic of Uzbekistan "On the Protection of Nature" dated December 9, 1992 is the principal act regulating the environment.

The Law of the Republic of Uzbekistan "On State Sanitary Inspections," adopted on July 3, 1992, regulates social relations, establishes sanitary requirements for economic activities, prohibits any activity that violates sanitary standards or induces a negative influence on the environment.

The Law of the Republic of Uzbekistan "On Water and Water Use", adopted on May 6, 1993, regulates water relations, rationalizes economic and household water usage and protects the rights of enterprises, organizations, farms and citizens in sphere of water relations..

The Law of the Republic of Uzbekistan "On Specially Protected Natural Areas", adopted on May 7, 1993, outlines a legal, ecological, economic, and organizational framework for the creation, management and protection of select natural areas, which are national property in interests of present and future generations.

The Law of the Republic of Uzbekistan "On Air Protection", adopted on December 27, 1996, regulates the activities of organizations, enterprises and citizens in the area of the air protection.

The Law of the Republic of Uzbekistan "On the Protection and Use of Animals", adopted on December 26, 1997, regulates the protection, use and reproduction of animal species.

The Law of the Republic of Uzbekistan "On the Protection and Use of Vegetation", adopted on December 26, 1997, regulates the cultivation and uses of vegetation.

The Law of the Republic of Uzbekistan "On Forests", adopted on April 18, 1999, regulates the protection and use of its forests.

The Criminal Code, the Code of Administrative Liability, and the Civil and Labor Codes of the Republic of Uzbekistan have established criminal, administrative, civic, and proprietary liability for violating the laws on environmental protection and specified disciplinary action. All ecological acts include special clauses on legal liability

2. National Inventory of Greenhouse Gas Emissions

In compliance with Articles 4 and 12 of the UN FCCC, Uzbekistan has developed its first National Inventory of Anthropogenic GHG Emissions and Sinks. Data include national emissions of the three gases that exert a direct greenhouse effect—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—as well the gases having only an indirect greenhouse effect—carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and non-methane hydrocarbons (NMVOC). The base years selected were 1990 and 1994. This emissions assessment can be used to understand of the dynamics of anthropogenic GHG emissions from 1990 to 1997.

2.1. Methodology

On the whole, the guiding principles set by the IPCC in 1996 for undertaking national GHG inventories were followed. Of the six basic categories, five were considered in developing Uzbekistan's National Inventory: Energy, Industrial Processes, Agriculture, Changes in Land Use and Forestry, and Wastes. Since no methodology for estimating "Use of Solvents and Other Products" exists either in the IPCC Guidelines or at the national level, the Inventory does not include emissions in this category. Quantitative assessments have been made based on past and current statistics collected by the state and various departments and sectors, using coefficients and criteria recommended by the IPCC.

In preparing the initial data on energy activity, classifications of economic, industrial, and transport sectors valid in Uzbekistan were used, and are somewhat different than those set by the UN. The production of thermal energy in boiler-houses and power plants by ministries, governmental agencies and individual enterprises is primarily included in the **energy** sector. Two methods were used to estimate emissions from energy-related activities. One method calculated emissions factors by fuel use and the other calculated emissions factors by sectoral use, both using official statistical data provided by the state of Uzbekistan**.** When the findings obtained by the two methods were compared, a marked similarity in the estimates was observed. The difference between the two methods amounted to 4.5%, except for the year 1997, when the difference was 6.9%.

Fuel balances were calculated using official average-calorie-equivalent conversion coefficients to convert **natural fuels to conditional ones (conversion energetic coefficients)**. These coefficients differ from the defaults set by the IPCC (see Table 2.1). However, the results obtained using the default conversion coefficients provided by the ISEEC and those used by Uzbekistan in its Inventory differ by only 0.3%-0.5%.

As research in Uzbekistan related to climate change was undertaken for the very first time, and quantitative national assessments of GHG emissions from the combustion of various fuels are presently unavailable, emissions factors recommended by the IPCC were used. The methodology and emissions factors set by the IPCC to calculate GHG emissions for other types of energy activity, including maximum factors for methane emissions, were also used, as they correspond well to the present technical conditions in Uzbekistan.

For assessments of GHG emissions in "Industrial Processes" and "Agriculture," IPCC guidelines for coefficients and multipliers were again used, in conjunction with official state statistics on industrial activity, livestock, areas under rice cultivation, and use of fertilizers.

In the category "Changes in Land Use and Forestry", estimates were based on official statistics from the State Forests Inventory using national conversion coefficients.

Urban landfills and wastewater are the main sources of methane emissions in the category of “Wastes”. To estimate the volume of solid waste and commercial and household sewage, population data were used in conjunction with coefficients recommended by the IPCC.

Table 2.1.

Energy Conversion Coefficients Used to Calculate CO_2 Emissions

Type of energy	Unit of measurement	Conversion coefficients used		IPCC Coefficients GJ
		toe	GJ	
Uzbek brown coal	1 ton	**0.33**	**13.775**	–
Uzbek coal	1 ton	**0.48**	**19.929**	–
Uzbek coal briquettes	1 ton	**0.55**	**22.860**	–
Coke	1 ton	**0.63**	**26.377**	–
Gas of underground gasification	1000 m^3	**0.07**	**2.931**	–
Crude oil and NGL	1 ton	**1.00**	**41.868**	**41.868**
Gasoline	1 ton	**1.04**	**43.668**	**44.800**
Aviakerosene	1 ton	**1.03**	**43.082**	**44.590**
Other kerosene	1 ton	**1.03**	**43.082**	**44.750**
Diesel fuel	1 ton	**1.01**	**42.496**	**43.330**
Furnace fuel oil	1 ton	**0.96**	**40.151**	**40.190**
Domestic furnace fuel	1 ton	**1.01**	**42.496**	–
Natural gas liquids	1 ton	**1.10**	**46.013**	**47.310**
Oil refinery gas (LPG)	1 ton	**1.05**	**43.961**	**48.150**
Bitumen	1 ton	**0.94**	**39.565**	**40.190**
Petroleum oil	1 ton	**0.96**	**40.151**	**40.190**
Other oil products	1 ton	**0.96**	**40.151**	**40.190**
Natural and bypass gas	1000 m^3	**0.81**	**33.997**	–

Similarly, emissions from industrial wastewater discharges were estimated using national statistics on production volumes and local emission factors. It should be pointed out however, that insufficient data on industrial wastewater discharges may have resulted in low estimates.

2.2. Total GHG Emissions

Aggregate emissions of gases with direct greenhouse effects (CO_2, CH_4, and N_2O) and their values in the CO_2-equivalent for the period 1990-1994 are provided in Table 2.2. The following values for global warming potential (GWP) have been used: for CO_2 – 1, for CH_4 – 21, for N_2O – 310.

Total GHG emissions in Uzbekistan reached 163,204 thousand tons in CO_2-equivalent in 1990, decreasing to 154,153 thousand tons in 1994. Thus, during this period, a net

reduction of GHG emissions by 9,051 thousand tons or 5.5% occurred. Similarly, total GHG emissions in CO_2-eqvivalent were 8 tons per capita in 1990, but only 6.9 tons per capita in 1994, of which 5.6 tons and 4.6 tons respectively were just CO_2 emissions.

The 5.5% reduction in total GHG emissions between 1990 and 1994 is intimately linked to the unique evolution of Uzbekistan's socioeconomic development described in Chapter 1. In particular, the total volume of energy supplied to consumers dropped by 6.3% during this period, except for natural gas, which increased 2.7 fold, from 4.2 to 11.3 billion cubic meters.

Table 2.2

Aggregate GHG Emissions in Uzbekistan

Gas type	1990			1994			Change 1990-1994 (%)
	Absolute emissions Gg	Emissions in CO_2-equivalent, Gg	Share of Total GHG Emissions (%)	Absolute emissions Gg	Emissions in CO_2-equivalent, Gg	Share of Total GHG Emissions (%)	
__2	114559	114559	70.2	102157	102157	66.3	89.2
__4	1798	37748	23.1	1991	41812	27.1	110.8
N_2O	35	10897	6.7	33	10184	6.6	93.5
Total		163204	100.0		154153	100.0	94.5

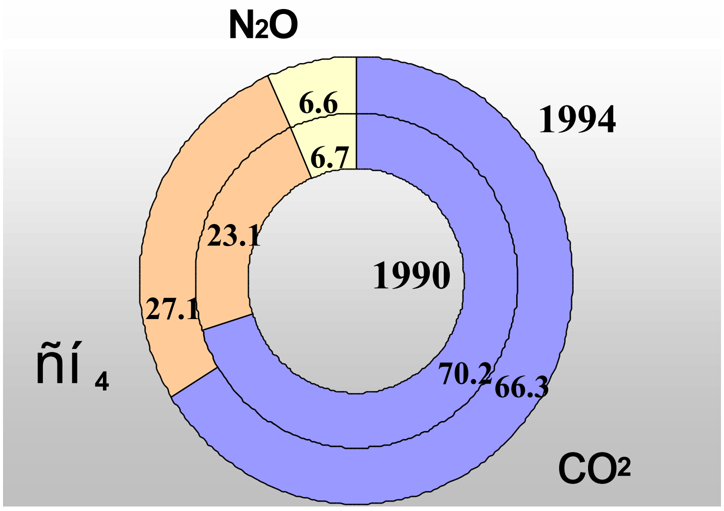


Fig. 2.1 Composition of GHG emissions (%) in 1990 and 1994.

In 1990, carbon dioxide accounted for the largest proportion of emissions with direct greenhouse effects (70.2%), while methane emissions accounted for the second largest (23.1%), and nitrous oxide emissions the smallest (6.7%). In 1994, the proportion of carbon dioxide declined to 66.3%, while the proportion of methane increased slightly constant (27.1%), and the proportion attributed to nitrous oxide remained relatively constant (5.6%).

The distribution of GHG emissions with direct greenhouse effects is provided in Table 2.3.

Table 2.3.

Emissions of GHGs with Direct Greenhouse Effect
Gg in CO_2-equivalent

Source criteria	__$_2$		__$_4$		N_2O		_____	
	1990	1994	1990	1994	1990	1994	1990	1994
Aggregate emissions	***114559***	***102157***	***37748***	***41812***	***10897***	***10184***	***163204***	***154153***
Energy sector	***108010***	***97215***	***27728***	***30640***	***0***	***0***	***135738***	***127854***
Fuel combustion	108010	97215					108010	97215
Power industry	54698	44785					54698	44785
Industries and construction	10736	6263					10736	6263
Agriculture	5667	3855					5667	3855
Transport	17326	9006					17326	9006
Municipal and household sector	7344	10718					7344	10718
Households	12239	22587					12239	22587
Fugitives			27728	30640			27728	30640
Coal mining and processing			469	274			469	274
Oil and gas systems			27259	30365			27259	30365
Industrial processes	***6549***	***4942***	***0***	***0***	***391***	***78***	***6940***	***5020***
Mineral products	2926	2330					2926	2330
Chemical products	2625	1838	0	0	391	78	3016	1915
Metals	998	774					998	774
Agriculture			***6890***	***7910***	***10506***	***10106***	***17396***	***18016***
Enteric fermentation			5829	6706			5829	6706
Manure			799	916	285	260	1084	1177
Rice cultivation			262	288			262	288
Agricultural soils					10221	9846	10221	9846
Waste			***3130***	***3262***			***3130***	***3262***
Solid waste landfills			2924	3054			2924	3054
Wastewater			206	208			206	208

The contribution of these sources to total GHG emissions with direct greenhouse effects are found in Figure 2.2. The largest source is the power industry, whose share accounts for 83.0% of aggregate emissions.

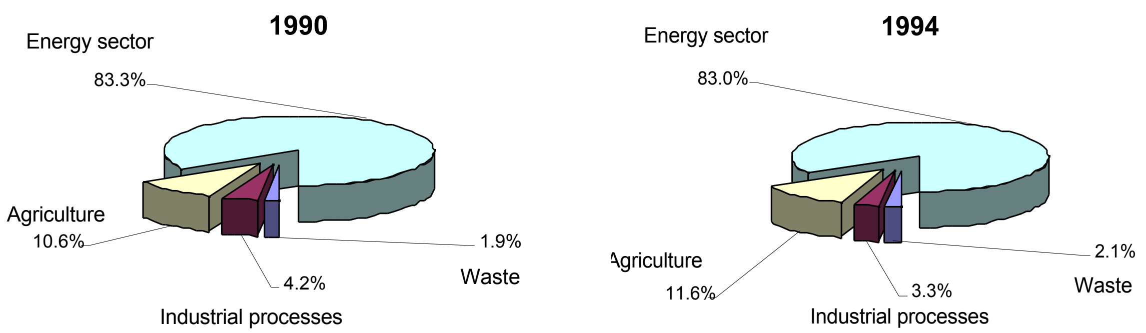


Fig. 2.2. GHG emissions in 1990 and 1994 (by source).

2.3. Carbon Dioxide Emissions

Between 1990 and 1994, carbon dioxide emissions decreased by 10.8%, or by more than 12.4 million tons. Emission in the energy sector, as defined above, declined by 10.0% due to reduced fuel consumption in the productive sectors of economy. Specifically, emissions in the power industry declined by 18.1%, emissions in industry and construction" decreased by 41.7%, emissions in Agriculture dropped by 32.0%, and emissions in the transport sector almost halved. Conversely, emissions in the **household** and municipal and household sectors increased during this period, by 84.5% and 46.0%, respectively. . The changes have also occurred in the composition of emissions according to sectors (Fig. 2.3).

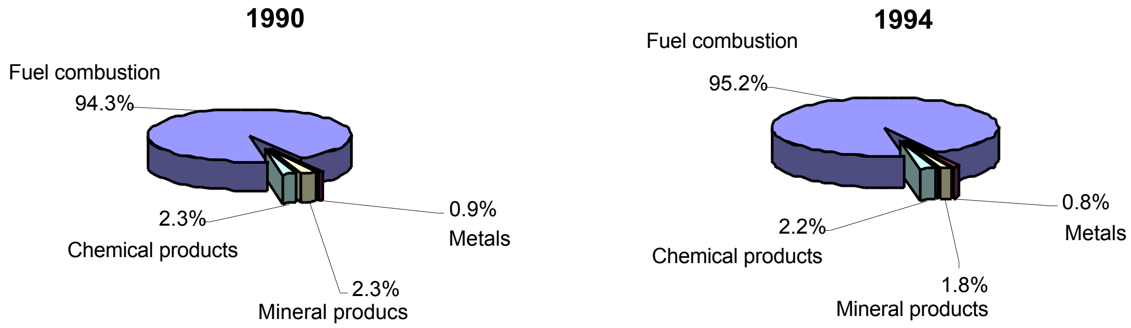


Fig. 2.3 Composition of carbon dioxide emissions in 1990 and 1994 (by source).

The main sources of CO_2 emissions are fuel combustion processes. In 1990, they accounted for 94.3% of total emissions, industrial processes accounted for 5.7% (or 2.5% for minerals production, 2.3% for other chemical products, and 0.9% for metals). After the drop in industrial output in 1994, the power sector's share of emissions totaled 95.2%, and the share of carbon dioxide emissions from industrial processes declined to 4.8%.

The power sector (power energy and fuel industries) also accounted for the largest share of carbon dioxide emissions in the energy sector category, accounting for almost half of the total emissions (46.1%) in 1994. The share of emissions from the households and municipal-household sector grew significantly in volume, to 34.2% in 1994. Notably, households' proportion increased markedly from 11.3% in 1990 to 23.2% in 1994, mainly due to an increase in gas consumption in the residential sector.

The proportion of transport-related emissions declined significantly, from 16.0% in 1990 to 9.3% in 1994. Emissions from fuel combustion in agriculture, industrial production and construction declined as well. In the National Inventory calculations, emissions from the combustion of firewood, lumber waste, and agricultural wastes for fuel were not included, due to their insignificant contribution to greenhouse gas emissions, on the one hand, and the lack of official data on such activities, on the other hand. (Official statistics estimates that 24 thousand tons of conditional fuel of these types was burned in 1985, and in 23.0 thousand tons equivalent to 40 thousand tons of CO_2 emissions. Since imports of lumber dropped dramatically after 1991, it is reasonable to assume that incineration of firewood and lumber waste also declined.

The share of CO_2 emissions from industrial production processes in 1990 was as follows: minerals such as cement and lime (44.7%); chemicals such as ammonia (40.1%); and metallurgy (15.2%). While the drop in industrial output reduced total CO_2 emissions in this category by 24.5% in 1994, the sub-category breakdown remained proportional.

2.4. Methane Emissions

Uzbekistan has a well-developed coal, oil, and natural gas production infrastructure, as well as pipeline transmission facilities. Methane emissions leakage is associated with all of these activities. The energy sector accounted for 73.5% of total volatile emissions in 1990, while the agricultural sector accounted for 18.3% of emissions and wastes for 8.2%.

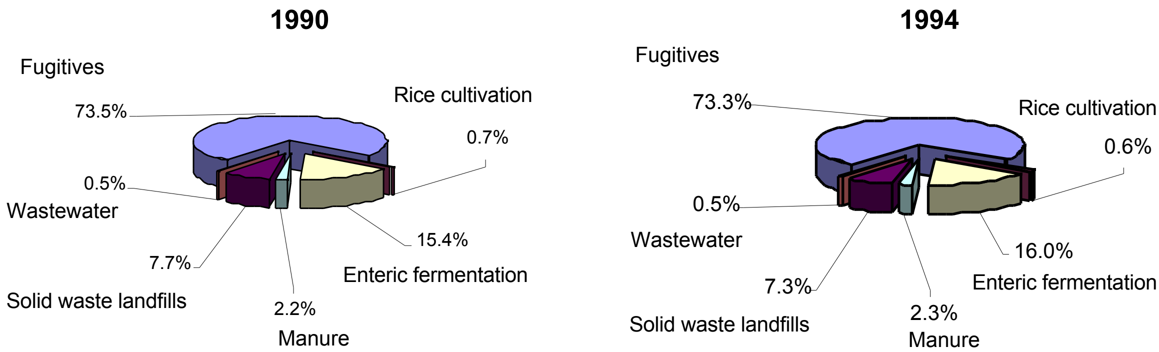


Fig. 2.4 The composition of methane emissions (by source).

Between 1990 and 1994, total methane emissions increased in all categories by a total of 10.7%. Methane emissions in the energy sector rose by 10.5%, in the agricultural sector by 14.3%, and by 4.25% in the category of wastes.

Methane emissions increases were linked to population growth (+4.4%) and increased production and consumption of natural gas (+16.2% in bcms), rice (+13.8% in area under cultivation), and livestock (+19.7% in area) between 1990 and 1994. The breakdown of emissions in this period changed slightly (see Figure 2.4).

In 1994, the oil and gas industry accounted for more than 99.0% of CH_4 emissions in the energy sector (see Table 2.3). Enteric fermentation accounted for more than 85.0% and manure accounted for more than 11.0% of methane emissions in the agricultural sector. Solid waste landfills were the main source of methane emissions in the waste category (around 94.9%).

2.5. Nitrous Oxide Emissions

Soil used in agriculture is the main source of nitrous oxide emissions (96.8% in 1994). Manure (2.5%) and of chemical substances (0.5%) account for relatively minor fraction of nitrogen oxide emissions. Quite remarkably, total nitrous oxide emissions declined only by 6.5% between 1990 and 1994, with reductions in the agricultural sector accounting for 3.8% of this decrease. Nitrous oxide emissions in industrial processes reduced 5-fold, due to a sharp drop in the production of nitric acid.

2.6. Changes in Land Use and Forestry

Emissions and sinks in this category were estimated using statistics outlined in the "State Inventory and Disposition of Forests by Kind and Age Group". Calculations followed the methodology in the State Inventory and were based on tree trunk phyto-mass by type and groupings in natural zones: a) mountainous forests (juniper, other arboreous kinds); b) wetland-valley forests (poplar or turanga, other arboreous kinds); and c) desert forests (saxaul). Shrubs were classified separately.

The annual increase of juniper averaged 39.1 thousand m^3, other mountainous trees 13.8 thousand m^3, poplar trees 40.1 thousand m^3, other valley trees 5.1 thousand m^3, saxaul 246.4 thousand m^3, and shrubs 100.2 thousand m^3. National conversion coefficients were used to convert volumetric indicators of humid wood into dry substances. Dry wood mass was calculated with regard to volumetric weight loss through the drying and density of woody substances.

Total forest-covered area was 1789.4 thousand hectares in 1998, and 1911.7 thousand hectares in 1993. Despite the increase of the area under forestry during this period, net absorption of carbon dioxide declined by 6 thousand tons (to 108.8 thousand tons). This can be explained by reduced growth of poplar trees—the main tree species that affects water flows—from 2.256 m^3/hectare to 1.759 m^3/hectare.

Estimated sinks for 1988 total 421 Gg of CO_2. As the State Inventory of Forest Reserves is conducted every five years, the same indicators were used for the years 1990, 1991, and 1992. Sinks totaled 399 Gg of CO_2, according to the 1993 Inventory. This value was also used for the year 1994. It was not possible to follow the recommendations of IPCC to use a 3-year average of forestry data due the differences in reporting intervals.

2.7. International Cargo

The IPCC methodology for calculating GHG emissions from fuel combustion by international air and sea transport was followed. Emissions were calculated, but not included in the National Inventory. Rough emissions estimates were made because official statistics on the utilization of fuel by international cargo transport were limited. According to these calculations, carbon dioxide emissions declined from 2.0 million tons in 1990, to 0.7 million tons in 1994. This was due to the fact that during the period in question, turnover of goods remained constant while passengers carriage fell more than 3.8-fold.

2.8. GHG Emissions from 1990 to 1997

An analysis of anthropogenic GHG emissions for the period 1990-1997 was conducted to identify trends and dynamics. Quantitative emissions indicators are found in Table 2.4.

Table 2.4

GHG Emissions with Direct Greenhouse Effects
Gg, in CO_2 -Equivalent

Greenhouse gas	1990	1991	1992	1993	1994	1995	1996	1997
Carbon dioxide	114559	114146	107220	107517	102157	101572	104601	102844
Methane	37748	39288	40091	41835	41812	42306	42554	43685
Nitrous oxide	10897	10872	10869	10664	10184	9368	9167	9182
Total	***163204***	***164306***	***158179***	***160016***	***154153***	***153247***	***156322***	***155711***

The dynamics of GHG emissions with direct greenhouse effects for 1990-1997 (by type) is illustrated in Figure 2.5.

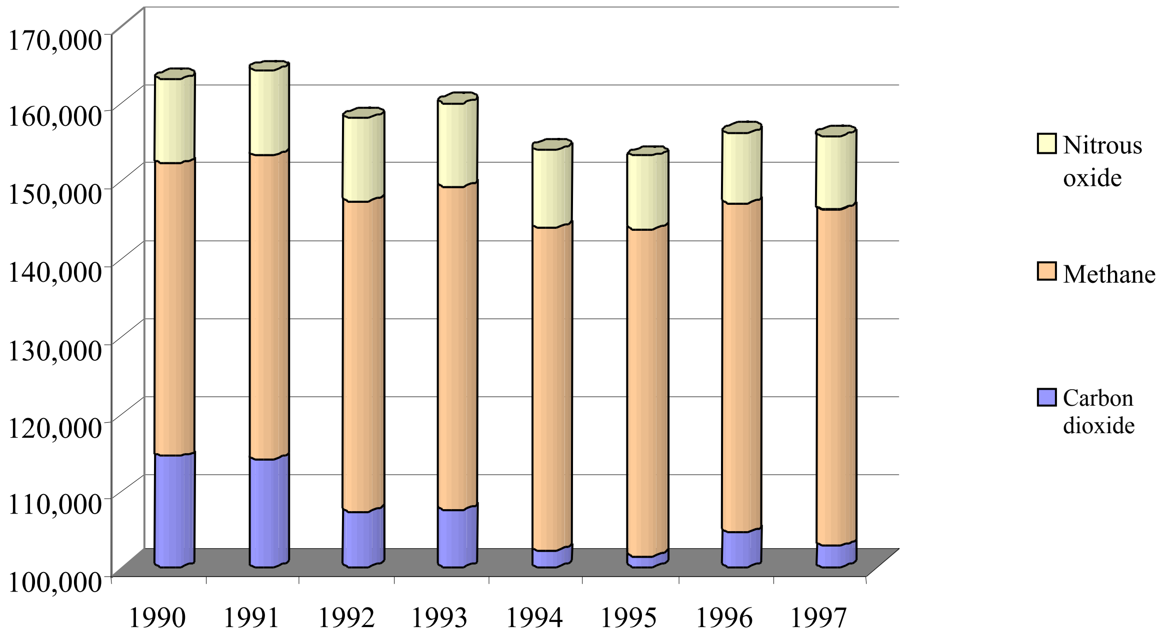


Fig. 2.5 GHG Emissions (Gg) during the 1990-1997 period

2.9. GHGs Emissions with Indirect Greenhouse Effects

Table 2.5 reveals data on GHG emissions with indirect greenhouse effects for the period 1990-1994. Processes related to fuel combustion are the main sources of carbon monoxide and nitrogen oxides, accounting for more than 99.0% of the emissions for those gases. To a great extent, sulfur dioxide, nitrogen oxides, and carbon monoxide emissions declined between 1990 and 1994.

Table 2.5

GHG Emissions with Indirect Greenhouse Effects (in Gg)

Gas	1990	1994	1994 to 1990, %
__	1979	1355	68.5
N_x	343	243	70.9
SO_2	554	276	49.8
NMVOC	73	61	83.6

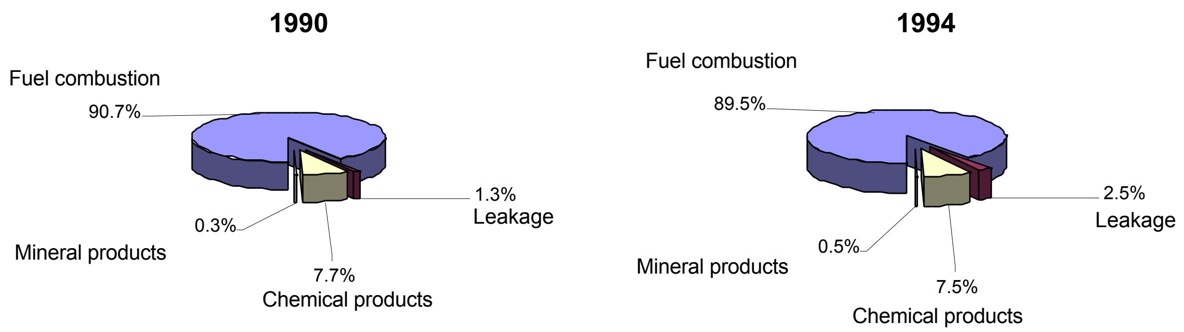


Fig. 2.6 The composition of sulfur dioxide emissions

The distribution of sulfur dioxide (SO_2) by source is depicted in Figure 2.6. Again, fuel combustion is its main source, followed by the production of sulfuric acid.

Surveys indicated that the greatest volume of non-methane hydrocarbons stems from leakage in the oil and gas industry. Some NMVOC emissions also occur in the food and chemical industries (Figure 2.7).

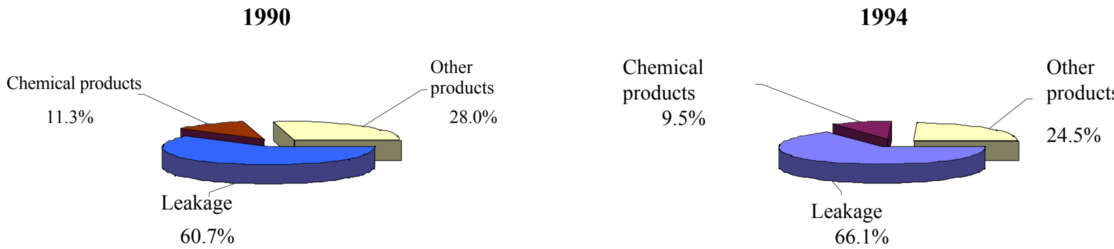


Fig. 2.7 Composition of NMVOC emissions (by source).

Quantitative indicators for GHG emissions with indirect greenhouse effects (by type) for the period 1990-1997 are found in Table 2.6.

Table 2.6

Gas Emission with Indirect Greenhouse Effect, Gg

___ ____	1990	1991	1992	1993	1994	1995	1996	1997
__	1979	1818	1687	1471	1355	1223	1077	1208
N_x	343	323	308	269	243	210	203	211
SO_2	554	492	375	303	276	281	294	276
NMVOC	73	73	63	65	61	55	54	56

As indicated in Table 2.6 and Figure 2.8, the volume of GHG emissions with indirect greenhouse effect continuously declined between 1990 and 1996. Sulfur dioxide more than halved, carbon monoxide and nitrogen oxides dropped by almost 40%, and non-methane hydrocarbons declined by 25%. Only from 1997 onwards, do emissions from such gases manifest an increasing trend, mainly due to increased consumption of fuel in the transport sector, and slight emissions increases of NMVOC.

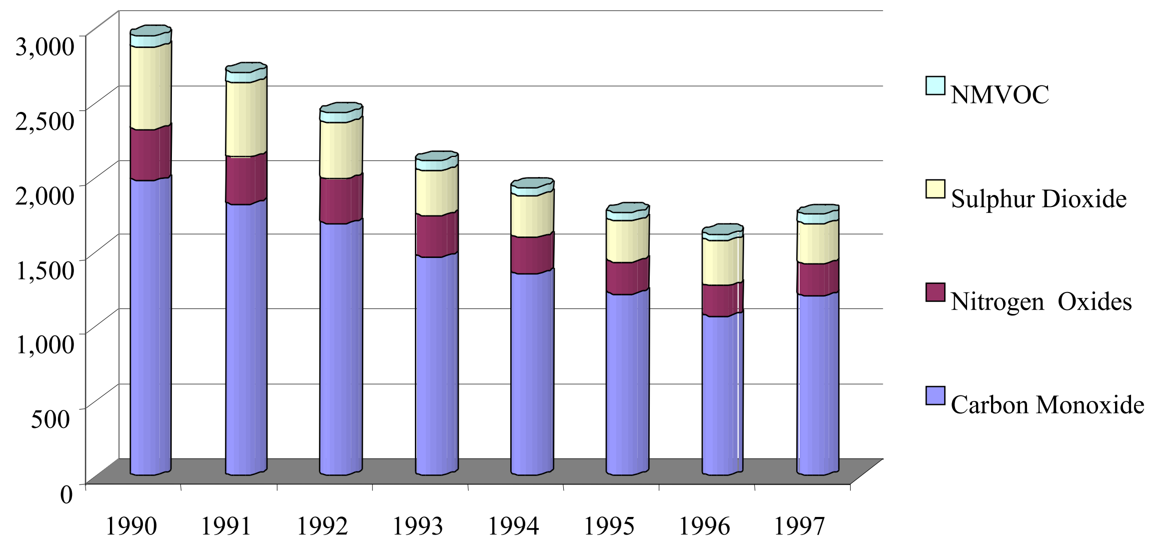


Fig. 2.8. Dynamics of GHG emissions with indirect greenhouse effects (Gg)

SO_2, NMVOC, and partially CO and NO_x emissions (particularly in the "Industrial Processes" sector and its associated "Leakage") were calculated using the methodology of **IPCC**. CO and NO_x emissions form fuel combustion were not calculated, but rather taken from state inventory reports, as these gases are toxic and subject to compliance with national standards. The methodology used to estimate these gases that was approved by the State Committee for Environmental Protection is partially based upon instrumental variables partially upon accepted emission factors for transport. For example, CO emission factors for gasoline engines is 0.6 t/t, 0.1 t/t for Diesel engines, and NO_x emission factors are 0.04 t/t for each engine type. Below, estimates for these gases will be further specified.

The general reduction in fuel consumption and the shift in the composition of fuel consumption that occurred between 1990 and 1994 were the main causes of CO, NO_x, and SO_2 emissions reductions. Specifically, fuel consumption declined from 1705.8 PJ to1630.6 PJ, liquid fuel utilization dropped from 467 PJ to 267 PJ, and solid fuel usage fell from 48.9 PJ to 42 PJ. Consumption of gaseous fuel increased by 1.2 times, from 1095 PJ in 1990 to 1348 PJ in 1994.

2.10. Estimation of Uncertainty

Estimation of uncertainty for economic activity and emission factors was calculated in order to estimate the reliability of the data in the National Inventory. Parameters of statistical error related to GHG emissions range between 5-10% for almost all categories, except "Changes in Land Use and Forestry" (standard error is ± 50%), nitrous oxide and carbon monoxide emissions (error is ± 20%).

The estimates of standard errors related to emission factors range between 7–60% for different sectors and gases as follows:

- ± 7% for CO_2 emissions in the power sector;
- ± 10% for CO_2 emissions in the Industrial Processes sector;
- ± 55% for CH_4 emissions from leakage and cattle breeding;
- ± 60% for methane emissions from Wastes.

The largest margins of error accepted were for estimates of sinks in the category "Changes in Land Use and Forestry"(±25% for emission factors and ±50% for data on activity) and for nitrous oxide emissions from agriculture (±80%).

An, taking into account all emission factors and data on economic and biological activities, ranges from 9% to 80%. Aggregate estimates of uncertainty by category are:

- ± 9% for CO_2 emissions in the power sector;
- ± 11% for CO_2 emissions from Industrial Processes;
- ± 56% for CH_4 emissions from leakage and cattle breeding;
- ± 60% for CH_4 emissions from "Wastes".

Thus, parameters of general uncertainty for the emission of each gas are as follows:

- In 1990: ± 8.5% for CO_2, ± 42.7% for CH_4, ± 77.4% for N_2O.
- In 1994: ± 8.6% for CO_2, ± 42.6% for CH_4, ± 79.5% for N_2O.

3. Development Forecast

3.1. Economic Development Forecast

3.1.1. Macroeconomic Forecast

The prevailing model of development in Uzbekistan is oriented to social and sustainable economic development. A number of conditions and limitations influence the course of its development, the most important of which are:

· Demographic trends, such as relatively high population and labor growth rates.

· Increased water scarcity, decreasing fertility of irrigated land, and urgent need to solve environmental problems in the Aral Sea and other densely populated regions.

· The orientation of the economy toward raw production and unfinished goods requires implementation of structural-investment policies.

As Uzbekistan is currently in a state of transition, economic development forecasts need to adopt a scenario approach, based on a combination of econometric modeling and expert judgements on growth in individual sectors. Uzbekistan's own long-term strategy for economic development similarly hinges on alternative scenarios, which suggest different targets and indicators of their achievement. Two scenarios for economic development have been identified: inertia and mobilizing (Table 3.1).

Table 3.1

Critical Economic Development Indicators and National Economy Reforming Forecast up to 2010 (average change in rate in %)

Indicators	Reported estimates			Forecast				
				Inertial scenario		Mobilizing scenario		
	1995	1997	1998	2000	2001-2005	2000	2001-2005	2006-2010
Gross Domestic Product	-0.9	5.2	4.4	2-3	-3	5	6-7	8-9
Industry	0.1	4.1	5.8	1-2	1-2	6	7-8	10-11
Extracting	1.1	1.5	4.5	2-3	3-4	4	4-5	4-6
Processing	-0.1	4.7	7.2	2-3	-5	8	8-10	10-12
Agriculture	-3.0	5.8	4.0	3-4	1-2	5	4-5	4-5
Fixed capital investment	4.0	17.0	15.0	8	2	7	15-16	12-13
Export of goods and services	3.9	-4.4	-20.0	-8	-3	10	10-12	12-13

The **inertial scenario** envisions a number of limitations on economic growth to prevail, the most basic of which are: increases in non-payments in different sectors of the economy resulting from poor efficiencies after enterprise restructuring and slow rates of adaptation to market economic conditions; sluggish movement in increased purchasing power. Even assuming an increase of foreign investment, the high capital intensity requirements for GDP growth in this scenario would not be attainable, and therefore, sustainable economic growth would not occur. Under the inertia scenario, GDP growth would reach 2-3% only by some time in 2000, and for subsequent periods, economic recession is projected.

In contrast to the inertia scenario, the **mobilizing** scenario assumes a dynamic process of economic reform and **structural adjustment**. This scenario assumes that new factors and sources of production and income will ensure sustainable economic growth and adequate living conditions for the country's entire population. Table 3.2 provides the forecasts for the structure of GDP up to 2010. According to these projections, ensuring sustainable development necessitate that GDP growth rates exceed population growth by at least 1.5 - 2.0 times in 1999-2000, and reach 6-7% in the 2001-2005 period, and subsequent increases of up to 8-9%.

Table 3.2

GDP Structure Forecast up to the Year of 2010

Indicators	Reported estimates		Estimates	Forecast			
				2005		2010	
	1990	1995	2000	Inertial	Mobilizing	Inertial	Mobilizing
GDP	100	100	100	100	100	100	100
Industry	22.7	17.1	15.0	15.1	15.5	-	17.4
Agriculture	33.4	28.0	26.0	28.2	24.1	-	20.9
Construction	10.6	7.1	7.8	8.1	9.1	-	9.3
Transport	5.9	7.3	6.2	6.3	5.6	-	5.0
Services	28.5	27.4	29.1	31.4	31.3	-	34.9
Net taxes	-1.1	13.1	15.9	11.9	14.4	-	12.5

The distinguishing features of Uzbekistan's macroeconomic strategy in the mobilizing scenario include: high investment activity (rates of investment would increase to 15-16% between 2001-2005 and 12%-13% between 2006-2010); dynamic export growth (the ratio of exports to GDP would increase from 24.7% to 40% by 2010); significant inflation reduction; and the strengthening of the national currency—the *Soum*.

A favorable macroeconomic environment would be attained with improvements in taxation, budgetary, monetary and fiscal policy, liberalization of the hard currency market, and further development of Uzbekistan's financial and banking systems. Increasing export-orientated production, particularly in processing industries, would help ensure sustainable economic growth.

3.1.2. Social Development

According to current demographic trends, Uzbekistan's population will grow by four million people within 12 years and total 28.2 million by 2010. The annual population growth rate will average 1.5% for this period, down from to 2.1% in the period 1991-1995. (Table 3.3). The macroeconomic forecast projects average per-capita consumption of goods and services to grow by 1.6-1.7 times between 1999 and 2010. By 2005, average per capita income will increase by 1.8-2.0 times.

Table 3.3

The Indicators of Social Development up to the Year of 2010

Indicator	1990	1995	1997	2000	2005	2010
Population (mln.)	20.4	22.7	23.5	24.0	26.4	28.2
urban	8.3	8.7	8.9	9.2	9.7	10.2
rural	12.2	14.0	14.6	15.5	16.7	18.0
Unemployment rate, %	-	0.3	0.3	0.3	0.4	0.4
Life expectancy	69.3	70.2	70.3	70.5	71.0	71.5

Ameliorating, housing, municipal, and medical services is currently a social development priority. Providing the rural population with good drinking water and natural gas is also a priority. By 2005, 85% of the rural population should have access drinking water and 82% of the rural population provided with natural gas. Social and human development can only be achieved with the implementation of long-term programs in job creation, development of social infrastructure in rural areas, training, public health, housing, and municipal services, and environment protection.

3.2. Economic Restructuring

3.2.1. Industry

Industrial policy will target the following problems:

- Transitioning from an agrarian-industrial economy to an industrial-agrarian one dominated by the processing industry, and ensuring that local production meets the needs of the population;
- Strengthening energy and food security, and boosting high-tech, export-orientated production;
- More robust processing of mineral and raw material resources and development of agricultural production, to compete effectively on international markets;
- Fostering scientific- and labor-intensive production.

Industrial output is projected to increase 2.5-3 times between 1999 and 2010. Processing industries are to be given priority, for which average annual growth rates are projected to be 10-12% by 2006-2010, compared to 4-6% growth rates for the mining industry. The processing industry's share of GDP will increase from 30.6% in 1997 to 62% of GDP by 2010. During the next 5 years, consumer goods will account for 50% of total industrial output (Table 3.4). The most rapid rates of development will occur in machine building (by 3.0-3.5 times), light industry (by 2.5-3.0 times), food processing (by 3.0-3.5 times), and chemicals (by 2.5-3 times). Machine building will increase from 13% of industrial output in 1998, to 18% in 2010. Increased production of machines and equipment to meet local demand and increase global competitiveness is a development priority, as well as reducing dependency on imported raw materials and competing in world markets.

An important place in Uzbekistan's development policy is reserved for the traditional industrial sector, namely, light industry, and in particular, a textile industry based on advanced technologies and orientated to foreign markets. In the food processing sector, structural changes connected with autonomy in food production with increased foreign investment, is envisioned.

Table 3.4

Basic Industrial Production (1990 – 2010)

Type of product	1990	1995	1997	2000	2005	2010
Rolling of ferrous metals, thsd t.	955	322	350	430	500	520
Steel, thsd. t	957	355	371	460	530	550
Mineral fertilizers, thsd t.	1762	943	955	1000	1556	1892
Cars, thsd p.	-	-	64.9	80.0	160.0	160.0
Tractors, thsd p.	23.2	4.0	2.8	6.3	8.5	9.3
Cement, thsd t.	6385	3419	3286	3530	4800	5500

In order to carry out these structural changes, state programs will be designed to develop base industries (energy sector, oil and gas industry, geological prospecting), upgrade light industry, revamp agricultural machine-building enterprises, and accelerate the development of high-tech, science-intensive production for the medium-and long-term future.

3.2.2. Agriculture

The development strategy in the agricultural sector is targeted at ensuring food and environmental security, while increasing the efficiency and export-potential of domestic production. According to the macroeconomic forecast, the agrarian sector will maintain its leading role in the economy (at 25% of GDP). To meet the strategic development goals by 2010, annual growth in agricultural output must be at least 5-6%.

Table 3.5

Agricultural Production for Basic Produce (1990 – 2010)

Product	Unit of measure	1990	1995	1997	2000	2005	2010
Seed cotton	Tons (000s)	5058.0	3934.2	3641.0	4000	4000	4000
Wheat	Tons (000s)	553.5	2346.9	3073.0	4800	5400	6000
Potato	Tons (000s)	336.4	440.0	691.9	750	950	1000
Vegetables	Tons (000s)	2842.5	2724.7	2384.2	2720	3200	3500
Melons and gourds	Tons (000s)	1000.0	472.0	376.2	550	770	850
Fruit	Tons (000s)	660.4	602.3	547.7	550	850	950
Grape	Tons (000s)	744.7	621.0	511.5	500	850	950
Cattle and poultry (net weight)	Tons (000s)	789.1	853.0	800.7	845	875	930
Milk	Tons (000s)	3034.2	3665.4	3406.1	3710	4155	4680
Eggs	Mln. p	2452.9	1231.8	1075.4	1390	1640	2030

By 2010, production of cereals will increase to 6 million tons, vegetables to 3.5 million tons, melons and gourds to .850 million tons, and meat to .930 million tons. Seed-cotton will continue to occupy an important position in Uzbekistan's agricultural development and export profile, subject to available land and water resources, yield growth, and relevant technical indicators. Seed-cotton cultivation is projected to stabilize at 4 million tons. Foreign trade will be enhanced with exports of vegetables, fruit, melons and gourds, grapes, astrakhan pelt, and other agricultural products.

3.2.3. Transport

State transport policy is targeted at structuring an optimal vehicle fleet, developing a national transport program for the future, designing implementation mechanisms through institutional and market transformations, and developing the legal and organizational framework to regulate the country's transport network. Turnover of goods by all types of transport will increase 1.4-fold, while passenger turnover will increase 1.2-fold between 1997 and 2010 (Table 3.6).

Table 3.6

Development Indicators for the Transport System

Indicator	Units of measure	1990	1995	1997	2000	2005	2010
Turnover of goods by all types of transport (without gas pipelines)	Bln. t/km	62.7	26.61	26.91	28.4	32.9	37.4
Passenger turnover by all types of transport	Bln. pas/km	37.2	22.0	21.0	19.8	22.4	24.8

The design of alternative exits to the World's Oceans, and construction of international transport corridors is planned to boost foreign trade. New, electrified railroads will be constructed, and railroad infrastructure and repair depots will also be developed. Plans for improving automobile repair and retrofitting potential, developing operational and transit services for goods and passengers, constructing new roads and highways subject to international standards, and expanding existing roads will also be realized.

3.3. Energy Sector Development Forecast

Indicators for Uzbekistan's Energy Program, which is currently under development, were used to estimate GHG emissions until 2010. The objective of the Energy Program is to identify and design methods to utilize energy resources more efficiently and increase the productive potential of the Fuel and Energy Complex (FEC). The ultimate goal is to advance Uzbekistan's socioeconomic revival.

The draft of the Energy Program states the following major objectives as the country's main goals for energy policy in the next decade:

- Sustainable delivery of power;
- Maximization of efficiency of fuel and energy utilization and the creation of a favorable economic environment for energy saving;
- Preservation of the country's energy self-reliance;
- Creation of reliable energy basis for the development of fuel extracting and processing industries;
- Preferred use of natural gas in energy saving measures;
- Expanding geological prospecting and exploration;
- Further study of non-fuel energy sources;
- Persistent development of coal industry to ensure step-by-step replacement of gas by coal fuel in the power and thermal supply sector;
- Partial decentralization of power generation systems and use of co-generation;
- Reducing the negative environmental effects of power sector development;
- Further expansion of electrification in all economic sectors with reduced direct utilization of fuel;
- Reducing required fuel and power expenditures as well as transmission and distribution losses;
- Expanding the application of natural gas as a motor fuel and in industrial production, while reducing the overall consumption of gas.

In the forecasts for energy and power sector development—as well as GHG emissions—a sustainable supply of energy was assumed, as well as optimal energy efficiency and fuel utilization in the power sector and households, following the government's energy policy objectives. Forecasting models also allowed for fuel and energy substitutability for some types of sources

The energy sector is a subsystem and major contributor to the national economy. It strives to ensure acceptable living standards for the population and facilitate the stable functioning and development of other sectors of the economy.

. However, in the course of shaping the Energy Program, state actors could approve other energy policy objectives and priorities. Changes in the current strategy for energy sector development could possibly render it necessary to recalculate GHG emission levels from energy sector activities.

Three scenarios were designed to model Uzbekistan's energy demand, energy mix, and energy sector development. The two macroeconomic development scenarios for the next decade, namely, the inertia and mobilizing scenarios, overlap these three energy scenarios

(Section 3.1.1). The forecasts of the energy mix and the development of the energy and power sector were modeled on predictions of future energy demand, which are as follows:

Scenario 1. Demand under the inertia economic development scenario and limited opportunity for most consumers to save energy;

Scenario 2. Demand under the mobilizing scenario with no regard to consumer energy saving measures;

Scenario 3. Demand under the mobilizing scenario and increased production from new oil deposits. Implementation of the energy efficiency measures designed by governmental institutions and individual enterprises.

3.3.1. Energy Consumption

Projected energy demand by sector varies substantially depending on which economic development scenario is employed, due to related effects on GDP growth rates, changes in the inter-sectoral and intra-sectoral structure of goods and services, and the adoption of energy efficiency measures. Table 3.7 forecasts aggregate energy demand until 2010 under each scenario, the third of which assumes remarkable growth in consumption.

Table 3.7

Total Energy Demand (1990 – 2010)
(mln. toe)

1990	1995	Demand scenario	2000	2005	2010
		1	50.3	54.5	58.5
44,9	42,6	2	51.1	57.6	64.3
		3	50.6	53.8	56.2

Table 3.8 forecasts demand for specific fuel types and energy resources. The predominant fuel to be used in the Republic is gas, much as in present time, although its share is slowly declining over time.

Table 3.8

Energy Demand by Type (1990 – 2010)

Energy type	1990	1995	Demand scenario	2000	2005	2010
			1	7.3	7.8	8.5
Oil (mln toe)	12.5	7.0	2	7.27	8.3	10.0
			3	7.2	8.0	8.9
			1	1.05	1.6	2.1
Coal (mln toe)	3.4	1.05	2	1.05	1.5	2.03
			3	1.05	1.5	2.0
			1	41.5	44.6	47.6
Gas (mln toe)	28.6	34.2	2	42.6	47.1	52.0
			3	42.3	44.1	45.0
			1	47.7	54.5	59.4
Electricity	54.2	46.2	2	49.2	60.4	70.1
(bln kW per hour)			3	48.7	57.3	64.1
			1	52.6	54.1	56.1
Thermal energy	58.7	56.5	2	53.3	60.3	67.1
(mln Gcal)			3	53.1	57.8	62.2

Projected energy demand by sector is found in Table 3.9.

Table 3.9

Energy Demand by Economic Sector (1990 – 2010)

Economy sector	1990	1995	Demand scenarios	2000	2005	2010
Energy sector	12.5	10.2	1	11.0	11.3	12.3
			2	11.7	12.7	14.5
			3	11.5	12.2	12.4
Industry	7.3	4.8	1	4.5	4.8	5.1
			2	4.6	5.7	6.5
			3	4.5	5.3	5.8
Construction	0.6	0.3	1	0.3	0.35	0.4
			2	0.3	0.5	0.6
			3	0.3	0.4	0.5
Transport	7.1	3.4	1	3.6	4.1	4.6
			2	3.7	4.4	5.4
			3	3.7	4.2	4.9
Agriculture	3.2	2.4	1	2.3	2.4	2.5
			2	2.7	2.7	3.2
			3	2.3	2.6	2.7
Households	6.4	12.7	1	14.6	16.1	17.5
			2	14.6	16.2	17.8
			3	14.6	14.6	14.8
Municipal and household and other	3.1	5.3	1	5.4	5.7	5.9
			2	5.2	5.6	6.1
			3	5.1	4.8	4.8

According to these projections, the energy sector itself and households will be the largest consumers of power.

3.3.2. Development of the Energy Sector of the Economy

Ministries, governmental agencies and associations have proposed the following energy sector development strategy:

- Further exploitation of open-pit mining of brown coal;
- Development of underground gasification of coal;
- Maintaining production of liquid hydrocarbon at current levels;
- Increasing and stabilizing natural gas production;
- Expansion of hydrocarbon processing;
- Enhancement of product-quality to international standards level;
- Preserving balance in the electric power supply.

Production companies' proposals for the development of coal, oil and gas industries are found in Table 3.10. Table 3.11. lists proposals concerning capacity in the power supply sector.

Plans have been made to finish construction of the Novoangren power plant, finish construction on the first block of the Talimarjan power plant, to begin construction of Tupalan, Pskent and a number of other small hydropower plants. Further construction of the Talimarjan power plant will be steam-to-gas units (SGU).

Table 3.10

Development Variants of Primary Energy Production until 2010

Primary energy type	1990	1995	Demand variants	2000	2005	2010
Coal (mln t)	6.5	3.1	1 2 3	3.2 3.8 3.8	3.2 5.0 5.0	3.2 5.0 5.0
Underground gasification of coal (mln t)	0.6	0.6	1 2 3	0.4 1.4 1.4	0.5 6.8 6.8	0.8 6.8 6.8
Oil and gas condensate (mln t)	2.8	7.6	1 2 3	7.0 7.4 8.1	4.9 5.6 8.1	3.8 4.6 8.5
Crude Oil (mln t)	1.5	5.2	1 2 3	4.0 4.2 4.9	2.4 2.8 5.3	1.5 2.1 6.0
Gas condensate (mln t)	1.3	2.4	1 2 3	3.0 3.2 3.2	2.5 2.8 2.8	2.2 2.5 2.5
Natural gas (bln m^3)	40.8	48.6	1 2 3	55.1 56.3 56.3	54.1 56.4 56.4	54.3 56.4 56.4

Table 3.11

Capacity (in MW) of Energy Demand: Possibilities

Type of installation	1998-2000			2001-2005			2005-2010			_____		
	Variant			Variant			Variant			Variant		
	1	2	3	1	2	3	1	2	3	1	2	3
HPP	119	119	119	395	395	395	82	404	404	596	918	918
TPP	800	800	800	800	800	800	-	-	-	1600	1600	1600
SGU	100	100	100	240	780	2080	540	1230	3680	880	2110	5860
GTU	-	-	-	264	264	264	-	-	-	264	264	264
Total	1019	1019	1019	1699	2239	3539	622	1634	4084	3340	4892	8642

An increase in production of primary types of energy is planned through the exploitation of the Angren coal deposit as well as of the oil and gas deposits in Kashkadarya, Surkhandarya, and Namangan provinces, and in the Republic of Karakalpakstan.

The introduction of gas turbine units and SGU for combined production of thermal and electric power has been suggested at a number of power plants and district boiler houses (the Tashkent power plant, Navoi power plant, Mubarek district heating plant, Bukhara and Kokand boilers) in order to save fuel and energy resources. The introduction of steam-gas and gas turbine units at some large industrial enterprises has also been proposed in order to save resources.

Depending on which path of energy development is supposed, power supply and electricity output might reach up to 73.6 billion kW/h as a whole and thermal energy up to 67.1 mln. Gcal. in 2010 (Table 3.12).

Table 3.12

Development of Production and Delivery of Electric and Thermal Energy

1990	1995	Demand variants	2000	2005	2010
Electricity production, bln kW/h					
		1	48.7	55.5	61.4
56.3	47.5	2	53.2	61.9	73.6
		3	53.2	61.9	68.6
Thermal energy delivery, mln Gcal					
		1	52.6	54.1	56.1
58.7	56.5	2	53.3	60.3	67.1
		3	53.1	57.8	62.2

Implementation of the New Energy Program (to increase capacity) and an increase in the hours of use of existing power plants and boilers will result in production of an additional 82.2 billion kW/h of electricity and deliver about 89.6 mln. Gcal. of thermal energy

4. GHG Emissions Forecast

4.1. Development Possibilities: Main Characteristics

Two scenarios of economic development for Uzbekistan until 2010 (the inertia scenario and the mobilization scenario) are the basis for three possible emissions projection forecasts of the main GHGs, namely: CO_2, CH_4, and N_2O.

The first GHG emissions projection forecast corresponds to the inertia scenario, the second and third emissions projection forecasts to the mobilization scenario. The third emissions projection forecast differs from the second in that the third forecast includes measures to mitigate GHG emissions.

Estimates of GHG emissions were made from four individual sectors of emission sources: “Energy Sector”, “Industry”, “Agriculture”, and “Waste”.

The resulting GHG emissions estimates from these four individual sectors of GHG emissions were consolidated in each of the three possible forecasts. The main indicators of each forecast can be found in Table 4.1.

Table 4.1

The Main Indicators of Development Scenarios to the Year of 2010

Indicators	1990	2000			2010		
		Variant			Variant		
		1	2	3	1	2	3
Population (mln people)	20.5		24.7			28.0	
GDP growth rates (% to 1990)	100.0	97.8	99.6	99.6	116.4	205.1	205.1
GHG emissions (mln. t)	163.2	166.1	170.4	169.2	190.5	209.0	185.6
CO_2 emission (mln. t)	114.6	109.2	112.6	111.5	129.9	145.8	125.8
CH_4 emission (mln. t of CO_2 –eq)	37.7	47.7	48.6	48.5	49.7	52.3	48.9
N_2O emission (mln. t CO_2 -eq)	10.9	9.3	9.3	9.3	10.9	10.9	10.9
GHG emission (000.0 t)/1 bln Soums of GDP	437.6	455.3	459.1	455.8	439.1	273.2	242.6
CO_2 emission (000.0 t)/1 bln Soums of GDP	307.2	299.2	303.2	300.2	299.4	190.6	164.5
GHG emission per capita (t)	8.0	6.7	6.9	6.9	6.8	7.5	6.6
CO_2 emission per capita (t)	5.6	4.4	4.6	4.5	4.6	5.2	4.5

Under the assumed calculations of probable GHG emissions, Variant 3 is the most optimal. Under this variant, GHG emissions could exceed 1990 levels by 13.7%. However, emissions per unit of GDP would be reduced by 44.6% as compared to 1990, and per capita emissions would drop by 46.4%.

Calculations show that, by the year 2010, it will not be possible to reduce GHG emissions levels to 1990 levels, even if all planned GHG mitigation measures are implemented. In order to reduce GHG emissions levels to those of 1990, additional mitigation measures will be necessary.

Below are the results of the GHG emissions forecast both by sector and in the aggregate.

4.2. Emission Forecast by Sector

4.2.1. Energy Sector

Table 4.2 shows GHG emissions projections until the year 2010 and rates of change in comparison with 1990 for the Energy Sector. Growth in fuel production and consumption subsequently would result in GHG emissions growth; GHG emissions in 2000 would exceed 1990 levels under all variants of development (Figure 4.1).

Table 4.2

Energy Sector: GHG Emission Projections until the Year 2010 (mln t CO_2 /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	135.7	100.0	**2000**	141.0	103.9	145.4	107.1	144.1	106.2
1994	127.9	94.2	**2005**	151.0	111.2	160.8	118.5	151.6	111.7
1995	129.0	95.0	**2010**	162.4	119.6	179.8	132.5	158.3	116.6

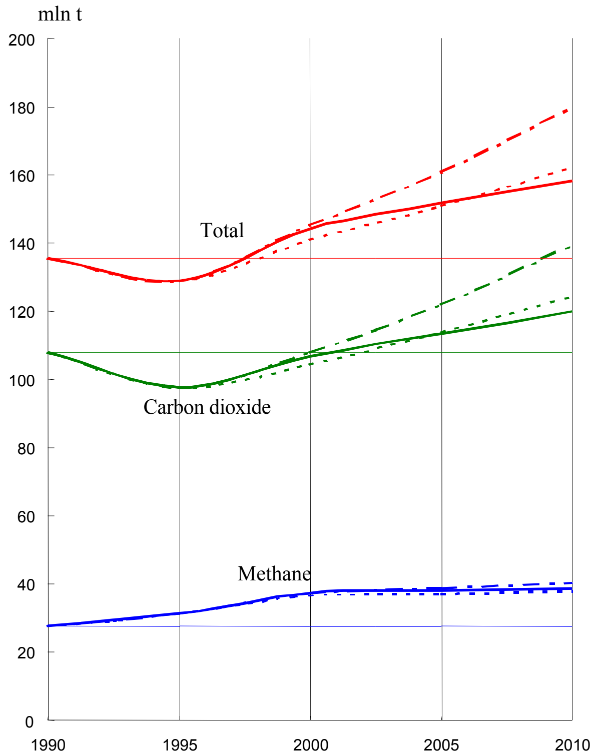


Fig. 4.1. Energy Sector: Forecast of GHG emissions until 2010

variant 1 variant 2 variant 3

Depending on which emissions projection forecast is considered, emissions of the main GHGs could grow in comparison with 1990 by 32.5% and reach 179.8 mln. t (under the second variant of energy sector development shown below). Under the best possible emissions projection forecast (the third one), the total emissions would account for 158.3 mln. t, 16.6% higher than in 1990.

The dynamics of GHG emissions in the Energy Sector are dependent on the dynamics of carbon dioxide and methane emissions. As methane emissions are directly connected to the production and consumption of fuel, it is assumed that there will be further growth of methane emissions in comparison to 1990 levels (from 38.1 mln. t up to 40.4 mln. t, or from 37.0% to 45.2%) under all variants of development. In other words, methane emissions are expected to grow by 1.8-1.9 mln. t. in absolute numbers.

The main sources of methane emissions will continue to be the gas supply system of Uzbekistan, which accounts for 99.0% of all CH_4 emissions.

Carbon dioxide emissions are expected to grow, too, exceeding 1990 levels only after the year 2000 (Fig. 4.1).

The total increase in carbon dioxide emissions is due to fuel combustion. By 2010, under the third variant of development, carbon dioxide emissions might account for 116.4 mln. t, which is 11.9% higher than 1990 levels. The energy sector, municipal and household sectors, and the transport sector are expected to remain the main sources of CO_2 emission.

Calculations show that under all three GHG emissions projection forecasts, CO_2 emissions resulting from the use of fuel resources and non-fuel materials such as raw materials will be lower than in 1990 and will not exceed 3.4 mln. t.

In the Energy sector, it is expected that carbon dioxide will continue to make up the majority of GHG until 2010 and emissions from natural gas will account for the majority of CO_2 emissions, yet a smaller share than they currently do. Emissions from the use of solid and liquid fuels are expected to significantly increase compared to current levels, but not reach 1990 levels.

As the result of mitigation measures, the total GHG emissions reduction in CO_2 –equivalent, as shown in the third variant, is equal to 9.2 mln. t in the year 2005, and 21.5 mln. t in the year 2010.

4.2.2. Industrial Processes

Forecast GHG emissions and rates of change compared to 1990 under the Industrial Processes Sector are found in Table 4.3.

Table 4.3

Industrial Processes: GHG Emission Projections until the Year 2010 (mln t CO_2 /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	6.9	100.0	**2000**	4.8	68.8	4.8	68.8	4.8	68.8
1994	5.0	72.3	**2005**	5.2	74.5	5.7	82.6	5.6	81.3
1995	4.0	57.3	**2010**	5.7	82.2	6.4	92.1	6.1	88.3

The inventory and emission forecast data under this sector and their comparison with the dynamics of GHG emissions under the other sectors show that, because of a significant reduction in the production of chemical and mineral products and changes in the structure of industrial production, the Industrial Processes Sector accounts for the largest reduction of GHG emissions. Emissions levels under this sector are not expected to exceeded 1990 levels by the year of 2010 under any of the development scenarios.

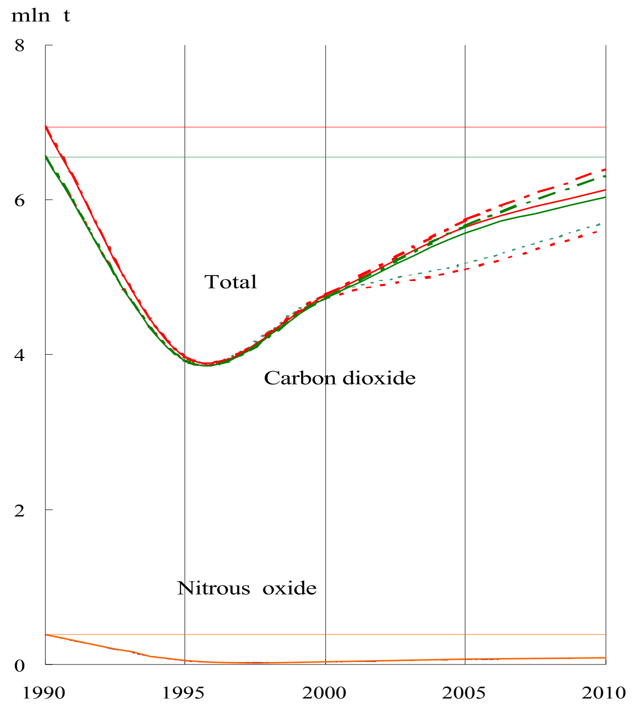


Fig. 4.2. Industrial Processes: GHG emissions projections until 2010.
variant 1, variant 2, variant 3.

Under the Industrial Sector, the processes which are connected to production of mineral and chemical products are expected to remain the main sources of GHG emissions, with carbon dioxide remaining the main component of GHG emissions and accounting for 98.0-99.0% of emissions under this sector in 2010 (Fig. 4.2).

Regardless of the forecasted growth of the production of cement and some types of chemical products, CO_2 emissions are expected to continue to grow but not exceed 1990 levels by 2010.

As a result of GHG mitigation measures under Variant 3, total GHG emissions reduction are expected to equal 0.1 mln. t in 2005 and 0.3 mln. t in 2010.

4.2.3. Agriculture

In this sector, soils used in agriculture and domestic animals are the main sources of GHG emissions until 2010. Forecasts of GHG emissions levels and their rates of change compared with 1990 are as follows:

Table 4.4

Agriculture: GHG Emissions Projections for the Period until 2010 (mln t CO_2 /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	17.4	100.0	**2000**	16.9	97.0	16.9	97.0	16.9	97.0
1994	18.0	103.6	**2005**	17.9	102.9	18.0	103.2	17.2	98.8
1995	17.0	97.8	**2010**	18.6	107.0	18.9	108.7	17.3	99.5

An increase of cattle and poultry, probable development of new lands into agricultural production and an increase in rice production during the period to 2010 will result in an insignificant growth in GHG emissions in this sector.

The total GHG emissions in this sector are expected to exceed 1990 levels somewhere between 2000-2005 under the first two development scenarios.

Under Variant 3 (which assumes the implementation of some mitigation measures) the total GHG emissions in the Agriculture sector will approach 1990 levels in 2010, regardless of some expected increases of nitrous oxides.

Depending on the development scenario under consideration, GHG emissions could reach 18.9 mln. t. of CO_2 –equivalent (Variant 2), which would be 8.7% higher than 1990 levels. Under the most optimal variant of development (Variant 3, which assumes some mitigation measures), total GHG emissions levels are expected to equal 17.3 mln. t., that is, be 0.5 % lower than 1990 levels .

In absolute numbers, methane emissions are expected to total to 0.36-0.39 mln.t., and nitrous oxide around 30.0-35.0 mln. t.

During the period until 2010 some increase of nitrous oxide in total GHG emissions is expected under the Agricultural Sector: from 54.8% in 1995 up to 62.3% in 2010 under Variant 3.

The total volume of GHG emissions reduction in CO_2 –equivalent due to the mitigation measures under Variant 3 is expected to account for 0.8 mln. t. in 2005, and 1.6 mln. t. in 2010.

4.2.4. Wastes

The GHG emission volumes and their rates of change as compared to 1990 under the Waste Sector are found in Table 4.5 (methane emissions are taken into account in this category).

Table 4.5

Waste: GHG Emissions Projections for the Period until 2010 (mln t CO_2 /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	3.1	100.0	**2000**	3.4	110.1	3.4	110.1	3.4	110.1
1994	3.3	104.2	**2005**	3.6	115.9	3.6	115.9	3.6	115.9
1995	3.3	104.9	**2010**	3.8	121.6	3.8	121.8	3.8	121.8

As solid waste land fills and household wastewater are the main sources of GHG emission under this category, growth of methane emissions are forecasted at the same rate as population growth.

Development and implementation of measures to reduce methane emissions will result in a reduction of the rates of GHG emissions growth under the Waste sector.

4.3. Combined Scenarios of GHG Emissions

The forecast of GHG emissions levels and their rates of change as compared to 1990 are found in Table 4.6.

Table 4.6

GHG Emissions Projections for the Period until 2010 (Mt CO_2 /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	163.2	100.0	**2000**	166.1	101.8	170.4	104.4	169.2	103.7
1994	154.2	94.5	**2005**	177.6	108.8	188.1	115.3	178.1	109.1
1995	153.2	93.9	**2010**	190.5	116.7	209.0	128.0	185.6	113.7

As the table and Figure 4.3 illustrates, total GHG emissions are expected to exceed the 1990-year level by the year 2000 regardless of the implementation of a number of GHG mitigation measures.

By the year 2010, the volume of GHG emissions might reach 209.0 mln. t. (Variant 2), which is 28% higher than in 1990. Implementation of the suggested mitigation measures would make it possible to minimize GHG emissions, reducing them to a level of 185.6 mln. t. in 2010 (Variant 3). However, even in this case, emissions levels would still be significantly higher than 1990 levels (by 13.7%).

As a result of mitigation measures, the total amount of GHG emissions reductions in CO_2 –equivalent under Variant 3 would equal 10.0 mln. t. in 2005 and 23.4 mln. t. in 2010, as compared to Variant 2 levels.

During the period until 2010, the structure of GHG emissions by types of greenhouse gases will not change significantly. Carbon dioxide is expected to make up the majority of GHG emissions (depending on the development scenario considered CO_2 will make up 65.0-70.0% of total GHG emissions) and methane will account for 29.0-25.0% of total GHG emissions. Nitrous oxide will account for the remainder of GHG emission (5.0-6.0%).

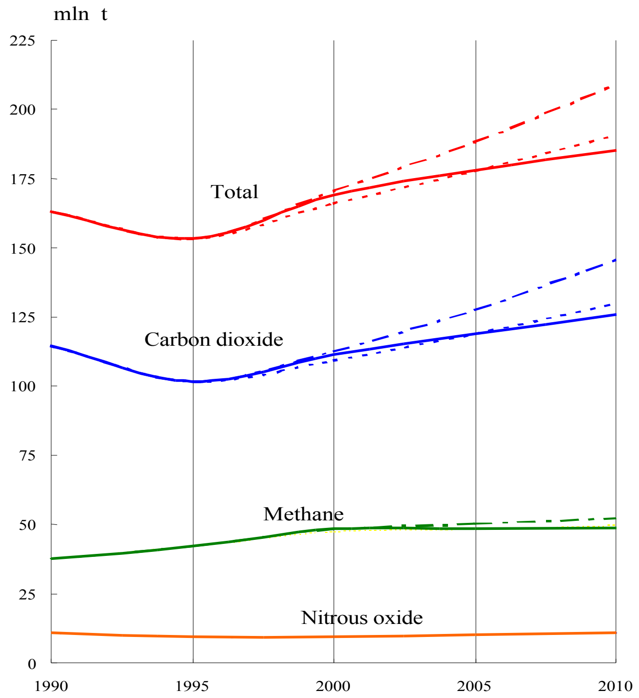


Fig. 4.3. Forecast of GHG emissions for the period until 2010.
.... Variant 1, — . — variant 2, —— variant 3.

The 1990 carbon dioxide emissions level will be exceeded within the 2000-2005-year period. 1990 methane emissions levels were exceeded in the beginning of 1990's and continue to grow. Nitrous oxide emissions are expected to come close to 1990 levels sometime after 2010 (Fig. 4.3).

The combined projection of GHG emissions has shown that the main sources of GHG emission are expected to remain those which are connected with production, processing, and the use of fuel, that is the sources that fall under the Energy Sector, until 2010 (Fig. 4.4). This sector accounts for 83.2-85.2% of total GHG emissions.

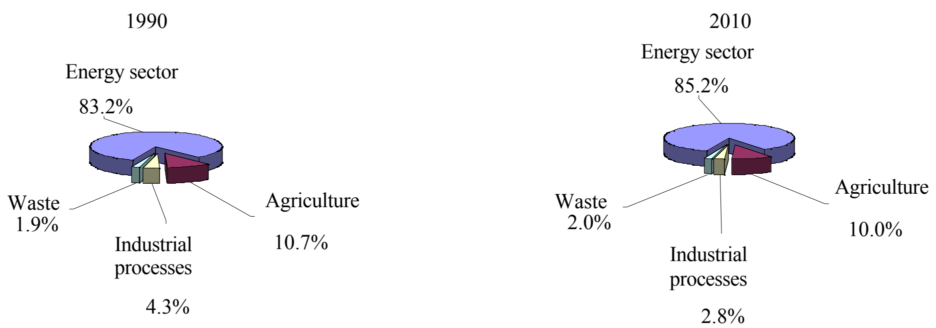


Fig. 4.4 GHG emissions by sectors

The Agriculture Sector is not expected to exceed 10.0% of total GHG emissions, and the Industrial and Waste Sectors are expected to account for almost 5% of total GHG emissions combined.

The total emissions of carbon dioxide and methane under all sectors of emission sources are shown in Tables 4.7 and 4.8.

Calculations demonstrate that the level of CO_2 emissions in 1990 will be exceeded by the year 2005 under any development variant, and current methane emissions levels have already exceeded 1990 levels and are expected to continue to grow through the period until the year 2010.

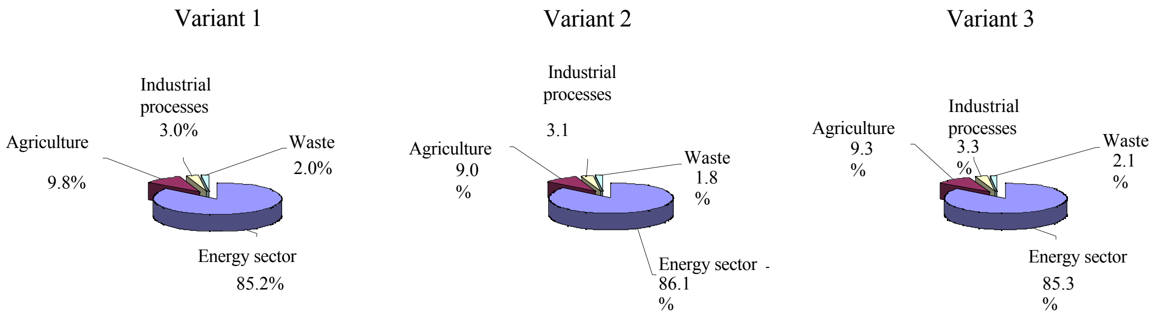


Fig. 4.5 The structure of GHG emissions by sector of sources in 2010

The Energy sector is expected to remain the main source of carbon dioxide emissions (Fig. 4.5) and the dynamics of emission under this sector will determine the dynamics of total CO_2 emissions. CO_2 emissions levels under the Industrial Sector are expected to be lower in 2010 than 1990 levels.

Table 4.7

CO_2 Emission Projections for the Period until 2010

(Mt __$_2$ equiv. /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	114.6	100.0	**2000**	109.2	95.3	112.6	98.3	111.5	97.3
1994	102.2	89.2	**2005**	118.9	103.8	127.6	111.4	119.1	104.0
1995	101.6	88.7	**2010**	129.9	113.4	145.8	127.3	125.8	109.8

Table 4.8

Methane Emission Projections for the Period until 2010

(Mt CO_2 - equiv. /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	% to 1990		Emission	% to 1990	Emission	% to 1990	Emission	% to 1990
1990	37.7	100.0	**2000**	47.7	126.3	48.6	128.7	48.5	128.5
1994	41.8	110.8	**2005**	48.5	128.4	50.3	133.3	48.8	129.2
1995	42.3	112.1	**2010**	49.7	131.7	52.3	138.5	48.9	129.4

In 2010, the maximum level of carbon dioxide emissions, (estimate 145.8 mln. t.), is expected under Variant 2. Implementation of the planned GHG mitigation measures would make it possible to reduce CO_2 emissions down to 125.8 mln. t.. This level is, however, higher than in 1990 levels by 9.8% (Fig. 4.6).

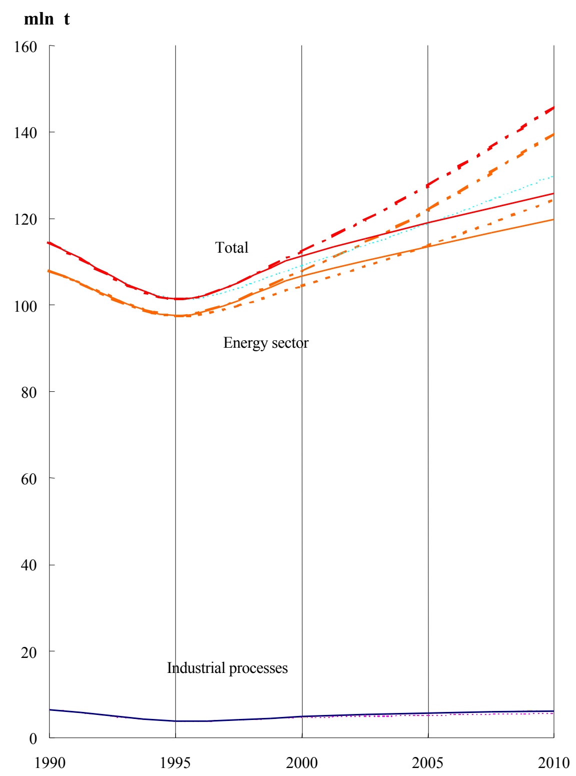


Fig. 4.6. Projections of carbon dioxide emissions
······· Variant 1, — · — variant 2, —— variant 3.

Methane emission growth is expected in nearly all sectors (Fig. 4.7). In order to stabilize methane emissions at their present levels, development and implementation of many mitigation measures, especially in the oil and gas sectors (which are the main source of this emission) would be required.

Table 4.9

Nitrous Oxide Emission Projections for the Period until 2010 (Mt CO_2 equiv. /year)

Year	Actual		Year	Variant 1		Variant 2		Variant 3	
	Emission	%		Emission	%	Emission	%	Emission	%
1990	10.9	100.0	**2000**	9.3	85.2	9.3	85.2	9.3	85.2
1994	10.2	93.5	**2005**	10.2	94.0	10.2	94.0	10.2	94.0
1995	9.4	86.0	**2010**	10.9	99.8	10.9	99.8	10.9	99.8

Total nitrous oxide emissions under all sectors are shown in Table 4.9. The table and Figure 4.8 demonstrate that this type of GHG emission is expected to decrease until the year 2000, then it is expected to increase slightly and reach the 1990-year level in 2010.

N_2O emissions under the Agriculture sector make up the majority of N_2O emissions. The impact of industrial processes on total N_2O emissions will be minimal, and significant growth of N_2O under the Industrial Processes Sector is not expected until the year 2010.

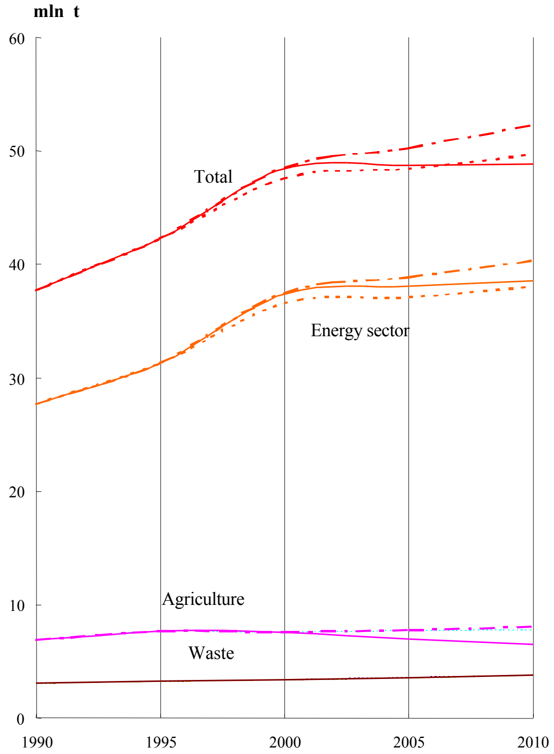


Fig. 4.7. Methane emission forecast until 2010.

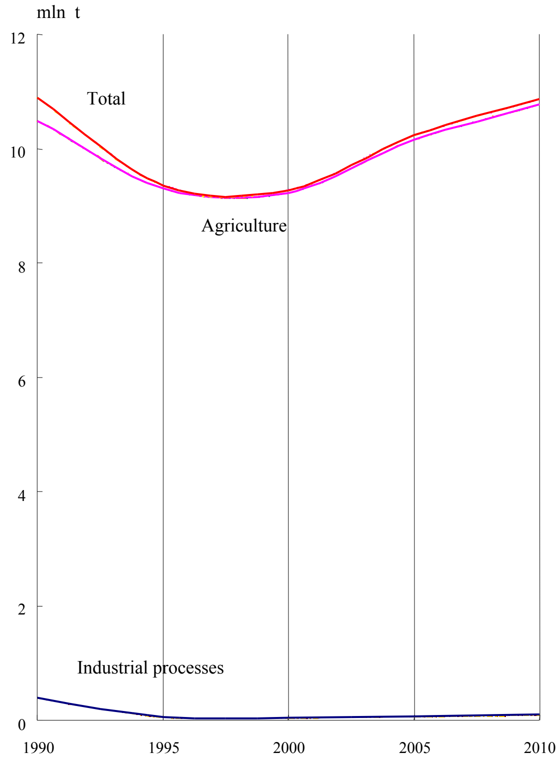


Fig. 4.8. Nitrous oxide emission forecast until 2010

······· Variant 1, — · — variant 2, ——— variant 3. ······· Vaariant 1, — · — variant 2, ——— variant 3.

In order to preserve N_2O emissions at the present level, it is necessary for agricultural enterprises and agencies to develop and implement respective mitigation measures.

5. Potential Evaluation and Measures to Reduce GHG Emissions

At present, after several years of economic recession, evident growth of economic activity and growth of the Gross Domestic Product can be seen in Uzbekistan. Economic forecasts presume further economic growth of GDP production in the period until 2010 with increased use of raw materials and fuel-energy resources and, consequently, lead to growth of GHG Emissions. Under such conditions it will be impossible to stabilize GHG emission at a certain level without development of a complex of mitigation of measures.

Research has shown that the most optimal measures to reduce GHG emissions include the introduction of modern technologies of production and machinery in the Energy Sector, Industry and Agriculture Sectors, increases in efficiency of agricultural production, reduction of losses and increases in the effectiveness of the use of raw materials and fuel-energy resources in all economic sectors, introduction of new, energy efficient technology, improvement of the energy structure of the country, and further development of renewable sources of energy.

The Energy Sector has the highest possible potential of GHG reduction of all the sectors. Calculations demonstrate that the (theoretical) potential of, say, CO_2 reduction due to energy saving might account for almost 75.0 mln. t. (estimated by means of comparison of power consumption of GDP of Uzbekistan with analogous countries or groups of countries).

However, it is unlikely that this potential reduction will be realized in full because it would be necessary to replace not only all the machinery and technology in present use, but to radically change the economic structure, the mentality of energy consumers, and climatic and natural conditions in the country.

That is why the technical potential to reduce CO_2 emissions, which is correlated to the energy saving potential to be realized if investments are to be made, is calculated to be 25 mln. t. This is the CO_2 reduction level assumed in the Energy Program of the republic for the period until 2010.

Other sectors of GHG emission sources have less GHG mitigation potential. Local experts estimate that the total technical potential to mitigate GHG emissions under the Industrial Processes, Agriculture, and Waste Sectors would account for 2.2 mln. t. in CO_2 –equivalent (Table 5.1).

Table 5.1

Technical Potential of GHG Emission Reduction by Sector of Sources
(mln. t in __$_2$-equivalent)

Source of emission	Potential of emission reduction	Emission Reduction through measures under development
Energy sector	25.0	17.1
Industrial Processes	1.5	0.3
Agriculture	0.4	-
Waste	0.3	-
Total	***27.2***	***17.4***

The development of renewable and non-fossil energy sources is an important way to reduce GHG emissions. Renewable and non-fossil energy sources have an over all energy potential estimated to be almost 6.8 mln. tons in oil equivalent for Uzbekistan. The technical potential of renewable and non-fossil fuels is estimated to be 179.0 mln. tons in oil-equivalent , of which 0.6 mln. tons in oil-equivalent or 0.33% (Table 5.2) is already currently in use.

Table 5.2

Potential of Energy Sources

Indicator	Total	Energy			
		Hydraulic	Solar	Wind	Geothermal
Gross potential (mln. toe)	6750984.6	9.2	50973.0	2.2	6700000.2
Technical potential	179.0	1.8	176.8	0.4	no estimates
In use	0.6	0.6	0.0		
Potential of CO_2 – emissions (mln. t)	447.5	4.5	442.0	1.0	0
In use	1.5	1.5	0	0	0

If the technical potential of renewable energy sources is realized in full, it would be possible to use renewable energy as a substitute for fossil fuel, the combustion of which generates 447.5 mln. t of CO_2 - emissions.

Under contemporary conditions in Uzbekistan, however, it would be very difficult to realize this renewable energy potential in full due to the current low level of technology and equipment for transforming and using renewable energy sources, the high cost of renewable energy generation and because of a lack of reliable information on the environmental impacts of traditional energy use vs. use of renewable energy sources. A rough estimate shows that the use of renewable sources of energy might result in a 1.3 mln. t. CO_2 –equivalent emissions reduction, maximum.

There is another way to reduce GHG emissions, and that is to improve the structure of the energy structure of the country, through utilization of fuels that emit less GHG.

However, under the particular conditions of contemporary Uzbekistan, it is difficult to realize this opportunity because of the existing energy balance, where the share of natural gas use, which is a fuel with lower CO_2 emissions, already exceeds 80.0%. Estimates show that, regardless of an expected increase in gas use in some sectors, overall, there will be a slight decrease in gas use in the future, and consequently, GHG emissions will be increased on the whole in the republic.

As noted, the Energy Sector has the highest potential for GHG mitigation, and mitigation measures in this sector should be the center of efforts to reduce of GHG emissions.

5.1. Energy Sector

Suggested GHG mitigation measures from power generation have focused on energy saving measures. These measures were prepared by ministries and governmental agencies for the development of “The Energy Program of Uzbekistan for the Period until 2010”. A specific feature of the majority of the suggested measures is that they have been designed as part of an over-all development program of this or that enterprise or sector, and CO_2 emission resulting from these measures are seen as an auxiliary benefit.

Documents on power supply demonstrate that the energy saving potential under this sector likely to be realized for the period until the year 2010 is around 10.0 mln. tons energy equivalent (7.0 tons oil equivalent energy), resulting in CO_2 emissions reductions of about 17.1 mln. t.

The fuel-energy complex, municipal housing, enterprises of chemical industry, building materials industry, agriculture, non-ferrous and ferrous metallurgy (Table 5.3) have the largest potential for energy-saving, and, consequently, of GHG emission reduction.

Table 5.3

Potential of Energy-Saving and Reduction of CO_2 Emissions

Sectors of national economy	Potential		Investments required	Specific costs* for	
	Energy saving	CO_2 emissions		Energy saving	CO_2 emissions
	000.0 toe	000.0 t	($ Mln.)	$000.0 /toe	$000.0/t
Total for national economy	***6903.6***	***17090.4***	***9953.6***	***1.4***	***0.6***
Industry and Construction ***– total***	***3158.6***	***7727.9***	***2937.5***	***0.9***	***0.4***
Power sector	1005.7	2460.6	787.5	0.8	0.3
Fuel industry	558.1	1395.1	969.1	1.7	0.7
Ferrous metallurgy	96.7	241.8	16.0	0.2	0.1
Nonferrous metallurgy	94.1	235.3	259.3	2.8	1.1
Chemical and petrochemical industry	297.3	688.4	171.8	0.6	0.2
Building materials industry	1071.8	2619.5	713.0	0.7	0.3
Light industry	14.9	37.2	9.7	0.7	0.3
Food industry	20.0	50.0	11.1	0.6	0.2
Agriculture	***1213.0***	***3032.5***	***1195.0***	***1.0***	***0.4***
Transport-total	***300.0***	***750.0***	***4464.0***	***14.9***	***6.0***
Road	150.0	375.0	2000.0	13.3	5.3
Railroad	100.0	250.0	1464.0	14.6	5.9
Air transport	50.0	125.0	1000.0	20.0	8.0
Municipal-household sector	***1632.0***	***4080.0***	***637.1***	***0.4***	***0.2***
Renewable energy sources	***600.0***	***1500.0***	***720.0***	***1.2***	***0.5***

*Ratio of capital investments required to the energy-saving potential and emissions per year.

The guidelines of energy saving potential are as follows:

- to improve the technology of industrial production;
- to improve use and structure of production equipment;
- to develop combined production of electric and thermal energy on the basis of steam-to-gas and gas turbine units;
- to install meters for natural gas, thermal power and water at all stages of flow of those resources;
- to reduce losses and improve technologies of fuel and energy use;
- to improve fuel quality;
- to improve the quality of raw materials and use less energy intensive types of raw materials extraction;
- to improve the technical capacities of internal combustion engines;
- to enhance the structure of the road vehicle fleet of the country, develop urban public transport;
- to reduce the level of industrial waste and to increase the level of waste utilization in production processes;
- to introduce thermostats (temperature regulation systems) in apartment buildings;
- to electrify railroads and machine irrigation pumping plants;

- to develop electric urban transport;
- to introduce more strict building standards and rules aimed at improvement of thermo-technical properties of dwellings and public buildings;
- to apply strict standards of energy efficiency to automobiles, domestic appliances and light;
- to enhance the level of awareness of people about energy-saving, efficient technologies and devices and so on.

Table 5.4

Preliminary List of Measures for Reduction of CO_2 Emissions Under the Energy Sector

Measure	Volume of energy-saving (000.0 toe).	Volume of CO_2 emission reduction (000.0 t)	Investments required ($ mln.)
Electric power supply			
Upgrading 2 power units of 300 MW each at the Syrdarya Power Plant (credit of EBRD)	65.0	163.0	27.8
Upgrading the Tashkent Power Plant through installation of a 370 MW steam-to-gas unit (credit application submitted)	316.0	790.0	221.0
Upgrading of Navoi Power Plant through installation of a 200 MW steam-to-gas unit (financial study under development with Mitsubishi)	112.0	280.0	120.0
Upgrading Mubarekski District Heating Plant through installation of a 240 MW steam-to-gas unit (financial study under development with ABB)	56.0	140.0	60.0
Installation of a 240 MW stem-to-gas unit in Novoangren Power Plant (financial study is under development with Mitsui)	164.0	410.0	150.0
Installation of gas-turbine unit at Fergana Thermal Power Plant (2x60 MW)	102.0	236.3	48.0
Installation of gas-turbine unit at Tashkent Heating Plant (2x16 MW)	27.6	63.8	12.8
Installation of gas-turbine unit at Kokand Heating Plant (2x16 MW)	13.8	31.9	6.4
Installation of gas-turbine unit at Fergana Heating Plant (16 MW)	6.9	16.0	3.2
Installation of gas-turbine unit at Urgench Heating Plant (2x16 MW)	13.8	31.9	6.4
Construction of a 240 MW steam-to-gas unit in Bukharenergomarkaz	128.6	297.7	131.9
Total	***1005.7***	***2460.6***	***787.5***
Oil and Gas Industry			
Organizational and technical measures to improve technical conditions of power generation equipment and enhance technology of production in enterprises of the sector	234.9	587.3	2.8
Upgrading of active enterprises of “Uzneftegazdobycha”	43.5	108.7	131.6
Upgrading of the active facilities of “Uztransgaz”	239.1	597.7	611.5
Upgrading of energy efficiency and heating systems at oil refineries	2.9	7.2	4.1
Installation of equipment of energy consumption systems with metering and control devices at the "Uzbekneftegas"	3.3	8.2	0.1
Total	***523.7***	***1309.1***	***750.1***

Table 5.4

Preliminary List of Measures for Reduction of CO_2 Emissions Under the Energy Sector

Measure	Volume of energy-saving (000.0 toe).	Volume of CO_2 emission reduction (000.0 t)	Investments required ($ mln.)
Fuel industry (coal)			
Technological upgrade of the Angren block	34.4	86.0	219.0
Total	***34.4***	***86.0***	***219.0***
Ferrous Metallurgy			
Organizational and technical measures to improve technical conditions of power equipment and enhance technology of construction work at the enterprises of the sector	43.3	108.3	0.8
Installation of equipment of energy consumption systems with metering and control devices	6.9	17.2	0.6
Upgrading of the active fleet of technological aggregates, machinery and equipment of the enterprises of construction sector	14.7	36.8	1.7
Upgrading and technical re-equipment of the active enterprises of construction sector	31.8	79.5	12.9
Total	***96.7***	***241.8***	***16.0***
Non ferrous Metallurgy			
Reconstruction and upgrading of the Kalmakyr refinery	3.1	7.8	132.0
Completing technology upgrade of bronze ore at the Almalyk Integrated Works	60.0	150.0	116.0
Reconstruction of metallurgy department at the Almalyk Integrated works	31.0	77.5	11.3
Total	***94.1***	***235.3***	***259.3***
Chemical			
Upgrading an the energy system at Navoyi fertilizer Production company	204.0	472.3	140.6
Upgrading an the energy system at Cherchik Production Company named "Electrokhimprom"	29.4	68.1	4.2
Reconstruction of furnaces for granulator-driers at Samerkand Chemical factory and Almalyk Production company named "Ammophos"	63.9	148.0	27.0
Total	***297.3***	***688.4***	***171.8***
Building and Industrial building Materials Sector			
Upgrading and modernization of equipment at the Uzstroimaterial company	982.0	2455.0	600.0
Modernization of equipment throughout the industrial building materials sector	38.5	36.3	28.8
Installation of equipment to measure energy use in the industrial building materials sector	9.0	22.5	3.6

Table 5.4

Preliminary List of Measures for Reduction of CO_2 Emissions Under the Energy Sector

Measure	Volume of energy-saving (000.0 toe).	Volume of CO_2 emission reduction (000.0 t)	Investments required ($ mln.)
Modernization of acting technological units, machines and equipment of construction sector factories	6.2	15.5	57.1
Reconstruction and upgrading of the industrial building materials sector	11.1	27.7	21.4
Development of non-traditional and renewable energy sources at the enterprises of the sector	25.0	62.5	2.1
Total	***1071.8***	***2619.5***	***13.0***
Cotton Ginning Industry			
Organizational and technical measures aimed at improvement of technical conditions of power generation machinery and enhancement of production technologies in the enterprises of the sector	14.9	37.2	9.7
Total	***14.9***	***37.2***	***9.7***
Butter-Oil Production			
Organizational and technical measures aimed at improvement of technical conditions of power generation machinery and enhancement of production technologies in the enterprises of the sector	10.0	25.0	0.1
Upgrading and replacement of technological equipment in the enterprises of the sector	10.0	25.0	11.0
Total	***20.0***	***50.0***	***11.1***
Agriculture			
Replacement of Diesel pumping plants by electric drive	413.0	1032.5	120.2
Rationalization of energy-saving of irrigation systems and reduction of irrigation water losses	200.0	500.0	2.5
Replacement of out-of-date machinery by qualitatively new machinery	300.0	750.0	1000.0
Introduction of metering and control systems of consumption of energy resources and water	300.0	750.0	72.3
Total	***1213.0***	***3032.5***	***1195.0***
Transport			
Complex of measures aimed at reduction of energy intensive characteristics of vehicles, enhancement of the structure of transportation and energy consumption at:			
Road transport	150.0	375.0	2000.0
Railroad transport	100.0	250.0	1464.0
Air transport	50.0	125.0	1000.0
Total	***300.0***	***750.0***	***4464.0***

Table 5.4

Preliminary List of Measures for Reduction of CO_2 Emissions Under the Energy Sector

Measure	Volume of energy-saving (000.0 toe).	Volume of CO_2 emission reduction (000.0 t)	Investments required ($ mln.)
Municipal and household sector			
Upgrading of small capacity boilers	132.0	330.0	331.1
Installation of gas meters with consumers	1425.0	3562.5	261.0
Waste incinerating plant for Tashkent	75.0	187.5	45.0
Total	***1632.0***	***4080.0***	***637.1***
Renewable sources of energy			
Small capacity hydro-power plants	360.0	900.0	300.0
Pskent hydro-power plant	240.0	600.0	420.0
Total	***600.0***	***1500.0***	***720.0***

The list of above measures could provide a basis for the development of particular GHG emission mitigation projects in diverse sectors of economy in the nearest future.

Currently, there aren't any specific activities being conducted in the Energy sector to reduce methane emissions. However, estimations show that methane emissions could be reduced down to a level of 20.0 mln. t in CO_2 –equivalent if the necessary measures are implemented in the oil and gas sector.

5.2. Industrial Processes

Of the total potential of GHG emission reductions under the Industrial Processes Sector, at present plans have not been made to realize this potential. Part of this potential (estimated to be equal to 0.27 mln. t.) might be captured through the implementation of specific measures (reduction of ammonia and carbonic acid for production of nitrate, ammonia saltpeter, and so on) (Table 5.5).

Table 5.5

The Preliminary List of Measures to Reduce CO_2 Emissions Industrial Processes Sector

Measures	Reduction of CO_2 emission (000.0 t)	Investments required ($ mln.)
To finish construction of the aggregates for production of weak nitric acid and ammonia saltpeter At Fergana PO "Azot"	58.0	8.8
Upgrading of nitrate producing shop in Chirchik PO "Elektrohimprom"	30.0	20.0
Updating technology of nitrate producing aggregate at the Fergana PO "Azot"	40.0	30.0
Transfer of the first shift of ammonia production of PO Navoiazot for production of methanol	140.0	2.5
Total	***268.0***	***61.3***

The main objective of the chemical industry in their future development is to improve production equipment and reduce power-consuming production. GHG emissions reductions resulting from these measures are considered an auxiliary benefit. Implementing these measures will reduce the consumption of natural gas and electricity by approximately 145.0 mln. tons of energy equivalent per year and, respectively, will reduce carbon dioxide emissions by 230.0 thousand tons republic-wide. This volume of reduction is taken into account in the Energy Sector.

At the present time, specific measures to reduce GHG emissions in the metal, mineral and food products production sectors are not in place, except for those which are related to fuel combustion and included into the Energy Sector.

Because the level of carbon dioxide emissions in these sectors mainly depends on the composition of primary raw materials and only to a lesser degree on the conditions of production equipment, main efforts to reduce GHG emissions should be focused on searching for new technologies, improving the quality of the primary raw materials and cutting a wide variety of other losses.

5.3. Agriculture

The main areas of potential GHG emissions reduction in the Agriculture Sector are increasing productivity of agricultural production and introducing progressive technologies of production into plant-growing and cattle-breeding. In the Waste Sector, potential GHG emissions reduction measures include **improving systems of collection, processing and the utilization of solid waste and wastewater**.

At present, specific GHG reduction measures have not been developed for these two sectors, however, the following estimates on potential GHG emissions reductions measures have been made:

· Change in the technology of rice growing would help in reducing methane emissions by 8.0-14.0% per product unit;

· A complex of measures to increase cattle-breeding productivity and optimize livestock would reduce methane emissions down to 20.0% per product unit;

· Incineration of cattle manure would reduce methane by 70.0-80.0%;

· Application of reasonable amounts of fertilizers with due regard of soil and plants as well as water regimes could be one more effective measure to reduce GHG emissions;

· Implementation of a complex of measures to increase crop yield would also reduce specific emissions.

5.4 Forestry

Forests are natural long-term absorbers of carbon dioxide. There is a relationship between forestry development level and volume of __$_2$ sinks.

The main potential of increase in sinks lies in utilization of lands available in the State Forest Fund, on which aforestation is possible. This type of land includes slashes, felling areas and glades.

Extending the areas covered with forests on the country's territory and increasing the productivity of the existing and planned wood can result in the growth of __$_2$ sinks. The selection of long-term wood species assortment is also taken into account.

The technical potential of the Uzbekistan's sinks is estimated at 2.53 million ton per year. It comprises the volume formed in the result of aforestation on the lands of State Forest Fund (0.58 mln t/y) and potential depositing of carbon dioxide with protective forestation on agricultural areas (1.95 mln t/y).

6. Climate System Research

6.1. Data Collection of Systematic Monitoring, Data Base

Meteorological studies have been carried out on the territory of Uzbekistan for more than a century; hydrologic studies have been made since 1896. Systematic surveys of the level of the Aral Sea have been conducted from 1911. At the present time the meteorological monitoring network consists of 87 meteorological stations, 94 posts and 120 hydrologic stations. Monitoring of the conditions of agricultural crops and pasture vegetation are conducted at more than 100 points. Some 18 stations are included into the Global Monitoring System, 3 – into the Global System of Climate Monitoring.

Satellite systems are used to monitor and study weather and climate. Technologies of satellite data processing have been developed.

Glavgidromet monitors all large water facilities: the Syrdarya River, the Amudarya River and their tributes, large reservoirs. There are observation posts located at small streams and in upper watersheds. However, the current monitoring network does not meet the requirement of the World Climate Program (WCO). Insufficient funding has resulted in a reduction of the number of monitoring posts and makes upkeep of equipment at the stations difficult. There are no automatic meteorological stations.

Current hydro-meteorological information in Uzbekistan is to a large extent kept in the form of tables, books and journals. Development of databases and data banks on climatic data is extremely necessary to make this information more accessible to a broader circle of users and to make access to climate data more user-friendly. The main databases are as follows: "Meteorology", "Hydrology", "Aerology", "Glaciers", Snow Cover in Mountains", "Air Pollution" and "Hydrochemistry". However, they are poorly interconnected with each other, both in terms of methodology and in terms of software. In light of the increasing demand for information on the climate system, databases and methodology should be updated and improved in order to facilitate access to information on the climate system. The introduction of a system of unified calculation and monitoring of climatic data in compliance with recommendations of the (WCO) on the basis of the CLICOM automated system is recommended.

In parallel with the introduction of the CLICOM automated system, it is necessary to develop a database of all available information. Glavgidromet has already started work on inputting information on water and climate systems in the republic. Improvements in current systems of monitoring of the hydro-meteorological land network are directed at the automation of monitoring through the use of computing equipment and new data processing software, improvement of the quality of monitoring and operational transfer of the data to those who need it.

6.2. Development of Research

A broad range of research is connected to the study of the climate system, hydrologic and environmental problems related to the whole Central Asian region. At the present time, diverse variants of climatic and agro-climatic zoning have been designed, a set of bio-climatic charts made, a solar- and wind-energy inventory is underway and numerous climatic, (including agro-climatic, aero-climatic, bio-climatic) descriptions and manuals have been compiled. Research on the specific regional characteristics of the atmospheric processes in Central Asia is being conducted.

In parallel with direct study of climate change in Central Asia, research on the vulnerability of individual components of the regional environment is underway. This research is conducted with support from the State Committee for Science and Technology. A bulk of this research is related to the Aral Sea and the Aral Sea basin. Glavgidromet caries out monitoring on the conditions of the sea and its basin, improving methods for obtaining and processing of this information.

Estimates on the impacts of changes in the climate on water and agro-climatic resources as well as individual natural ecosystems and consideration of adaptability of the environment are partially based on recommendations of IPCC, and, to a larger extent, on analysis of current conditions and changes as well as estimation of anthropogenic impacts. Assessment of the vulnerability of water resources (river flows, glaciers, and level of snow in the mountains) are obtained by means of mathematical models, which were developed by CANIGMI of Glavgidromet.

The National Climate Program, which was designed under the WMO has been developed to improve monitoring and research of the climate system of the region.

6.3. The National Climate Program (NCP)

The main objective of this program is to provide the government, organizations and the population with information on the weather and climate.

The following work is done under the NCP to meet this objective,

· Collection of data on the climate and management of this data, monitoring and evaluation of the climate, including climactic changes;

· Development of methods of application of knowledge on climate, presentation of information about the climate and weather forecasts;

· Evaluation of vulnerability of the environment to changes in the climate and development of various socio-economic programs to respond to changes in the climate;

· Study of climatic processes in order to predict climate changes and anthropogenic impacts on the climate; development of climate forecast methods.

Taking into account the multi-purpose character of NCP and its interdisciplinary structure which strives to respond to a whole complex of climate-related problems, the National Commission of the Republic of Uzbekistan for the Problems of Climate Change (NCC) (which consists of the representatives of the Government, and relevant ministries, agents and organizations, directly or indirectly involved in GHG emissions) is coordinating NCP implementation.

The implementation of NCP embodies the flexibility to respond to the growing demand for climatic data due to the critical situation in the Aral Sea zone and other environmentally critical issues, such as the shortage of water resources in Central Asia and population growth.

6.4. Study of Paleoclimatic Situation in the Aral Sea Basin in Late Pleistocene and Holocene Periods.

6.4.1. Ancient Rivers' Flow

In the past, for long periods at a time, dramatic changes in the climate occurred, the changes being named the arid and the pluvial phases. Research has shown that there were more dramatic climatic fluctuations in the Pleistocene period than was earlier supposed. Two variants of Central Asian arid phases (hot and cold), as well as internal differences in pluvial phases were established. Of late, a new methodology to obtain quantitative characteristics of the paleoclimate has been developed using of water-balance calculations.

The history and chronology of climate changes in the zones of the Caspian Sea and the Aral Sea over the course of the last two thousand years have been analyzed. As a result, two humid periods (in the 8^{th} century and in the 13^{th}-15^{th} centuries AD) and two arid intervals, which were separated from the pluvial phases by transitional phases, were discovered. Values of precipitation and temperatures were obtained from palentological data.

The largest changes in climate characteristics were shown to occur at the end of late Pleistocene period when the temperature of the air was $10\text{-}14^0$ C colder than today. There was 3-4 times less precipitation. It was much colder in early and middle stages of the Holocene period than today. Under such conditions, where there was 1.5-2 times more humidification in the region, which resulted in glacial formation and 3-4 times larger river flow.

Flow evaluation of the paleo-rivers was made on the basis of the ancient middle Holocene riverbeds of the Amudarya (Akchadarya), Zeravshan (Echkiliksay, Daryasay, Makhandarya, Gujayli and Taikyr), and Uzboy. The water discharges of the Zhanadarya – the ancient Syrdarya River –was estimated, too.

Calculations were made using hydraulic formulas which consider the characteristics of ancient riverbeds at specific times, as well as the characteristics of the river bends, the length of a waves, radius of the wave break and width of the paleo-channel. The characteristics of river bends are known to be mostly determined by water discharges. This made it possible to find an equation of connection between the characteristics of river bends and water discharges. The main finding of the research is that the flow of the Central Asian rivers was 3-4 times heavier in the early and middle Holocene period than now.

6.4.2. The Aral Sea during the last 20,000 years

In the Aral Depression, the prints of seven levels of the sea were found (Fig. 6.1). The most important of these are: terrace at the absolute mark of 72-73 m, ancient Aral terrace (absolute level of 57-58 m), late Aral terrace (absolute level of 54-55 m), and terrace, which corresponds to the highest level of the current stage – 53 m. In addition, investigation in the Paskevich Bay and Tshche-Bas Bay identified sea bottom sedimentation of the so called Paskevich stage of sea development at a mark of 31 m. This was a stage of sustainable, prolonged regression of the sea. A terrace at the mark of 63-64 m was found, however, it was fragmentary and was significantly ruined. It obviously also relates to the ancient Aral stage of development of the Aral Sea.

Lack of clear Mesolithic materials in this area (excluding the final stage of the Mesolithic Age) and the abundance of remnants from the Neolithic Age made it possible to date climatic transitions from conditions climatically unfavorable for the existence of man to the settling of primitive men and water availability (Paskevich stage) to the relatively humid Lyavlyakan stage of the pluvial period which occurred 6-8 thousand years ago. Evidence that the Aral Sea basin was already in existence 5-6 thousand years ago is suggested by the fact that the ancient Aral transgression took place during a period of a warm and relatively humid pluvial climate with high river flows in which all old rivers delta of the Amudarya River and currently dry channels of Syrdarya Kuvandarya and Inkardarya simultaneously existed.

The sea existed at a mark of 72 m. for relatively short time. Due to water outflows through the Uzboy River, the level of the sea was decreased to 63-64 m, and then - to 57-58 m. Since the hydro-meteorological conditions of the Aral Sea basin did not change, inflow into the sea varied from 91 to 131 km^3 a year, and annual outflow ranged from 63 to 72 km^3.

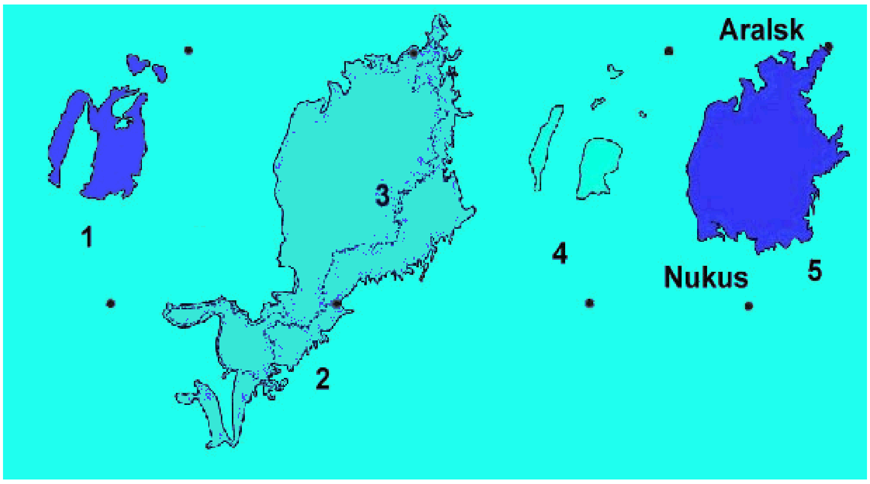


Fig. 6.1. Paleo-basins of the Aral Sea

1. The Paskevich stage (12-20 thousand years ago, level of 35-36 m.); 2. The Pre-Uzboy phase (7-9 thousand years ago, level of 72-73 m); 3. The Uzboy phase (4-5 thousand years ago, level of 57-58 m); 4. The lowest regression (around 2 thousand years ago, level of 28-29 m); 5. Conditionally modern period (1911-1961, level of 53 m).

A method was developed to calculate probable air temperature given specific changes in precipitation and this method in turn can be used to determine the reverse: given specific air temperatures, this method can be used to calculate necessary precipitation levels. Through this method, general information on the changes in climatic and hydrological conditions of the Aral Sea basin over the course of the last 20 thousand years has been determined.

The climatic conditions of the late Pleistocene and early middle Holocene periods resulted in high river-flow. That evaporation from the Aral Sea was less than at the present time resulted in the sea's transgression stages with very high levels and flows of water through the Uzboy River towards the Caspian Sea.

Not all stages of development of the Aral Sea in Pleistocene and Holocene periods have been explained. It is not clear, for example, what climatic situation corresponded to the super-low regression of the sea in the beginning of the AD era. It is probable that the Amudarya River during this time changed its course and under conditions which are comparatively close to those of the present day, the Aral Sea was dried out to even lower levels than its present state. If this assumption is correct, then today we face an analog to the past.

6.4.3. Paleo-Glaciation in the Aral Sea Basin

Glaciation is largely dependent on climate changes. It is widely accepted that the highest level of glacial formation in the Aral Sea basin took place in the late Pleistocene period. In the Holocene period, several stages of reduction of glaciation occurred, each lasting for about 3-5 thousand years. A relatively high level of glaciation took place in the early middle Holocene period. The period of degradation of glaciers is connected with the early (10 thousand years ago) and middle (5 thousand years ago) Holocene period.

Determination of the size of ancient glaciation of mountainous glaciers is connected to the identification of the valleys and large glacier areas. Such a task was carried out on the Zeravshan River basin on the whole, as well as for its small left tributes in the middle stream of the river.

The most distinctive differences from the modern size of glaciation took place at the end of late Pleistocene and early-middle Holocene periods: the area of glaciation in the basins of the major Central Asian rivers exceeded the current area by 5-6 times.

6.5. The Changes in Glaciation of the Pamir-Alay Range in the Second Half of the 20th Century

6.5.1. Analysis of the Changes in Area and Volume of Glaciers of the Pamir-Alay Range

Study of the glaciation of the of Pamir-Alay mountain system (which is located to the south from latitude 40 North on the territory of Uzbekistan, Kyrgyzstan and Tajikistan, and includes Gissar-Alay, the Tajik Depression and the Pamirs) has made it possible to evaluate the changes in glaciation of the Aral Sea basin.

The obtained results (quantity of glaciers, their area and volume) are demonstrated in Table 6.1 and Figure 6.2.

Table 6.1

Glaciation Characteristics in the Pamir-Alay Basins

River Basins	Quantity of glaciers		Area of glaciers , km^2		Volume of glaciers, km^3	
	1957	**1980**	**1957**	**1980**	**1957**	**1980**
Syrdarya	1388	1373	795.14	659.68	33191	26193
Zeravshan	1226	1225	655.70	573.40	36685	27712
Markansu, Karakul lake	1118	1138	1261.21	1185.49	78034	68000
Amudarya	8037	8179	7144.48	6205.14	511640	412053
Total	***11769***	***11915***	***9856.53***	***8623.71***	***659550***	***533958***

The area losses are especially high in the basins of vast glaciation (Bartang, Muksu, and the systems of the Fedchenko Glacier) and in the center and in the south of the region. Area losses are less dramatic in the basins with less glaciation (the South of the Fergana Valley, Surkhandarya River and Kashkadarya River) – in the North and West. On the whole, the glacial area has been reduced by 1233 km^2 or by 12.5% in comparison with 1957.

The highest losses of mass are in the basin of the Central Pamir Range. For example, the volume of glaciers in the basins of the Muksu and Bartang Rivers has been reduced by 45 km^3. There are some glaciers in the Pamir-Alay mountains that have lost 40% of their ice reserves: in the basins of the Kurshaba River (49%), Keksu River (48%), some tributes of the Pyanja (47%) and Isfairamsay (44%) Rivers.

On the whole, the glaciers of the region have lost 126 km^3 of ice (around 113 km^3 of water) during the 1957-1980-year period, which accounts for 19% of the 1957total ice reserves.

6.5.2. Evaluation of Tendencies of Changes in Present Glaciation.

Detailed measurements in the basin of the Abramov Glacier, which were started in September 1967 and are still underway, give a unique opportunity for such investigation.

Fig. 6.3 shows the ratios of correlation between the summer temperature on the Abramov glacier and that of the other meteorological stations of the region. The temperature fluctuations on the Abramov glacier and in the larger part of Pamir-Alay range move in tandem with each other and their annual temperature levels are also statistically significant. This is why the conditions on the Abramov glacier may be considered to be representative for the entire territory under consideration.

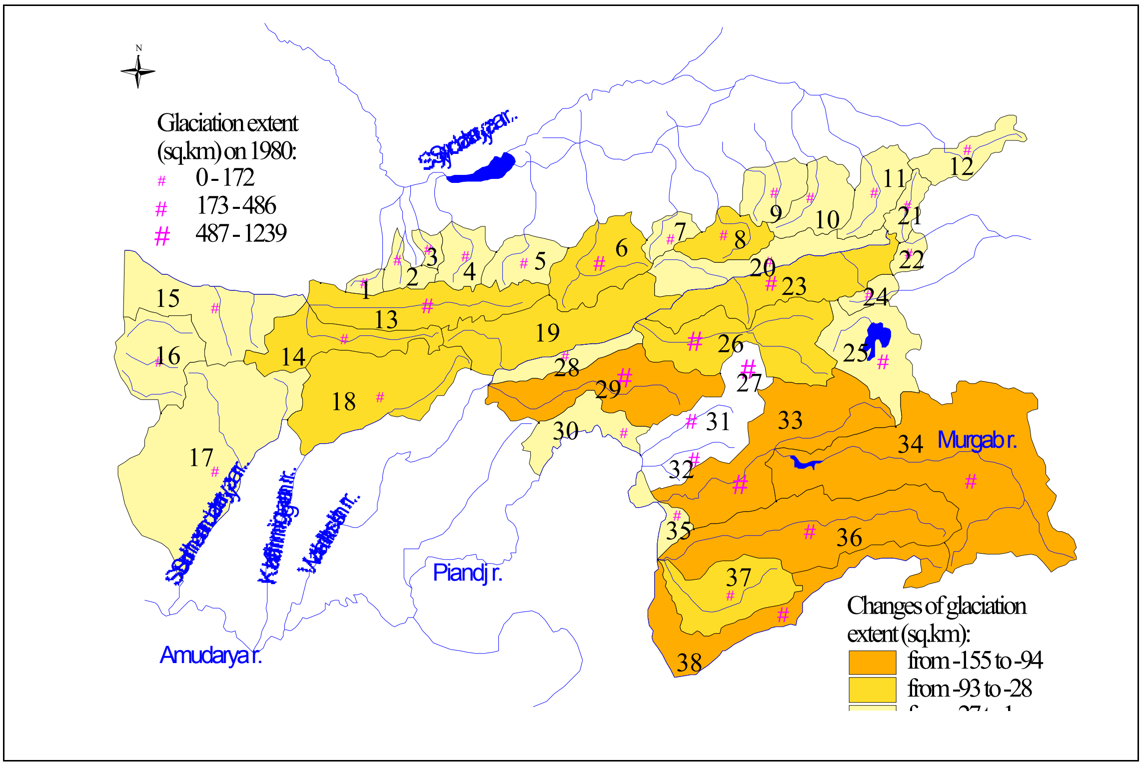


Fig. 6.2. The Pamir-Alay glaciation area in 1980 and its changes since 1957
Figures are numbers of basins.

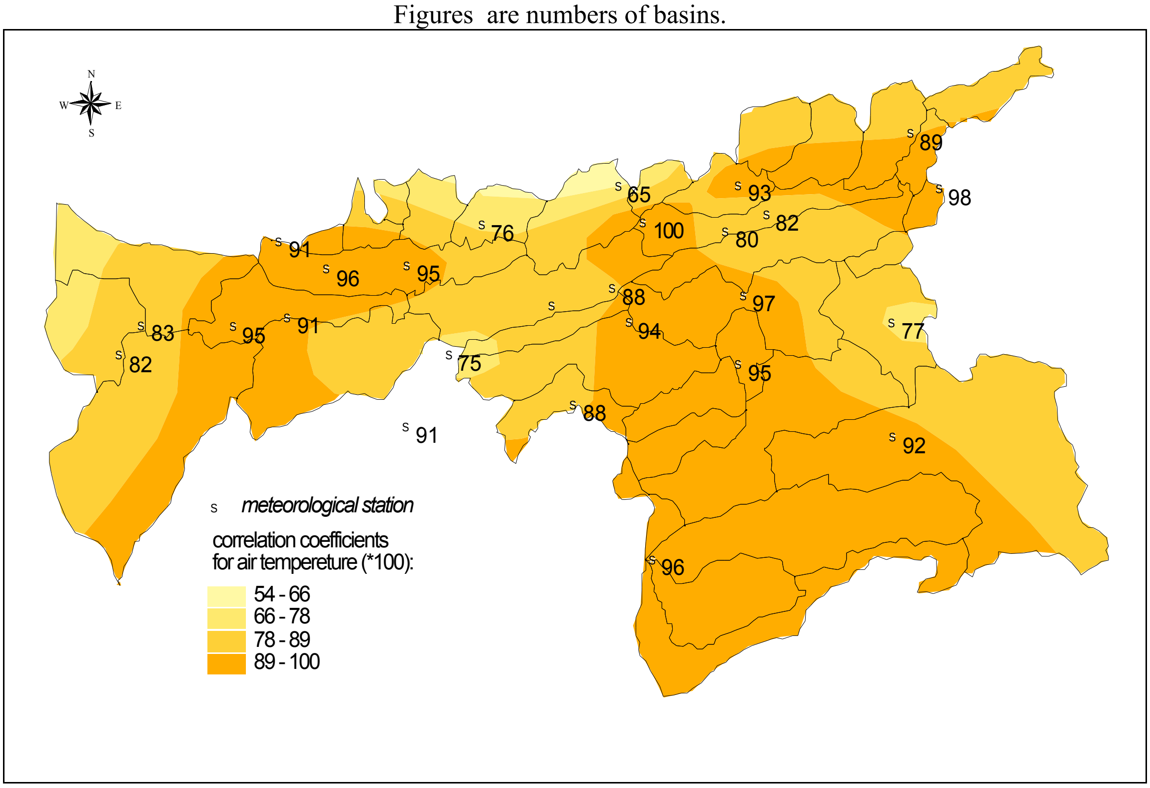


Fig. 6.3. The ratios of correlation between the summer air temperature on the Abramov glacier and that of the other meteorological stations

Using measurement results from the Abramov station, the dependence of the annual water flow in the basin on the average summer air temperature was determined. The basin flow varies from year to year (the variation ratio equals 0.21) and is closely related to the air temperature (Fig. 6.4).

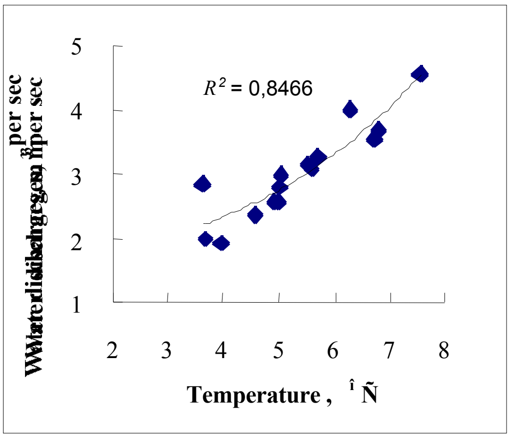


Fig. 6.4. The relationship between annual runoff from the basin and mean summer air temperature.

The calculated average water outflow from the basin (basin area 55.5 km^2) is 1.69 meters, whereas precipitation layer in the basin is 1 mm a year . This net outflow is due to the melting of the ancient ice reserves of the glaciers. Within the 31-year period under study, the Abramov glacier has lost 21m of its mass in water equivalent.

Considering that the glacier area is 22.5 km^2, total glacier losses are equal to the projected volumes of the biggest reservoirs in Central Asia.

The main mass losses have been observed on the glacier's appendix. This was the case, was, for instance, in 1990, a year that has been selected as a typical year of observation (Fig. 6.5)

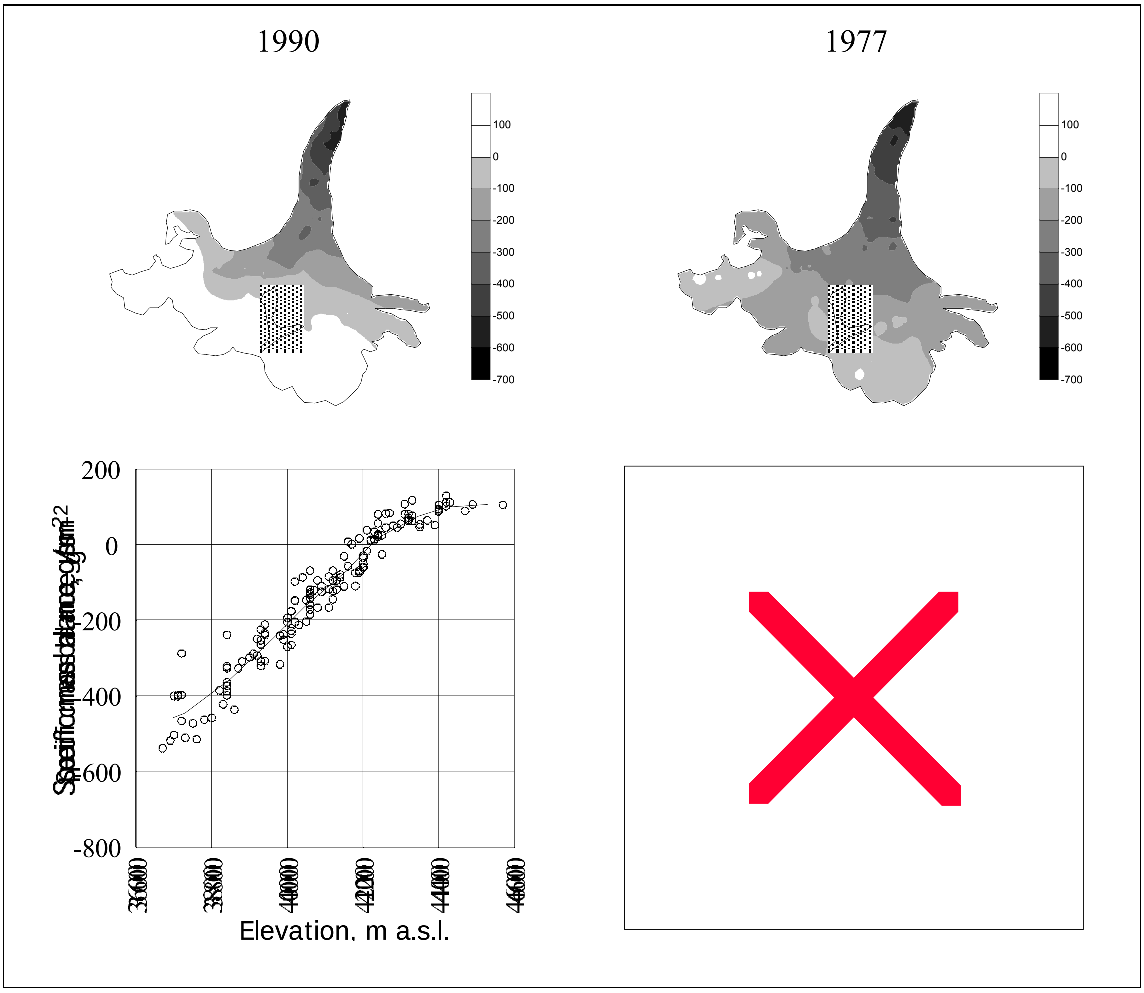


Fig. 6.5 . Spatial variations of glacier mass balance for different years

During such years, at the glacier base, layers 5 meters deep in water equivalent, begin to melt. At the same time, snow belts located higher up on the glacier form, making a transitional snow reserve, which to some degree compensates for the loss in mass at the glacier's base..

During the most unfavorable years (for example, 1977, shown in Fig. 6.5) the seasonal snow melts completely, and the granulated snow reserves, many years in the making, begin to melt, even at the glacier's peak. During such years the mass loss on one glacier is equal to the total annual volume of precipitation in the basin.

The analysis on the balance between the glacier mass, the precipitation and the air temperature shows that decreases in glacier mass are caused by unfavorable weather conditions of the last 30 years. The glacier may be kept in balance either by a **decrease** in summer temperature on the order of two standard deviations or by a **rise** in precipitation of 38 % above average or by some combination of the two which is positive for the glacier. Such changes are too dramatic to expect and hardly probable for the named parameters.

The forecast for the Abramov glacier's near future on is very **unfavorable.** This conclusion holds true for the other big valley glaciers of Pamir-Alay as well. These are the very glaciers that contain the major portion of the water reserves in this region.

Modeling of change in the balance of mass shows that if today's conditions are continued, the glacier will loose 14 meters of its mass in water equivalent in the next 20 years. Calculations show that within the 31-year period of observation, the glacier has already lost 18 % of its initial mass and it is expected to lose additional 17 % of its ice.

Thus, on the basis of the research conducted it is possible to conclude the following:

- at present there is a great decrease in the water reserves of Pamir-Alay;
- big valley glaciers are easily affected by changes in the climate;
- reduction of the glacier areas in near future will have negative impact on the water flow volume, regime, and quality of fresh water.

6.6. Observed Climate Changes in Uzbekistan

Study of the climate dynamic in Uzbekistan and Central Asia has shown that various climate system changes are taking place in the region. On the basis of analysis of observation data, warming trends in air temperature have been observed (Fig. 6.6). Moreover, this warming tendency is found throughout the whole territory of the Republic, both during the cold and the warm halves of the year.

These on-going changes in the climate have substantial impact on the climate characteristics as well as on the water balance and water resources of the region. In the mountainous part of the region, there is degradation and reduction of the glaciers. The data on the snow cover in the mountain river basins show that there is continuing decrease in transitional snow reserves.

A database on the main climatic characteristics has been created in order to estimate regional climate conditions and to develop regional climate scenarios. The primary data are the observation data gathered at 40 observation stations. During data selection, such criteria as the length and continuity of observation, the density of the observation net, the land relief particulars, and the absence of significant sources for local climate changes were considered.

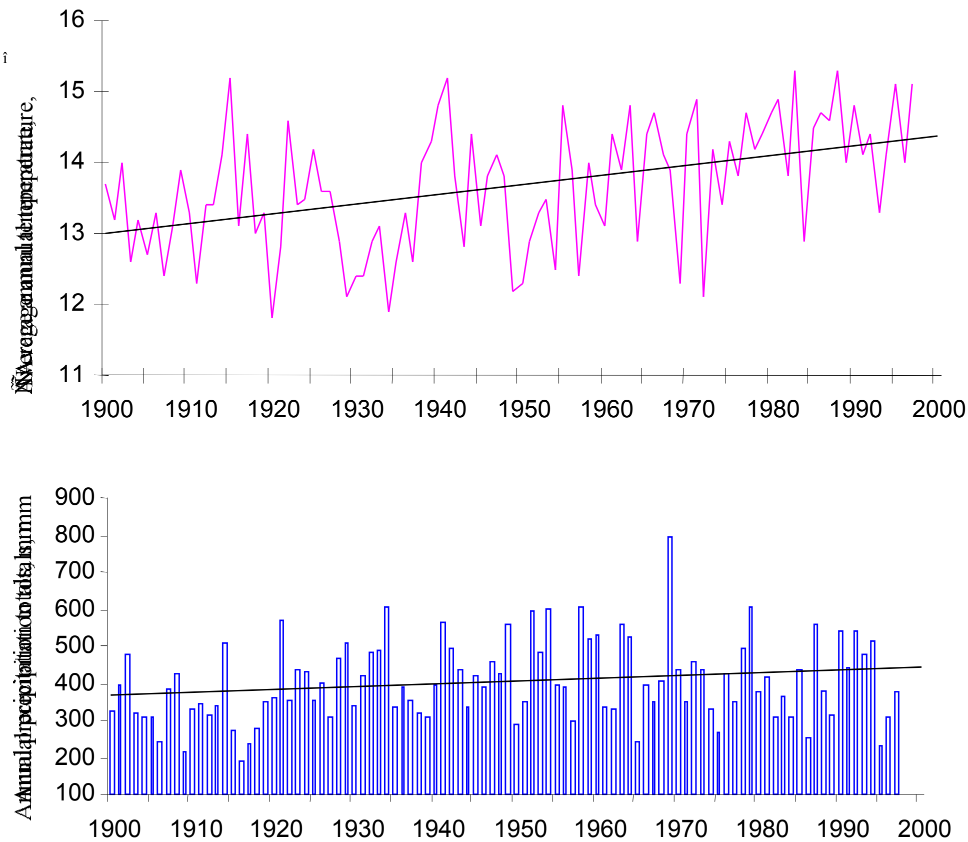


Fig. 6.6. Variations of the average annual air temperature and annual precipitation totals at the Tashkent observation station

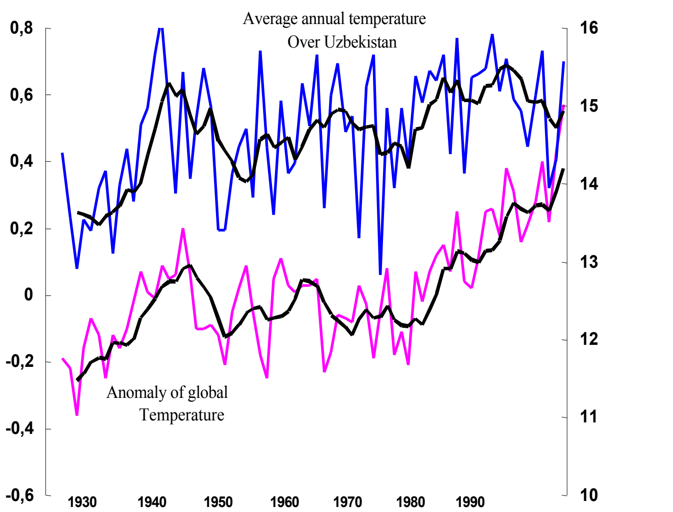


Fig. 6.7 Variations of annual anomalies of global temperature and mean annual temperature over Uzbekistan

According to the observation results there is a big similarity between global and regional air temperatures. This allows for the possibility that regional climate changes might be caused by ongoing global warming. The warming of 1930's and the drop in temperature of the 1960's can be clearly observed in the average annual air temperature data for Uzbekistan (Fig. 6.7).

There is some increase in the annual volume of precipitation in some parts of the valley territory. Statistically significant trends for the mountain and foothill areas have not been identified.

6.7. Expected Climate Changes and Climate Scenarios

Scenarios on climate changes in Uzbekistan and neighboring mountain territory were developed in order to estimate to what extent certain climate system components are vulnerable to possible regional climate changes and to develop an adaptation strategy. These scenarios were based on different approaches.

The first of these scenarios combined the results from models on general circulation of the atmosphere and the ocean (GCM) and historical analogues. The estimation of possible changes in the regional climate if CO2 emissions into the atmosphere were doubled included temperature changes of 2.0-3.0 degrees C in the winter and 1.5 degrees C in summer. Thus, the possible annual changes were estimated to be within a range of 1.0-3.0 degrees C.

Other scenarios of regional climate changes were developed using the empirical-statistical method. This method looks for any influence of annual global air temperatures on the average annual air temperatures in the regions of Uzbekistan and neighboring mountain territories. To forecast the global temperatures, results of the model on estimation of green house gas and climate changes (MAGICC) for six variants of green house gas emission were used (these variants were suggested by IPCC IS92a-IS92f). In this variant, the scenarios were combined in pairs. If the scenarios on green house gas emissions prove to be true, then by the year 2030 we can expect a rise in average annual temperature of 0.8-3.4 degrees C under scenarios IS92ab, of 0.6-2.4 degrees C under scenarios IS92cd, and of 0.9-3.7 degrees C under scenarios IS 92ef in the territory of Uzbekistan. This scenario also provides estimations on changes and seasonal characteristics. The expected rise in average annual temperatures for the territory is shown in Figure 6.8.

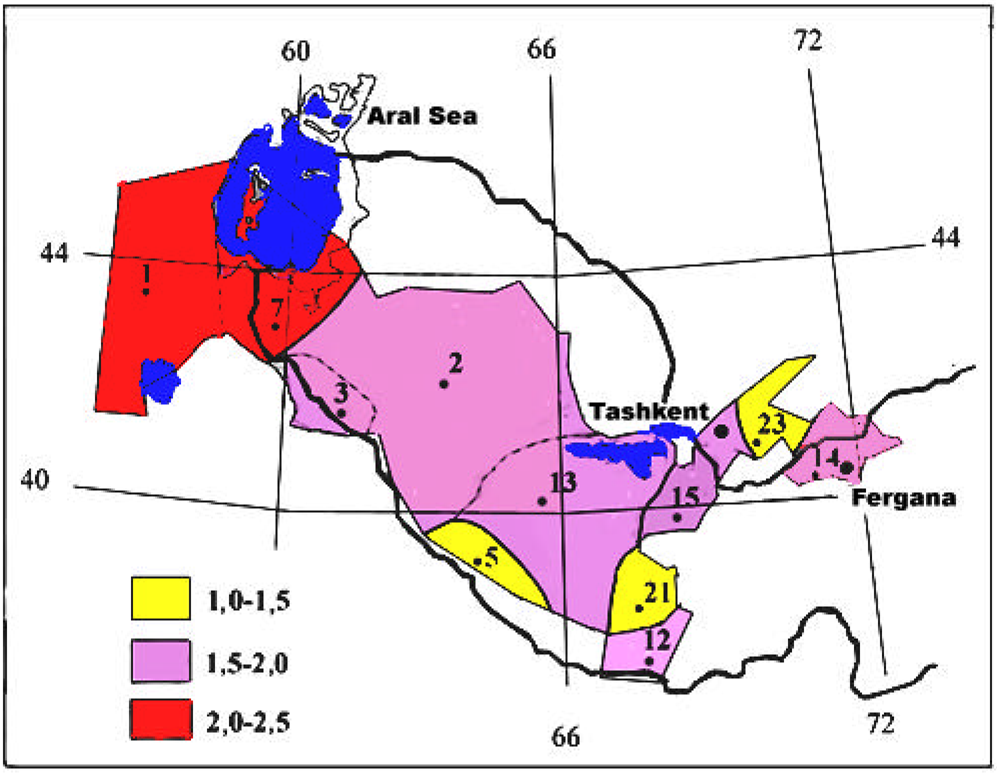


Fig. 6.8. Changes in average annual air temperature by 2030 as compared to 1961-1990 (under emission scenarios IS92ab).

The analysis of expected air temperature changes shows that global warming will have a bigger impact on the northWestern valley regions of the Republic, whereas the impact will gradually decrease in Southern areas. The impact of global warming will be smaller in mountain regions.

To develop a scenario on the probable changes in precipitation in Central Asia, expert estimation based on numerous model estimates that were taken from literature sources as well as from existing regional climatic tendencies in precipitation regime and from the empirical-statistical method were used. The scenario presented in this research should be viewed as an initial result. By 2030, the annual precipitation volume for Uzbekistan and neighboring mountainous territories is expected to be within a range of 100 to 120 % of the norm under different scenarios of emissions.

In addition, these conclusions are confirmed by GCM scenario results. Nearly all known climate forecast models predict that the average air temperature in the Central Asian territory will increase. Developing regional climate scenarios for temperature and precipitation was conducted using GCM results under the technical guidelines of IPCC. The results of four GCM scenarios were used under the assumption that the concentration of CO2 in atmosphere would not increase (control runs) and under the assumption that it would double (2xCO2) [CCCM - model of the Canadian Climate Center, UKMO - model of the United Kingdom Meteorological Bnitrateu, GFDL - model of the USA Laboratory on Geophysical Hydro-dynamics, GISS - model of the Goddard Institute on Space Research].

A comparison of the model control runs with the data from the climatic basis was conducted. In accordance with the recommendations of IPCC, data from meteorological observance at the stations for the 1951-1980 period were selected to be the climatic basis for the model result analysis.

Table 6.2 shows the average seasonal deviations of the estimated air temperature from real temperature. All the models in general give lower temperature estimations. The biggest deviations from the actual data during the control runs were under the CCCM and GFDL models. Models UKMO and GISS provided more realistic results for the valley territory of Uzbekistan.

Table 6.2

Deviations of the Control Model Data on Air Temperature (degrees C) for 1951-1980 in Valley Territories of Uzbekistan

Model	Winter	Spring	Summer	Autumn	Year
CCCM	-9.9	-6.6	0.5	-4.3	-5.1
UK__	-3.5	-2.1	1.1	0.4	-1.0
GFDL	-9.5	-1.1	1.1	-2.0	-2.9
GISS	0.3	-2.8	-1.5	-0.9	-1.2

Scenarios of probable variations were developed separately for valley and mountain territories. There was no reason for coming up with averages of temperature and precipitation of the territory the Aral Sea basin as a whole, given that the humidity level and temperature in the basin vary widely and depend on the relief of the land.

Expected temperature changes in Uzbekistan and in neighboring mountainous territories if CO2 concentration were to double are shown in Fig. 6.9.

Calculated control model data on precipitation volume were also compared to the climatic data of the base period (1951-1980). The variations of the calculated control data on for precipitation volume are significant. The outputs under models UKMO and GFDL for the valley territory, were closest to the actual conditions. For the mountain territory the deviations of the model results from actual data under all the models were approximately the same.

Figure 6.10 displays changes of the monthly precipitation volume under various model scenarios for the valley and mountain territories. It is important to note the differentiation in these models relate to the seasons of the year and the various territories. The differentiation between models is more pronounced when considering valleys and slightly less pronounced for the mountain territory. This conclusion corresponds with the statistical structure of precipitation fields in the Aral Sea basin. The ratios of precipitation variations are the highest for the valley territory, which is characterized by a big deficit of humidity during the warm part of the year. These ratios are smaller for mountain areas that are wetter.

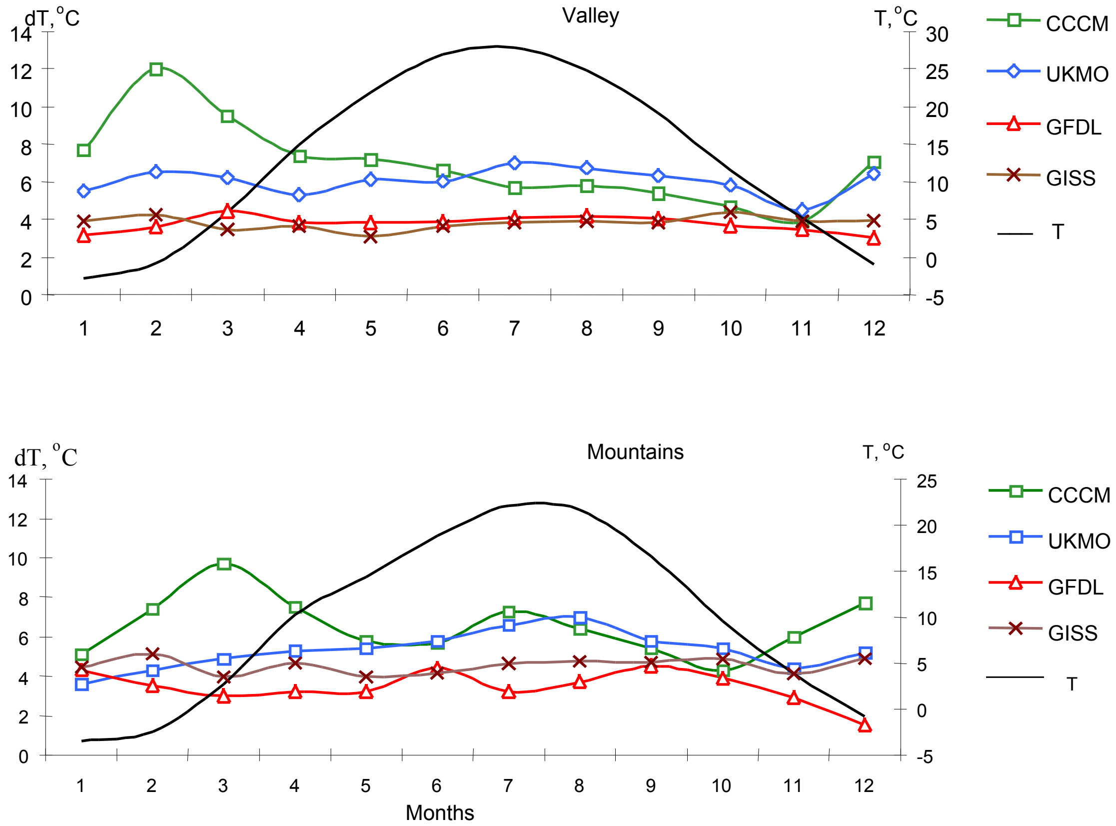


Fig. 6.9. Expected Changes in Average Monthly Air Temperature in the Valley Territory of Uzbekistan and the Adjacent Mountain Territories in Comparison with Averages for 1951-1980.

Thus, the level of uncertainty for the model scenarios on precipitation changes is very high for regions with high fluctuation in precipitation levels, especially during the dry period of the year. The average of the monthly precipitation volume for many valley and foothill stations (zones of desert and semi-desert) in the summer is close to zero. This explains why the models predict precipitation changes of 250-300 % in precipitation volume even though the actual precipitation volume is only on several mm (Fig. 6.10).

Table 6.3 shows scenarios of possible changes in temperature and in precipitation volume for Uzbekistan and neighboring mountainous territories. It is necessary to note that, unlike the temperature change scenarios, the precipitation change scenarios do not closely predict the same results, even for the anomaly signs. The CCCM model shows an expected decrease of the annual volume of precipitation (up to 89 % from the norm for mountain territory). The UKMO and GFDL models predict a rise in annual precipitation volume within the range of 106-114 %. The GISS model predicts a possible rise in precipitation volume for valley territory up to 140 % of the norm.

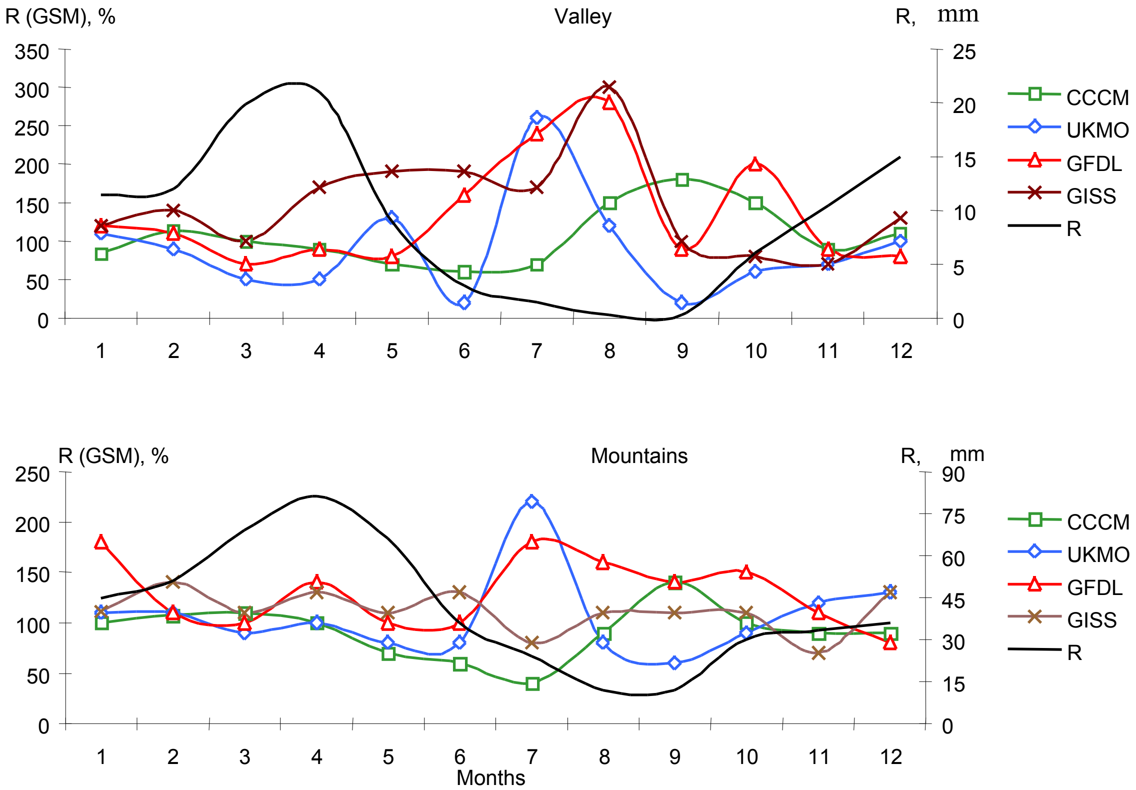


Fig. 6.10. Expected precipitation variations under the GCM model for valley territory of Uzbekistan and neighboring mountainous territories given in % of the norm (R) for 1951-1980.

________ 6.3

. Model Scenarios on Probable Temperature Variations (dT, degrees C) and Precipitation (R, %) from the Norms for Valley and Mountain Territory

Territory	Winter		Spring		Summer		Autumn		Year	
	d_,°C	R,%	d_,°C	R,%	d_,°C	R,%	d_,°C	R,%	_,°C	R,%
CCCM										
Valley	8.9	108	8.0	88	6.0	75	4.6	133	6.9	100
Mountains	6.7	98	7.7	93	6.5	57	5.2	104	6.5	89
UKMO										
Valley	6.1	100	5.8	65	6.6	150	5.5	67	6.0	90
Mountains	4.3	117	5.2	93	6.4	128	5.1	103	5.2	106
GFDL										
Valley	3.2	100	5.1	76	5.1	200	4.3	133	4.4	110
Mountains	3.1	122	3.1	105	3.7	140	3.7	129	3.4	114
GISS										
Valley	5.1	131	3.5	141	4.5	192	4.2	83	4.6	140
Mountains	5.3	128	4.0	117	4.7	108	4.8	91	4.7	113

Thus, taking into consideration the fact that in many regions of Uzbekistan local anthropologically caused changes in the climate and in whole ecological systems can already been seen, future changes in climatic conditions caused by the green house gas effect are likely to cause even more substantial consequences.

7. Consequences of Climate Change: Vulnerability Assessment and Ways of Adaptation

Climate change is one of the most important natural factors, which should be taken into account for developing the strategy of sustainable development.

Natural climate change affects the development and allocation of economy sectors, and social conditions. Construction and agriculture are the most vulnerable to possible climate change.

In agriculture, temperature increase can result both in negative consequences (decrease in productivity of crops due to evaporation increase, and decrease in relative water supply) and positive ones (increase in vegetation period and in heat supply to crops referred to tropic group).The utilization of land and water resources under climate change is a prior aspect in the socioeconomic and ecological policy of Uzbekistan.

7.1. Approaches to Vulnerability Assessment

For Uzbekistan, estimates to predict vulnerability and adaptation should be focused on **agriculture, water resources, ecologically fragile territories and specific ecological systems**. To estimate the impact of climate change on the environment and national economy industries, it is necessary to apply climatic scenarios to large areas of territory and to long periods of time. Deviation from average annual and seasonal characteristics as predicted for a selected period in time was done with the use of correlation analysis and methods of dynamic description of annual climatic characteristics. This allowed for the use of climatic scenarios in mathematical models of the natural processes.

The effect of climate change on agro-climatic resources and agricultural production was estimated with the empirical-statistical approach and with "Soil-Climate-Harvest" models.

Assessment of the vulnerability of water resources was calculated considering only the climatic impact, given that the water flow formation area is mainly located in high mountain regions and non-climatic factors are expected to have only minimal influence. The estimation methodology was developed through the use of a mathematical model of mountain river flow. This model allows for the consideration of the main particularities of flow formation. It can estimate the effect of climatic change on mountain hydrology, snow cover and glaciers on a scale of specific river basins.

7.2. Agro-Climatic Resources and Agriculture

7.2.1. Estimation of Probable Changes in Agro-climatic Resources

Agro-climatic resources of the valley territories. To estimate the changes in agro-climatic resources and their impact on agricultural production, the regional climate scenarios that estimate the changes by the year 2030 (see section 6) were selected as base scenarios. The background scenario values were calculated in accordance with actually occurring climatic differentiation on the territory of Uzbekistan and then these were related to the Agro-climatic districts and groups of regions.

The most substantial rise in air temperature is expected in Karakalpakistan during all seasons. As a result, the Agro-climatic resources of the territory will increase. In the Kashkadaria, Navoy, Samarkand, Surkhandaria, and Tashkent regions, the temperature will increase: in the spring around 0.5-2.0 degrees C, in summer up to 1.5-2.5 degrees C, in autumn on up to 0.5-2.0 degrees C, in winter up to 1.5-3.5 degrees C. In other regions the temperature changes during the spring-summer-autumn period will not be bigger than 1.5 degrees C.

As a result of warming, the border between the dry tropical and temperate climatic zones will move North about 150-200 kms, and the high climatic zones will rise about 150-200 meters.

On average, within the territory of the Republic, the duration of the frost-free period will increase by 8-15 days. The dates of the temperature transition period from 5-10 degrees C will occur 5-10 earlier days in spring, and in autumn this transition will occur 5-15 days later (Fig. 7.1). The effective air temperature will increase in 5-10 %.

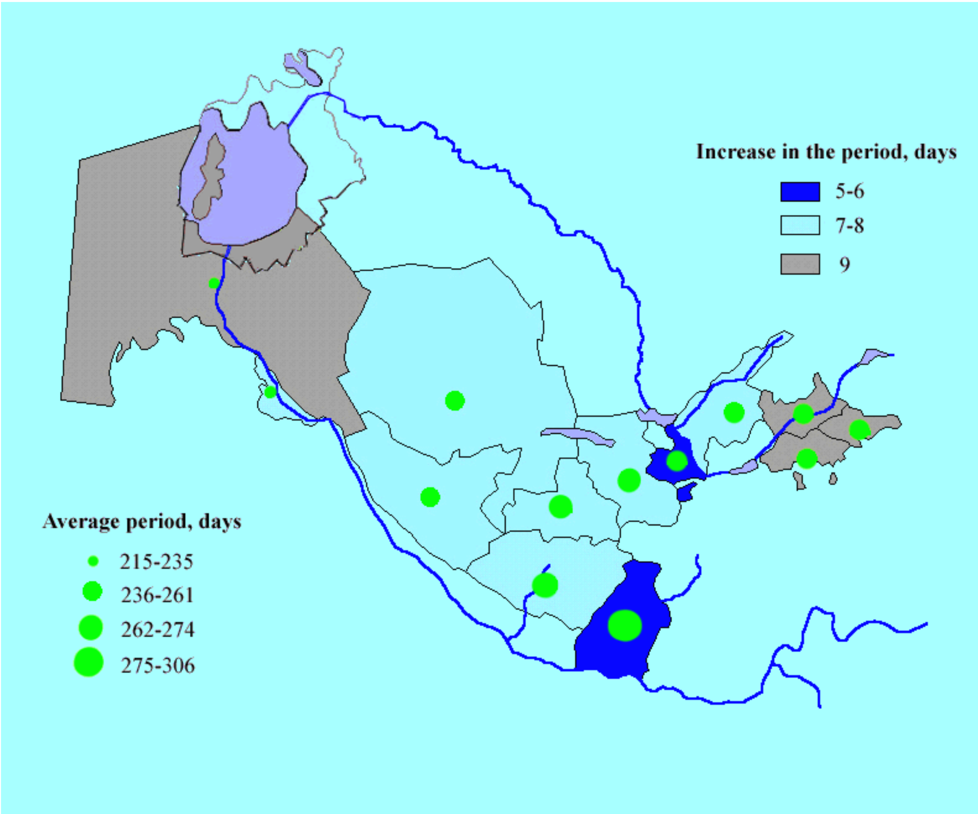


Fig. 7.1. Expected increase in the period (in days) between the dates of steady transition of 5 degrees in the air temperature in winter and autumn.

The expected 1.5-2.0 degree C temperature increase in Central Kyzylkum will lead to a replacement of the winter regime, i.e. the vegetation autumn vegetation will continue to grow during the winter.

In connection with expected climate changes there will an increase in the number of days with high temperatures that are unfavorable for the productivity of crops and pastures (fig 7.2).

The estimation of the change in **Agro-climatic resources of mountain zone** areas of the Republic (spurs of Turkestan and Gyssarks mountain ranges, Western Tyan-Shan) are shown separately. Calculations show that the dates of the transition of the air temperature within +5 degrees C period in the spring will take place 3-8 days earlier in Western Tyan-Shan mountains, 6-7 days earlier in Samarkand region, and 9-12 days earlier in Kashkadaria and Surhandaria regions. As a result, the growth of pasture vegetation in these areas will begin earlier by a corresponding number of days.

7.2.2. The Climate Change Impact on Agricultural Production

The increase of carbonic acid gas concentration in the environment under other favorable conditions has a positive impact on the growth and yield capacity of most agricultural crops. Thus, when the concentration of the carbonic acid gas in the atmosphere doubles, there is a probability of an increase in the crop capacity of corn, cotton, millet, sorghum and vegetable cultures of 10 to 50 %, and a rise in the crop capacity of cereals (wheat, rice, barley, oats) up to 10 %. The maximum increase in crop capacity on average for all cultures may reach 20-40 %. However, if there is a lack of sufficient soil minerals, especially if there is a lack of phosphorus, it will be impossible to take advantage of the potential possibility of crop capacity increase

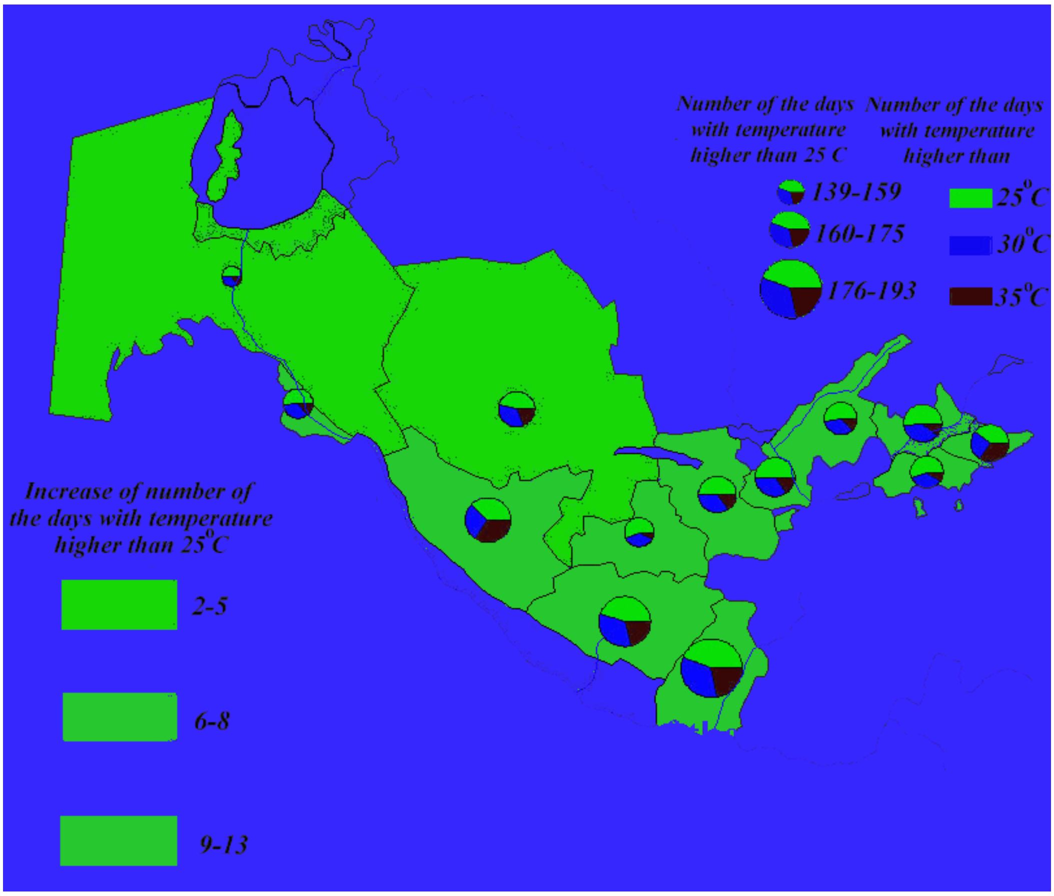


Fig. 7.2. Expected increase in a number of the days with temperature higher than the estimated limits for Uzbekistan regions.

For the majority of tropical group crops (such as cotton, rice and corn) the main limitations are average minimum temperatures below 10-15 degrees C during the spring and autumn periods. The increase of the duration of vegetation period in general has a positive impact on these crops' production. The rise in the occurrence of natural disasters (drought, dry wind, high temperatures, etc.) will worsen conditions for plants and will decrease the crop quantity and quality.

Cotton. In the main regions of cotton growing, warming will lead to an increase in the vegetation duration period. As a result, in general there will be an improvement in conditions for cotton ball ripening and opening. This will lead to an increase in raw-cotton crops as well as to the improvement of cotton fire quality. The increase in cotton crop capacity is estimated on average to equal 11 % for all the growing regions of the Republic, provided crops receive enough moisture.

The main factor that might lead to decline in cotton crop capacity is extremely high air temperatures. This situation is observed at present and is expected to continue in the Bukhara, Kashkadaria, Surhandaria, and Tashkent regions. The crop losses may on average make up to 9-15 %, if the crops are not provided with enough water.

Cereals. Most of the total area planted with cereal crops is irrigated land, which will decrease the probability of negative impacts of climate change on cereal crops. The concentration of carbonic acid gas will result in an increase in crop capacity. On lands that receive enough precipitation as well as on irrigated lands, crop capacity increases of 7-15% can be expected due to changes in climate factors.

The possible effect of temperature rises on the non-irrigated dry foothill regions may be a decrease in cereal crops. The difference between the crop capacity of winter wheat crops on irrigated land and in dry lands will increase. On dry lands that are not provided with sufficient water resources, decreases in crop capacity will big high. The winter crops in the Samarkand, Djizak, and Kashkadaria regions will be most affected. The crop capacity will be determined by the correlation of precipitation and the vegetation phases. The expected increase in precipitation under the regional climatic scenario will in general be compensated by the losses of moisture caused by evaporation.

Other crops. Crops of rice, Lucerne, corn, potatoes, vegetables and melons can be found in practically all regions of Uzbekistan. The main regions of rice cultivation are in the Khorezm, Tashkent and Syrdaria regions, and in the Karakalpakstan Republic. This crop specialization is expected to continue.

The high temperatures mostly affect rice during the period of ear formation and blossom. High temperatures lessen rice crop capacity under temperatures higher then 32 degrees C by 10%, under temperatures higher than 34 C by about 20%, even if the carbonic acid gas concentration is doubled .

Lucerne is the most important culture for cotton crop rotation. It is adapted to the conditions of the Republic. Under optimal conditions of adequate moisture, the rise in temperatures and in carbonic acid gas concentration will result in an increase in crop capacity and in the number of possible harvests.

Earlier springs are favorable for earlier sorts of vegetables, like potatoes and melons. Later growth crops, such as tomatoes, melons and watermelons may not get enough warmth in Karakalpakstan, Samarkand, and Khorezm regions to completely ripen.

The rise in the number of days with high temperatures is unfavorable for vegetable crops. The largest number of such days is expected in the Surhandaria, Kashkadaria, and Bukhara regions (Fig. 7.2). For early and fast-ripening sorts of cabbage, high temperatures may cause a crop capacity decrease by 11-50 %, for late sorts – by 6-45 %.

For middle-ripening tomato sorts, the increase in the number of days with temperatures higher than 35 degrees C may cause a crop capacity decrease of 12-46 % in the Tashkent, Andijan and Namangan regions, and of 10-42 % in the Surhandaria, Bukhara, and Khorezm regions.

Temperatures above 40 degrees C are unfavorable for watermelon crops. Depending on the duration of high temperature periods, watermelon crop capacity may decrease by 10-42%, and melon crop capacity may decrease by 9-30 %.

The negative impacts of higher summer temperatures and evaporation will increase combined with the negative consequences of all types of natural and anthropogenic soil erosion. In the future this situation will worsen, because the anthropogenic impact on the regional natural resources and ecological systems will increase along with Uzbekistan's growing population and corresponding need to increase agricultural outputs.

7.2.3. Vulnerability of Natural Pastures

Pasture Vegetation of the Desert Zone. The expected switch from a winter regime to more milder winters, where vegetation continues to grow, may cause a crop capacity decrease on ephemeral pastures, given that winter vegetation is not favorable for growth of grasses in the spring.

The rise in temperature and switch to earlier springs on pasture territories will effect the formation of autumn forage reserves. In the Northern Kyzylkum district, the conditions for forage formation will worsen. As a result, a decrease in forage volume of 20-26 % is expected. In central regions (Central-Kyzylkum Valley and Tamdy-Kuldjuktausk) the decrease in forage reserves may reach 33-44 %.

The decline in desert pasture capacity and an increase in the number of days with high temperatures will negatively effect grazing conditions. As the air temperature increases the duration of unfavorable hot periods will increase, too. Such weather has a negative impact on animals and decreases their productivity.

Mountain pastures. The main mountain pastures are located in the spurs of the Turkestan and Gyssar mountain ranges and in the Western Tyan-Shan Mountains within the Tashkent, Samarkand, Kashkadaria and Surkhandaria regions. They are used for pasture mainly during the spring-summer period. The Southern Mountain territories in the Kashkadaria and Surkhandaria regions may also be used during the autumn-winter periods, given that the snow cover in these regions is light and that there is vegetation during the winter.

The seasonal usage of the pastures assumes cattle driving in the spring from the foothills and low hills to the middle hills and high hills. In spring it is necessary to drive the cattle upward as lower valley pastures become withered due to hot weather. In autumn, when it becomes cold, the cattle are driven back.

Because of the climate changes, autumn cattle driving will be switched to later dates. As a result the duration of the pasture period in mountain regions of the Samarkand region may increase for a period of 6 days. In Western Tyan-Shan Mountains and in the Kashkadaria and Surkhandaria regions, the pasture period may increase 11-19 days. The duration of high temperature periods, which may effect cattle productivity, will increase in 1-2 decades.

The pasture vegetation crops in the South of Uzbekistan depend on precipitation trends. A rise in precipitation of 20 % will increase the crop capacity 23-34 % (the present average crop capacity is 4.3 metric centners per hectare). In high hills and mountains such a precipitation increase will have smaller impact on the crop capacity, increasing capacity by up to 16-23 %. In general, the crop capacity may increase up to 13-25 % through out the basin.

Calculations of vertical temperature grades help to identify possible changes in the altitude at which mountain pastures grow. In the Western Tyan-Shan, mountain pastures are expected to move 100-130 meters up in altitude and in spurs of the Turkestan and Gyssar mountain ranges, mountain pastures are expected to move 270-300 meters up in altitude.

7.2.4. Adaptation Measures in Agriculture

The analysis of assessment of agroclimatic resources and climate change impact on agricultural production showed that a fundamental review of allocation schemes for main crops is not required for the future 10-20 years.

Measures of adaptation to expected climate change in agricultural production should be coordinated both with measures to encourage sustainable social-economic development in the

Republic and with anti-desertification measures. These measures should be also be coordinated with the foreign policy of the state.

Specific variants of adaptation measures for agriculture include optimization of the land and water resources use. They also include economic reconstruction of the water and irrigation systems; introduction of water-saving technologies; restoration of degraded lands; crops structure improvement; introduction of high-yielding and drought-resistant crop varieties; use of advanced agro-technical arrangements as well as plant-growing technologies; rational use of fertilizers and plant protection; regeneration of plants; pasture phytoreclamation; use of water-saving technologies and measures to increase precipitation in the flow formation zone and in desert areas.

The recommendations on adaptation measures in response to the expected climate change in irrigated agriculture are mainly related to the necessity of increasing the capacity of crops.

To achieve the above, the following measures are suggested:

- conduct land-improvement activities on salty lands;
- conduct measures to prevent wind and water erosion and to rehabilitate degraded lands;
- optimize the parameters and economic indices of the hydroreclamation on land-improvement;
- set up systems of estuary irrigation; improve the water regime for soils and plants by using polymer composites and soil mulching;
- ensure increased levels of mechanization of farming on irrigated lands;
- encouraging crop rotation with use of intermediate winter crops of; this could allow for two-three harvests annually on irrigated lands, given the expected climate changes;
- improve the conditions of mineral and air (carbonic acid gas) feeding of plants; this would increase the agricultural crop capacity based on the expected climate warming and increase the carbonic acid gas concentration;
- improve the sowing structure as well as the location of agricultural production on a regular basis, taking into consideration new types and sorts that are resistant to drought, diseases, and pests;

To increase fodder crops capacity **on natural pastures in arid areas** the following measures are recommended:

- set up autumn-winter harvested pastures in foothill regions as well as protective forest belt zones;
- set up spring-summer harvested pastures planting indigenous grasses;
- improve high saline pastures through the application of run-off water from takyr soils;
- improve high saline wormwood pastures;
- improve forage capacity of the pastures in sand deserts by changing the sorts of pasture vegetation;
- set up pastures using estuary irrigation in foothills areas, and in low and middle mountains;
- ensure development of irrigated forage production in deserts and semi-deserts using underground and drainage water.

To preserve mountain pastures under the changing climate conditions, it is necessary to avoid overgrazing. To do this, it is necessary to have data on the condition and development of pasture vegetation as well as on fodder reserves. This could be accomplished through pasture monitoring.

7.3. Water Resources, Changes and Adaptation Measures

7.3.1. Vulnerability of Surface Water

The assessment of vulnerability of water resources have been obtained by use of all designed climatic scenarios (see Chapter 6). Availability of the different scenario variants made it possible to take into account climatic scenarios and assess the most critical situations. Calculations were made for every basin-indicator zone for flow formation of the Syrdarya River (Chatkal, Pskem, Akhangaran, Ugam, Kugart, Karauldja, Tentyaksay) and for the Amudarya River (Zeravshan, Vakhsh, Obikhingou, Vanch) with consequent integral evaluation.

Blanket of snow. The blanket of snow in the mountains is an important feeding source for the rivers of Uzbekistan. At present the contribution of snow to total moisture delivery of the watershed surface amounts to 60-75%. Simulation modeling of the integrated snow reserves shows their gradual decrease in all spring months during the last decades.

The sustainable seasonal blanket of snow in the mountains is at a level of 1400-1800 m. Melting of the seasonal blanket of snow, with exception of the densest accumulations of it in the negative forms of the relief, take place during April-May.

Model calculations of snow reserves in the mountains under different climatic scenarios have demonstrated their gradual decrease due to growing aridity of the climate. Contribution of the snow is expected to decrease by 15-30%, especially for rivers which are snow-fed (Figure 7.3). Changes in the snow border and a one-month shift in melting of the blanket of snow are also expected.

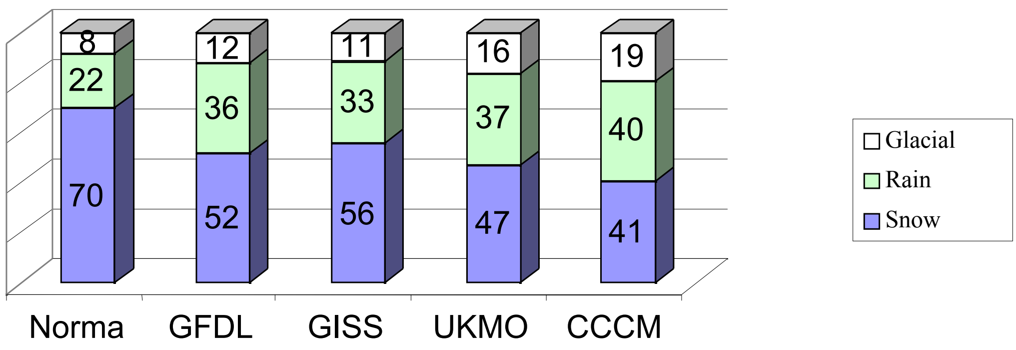


Fig. 7.3. The correlation (%) of snow, rain, and glacial components to the total annual water delivery to the Pskem River watershed for a base period under different climatic scenarios (The Syrdarya River basin, snow-rain type of river feeding)

Rain run-off. The contribution of precipitation from rain might grow from 12-15% up to 25-35%, which would negatively affect formation of snow reserves. This means that there would be proportionally more rain shower precipitation. This would result in rain floods, primarily on smaller water flows, expansion of soil erosion and flow turbidity. The foothill zones, especially in Fergana Valley, often experience heavy rains and showers. Given the expected changes in the climate, whole strips of foothills in this area could become intensive mudslide zones.

The spring high water season would shift by one month in the annual course of river runoff fed by snow and rain (Fig. 7.4) and, as a result, the regime of operation of hydro-technical facilities would change, too.

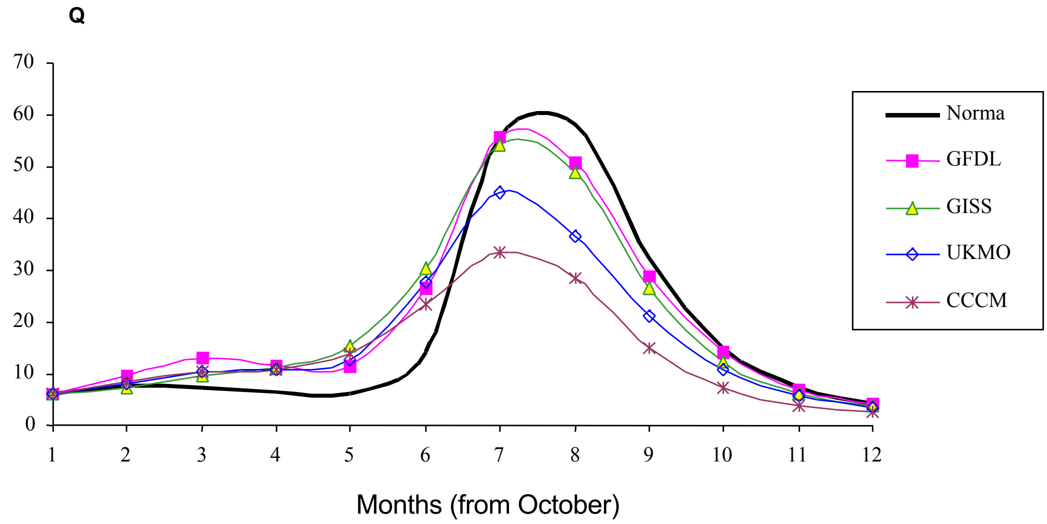


Fig. 7.4 The Hydrographs of the Kugart River run-off for the base period under climatic scenarios (the Syrdarya River basin)

Glacial run-off. There are glaciers in the basins of the Pskem River, Kashkadarya and Surkhandarya Rivers in Uzbekistan. Other glaciers that feed the rivers of Uzbekistan are situated beyond its territory.

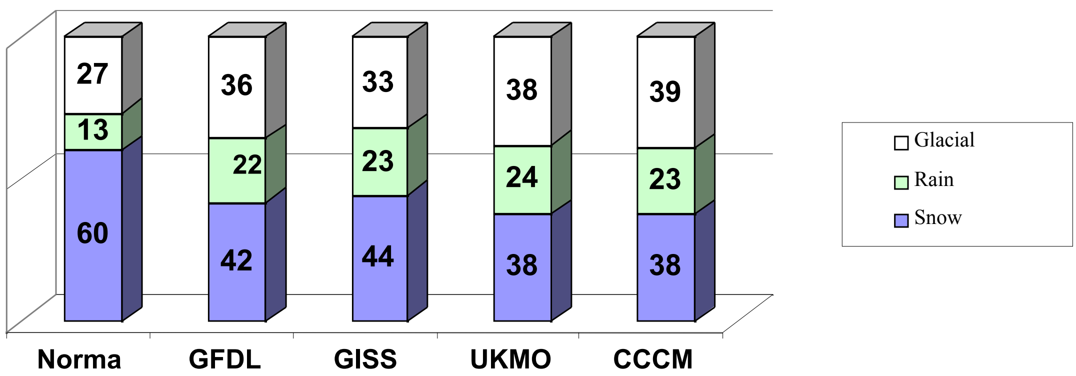


Fig. 7.5. The correlation (%) of snow, rain and glacial contribution to the watershed of the Zeravshan River for the base period under different climatic scenarios (the Amudarya River basin, snow-glacial type of river feeding)

Mountain glaciers are an important source of river feeding at the height of the summer season, when there is practically no water delivery from snow melting and rains. Model calculations demonstrate that in the distant future, the glacial run-off would depend on the rates of reduction of mountain glaciation. At present, the annual glacial run-off to the rivers of the Syrdarya River basin amounts to 8-15%. Under different prognoses, increase in this flow of up to 20% is expected (Fig. 7.3). Contribution of glacial run-off to the rivers of the Amudarya River basin might grow 32-39% under the most "severe" climatic scenarios.

7.3.2 Prospective Assessment of Water Resources

An integrated runoff assessment was made for the Syrdarya and Amudarya rivers based on numeric experiments with indicator-basins under different climatic scenarios.

During the cropping season, an increase is expected in evaporation from water surfaces of 15-20%. The most severe arid climate conditions in the watershed area were predicted under the CCCM model (average annual temperature increase by 6.5^{O}C, decline in annual precipitation rate by 11%). According to this model, if CO_2 concentration in the atmosphere is doubled, then the runoffs of the Syrdarya and Amudarya rivers are expected to be reduced by 28 and 40%, respectively (Table 7.1).

The UKNO model also predicts unfavorable outputs where temperatures may increase by 5.2^{O}C, while annual precipitation increases by 6%. In this case, runoff could be reduced by 15-21%.

Table 7.1

Expected Changes in Water Resources of the Main Rivers of the Aral Sea Basin under Implementation of Different Climatic Scenarios (% of the Base Norm)

Rivers	Basic Rate (km^3/year)	Climate scenarios				
		Regional, by the year 2030	GFDL	GISS	UKMO	CCCM
Syrdarya	37.9	+4	+1	-2	-15	-28
Amudarya	78.5	-3	0	-4	-21	-40

According to GFDL and GISS scenarios, average annual temperature in the catchment area would increase by 3-4^{O}C and average annual precipitation volume – by 10-15%. Under these scenarios, one could expect that no significant reduction in the Amudarya or Syrdarya runoff ould occur.

Calculations of regional climate scenarios by the year 2030 also indicate persistence of present run-off volumes accompanied by an increase in fluctuations from year to year. Longer-term assessments are more pessimistic, since, along with increasing evaporation, water resource inputs (snow and glaciers in the mountains) are continuously shrinking.

Under the current conditions of water shortage in Central Asia, even this small but continued reduction becomes a serious problem. The supposed flow reduction would be more pronounced during the vegetation period, thus being especially hazardous for irrigated farming and regional ecosystems (located on riverbanks and in deltas).

7.3.3 Adaptation Measures

In order to mitigate the negative consequences of water resource changes, establishing reliable hydro-meteorological monitoring and using information on snow cover and glacier characteristics for water management planning will be necessary.

According to the estimation of runoff formation regime, climate change will bring about increase in runoff variability, rise in the occurrence of extreme phenomena (droughts, intensive freshets, mudflows). Systematic activity on wood amelioration in the basins of lowland rivers is the most effective measure to combat mudflows.

Special attention should be given to the construction of water reservoirs on mountain rivers. This would allow for regulation of the river regime in accordance with the requirements of water users, *i.e.* to solve the ***water supply*** problem and to secure guaranteed water availability at the source.

Water supply activities are very time consuming - design, construction, and commissioning of water facilities could take some 10-15 years. Major water management should therefore be planned some 25 years ahead, and their commissioning should precede water demand by 10-15 years.

Long-term planning of water management activity requires that due consideration is given to the vulnerability of surface waters and to certain limitations of adaptation measures. Adaptation of measures should above all include water savings, extensive application of low water consuming technologies and more rational irrigation methods.

The current problem of water supply in Uzbekistan may become more severe if the dramatic changes predicted under the climate scenarios based on models of general atmospheric circulation are realized. Realization of the more severe climate change scenarios will result in a decline of the river run-off rate (Table 7.1) and sharply reduce irrigation capacity of the water supply system. At present, water resources of the rivers are almost fully consumed, and therefore, planned adaptation measures are required to address possible decreases in river water availability.

Water sector reorganization strategy should comprise:

- Restructuring and reorientation of the water sector towards efficient use of available water resources;
- Broad application of water-saving technologies in water consuming branches of industrial, agricultural, and household sectors;
- Upgrading of hydroreclamation systems, providing optimal water consumption per product;
- Use of water with higher salinity (as compared to standard) for irrigation purposes;
- Expansion of irrigated farmlands, mainly through the development of marginal lands;
- Upgrading the level of mechanization and automation of water distribution systems in river basins and irrigation districts;
- Transition to non-discharge systems of water use;
- Possible replenishment of water resources involving non-customary water sources (precipitation, glaciers, and snow-beds) within environmentally safe limits.
- Transition to a flexible system for optimal planning of agricultural production.

The following ***water sources*** should be considered:

- Part of the available mineralized water (approximately 4-6 km^3 out of 10-15 km^3/year are not currently used);
- Efficient use of precipitation;
- Cutback of non-productive evaporation from the lands of irrigated and non-irrigated areas, natural depressions, surface of water bodies and irrigation channels which equal a volume of 8-10km^3/year;
- Bringing in water resources from outside.

Rational water use in irrigated farming, as well as protective measures are the cornerstone of water savings. Reduction of specific water discharge is possible at four main points of total water intake: aggregated water consumption in the field; volume of water for leaching purposes; on-field losses; irrigation system losses. The following specific water-saving activities are suggested for the four above-listed points:

- reduction of leaching water rate;
- reduction of on-field losses;
- reduction of irrigation system losses.

Assessments have shown that the introduction of these measures will save 4.5-5.4 BCM of water by the year 2010.

The expected increase in evaporation will also reduce soil humidity. At present, the volume of average annual physical evaporation from an irrigated field in the Republic varies from 1000 to 1300 m^3/ha, with 90% of the irrigation volume occurring during the daytime.

According to calculations, it is possible to reduce water losses down to 2-3 km^3/year by means of the following activities:

- transition to closed-type irrigation systems with drip or subsoil irrigation; introduction of discreet technology for mechanized or automated subsoil by-furrow irrigation systems; concentrated (targeted) irrigation; sub-crown sprinkling of orchards and vineyards, etc.;
- transition to overnight irrigation;
- reduction of the area of marginal lands farmed;.

7.4 Consequences of Climate Change. Mitigation Measures for Some Ecosystems

7.4.1 Problems of the Aral Sea and Amudarya Delta

During the last third of this century, irrational water management caused a sharp decline in the volume of river water flowing into the delta (Fig. 7.5), a reduction in water availability in the delta, the shrinking of the Aral Sea (Fig. 7.6) and also deterioration of the environment in the Area adjacent to the Aral Sea (***Priaral'ye***) which became a zone of rapid development of all kinds of natural and anthropogenic desertification.

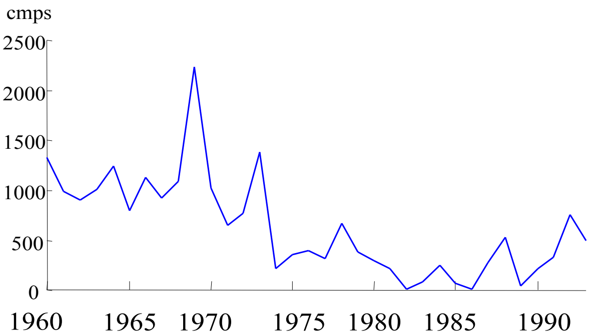


Fig 7.5. Mean annual discharges (cmps) of water inflow to the upper Amudarya delta

Environmental and socio-economic problems in the Aral Sea area emerged along with changes in the hydrographic network and decreases in the number of lakes and wetlands. For the period of 1955-1980 alone, reduced water delivery to Amudarya delta resulted in drying of more than 50 river-fed lakes, while the total surface area of the lakes was reduced from 600 km^2 to 80 km^2 (Fig. 7.7).

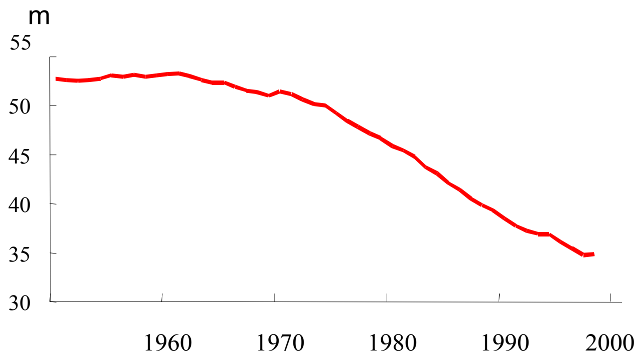


Fig. 7.6. Changes in the Aral sea water level

At the same time, the area occupied by reeds on shoals and wetlands was reduced 3.5 times, thus lessening the self-purification capability of delta and undermining traditional income generating activity of local people – fishing and fur trade. The feeding ground for herd breeding was ruined. The disappearance of unique fresh water lakes in the delta, intensive reformation of landscapes, and degradation of Aral ecosystems are jeopardizing the biodiversity in the region. The drying of the Aral Sea has lead to local-scale climate changes. In the former coastal areas, the climate has become more continental, the thermal regime has changed as well as the humidity level and wind regimes. According to the existing assessments, shrinkage of the Aral Sea affects meteorology of the lowest atmospheric layer of an area of 100-150 km, causing restructuring of the landscapes of the region. According to the regional climatic scenario, air temperature in Priaral'ye in summer could increase by 2-3 ^{O}C by the year 2030. Of all the components of water availability in the delta, water surface evaporation, evapotranspiration, and soil surface evaporation are the first to respond to climate change. According to instrumental evaporation monitoring data, there is a positive trend in the temporal series of changes of the evaporation layer (evaporation layer equaled 8-10 mm per year during the 1960-1995 period in Priaral'ye). Currently, evaporation value for the water surface of delta lakes is estimated to be 1150-1300 mm during the non-frost period, typically with increases in losses in the Southern areas

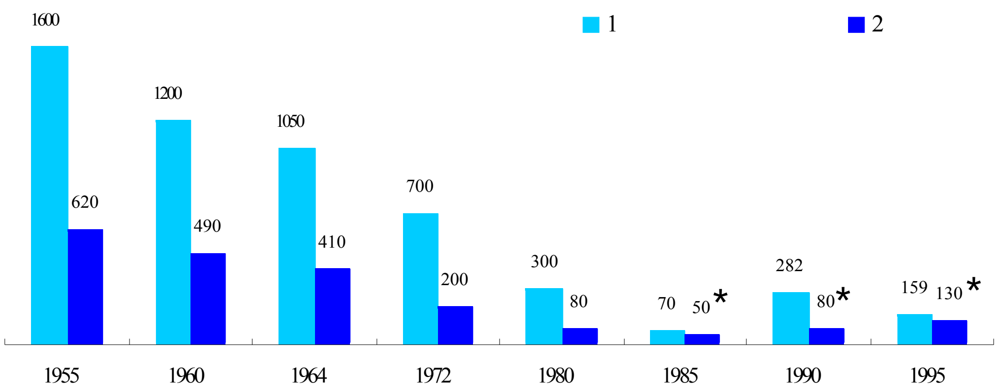


Figure 7.7 Ratio of Total Area of river-fed Amudarya delta lakes and water inflow to the upper delta (*- with consideration of man-made lake systems on the exposed seabed).
1 - water inflow to the delta, cmps; 2- total area of lakes, km^2

The expected temperature increase may cause thickening of evaporation layers by 8 – 15%. Transpiration by hydrophilous plants under conditions of Priaral'ye is 1.7 times higher than water surface evaporation. Because of further climate aridization, reduction of the area of lakes, advection of heat from the adjacent deserts and extension of the vegetation period, transpiration will be 1.8 – 1.9 times higher than evaporation.

Expected thickening of the evaporation layer will consequently increase water losses and irrigation rates in irrigated areas.

Thus, provided that the volume of water delivery to the delta remains the same, temperature increases and climate aridization will cause further reduction of water availability in the area. It will be accompanied by a reduction of humus in the soil, increases in salinity levels of internal-drainage lakes, accelerated eutrophication of water bodies, and gross deterioration of water quality.

Increased evaporation from the soil will lead to the migration of salts and affect the productivity of desert landscapes. Wind erosion will be increased. The level of equilibrium of the Aral Sea will go down, while salinization of the sea will continue to increase.

The expected increase in temperature and growth of heat consumption at evaporation along with decrease in accumulated resources (shrinking of the Aral Sea, depletion of groundwater resources) will cause deterioration of water quality in Priaral'ye.

The estimation of future water resources changes (see Section 7.3.2) does not show an increase in runoff, but assumes its considerable reduction during vegetation period in accordance with the scenarios of climate change. Therefore an intensification of the Aral Sea crisis can be expected.

7.4.2 Measures for Mitigation of Negative Effects of the Drying up of the Aral Sea

The ongoing "Aral Crisis" demands immediate implementation of measures to stabilize the environmental situation.

One of the priorities of "The Action Program for Improvement of the Socio-Economic Situation in the Aral Sea Basin" is the development of buffer protection areas in the form of a chain of local-scale water reservoirs which will partially compensate the declining productivity of the Aral Sea. Development of wetlands in Priaral'ye (Sudoch'ye lake system, Mezhdurechenskoe water reservoir, Rybachii and Muinakskii bays, the Smaller sea, and some reservoirs on the exposed seabed) will help to limit negative natural processes and to restore environmental equilibrium, protect natural landscapes from desertification, restore of biodiversity, and improve socio-economic conditions of the population.

Important adaptation measures also include development of a system for regulating the hydrological regime and water quality management, including a system to regulate water exchange in lakes, and also a system of mechanical refill of fresh groundwater lenses with river water.

Less expensive methods for water desalinization and purification must be developed and also a water supply for the population of Priaral'ye, including development of infrastructure for drinking water supply in urban and rural areas, should be established.

Desert landscapes and salt-lands are developing on territories previously occupied by now-dried lakes, as well as on the exposed seabed. More than 60% of such territories have a moderate saline level and are appropriate for efficient vegetative amelioration. On experimental sites of Priaral'ye, various agrotechnical methods are being tested along with selection of optimal types of ameliorative plants for different topographical conditions, hydrological regimes and salinity levels.

Positive results have been achieved by creating pasture-protective and ameliorative fodder-crop sites on sandy soils of the exposed seabed, and also by planting perennial halophytes on the coastal salt marches. The environmental effect of these activities includes reduction of wind velocity at ground level, formation of a more favorable microclimate and impeding salt transportation.

Efficiency of vegetative amelioration measures, as adapted to the changing conditions of the climate, will considerably increase provided that the genetic fund of the biogenesis existing in Priaral'ye can be preserved, including new species, that are growing on the exposed seabed and in irrigation-and-drainage lakes. Development of natural plant reserves and strengthening of their potential should be encouraged.

It is necessary to lessen extensive application of traditional surface irrigation methods, which have already had a negative impact (salinization and flooding of the territories, soil erosion, export of nutrients, etc.). In the future, under conditions of climate desertification and deterioration of surface water quality in Priaral'ye, application of water-saving technologies will be essential.

Improvement of life in Priaral'ye and creation of jobs are the cornerstone of adaptation measures.

The measures suggested for stabilization of the environmental situation are an important step in addressing the problems of Priaral'ye. Monitoring and analysis of implemented projects will become a basis for further development of adaptation measures to the expected climate change in the region.

7.4.3 Vulnerability of Forest Resources

The method of agroclimatic analogues is a theoretical base for assessing vulnerability of forest ecosystems. In accordance with this method, when plants are replaced form one climatic zone to another, we should establish the ratio of correspondence of climatic resources of new territory to the plant requirements expressed in agroclimatic indicators. In this case, new conditions appear on the old place. The sum of positive monthly temperatures and empirical indicator of climate humidity were assumed as agroclimatic indicators.

Mountain forests. Archa (mountain juniper) forests of Uzbekistan mountains are formed by three species: *Juniperus seravshanica Komar., J. semiglobosa Rgl. and turkestanica Komar*. They are widespread on the low-, middle and highland belt respectively. The probable climate warming will result in the following changes in location of juniper formations:

- the hypsometric level of juniper formation boundaries, especially of lower boundary of zeravshan archa, will rise. The hypsometric marks of the upper boundary of zeravshan and hemisphere junipers will rise by smaller values, while the upper boundary of turkestan juniper will remain at the present-day level.
- Shifting of juniper formation boundary will result in reduction of the elevation belt of juniper formation. Moreover, the elevation belt of lowland formations will reduce by bigger value in comparison with highland formation.
- Probably, the formation of wood type of turkestan juniper will be the most vulnerable. Under the 10% increase in annual precipitation norm, a considerable reduction of elevation belt of juniper in Turkestan-Alay forest region is possible.

Desert forests. Saxaul forests consisting of white and black saxaul occupy the largest areas. White or sandy saxaul grows within the territory of sand soils. It is drought-resistant, but rather vulnerable to soil salinization. Black or salty saxaul is salt-resistant, but vulnerable to droughts.

Under expected climate change, a new combination of positive temperature totals and indicators of climate humidity will not significantly affect the conditions of saxaul plantations, though the habitat conditions will be more severe.

Flood-plain forests (tugays). Tugays occupy flood-plains and river deltas periodically flooded. The main wood forming varieties of tugays are "turanga", willows and tamarisk. To a greater extent, the vulnerability of tugays depends on the people's activity (river water use, the level of ground water, taking into account the runoff regulation, regime of water releases and so on) rather than on climate warming.

The measures on mitigation of climate change impact include measures increasing the resistance of plantings, such as follows:

- limitation of grazing;
- promotion of natural renewal;
- combat against diseases and pests;
- prevention of fires;
- creation of wood crops and increasing the density of existing plantations with selective planting and sowing method;
- compliance with the legislative norms on nature protection;
- consideration of displacement of elevation zonality, when wood planting is planned in mountains

8. Education and Popularization

In recent years, significant attention has been paid to the matter of ecological education on all levels: in schools, colleges, and universities. At the school level, the topic is now included in biology, geography, chemistry, and economics courses, while in the higher education establishments (depending on the profile) special courses in ecology have been introduced.

Training of professionals in “Ecology and Natural Resource Use” is done in the majority of universities of the country. Specialists in hydrometeorology are trained in geography and physics faculties of Tashkent State University and in the Tashkent Hydro-Meteorological Technical College.

The program of courses in “Nature Protection”, “Engineering Ecology”, “Medicinal Ecology”, “Environmental Laws”, “Economics of Nature Use”, and “Social Ecology” should be amended and expanded with new information to incorporate the results of scientific studies on climate change. Adoption of special statutes, as well as a concept and strategy of the country in this regard, should contribute to the improvement of the system of ecological education in the field of climate change. It will facilitate the development and introduction of programs for training in the fundamentals of natural and associated social problems, and contribute to achievement of a higher level of ecological culture.

The latest information on anthropogenic impacts on climate change should be broadly popularized and made available to public. This could be achieved primarily by well-organized education and training activities. At present, there are no specialized popular scientific or scientific-engineering magazines devoted to the topic, while the small-scale publications issued by Glavgidromet and other agencies are unable to provide adequate coverage of these problems. A developed system of general and specialized education in Uzbekistan, as well as development of scientific research establishments are the necessary prerequisites for broadening knowledge about climate.

The experience of “Uzbekistan Country Study on Climate Change” Project offered a start for addressing this problem. Under the umbrella of this project, a number of workshops were conducted where discussion was possible on the results of climate change study, on the assessment of the probable consequences and mitigation measures including the workshop held in the Institute of Strategic and Interregional Researches on "The Problems of Realization of National Strategy to Reduce GHG Emissions". Seminars on the financial mechanisms of the Kyoto Protocol are recommended. ,. Government officials, scientists, teachers, and students of higher schools, NGO activists, and representatives of international agencies dealing with environmental problems attended these seminars. Articles were published in newspapers and magazines, and presentations were made on national TV and broadcast stations. Popular publications were issued and distributed in Uzbek and Russian languages. Three information bulletins were published on Uzbekistan's fulfillment of obligations under the Framework UN Convention on Clime Changes.

In this manner, we initiated the process of strengthening the information base of decision-makers and drawing public attention to the problem.

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9. Problems and Directions of Subsequent Activities

In the course of preparation of the First National Report of the Republic of Uzbekistan under the UNFCCC, we encountered a number of problems. Some of them were solved in the process of work on the report; others still require additional efforts and support.

The national inventory of greenhouse gases has revealed the need to create a registry of ***local emission factors, to specify coefficients for some types of fuel, and to upgrade data collection mechanisms in the Republic***. The lack of production of pumice, soda and aluminium, and the absence of statistics of asphalt and roofing bitumen production were the difficulties in the use of data on activity.

There is a separate objective of ***improving the existing data bank of greenhouse gases and inventory software***.

During the course of operation of IPCC software, some deficiencies in the software were discovered that complicated the inventory process: these included repeated input of coefficients for each new type of inventory, repeated input of the same data for the same year, and an incomplete original databank of greenhouse gases.

Therefore, in the future it will be necessary to:

a) supplement the existing database with information required for IPCC software operation;

b) integrate the database and IPCC software, so that the data may be transmitted from the database;

c) complement IPCC software with a reference system including lists with conversion factors and coefficients.

The National Action Plan should be extended. The possibility of making commitments by Uzbekistan to reduce GHG emissions should be considered. A number of regulated provisions and laws related to climate change issue should be developed.

Completing these tasks will expedite the logging procedure and reduce the probability of typing errors and blanks.

According to Article 4 of the UNFCCC, country-members of the Convention are required to develop activities for mitigation of climate change, in the following two areas:

- development of measures for reduction of greenhouse gas emissions in those sectors of economy, which directly affect the climate (energy, industry, transport, communal sector, agriculture, etc.);
- development of adaptation measures for the environment, ecosystems, and those branches of economy that are most susceptible to climatic change (agriculture, water sector, etc.).

The main problem in the first of these areas is the absence of unified procedures for economic assessment of projects dealing with reduction of greenhouse gas emissions. Nevertheless, preliminary assessment of some 20 new projects has been done already.

Assessment of possible future climate changes in the region and the generation of climate scenarios should precede work in the second of the two areas. The major obstacle in this case is the high extent of uncertainty of the existing climate scenarios. For many sectors (agriculture, water management), scenarios are required with seasonal and monthly resolution. The general circulation models, which are currently used as recommended by the IPCC for generation of climate scenarios, are being continuously improved. Therefore, for the assessment of changes in different regional climatic characteristics, it is necessary to develop procedures for statistical interpretation of the output of global models.

The IPCC recommends using different approaches to assess climate change: considering impact only, considering interaction, and a comprehensive approach. In the first approach, the influence of non-climatic factors is ignored. The second approach takes into account both climate and a combination of other factors. Such an approach makes it possible to consider feedback, which could strengthen or weaken other impacts. A comprehensive approach is the most universal consideration of correlation between climate and society. This approach envisages general interaction inside the sectors, between the sectors, feedback links, and adaptation measures.

So far, assessment of vulnerability of water resources of the Aral Sea basin had been carried out with consideration of climatic factors only. ***An integrate assessment of vulnerability is required, one that would take into account development of agricultural and water sectors.*** In the future, it is recommended that comprehensive approaches for vulnerability assessment of environmental components and various sectors be used. Hence, the need for additional studies and application of special models is evident. The expected increase in a number of droughts, extreme floodings and mudflows bring about the need for developing the relevant studies and for elaborating some preventive measures.

Atmospheric aerosol is an element of the climate system that directly affects radiation balance of the atmosphere, and also the formation and microstructure of clouds. Central Asia is one of the most heavily aerosol polluted regions of the world - geographical and climate conditions of the area (dry climate, vast areas of deserts and saline lands, soil loss in the irrigated territories) contribute to this pollution.

Analysis of the density trends of dry atmosphere precipitation (as an indirect trait of aerosol concentration in atmosphere) and changes in direct solar radiation confirm the growth in concentration of atmospheric aerosol, and continued shrinking of the Aral Sea aggravates the problem.

All of the above stands as evidence to the relevance of the aerosol effect on climate characteristics of the region. A fine-tuned aerosol-monitoring system is needed, capable of determining physical and physio-chemical properties of aerosol and to identify the emission sources.

Article 6 of the Framework Convention indicates the need to develop programs related to public awareness of climate change. Therefore, it is extremely important ***to develop and improve regional climate monitoring systems***. It is absolutely necessary to develop climate monitoring in environmentally fragile areas, such as the Priaral'ye and Fergana Valley.

The Pamirs and Tien-Shan Mountains are runoff formation areas for the rivers of Central Asia. The process is most intensive in glacier basins. Glaciers are the last sources of chemically pure water and are very susceptible to climate change. ***Monitoring of mountain glaciers and snow stock is required*** in the areas that serve as indicators of climate change.

An important component of glacier monitoring is regular observations at Abramov Glacier that were started in September 1967 and have continued to the present. Monitoring data on this glacier appears to be representative for such a vast mountain territory as the entire Pamir-Alay range. The observed changes are unique for Central Asia and for the whole world. It is also very important that monitoring results be integrated into a specialized database that makes them suitable for analysis. However, the systems of collection, analysis and presentation of information require upgrading to a more contemporary technical level. This will provide timely generation and presentation of unique information on the current condition and the expected changes in water reserves of this benchmark glacier.

The observed reaction of the regional climate to global warming underlines the necessity of improving the operative processing, analysis, and distribution of complete climate information and delivery of this information to the users in a convenient, visual and informative form. In many countries and regions of the world, reviews and bulletins on global and regional climate systems are published on a regular basis.

At the present time in Uzbekistan there are no regular publications on changes in climate systems (climate monitoring bulletins), although this is customary in much of the world. Therefore, it is necessary to create a mechanism for publication of such periodic bulletins to provide public access to data on climate change, prepared in an informative manner.

In order to rationalize preparation of reviews on conditions and changes in the climate system of Central Asia and provide broad and open distribution thereof, certain specific tasks must be completed:

a) integration of uniformly presented, good quality data from the existing databanks and databases of various disciplines into a single database of climate data and development of a system for maintenance of this database; and

b) development of a mechanism for publication of bulletins on climate monitoring on a regular basis.

Regular publication of a regional bulletin on climate monitoring will help to draw the attention of the public and politicians to the problems related to climate change on both a regional and global scale.

The most important problem in the Central Asian countries is the scarcity of water resources. After gaining independence, each of the republics declared their rights to water resources formed on their territories. Unequal supply of population and territories with water resources, different intensity of agricultural and industrial production and related water demand, as well as existing peculiarities in approaches to ownership rights in national water laws have attached an unique character to water use. Under the conditions of climate change, an ***integrated information exchange system*** of water resource assessment for the entire region and separate republics is required in order to elaborate adaptation measures. Development of such a system would require cooperation of different international agencies, such as WMO, UNDP, and others.

Another problem that needs to be addressed is the ***development of an inventory of renewable energy sources***. Reserves of organic fuel in the region are limited. Development of nuclear power production in Uzbekistan, since it is located in seismically active zone, is a rather remote possibility. UNFCCC requirements demand gradual reduction of the amount of fuel burned, and introduction of non-traditional power sources. For a realistic assessment of wind and solar power resources in the region, it is necessary to study the patterns of space-time mutability of the energy sources including consideration of the peculiarities and technical parameters of wind- and solar power stations. Examination of the combination of the two processes – energy accumulation from the source and power generation for further delivery to consumers – will allow scholars to determine the real volume of energy received, as well as the need in energy accumulation or involvement of other energy sources. Data on wind velocity and monitoring solar radiation in the meteorological network should be calculated and included into the appropriate inventory. Development of an inventory of wind and solar power resources will make it possible to use wind and solar power stations more actively, and avoid the extra costs associated with use of technology that does not fit local conditions. For separate districts it will be necessary to assess the relative expediency of use of various technologies, as well as the necessity of using additional energy sources.

Information on the condition of the climate system and problems related to climate change will contribute to fulfillment of a variety of social, economic and environmental tasks, since the information is required to forecast natural phenomena, determine the demand in irrigation, energy, and many other areas of human activity. Broad awareness of politicians and the public about the conditions and extent of climate change is necessary for decision making and popularization of knowledge.

A priority list of possible projects that would require funding is given below:

Inventory of greenhouse gases:

- to examine local emission factors and develop a more precise definition of coefficients for some types of fuel;
- to improve data collection mechanisms;
- to upgrade greenhouse gas inventory software and further develop the existing databank;
- to elaborate a procedure for economic assessment of projects connected to the reduction of greenhouse gas emissions.

Climate studies:

- to make a comprehensive vulnerability assessment of water resources in the Aral Sea Basin including consideration of developing agricultural and water management sectors;
- to elaborate procedures for statistical interpretation of the results of global climate models for the assessment of changes in regional climate characteristics;
- to study the impact of aerosol on the climate system.

Development and improvement of a system for regional monitoring of climate and information dissemination:

- to support efforts to maintain and develop an observation network in the region, especially at stations that serve as indicators of anthropogenic changes of climate (stations in Priaral'ye);
- to generate local geographical information on the "Abramov Glacier" by integrating the collected data on accumulation and melting of snow and ice, and the mass balance of the glacier on a cartographic basis;
- to generate a uniform climate database and elaborate a system for maintenance and replenishment thereof;
- to develop a mechanism for regular publication of a Regional Climate Monitoring Bulletin;
- to construct an integrated information exchange system for water assessment in the entire Central Asia and separate republics;
- to elaborate inventories of renewable power sources based on the data gathered by observations of solar radiation and wind velocity.

Atmospheric aerosol monitoring:

- to establish an atmospheric aerosol monitoring system;
- to develop a model of transportation and sedimentation of atmospheric aerosol on the territory of Uzbekistan.

10. Proposals for Institutional Structure for Implementation of the UNFCCC in Uzbekistan

According to Article 4.1(b) of the UN Framework Convention on Climatic Changes "All Parties … shall formulate, implement, publish, and regularly update national and, where appropriate, regional programs containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks …". Hence, elaboration, implementation, and regular renewal of national programs comprising the measures for mitigation of the consequences of climatic changes, as well as contribution to adequate adaptation to the impact are the key obligations of the Parties under the Convention.

Long-term fulfillment of the UNFCCC obligations requires the Parties to carry out policies and measures on a regular basis in all the sectors of economy that are linked to climate changes, or could potentially impact the climate. According to the greenhouse gas inventory data, these are the energy sector, transport, industry, agriculture and forestry sectors, the water management sector, and the waste utilization sector.

Recognizing the importance of addressing the problem of climate change and the necessity of adopting efficient measures for prevention of possible negative consequences, and for coordination purposes, the Uzbek Government in 1995 formed the National Commission of the Republic of Uzbekistan for Addressing the Problems of Climate Change, headed by the Deputy Prime Minister of the Republic. There are 34 members in the commission, representing the following ministries, departments, and agencies:

- Ministry of Macroeconomics and Statistics
- Hydro-Meteorology Directorate (Glavgidromet)
- State Nature Protection Committee (GosComPriroda)
- Ministry of Energy and Electrification
- Ministry of Finance
- Ministry of Higher and Secondary Special Education (MinVUZ)
- Ministry of Agriculture and Water Management
- Ministry of Justice
- Ministry of Public Health
- Ministry of Foreign Affairs
- Ministry of Housing and Communal Services
- State Committee for Science and Engineering (GKNT)
- Academy of Science
- State Forestry Committee
- State Committee for Architecture and Construction
- State Publication Committee
- Uzbek State Committee for Standards
- Uzbek State TV and Broadcast Company
- National Aviation Company "Uzbekiston Khavo Yullari"
- State Joint Stock Railway Company "Uzbekiston Temir Yullari"
- Association of Chemical Industry Enterprises "Uzkhimprom"
- State Joint Stock Company for Automobile Transport "Uzaavtotrans"
- Uzavtodor
- Uzbytsoyuz
- *APO "UzMetKombinat"
- GosGorTechNadzor
- Joint Stock Company "UzVtorTsvetMet"
- Joint Stock Company "Ugol" (Coal)
- Angren Mining and Metallurgical Industrial Complex

- AK “UzStroyMaterialy” (Construction Materials)
- Navoii Mining and Metallurgical Industrial Complex
- National Oil and Gas Corporation “UzbekNefteGas”
- “SpetsSplav” State Facility (Special Alloys)
- GGP ”UzbekGidroGeologiya” (State Hydrogeological Facility)

In 1992, the Government of Uzbekistan has assigned the State Hydro-Meteorology Directorate (Glavgidromet) as the agency in charge of providing the Government and other agencies with information on actual and expected hydro-meteorological conditions and climate change, the level of environmental pollution, and a centralized compilation of associated information. Glavgidromet performs the analysis of anthropogenic impacts on hydro-meteorological processes, climate, and environment, and generates recommendations on elimination of hazardous consequences thereof; takes part in international cooperation with regard to the matters of hydro-meteorology, climate and climate change, pollution monitoring, condition of the higher strata of the atmosphere and the ozone stratum. In 1995, Mr. V. E. Chub - the Chairman of Glavgidromet - was assigned as a national representative of Uzbekistan in the secretariat of the UNFCCC.

During implementation of the UNDP/GEF Project “Uzbekistan Country Study on Climate Change”, Glavgidromet formed teams of national experts in greenhouse gas inventory, analysis of regional climatic vulnerability, and development of measures for adaptation to and mitigation of climate change.

The following organizational structure (see Fig. 10.1) was formed for further fulfillment of the national obligations of the Republic of Uzbekistan under the Convention.

In the course of preparation of the First National Report, Glavgidromet has concentrated greenhouse gas inventory databases, refined the software for the inventory, and established a specialized information center for elaboration of National Communications, for analyses of issues connected with the mechanisms of the Kyoto Protocol and technologies exchange.

Research on the climate system was carried out by a specialized research organization – the Central Asian Scientific Research Hydro-Meteorological Institute (SANIGMI), which is a unit of Glavgidromet and has a climate system database.

A study on vulnerability of ecosystems and development of adaptation measures was carried out by several specialized agencies – Glavgidromet, the State Nature Protection Committee, the State Forestry Committee, the Ministry of Agriculture and Water Management, the State Committee for Science and Engineering, and the Academy of Science.

The Ministry of Macroeconomics and Statistics, in association with the State Nature Protection Committee and with the involvement of necessary experts, developed recommended measures for mitigation of climate change.

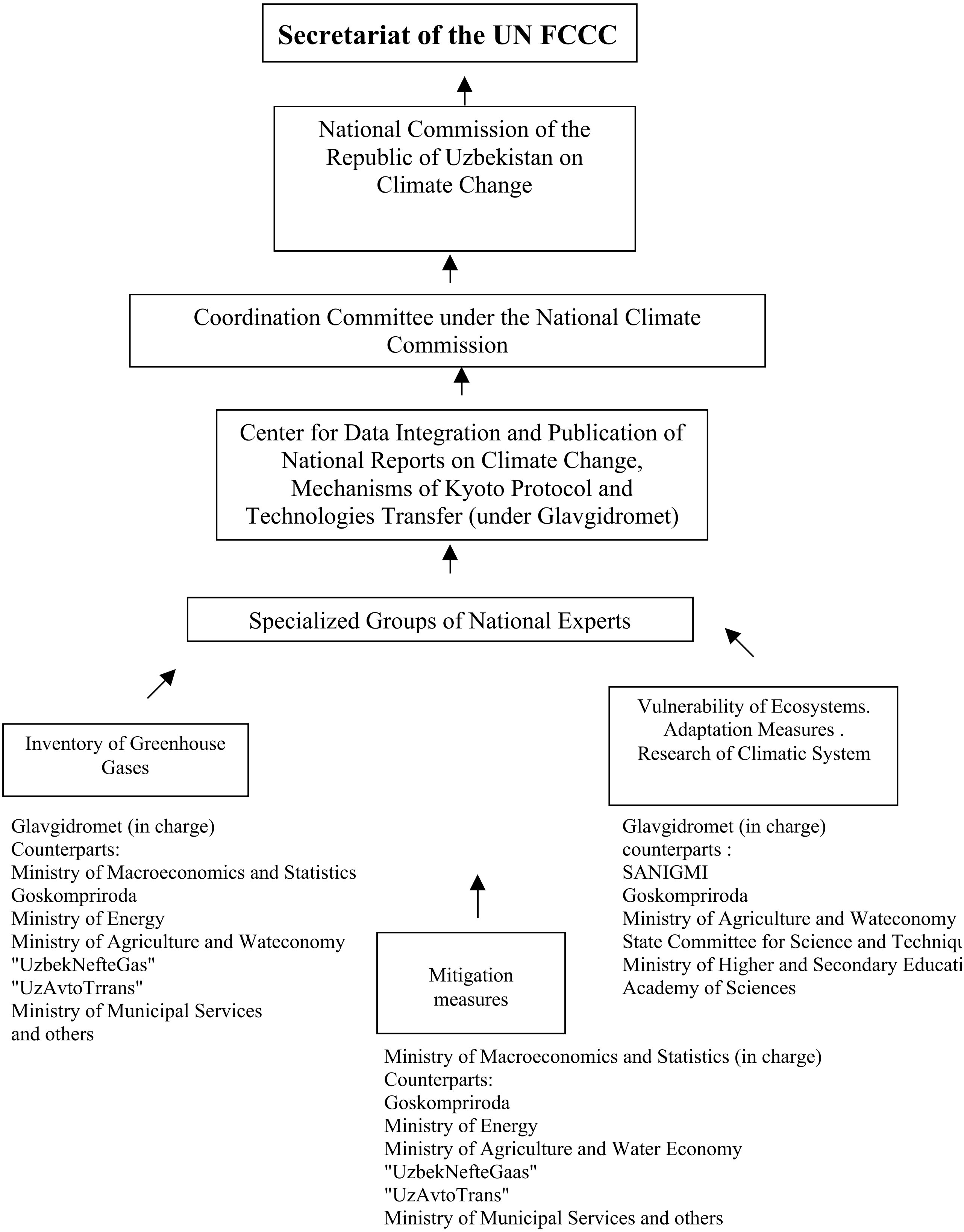

Fig. 10.1 Organizational Structure for Activity under the UNFCCC and Kyoto Protocol in the Republic of Uzbekistan

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REFERENCES

Chapter 1

1. Report on Human Development. Uzbekistan, 1998. Tashkent, 1998, Center of Economic Researches, 1998. –114 p.
2. I. A. Karimov. Uzbekistan on the threshold of XXI century. Threat to the security: conditions and guarantees of progress. – Tashkent, 1997. –315 p.
3. Climate of Uzbekistan. Edited by S. G. Chernyshova. – Tashkent, 1996. –71 p.
4. Muminov F. A., Abdullaev H. M. Agricultural-and-climatic resources of the Republic of Uzbekistan. Tashkent: Glavgidromet RUz. – 1997. –179 p.
5. Nikitin A. M. Lakes of Central Asia. –L.:Gidrometeoizdat, 1991. –163 p.
6. Glaciation in Pamir-Alay Mountains. 1993., Edited by V. M. Kotlyakov. – Moscow, Publishing House “Nauka”. – 256 p.
7. The main provisions of regional water strategy in the Aral Sea Basin. Report Brief. IFAS-ICWC. Tashkent, 1997. – 66 p.
8. Chub V. E., Ososkova T. A. Climatic changes and surface water resources of the Aral Sea Basin. / Bulletin #3, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –p 5-15.
9. Ososkova T.A., Vasikov A.P., Chub V.E. Main results of inventory of GHG from energy activity. / Bulletin #2, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. - p. 11-20.

Chapter 2

1. Greenhouse Gas Inventory Handbook. Revised Guidelines for National Greenhouse Gas Inventories. IPCC, 1996, Vol. 2.
2. Greenhouse Gas Mitigation Assessment: A Guidebook. Jayant Sathaye, Stephen Meyers. Kluwer Academic Publishers. Dordrecht/Boston/London. 1995.
3. International Energy Agency. Energy statistics and balances of non-OECD countries. 1995-1996. OECD/IEA, Paris, 1998.
4. FCCC/SBSTA/1999/L. 5/p. 18
5. Instruction on the procedure of State account of forests, Moscow, 1982, 96 p.
6. Main results of inventory of GHG from energy activity. / Bulletin #2, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. - p. 50.

Chapter 3

1. Minmacroeconomstat. Macroeconomic forecast for future development of economy of Uzbekistan., Tashkent, 1998.
2. Vasikov A.P. Energy balance of Uzbekistan - database for GHG inventory. // Bulletin #2, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent, SANIGMI, RUz, 1999. - p. 5-10.

Chapter 4

1. Mitigation measures on climate change in Uzbekistan. Bulletin #4 in edition, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent.

Chapter 5

1. Mitigation measures on climate change in Uzbekistan. Bulletin #4 in edition, Information on fulfillment of commitments to the UNFCCC by Uzbekistan., Tashkent.

Chapter 6

1. Avsyuk F. A., Grosvald M. G., Kotlyakov V. M. Palaeoglaciology: subject and methods, objectives and successes. –Materials of glaciologic studies. Chronicle. Discussions. 1972, issue #19. Pp 92-98.
2. Agakhanyants O. E., Nikonov A. A., Pakhomov M. M., Ranov V. A., Trofimov A. K., Chediya O. K. About the ancient glaciation of Pamirs.//Newsletters of the Academy of Science of the USSR. 1981. #14, geography series, pp 123-133.
3. Vainbergs I. G., Stelle V. Ya. Late Quaternary stages of development of the Aral Sea and their link to present time changes of climatic conditions.// Fluctuation of humidification in the Aral-Caspian region in Holocene. M., "Nauka".:1980.pp 175-181.
4. Glazyrin G. E., Spektorman T. Yu., Chanysheva S. G. Climatic studies of the last years.// In "Hydrometeorology of Uzbekistan – successes, problems, prospectives. – Tashkent, 1998, pp 89-90.
5. Glazyrin G. E. Calculation of main parameters of mountain glaciation under climatic changes. – MGI. 1986. Issue #57., pp 44-47.
6. Glazyrin G. E., Mamedov E. D., Merkushin A. S., Trofimov G. N., Chernova N. A. Assessment of glaciation and runoff in the basin of Zeravshan River in Holocene.- Proceeding of SARNIGMI, 1989, Issue #1332(213), pp 107-113.
7. Abramov Glacier (the Alay Mountain Range)/V. F. Suslov, A. A. Akbarov, V. K. Nozdryukhin, et al. – L.:Gidrometeoizdat, 1980. –260 p.
8. Mamedov E. D. Pluvial and arid landscapes in late Pleistocene and Holocene history of desert of the USSR and neighboring countries. // Development of nature in the USSR during late Pleistocene and Holocene. M.: "Nauka". 1982. pp 37-43
9. Pertsiger F. I. Abramov Glacier Data Reference Book: Climate, Runoff, Mass Balance (in Russian and English). Technical University, Munich, 1996.-279 p.
10. Pertsiger F. I. Water resources of the glacier basin – response to climatic changes. /Bulletin #3, Information on fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 33-37.
11. Spectorman T. Yu., Nikulina S. P. Scenarios of possible climatic changes in Uzbekistan and adjacent mountain territory on the basis of outputs of general circulation model. / Bulletin #1, fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 41-53.
12. Strelnikova T. V. On-land hydro-meteorological network. // In "Hydrometeorology of Uzbekistan – successes, problems, prospective. – Tashkent, 1998, pp. 29-32.
13. Ice thickness and under the ice relief at Abramov Glacier according to data of low-frequency logging / V. A. Kuzmichenok, E. V. Vasilenko, Yu. Ya. Matcheret, M. Yu. Moskalevskii // Proceedings of glaciological studies. Chronicle, discussions. – 1992. – Issue #75. pp. 92-97
14. IPCC Technical Guidebook for the assessment of influence of climatic changes and adaptation/ Edited by T. P. Carter, M. L. Parry, H. Harasava, S. Nishioka,. – Geneva: WHO, 1995. –65p.
15. Chub E. V., Chanysheva S. G., Nikulina S. P., Spektorman T. Yu., Subbotina O. I. Elaboration of regional climatic scenarios. / Bulletin #1, fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 5-14.

16. Chub V. E. 75th anniversary of Hydro-Meteorological Service // In "Hydrometeorology of Uzbekistan – successes, problems, prospective. – Tashkent, 1998, pp. 5-13.
17. Country Studies Program, 1994. Guidance for Vulnerability and Adaptation Assessment. Version 1.0. Washington. D.C.
18. Climate Changes 1995, The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change./Edited by J. T. Houghton, L. G. Miera Filho, B. A. Calldner, N. Harris, A. Kattenberg, K. Maskell. –Cambridge: University Press, 1995. – 527 p.
19. The Regional Impacts of Climate Change. An Assessment of Vulnerability / Edited by R. T. Watson, M. C. Zinyowera, R. H. Moss. – Cambridge: University Press, 1998. – 517 p.

Chapter 7

1. Agaltseva N. A. Borovikova L. N. Assessment of Vulnerability of the Flow of Central Asian Rivers in the Catchment Area to Possible Influence of Climate Change. / Bulletin #3, Fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 38-47.
2. Babushkin O. L., Chub V. E. Change In Agro-climatic Conditions of Pastures of Uzbekistan Related to Possible Climate Change. Bulletin #1, Fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 34-40.
3. Borovikova L. N., Gorelkin N. E. Impact of Climate Change and Water Availability of Territories on Environmental Condition of the Southern Priaral'ye./ Bulletin #3, Fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 63-74.
4. Usmanov V. O., Nikulina C. P., Chub V. E. Assessment of Climate Change Impact on Agro-climatic Resources and Productivity of Major Crops of Uzbekistan. / Bulletin #1, fulfillment of obligations under UNFCCC by Uzbekistan., Tashkent, Glavgidromet RUz, 1999. –pp 26-33.
5. Hamraev N. R., Bedrintsev K. N. The Matters of Water Supply Strategy in the Development of National Economy of Uzbekistan. // Social Sciences in Uzbekistan, 1989, #1. – pp.3-12.
6. Assessment of Water Resources and Water Availability in the World. Scientific Leader and Editor Prof. I. A. Shiclomanov. – WMO and Stockholm Environment Institute, 1998.

LIST OF ACRONYMS AND ABBREVIATIONS

NPS	Nuclear Power Station
GDP	Gross Domestic Product
RES	Renewable Energy Sources
WMO	World Meteorological Organization
WPS	Wind Power Station
GosKomLes	State Forestry Committee
HPP	Hydropower Plant
SDPS	State District Power Station
GEF	Global Environmental Facility
IPCC	Intergovernmental Panel on Climate Change
MMES	Ministry of Macroeconomics and Statistics
NRES	Non-traditional Renewable Energy Sources
NAP	National Action Plan
OR	Oil Refinery
NGO	Non-Government Organization
NMH	Non-Methane Hydrocarbons
o.e.	Oil Equivalent
GG	Greenhouse Gas
GWP	Global Warming Potential
PPP	Parity of Purchasing Power
UNDP	United Nations Development Program
UNFCCC	UN Framework Convention on Climate Change
RUz	Republic of Uzbekistan
SANIGMI*	Central Asian Scientific Research Institute of Hydrometeorology
FEC	Fuel- Energy Complex
TPP	Thermoelectric Power Plant
FS	Feasibility Study
TEP	Thermoelectric Plant
SGU	Steam-and-Gas Facility
GTU	Gas Turbine Unit
FER	Fuel-Energy Resources
IA	Industrial Amalgamation
e.f.	Equivalent Fuel
USAID	United States Agency for International Development
GCMs	General Circulation Models
CCC	Canadian Climate Center
GFDL	Geophysical Fluid Dynamics Laboratory of Princeton University (US)
GISS	Goddard Institute for Space Studies (US)
UKMO	Meteorological Agency of the United Kingdom

CHEMICAL SYMBOLS

CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
N_2O	nitrous oxide
NO_x	nitrogen oxides

UNITS OF MEASUREMENT

^{O}C	Degree Celsius
ha	Hectare
GW	Gigawatt (10^9 Watt)
Gg	Gigagram (10^9 gram)
kW/h	Kilowatt/hour
km	Kilometer
km^2	Square kilometer
m	Meter
cmps	cubic meters per second

Annex

Summary Tables of Presented Data for 1990, 1994, in the Standardized Format and Table of the Estimation of Data Completeness and Quality

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Total National Emissions and Removals	**114,560**	**-421**	**1,798**	**35**	**343**	**1,979**	**73**	**569**	**0**	**0**	**0**	**0**	**0**	**0**
1 Energy	**108,010**	**0**	**1,320**	**0**	**340**	**1,965**	**44**	**525**						
A Fuel Combustion (Sectoral Approach)	108,010		0	0	340	1,964	0	518						
1 Energy Industries	54,698		0	0	0	0	0							
2 Manufacturing Industries and Construction	10,736		0	0	0	0	0							
3 Transport	17,326		0	0	0	0	0							
4 Other Sectors	24,747		0	0	0	0	0							
5 Other (please specify)	503		0	0	0	0	0							
B Fugitive Emissions from Fuels	0		1,320		0	1	44	7						
1 Solid Fuels			22											
2 Oil and Natural Gas			1,298		0	1	44	7						
2 Industrial Processes	**6,549**	**0**	**0**	**1**	**2**	**14**	**29**	**44**	**0**	**0**	**0**	**0**	**0**	**0**
A Mineral Products	2,926					0	0	2						
B Chemical Industry	2,625		0	1	2	14	8	42						
C Metal Production	998		0	0	0	0	0	0	0	0	0	0	0	0
D Other Production	0				0	0	20	0						
E Production of Halocarbons and Sulphur Hexafluoride									0	0	0	0	0	0
F Consumption of Halocarbons and Sulphur Hexafluoride									0	0	0	0	0	0
G Other (please specify)	0		0	0	0	0	0	0				0		0

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach.

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs		PFCs		SF6	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**0**			**0**			**0**							
4 Agriculture			**328**	**34**	**0**	**0**								
A Enteric Fermentation			278											
B Manure Management			38	1										
C Rice Cultivation			12											
D Agricultural Soils				33										
E Prescribed Burning of Savannas			0	0	0	0								
F Field Burning of Agricultural Residues			0	0	0	0								
G Other (please specify)			0	0										
5 Land-Use Change & Forestry	**(1) 0**	**(1) -421**	**0**	**0**	**0**	**0**								
A Changes in Forest and Other Woody Biomass Stocks	(1) 0	(1) -421												
B Forest and Grassland Conversion	0		0	0	0	0								
C Abandonment of Managed Lands		0												
D CO2 Emissions and Removals from Soil	(1) 0	(1) 0												
E Other (please specify)	0	0	0	0	0	0								
6 Waste			**149**	**0**	**0**	**0**	**0**	**0**						
A Solid Waste Disposal on Land			139											
B Wastewater Handling			10	0										
C Waste Incineration														
D Other (please specify)			0	0										
7 Other (please specify)														

(1) The formula does not provide a total estimate of both CO2 emissions and CO2 removals. It estimates "net" emissions of CO2 and places a single number in either the CO2 emissions or CO2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs		PFCs		SF6	
									P	A	P	A	P	A
Memo Items														
International Bunkers	**1,996**		**0**	**0**	**0**	**0**	**0**	**1**						
Aviation	1,996		0	0	0	0	0	1						
Marine	0		0	0	0	0	0	0						
CO2 Emissions from Biomass	**0**													

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOUR AND SINK CATEGORIES	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		HFCs		PFCs		SF6		Documen-tation	Disaggrega-tion	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Total National Emissions and Removals																							
1 Energy																							
A Fuel Combustion Activities																							
Reference Approach	ALL	H																					
Sectoral Approach	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
1 Energy Industries	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
2 Manufacturing Industries and Construction	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	2	
3 Transport	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
4 Other Sectors	ALL	H	NE		NE		NE		NE		NE		PART	H	NA		NA		NA		H	3	
5 Other (please specify)	PART	M	NE		NE		NE		NE		NE		NE		NA		NA		NA		H	1	
B Fugitive Emissions from Fuels	NE		ALL	M	NE		PART	H	NE		PART	H	NE		NA		NA		NA		H	2	
1 Solid Fuels	NE		ALL	M	NE		NE		NE		NE		NE		NA		NA		NA		H	2	
2 Oil and Natural Gas	NE		ALL	M	NE		ALL	H	ALL	H	ALL	H	NE		NA		NA		NA		H	2	
2 Industrial Processes																							
A Mineral Products	PART	H	NA		NE		NE		NE		PART	H	PART	H	NA		NA		NA		M	2	
BChemical Industry	PART	H	NE		PART	M	PART	M	NE		PART	H	ALL	H	NA		NA		NA		M	2	
CMetal Production	PART	H	NE		NE		NE		PART	H	PART	H	PART	H	NE		NE		NE		M	2	
D Other Production	NE		NE		NE		NE		NE		PART	H	NE		NA		NA		NA		M	2	
E Production of Halocarbo and Sulphur Hexafluoride	NA		NA		NA		NA		NA		NA		NA		NO		NO		NO				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 2 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		HFCs		PFCs		SF6		Documen-tation	Disaggre-gation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Industrial Processes (cont...)																							
F Consumption of Halocarbons and Sulphur Hexafluoride	NA		NA		NA		NA		NA		NA		NA		NO		NO		NO				
Potential (1)																							
Actual (2)																							
G Other (please specify)																							
3 Solvent and Other Product Use																							
4 Agriculture																							
A Enteric Fermentation	NA		ALL	H	ALL	H	NA		NA		NA		NA		NA		NA		NA		H	3	
B Manure Management	NA		ALL	H	ALL	L	NA		NA		NA		NA		NA		NA		NA		H	3	
C Rice Cultivation	NA		ALL	M	NA		NA		NA		NA		NA		NA		NA		NA		H	1	
D Agricultural Soils	NA		ALL	M	ALL	L	NA		NA		NA		NA		NA		NA		NA		H	1	
E Prescribed Burning of Savannas	NO		NO		NO		NO		NO		NO		NO		NO		NO		NO				
F Field Burning of Agricultural Residues	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				
G Other (please specify)																							
5 Land-Use Change & Forestry																							
A Changes in Forest and Other Woody Biomass Stocks	PART	M	NE		NE		NE		NE		NE		NE		NA		NA		NA		H	1	
B Forest and Grassland Conversion	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				

(1) Potential emissions based on Tier 1 Approach.

(2) Actual emissions based on Tier 2 Approach.

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 3 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		HFCs		PFCs		SF6		Documentation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
5 Land-Use Change & Forestry (cont....)																							
C Abandonment of Managed Lands	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				
D CO2 Emissions and Removals from Soil	NE		NE		ME		NE		NE		NE		NE		NA		NA		NA				
Other (please specify)																							
6 Waste																	NA		NA		H	2	
A Solid Waste Disposal on Land	NA		ALL	M	NA		NA		NA		NA		NA		NA		NA		NA		H	2	
B Wastewater Handling	NA		PART	M	NA		NA		NA		NA		NA		NA		NA		NA		M	2	
C Waste Incineration	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				
D Other (please specify)																							
7 Other (please specify)																							
Memo Items:																							
International Bunkers																							
Aviation	ALL	M	NE		NE		NE		NE		NE		NE		NA		NA		NA		H	2	
Marine	NO		NO		NO		NO		NO		NO		NO		NA		NA		NA				
CO2 Emissions from Biomass	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs		PFCs		SF6	
									P	A	P	A	P	A
Total National Emissions and Removals	**102,157**	**-399**	**1,991**	**32**	**243**	**1,355**	**61**	**276**	**0**	**0**	**0**	**0**	**0**	**0**
1 Energy	**97,215**	**0**	**1,459**	**0**	**242**	**1,346**	**40**	**254**						
A Fuel Combustion (Sectoral Approach)	97,215		0	0	242	1,345	0	247						
1 Energy Industries	44,785		0	0	0	0	0							
2 Manufacturing Industries and Construction	6,263		0	0	0	0	0							
3 Transport	9,006		0	0	0	0	0							
4 Other Sectors	36,824		0	0	0	0	0							
5 Other (please specify)	337		0	0	0	0	0							
B Fugitive Emissions from Fuels	0		1,459		0	1	40	7						
1 Solid Fuels			13											
2 Oil and Natural Gas			1,446		0	1	40	7						
2 Industrial Processes	**4,942**	**0**	**0**	**0**	**0**	**10**	**21**	**22**	**0**	**0**	**0**	**0**	**0**	**0**
A Mineral Products	2,330					0	0	1						
B Chemical Industry	1,838		0	0	0	10	6	21						
C Metal Production	774		0	0	0	0	0	0	0	0	0	0	0	0
D Other Production	0				0	0	15	0						
E Production of Halocarbons and Sulphur Hexafluoride									0	0	0	0	0	0
F Consumption of Halocarbons and Sulphur Hexafluoride									0	0	0	0	0	0
G Other (please specify)	0		0	0	0	0	0	0				0		0

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach.

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs		PFCs		SF6	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**0**			**0**			**0**							
4 Agriculture			**377**	**32**	**0**	**0**								
A Enteric Fermentation			319											
B Manure Management			44	1										
C Rice Cultivation			14											
D Agricultural Soils				31										
E Prescribed Burning of Savannas			0	0	0	0								
F Field Burning of Agricultural Residues			0	0	0	0								
G Other (please specify)			0	0										
5 Land-Use Change & Forestry	**(1) 0**	**(1) -399**	**0**	**0**	**0**	**0**								
A Changes in Forest and Other Woody Biomass Stocks	(1) 0	(1) -399												
B Forest and Grassland Conversion	0		0	0	0	0								
C Abandonment of Managed Lands		0												
D CO2 Emissions and Removals from Soil	(1) 0	(1) 0												
E Other (please specify)	0	0	0	0	0	0								
6 Waste			**155**	**0**	**0**	**0**	**0**	**0**						
A Solid Waste Disposal on Land			145											
B Wastewater Handling			10	0										
C Waste Incineration														
D Other (please specify)			0	0										
7 Other (please specify)														

(1) The formula does not provide a total estimate of both CO2 emissions and CO2 removals. It estimates "net" emissions of CO2 and places a single number in either the CO2 emissions or CO2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)															
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2 Emissions	CO2 Removals	CH4	N2O	NOx	CO	NMVOC	SO2	HFCs		PFCs		SF6	
									P	A	P	A	P	A
Memo Items														
International Bunkers	**682**		**0**	**0**	**0**	**0**	**0**	**0**						
Aviation	682		0	0	0	0	0	0						
Marine	0		0	0	0	0	0	0						
CO2 Emissions from Biomass	**0**													

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 1 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		NO_x		CO		NMVOC		SO_2		HFCs		PFCs		SF_6		Documen-tation	Disaggrega-tion	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Total National Emissions and Removals																							
1 Energy																							
A Fuel Combustion Activities																							
Reference Approach	ALL	H																					
Sectoral Approach	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
1 Energy Industries	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
2 Manufacturing Industries and Construction	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	2	
3 Transport	ALL	H	NE		NE		PART	M	PART	M	NE		PART	H	NA		NA		NA		H	3	
4 Other Sectors	ALL	H	NE		NE		NE		NE		NE		PART	H	NA		NA		NA		H	3	
5 Other (please specify)	PART	M	NE		NE		NE		NE		NE		NE		NA		NA		NA		H	1	
B Fugitive Emissions from Fuels	NE		ALL	M			PART	H	NE		PART	H	NE		NA		NA		NA		H	2	
1 Solid Fuels	NE		ALL	M	NE		NE		NE		NE		NE		NA		NA		NA		H	2	
2 Oil and Natural Gas	NE		ALL	M	NE		ALL	H	ALL	H	ALL	H	NE		NA		NA		NA		H	2	
2 Industrial Processes																							
A Mineral Products	PART	H	NA		NE		NE		NE		PART	H	PART	H	NA		NA		NA		M	2	
BChemical Industry	PART	H	NE		PART	M	PART	M	NE		PART	H	ALL	H	NA		NA		NA		M	2	
CMetal Production	PART	H	NE		NE		NE		PART	H	PART	H	PART	H	NE		NE		NE		M	2	
D Other Production	NE		NE		NE		NE		NE		PART	H	NE		NA		NA		NA		M	2	
E Production of Halocarbo and Sulphur Hexafluoride	NA		NA		NA		NA		NA		NA		NA		NO		NO		NO				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 2 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		HFCs		PFCs		SF6		Documen-tation	Disaggre-gation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Industrial Processes (cont...)																							
F Consumption of Halocarbons and Sulphur Hexafluoride	NA		NA		NA		NA		NA		NA		NA		NO		NO		NO				
Potential (1)																							
Actual (2)																							
G Other (please specify)																							
3 Solvent and Other Product Use																							
4 Agriculture																							
A Enteric Fermentation	NA		ALL	H	ALL	H	NA		NA		NA		NA		NA		NA		NA		H	3	
B Manure Management	NA		ALL	H	ALL	L	NA		NA		NA		NA		NA		NA		NA		H	3	
C Rice Cultivation	NA		ALL	M	NA		NA		NA		NA		NA		NA		NA		NA		H	1	
D Agricultural Soils	NA		ALL	M	ALL	L	NA		NA		NA		NA		NA		NA		NA		H	1	
E Prescribed Burning of Savannas	NO		NO		NO		NO		NO		NO		NO		NO		NO		NO				
F Field Burning of Agricultural Residues	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				
G Other (please specify)																							
5 Land-Use Change & Forestry																							
A Changes in Forest and Other Woody Biomass Stocks	PART	M	NE		NE		NE		NE		NE		NE		NA		NA		NA		H		1
B Forest and Grassland Conversion	NE		NE		NE		NE		NE		NE		NE		NA		NA		NA				

(1) Potential emissions based on Tier 1 Approach.

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES
(Sheet 3 of 3)

OVERVIEW TABLE																							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2		CH4		N2O		NOx		CO		NMVOC		SO2		HFCs		PFCs		SF6		Documentation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality			
5 Land-Use Change & Forestry (cont....)																							
C Abandonment of Managed Lands	NE		NE		NE		NE				NE		NA		NA		NA		NA				
D CO2 Emissions and Removals from Soil	NE		NE		NE		NE				NE		NA		NA		NA		NA				
Other (please specify)																							
6 Waste																							
A Solid Waste Disposal on Land	NA		ALL	M	NA		NA				NA		NA		NA		NA		NA		H	2	
B Wastewater Handling	NA		PART	M	NA		NA		NA		NA		NA		NA		NA		NA		H	2	
C Waste Incineration	NE		NE		NE		NE		NE		NE		NA		NA		NA		NA		M	2	
D Other (please specify)																							
7 Other (please specify)																							
Memo Items:																							
International Bunkers																							
Aviation	ALL	M	NE		NE		NE		NE		NE		NA		NA		NA		NA		H	2	
Marine	NO		NO		NO		NO		NO		NO		NA		NA		NA		NA				
CO2 Emissions from Biomass	NE		NE		NE		NE		NE		NE		NA		NA		NA		NA				

Notation Key for Overview Table (Table 8A)

Estimates

Code	Meaning
PART	Partly estimated
ALL	Full estimate of all possible sources
NE	Not estimated
IE	Estimated but included elsewhere
NO	Not occurring
NA	Not applicable

Quality

Code	Meaning
H	High Confidence in Estimation
M	Medium Confidence in Estimation
L	Low Confidence in Estimation

Documentation

Code	Meaning
H	High (all background information included)
M	Medium (some background information included)
L	Low (only emission estimates included)

Disaggregation

Code	Meaning
1	Total emissions estimated
2	Sectoral split
3	Subsectoral split