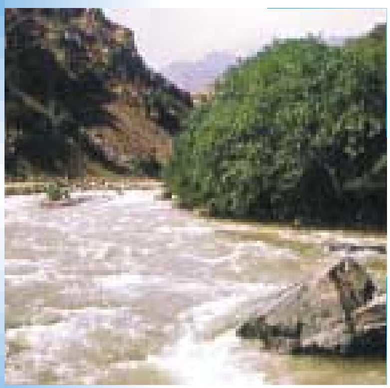
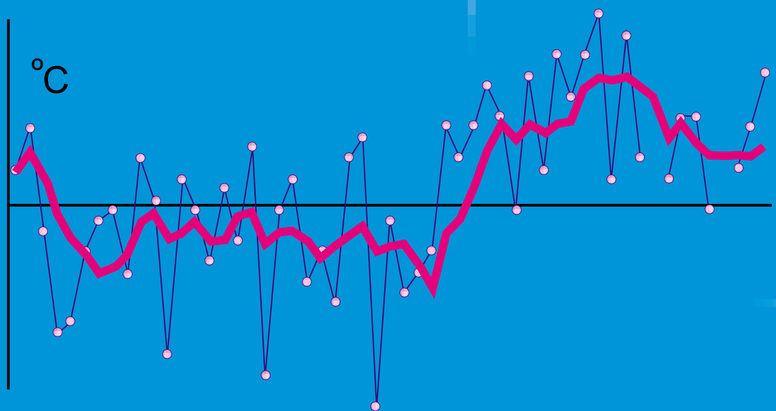
2002





The First National Communication of the Republic of Tajikistan under the United Nations Framework Convention on Climate Change

Republic of Tajikistan

Ministry for Nature Protection

Main Administration on Hydrometeorology and Environmental Monitoring

The First National Communication of the Republic of Tajikistan to the United Nations Framework Convention on Climate Change

Dushanbe 2002

National Project Manager Begmurod MAKHMADALIEV

Information Manager Victor NOVIKOV

The First National Communication of the Republic of Tajikistan to the United Nations Framework Convention on Climate Change has been prepared by the Main Administration on Hydrometeorology and Environmental Monitoring with financial and technical assistance from the Global Environmental Facility and Tajik Government.

Shevchenko str. 47, Dushanbe, TAJIKISTAN
Phone: (992 372) 21-41-24
Fax: (992 372) 21-55-22
E-mail: meteo@tjinter.com

FOREWORD

Recognizing the importance of the climate change problem the Republic of Tajikistan joined the UN Framework Convention on Climate Change on January 1998.

I have the pleasure in presenting to you the First National Communication of the Republic of Tajikistan, which represents the commitment of the Government of Tajikistan and its people to address the issue of climate change. Enormous efforts have been made by many specialists to prepare this First National Communication and National Action Plan for Climate Change Mitigation.

The First National Communication of Tajikistan is an assessment of the country's present status with respect to climate change. It offers opportunities for raising awareness of international community about national circumstances of the Republic of Tajikistan, greenhouse gas emissions dynamics as well as the main findings of studies, which assessed the possible impact of, and vulnerability to, climate change of various economic sectors and natural resources.

Tajikistan has minor influence on global warming . On the other hand, Tajikistan's natural resources and sectors of economy are vulnerable to climatic changes, especially its fragile biodiversity, water and land resources, agriculture, public health etc.

The First National Communication represents the national priorities in climate change mitigation and needs for further actions and research. I hope that outcomes of studies will serve not only national environmental and economic decision makers but also will be of some interest for the international community dealing with climate change issues.

Finally, on behalf of the Government of Tajikistan, I avail myself of this opportunity to express gratitude to the Global Environment Facility, UNDP and UNFCCC Secretariat for their support to enable Tajikistan to prepare its First National Communication.

Minister for Nature Protection U. Shokirov

Dushanbe,
September 2002

CONTENTS

ACKNOWLEDGEMENTS

On behalf of the Governmental Workgroup on Climate Change and leading authors of the First National Communication, we express our gratitude to the Global Environmental Facility, United Nations Development Programme and the Government of Tajikistan for providing consultative, technical and financial support for the preparation of the First National Communication.

We highly appreciate the efforts of highly skilled specialists from UNEP/GRID-Arendal, UNDP RBEC, National Communications Support Programme, UNDP CO Tajikistan and UNFCCC Secretariat, who have collaborated and enormously assisted throughout the process of preparation of the First National Communication.

We express special appreciation to the Governments of Russian Federation and Azerbaijan, which supported their experts to promote the researches in such new area for Tajikistan as global climate change.

We express our gratitude to the leaders of workgroups and sub-workgroups, lead authors, contributors, review-editors, national and international consultants. These individuals have devoted enormous time and effort to produce this document.

National Focal Point on Climate Change **B. Makhmadaliev**

ABBREVIATIONS, ACRONYMS AND UNITS OF MEASUREMENT

Abbreviations and acronyms:

CDIAC	Carbon Dioxide Information Analysis Center
EIA	Environmental Impact Assessment
EWE	Extreme Weather Events
FAO	Food and Agricultural Organization
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
HPP	Hydropower Plant
HRPT	High Resolution Picture Transmission
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land Use Change and Forestry
NMVOC	Non-Methane Volatile Organic Components
NAP	National Action Plan for Climate Change Mitigation
NGO	Non-Governmental Organization
RT	Republic of Tajikistan
Tajik Met Service	Main Administration on Hydrometeorology and Environmental Monitoring under the Ministry for Nature Protection RT
TAR IPCC	Third Assessment Report IPCC
TOMS	Total Ozone Measurement System
UNFCCC	Unites Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
WMO	World Meteorological Organization

Chemical formulas:

CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
N_2Ş	Nitrous oxide
NŞş	Nitrogen oxides
PFCs	Perfluorocarbons
SO_2	Sulphur dioxide

Units of measurement:

°C	Celsius degree
cub.m	cubic meter
cub.m/sec	cubic meter second
Gg	gigagram = 1,000,000,000 gram = 1,000 tonne
ha	hectare = 10,000 square meters
km	kilometer = 1,000 meters
kWh	kilowatt per hour
m	meter
masl	meters above sea level
m/sec	meter per second
MW	megawatt = 1,000,000 watts
sq.m	square meter
TJ	terrajoule = 1,000,000,000,000 joules

1. Executive Summary

1.1. Introduction

One of emerging environmental problems is global climate change due to increased concentrations of greenhouse gases in the atmosphere that intensify greenhouse effect and lead to the rise of global temperature. As a result, polar and mountain glaciers retreat, sea level raise, precipitation pattern and runoff change etc. Global warming poses a serious threat to the global ecology and socio-economic development of humankind.

In 1992 at the Earth Summit in Rio-de-Janeiro, the United Nations Framework Convention on Climate Change (UNFCCC) was signed by many nations of the world.

Tajikistan ratified the UNFCCC on 7 January 1998 taking commitments as the Party not included in Annex I of the Convention.

In 1999, the national government established the working group consisting of key ministries and departments to prepare the National Action Plan for Climate Change Mitigation. For coordination of this group the National Focal Point on Climate Change has been appointed.

The First National Communication has been prepared in the period from 2001 till 2002 with participation of over 100 qualified experts from 30 ministries, research institutions and public organizations.

The First National Communication contains an information on national circumstances of the Republic of Tajikistan, national greenhouse gas inventory for the period 1990-1998, emission scenarios, vulnerability assessment and adaptation to climate change, systematic observation and research, public awareness, measures for climate change mitigation, as well as problems, constrains and needs in the fulfillment of national obligations to the UNFCCC.

Appropriate sections of the First National Communication were discussed on a series of national workshops involving public organizations, mass media and international experts. Partnerships with UNFCCC Secretariat, National Communication Support Programme and climate change centers of various countries ensured successful results of this work.

Preparation of the First National Communication and National Action Plan for Climate Change mitigation is the first stage of implementation of the national commitments to the UNFCCC and it enable a good basis for subsequent national activities on climate change mitigation.

1.2. Geographic profile

Tajikistan is situated in Central Asia, between the latitudes 36°40'N to 41°05'N and longitudes 67°31'E to 75°14'E. The area of Tajikistan's territory is 143,100 sq.km. The general length of the state borders is 3,000 km.

Tajikistan is a mountainous and landlocked country. Mountains occupy about 93% of the terrain, while about half of the territory is situated at an altitude of above 3,000 masl. The highest elevation of the republic is the peak of Ismoil Somoni (7,495 masl) in the Pamirs.

1.3. Natural resources

The climate of Tajikistan differs by the variety of temperatures, humidity conditions, precipitation and intensity of solar irradiation. The annual mean temperature varies from +17°C in the south to -6°C in the Pamirs. The annual precipitation in lowland hot deserts of Northern Tajikistan and cold mountain deserts of Eastern Pamir averages from 70 to 160 mm, while in Central Tajikistan precipitation exceeds 1,800 mm a year.

Due to specific climate and landscape conditions, the mountains of Tajikistan are considered as the main glacial knot of Central Asia. Glaciers regulate river flow and climate, and comprise 6% of the total country area. The largest glacier of Tajikistan is the Fedchenko Glacier which length exceeds 70 km. Recently, due to climate warming many small glaciers retreated dramatically.

Rivers of Tajikistan are the main sources of water replenishing the Aral Sea. They provide neighboring areas with water for irrigation and power generation. The largest rivers are Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, Bartang etc. There are 947 rivers in Tajikistan with the length more 10 km. Total river length is 28,500 km. According to up-to-date assessments, the annual river flow of Tajikistan's rivers is equal to 53 cub.km a year.

Tajikistan is rich with its lakes. There are about 1,300 lakes, 80% of which are situated at an altitude of 3,000 meters with an area of less 1 sq.km. The area of large lakes exceeds 680 sq.km. The largest salty water lake in Tajikistan is Karakul, which is located in Eastern Pamir (3,914 masl), total area 380 sq.km. The deepest fresh water lake in Tajikistan is Sarez (3,239 masl); its depth exceeds 490 meters, total area 86.5 sq.km.

Forests in Tajikistan occupy an area of 410 thousand hectares (around 3% of country's area). Juniper forests are major national forests and spread on elevations ranging from 1,500 to 3,200 masl. Junipers occupy about 150 thousand ha. Pistachios are well adapted to hot and dry climate and concentrated in the Southern Tajikistan on the altitudes from 600 to 1,400 masl. The area of pistachios is 78 thousand ha. Walnut forests grow in Central Tajikistan at the altitudes from 1,000 to 2,000 masl and differ by very demand in terms of soil and climatic conditions. Maple forests occupy 44 thousand ha of national forests. Poplars, willows, birches, sea-buckthorns and other types of groves are spread fragmentarily.

Land surface, soils and climatic factors favor to the formation of rich diversity of natural habitats for animals and plants in Tajikistan. The flora of Tajikistan has the richest diversity in Central Asia and comprise of 5,000 species of higher plants, over 3,000 species of lower plants. Local flora differ with high endemism and includes many rare species.

There are a few rare and endangered species of animals in Tajikistan, such as screw-horned goat, argali, urial, Bukhara red deer, snow leopard, Central Asian cobra, desert monitor, peregrine, snow-cock, and others.

1.4. Socio-economic development

According to the census conducted in 2000, the population of the republic is 6.1275 million people. For the last 70 years, the population has increased by 6 times. The increase of population is 22-25 people per 1000 inhabitants. Share of rural population in Tajikistan exceeds 70% of the total country population. Totally, 49.5% comprise male, 50.5% female and over 30% of population are children aged from 0 to 9 years old.

Out of 80 branches of Tajikistan's industry, the prevailing role belongs to the non-ferrous metallurgy, which share in industrial output in 1999 amounted to 50%. The enterprises of this industry produce aluminum, gold, silver, lead, zinc, molybdenum, tungsten, and mercury. Industry contributes about 20% of Gross Domestic Product (GDP).

The county's needs for electricity are met mainly by the hydropower plants and in a small scale, by the thermo power plants. The hydropower plants provide more 95% of the produced electricity. The total production capacity makes 4,412.7 MW, 93% of which is hydropower plants' capacity. The highest volume of electricity production was in the early 1990s and comprised 17-18 billion kWh a year. Currently, this indicator averages 15 billion kWh a year. The industry, construction and agriculture consume most of electricity.

Agriculture of the republic is based on cotton growing which is the main export product. Other important agricultural focal areas are cultivation of rice, grain, tobacco, corn, potato, vegetables, gardening, vineyard and cattle breeding. Agricultural sector contributes about 25% of GDP.

Transport is an integral part of the economy in Tajikistan and plays the most significant role in view of the complicated mountainous pattern of the country. The length of paved roads in general use is 13.6 thousand km. The length of mainline railway is 533 km.

At present, there are 3,357 schools with the total number of 1.5 million pupils. Some 100 thousand students attend 30 universities and 72 colleges. More than 5 thousand scientists work in the Academy of Sciences and research institutes.

More than 1 thousand health institutions including 433 hospitals provide their services to the population. Many famous health resorts such as Khoja-Obigarm, Shohambary, Zumrat, Havotague, Ura-Tube, and Garm-Chashma offer their services to those who need rehabilitation.

The export is mainly concentrated on raw materials, including aluminum, raw cotton, electricity, precious metals and jewelry stones, fresh vegetables and fruits, canned vegetables, raw leather, silk fabrics, carpets, handicraft products, etc.

The import mainly consists of raw materials for aluminum industry, natural gas, liquid fossil fuels, vehicles, and machinery.

1.5. Anthropogenic greenhouse gas emissions and scenarios

Industrialization, urbanization, the increase of industrial and agricultural production, development of motor transport apart from social and economical benefits have resulted in the increase of greenhouse gas emissions and overall anthropogenic impact on the environment and climatic system.

According to expert estimates, contribution of Tajikistan to the global warming during 1970-2000 totalled 300 million tonnes of CO_2, including emissions from fossil fuel combustion and cement production.

The greenhouse gases (GHG) inventory of Tajikistan is developed according to the revised 1996, IPCC Guidelines. It considers five main modules of the revised 1996, IPCC Guidelines: Energy, Industrial Processes, Agriculture, Land Use Change and Forestry, Wastes. Solvents were not analyzed. The national GHG inventory represent emissions data for the five gases of direct greenhouse effect: CO_2, CH_4, N_2O, CF_4 and C_2F_6 as well as the three other gases of indirect greenhouse effect like CO, NO_x, NMVOC and aerosol SO_2.

The results of GHG inventory show that most of emissions in Tajikistan were observed in 1991 and amounted to 31 million tonnes of CO_2-eqv. without consideration of their removal by natural sinks. The least emissions were observed in 1998 and amounted to 6,3 million tonnes. Table 1.1. shows the differences between GHG emissions occurred in 1990 and 1994 in Tajikistan. Data for 1998 are preliminary and not included into the table.

Table 1.1.

Summary of GHG Emissions in 1990 and 1994 for Tajikistan (Gg)

Source Category	CO_2		CH_4		N_2O		PFC_s		CO_2 eqv.	
	1990	1994	1990	1994	1990	1994	1990	1994	1990	1994
Energy	*17,730*	*5,115*	*49*	*15*	*0.2*	*0.0*	*0*	*0*	*18,791*	*5,442*
Industrial processes	*1,565*	*498*	*0*		*0*	*0*	*0.7*	*0.4*	*6,212*	*2,918*
Agriculture	*0*	*0*	*98*	*89*	*3.6*	*1.8*	*0*	*0*	*3,182*	*2,433*
LUCF	*- 1,528*	*-2,048*	*0*	*0*	*0*	*0*	*0*	*0*	*- 1,528*	*-2,048*
Waste	*0*	*0*	*7*	*7*	*0*	*0*	*0*	*0*	*155*	*138*
TOTAL	*19,295*	*5,613*	*154*	*111*	*3.8*	*1.8*	*0.7*	*0.4*	*28,340*	*10,931*

Source: Tajikistan's Greenhouse Gas Inventory * total emissions do not include LUCF category

For the period 1990-1998, the biggest reduction is observed in CO_2 emissions, and the small reduction in emissions of CH_4, PFCs and N_2O.

CO_2 emissions per capita in the period under review have reduced from 3.8 to 0.5 tonnes; they are the lowest in Central Asia. Tajikistan takes 100th place in the world on the volume of greenhouse gas emissions (CDIAC).

High capacity of hydropower engineering in many respects potentially makes low level of CO_2 emissions nowadays and in the outlook.

CO_2 emissions. In Tajikistan in the period of 1990-1998, the biggest CO_2 emissions were observed in 1991 (22,568 Gg), mainly because of fossil fuels combustion.

Totally, the volume of carbon dioxide emissions in the period under review has decreased more than 10 times, mainly because of decline in energy-related activities.

Most of national CO_2 emissions come from:

- Fossil fuel combustion in industry, transport and residential sector (82-92%);
- Production of cement, lime, aluminum, ferrous metals and ammonia (8-18%).

Since 1990, because of illegal deforestation, the absorption of CO_2 by forests and other woody biomass has decreased by 35%. Given that in 1990 this indicator was 588 Gg, in 1998 it was only 447 Gg.

In the result of changes in land use and reclamation of new lands, absorption of CO_2 by soils increased from 932 Gg in 1990 to 1,436 Gg in 1998. Emission of CO_2 from intensively used soils increased from 19 Gg in 1992 to 84 Gg in 1998. However, there are significant uncertainties in the category "Land use change and forestry" due to lack of data, reliable emission factors etc.

ţû$_4$ emissions. The biggest volume of ţû$_4$ emissions in the period 1990-1998 in Tajikistan was indicated in 1991 (176 Gg) mainly because of intestinal fermentation, manure management and oil-gas systems. Totally, in the period under review, the volume of methane emissions has decreased more than 40% as a consequence of structural changes in the agricultural sector and decrease in production and consumption of fossil fuels.

Methane emissions from fossil fuel consumption occur in coal mining, oil and gas production and transportation. Contribution of these sources to the total CH_4 emissions in different years comprises 5-35%.

Rice cultivation, solid waste disposal sites and wastewater treatment processes are the sources of CH_4 emissions. The volume of methane emissions from these sources comprises not more than 10%.

N_2O emissions. The biggest volume of N_2O emissions in the period 1990-1998 in Tajikistan was indicated in 1990 (about 4 Gg); the lowest emission was indicated during 1995-1998 (up to 2 Gg), mainly because of applying mineral fertilizers in agricultural soils. Nitrous oxide emissions in the category "Agriculture" make in different years 97% to 99% of national N_2O emissions. Nitrous oxide emissions from other sources in the category "Agriculture" (manure management, burning of agricultural residues) are insignificant. Few N_2O emissions occur due to fossil fuel combustion, mainly in transport sector.

Perfluorocarbon emissions. The only source of anthropogenic perfluorocarbon emissions in Tajikistan is the aluminum smelting, which emits practically up to 100% of these gases. CF_4 comprises the biggest part of emissions (91%); the smallest part is C_2F_6 (9%).

Since the production of primary aluminum has decreased from 450.3 thousand tonnes in 1990 to 195.6 thousand tonnes in 1998, perfluorocarbon emissions have proportionally decreased by 57%. The biggest volume of perfluorocarbon emissions was registered in 1990 - 0.69 Gg. The least PFC emissions indicated in 1997 - 0.29 Gg. Due to the lack of local emission factors the uncertainty of this emission data is not assessed.

Aluminum production gives rise to the emissions of harmful substances, including nitrogen oxides, carbon oxide, sulphur dioxide, fluorides and other pollutants that affect both environment and climate system.

Perfluorocarbons have a very big potential of global warming. Small quantities of emissions of these gases (less 1 Gg) have significant contribution to the total GHG emissions and comprise up to 32% of total CO_2-equivalent.

In the perspective, without taking response measures on reduction of greenhouse gas emissions, the annual volume of aggregate GHG emissions will increase together with economic growth (baseline scenario). Implementation of the measures indicated in National Action Plan has the potential to significantly reduce GHG emissions by 20-30% and more.

1.6. Climate change trends and scenarios

Vertical zonation, geographical contrasts and forms of land surface favor to great diversity of the climatic conditions that can be observed in Tajikistan, which is of big interest for local and regional climate change studying and modeling.

Since comprehensive meteorological observations have started in Tajikistan from 1950s-1960s and remarkable changes in the climate system attributable to human activities have also occurred and further accelerated from this period (as noted by IPCC), national research considers in details the aspects of climate changes for the period 1961-1990 and throughout the period of instrumental observations in Tajikistan.

During period under investigation, the increase of 0.7-1.2°C in the annual mean air temperature was observed in the wide valleys of Tajikistan. To a lesser degree, the growth of temperature had taken place in mountain areas by 0.1-0.7°C, and only in the mountains of Central Tajikistan, Rushan and lower reaches of Zeravshan river there was a small decline in temperature of 0.1-0.3°C.

In large cities, the growth of near surface temperature was especially significant and reached 1.2-1.9°C that is obviously associated with urbanization (construction of roads, buildings, vehicles, industrial emissions, etc.).

The 1990s was the warmest decade during the period of instrumental observations in Tajikistan, and 1997 and 2001 the warmest years.

Models of future climate project that annual mean near surface temperature in Tajikistan will increase within the interval of 1.8-2.9°C by the year 2050. The projected rate of warming is much greater than the observed changes during the 20th century. It is likely that increase of temperature will be essential in the warm period of a year and in some regions of Tajikistan will reach 4.9°C.

The tendencies in precipitation in Tajikistan are not uniform. In the period from 1961 till 1990s in the mountains of Central Tajikistan, as well as in the valleys of Southwest and Northern Tajikistan, foothills of Turkestan range and mountain areas of Eastern Pamir, a reduction in the amount of annual precipitation of 1-20% is observed. In Karategin and Darvaz, from the altitude of 1,500 m and higher, the amount of precipitation has increased by 14-18%. In Western Pamir, the increase of precipitation is 12-17%. The greatest increase in precipitation (36%) is observed on Fedchenko glacier.

The most arid years in Tajikistan were 1944 and 2000, when a precipitation deficit of 30-70% was observed all over the territory of the country. The most humid year was 1969, when precipitation was as much as 1,5 times above the long-term average.

Due to complexity of mountain landscape, there is medium and low confidence in precipitation scenarios. According to some models (HadCM2 and others), the increase of annual precipitation to 3-26% is expected by the year 2050. Other models (CCCM and others) project the decrease of precipitation by 3-5% and more.

Changes in snow stock vary in different altitude zones. An increase of snow stock is observed in the most of the foothills and low mountains of the republic. On the contrary, the reduction of snow stock has been reported in many high altitude zones (exceptions are Fedchenko glacier and some other regions).

The increase of hot days, heavy rainfalls, floods and avalanches can be observed. Conversely, the number of cold days decreased substantially. The dynamics of occurrence of other extreme weather events appear not to have changed.

1.7. Climate change impacts on the environment, economy and health

Projected climate change in global and regional scales will have beneficial and adverse effects on both environmental and socio-economic systems, but the larger the changes and the rate of change in climate, the more the adverse effects predominate. In this regard, adaptation to climate change is of the highest importance.

In the mid-term, the increase of air temperature by 2-3°C will likely accelerate the process of glacier retreat. It is very likely that thousands of small glaciers will disappear in Tajikistan. Countrywide, the ice cover will reduce by 20%; the ice volume will decrease by 25-30%. Initially, glacier melting will increase stream flow in some rivers and will partially compensate the decrease of stream flow in other rivers. In the mid- and long-term, a catastrophic reduction of water flow in many rivers is expected.

Water resources in the mid-term will increase in some regions (Western Pamir); conversely, in other regions (Zeravshan, Kafirnigan river basins) water resources will likely essentially deteriorate due to glacier retreat, change in precipitation pattern and an increase of evaporation. It is likely that scales and consequences of natural disasters will be more spread and destructive due to changes in the global and regional hydrological cycles.

Climate changes have the impacts on the quantity and quality of water resources. The character of river flow is constantly altering that negatively affects local ecology and vulnerable sectors of national economy such as irrigation, water supply and hydropower engineering in Tajikistan and Central Asian region.

Changes in vertical zonation of flora and fauna may occur in mountain ecosystems with a rich biodiversity. Mountain pastures and alpine meadows will likely favor, others, such as winter pastures on the contrary will degrade in result of temperature rise and lack of precipitation in spring and summer seasons.

It is likely that tugai ecosystem (flood plain) will degrade because of shortage of water resources, increase of temperature, and fire risk. Frequent and long lasting droughts are expected to affect the condition of broad-leaf forests. Climate warming will shift phenological parameters of forest vegetation (earlier ripening, fading, blooming, etc.). Biological linkages within ecosystems are expected to alter. The area of deserts will continue to expand.

Agriculture in Tajikistan is at particular risk of severe effects of climate change, where apart from other factors, land degradation and desertification are the typical natural processes. On the other hand, low efficiency of agriculture aggravates climatic impacts.

<u>The most damage to agriculture in Tajikistan is occurred in result of such hydro-meteorological phenomena and related to them factors as:</u>

- High temperatures, hot winds and low temperatures;
- Heavy rainfalls, snowfalls and hailstones;
- Floods and mudflows;
- Strong winds and sandstorms;
- Agricultural pests and diseases.

During 1991-2000, annual loses of agricultural gross product from extreme weather events totaled to 1/3 of overall agricultural loss.

Long dry periods together with high temperatures in spring and summer seasons lead to the intensification of desertification processes in Southern and Central Tajikistan. Uncontrolled deforestation conditioned by lack of energy resources lead to catastrophic scales of those processes. It is likely that climate change will expand land degradation.

In the outlook, water economy will need more water, especially for irrigation, in view of climate warming and increased evaporation. It is estimated that water needs for irrigation of basic agricultural crops will rise by 20-30% compared to present climate conditions.

Hydropower engineering is relatively stable towards the hydrological cycle fluctuations, however long-term drought and increased suspended solids will negatively affect this economy. Without preventive measures, the influence of natural disasters (e.g. mudflows, landslides) will worsen the condition of hydropower engineering facilities.

Development of road transport is limited by unfavorable natural-climatic conditions. High temperatures in summer season in valleys and foothills cause infringement of fastness indicators and deformation of road surfaces. Flash floods in spring and mudflows, which spread over the big territories, wash out tens of kilometers of road ballast bed. More than 500 km of roads every year prone to unfavorable natural phenomena, among which climatic factors play essential role.

Alterations in the hydrological cycle will lead to water shortage and an increase of water temperature in the rivers. This fact will favor to the formation of potential choleric and malaria water reservoirs, especially in lower reaches of Syrdarya, Vakhsh, Kafirnigan and Pyanj rivers.

Because of climate warming, vector-born and other dangerous diseases, including malaria will spread significantly. It is very likely that the rise of extreme summer temperatures will lead to higher infant and adult mortality.

In the circumstances, when the climate is changing very rapidly, human adaptation mechanisms are overstrained, and cannot react appropriately, which increases human being's vulnerability. Most vulnerable to the climate change is the population in poverty because of absence of necessary resources for coping climate change adverse effects and adequate adaptation.

It should be noted that V&A research has revealed uncertainties that refer to the lack of scientific knowledge and an inadequate system of observations over the climate change indicators and consequences, including ecosystems, water resources, public health, etc. There is a need in further in-depth study.

1.8. National Action Plan for Climate Change Mitigation

Although Tajikistan as a non-Annex I Party has no emission reduction targets under the UNFCCC, comprehensive measures to address various aspects of climate change are elaborated and presented in Tajikistan’s National Action Plan for Climate Change Mitigation.

It is established that climate change mitigation requires complex approach, which primarily involves the measures on reduction of greenhouse gas emissions and adaptation. Implementation costs of climate change mitigation measures can be covered by further economic, social and ecological benefits and promote sustainable development.

Expected outcomes from the National Action Plan are the following:

- Reduction of GHG emissions and enhancing the state of carbon natural sinks;
- Regular preparation of, and improvement of national GHG inventory quality;
- Reduction of the vulnerability;

- Adaptation to expected climate change and risk minimization;
- Promotion of sustainable development;
- Elimination of poverty;
- Environmental conservation and rational use of natural resources;
- Institutional strengthening and capacity building;
- Establishment of the legal framework to address climate change issues;
- Raising public awareness and enhancement of scientific knowledge and research.

<u>The selection of NAP measures is made on the basis of:</u>

- Cost effectiveness;
- Emissions reduction potential;
- Contribution to risk minimization;
- Strengthening of adaptation abilities;
- Socio-economic and ecological benefits;
- Potential for international support.

The findings of the GHG inventory, abatement analysis and vulnerability assessment are the basic materials used for the compilation of NAP document. The implementation of NAP measures requires a coordinated action between all relevant ministries and governmental agencies, non-governmental organizations and the general public. The responsibility on NAP implementation monitoring belongs to the Main Administration on Hydrometeorology and Environmental Monitoring under the Ministry for Nature Protection RT.

Reduction of GHG emissions. For the fulfillment of obligations to the UNFCCC (articles 4 and 12 UNFCCC) Tajikistan's National Action Plan includes the following directions of measures on GHG emission reduction and enhancing of carbon natural sinks:

- Enhancement of energy efficiency in relevant sectors of the national economy;
- Application of effective technologies and use of energy sources in the national economy that promotes high rates of economical growth and reduce or limit greenhouse gas emissions;
- Protection and enhancement of natural sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forest management practices, afforestation and reforestation;
- Promotion of sustainable forms of agriculture in the light of climate change considerations;
- Research on, promotion, development and increase used of, new and renewable energies, advanced, innovative, and environmentally sound technologies;
- Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures, which limit or reduce emissions of greenhouse gases.

Response measures are targeted at different levels of implementation and involve all relevant sectors: energy, transport, agriculture, forestry and wastes. Accession to the Kyoto Protocol to the UNFCCC in the perspective is a key factor and necessary condition for successful implementation of national commitments and participation in Clean Development Mechanism of the Kyoto Protocol.

Adaptation. Scientific data confirms, that at present, development and implementation of only measures on greenhouse gas emissions reduction is not sufficient for the prevention of anthropogenic impacts on the climate system.

Considering Tajikistan's circumstances, adaptation to climate change is as important task in solving climate change problem as reduction of GHG emissions.

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

The results of vulnerability assessment of natural resources, national economy and public health to climate change confirm that influence of climate factors sometimes is very high, and appropriate adaptation measures could decrease or prevent severe effects of climate change and provide common preparedness.

The present stage of adaptation strategy includes primary possible adaptation measures, which might be implemented in order to cope with climate change effects and support the sustainable development of the republic. Next stages of adaptation strategy development are expansion, probation and detalization of adaptation measures.

Important directions of NAP measures on adaptation to climate change include:

- In-depth research on climate change, its impacts on natural resources, national economy, public health and development of specific adaptation measures;
- Improvement of the systematic observation networks and environmental monitoring to revise and renew adaptation measures;
- Improvement of the system of data collection, interpretation and dissemination;
- Enhancement of weather forecasting, climate modeling and early warning systems for minimization of natural disasters risk and preparedness to extreme phenomena;
- Capacity building to strengthen institutional, technical and human resources to promote adaptation and research in fields of climate and hydrological investigations, geographical information systems, environmental impact assessment, protection and re-cultivation of lands, rational use of water resources, conservation of ecosystems, sustainable agriculture, infrastructure development and health protection;
- Implementation of actual projects on adaptation in priority areas related to rational use of natural resources, development of national economy and health protection.

1.9. Systematic observation and research

Tajikistan has two stations (tab. 1.2.) representing the Global Climate Observing System (GCOS). Tajikistan belongs to the Region II WMO (Asia). The World Weather Watch (WMO’s WWW) involves 10 national stations, including 2 stations that conduct upper air observations. A few national river gauges contribute to the operating of Aral HYCOS.

In Tajikistan, the most advanced network of hydrometeorological observation had existed till 1990. After, there has begun a steady reduction in the number of stations and gauges and the volume of observations.

At present, the hydrometeorological observation network of Tajikistan includes 58 meteorological stations, and 126 hydrological, meteorological and agrometeorological gauges and environmental pollution monitoring points. However, the state of the network does not meet modern requirements and the effective participation in the regional and global observation systems appears to be problematic.

Table 1.2.

Information on GCOS Stations in Tajikistan

Station Index	Station Name	Latitude	Longitude	Elevation (masl)	Period of observation
38954	Khorog	37º 30'N	71º 30'E	2,077	Since 1898
38933	Kurgan-Tube	37º 49'N	68º 47'E	429	Since 1929

Source: Tajik Met Service

Because of financial impoverishment a number of stations and gauges have reduced or completely stopped observations. Economic reasons have resulted in the reduction of the observation network, and have been reflected in the deterioration of equipment. Most stations are equipped with out-of-date instruments, and in the last decade, the updating of the network with modern equipment has not been conducted. A few stations are temporarily closed, and some stations do not transfer data because of communications damage. The situation has resulted in some areas of Tajikistan no longer being observed meteorologically.

The development and implementation of measures to optimize the observation network, conserve the most important points of observation, minimize expenses, and ensure its conformity to the modern requirements in terms of management, technical conditions and effective data dissemination among consumers is required. This will allow Tajikistan's contribution to the regional and global observation networks in the given region. There is a need to develop the National programme for optimization of systematic observation network.

The issue of climate change in its contemporary understanding has not been considered by national researches to date. Since the beginning of the preparation of the First National Communication and National Action Plan for Climate Change Mitigation, it was possible to carry out scientific research and analysis of anthropogenic impacts on the climatic system. Within this framework, the national experts and scientists has prepared the national inventory of GHG emissions, assessed the vulnerability to climate change and developed climate change projections and emission scenarios. The summary and collection of the reports about climate change and the monography "Climate change and its impacts on human health" have been published. More than 150 vital maps and graphics on various aspects of climate change in Tajikistan prepared and stored in the Internet.

1.10. Public awareness

In the course of NAP preparation, a series of national workshops involving governmental officials, scientists, mass media and NGOs were dedicated to various aspects of the climate change problem. Thematically presentations and papers by national experts prepared and publicized. Public awareness companies and radio broadcasts arranged and articles in popular newspapers published. Climate change information kits in local languages issued and disseminated among the public and in the educational entities.

The information about Tajikistan's contribution to global climate change and its adverse consequences has been recorded on the electronic medias and lunched in the World Wide Web to provide appropriate access of global community to the national information. The electronic version of the report "Vital maps and graphics on the environment and climate change in the Republic of Tajikistan" to support the process of preparation of the National Action Plan for Climate Change Mitigation has been developed and stored in the Internet: http://www.grida.no/enrin/htmls/tadjik/vitalgraphics/eng/index.htm. Comprehensive and consistent environmental information about Dushanbe city (capital), including data on climate change and air quality can be found at http://www.ceroi.net/reports/dushanbe/eng/index.htm.

1.11. Problems and constrains

During the process of preparation of the First National Communication Tajikistan faced a few constrains related to institutional issues, technical problems, availability of accurate data, level of expertise and scientific knowledge, methodologies etc. Many problems have been successfully solved, but some still exist and need to be solved in future.

It is clear that awareness on climate change among different stakeholders is not adequate and need to be improved. Activity data for some categories of GHG inventory is not consistent with IPCC format or unavailable. Local emissions factors for key sources (e.g. aluminum industry) are not studied. Energy balance of the national economy during the last 11 years has not been compiled. There is the lack of scenarios for few sectors (e.g. energy).

The methodological problems relate to the LUCF category and solvent use. There is the lack of models and software for emission scenarios development and vulnerability assessment (water resources, agriculture, transport, health etc.), inadequate resolution of climate modeling software, the lack of methods for simulation of extreme weather events.

1.12. Capacity building and technological needs assessment

Capacity building

Existing institutional framework requires further development. Human resources need to be trained and methodological base should be strengthened. Raising public awareness is important. Identification of appropriate technologies on national and international levels for GHG emission reduction, adaptation to climate change and improvement of systematic observation networks is of uppermost priority.

Sectoral Technology Needs

Oil and gas production needs essential update of technologies with respect to environmental protection and minimization of accident risk. The reduction of fugitive emissions is possible through the improving of gas and oil pipeline efficiencies, enhancing fossil fuel storage and distribution systems.

The energy sector requires technology support to improve energy efficiency and conservation through enhancement of electricity networks, stations and transmission lines, thermal insulation of buildings etc. Renewable energies, primarily hydropower, have big perspectives and require further support. It will promote the reduction of poverty, improving social conditions and prevention of forest cuttings. Adaptation technologies in hydropower engineering sector to reduce sedimentation processes, adjust to changing hydrological cycle and to minimize the risk of floods and landslides are needed.

Manufacturing industry and construction requires the technologies for improved water-use and energy efficiency, including high efficient drivers, heat utilization etc.

Existing cement production technologies based on "wet method" need to be replaced by "dry method". Gas purification facilities at many enterprises require urgent rehabilitation. Smelting technologies that reduce greenhouse gas emissions are also required, especially in aluminum industry. There is a need in joint research on the subject of non-carbon technologies, low polluting industrial processes etc.

The transport sector requires technology to enable rationalization of freight and passenger transportation and improving fuel quality and road surface. Technologies on alternative transport, liquefied gas and high efficient internal combustion engines are required. Use of electrified public road and railway transport should be promoted. Currently, national nature protection authorities monitor harmful emissions from motor vehicles. In this regard, appropriate measuring instruments and methods of emission regulation are required. In adaptation respect, there is a need in in-depth research of climatic and geodynamic factors influence on roads and securing transportation in the conditions of climate change and extreme weather events manifestation. Technologies for landslide, mudflow and avalanche prevention are needed.

Residential and commercial sectors require technologies that reduce domestic energy demand. Improved insulation of buildings and transition to modern lighting equipment is needed. Installation of gas consumption monitoring systems in households is necessary.

Agriculture requires testing and deployment of drought-tolerant and disease-resistant crop cultivars (e.g. cotton, cereals) with respect to appropriate adaptation to climate change. Advanced technologies in the filed of forecasting of pest and disease incidence are needed. Important element of adaptation strategy is rational use and conservation of water resources, since agriculture consume about 93% of water. The reduction of GHG emissions in agricultural sector requires technologies that enhance livestock management, recover the methane from manure and increase rice cultivation efficiency. Genetic research to reduce methane production from livestock should be further pursued. Public participation, particularly concerning issues of land conservation and rational grazing, is important and should be further improved. Tillage technology, which maximizes the storage of carbon and efficient use of water, is required.

Land use change and forestry requires technology for the detection and quantification of land-based carbon stocks; it is needed for refinement of the inventory and the assessment of options under the Clean Development Mechanism of the Kyoto Protocol. Affordable and applicable access to remote sensing (both from satellites and aircraft) is an important part of this technology. Technologies such as remote sensing analysis, geographical information systems, modeling and baseline inventory techniques need to be transferred to the appropriate scientific and governmental institutions. The advanced methods and technologies of sustainable forest management and forestation are needed.

Appropriate technologies for solid communal waste recycling and recovery of methane are essentially needed. It will reduce GHG emissions, decrease primary energy consumption and improve ecological conditions and sanitation of urban areas.

The health sector needs technology for the control of malaria-carrying mosquitoes, including engineering solutions and biological methods. The upgrading of water supply and sanitation facilities is also required. Water testing technology to detect pathogens (typhoid, dysentery, hepatitis etc.) is needed to protect public health. Awareness of climate change issues within the health sector needs to be improved, both amongst the health professionals and the general public.

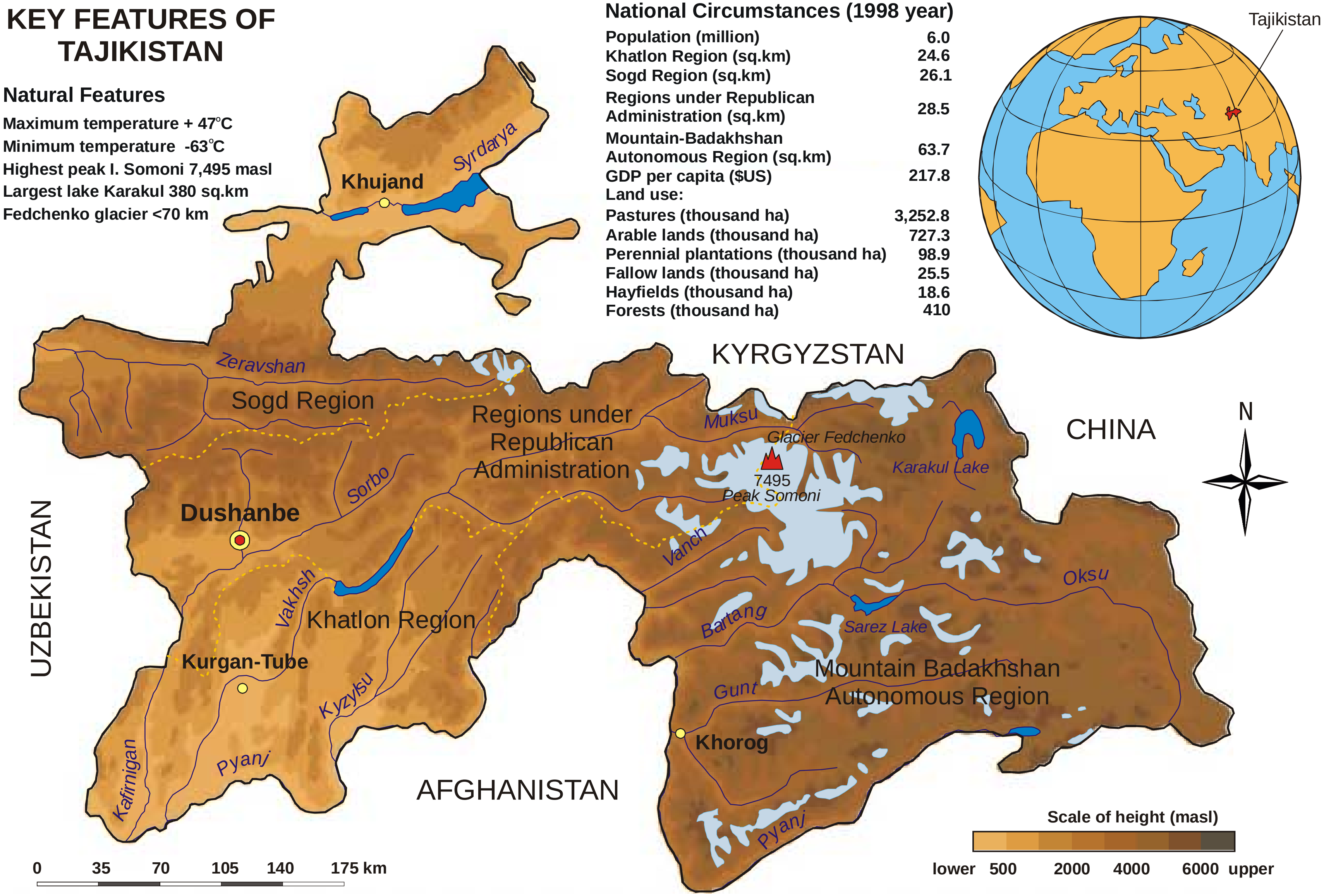
KEY FEATURES OF TAJIKISTAN

Natural Features

Maximum temperature + 47°C
Minimum temperature -63°C
Highest peak I. Somoni 7,495 masl
Largest lake Karakul 380 sq.km
Fedchenko glacier <70 km

National Circumstances (1998 year)

Population (million)	6.0
Khatlon Region (sq.km)	24.6
Sogd Region (sq.km)	26.1
Regions under Republican Administration (sq.km)	28.5
Mountain-Badakhshan Autonomous Region (sq.km)	63.7
GDP per capita ($US)	217.8
Land use:	
Pastures (thousand ha)	3,252.8
Arable lands (thousand ha)	727.3
Perennial plantations (thousand ha)	98.9
Fallow lands (thousand ha)	25.5
Hayfields (thousand ha)	18.6
Forests (thousand ha)	410



2. National Circumstances of the Republic of Tajikistan

2.1. Geographic position

Tajikistan is situated in the south of the Commonwealth of Independent States, within Central Asia, in the center of Eurasia, between 36°40' - 41°05' northern latitude and 67°31' - 75°14' eastern longitude.

The area of Tajikistan is 143,1 thousand sq.km, stretching 700 km from west to the east and 350 km from north to the south. In the north and west, Tajikistan borders on Uzbekistan and Kyrgyzstan, in the south on Afghanistan and in the east on China. The country’s borders perimeter total 3,000 km. The territory of the country is divided into 4 administrative regions: Sogd Region, Khatlon Region, Mountain-Badakhshan Autonomous Region and Regions under Republican Administration.

Tajikistan is a mountainous country. Mountains occupy about 93% of the terrain while about half of the territory is situated at an altitude above 3,000 m. The absolute heights vary from 300 to 7,495 masl. Western deserts and semi-deserts of Turan lowland gradually translate to the foothills. To the east, there are the huge mountain ranges of the Tibetan plateau and Tian Shan. Such geographical positioning results in great diversity of natural conditions and environments.

The form of the landscape is not uniform. In the north lie the Ferghana valley and the Kuramin range. The central region of the republic is occupied by the Kuhiston mountain ranges, while on the east there are Pamirs - the most severe and mountainous region of Tajikistan (the highest summit being Ismoil Somoni at 7,495 masl).

Peak Ismoil Somoni (7,495 masl)

Western Pamir includes high mountain ranges separated by deep river valleys. The valleys are located at an altitude between 1,700-2,500 masl, while the mountain range heights exceed 6,000 masl. Thus, the terrain of Western Pamir is mostly rugged. Smooth relief characterizes Eastern Pamir, despite its high elevation above sea level, where wide valleys at elevations of 3,500-4,000 masl prevail. The absolute elevations of Eastern Pamir are high, but local mountains rise only 1,000 to 1,500 m above the valley’s floor.

Low mountain ranges and wide valleys occupy the southwest part of Tajikistan. The plains of Tajikistan lie at various heights above sea level - from 300 to 1,000 m. The largest plains are Western Ferghana, Penjikent, Kuliab, Gissar, Vakhsh and lowland Kafirnigan.

2.2. Climatic conditions

Aridity, abundance of heat, and significant variability of almost all climatic elements are characteristics for Tajikistan's climate.

Local climate covers a wide range of temperatures, humidity conditions, precipitation and intensity of solar radiation. The annual mean temperatures vary from +17°C in the south to -6°C in the Pamirs. Maximum temperatures are observed in July and minimum in January. East Pamir is distinguished with its extreme severe climate, where minimum reaches -63°C (Bulunkul Lake). In the south maximum surface air temperature can exceed +47°C (Shaartuz).

The annual precipitation in lowland hot deserts of Northern Tajikistan and cold mountain deserts of East Pamir averages from 70 to 160 mm, while in Central Tajikistan precipitation can exceed 1,800 mm a year.

Annual average sunshine is about 2,100-3,170 hours. The least duration of sunshine is observed in mountainous areas, which are characterized by cloudiness. The most duration of sunshine is observed in the lowlands of northern Tajikistan, Gissar and Zeravshan valleys, southwest Tajikistan and in the Pamirs.

Cloud cover reduces solar radiation and radiation balance. During the year clouds reduce direct solar radiation by 32-35% in lowlands and by 50% in the mountains. Total solar radiation reaches its maximum during May-July. The intensity of the total radiation changes in the foothill areas from 280 to 925 MJ/sq.m. In mountain areas it fluctuates from 360 to 1,120 MJ/sq.m throughout the year.

2.3. Glaciers and water resources

Due to specific climate conditions and landscape, mountains of Tajikistan are considered the main glacial knot of Central Asia. Glaciers retain huge amounts of water, and regulate river flow and climate. Glaciers and snowfields are the main source of water replenishing the Aral Sea. Glaciers occupy more than 8.4 thousand sq.km, which is about 6% of the total country area. The most ice cover is observed in the western part of Pamir Mountains.

The largest glacier of Tajikistan is Fedchenko Glacier. Its length exceeds 70 km, width - 2 km, and maximum thickness - 1 km. The volume of glacier itself with tributaries is 144 cub.km. Upper elevations of the glacier reach 6,200 masl, and the glacier tongue is located at 2,909 masl. The total number of glaciers is about 8 thousand and 7 of the glaciers have a length of more than 20 km.

Tajikistan's rivers are the basic source of fresh water for the Aral Sea. These rivers bring life to the neighboring areas down stream; they are important for irrigation, power generation, water supply, etc.

Major watersheds of Tajikistan are Syrdarya (North Tajikistan), Zeravshan (Central Tajikistan), Pyanj (Southwest Tajikistan and Pamirs) and blind drainage area of East Pamir. The largest rivers are Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, Bartang, etc. Most of the rivers in Tajikistan are mountainous; some of them originate at an altitude of more than 3,000-4,000 masl.

There are 947 rivers in Tajikistan with a length of more than 10 km. Total river length is 28,500 km. The annual surface runoff reaches 30-45 l/sec/sq.km in the highlands. The annual river flow is about 53 cub.km. Most of the water resources are formed in the basins of Pyanj and Vakhsh rivers. During flood season, when snow melts intensively and heavy rainfall occurs (April-August), the rivers carry much suspended solids, which can exceed 5,000 g/cub.m (Kysylsu).

Amplitude of water fluctuation during the year in most of the rivers is not very high and varies between 0.6-2.0 m. The level of water can significantly rise during floods in the Vakhsh, Pyanj and Obihingou rivers. Water level in flood season on the rivers Vakhsh, Pyanj and Obihingou can raise in one day by 4-5 m that lead to the destruction of roads, engineering facilities, flooding of agricultural fields and the overflowing of dams and canals.

Hot and cold mineral waters are widely spread over the territory of Tajikistan. The best-known mineral water sources are Garm-Chashma (Hot spring), Liyangar, Anzob, Khodja-Obigarm, Sangkhok, Yavroz, Shambari, and Tashbulak. Many mineral water sources are used for drinking, medicinal and other purposes.

Tajikistan is rich in lakes. There are more than 1,300 lakes, 80% of which are located at an altitude of around 3,000 m with an area of less 1 sq.km. The total area of large lakes exceeds 680 sq.km. According to their origin, lakes are divided into tectonic, erosive and glacial.

The largest salt-water lake in Tajikistan is Karakul (this lake was formed at the site of an asteroid impact), which is located in East Pamir (3,914 masl), total area 380 sq.km. The deepest freshwater lake in Tajikistan is Sarez (3,239 masl); its depth exceeds 490 m, total area 86.5 sq.km. Sarez Lake is located on the West Pamir within the Bartang River canyon. The lake was formed as the result of a powerful earthquake and rockslide in 1911. The volume of water in Sarez Lake exceeds 17 cub.km.

Lake Iskanderkul. Photo by U. Karimov

Other big lakes are Iskanderkul, Zorkul, Yashilkul. Sometimes temporary lakes occur as a result of glacier shearing movement or rockslides. In addition to natural lakes there are reservoirs Kairakkum, Nurek, Farkhad and others.

2.4. Forests

Forests in Tajikistan are State property referred to as "first group forests", which means that all forestry activities are aimed at expansion and improvement.

The role of forests in Tajikistan is essential. Forests are needed, in the first instance, as accumulators of moisture for soil protection, regulators of climate, and sources of food, botanical and medical goods.

At present, the total area of the state forest reserves is 1.8 million hectares; some 23% of them are under tree plantations. Forests in Tajikistan occupy an area of 410 thousand hectares. Juniper forests occupy an essential part of national forests, which are located at different altitudes between 1,500 and 3,200 masl on the slopes of Gissar, Zeravshan and Turkestan ranges. Juniper forests are good regulators of surface runoff preventing soils from erosion in mountains and valleys, as well as CO_2 sinks. Junipers can be as old as five centuries.

Pistachio forests are well adapted to the arid hot climate and occupy 78 thousand hectares. Pistachios dominate the landscape in the south of Tajikistan at altitudes from 600 to 1,400 masl.

Walnut forests occupy a territory of 8 thousand hectares and differ by very demand in terms of soil and climatic conditions. Walnut forests grow in Central Tajikistan at an altitude from 1,000 to 2,000 masl.

Maple forests occupy a significant part of national forests - 44 thousand hectares. Poplars, willows, birches, sea-buckthorns and other types of groves are spread fragmentarily.

2.5. Flora and fauna

Flora of Tajikistan is rich and diverse and includes more than 5,000 species of higher plants, over 3,000 species of lower plants, including endemic, rare and endangered species.

Tajikistan as a typical mountain country is unique with its high-altitude flora distribution and its geographic isolation. Plant communities typical for Tajikistan are: broad-leaf forests (Acer turkestanicum, Juglans regia), tugai flood plain forests (Populus pruinosa, Elaeagnus angustifolia, Tamarix laxa, Phragmites communes), small-leaf forests (Salix turanica, Hippophae rhamnoides, Populous tadshicistanica, Betula tadshicistanica), juniper forests (Juniperus turkestanica, J. seravschanica, J. semiglobosa), light forests (Pistacia vera, Cercis griffithii, Amygdalus bucharica), saxaul deserts, shrub deserts, steppes, meadows, pulvinates and thorn dwarf shrubs.

Mountain ecosystem. Photo by I. Abdusalyamov

The fauna of Tajikistan is very diverse. There are 84 species and subspecies of mammal, 385 species of bird, 46 species of reptile, 52 species of fish, 2 species of amphibian, more than 10,000 species of invertebrate. Such diversity takes place due to the specific geographical location of Tajikistan inside the Eurasian continent with its diverse habitats, ranging from the hot lowland deserts of Southern Tajikistan to the high mountains of Western and Eastern Pamir.

A few rare and endangered species of animals can also be listed, such as screw-horned goat, argali, urial, Bukhara red deer, snow leopard, Central Asian cobra, desert monitor, peregrine, snow-cock, and others.

2.6. Population

According to the census conducted in 2000, the population of the republic is 6.1275 million people. Over the last 70 years, the population has increased by 6 times. In comparison with other CIS and CEE countries, the population's growth in Tajikistan is faster. Average annual increase is 1.5-3.5%.

The rural population of Tajikistan exceeds 70% of the country's total population; 49.5% male, 50.5% female with over 30% of the population children under the age of ten.

Natural and historical conditions have led to an irregularity in populating Tajikistan's territory. The valleys and mountain canyons are major places of human habitation. Here, the density of population exceeds 200 people per 1 sq.km (Gissar, Vakhsh valleys and northern regions of the country). In mountain regions, the density of population is as low as 4-10 people per 1 sq.km. Eastern Pamir is considered a less populated area of Tajikistan. The density of population here is the smallest and makes less than 1 person per 1 sq.km. The population density in the republic averages at about 42 people per 1 sq.km.

Most of the population in Tajikistan are involved in agriculture (65%). The rest of the population are occupied in industry, services, education, public health and other sectors.

More than 100 nationalities reside in Tajikistan. Native inhabitants of Tajikistan are Tajiks. According to the census conducted in 2000, they comprise 80% of the country's total population. Tajik, Russian, Uzbek and other languages are used for communication. The state language of Tajikistan is Tajik. Russian is the preferred language of international communication.

2.7. Social economic development

Independence of Tajikistan was declared on September 9, 1991. In 1992, Tajikistan was inducted into the United Nations. 170 countries acknowledged Tajikistan's sovereignty. Many countries have their diplomatic missions in Tajikistan.

The supreme public official in the country and the head of the state is the President. By free vote and on an alternative basis, Emomali Rakhmonov was elected as the President of the Republic of Tajikistan.

The national unit of currency is the SOMONI, which was introduced as of November 1, 2000. The annual GDP in 1998 was US$ 217.8 per capita. The GDP and manufacturing trends are shown in the table 2.1. Key indicators of national circumstances are shown in the table 2.2 below.

Table 2.1.

GDP and Production (1990=100%)

Indicator	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gross Domestic Product (GDP)	100	94.6	63.6	53.2	41.9	36.7	30.6	31.1	32.7
Industrial Production	100	96.4	73.0	67.3	50.2	43.4	33.0	32.3	34.9
Agricultural Production	-	100	88.2	69.0	57.2	50.0	47.2	46.1	46.5

Source: State statistics

Table 2.2.

Socio-economic indicators

Criteria	1990	1994	1998
The area of national territory (10^3 sq.km), including:	143.1	143.1	143.1
• Khatlon Region (10^3 sq.km)	24.6	24.6	24.6
• Sogd Region (10^3 sq.km)	26.1	26.1	26.1
• Regions under Republican Administration (10^3 sq.km)	28.5	28.5	28.5
• Mountain-Badakhshan Autonomous Region (10^3 sq.km)	63.7	63.7	63.7
Population (million)	5.2	5.7	6.0
Urban population as percentage of total population (%)	32.0	28.6	27.1
Increase of population (per 1,000 inhabitants)	32.8 *	21.2	16.1
Life expectancy at birth (years)	69.4	66.3	68.4
Literacy rate (%)	97.7	97.7	97.8
GDP (US$ million)	8,300	810.6	1,317.2
GDP per capita	1587	141.2	217.8
Share of industry in GDP (%)	22.9	27.5	20.7
Share of agriculture in GDP (%)	30.4	24.1	25.1
Share of services in GDP (%)	33.8	37.0	42.3
Agricultural land use (10^3 ha), including:	4,123.8	4,214.7	4,123.1
• Pasturelands	3,278.9	3,269.7	3,252.8
• Arable lands	809.3	800.2	727.3
• Perennial plantations	95.4	104.7	98.9
• Fallow lands	18.8	18.9	25.5
• Hayfields	22.4	21.2	18.6
Forest area (10^3 ha), including:	410	410	410
• Evergreen	150	150	150
• Broad-leaf	58	58	58
• Pistachio-almond	96	96	96
• Small-leaf	12	12	12
• Other woods	94	94	94
Protected area (10^3 ha)	85.6	85.6	173.4 **
Livestock population (thousand), including:			
• Cattle	1,351.5 *	1,199.0	1,036.9
• Sheep	2,461.8 *	1,958.2	2,195.7
• Goats	830.1 *	741.9	667.7
• Pigs	183.2 *	32.7	1.2
• Horses	52.3 *	57.6	67.1

Source: State statistics — * 1991 data; ** 2000 data

Out of 80 sectors of Tajikistan's business, the prevailing industry is non-ferrous metallurgy, which amounted to a 50% share in the total industrial output for 1999. The enterprises of this branch produce aluminium, gold, silver, lead, zinc, molybdenum, tungsten, and mercury.

Recently, more than 400 mineral deposits have been explored and 200 of them are currently being exploited. Some 45 types of metal ores, fossil fuels, and minerals are being mined.

Energy industry is another important branch of the country's economy. Electricity production in the country in 1998, in comparison with that in 1940 has increased 233 times. During the years of independence, the average production of electricity has been more than 15 billion kilowatt-hours annually.

Light and food processing industries, especially cotton, canning and meat production are being developed on an agriculture basis. Few agricultural crops such as rice, grain, tobacco, corn, potato, vegetables, gardens and vineyards are cultivated. Animal husbandry is very popular in mountain regions.

Transport is an integral part of the economy in Tajikistan. In view of the complicated mountainous pattern of the country, transport plays a most significant role. In a brief period, Tajikistan turned from a land of few roads into a country of modern transport. It has transformed its traditions of caravan tracts to highways and air routes.

Some 533 km of railroads, 13.6 thousand km of asphalt-coated roads run through the country's territory. The total length of national air routes exceeds 53.2 thousand km. Transportation dynamics are shown in the tables 2.3 and 2.4.

Table 2.3.

Passenger traffic (million people)

Type of transport	1990	1991	1992	1993	1994	1995	1996	1997	1998
Road	472.3	444.0	242.7	152.4	92.7	97.8	92.1	83.1	140.8
Railway	1.6	1.1	1.0	1.2	0.6	0.6	0.5	0.6	0.7
Aviation	2.3	2.1	0.7	0.2	0.2	0.3	0.2	0.2	0.2

Source: State statistics

Table 2.4.

Freight (thousand tonnes)

Type of transport	1990	1991	1992	1993	1994	1995	1996	1997	1998
Road	285,326	296,598	140,775	90,537	106,005	103,718	101,879	42,586	21,242
Railway	6714	6412	1647	2661	1479	861	610	623	631
Aviation	16	11	6	2	2	1	1	4	4

Source: State statistics

At present, there are 3,357 schools with a total number of 1.5 million pupils. Some 100 thousand students attend 30 universities and 72 colleges. More than 5 thousand scientists work in the Academy of Sciences and scientific-research institutes, and about two thousand of them have academic degrees.

The number of doctors in the country has reached 13 thousand. For every 10 thousand residents there are 21.2 physicians and 52.8 medical nurses. More than 1 thousand health institutions including 433 hospitals provide their services to the population. Many famous health resorts such as Khoja Obigarm, Shohambary, Zumrat, Havotague, Ura-Tube, Garm Chashma offer their services to those who need rehabilitation.

During these years of independence, the country has put into operation the Pamir hydropower station, small hydropower stations in Badakhshan region, gold and silver branches of the "Vostokredmet" enterprise, mineral water plant "Obi Zulol", Tajik-British joint venture "Zeravshan", a segment of the railroad between Kurgan-Tube and Kulyab, motorway "Murgab-Kulma pass" with the outlet at the Chinese border. The Anzob tunnel, which will enable year round transportation between the northern and southern parts of the country, is under construction. Besides, a number of light and food processing enterprises have been established. Some houses and public buildings, schools and hospitals have been constructed.

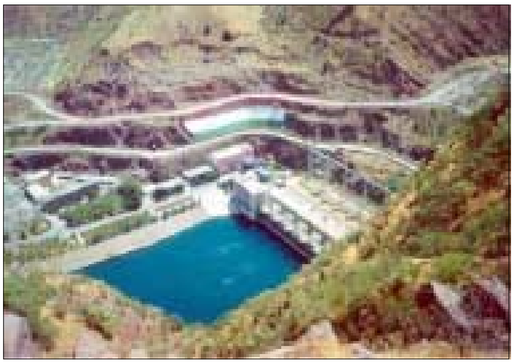
At present, the Republic of Tajikistan has trade partners in 71 countries of the world. Foreign trade turnover in 1998 amounted in almost US$ 1.4 billion. Some 64% of this amount is related to CIS partnership. The share of export is 45.6% of foreign trade turnover.

Exports mainly concentrate on raw materials, including aluminum, raw cotton, electricity, precious metals and jewelry stones, fresh vegetables and fruits, canned vegetables, raw leather, silk fabrics, carpets, handicraft products, etc.

Imports mainly consist of raw materials for the aluminum industry, natural gas, liquid fossil fuels, vehicles, and machinery.

2.8. Energy production and use

Tajikistan is relatively poor in deposits of fossil fuels. In total, 18 deposits of oil and gas (Kanibadam, Airitan, Niyazbek, Kichikbel and others) and over 40 deposits of coal (Nazaraylok, Shurab, Fan-Yagnob and others) are explored and registered in Tajikistan. Proven reserves of oil and gas obviously do not pose significant industrial importance. Coal is available in large quantities in Tajikistan but its deposits according to estimates are not efficient for industrial and energy-related use in current conditions. About 15-20 thousand tonnes of coal are being mined in Tajikistan annually.



Nurek hydropower plant. Photo by G. Petrov

Development of nuclear power in the country is problematic because of high seismic risk and other circumstances. Wind energy potential is not sufficiently researched and would require significant investment for equipment and maintenance.

Hydropower resources are abundant and evenly located over the territory of Tajikistan. In terms of hydropower potential, Tajikistan is one of the world leaders. For the time being, only 5% of this potential is being exploited. Hydropower engineering is the base for the electric energy sector of the country. The total capacity of operating power plants comprises 4,412.7 Megawatts, 93% of which is being produced by hydropower plants. Tajikistan's peak energy production was recorded in the early 1990s, when it reached 17-18 billion kilowatt-hours a year. At present, this has diminished and on average is 15 billion kilowatt-hours.

The biggest hydropower plants in Tajikistan are: Nurek hydropower plant (height of dam is 300 m) with production capacity of 3,000 Megawatts, Baipaza hydropower plant - 600 Megawatts, Golovnaya HPP - 240 Megawatts, Kayrakkum HPP - 126 Megawatts. Small hydropower plants have big prospects. At present, their total capacity is about 30 Megawatts.

Several new big hydropower plants are under planning and construction: Rogun hydropower plant with production capacity at 3,600 (3,000) Megawatts, Sangtuda-1 HPP - 670 Megawatts, Sangtuda-2 HPP - 220 Megawatts and Niznekafarniganskaya - 100 HPP. Once fully operational these hydropower plants will be responsible for doubling the current level of electricity generation.

Dushanbe thermal power plant (capacity 198 Megawatts) and Yavan thermal power plant (capacity 120 Megawatts) are using natural gas and oil as the basic fuels, which are environmentally safer than thermal stations on solid fuels.

The structure of primary energy consumption in Tajikistan has significantly changed. During the period between 1990-1998, the consumption of natural gas decreased somewhere between 10 and 15 times, consumption of liquid fuels decreased by 8 times, and the consumption of coal decreased by approximately 400 times. The major consumers of energy resources are: the manufacturing industry, construction, motor vehicles and the residential sector.

Less significant changes have taken place in electricity consumption. In 1990, all sectors of the national economy consumed 19,388 million kilowatt-hours of electric energy, and 14,667 million kilowatt-hours in 1998.

At the same time, there have been substantial changes in the structure of electricity consumption. In 1990, electricity consumption by the manufacturing industry and construction amounted to 11,578 million kilowatt-hours of electric energy, while by 1998 it had decreased to 5,154 million kilowatt-hours. Electricity consumption within the transport sector in the period between 1990-1998 decreased from 158 million kilowatt-hours to 67 million kilowatt-hours. The lack of fossil fuels has been responsible for electricity consumption in residential and agricultural sectors increasing by somewhere between 1.2 and 1.5 times.

2.9. Industry

There are 80 main branches of industry within Tajikistan comprising of 1,300 different enterprises.

The share of industry in GDP in 1990 made up 22.9% and by the year 1998 it had decreased to 20.1%. Between 1992 and 1998, there was a clear indication of production decline in the manufacturing industry (tab. 2.5). However recently, there has been a tendency for some growth.

The major enterprises of metallurgy are; Isfara hydro metallurgic plant, Anzob ore-dressing plant, Adrasman lead-zinc plant, industrial venture Vostokredmet, joint

Table 2.5.

Industrial production

Criteria	1990	1991	1992	1993	1994	1995	1996	1997	1998
Electricity (million kWh)	18146	17597	16822	17741	16982	14768	14980	14005	14422
Gas production (million cub.m)	111	93	72.4	48.8	33.2	38.7	47.4	41.6	32.4
Oil production (thousand tonnes)	144	108	61.4	41.9	32.6	25.7	25.8	26.0	19.4
Coal production (thousand tonnes)	475	313	214	174	106.4	33.9	20.1	17.0	18.5
Mineral fertilizers (thousand tonnes)	81.5	83.5	52.8	19.7	8,0	12.6	11.0	9.8	11.9
Ammonia (thousand tonnes)	109.5	110	69.5	29.5	13.3	22.0	18.5	18.9	21.3
Sodium hydrate (thousand tonnes)	45.3	31.1	16.4	6.0	5.6	2.2	0.3	0.5	0.6
Cement (thousand tonnes)	1067	1013	446.8	261.5	178.2	78.0	49.3	36.4	17.7
Lime (thousand tonnes)	107.4	98.0	55.6	21.2	15.8	13.6	7.3	7.5	6.0
Aluminum (thousand tonnes)	450.3	380.0	345.3	252.3	236.5	237	198.4	188.9	195.6
Lead (tonnes)	2834	3252	3301	2689	1711	1558	1615	1069	762
Antimony and mercury (tonnes)	14586	15158	14125	14233	8590	6600	4506	4538	2223
Cotton fabrics (thousand sq.m)	121836	102422	58218	57206	34338	27987	17379	8250	13113
Armature (thousand units)	983	858	531	538.6	282	273.7	154	71.7	68.7
Motor vehicles (units)	324	160	169	352	195	127	57	48	55
Refrigerators (thousand units)	166.9	145.2	61.3	18.0	3.2	0.05	0.9	1.54	0.9

Source: State statistics

venture "Zeravshan", joint venture "Darvaz" and the industry giant - Tajik Aluminum Plant. The aluminum industry is the main cause for industrial exports and national income. More than 460 thousand tonnes of aluminum was produced in 1989.

The chemical industry has 9 different enterprises, the biggest of them being the joint stock company "Azot" producing ammonia and the joint stock company "Tajikhimprom" producing chlorine-containing products, caustic sodium, lime and sodium chloride.

The construction industry includes the Dushanbe cement plant and other plants producing reinforced concrete, lime products, alabaster, and construction designs. These enterprises are located in all areas of the country. Cement production has decreased from 1.067 million tonnes in 1990 to 17.7 thousand tonnes in 1998.

Mechanical engineering produces a variety of goods ranging from spare parts for agricultural machines and vehicles to electric transformers, refrigerators, industrial equipment, etc.

Despite the fact that industrial production has been severely reduced, many enterprises are trying to use foreign investments and undertake reforming projects to solve their problems during the conditions of transitional period.

2.10. Agriculture

The share of GDP in agriculture is about 25%. Light and food processing industries, especially cotton, canning and meat production are being developed.

Most agricultural ventures are either privatized or incorporated into collective farms. At present, some 283 collective farms, 260 soviet farms, 47 state and local farms, 230 farming associations and 12.3 thousand private and family farms produce agricultural products.

Cereals, cotton, potatoes, vegetables, melons, fruit and grapes are cultivated in the country. Before the 1990s, production of raw cotton ranged from 800 thousand to 1 million tonnes. In recent years, the country has been producing up to 400 thousand tonnes of raw cotton. Annual productivity of cotton varies from year to year in different regions and averages 1,400-2,700 kg/hectare. The volume of cereal production in the year 1998 in comparison with 1990 has increased by 1.6 times and amounted to 499.6 thousand tonnes of cereals. In 1998, the country produced: 174.5 thousand tonnes of potatoes, 40.3 thousand tonnes of rice, 35.5 thousand tonnes of corn, 97.3 thousand tonnes of fruit and 46.3 thousand tonnes of grapes (tab. 2.6).

Table 2.6.

Agriculture production

Criteria	1990	1991	1992	1993	1994	1995	1996	1997	1998
Cereals (thousand tonnes)	318.0	304.4	275.7	273.0	229.0	249.2	548.2	559.4	499.6
Raw cotton (thousand tonnes)	842.1	826.0	513.2	524.2	531.3	411.5	317.7	353.3	383.7
Potato (thousand tonnes)	207.0	180.1	167.4	147.0	134.3	111.6	107.7	128.1	174.5
Rice (thousand tonnes)	29.1	25.7	20.2	22.7	23.4	24.1	20.7	44.2	40.3
Popcorn (thousand tonnes)	84.7	60.4	32.3	33.5	17.8	19.4	90.0	30.3	35.5
Leguminous plants (thousand tonnes)	7.7	8.9	5.6	5.6	5.2	5.3	18.7	8.2	8.9
Fruits (thousand tonnes)	220.4	176.8	183.4	149.2	147.8	148.7	126.3	112.7	97.3
Vegetables (thousand tonnes)	528.4	627.8	542.6	484.8	490.3	491.4	397.5	350.6	322.1
Grape (thousand tonnes)	189.5	120.9	99.9	87.7	80.1	96.4	121.6	126.9	46.3
Meat (thousand tonnes)	107.5	75.3	63.1	61.6	61.2	47.6	41.6	29.5	30.0

Source: State statistics

As well as the cultivation of fruit and vegetables, due to the great assortment and diversity of pastures, animal husbandry is also well developed in Tajikistan. During the last 8 years, the structure of animal husbandry has significantly changed due to the reorganization of the economy and the realization of land reform. The volume of production in the cattle-breeding sector has significantly decreased and makes only 40-50% of that of the 1990's. The volume of meat production during 1990-1998 has decreased from 107.5 thousand tonnes to 30 thousand tonnes. The total number of cattle stock, pigs and birds has significantly decreased in comparison with the 1990's.

2.11. Land use

The total land area of Tajikistan is 14.2545 million hectares. The area of agricultural lands in 1998 in Tajikistan was 4.5461 million hectares.

More than half of the country's area is unsuitable for agriculture: watercourses, glaciers, rocks, mountain slopes, riverbeds, low productive pastures, etc.

The total area of arable land was 734.2 thousand hectares in 1998, which is 70 thousand hectares less than in previous years. Rather large agricultural fields in the south of the country have not been in use over the last few years because of salinization and swamping. This has been the result of economic instability and the lack of technical resources, fuels, seeds, etc.

The total area of irrigated land is 600.2 thousand hectares; the total area of pastures - 3.6595 million hectares; perennial plantations - 102.7 thousand hectares; fallow lands - 26.1 thousand hectares; hayfields - 23.6 thousand hectares. During the 1950-1990s, the area of irrigated land has increased by 320 thousand hectares.

2.12. Nature protection

The problem of climate change and atmospheric air protection has been declared in the national legislation and other state provisions of the Republic of Tajikistan. This problem is indicated in the relevant articles of the Law on nature protection, the State ecological program, the State program on public awareness and environmental education, and other documents.

At present, the country has developed a series of strategies and action plans on such environmental problems as desertification, biological diversity, climate change, ozone layer depletion, water management and flood prevention. All these documents consider the aspects of climate change problem.

For the conservation of biodiversity and protection of endangered species, there have been established 4 strict nature reserves, 14 species management areas, and 2 national parks. One of the oldest natural reserves in Tajikistan "Tigrovaya balka" has recently celebrated its 60-th anniversary.

3. Inventory of Anthropogenic Greenhouse Gases

3.1. Methodology

In accordance with articles 4 and 12 of the UNFCCC, each Party to the Convention shall communicate to the Conference of the Parties "a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol to the extent its capacities permit, using comparable methodologies".

The main requirement in the preparation of the national GHG inventory is applying a methodology of calculations agreed and adopted in the COP UNFCCC, which allows international comparing of results. Revised 1996 IPCC Guidelines for the National Greenhouse Gas Inventories, including software IPCC v 1.1 served as the basic documents and methodologies for all GHG calculations.

In accordance with IPCC, Tajikistan's inventory includes 5 categories of anthropogenic greenhouse gas emissions by sources and removals by sinks comprising of 9 gases with direct and indirect greenhouse effect during a 9 year period from 1990 to 1998.

Gases with direct greenhouse effect include: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (CF_4, C_2F_6). Gases with indirect greenhouse effect: carbon monoxide (CO), nitric oxide (NOx), non-methane volatile organic compounds (NMVOC). Sulphur dioxide (SO_2) is considered as a gas advancing the formation of anthropogenic aerosols.

The state statistical data served as a basis for all calculations of greenhouse gas emissions. Additional data was obtained from: Ministry of energy, Ministry for nature protection, State forestry authority, State industrial committee, State committee on land resources and Ministry of agriculture.

GHG emissions related to production, storage, distribution and combustion of fossil fuels were studied under the category "Energy activities". Calculations of CO_2 emissions in this category are based on two approaches. The first considers statistical data on production, import, export, international bunker, and changes of fuel stocks in the country. The second approach, which was adopted as basic according to the IPCC recommendations, was based on statistical data on fuel consumption by various sectors of the national economy.

Gross calorific values recommended by IPCC are adopted in all calculations under the category "Energy activities", apart from the natural gas imported from Uzbekistan; therefore, local coefficients were applied for. IPCC emission factors were adopted as default.

GHG emissions, which occur as a result of a physical-chemical processes, were calculated in the category "Industrial processes". Activities such as the manufacturing of ammonia, aluminum, steel, iron, cement, and lime were included in this category. The industrial activities related to refrigerant production were not considered in view of the absence of data. Emission factors in the category "Industrial processes" were adopted according to the IPCC recommendations.

GHG emissions related to animal husbandry, rice cultivation, combustion of agricultural residues, and agricultural soils were studied in the category "Agriculture". Emission factors in the category "Agriculture" were adopted in accordance with the IPCC recommendations.

In the category "Land use change and Forestry" calculations covered two types of activities recommended by IPCC, including "Changes in forest and other woody biomass" and "Emission and removal of CO_2 in soils". Coefficients and emission factors recommended by IPCC were applied in calculations taking into consideration proposals by national experts as well as consultations by UNFCCC.

Emissions of methane from solid wastes and wastewater purification are calculated in the category "Waste". Solid wastes in rural areas were not taken into account, in view of their dispersion over the territory. Coefficients and emission factors recommended by IPCC, along with proposals by nature protection institutions, were used in these calculations.

The category "Solvents" was not considered in view of the absence of activity data and little potential contribution of this category to the total national emissions.

Following the "IPCC Guidelines on uncertainties management" national experts have calculated and explained uncertainties in the national inventory caused by the lack of data and emission factors, and prepared recommendations.

Significant contribution to the preparation of the national inventory was ensured by regular consultations and close cooperation with the experts from the National Communication Support Program GEF-UNDP, UN FCCC Secretariat, Azerbaijan Climate Change Center, etc.

3.2. Tajikistan's contribution to global warming

Industrialization, urbanization, the increase of industrial and agricultural production, development of motor transport apart from social and economical benefits have resulted in the increase of greenhouse gas emissions and overall anthropogenic impact on the environment and climatic system.

According to expert estimates, contribution of Tajikistan to the global warming during 1970-2000 totalled 300 million tonnes of CO_2, including emissions from fossil fuel combustion and cement production.

Until the 1990s, there had been a significant increase of carbon dioxide emissions, particularly emissions from solid fuel combustion rose by 22%, liquid fuels - 55%, gaseous fuels - 4 times.

In the 1990s, there was a decline in industrial production in Tajikistan, which resulted in the reduction of GHG emissions from fossil fuel combustion by 10 times, but cement production by 40 times.

3.3. Total greenhouse gas emissions

Five different gases with direct greenhouse effect considered in Tajikistan's GHG inventory. For comparison of their contribution into total emissions and assessment of their impact on the climate system, IPCC recommends submitting the results of the inventory in both absolute units and in ţŞ$_2$-equivalent. The latter depends on the global warming potentials (GWP), which consider the radiative influence of greenhouse gases during a certain period, as well as the lifetime of those gases in the atmosphere (tab. 3.1).

Table 3.1.

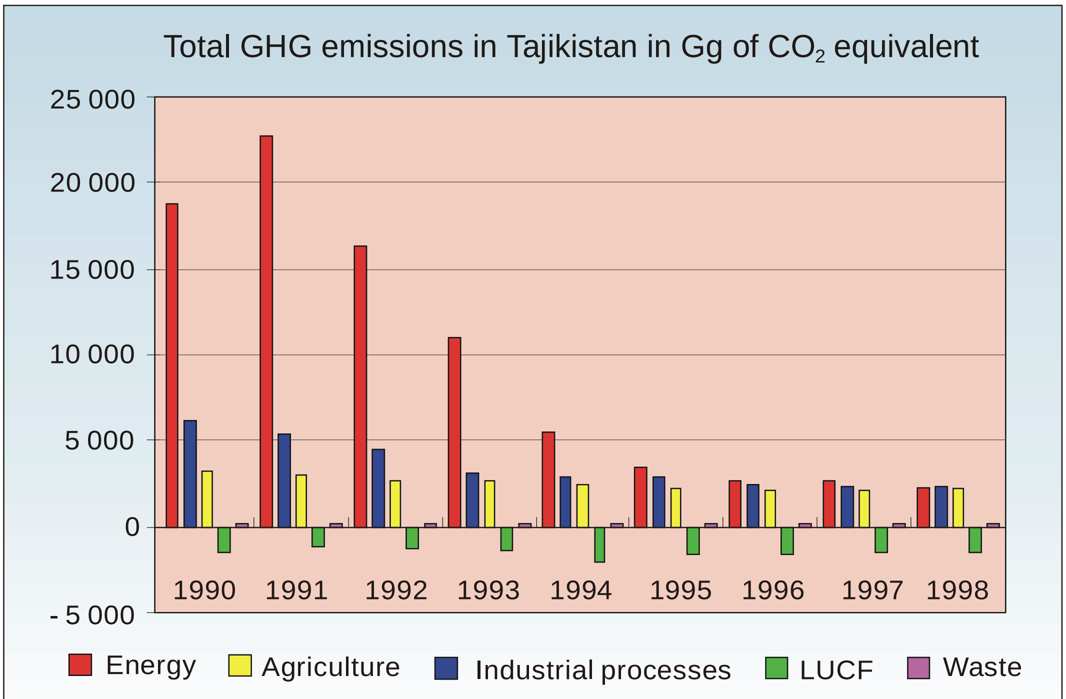
Global warming potentials for main greenhouse gases for 100-year horizon

Greenhouse gas	Chemical formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Tetrafluorcarbon	CF_4	6,500
Hexafluorcarbon	C_2F_6	9,200

Source: IPCC

Some greenhouse gases in view of their physical and chemical properties possess an extremely high GWP. Among those are perfluorocarbons. In light of high GWP, even a small volume of their emissions accounts for a significant ţ Ş$_2$-equivalent value.

The results of calculation show that the greatest greenhouse gas emissions in Tajikistan were observed in 1991; they resulted in 31 million tonnes of ţ Ş$_2$-equivalent, and taking into account absorption in LUCF sector, they amounted in 30 million tonnes of ţ Ş$_2$-equivalent. The lowest volume of GHG emissions was observed in 1998 and resulted in 6.3 million tonnes of ţ Ş$_2$-equivalent. Taking into consideration absorption in LUCF sector, they amounted in 4.8 million tonnes (fig. 3.1.).



Source : National GHG Inventory

Fig. 3.1.

During 1990-1998, carbon dioxide emissions dropped significantly when compared to methane, perfluorocarbons and nitrous oxide emissions.

The decrease in greenhouse gas emissions is mainly related to the economic decline and deficiency in power supply; the increase of their absorption is connected with land use changes in the late 1990s.

3.4. Per capita greenhouse gas emissions

ţŞ$_2$ emissions per capita have decreased from 3.8 tonnes to 0.5 tonnes; this index is the lowest in the Central Asian region. At a global level, Tajikistan has the 100th position in terms of specific CO_2 emissions (CDIAC). Given that combustion of fossil fuels is the major source of ţŞ$_2$ emissions, it should be noted that essential hydropower potential explains the low level of ţŞ$_2$ emissions for the time being.

3.5. Key sources of greenhouse gas emissions

Key source categories of the greenhouse gas emissions in Tajikistan, which aggregate 95% of all emissions during 1990-1998 varied from year to year (tab. 3.2)

Table 3.2.

Key sources of GHG emissions for the period 1990-1998

IPCC category	Greenhouse gas	Contribution
ENERGY, Industry and construction	CO_2	8-27%
ENERGY, Residential sector and other sectors	CO_2	18-33%
ENERGY, Transport	CO_2	8-16%
ENERGY, Oil-gas systems	CH_4	5-10%
INDUSTRIAL PROCESSES, Production of metals	CF_4, C_2F_6	13-32%
INDUSTRIAL PROCESSES, Production of metals	CO_2	2-3%
AGRICULTURE, Enteric fermentation	CH_4	6-19%
AGRICULTURE, Agricultural soils	N_2O	4-8 %

Source: National GHG Inventory

3.6. CO_2 emissions

In Tajikistan in the period of 1990-1998, the biggest CO_2 emissions were observed in 1991 (22,658 Gg), mainly because of the combustion of fossil fuels.

In total, the volume of carbon dioxide emissions in the period under review has decreased more than 10 times, mainly because of the decline in energy-related activities (fig. 3.2.).

<u>Most of national CO_2 emissions come from:</u>

- Fossil fuel combustion in industry, transport and residential sector (82-92%);
- Production of cement, lime, aluminum, ferrous metals and ammonia (8-18%).

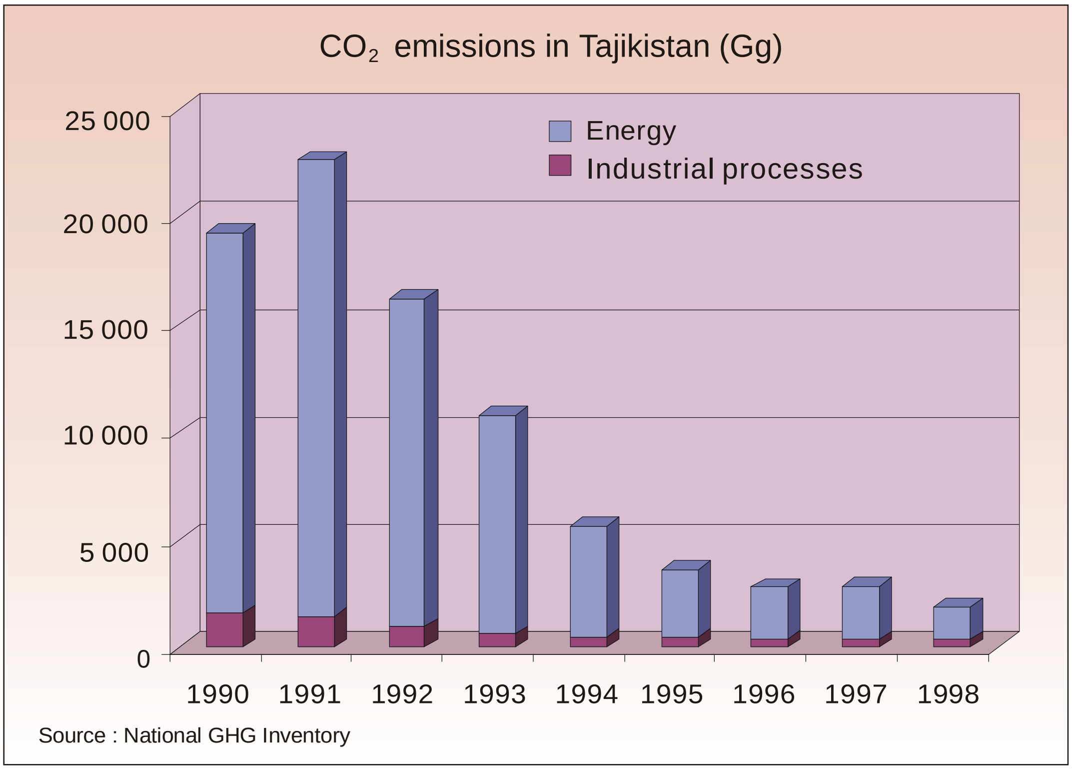


Fig. 3.2.

3.6.1. CO_2 emissions in the category "Energy activities"

In Tajikistan, the biggest CO_2 emissions were observed in 1991 at 21,235 Gg, the least in 1998 at 1,524 Gg. The residential sector is a major source of energy-related CO_2 emissions. From year to year, the share of this source amounted to 35-45% of total energy-related emissions. According to expert judgments, this source makes some 50% of CO_2 emissions considering unaccounted fuel consumption (wood, coal, etc.).

The second biggest source of energy-related ţŞ2 emissions is the manufacturing industry and construction. These sectors use fossil fuels (basically gaseous fuel) for its industrial needs. Fossil fuel is needed for the manufacturing of cement, aluminum, ammonia, etc. The most ţŞ2 emissions in manufacturing industry and construction were recorded in 1991 and amounted to 8,279 Gg. In 1998, the volume of CO_2 emissions was 193 Gg.

According to expert estimates, there is an uncertainty in data on fuel consumption, especially natural gas, for 1990 and other years. Tendency of fuel consumption does not coincide very much with GDP and other indicators dynamics.

There are about 250 thousand vehicles in the country, including 170 thousand individual motorcars. The number of vehicles per capita is 24 cars per 1,000 people. The biggest number of individual motorcars per 1,000 people is 31 cars in the capital city, Dushanbe.

CO_2 emissions in the transport sector in Tajikistan are quite high particularly from motor transport but still they are less then in residential and industrial sectors. In the period between 1990-1998, due to the economic crisis and lack of energy carriers, CO_2 emissions in road transport sector have significantly decreased by 9 times, civil aviation by 10 times, railway transport by 5 times. The international bunker has not been considered in national GHG inventory.

The energy industry in Tajikistan is based on hydropower plants. This explains little contribution of energy industry into total CO_2 emissions. Use of natural gas in heat power plants reduces CO_2 emissions in comparison with coal plants. The share of the electric-power industry to the total CO_2 emissions in the "Energy" category for the period of 1990-1998 reduced from 0.3% to 0.1%. The national inventory does not consider consumption of natural gas in heat power engineering for the period of 1990-1992 due to the lack of data. CO_2 emissions from burning of biomass have decreased from 93 Gg in 1990 to 5 Gg in 1998.

3.6.2. CO_2 emissions in the category "Industrial processes"

The manufacturing industry makes a significant contribution to the national total of CO_2 emissions. From year to year the contribution of industrial processes range from 8% to 18%. The major sources of CO_2 emissions in this category are aluminum, cement and ammonia production.

Tajik Aluminum Plant. Photo by T. Kirilova

The Tajik Aluminum Plant is the biggest producer of non ferrous metals in Tajikistan. The aluminum plant was built in the southwest of the country in 1985. Production of aluminum is based on a method of electrolysis on prebaked anodes. During processing aluminum, CO_2 (1.5 tonnes per 1 tonne of product) and other gases (CF_4, C_2F_6) occur and affect the climate and environment. Contribution of aluminum production in ţŞ$_2$ emissions in the category "Industrial processes" is the biggest and at various periods has amounted to 43-85%. ţŞ$_2$ emissions in aluminum production during 1990-1998 dropped from 675 Gg to 293 Gg. Production of ferrous metals (cast iron and steel recycling) in Tajikistan is poorly developed, thus contribution of this source to the total CO_2 emissions is insignificant (from 4 Gg to 108 Gg in different years).

CO_2 emissions from cement and lime production are significant in the non-energy industrial sector. High temperatures in the process cement manufacturing turn raw materials into clinker. This process forms carbon dioxide (0.4985 tonnes of ţŞ$_2$ per 1 tonne of cement). Before 1996, cement production was the second major source of ţŞ$_2$ emissions (up to 34%). However, in the period 1996-1998, the contribution of mineral production to the total emissions decreased to 3-7%, and conceded emissions from ammonia production.

Production of lime involves several phases including extraction of raw materials, crushing, and screening, decarbonization, lime hydration to dioxide calcium and further transportation, storage and usage. Emission coefficient for lime production constitutes 0.79 tonnes ţŞ$_2$ per 1 tonne of final product.

Vakhsh fertilizer plant located in the south of the republic nearby Kurgan-Tube is the main producer of ammonia in Tajikistan. During 1990-1998, production of ammonia has significantly decreased - from 109.5 to 21.3 thousand tonnes. Ammonia is being produced from natural gas. About 1.5 tonnes of ţ Ş2 is formed per 1 tonne of ammonia. The contribution of ammonia production to the total CO_2 emissions in industrial processes during 1990-1998 made 8-10%.

The most CO_2 emissions in the category "Industrial processes" were observed in 1990 and amounted to 1,565 Gg, including: metal production - 784 Gg, mineral production - 617 Gg and the production of chemicals - 164 Gg. In 1998, due to economic decline, lack of energy resources and decreased production volume, CO_2 emissions in the industrial sector decreased by 4.6 times. The least significant decrease (2.3 times) was in aluminum production, and the most significant was in mineral production (60 times).

3.7. State of the natural sinks of carbon and CO_2 dynamics in the category "Land use change and forestry"

Forests and soils are the biggest absorbers of CO_2. Change of organic substances in soils takes place over a long time period (20 years), while in forests it occurs annually.

Distinctive feature of land resources in Tajikistan are:

- Domination of non-agricultural lands (68%) among which are glaciers, snowfields, mountains, pebbles, rocky cones, mountain deserts and other unusable lands;
- Small areas of forests and bushes (3%);
- Most agricultural lands are pastures;
- The most valuable parts of available lands are arable, which are being intensively used.

Until the 1940s, major cultivated areas were located in the foothills. Valleys were mainly used as winter pastures or for crops cultivation.

Significant increase of irrigated lands particularly under cotton happened in the second half of the 20th century.

In the period of 1997-1990s, irrigated areas of the Republic of Tajikistan increased to 178.4 thousand hectares as a result of land reclamation (Urtaboz, Tashrabad, Garauty, etc.), which increased arable lands to 150.6 thousand hectares, perennial plantations to 17.5 thousand hectares. Land reclamation took place due to fallow lands (53.9 thousand hectares), hayfields (10.2 thousand hectares), pastures (52 thousand hectares) and other lands (110 thousand hectares).

At present, out of 14.2545 million hectares of land in Tajikistan 4.5461 million hectares are being used for agriculture, which corresponds to 31.9% of the total area of Tajikistan. Arable lands occupy 734.2 thousand hectares.

Uncontrolled cattle grazing, substitution of forestlands by ploughed lands, inadequate agro techniques in mountain conditions lead to erosion and soil degradation over big territories.

Due to deforestation, the occurrence of landslides and mudflows become more frequent. Fertile topsoil gets washed away.

Soils with a high degree of erosion comprise 58.8% of all soils, including those with the highest extent of erosion at 23.9%. Almost all mountain and high mountain soils are prone to water erosion (more then 60-70%). Besides, some 23.5% of soils are prone to wind erosion, and a possible maximum share of light gray soil at 62%.

According to IPCC methodology, for CO_2 removal calculations, soils were conditionally divided into intensively and non-intensively used.

Intensively used soils are: gray-brown, gray, mountain brown, and carbonate soils, which are intensively used under rain-fed crop plantations, gardens, and vineyards. Also this category includes juniper forest soils, partly soils of lowland and mountain pastures.

Non-intensively used soils are saline lands, soils rich in stones, mountain deserts, mud-deserts, gray-brown, light-brown, steppe, and meadow soils.

As a result of land use change, soils annually absorb about 600-1600 Gg CO_2.

The total stock of carbon in intensively used soils in comparison to initial soil conditions sharply decreases. This is observed in valley and foothill soils under monoculture agricultural crops or lack of alfalfa sowings.

The most significant decrease of humus (dehumification) is observed in heavy saline soils and to a lesser extent this process occurs in gray-brown and gray soils. In mountain brown soils that are ploughed, the decrease of humus is insignificant.

Since 1992, due to the economic crisis, the population has been intensively developing hillside lands that formerly used to be pastures. In 1994-1997, steep slopes (up to 35°) were ploughed for cereal crops cultivation. Intensive land reclamation is accompanied by heavy erosion and loss of humus, which in turn leads to carbon loss and increased desertification.

In terms of CO_2 absorption, forests in Tajikistan take second place after land resources. They are good accumulators of moisture preventing soils from erosion and serving as valuable food, medical and industrial materials.

Juniper forest. Photo by U. Karimov

The total area of forests is 410 thousand hectares, which are mainly managed by the State Forest Authority. Arboreal species diversity includes 268 trees and bushes.

The most common national forests are junipers that spread in semi-arid mountain regions at an altitude from 1,500 to 3,200 masl and comprise one third of the total area of forestlands.

Juniper forests are good regulators of surface runoff preserving soils from the erosion process in mountains and valleys, as well as CO_2 sinks.

Juniper forests occupy an essential part of national forests. They are predominant in Northern Tajikistan on the slopes of Gissar, Zeravshan and Turkestan ranges and consist of 3 dominant species: Juniperus seravshanica, Juniperus turkestanica and Juniperus semiglobosa. The area of junipers with a plenitude of 0.3 and more is 150 thousand hectares (tab 3.3.). Average juniper timber stock makes 21.2 cub.m a hectare.

Table 3.3.

Forestlands and timber stock

Forest type	Total		Including state forest fund	
	Area (thousand hectares)	Timber stock (mln.cub.m)	Area (thousand hectares)	Timber stock (mln.cub.m)
Juniper	150	3.2	122	2.7
Pistachio	78	0.4	74	0.38
Almond	12	0.03	10	0.02
Walnut	8	0.4	3	0.1
Birch	2	0.05	0.4	0.02
Poplar	6	0.2	3	0.1
Willow	4.4	0.06	0.7	0.02
Maple	44	0.6	35	0.5
Elm	1	0.03	0.1	-
Saxaul	8	0.02	-	-
Cherry-plum	2.6	0.03	0.3	-
Bushes	58.4	0.4	37	0.3
Other woody plantations	35.6	0.2	4	0.03
TOTAL	410	5.62	289.5	4.17

Source: Tajik State Forest Authority (2001)

Pistachio forests are well adapted to the arid hot climate and occupy 78 thousand hectares (tab. 3.3.). As a rule, pistachios (Pistacia vera) comprise clean tree plantations or with portions of almond trees (Amygdalus bucharica). The pistachios are predominant in southern Tajikistan at an altitude from 600 to 1400 masl. Pistachios, together with walnut plantations (Juglans regia) and almonds are valuable sorts of nuceferous trees.

Walnut forests occupy a territory of 8 thousand hectares and differ by their demand in terms of soil and climatic conditions. Walnut forests grow in Central Tajikistan at an altitude between 1,000 and 2,000 masl, where annual precipitation is no less than 800-900 mm a year and annual mean temperature reaches 8-13°C.

Maples (Acer turkestanicum) occupy 44 thousand hectares of the national forests. Poplars, willows, birches, sea-buckthorns and other types of groves are spread fragmentarily. Saxaul plantations are spread in sand-deserts of the southern regions.

Sanitary forest cuttings are practiced in Tajikistan for improving ecological conditions. In the past, the felling volume totaled 15 thousand cub.m, while at present it has decreased to 7 thousand cub.m a year.

One of the main forest's state indicators in Tajikistan is tree density, because this value defines erosion and preventive properties of tree plantations. The area of plantations with a tree density of 0.6 and higher is only 20%. Plantations with a tree density of 0.3-0.4 and fragmentarily wood-shrubby plantings are most common.

The calculation of the total amount of carbon in the annual growth of forests and tree plantations is based on the IPCC methodology and coefficients. Data is obtained from Tajik State Forest Authority and FAO. When considering the changes in woody biomass such types of human activities as illegal deforestation and sanitary forest cuttings were taken into account (tab. 3.4).

Table 3.4.

Forested area and annual biomass growth

Forest types	Area (thousand hectares)	Annual biomass growth (tonnes of dry mass per hectare)
Evergreen	150	30.0
Deciduous	158	63.2
Others	102	20.4

Source: National GHG Inventory

For tree plantations out of forests (parks, squares, plantations), the growth of evergreen and deciduous trees was estimated as 8 tonnes of dry mass per hectare a year.

Recently, forest rehabilitation has diminished (tab. 3.5). At the same time, uncontrolled deforestation has significantly increased, since the provision of coal, wood, electricity and other types of energy for the rural population has ceased.

Table 3.5.

Reforestation in Tajikistan (thousand hectares)

Type of activity	1990	1994	1998
Forests sowing and planting	4.3	1.9	2.3
Promotion to natural reforestation	0.1	1.2	0.8

Source: Tajik State Forest Authority (2001)

Woodlands near to human settlements, forest shelterbelts along the roads, which are not protected at a national level, have been dramatically affected. For the period of 1990-1998, the number of trees outside the forests has decreased by 1.7 times.

Overgrazing that takes place on state forest territories has a long lasting impact. This causes soil degradation and the impoverishment of forests and herbal cover in forested areas. Uncontrolled deforestation and forest clearing with the purpose of agricultural crop cultivation have led to low density tree cover and vanishing forests over large territories. Because of deforestation, CO_2 absorption by forests and trees outside forests has been steadily decreasing since the 1990s. Given that in 1990 this was recorded at 588 Gg, by 1998 forests accumulated only 410 Gg. In the period of 1990-1998, absorption of CO_2 by forests has decreased by 35% (tab. 3.6).

Table 3.6.

Summary of GHG inventory in the category "LUCF" (Gg)

CO_2 sources and sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Change of carbon stock in mineral soils	940	635	713	923	1658	1295	1323	1210	1161
Intensively used organic soils (emission)	-	-	- 19	- 38	- 57	- 66	- 76	- 80	- 84
Net land-use	940	635	694	885	1601	1229	1247	1130	1077
Forests	588	582	546	491	447	428	425	414	410
TOTAL	1528	1217	1239	1376	2048	1657	1671	1544	1487

Source: National GHG Inventory

In the result of land use changes and reclamation of new lands, absorption of CO_2 by soils has increased from 932 Gg in 1990 to 1 436 Gg in 1998. Emission of CO_2 from intensively used soils has increased from 19 Gg in 1992 to 84 Gg in 1998.

3.8. ɥɩ 4 emissions

The biggest CH_4 emissions for the period of 1990-1998 in Tajikistan were in 1991 (176 Gg), mainly because of enteric fermentation, manure management and fugitive emissions in oil-gas systems (fig. 3.3).

In the period under review, the volume of methane emissions has decreased more than 25%, as a consequence of structural changes in the agricultural sector and decrease in fossil fuel production and consumption.

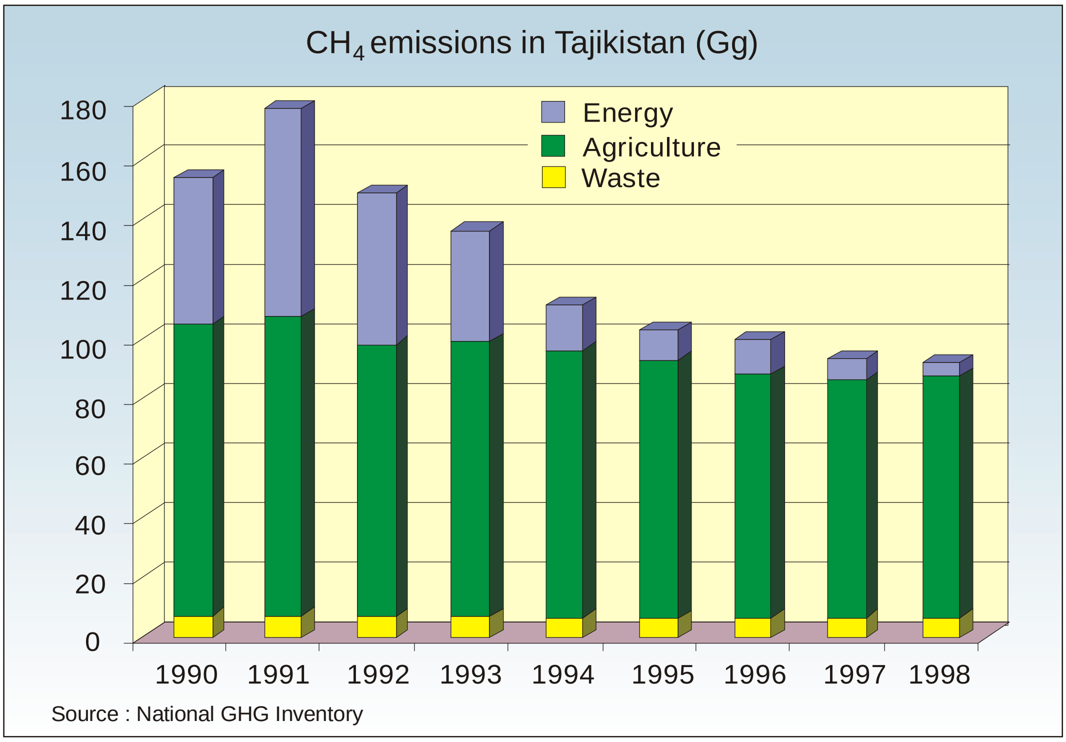


Fig. 3.3.

3.8.1. CH_4 emissions in the category "Agriculture"

The greatest volume of methane emissions (80-86%) occurs due to enteric fermentation, and, to a lesser extent, manure management (10-11%). The rest of emissions occur due to rice cultivation and the burning of agricultural residues (3-8%).

In 1990-1998, CH_4 emission in the category "Agriculture" decreased by 22% which generally corresponds to the number of livestock.

Methane is formed in the process of herbivorous animals' enteric fermentation. The amount of emitted methane depends on the number of animals, breed, age, feeding type, quality and quantity of food, climatic conditions within cattle breeding zones and grazing technologies. It should be mentioned that ruminants produce

97-98% of the total CH_4 emissions from enteric fermentation. Methane emissions from this source have decreased in the period of 1990-1998 from 83 Gg to 65 Gg.

CH_4 emissions from manure depend on the number of livestock, the method of storage and utilization of manure. If manure is managed as a liquid substance, it decays in aerobic conditions and forms methane. If manure is managed as a solid substance, or is used on the fields as a fertilizer, methane does not occur. In the period of 1990-1998, methane emissions from this source have decreased from 10 Gg to 9 Gg of these 90% are due to dairy cattle.

The flooding of rice fields leads to the decay of organic substances, which results in the formation of methane during vegetation. Rice crops constitute an area of 18-22 thousand hectares annually. Major zones of rice cultivation are Sogd Region, flood plains of the Vakhsh river and Gissar valley. In comparison with 1992, rice fields have increased by 1.5 times.

Variations of methane emissions from rice fields depend on the type and structure of soil, organic and mineral fertilizers, irrigation mode and other factors. During the period of 1990-1998, CH_4 emissions from this source have increased from 4 Gg to 6 Gg.

Some agricultural residues remain on the fields and they are usually burned. This leads to GHG emissions in small amounts. CH_4 emissions in this sector are insignificant.

3.8.2. CH_4 emissions in the category "Energy"

Methane emissions related to mining, processing and consumption of fossil fuels, occur in coal mining and oil-gas systems in Tajikistan. The contribution of this category in total CH_4 emissions varies from year to year between 5% and 35%.

Coal mining is developed mainly in the north of the country (Shurab and Fan-Yagnob coal deposits). The Shurab mine has been operating for more than 100 years. Since the 1950s, the annual volume of coal production amounted to 500 thousand tonnes, and in certain years, it reached 1 million tonnes. However, in the 1990s, due to structural changes in the economy, the annual volume of coal production decreased from 475 thousand tonnes in 1990 to 18.5 thousand tonnes in 1998.

Coal in Tajikistan is mainly being mined by an underground method, with only few coal deposits being operated aboveground. According to expert estimates, 1 tonne of coal mined underground in local conditions brings 15 cub.m of methane emissions, and coal mined on the surface produces 1.2 cub.m of methane. In 1990-1998, CH_4 emissions in coal mining decreased from 4.8 Gg to 0.2 Gg.

The volumes of oil and gas production in Tajikistan are low (25 thousand tonnes of oil and 35 million cub.m of gas). These volumes of production do not satisfy the growing demands of the country. Methane emissions in the oil-gas systems occur in the process of mining, transportation, storage and consumption of fuel, as well as due obsolete equipment, leakages, accidents, etc. CH_4 emissions from oil-gas systems were the biggest in 1991 at 60 Gg, and by 1998 they had decreased to 2.3 Gg.

3.8.3. CH_4 emissions in the "Waste" category

Main sources of CH_4 emissions in this sector are solid waste disposal sites and wastewater treatment facilities. Methane is formed from the decay of organic substances in anaerobic conditions.

There are no waste recycling and waste incineration plants in the country. Solid wastes are transported to specialized waste disposal sites with a depth of five meters and less. Methane, which is formed from solid waste is not utilized and directly emitted into the atmosphere.

To assess methane emissions from solid waste disposal sites many types of activity data were considered, taking into account the volume of formation of communal wastes at 0.5 kg/person/day, including wastes formed in gardens, yards and commercial sites. Communal wastes, which are formed in rural areas, were not taken into account in view of their dispersion over the territory.

<u>There are three basic types of waste disposal sites in Tajikistan:</u>

- Specialized solid waste disposal sites (Dushanbe, Tursun-Zade, Khujand, Penjikent, settlement Somoniyon). Composting and mechanical pressing is used for the management of such sites.
- Waste disposal sites with a depth greater than 5 meters. These type of sites are found in 12 different cities within the country;
- Waste disposal sites with a depth less than 5 meters. Such sites exist within 53 different towns of the country.

CH_4 emission from solid wastes in Tajikistan for the period of 1990-1998 has not changed significantly from 6.1 Gg to 6.8 Gg, which is conditioned by the dynamics of the urban population, types of dump and morphologic structure of solid communal wastes. Methane in wastewaters is being formed in anaerobic conditions. The amount of organic substances influences methane emission intensity.

Over 70% of wastewater is thrown into natural reservoirs and filtration fields without purification and constitutes 4.7 cub.km per year. CH_4 emission from wastewater purification was calculated for 30 settlements with sewage disposal facilities. The volume of CH_4 emissions from wastewaters in the period of 1990-1998 is insignificant and varies from 0.23 Gg to 0.25 Gg.

Methane emission also occurs in industrial wastewaters. The national inventory shows that wastewater from the food processing industry produces 62.9-76.2% of the total CH_4 emissions from this source. The least is contributed from the textile industry 0.28-1%. The volume of CH_4 emissions from industrial wastewaters is insignificant.

Total CH_4 emissions in the period of 1990-1998 in the "Waste" category have decreased from 7.4 Gg to 6.6 Gg, due to the reduction in wastewater and solid waste disposal volumes.

3.9. N_2O emissions

The biggest volume of N_2O emissions in the period of 1990-1998 in Tajikistan was indicated in 1990 (about 3.8 Gg); the lowest emission was indicated during 1995-1998 (about 2 Gg), mainly caused by the application of mineral fertilizers; this source account for between 95% and 99% of all N_2O emissions. N_2O emissions from other sources in the category "Agriculture" (manure management, waste) are insignificant (fig. 3.4).

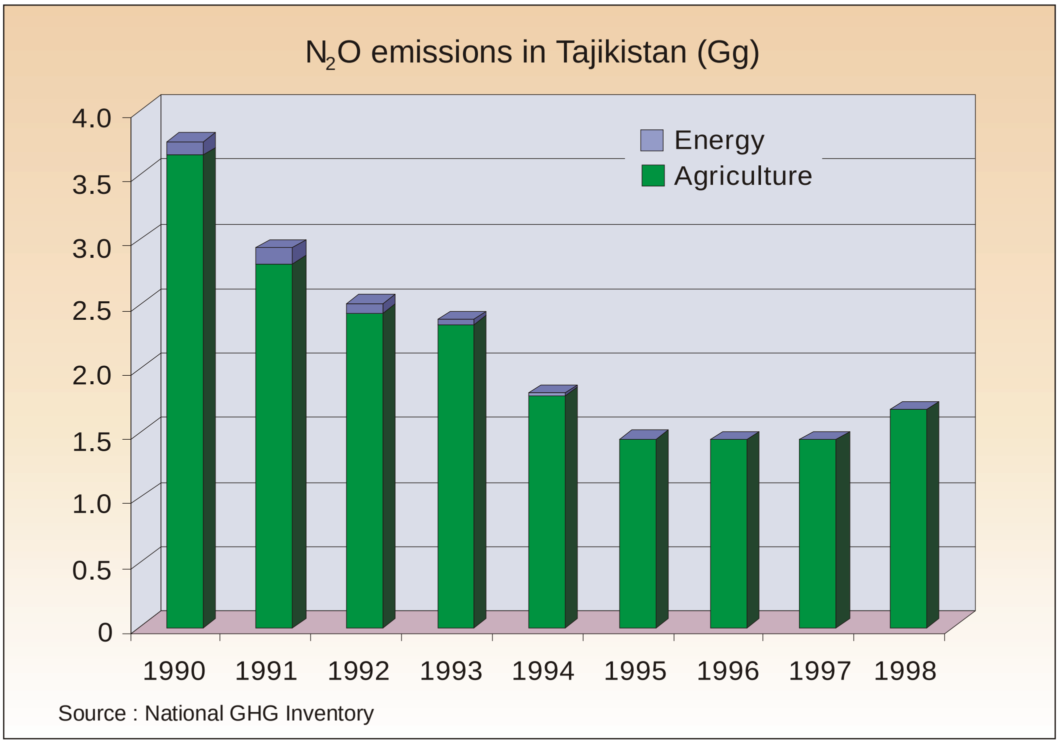


Fig. 3.4.

The volume of nitrous oxide emissions in the period under review has decreased by 50% as a result of reduced application of and organic mineral fertilizers and the reduction in fossil fuel consumption.

N_2O emissions from agricultural soils depend on: the types of soil, contents of humus, activities of microorganisms, liming, cattle pasturing, fertilizing, and other factors.

While calculating N_2O emissions from agricultural soils, the experts used data on the application mineral fertilizers, which enriches the soil with nitrogen and reinforces the processes of mineralization, changing the biological activity.

In Tajikistan the application of mineral fertilizers has been decreasing since 1991, due to the reduction in imports and the low capacity of domestic production.

Another source of N_2O emissions is the high-temperature combustion of fuel, when nitrogen consisting of atmospheric air reacts with oxygen. Given that thermal power plants and transport in Tajikistan are few, the volume of N_2O emissions is insignificant and for the period of 1990-1998 comprised less than 0.2 Gg.

3.10 Emissions of perfluorocarbons

The only source of perfluorocarbon emissions in Tajikistan is the aluminum smelting, which forms up to 100% of these emissions. CF_4 comprises the biggest part of emissions (91%); the smallest part is comprised by C_2F_6 (9%).

The Tajik Aluminum Plant is located 53 km west from Dushanbe. The plant capacity is more than 500 thousand tonnes of primary aluminum a year. The plant also produces various aluminum alloys and construction profiles. The plant is a giant of national metallurgy, and it consumes a lot of electricity and natural gas.

The global average coefficient of PFC emissions (1.4 kg of CF_4 per 1 tonne of produced aluminum) was adopted in the national GHG inventory. Given that the production of aluminum in the period of 1990-1998 has decreased from 450.3 thousand tonnes to 195.6 thousand tonnes, PFC emissions decreased respectively by 57%. The biggest volume of PFC emissions was recorded in 1990 at 0.69 Gg, which correspond to 4,647 Gg of CO_2-equivalent (tab. 3.7). The least PFC emissions were recorded in 1997 at 0.29 Gg.

Table 3.7.

PFC emissions in aluminum industry (Gg)

Greenhouse gas	1990	1991	1992	1993	1994	1995	1996	1997	1998
CF_4	0.63	0.53	0.48	0.35	0.33	0.33	0.28	0.26	0.27
C_2F_6	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03
CO_2-equivalent	4647	3905	3488	2551	2421	2421	2096	1966	2031

Source: National GHG Inventory

In the process of aluminum production, different hazardous pollutants are emitted into the atmosphere, including nitric oxide, carbon oxide, sulphur dioxide and fluorides that negatively impact the environment. Thus, emission control and the purification of hazardous pollutants should be priorities.

3.11. Emissions of GHG precursors and SO_2

Anthropogenic activities, along with GHG emissions lead to the emissions of CO, NOx, non-methane volatile organic compounds (NMVOC) and SO_2, which affect both the climate system and environment.

Nature protection institutions maintain records of these gas emissions. The data on emissions of GHG precursors is published on a regular basis in National environmental reports. However, in view of differences in methodologies and insufficient reflection of all emission sources in this data, new calculations in the national inventory were based on the IPCC methodology.

CO emissions in Tajikistan occur from incomplete fuel combustion and some industrial processes. The biggest share of CO emissions belongs to the transport sector and aluminum industry. Generally, the volume of CO emissions is significant and in the year 1990 it amounted to 430 Gg, at that most emissions resulting from fuel combustion (247 Gg). Recently, CO emissions amount to 96-100 Gg.

According to scientific research, carbon monoxide (CO) emissions are the reason for the methane atmospheric concentration increase, thus inventory and control of CO emissions are now a priority.

There are indications in state statistical reporting that CO emissions in Tajikistan are less than that indicated in the national GHG inventory. This can be explained by more detailed calculations used in the national GHG inventory, which is based on IPCC methodology.

Emissions of NOx (NO and NO_2) occur due to high-temperature fuel combustion and other processes. In Tajikistan, NOx emissions are insignificant since the volume of fossil fuel consumption is not large. The major source of NOx emission is the transport sector. The biggest volume of NOx emissions in the country was indicated in 1991 and amounted to 83 Gg. By 1998, NOx emissions decreased to 9 Gg. National statistics maintain the records of NOx emissions. However, as it was mentioned earlier, the volume of NOx emissions according to statistics is lower than that in national GHG inventory.

Non-methane volatile organic compounds (NMVOC) are emitted as a result of incomplete fuel combustion, high-temperature industrial processes, such as glass manufacturing, paving of roads, etc. NMVOC emissions in Tajikistan are not large. In the period under review, in 1990 they did not exceed 45.5 Gg. By 1998, they decreased to 7 Gg.

Sulphur dioxide is one of the most harmful components of anthropogenic emissions. SO_2 emissions in Tajikistan decreased from 35 Gg in 1990 to 3 Gg in 1998. The biggest share of SO_2 emissions belongs to the transport sector.

3.12. Uncertainty assessment

The assessment of anthropogenic emissions by sources and removals by sinks of greenhouse gases is based on the application of various activity data, coefficients, conversion factors and methods of calculations. Existing uncertainties (tab. 3.8) are due to data gaps, quality and quantity of activity data, status of scientific knowledge, national circumstances, skills of GHG inventory experts etc.

Table 3.8.

Uncertainty assessment of GHG emissions and removals

IPCC categories	Greenhouse gas	Uncertainty
ENERGY, Industry and construction	CO_2	Middle
ENERGY, Residential sector etc.	CO_2	Low
ENERGY, Transport	CO_2	Low
INDUSTRIAL PROCESSESS, Production of metals	PFCs	Not estimated
AGRICULTURE, Enteric fermentation	CH_4	Middle
ENERGY, Oil-gas systems	CH_4	Not estimated
AGRICULTURE, Agricultural soils	N_2O	High
INDUSTRIAL PROCESSES Production of metals	CO_2	Low
AGRICULTURE, Manure management	CH_4	Middle
INDUSTRIAL PROCESSES, Chemical industry	CO_2	Low
LUCF, Forestry	CO_2	Middle
LUCF, Emission and absorption of CO2 by soils	CO_2	Middle
WASTES, Solid waste disposal	CH_4	High
ENERGY, Residential sector	CH_4	Not estimated
AGRICULTURE, Rice cultivation	CH_4	High
ENERGY, Solid fuels	CH_4	Middle
ENERGY, Electro energetic industry	CO_2	Low
ENERGY, Transport	N_2O	Not estimated
WASTES, Wastewaters	CH_4	High

Source: National GHG inventory

To assess uncertainties, national experts applied IPCC Good Practice Guidance on Uncertainty Management. It was decided to identify an uncertainty percentage for each sector and subdivide the uncertainties into three basic groups:

- The low uncertainty group (10-33%),
- The middle uncertainty group (33-66%), and
- The high uncertainty group (66-100%).

Fuel and energy balances of Tajikistan have not been compiled during the last 11 years. This circumstance greatly complicates the process of GHG inventory compilation in the "Energy" category. There is a problem of coincidence in energy balance, particularly with gaseous fuel consumption and other fuels. In such conditions, uncertainty in the "Energy" category depends on the source of GHG emission and the year of inventory, and ranges from low to middle level. Further work on studying of local emission factors and improvement of data quality is needed.

A low uncertainty is observed in the category "Industrial processes". An exception is PFC emissions from aluminum production as they possess exceptionally high GWP, and instrumental monitoring is needed to define exact volumes of perfluorocarbon emissions.

A middle uncertainty is observed in the category "Agriculture". Uncertainties in methane emissions from enteric fermentation and manure management are estimated in some years to be low or middle because of the lack of statistical data and possible inaccuracy in emission factors in local conditions. The high level of uncertainty is estimated in N_2O emissions from agricultural soils.

A high uncertainty is stated in methane emissions from waste disposal on lands and domestic wastewaters because of the absence of statistical data and the possible inaccuracy in emission factors. A middle uncertainty is estimated in the category "Land-use change and forestry". It occurs because emission factors for different types of soils are not sufficiently researched. Besides, there are some gaps in the data on the potential of national forests to absorb CO_2.

4. Projected Impacts and Vulnerability Assessment

4.1. Climate change trends

Vertical zonation, geographical contrasts and forms of the land surface favor to great diversity of the climatic conditions that can be observed in Tajikistan.

Local climatic conditions differ by the variety of temperatures, humidity conditions, precipitation and intensity of solar irradiation. The annual mean temperature varies from +17°C in the south to -6°C in the Pamirs. The maximum temperature can reach between +43°C and +47°C (Shaartuz), and minimum temperature -63°C (Bulunkul Lake). The annual precipitation in lowland hot deserts of Northern Tajikistan and cold mountain deserts of Eastern Pamir averages from 70 to 160 mm, while in Central Tajikistan (Gissar) precipitation exceeds 1,800 mm a year.

Since comprehensive meteorological observations have started in Tajikistan from 1950s-1960s and remarkable changes in the climate system attributable to human activities have also occurred and further accelerated from this period (as noted by IPCC), national research considers in details the aspects of climate changes for the period 1961-1990 and throughout the period of instrumental observations in Tajikistan.

During the period under investigation, the increase of 0.7-1.2°C in the annual mean air temperature was observed in the wide valleys of Tajikistan. To a lesser degree, the growth of temperature had taken place in mountain areas by 0.1-0.7°C (fig. 4.1), and only in the mountains of Central Tajikistan, Rushan and lower reaches of Zeravshan River there was a small decline in temperature of 0.1-0.3°C.

In large cities, the growth of near surface temperature was especially significant and reached 1.2-1.9°C (fig. 4.2) that is obviously associated with urbanization (construction of roads, buildings, vehicles, industrial emissions, etc). The map (fig. 4.3) shows the trends in annual mean temperature over Tajikistan.

The 1990s was the warmest decade during the period of instrumental observations in Tajikistan, and 1997 and 2001 the warmest years (fig. 4.4).

The trends in atmospheric precipitation in Tajikistan are not uniform. In the period from 1960s till 1990s in the mountains of Central Tajikistan, as well as in the valleys of Southwest and Northern Tajikistan, foothills of Turkestan range and mountain areas of Eastern Pamir, a reduction in the amount of annual precipitation of 1-20% is observed. In Karategin and Darvaz, from the altitude of 1,500 m and higher, the amount of precipitation has increased by 14-18%. In Western Pamir, the increase of precipitation is 12-17%. The greatest increase in precipitation (30-36%) is observed in the area of Fedchenko Glacier.

The most arid years in Tajikistan were 1944 and 2000, when a precipitation deficit of 30-70% was observed all over the territory of the country. The most humid year was 1969, when precipitation was 1.5 times above the long-term average.

Changes in snow stock vary in different altitude zones. An increase of snow stock is observed in the most of foothills and low mountains of the republic. On the contrary, the reduction of snow stock has been reported in many high altitude zones (exceptions are Fedchenko glacier and some other regions).

The increase in the number of hot days, heavy rainfalls, floods and avalanches can be observed. Conversely, the number of cold days decreased substantially. The dynamics of occurrence of other extreme weather events appear not to have changed.

4.2. Climate change scenarios

Several leading global climate models (GCMs) such as: HadCM2, CCCM, GISS, GFD3, UK89 were used to study the possible scenarios of climatic changes in Tajikistan. Modeling was based on the climate data of 1961-1990 received from 10 representative meteorological stations of Tajikistan. The accuracy of reproducing real climate in the models was checked by comparing the results of projections based on the current concentration of CO_2 to real climate data.

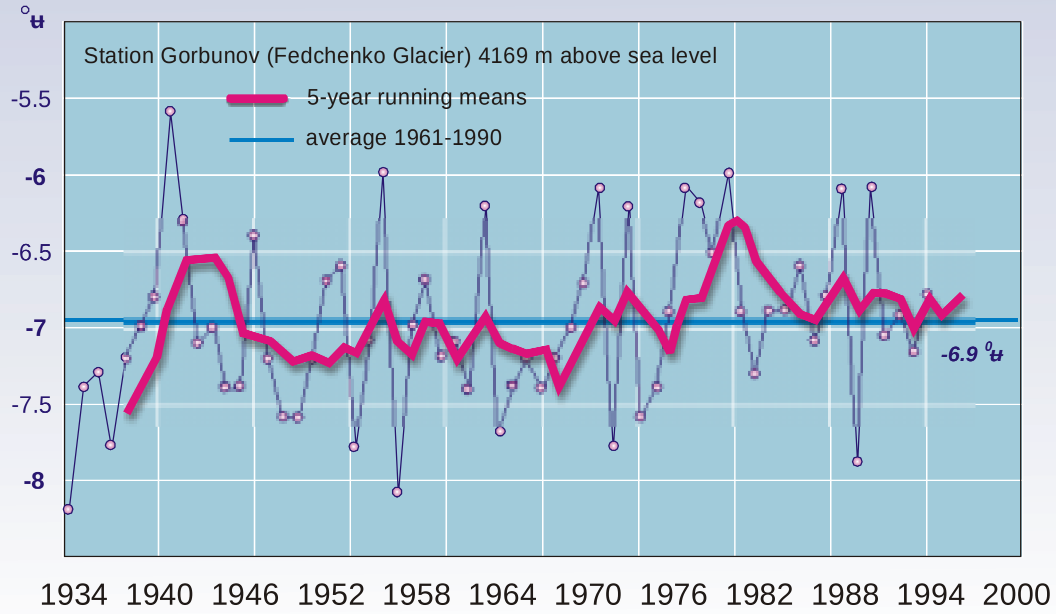
All the models tended to underestimate temperature values when compared to the real climate. The model HadCM2 was the most consistent for temperature analysis, except for Khorog area. The reproduction errors by HadCM2 range from 1°C to 5°C. Errors in climate reproduction by other models for plain areas reaches higher values. The GISS model can be applied in the transition zone from valleys to mountains as it underestimates the temperature in warm periods and overestimates it in cold periods. Other models underestimate temperature by 8-10°C. For mountain areas (above 2,500 masl), the models closest to real temperatures are UK-89 and HadCM2. For other climate models the deviation of temperature from real climate ranges from -7°C to +16°C.

All models essentially underestimate precipitation when compared to the real climate. In lowlands, HadCM2 is appropriate to some extent. In the area of Kurgan-Tube, this model is acceptable in the cold period of the year, and in the warm period the models GFD3 and CCCM approach real values. In the area of Kulyab, UK-89 provides a satisfactory description of precipitation. For the mountain areas of Central Tajikistan, good results are also given by UK-89. For the arid zone along the Turkestan range, HadCM2 provide the closest data. The areas of Western Pamir are described by near actual values using GFD3 and HadCM2. The models CCţM and HadCM2 are more acceptable for the area of Eastern Pamir, showing insignificant deviations for July-September.

Models of future climate project that annual mean near surface temperature in Tajikistan will increase within the interval of 1.8-2.9°C by the year 2050, when doubled CŞ$_2$ concentration is expected. The projected rate of warming is much greater then the observed changes during the 20th century (fig. 4.5). Projected increase of monthly mean temperature varies considerably within the models. Thus, according to ţţţM the greatest increase in temperature is expected in February-March at the stations of Dushanbe, Kurgan-Tube, Kulyab and Shaartuz, which will reach 4.7-4.9°C. For the same period, HadCM2 shows minimum increase, but for summer period maximum increase of 1.9-2.3°C.

Due to complexity of mountain landscape, there is medium and low confidence in precipitation scenarios. According to two models: UK-89 and HadCM2 an increase of 3-26% is expected in nearly all regions of the republic by the year 2050. Conversely, other models (CCCM and GFD3) project the decrease of precipitation by 3-5% and more. There is also significant difference in the seasonal precipitation scenarios. According to HadCM2, a maximum increase in precipitation of 41-69% is expected in July. Based on ţţţM, at the same period the biggest reduction in precipitation of 16-21% is expected (fig. 4.6).

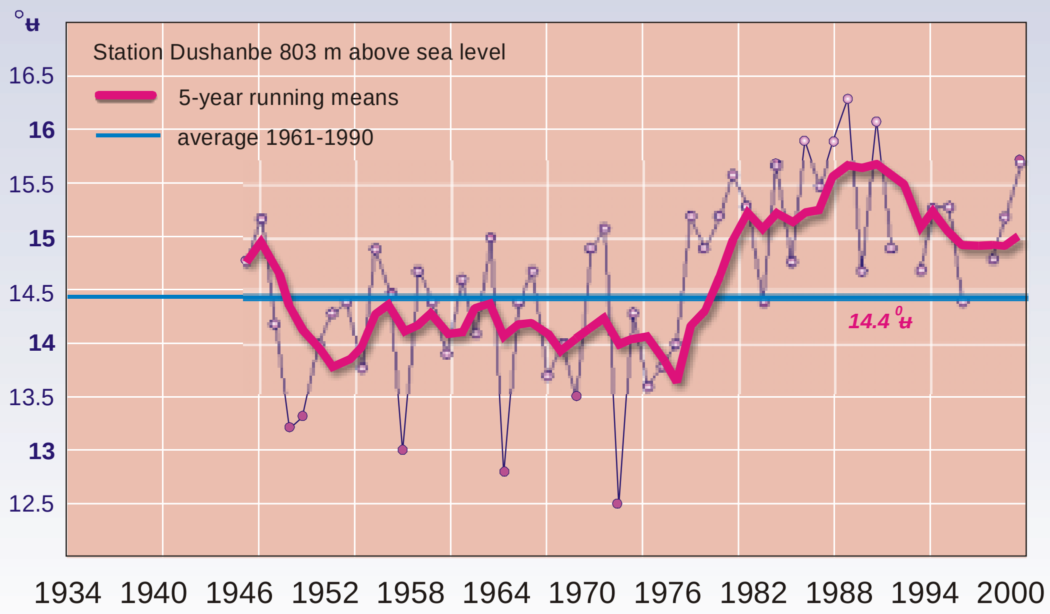
The dynamics of annual mean near surface temperature at Fedchenko



Source : Tajik Met Service

Fig. 4.1.

The dynamics of annual mean near surface temperature at Dushanbe



Source : Tajik Met Service

Fig. 4.2.

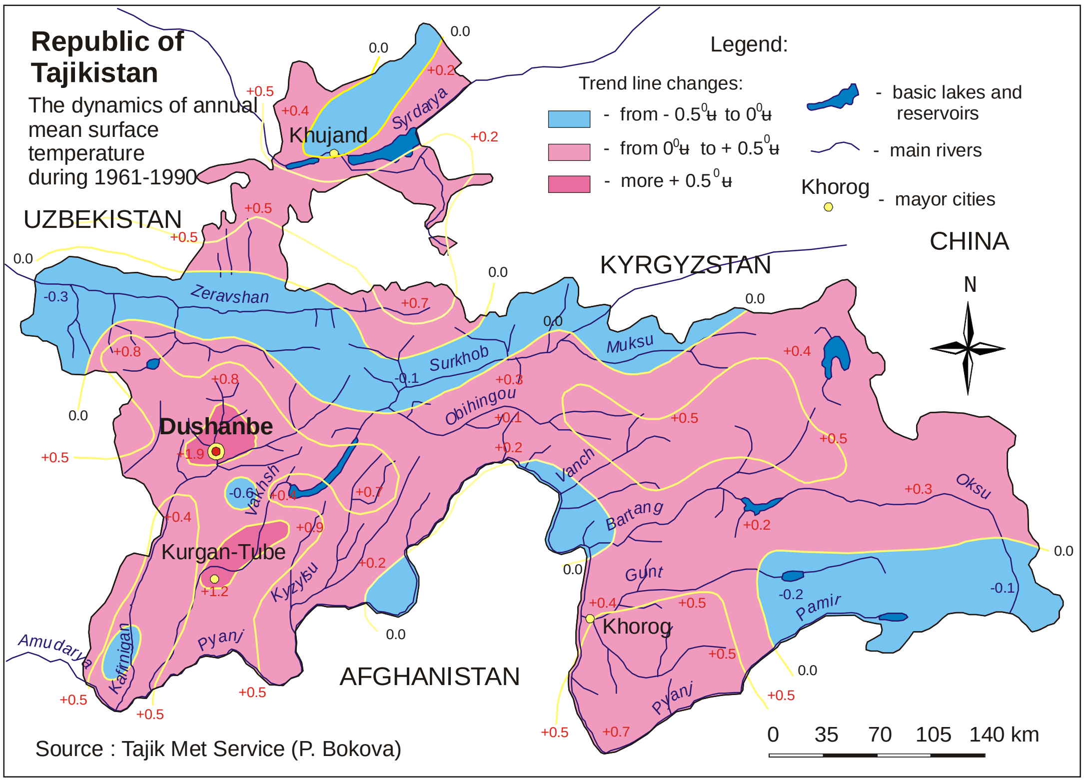

Republic of Tajikistan
The dynamics of annual mean surface temperature during 1961-1990
Legend:
Trend line changes:
- from - 0.5⁰ч to 0⁰ч
- from 0⁰ч to + 0.5⁰ч
- more + 0.5⁰ч
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
Khujand
Dushanbe
Kurgan-Tube
Khorog
Syrdarya
Zeravshan
Surkhob
Muksu
Obihingou
Vakhsh
Vanch
Bartang
Gunt
Pamir
Oksu
Pyanj
Kyzylsu
Kafirnigan
Amudarya
N
0 35 70 105 140 km
Source : Tajik Met Service (P. Bokova)

Fig. 4.3.

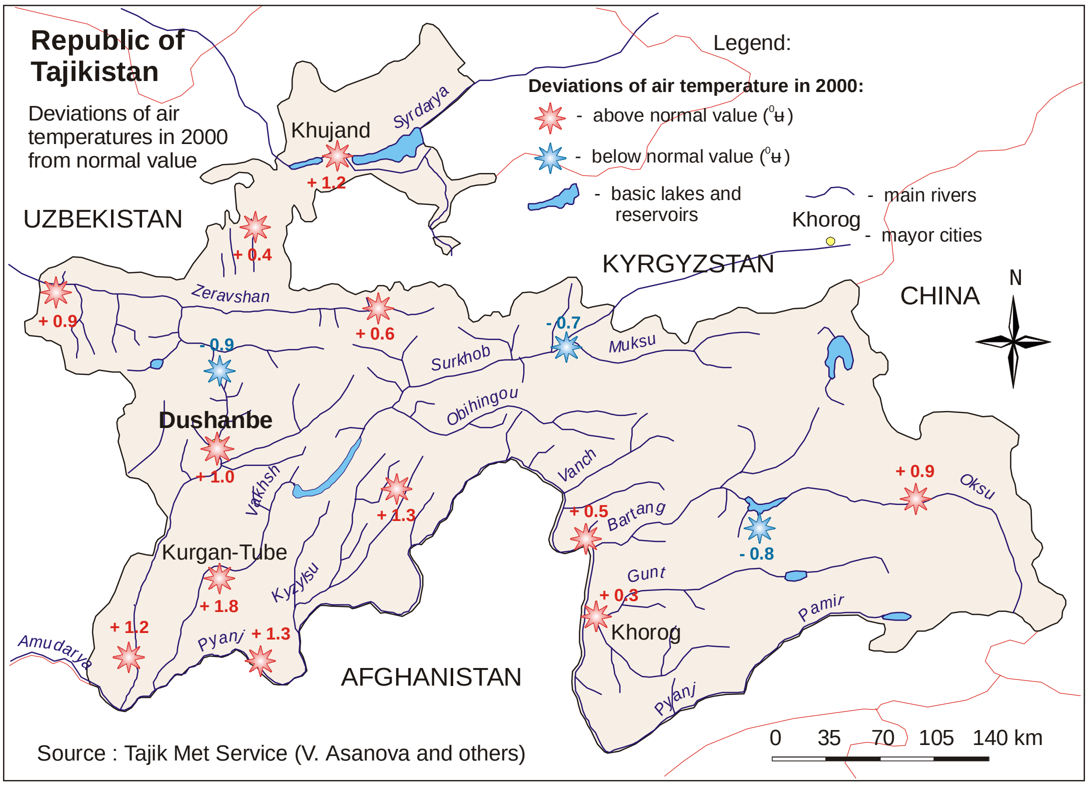

Republic of Tajikistan
Deviations of air temperatures in 2000 from normal value
Legend:
Deviations of air temperature in 2000:
- above normal value (⁰ч)
- below normal value (⁰ч)
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
Khujand
Dushanbe
Kurgan-Tube
Khorog
+ 1.2
+ 0.4
+ 0.9
- 0.9
+ 0.6
- 0.7
+ 1.0
+ 1.3
+ 0.5
- 0.8
+ 0.9
+ 0.3
+ 1.8
+ 1.2
+ 1.3
Syrdarya
Zeravshan
Surkhob
Muksu
Obihingou
Vakhsh
Vanch
Bartang
Gunt
Pamir
Oksu
Pyanj
Kyzylsu
Amudarya
N
0 35 70 105 140 km
Source : Tajik Met Service (V. Asanova and others)

Fig. 4.4.

Projected mean annual temperatures based on climate models by 2050s

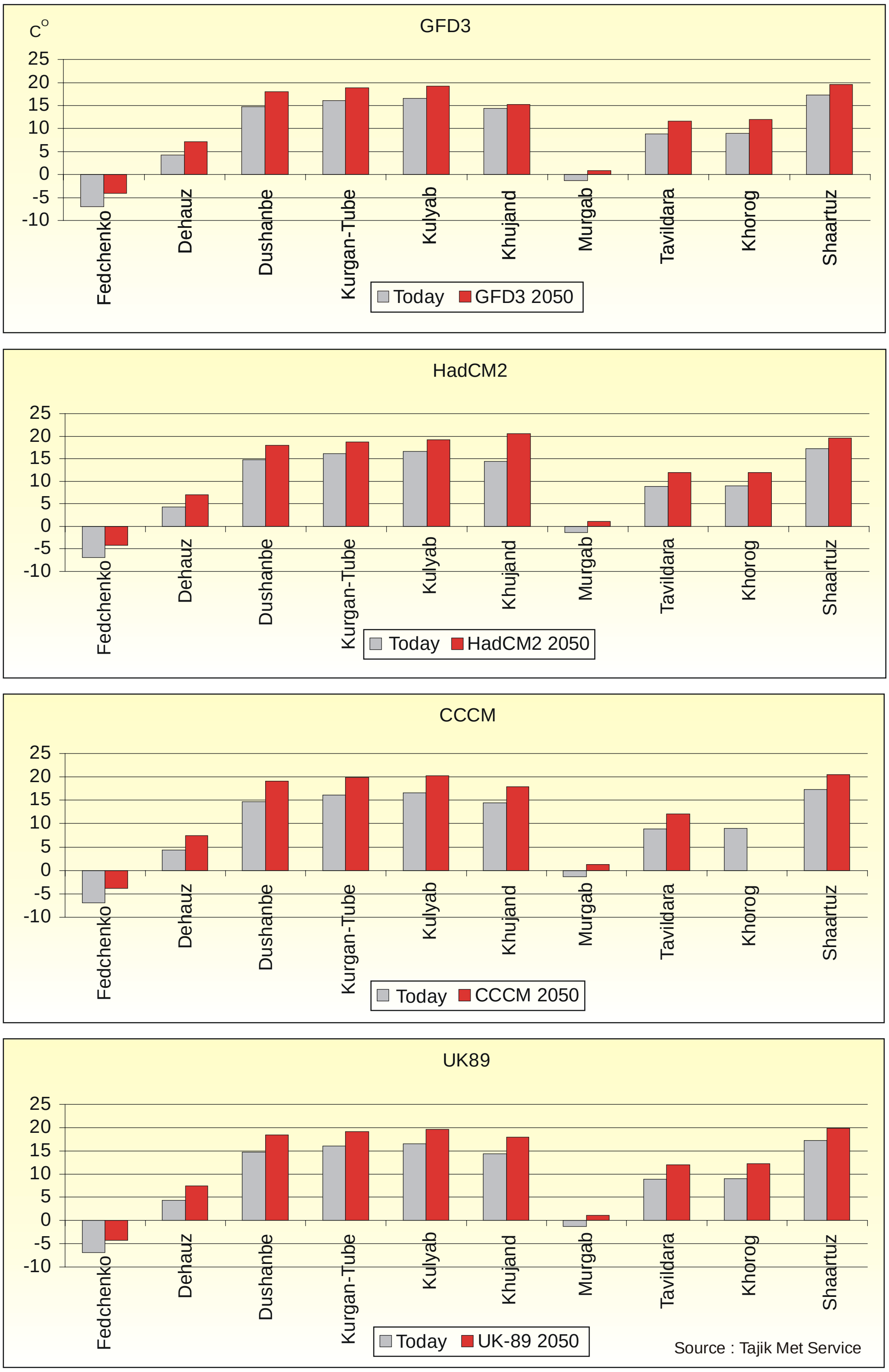


Fig. 4.5.

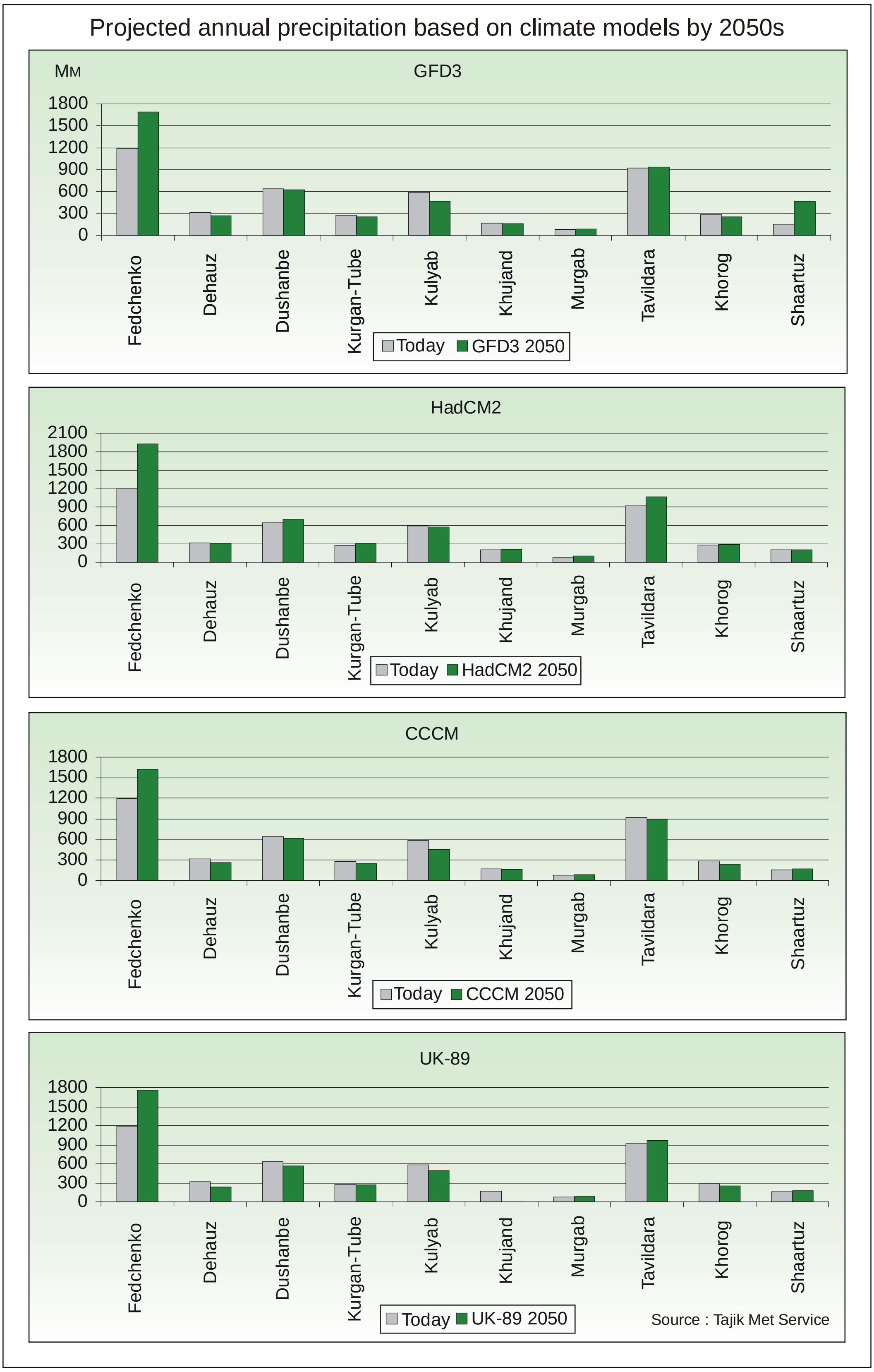

Projected annual precipitation based on climate models by 2050s
MM
GFD3
1800
1500
1200
900
600
300
0
Fedchenko
Dehauz
Dushanbe
Kurgan-Tube
Kulyab
Khujand
Murgab
Tavildara
Khorog
Shaartuz
Today
GFD3 2050
HadCM2
2100
Today
HadCM2 2050
CCCM
Today
CCCM 2050
UK-89
Today
UK-89 2050
Source : Tajik Met Service

Fig. 4.6.

4.3. Ice cover

Glaciers occupy the area 8.0∂0.4 thousand sq.km, which is about 6% of the total country area. The total stock of snow and ice from all these glaciers exceeds 500 cub.km. Glaciers form an abundance of water resources and influence local climate conditions. Glacier melting releases more than 13 cub.km of water annually, this amounts to almost a quarter of Tajikistan's annual flow.

There is evidence of Tajikistan's glacier retreat, both in area and volume, which is likely due to temperature rise and changes in precipitation. Temperature rise leads to the increasing volume of melted water stored under glaciers, thereby making ice unstable, which results in accelerating the glacier's movement. In many regions of the republic, glacier mass accumulation is lower than glacier melting which quickens glacier degradation.

In the second half of the 20th century the Gissar-Alai glaciers in Central Tajikistan decreased by 25%, and lost half of their former ice volume. Ice cover on the southern slopes of the Gissar range has degraded. Small glaciers (<1 sq.km), which comprise the majority in this region, melt very intensively that affect the Kafirnigan River flow.

In the Zeravshan River basin, the glacier of the same name retreated by 280 meters during 1927-1961. During 1961-1976, the Zeravshan Glacier retreated by 980 meters. From 1961 to 1991, the Zeravshan Glacier retreated by 1,092 meters. Nowadays, the Zeravshan glacier is in the process of intensive degradation.

The large Garmo Glacier, located in the Obihingou River basin melts intensively. During the 20th century, this glacier shrank by almost 7 km, having lost about 6 sq.km of its area. At present, on average, this glacier retreats by 9 m a year; because of melting, its surface caves 4 m a year. The Skogach Glacier, which is located in the same river basin, retreats annually by 11 meters. In the period from 1969 to 1986, the glacier lost 98.8 million cub.m, which is 8% of the total mass (fig. 4.7 and photo).

The biggest glacier in Tajikistan is the Fedchenko Glacier, the length of which is about 70 km, located in the upper stream of the Muksu River, during the 20th century shrank by almost 1 km; its area decreased by 11 sq.km, and it lost about 2 cub.km of ice. Almost all of its right side tributaries separated from the main glacier body. However, the degradation of this ice giant is slower than other glaciers. At present, the lower part of this glacier within 6-8 km is cracked and covered by glacial lakes, which evidences the continuing degradation of this biggest glacier in Central Asia.

Climate warming is also observed in Eastern Pamir. However, in view of high altitudes and severe climate, local glaciers retrieve slower than in other regions of the country. The M. Octyabrsky and Akbaital glaciers located at an elevation of 4,500 masl recede on average by 2-5 m a year.

Thus, Tajikistan's glaciers in the 20th century lost more than 20 cub.km of ice. Small glaciers (1 sq.km) that comprise 80% of all glaciers and occupy 15% of total ice cover melt intensively. The most intensive degradation is observed at the glaciers located on the southern slopes (Zeravshan, Garmo); the most stable are the glaciers on the slopes of northern exposure (Fedchenko, Skogach).

Below is a tentative projection of the glaciation dynamics over the territory of Tajikistan up to 2050. This projection is based on a series of climate change scenarios and the results of authoritative regional studies.

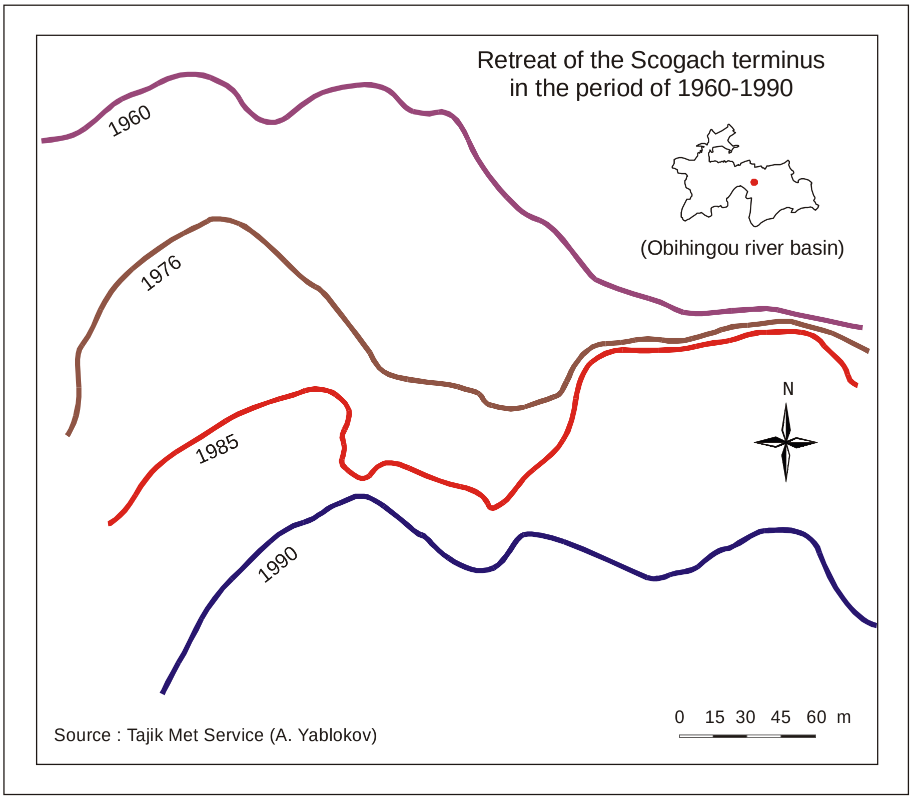


Fig. 4.7.

Scogach Glacier terminus. Photo by A. Yablokov

It is very likely, that during the next fifty years, hundreds of small glaciers in the Zeravshan basin will melt. The bigger ones will lose 20-30% of their ice volumes. By 2050, the ice cover in the Zeravshan River basin will reduce by 20-25%, and the ice volume will decrease by 30-35%. As a result, the ice feeding of rivers will almost halve.

The area of small glaciers (<1 sq.km) on the southern slopes of Gissar range (Central Tajikistan) will halve.

It is likely that in the next fifty years the Obihingou River basin will lose up to 25% of its ice area, and 35% of its ice volume. Obviously, Garmo Glacier will significantly retreat, which can currently be observed in the form of cracking and the appearance of small glacial lakes on its surface. Small glaciers in this basin will totally disappear by 2030-2050s.

Because of huge ice mass, the Fedchenko Glacier in the Muksu River basin will lose about 3-5% of its ice volume. At the same time, other glaciers in this basin will lose 15-20% of their ice volumes.

Western Pamir will lose many small glaciers. Generally, ice cover here will reduce by 15-20%, and ice volume by 20-25%, while Eastern Pamir will face less significant degradation in comparison with other regions because of its higher altitude.

Thus, a few thousand small glaciers in Tajikistan will disappear by 2050s. The increase of precipitation projected by some models will not compensate a glacier retreat caused by temperature rise. Conversely, the lack of precipitation will speed up the process of glacier retreat. Countrywide, the ice cover will reduce by 20%, and the ice volume will decrease by 25%. Glacier tongues will high up to 100-500 meters. The extension of ablation period will intensify glacier retreat. This process will cause alterations in stream flow of the Zeravshan, Kafirnigan and Obihingou rivers. Glacial feeding of the Pyanj River will shift insignificantly, whereas glacial feeding of the Vakhsh River will decrease.

4.4. Water resources

Hydrological network of Tajikistan can be divided into a few river basins, which differ by various character of stream flow and feeding (fig. 4.8). Up to 80% of stream flow of the Amudarya River that flows into the Aral Sea is formed in Tajikistan (fig. 4.9).

For the period from 1961 to 1990, annual mean flow has decreased from 57.1 cub.km/year to 53.2 cub.km/year, i.e. the annual decrease was 0.13 cub.km/year.

In 30 years, the biggest decrease in annual flow has been observed on the Kyzylsu, Zeravshan, Vakhsh and Pyanj rivers (up to 7%). To a lesser extent, the flow has decreased in the Kafirnigan River (3%). In the Eastern Pamir annual river flow changed insignificantly, and slightly increased (0.5-1%) in some regions of Western Pamir (fig. 4.10).

Data obtained from long-term observations shows the periods with significant annual flow inconstancy and synchronous flow vibrations. On the average the periods of high and low water flow alternate every 2-3 years; permanent periods of high and low water flow last for 4-5 years; the longest lasting up to 8 years. Low water levels were observed in 1974, 1976, 1980, 1988; high water levels were observed in 1969, 1972, 1990 and 1998. In 2000, the level of water in Tajikistan's rivers was low (40-85% from normal); it was caused by insufficient snow stocks in the mountains (50-70% from normal), the degradation of glaciers and the lack of spring rainfall.

Disastrous floods caused by climatic factors, mainly due to heavy rainfall and rapid snow melting, were observed in 1969, 1981, 1993, 1998, 2002.

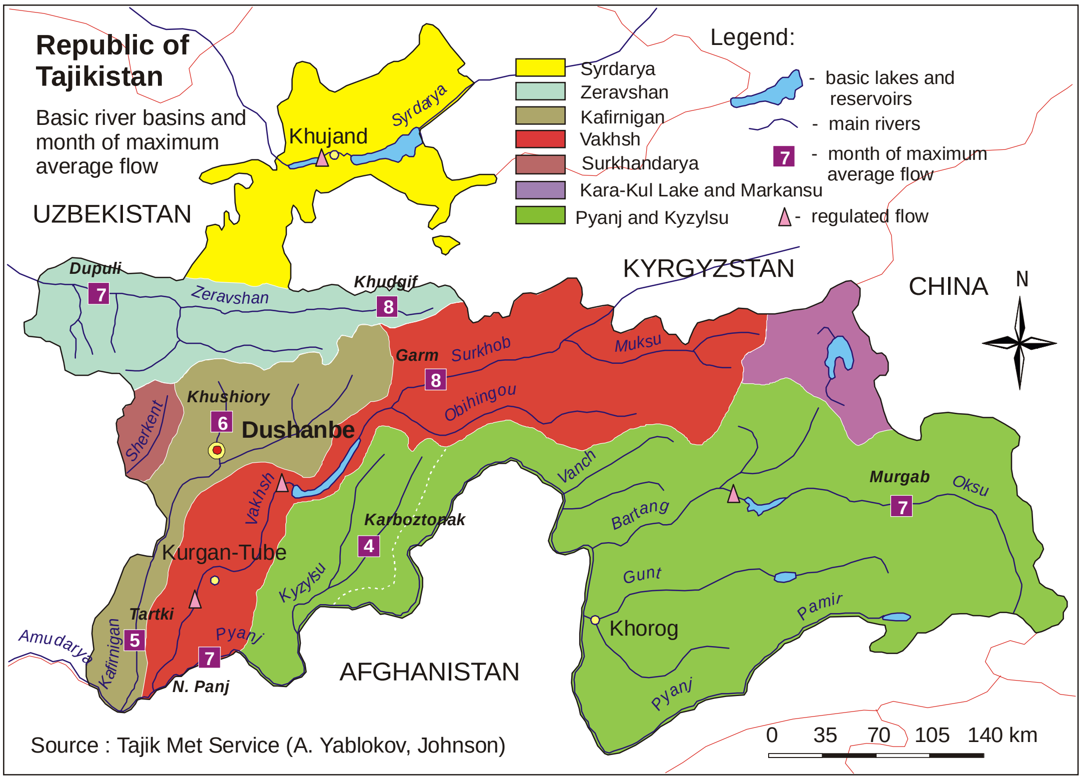

Republic of Tajikistan
Basic river basins and month of maximum average flow
Legend:
Syrdarya
Zeravshan
Kafirnigan
Vakhsh
Surkhandarya
Kara-Kul Lake and Markansu
Pyanj and Kyzylsu
basic lakes and reservoirs
main rivers
month of maximum average flow
regulated flow
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
Khujand
Dushanbe
Kurgan-Tube
Khorog
Source : Tajik Met Service (A. Yablokov, Johnson)
0 35 70 105 140 km

Fig. 4.8.

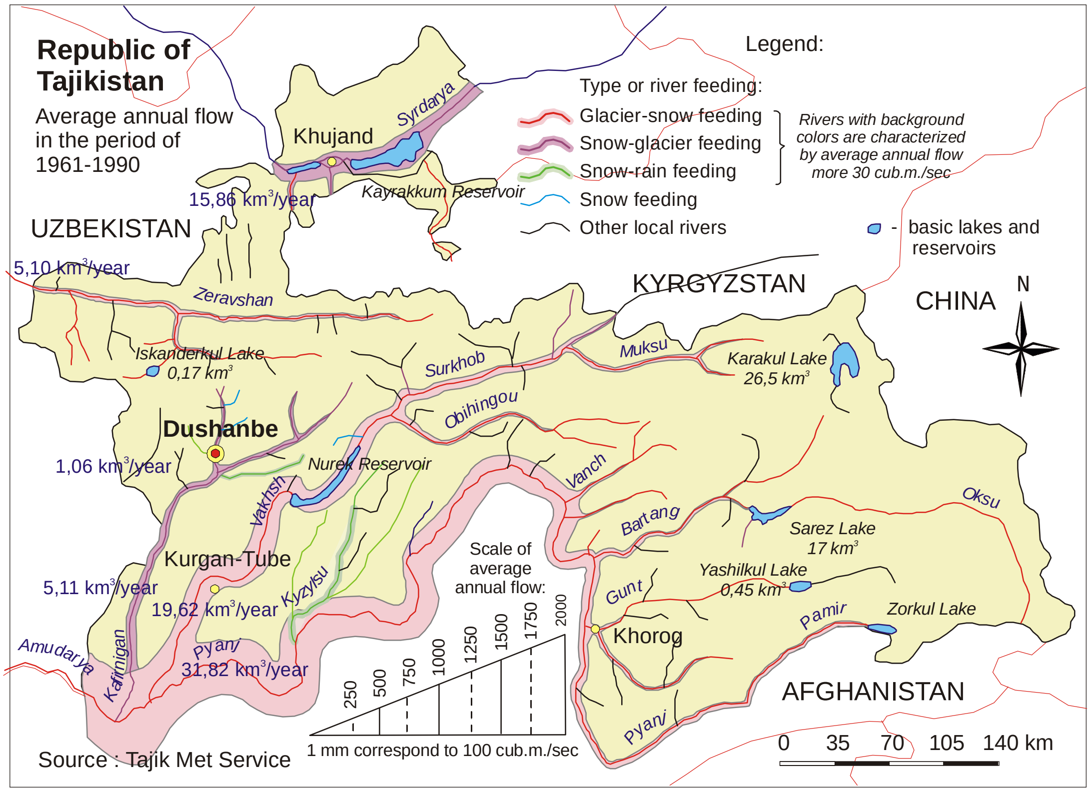

Republic of Tajikistan
Average annual flow in the period of 1961-1990
Legend:
Type or river feeding:
Glacier-snow feeding
Snow-glacier feeding
Snow-rain feeding
Snow feeding
Other local rivers
Rivers with background colors are characterized by average annual flow more 30 cub.m./sec
basic lakes and reservoirs
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
15,86 km³/year
5,10 km³/year
1,06 km³/year
5,11 km³/year
19,62 km³/year
31,82 km³/year
Karakul Lake 26,5 km³
Iskanderkul Lake 0,17 km³
Sarez Lake 17 km³
Yashilkul Lake 0,45 km³
Zorkul Lake
Kayrakkum Reservoir
Nurek Reservoir
Scale of average annual flow:
1 mm correspond to 100 cub.m./sec
Source : Tajik Met Service
0 35 70 105 140 km

Fig. 4.9.

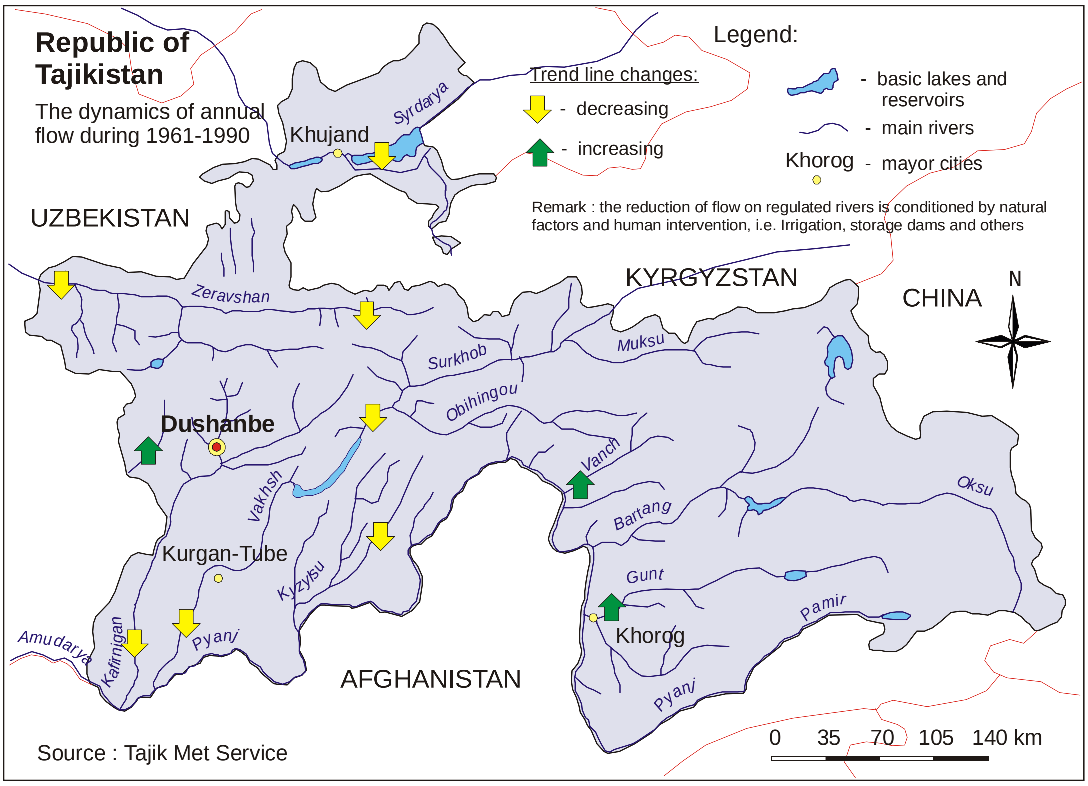


Fig. 4.10.

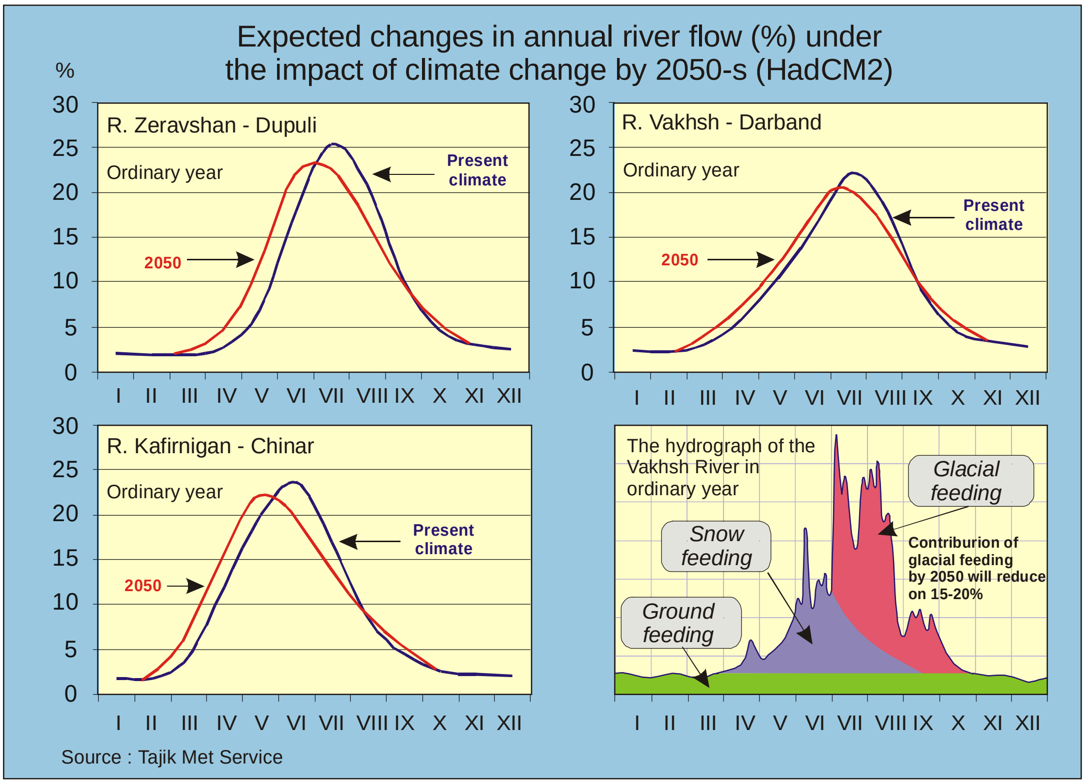


Fig. 4.11.

Apart from the decrease of annual mean flow, there are also indications of seasonal flow changes, which is clear within the catchment areas located below 2,000 masl (Kyzylsu, Tairsu and others). The portion of snow feeding on those rivers has decreased and the portion of ground water feeding and rainfall feeding has increased. A similar trend will continue along with climate warming. Flood season will start earlier.

Expected increase of annual mean temperature by 1.8°C (HadţM2) in addition to a higher rate of increase of summer temperatures will cause a decrease of ice cover all over the Gissar-Alai region by 50% and to a lesser degree in the Pamirs (15-20%). Under such conditions glacier feeding of many rivers will reduce by 20-40%, whereas annual flow of the Zeravshan, Kafirnigan, Vakhsh and Pyanj rivers will decrease by 7% (an optimistic assessment). According to projections, a constant increase of temperature by 3-4°C in comparison with today's climate will dramatically shift the area and the volume of glaciers thereby causing catastrophic decline of water resources by 30% and more.

It is likely that a projected increase of precipitation by 14-18 % (HadţM2) will not have significant impact on river flow, since most of the rainfall's water will evaporate and percolate. It is very likely that rainfall will be more occasional and intensive increasing possibility of floods. According to other climate models rainfall will decrease and thereby deteriorate the state of water resources, particularly in Central Tajikistan. On the other hand, intensive glacier and snow melting and an increase of precipitation will result in an increase of runoff in the Pamirs.

Climate warming by the year 2050 will result in shifting beginning, peak and duration of flood periods. The duration of flood period will expand due to an increase in temperatures. On the rivers with glacier-snow feeding this period will shift 30-50 days, on the rivers with snow-glacier feeding - 15-20 days. Flood peak will shift 15-25 and 7-10 days respectively. On the rivers with snow and snow-rain feeding flood peak will start 25-30 days earlier, and duration of flood period will shorten because of earlier thawing of snow reserves (fig. 4.11).

Projected decrease of steam flow in the first half of the 21st century by 7-10% and more is fairly significant, considering that actual deviations of river flow can range from +30% to - 24% from mean value. However, glacier retreat and the weakening role of glaciers as river flow regulators call for urgent adaptation measures to the change in climate.

4.5. Land resources and desertification

Out of the total land area of the Republic of Tajikistan, about 32% is being used in agriculture. Valleys of Tajikistan are located mainly in arid areas, where annual rainfall does not exceed 250 mm a year, and evaporation reaches 1,500 mm a year; irrigated farming in such conditions plays a leading role in agriculture.

Total land area suitable for agricultural purposes amounts to 5.212 million hectares, which is 36.6% of total land area of Tajikistan. Cliffs, mountains and slide-rocks occupy about 50% of the territory; the rest of land area is glaciers, pebbles, gravel, riverbeds, and low productive pastures.

Most of the territories of Tajikistan are prone to the impacts of climate, which contributes to the processes of land degradation. Such processes as freezing, physical destruction of soils under diurnal temperature variations, dehydration, wind erosion, intensive heavy rainfalls promote land degradation and desertification. Human intervention (uncontrolled cattle grazing, tree and shrubby plant felling) in addition to climate change has adverse affects on the state of land resources and give rise to widespread desertification. Intensification of gully erosion and landslides is observed due to reclamation of steep loess slopes. Wash out of fertile topsoil takes place over a hundred thousand hectares.

About 90% of Tajikistan's agricultural lands are prone to various types of erosion. Water erosion is widespread in the mountains (41% of the country territory); deflation is observed on desert territories (24% of the territory); irrigation and gully erosion takes place mainly on irrigated and rain-feed lands (1.5% of the territory).


Gully erosion. Photo by U. Isufov

Erosion results in the destruction of fertile topsoil; its biological productivity falls down. Thus, on the lands with lightly washed topsoil productivity falls by 10-20%; on the lands with averagely washed topsoil productivity falls by 30-40%; and on the lands with dramatically washed topsoil productivity falls twice or more. In dry years, the productivity of cereals on eroded rain-feed lands reduces by 3 times. Loss of productivity is reflected on the economy while cumulative damage from erosion significantly exceeds harvest loss. As much as 70 thousand hectares are being reseeded annually due to unfavorable weather conditions.

It is very likely that climate change will increase the intensity and spread of land degradation. Long dry periods in combination with high temperatures in spring and summer seasons will lead to the intensification of desertification processes in Southern and Central Tajikistan. Uncontrolled deforestation has reached disastrous levels and is worsened by climate change.

For conservation of land resources and increasing soil fertility, sustainable methods of land farming, adaptation and prevention of land degradation on the area 1.5 million hectares is vitally needed.

4.6. Pastures

Natural pastures and hayfields occupy a territory of 3.3 million hectares playing an important role in animal husbandry and serving as habitats for many species of flora and fauna. Herbal cover of pastures conserves and increases soil fertility, protects the soil from erosion and enriches the atmosphere with oxygen. The role of pastures is essential in regulating surface runoff, especially in mountain areas. Animal husbandry provides inexpensive production in comparison with stabling.

The productivity of pastures greatly depends on the climatic conditions during the vegetation period and geographic area of their distribution. Tall-herb savannoides have a very high productivity up to 900-1400 kg/ha; conversely, desert pastures have the lowest productivity between 50 kg/ha and 300 kg/ha.

The productivity of natural pastures is low and continues to decrease as a result of overgrazing, deterioration of pasture conditions, and violation of nature protection legislation, especially on autumn-spring-winter seasonal pastures of Southern Tajikistan. The area of most important winter pastures and hayfields decreases due to land reclamation and their use as arable rain-feed lands. Lately, many pasturelands on mountain slopes have been ploughed, and now used for the cultivation of cereals.

Projected parameters of climate change have a potential to affect animal husbandry in Tajikistan. The arguments for this can be drawn from analyzing the relationship between precipitation, temperature and productivity of pasture vegetation during the period between 1961 and 1990.

Providing precipitation levels are normal, a temperature rise of 2°C to 4°C in February and March decreases winter-spring pasture productivity by 20% and can be reduced by 3 times during dry years. In the mid-mountains, an increase of annual temperature by 1.5-2°C together with normal precipitation leads to a decrease of pasture productivity by 20%. In dry years, a decline in productivity and diversity of ephemeral vegetation can be observed (fig. 4.12).

On high-mountain pastures, a rise of temperature by 1.5-3°C favors the increase of pasture productivity by 25-50%. Steppe and mountain desert pastures will be better if annual temperature and rainfall increase, on the contrary they will degrade if rainfall decreases.

Low pasture productivity due to climatic factors was reported in 1966, 1970 and 1985. In 2000, pasture productivity decreased due to drought and high temperatures.

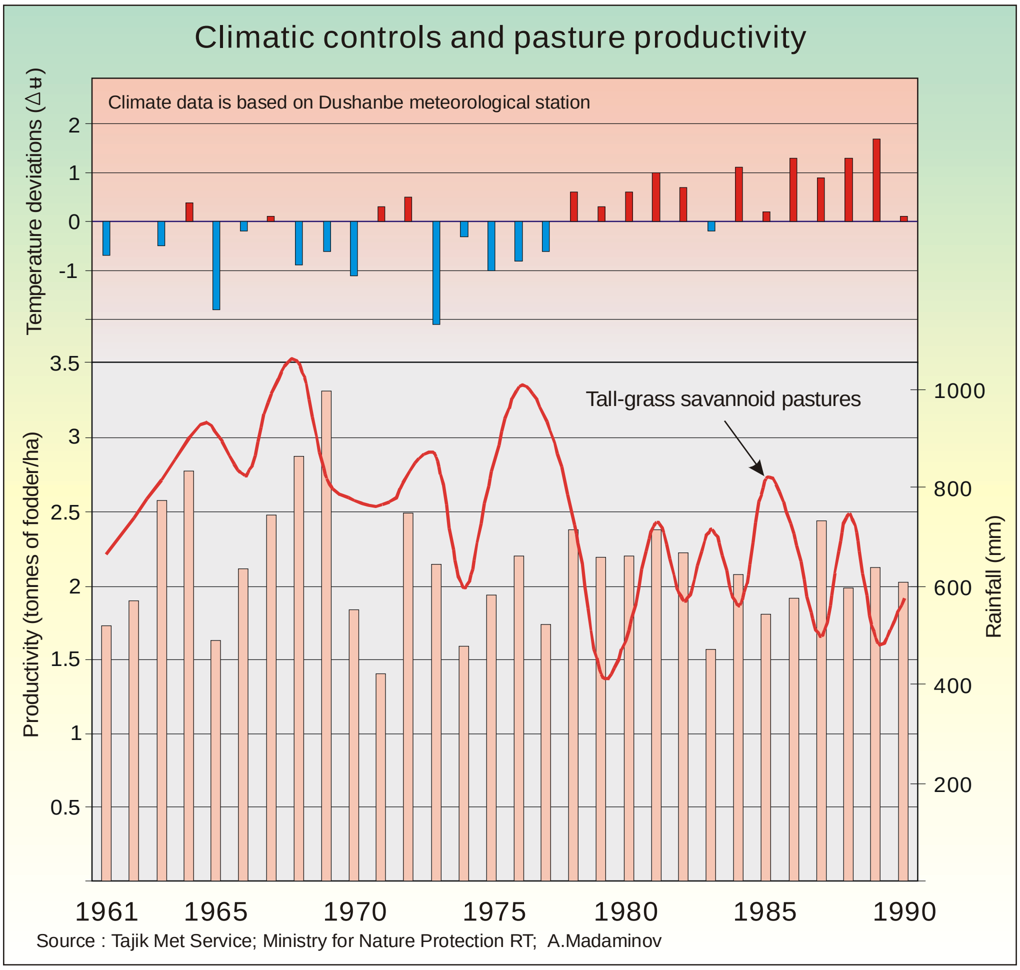


Fig. 4.12.

4.7. Ecosystems

The study and understanding of climate change impacts on the productivity and diversity of ecosystems, especially mountain environments of Tajikistan, have great scientific and economic importance.

The combination of vertical zonation, geographical isolation, land surface, soils and climatic factors give rise to a rich diversity of ecosystems within the relatively small territory of Tajikistan. Ecosystems respond to climate change and the increase of CO_2 concentration in different ways. The state of ecosystems and the changes within them are an important indicator of climate change.

It is very likely that climate warming by 1.8-2.9°C by 2050s will high up the area of distribution of forests and shrubs:

- Broad-leaf forests - up to 2,500 masl;
- Small- leaf forests - up to 3,800 masl;
- Pistachio forests - up to 2,000 masl;
- Heat-loving junipers - up to 3,000 masl;
- Cold-resistant junipers - higher than 3,200 masl.

Due to projected climate warming, the upper line of shrubs and sub-shrub vegetation will rise, whereas on the foothills this type of vegetation will degrade. Warming will have an essential impact on herbal vegetation: highland pastures and alpine meadows will benefit, whereas winter pastures and hayfields will likely degrade.

Probably, there will be degradation of tugai (flood plain) ecosystems due to a decrease of river flow, an increase in temperature and fire risk. The condition of broad-leaf forests can be endangered in the case of frequent and long droughts. Along with climate changes, there will be changes in phenological parameters of forest vegetation (earlier ripening, fading, blooming, etc.). Warming will also lead to the alteration of flora and fauna, and biological linkages within ecosystems. There is a possibility of occurrence of new species of flora and fauna that is not typical for local territories.

Edelweiss. Photo by A. Kayumov

It has been established that successful adaptation of mountain flora is possible with only a very small climate change, smaller than 0.1°C/10 years. Considering that projected rate of climate warming will range between 0.3-0.5°C/10 years, effective adaptation of natural vegetation will not be possible in some types of communities.

It is very likely that as a result of climate warming the habitats will degrade thereby reducing the number of endangered and rare species of flora and fauna. The fauna of high mountain regions is particularly sensitive to climate change.

4.8. Water economy and hydropower engineering

Water economy provides transportation of water to the consumers, and implements the accounting, planning, regulating, and protection of water resources.

According to expert estimates, the climate change will have both beneficial and adverse effects for the water economy of the republic.

Projected parameters of climate change will increase the intensity of evaporation from the surface by 5-10%, whereas evapotranspiration of hygrophilous vegetation will rise by 10-20%. This will lead to an increase of irrigation norms (fig. 4.13):

- Cotton - from 7,550-11,700 cub.m/ha to 9,600-14,900 cub.m/ha (27%) using existing technologies;
- Wheat - from 1,580-2,530 cub.m/ha to 1,920-3,100 cub.m/ha (22%);
- Alfalfa - from 4,220-9,240 cub.m/hectare to 5,820-12,750 cub.m/hectare (38%).

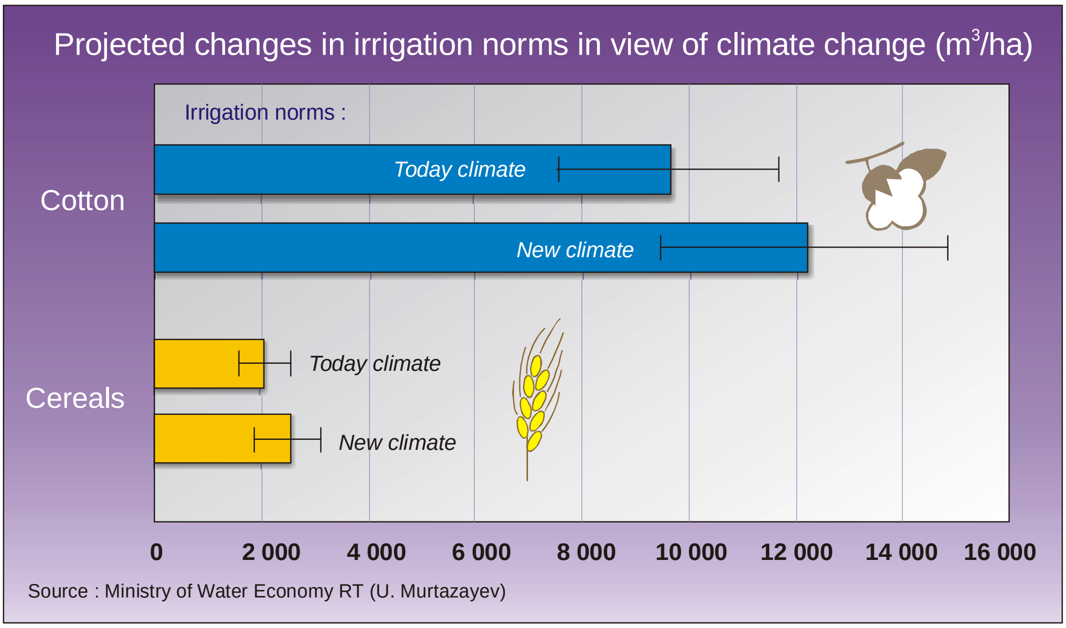


Fig. 4.13.

In a number of valleys, the ground water flow can decrease in view of surface water shortage and changes in the precipitation pattern; then, energy consumption for mechanical water lifting in agriculture will likely increase. Suspended solids in rivers will magnify because of soil erosion. The process of reservoir sedimentation will be more intensive. Low efficiency of irrigation systems (0.65) along with water resources shortage will complicate the water problem in the future, including Aral Sea crisis.

The most important task of water economy is to provide the population with good quality drinking water. At present, about 50% of the population has no access to clean (good quality) drinking water and this problem will dramatically increase if adaptation measures are not implemented to cope with climate change conditions.

Water resources are the basis for Tajikistan's hydropower engineering industry. The total annual potential of hydropower resources in the country is estimated at 527 billion kilowatt-hours, of which about 40-50% is technically applicable for energy production. Hydropower plants produce more than 95% of all electricity in the country.

The vulnerability assessment of hydropower engineering was focused on the Vakhsh River, because most hydropower facilities are located there. Some new hydropower facilities have been designed for construction on that river too.

It is identified that during 1961-1990, changes of water levels in the Vakhsh River did not affect the hydropower sector. The instability of hydropower facilities on the

Vakhsh River is caused by landslide activities and mudflows. The infrastructure of the Rogun HPP, which is currently under construction, was considerably damaged as the result of a flood in 1993. In March 2002, a massive landslide formed close to the Baipaza HPP as a result of complex geodynamic and climatic factors (heavy rainfalls). The map (fig. 4.14) shows the vulnerability of hydropower engineering to natural factors.

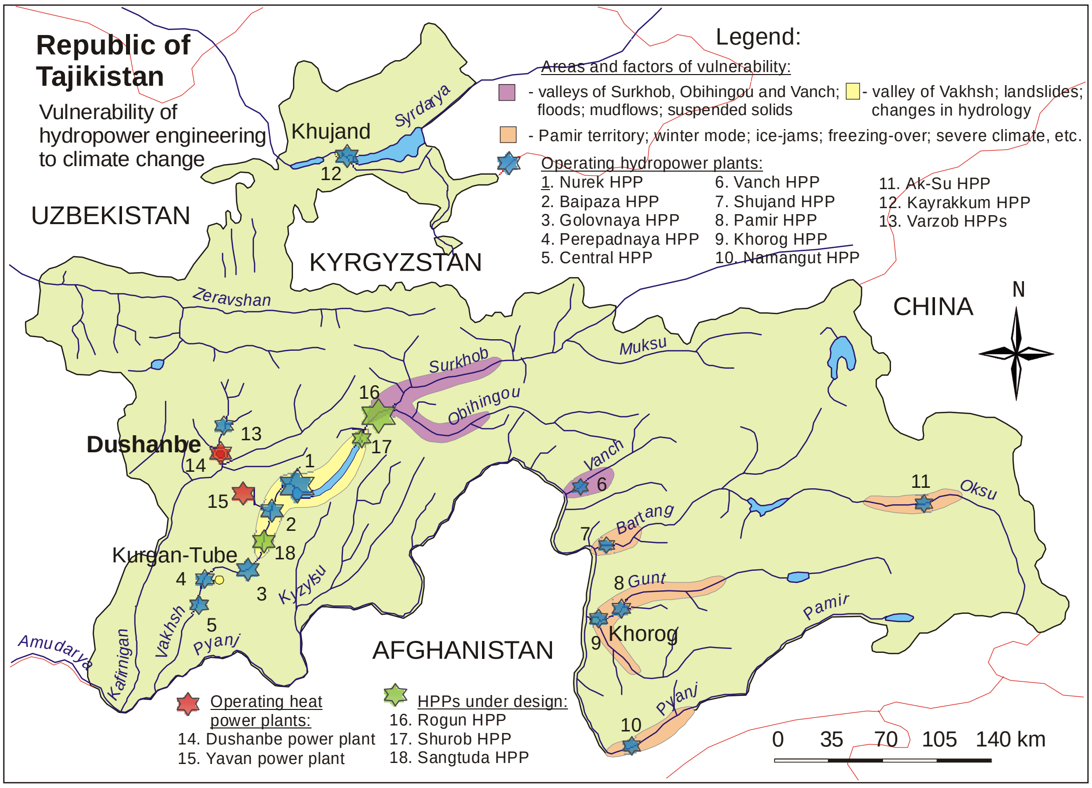


Fig. 4.14.

According to expert evaluations, a 10% increase in precipitation, especially in the regions prone to water erosion, will double the volume of suspended solids in the Vakhsh River, thereby increasing the intensity of sedimentation at the Nurek reservoir.

On the Surkhob, Obihingou, and Vanch rivers landslide activities, floods and other hydro-meteorological phenomena cause this instability. The formation and outburst of glacial lakes is also potentially dangerous for hydropower facilities in this region. Prompt rise of temperatures and the rapid melting of snow increases the possibility and intensity of floods. The Pamirs are characterized by a harsh climate. Thus, the winter mode here brings bigger influence: ice jams, frazil, alterations of frosts and thaws, etc.

Thus, expected climate changes will be unfavorable for hydropower engineering, as it will result in a decreased stream flow and increased risk of landslides and floods. There will be a necessity in reconstruction, alteration of the operation mode of hydropower facilities, etc.

4.9 Agriculture

Tajikistan is interested in development of agriculture and its reconstruction, as it is an agricultural and industrial republic, with the predominant share of agriculture in the national economy, fast growing population and degrading ameliorative conditions of arable lands.

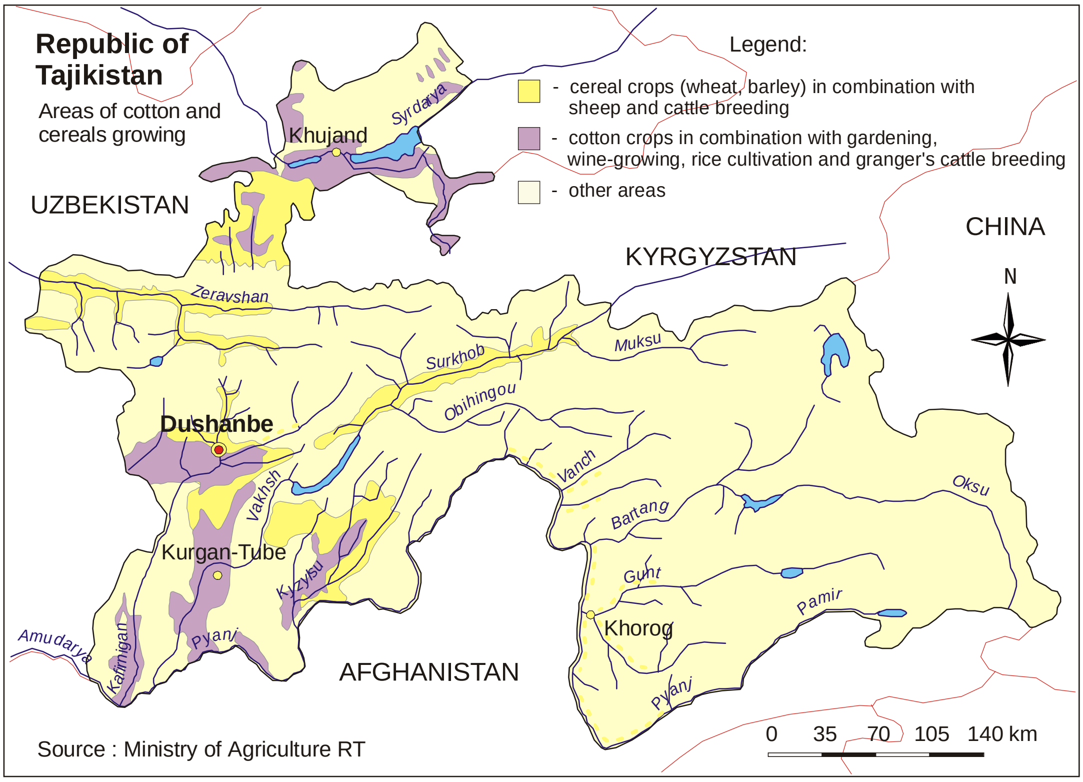


Fig. 4.15.

Agriculture is the major sector of Tajikistan's economy, and it is paramount for the sustainable development of the nation. This sector comprises about 25% of GDP. The main agricultural practices in the republic are cotton growing, gardening, viniculture, melon farming, potato planting, cereal farming and animal husbandry (fig. 4.15).

Natural and climatic factors determine optimal grazing conditions, application of the labor and machinery in agriculture, etc.

In Tajikistan, it is rather difficult to define a direct impact of the climate on agricultural production, since political, economic, social and various environmental factors also play an important role.

The vulnerability of agriculture related to hydrometeorological disasters is countable. Losses caused by climatic factors are much higher than ones caused by anthropogenic factors and other non-meteorological phenomena.

<u>The most damage to agriculture in Tajikistan is occurred in result of such hydro-meteorological phenomena and related to them factors as:</u>

- High temperatures, hot winds and low temperatures;
- Heavy rainfalls, snowfalls and hailstones;
- Floods and mudflows;
- Strong winds and sandstorms;
- Agricultural pests and diseases.

During 1991-2000, annual loses of agricultural gross product from extreme weather events totaled to 1/3 of overall agricultural loss.

As a result of droughts in 2000-2001, lack of precipitation and small snow stocks the harvest of cereals in comparison with previous years reduced by 10-30%. Hailstones, heavy rainfalls and other extreme whether events in 2002 resulted in significant damage to the agriculture of Tajikistan estimated at tens of millions of somoni, since the preventive and adaptation measures had not been taken.

The impact of climate change on agriculture will be considerable since destructive whether events, long lasting droughts and diseases will increase in the future. In this regard appropriate adaptation measures to ensure sustainable farming and the introduction of new technologies and methods of agriculture are needed to adapt to climate change.

4.9.1. Cotton production

Cotton is cultivated in the Gissar and Vakhsh valleys, Kulyab and Sogd areas. Cotton fields occupy about 3/4 of irrigated lands. The Vakhsh valley is the leading area in production of valuable fine-stapled cotton. The cotton productivity depending on areas vary from 1,500 to 4,000 kg per hectare. Cotton is a basic agricultural export product and is widely used in Tajikistan's light industry.

The assessment of vulnerability of cotton to climate change shows that cotton productivity depends on regular irrigation as well as effective sum of temperatures, rainfall, quality of soil, ground water levels and the application of fertilizers.

The influence of the climatic factors is marked in the spring period, when heavy rainfalls cause the formation of soil crust, washing off crops, breaking plants, which requires the cotton to be reseeded. Hailstones cause significant damage to plants, destroying flowers, leaves, cracking stalks, thus, reducing the quality and quantity of future crop. Strong hot winds usually result in the mass falling of buds, flowers and cotton ovary. Cotton is vulnerable to autumn frosts and to a lesser degree, spring frosts. Cotton perishes or loses a significant part of the crop being exposed to 2-3 fold autumn frosts.

In general, the HadCM2 model gives an insignificant change (±5%) in cotton productivity in the mid-term prospect depending on agro-climatic areas.

According to HadCM2 model, the increase of cotton productivity will probably take place in the Vakhsh and Gissar regions. However, cotton productivity will likely reduce in the Kulyab and Sogd regions.

Other GCMs, depending on the region, indicate the range of cotton productivity to increase or decrease by anywhere between +37% -13%. Further increase of maximum air temperatures, especially above 38°C will result in the overheating of the plants, depressing their growth. Other natural factors that influence cotton productivity are ground level water, availability of surface water resource, pests and diseases.

Water is the major factor for cotton development. During vegetation period, one cotton plant requires about 1 cub.m of water. Insufficient water supply causes slow growth of the plant, reduction of bolls and their early opening. The general water needs for cotton is 8-10 thousand cub.m/ha in the vegetation period. The most likely consequence of temperature increase, reduction of atmospheric precipitation, ground moisture deficit and reduction of water resources in spring-summer months will be the reduction of cotton productivity. A decreased water supply of 80% from normal levels in the vegetation period will cause the reduction of productivity on average by 15%, while a 50% water supply deficit will result in 35% of the cotton crops reduction.

The cotton crop is considerably vulnerable to the threat from various agricultural insects. Loss of a cotton crop of 20-30% can come from the damage caused by cotton noctuid pests, and if combative efforts with this wrecker are not started in time, or carried out ineffectively, the losses of the crop can be as much as 70%.

It is expected that harmfulness of all cotton noctuid generations, which is the basic cotton wrecker, will begin for one decade earlier at climate warming. Higher temperatures in the period since February till April will increase the risk of spread of diseases and cotton wreckers.

The lesion probability of cotton wilting can increase with a rise in temperature, and will negatively affect the fibre length and durability.

4.9.2. Cereals

Cereals occupy more than 420 thousand hectares (48%) out of the total area of Tajikistan's agricultural crops. Wheat is the leading sort of cereals. Other sorts are: rice, corn, haricot, barley, lentil and leguminous plants. Traditional areas of cereal cultivation are the foothills of Turkenstan, Kuramin and Gissar ranges and the Dangara, Kysylsu and Yavan valleys.

The assessment of vulnerability of cereals was carried out in five agro-climatic regions, where cereal crops are located mainly on rain-feed lands.

Productivity of cereals depends on sum of effective temperatures, rainfall, soil humidity and type of agro-machinery cultivation.

It is likely that in warmer climate cereal productivity will increase by 10-15% on irrigated and rain-feed lands of the Gissar, Karategin and Kyzylsu regions when precipitation is normal. However, the reduction of precipitation will lead to a reduction of cereal productivity. Cereal productivity will probably decrease in Northern Turkestan and Western Pamir. Precipitation deficit will strengthen adverse consequences of climate change.

The climatic factors favor the reproduction and spread of cereal pests and diseases. Climate change impacts can lead to the increase in the number of pests and their potential harmfulness.

Research shows that the harmfulness of gessen fly (Mayetiola destructor), which is widely spread all over the country and is the major pest of wheat, rye, barley, under conditions of insufficient soil humidity in spring-summer period will increase. Pedicellate mildew (Puccinia graminis) is actively developing and damaging the wheat, rye and other cereals in the conditions of a warm and wet climate. On the other hand, dry and hot whether prevents reproduction of some other pests and diseases.

4.10. Transport infrastructure

Tajikistan is a mountain country and in view of complicated landscape, motor-roads are the most important part of the infrastructure. Total length of national roads is about 30 thousand km, including 13.7 thousand km with a hard surface.

Road transport covers 90% of internal cargo turnover. In addition to the performance of important economic tasks, road transport plays a vital role in the maintenance of agricultural and social infrastructure. Development of railways in Tajikistan is very limited in territorial respect. There are only 3 isolated segments of the Tajik railway system with a total length of 533 km. Railway transport maintains about

90% of external cargo turnover. Aviation inside of Tajikistan is limited by complicated mountain conditions. In general, aircraft transportation, both internal and external, abruptly declined in the last decade, because of high usage costs and unsatisfactory conditions of the whole country's aircraft system. Water transport is applied insignificantly, basically in the form of small river vessels, barges and ferries on the rivers Pyanj, Vakhsh, Syrdarya and Amudarya.

Road transport will remain the major mean for cargo and passenger traffic for the foreseeable future. Economic development and regional integration will increase the intensity of road traffic countrywide.

The development of road transport is limited by unfavourable natural-climatic conditions. High temperatures in the summer season in the valleys and foothills cause infringement of fastness indicators and deformation of road surfaces. Significant daily temperature amplitudes lead to intensive physical destruction of rock masses leading to the formation of rockslides and rock-falls on the roads (fig. 4.16).

Major roads connecting the heart of the country with the Sogd Region and Mountain Badakhshan are closed at the point of mountain passes (Anzob, Shakhristan, Khaburabad, and others) for 6 months during the year from December till May, in view of significant snowfall and the risk of avalanches on many segments of roads. Therefore, the population of mountain regions is fully isolated in wintertime.

Flash floods in spring and mudflows spread over the big territories wash out tens of kilometers of road ballast bed. They put out of action or partly destroy hundreds of transport facilities and culvert constructions.

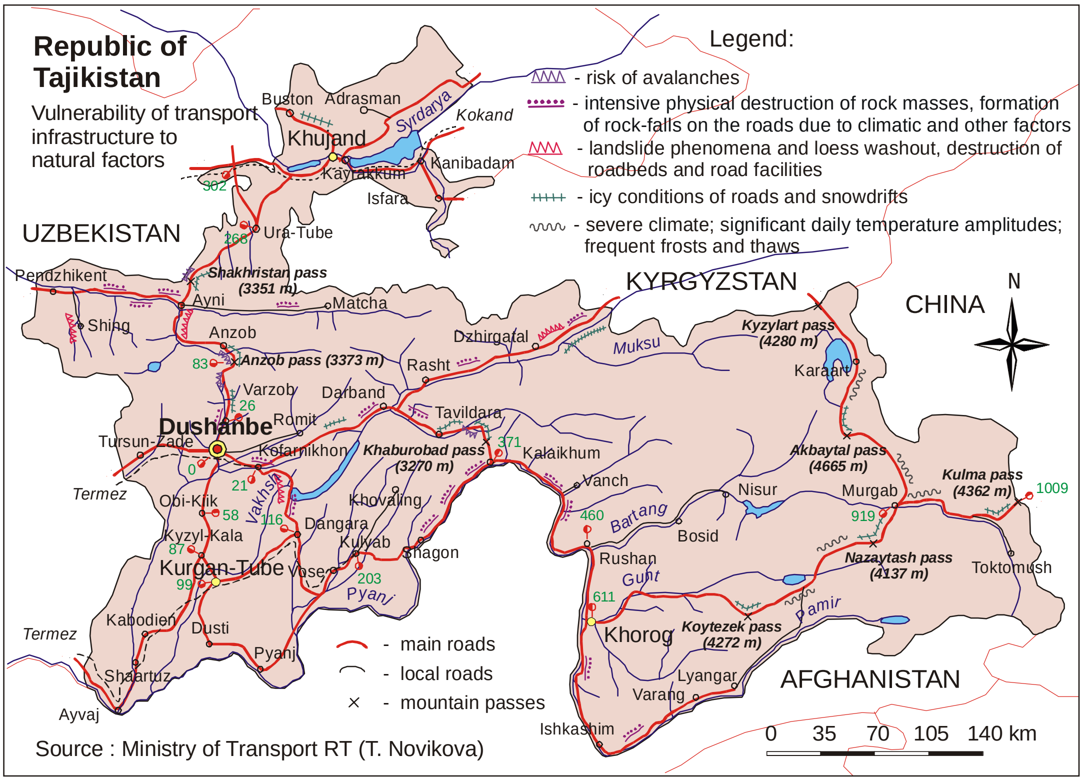


Fig. 4.16.

Table 6.1.

The length of roads under the impact of unfavorable natural conditions

Phenomena	Length (km)
Rock falls	323.7
Landslides	198.5
Avalanches	168.2
Karsts	119.7
Icy crusted roads	106.6
Debris cones	66.9

Source: Tajik Ministry of Transport (2001)

During 1997-2001, about 3.6 thousand km of roads, more than 500 bridges and other constructions, and much road equipment was destroyed and damaged. This was the result of different natural disasters without sufficient preventive and adaptation measures being taken.

More than 500 km of roads (tab. 6.1) are prone to unfavorable natural phenomena every year, among which climatic factors play an essential role. In that regard, adaptation measures in the transport sector are very necessary.

4.11. Public health

The study of climate change impact on public health is one of the actual topics covered in modern medicine. The importance of this issue comes from likely adverse effects on human being's health such as natural disasters, an increase of vector-born and infectious diseases, and new infections not typical for the region.

The increase of temperature in the mountains amplifies the impact of hypoxia, which makes people living in these regions more vulnerable in comparison with those living in valleys; most vulnerable are older people (fig. 4.17).

The longevity index reflects the possibility of reaching longevity and practically does not depend on population structure. Climate warming leads to a decrease in the longevity index. In the conditions of a hot climate (lowlands), the longevity index is lower than in moderate and warm climatic conditions (foothills and low-mountains). As the elevation increases and partial oxygen pressure declines, the longevity index substantively decreases. The longevity index in Badakhshan Region in comparison with average republican index is two times lower (fig. 4.18).

Temperature rise and lack of rainfall, will lead to an increase of cardiovascular pathology, and decrease of respiratory diseases. The urban population is more vulnerable to cardiovascular diseases, whereas the rural population is more vulnerable to respiratory diseases.

Temperature and humidity in some cases can create favorable conditions for the reproduction of pathogenic organisms and transmitters of infectious and vector-born diseases, increasing their number and area, and making human beings more vulnerable.

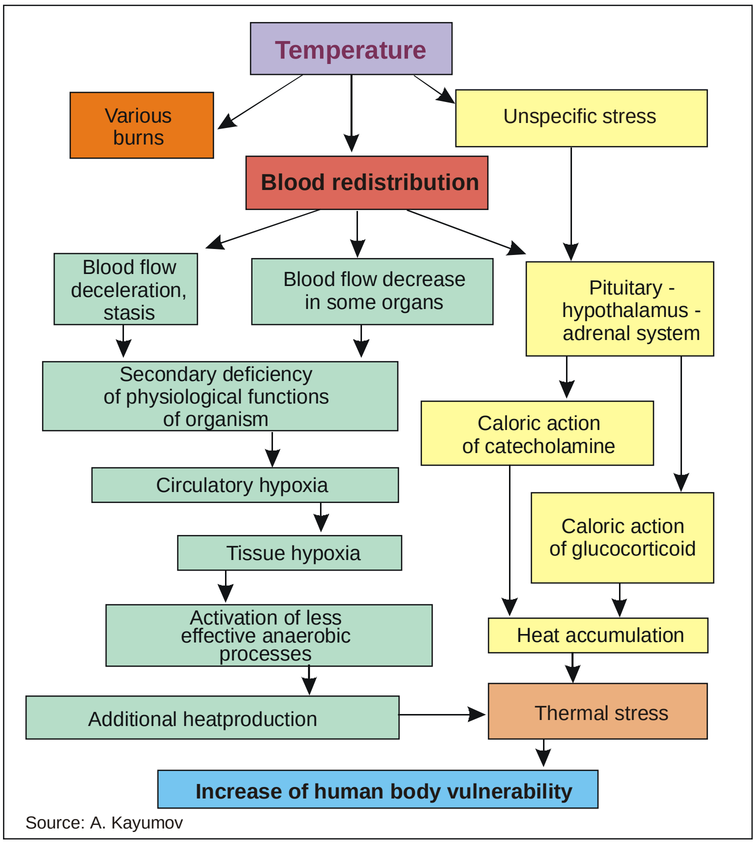


Fig. 4.17.

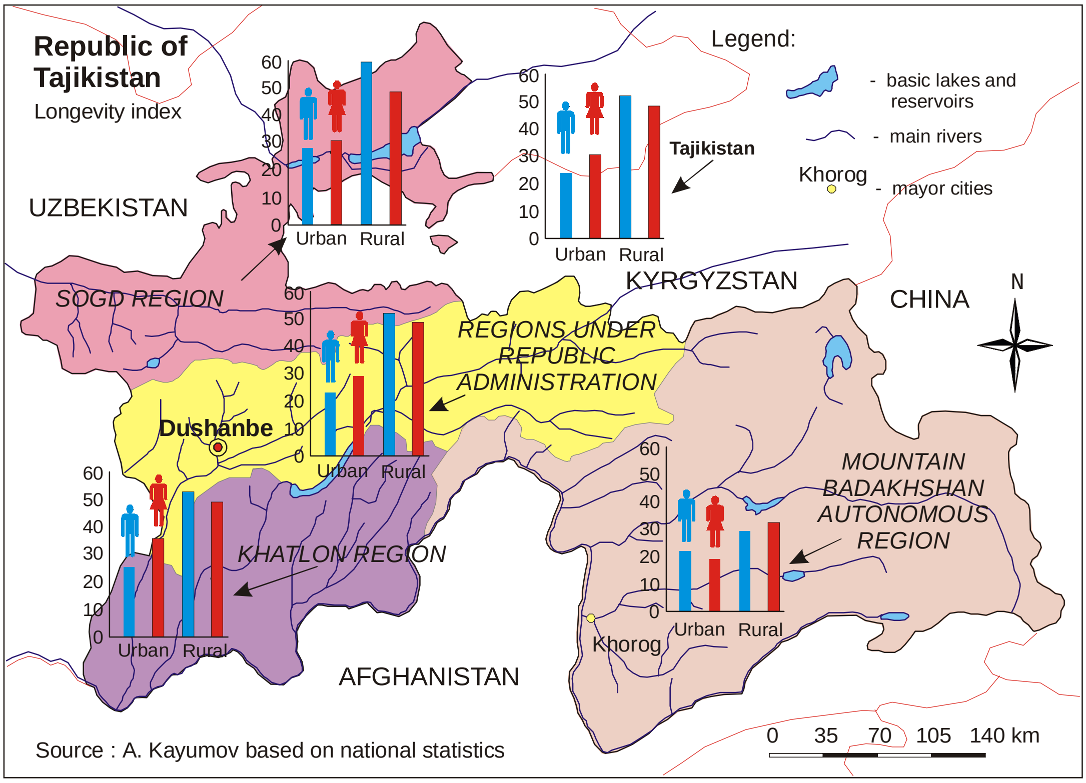


Fig. 4.18.

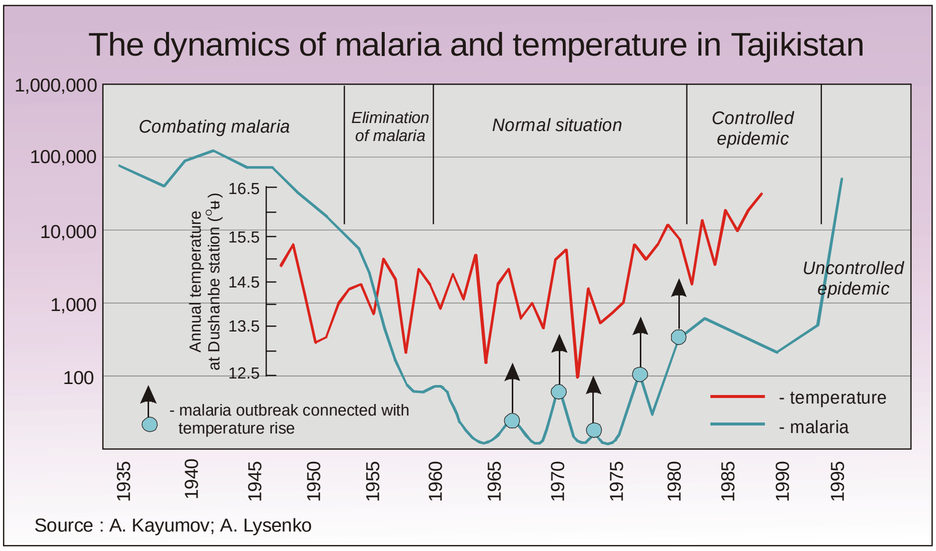


Fig. 4.19.

Research shows that the increase of malaria depends on the temperature of the environment (fig. 4.19). The temperature is a limiting factor in malaria development.

Climate warming will cause not only the increase of malaria but will also increase the number of days favorable for reproduction of malaria mosquitoes which in turn increases the risk of malaria outbreak.

Besides vector-born diseases being a danger for public health, there are such diseases as typhoid, paratyphoid, salmonellas, dysentery, amebiasis, helminthiasis and others, which mainly occur in spring, summer and autumn. These infectious diseases have an oral-fecal process of transmission and are spread by getting into food products and water. Flies play an important role in the transmission of infectious diseases. The reproduction of flies is identical to the spread of diseases. Temperature rise in the conditions of inappropriate communal water supply system, combined with flooding and heavy rainfalls increase the risk of infectious diseases.

In warmer climate, the chance of tropical diseases and dangerous infections to spread is very high.

Alterations in the hydrological cycle will lead to a water shortage and an increase of water temperature in the rivers. This favors the formation of potential choleric water reservoirs, especially in the lower reaches of the rivers Vakhsh, Kafirnigan, Syrdarya, and others. It is likely that the rise of extreme summer temperatures in hot regions will lead to increased infant and adult mortality.

According to the bioclimatic index of severity of meteorological conditions it is stated, that the maximum level of discomfort will be in summer. At this time of year, daytime discomfort will grow especially in the Kurgan-Tube area of the Khatlon region and will be characterized by expressed deterioration of health conditions and reduction of labor capacity. In addition, high temperatures cause high mortality amongst the population in the summer period.

In the conditions of rapid climate change, adaptive mechanisms of humans are overstrained and cannot normally react, which increases the vulnerability of the population. Nevertheless, climate change impact on public health and mortality has not been completely investigated in Tajikistan, and it requires additional study.

4.12. Urban air quality

Urban areas such as Kurgan-Tube, Dushanbe, Yavan, Tursun-Zade, Sarband and Kulyab are vulnerable to climate change. This vulnerability is conditioned by anthropogenic emissions, and local climatic factors, deteriorating urban air quality.

Dushanbe, the capital of Tajikistan is the political centre and an industrial city. This city with population of 580,000 inhabitants, 20 large industrial enterprises and about 30,000 vehicles, is vulnerable to the impact of meteorological and anthropogenic factors.

The city is located at the average altitude of 840 masl in the Gissar valley of Central Tajikistan, surrounded by the Gissar range to the north and Rangon mountains from the south. This valley is open to winds only from west and east. Local landscape advantages atmospheric air stagnation. Additionally, tree plantations and buildings are the factors that prevent free air circulation. As a result, windless weather (60% calm) prevails here and air pollutants stay in near surface layer for a long time. Rare rainfall in summer and high intensity of solar irradiation favor air pollution.

Anticyclone circulation promotes development of near surface inversion. Under such phenomena the temperature increases with height or remains constant. Inversions are formed predominantly during clear nights by means of cooling near surface air stratum and prevent the vertical movement of pollutants in the atmosphere.

All abovementioned factors intensify air pollution and increase the length harmful substances remain in the atmospheric air. Solid particulars (mineral dust, carbon) and harmful gases (ţ Ş, NOx, and others) are such substances. They have a negative impact on the urban population's health as well as architecture and historical monuments in Dushanbe. During the period of 1980-1995 there has been observed a high level of concentration of dust, carbon oxide, nitrous dioxide and sulphur dioxide.

Exact interrelation between concentration of carbon monoxide in the atmosphere and air temperature is observed during wintertime. Apparently, right after increase of carbon monoxide concentration, air temperature grows. On the contrary, the decrease of CO concentration makes air temperature fall.

Increased air pollution is also observed in other cities of the republic. Thus, climate change impacts air quality in urban areas and sometimes occur substantially.

Khujand city is the second largest and one of the most ancient cities of Tajikistan. Khujand is located in the north of the republic in a narrow canyon of the Fergana valley along the banks of the Syrdarya river within 40°18' N.L. and 69°38' E.L. The population is 150 thousand.

A feature of Khujand is the frequent occurrence of moderate and strong winds, which provide good conditions for air circulation thereby cleaning the environment from pollutants and promoting low level of concentration of pollutants in the atmospheric air, even though there are many industries and vehicles. For the period 1980-1995, the concentrations of polluting substances were relatively low.

Tursun-Zade city is located in western part of the Gissar valley within 38°32' N.L. and 68°30' E.L. The population is 38 thousand.

The Tajik aluminum plant is located in the north of the city. This industry is the basic source of atmospheric pollution of Tursun-Zade and surrounding areas. Main contaminants are fluoride compounds, sulphur dioxide, and carbon oxide. As well as the Tajik Aluminum Plant, other air pollution sources are vehicles, cotton-processing plants and a number of other enterprises. During 1980-1995 increased air pollution by carbon monoxide (up to 6.3 of maximum permissible concentrations in 1982), and sulphur dioxide (up to 5.6 maximum permissible concentrations in 1981) was recorded in the city. Dust in the atmospheric air was within 1 to 4 maximum permissible concentrations. The concentration nitrous dioxide was normal.

Kurgan-Tube city is located in Southern Tajikistan in the valley of the Vakhsh River, between 37°52' N.L. and 68°53' E.L. The population is 60 thousand.

About 12 km east from Kurgan-Tube there is a Nitrogen fertilizer plant ("Azot"), which is the main source of air pollution by ammonia, nitrogen oxides and other pollutants. There are also a few large enterprises in the city.

The research on atmospheric air pollution has shown that Kurgan-Tube is the most polluted city of Tajikistan, where meteorological conditions (high air temperatures, small amount of precipitation, calm) promote stagnation of pollutants. The maximal concentration of dust in Kurgan-Tube during 1980-1995 has reached 6 maximum permissible concentration (1983), carbon monoxide - 6.7 maximum permissible concentration (1982), sulphur dioxide and nitrogen dioxide - 3.8 maximum permissible concentration (1983).

Sarband town is located in Southern Tajikistan in the valley of the Vakhsh River, between 37°53' N.L. and 68°56' E.L. The population is 11 thousand.

Sarband is a relatively small town and is located near (about 2 km) to a major source of atmospheric air pollution - the Nitrous fertilizer plant. However, it is prone to relatively small impact from industrial emissions due to good positioning regarding wind direction. During 1980-1995, high concentrations of pollutants were observed, including: dust (2.7 maximum permissible concentration in 1980), carbon monoxide (5.3 maximum permissible concentration in 1982), sulphur dioxide (4.8 maximum permissible concentration in 1983) and nitrogen dioxide (2.5 maximum permissible concentration in 1984).

Yavan town is located in Southern Tajikistan in an intermountain valley of the Yavansu River, between 38°19' N.L. and 69°03 E.L. The population is 18 thousand.

About 9 km west of the town there is Yavan electrochemical plant, which is the main source of atmospheric pollution in Yavan. For the period under review, increased concentrations of dust (4.7 maximum permissible concentration in 1982), and sulphur dioxide (5.6 maximum permissible concentration in 1981) have been observed. Concentrations of carbon oxide and nitrous dioxide were acceptable.

Kulyab city is located in Southern Tajikistan in the valley of the Yakhsu River, between of 37°55' N.L. and 69°47' E.L. The population is 77 thousand. Local relief and geographical positioning of the city promote a stagnation and accumulation of air pollutants and favor thermal stress, especially in the summer period.

Atmospheric air pollution here occurs due to emissions from industrial enterprises, vehicles and high dust content. During the period under review, increased concentration of dust (4.7 maximum permissible concentration in 1988) was observed. Concentrations of nitrous dioxide and sulphur dioxide were normal.

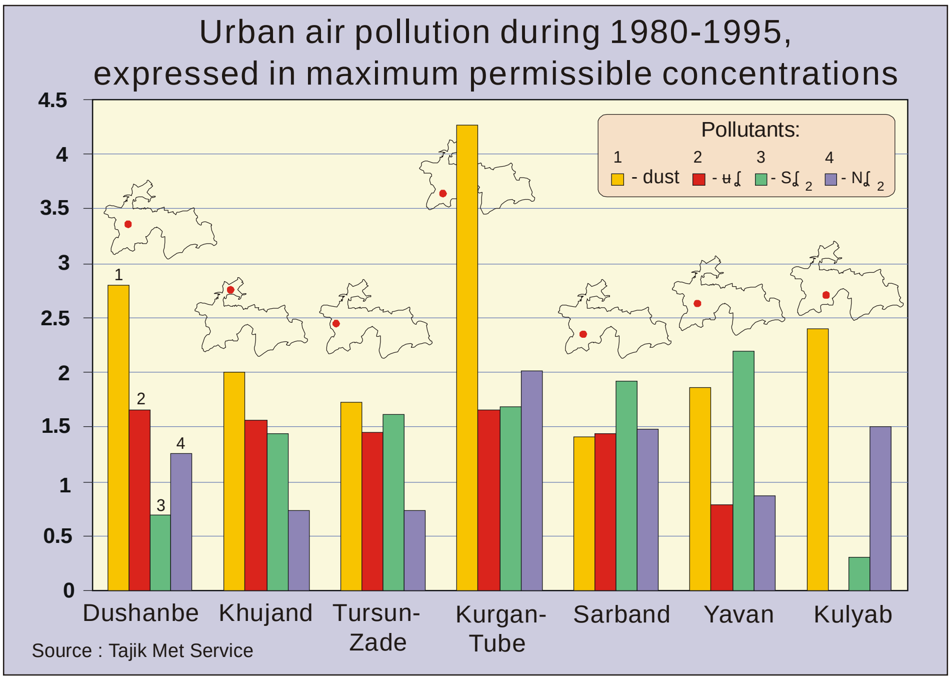


Fig. 4.20.

The vulnerability assessment shows that Dushanbe and Kurgan-Tube are the most vulnerable to atmospheric air pollution (fig. 4.20). The high level of pollution in these and other cities in many respects is caused by an influence of climatic factors: ground inversion, the lack of summer precipitation, calm, large intensity of solar radiation etc.

It is likely that human intervention (emissions from vehicles and industries, reduction of green areas) and climate change will increase atmospheric air pollution in many urbanized areas of Tajikistan.

4.13. Winter sports and recreation

Winter sports and recreation, particularly mountain skiing, are widely spread in the areas with long existing snow cover in Tajikistan. The basic mountain-skiing bases are Khoja-Obigarm, Takob, and Rogun and are located at an elevation of 1,500-2,700 masl. According to expert estimates, about ten middle and high-mountain plateaus have good prospects for the development of winter sports, including extreme ones (ski-extreme, alpine-ski).

Winter sports are important for strengthening public health. However, climate warming in combination with small snow stocks in mountains within mountain-skiing areas have adverse influence in terms of organization of sporting activities and contests, which is also caused by problems other then climate change.

Takob ski plateau. Photo by V. Minaev

During 1965-1980, climate conditions have favored the organizing of competitions on mountain-skiing plateaus in the period from October to June inclusively. Recently, the period of sport competitions has shortened due to climate change. The beginning of mountain-skiing season has shifted to the later dates of December-January and the end of the skiing period to the earlier date of May. The extent and thickness of snow cover on basic ski plateaus, according to expert judgments, has decreased by 0.5-1.5 meters.

Projected temperature rise in the winter season will be greater than the annual mean temperature increase. Thus, winter sports and recreation will be disadvantaged and the prospect for development of sport infrastructures and employment of local population will worsen.

4.14. Climate change adverse consequences

The territory of Tajikistan and its population are prone to the influence of various natural processes, which can sometimes lead to natural disasters. Out of many dangerous natural phenomena known in the world more than 20 events are registered in Tajikistan.

An irregularity of Tajikistan's landscape, active tectonic processes, advanced hydrological network, intense precipitation in characteristic areas, and arid climate are natural factors causing intensive development of geodynamic processes and the manifestation of disastrous phenomena such as landslides, landslips, snow avalanches, which promote an accumulation of disintegrated rock formations in river channels, and the occurrence of mudflows.

These phenomena annually cause significant damage to the national economy of the republic. During 1990-1995, 332 thousand hectares of agricultural crops were reseeded. Some 832 km irrigation canals, 195 km drainage system, 133 pump stations, and 332 hydraulic engineering designs were destroyed and seriously damaged. Natural disasters have been responsible for damaging as many as 376 industrial projects. The total damage upon the national economy of Tajikistan in the spring of 1998 amounted to 100 million somoni. The period from 2000 to 2001 was characterized by insufficient stream flow and drought that caused significant damage to many sectors of economy. Hailstone in 2002 seriously damaged the agricultural crops in Central Tajikistan.

Mudflows with high content of rocks and stones are most destructive. They carry out huge amount of fragmented rocks over a short period of time. Their speed can reach more than 5-10 m/sec. They can move big stone blocks weighting a few tonnes and thereby destroy many economic objects.

The territories with greatest mudflow activity are the basins of the Vakhsh, Obihingou, Kyzylsu, Pyanj and Zeravshan rivers; as many as 70-100 mudflows occur annually in these areas. The greatest mudflow activity can be observed in April (35% all mudflows) and in May (28% all mudflows). In the foothills and mid-mountains, mudflows occur in spring, whereas in the high-mountains they happen mainly in summertime. Intense precipitation is the dominant reason of mudflow occurrence (80%).

High air temperatures lead to rapid snow melting and ice thawing thereby creating conditions for formation of glacial-born mudflows. Sometimes mudflows happen as a result of a glacial lake outburst formed by surging glaciers. At the moment,

Snow avalanche in Central Pamir. Photo by A. Kayumov

there are 4 potentially dangerous situations in the Surkhob River basin, 6 situations in the Varzob River basin and a few in Western Pamir.

Thus, climate warming leads to the increase of a number of natural disasters that cause significant damage to many objects: arable lands become abandoned; settlements, roads, bridges, irrigation canals, hydraulic engineering designs, and other objects of national economy are being damaged or destroyed. The implementation of preventive and adaptive measures can reduce the negative consequences of natural disasters, and prevent damage in some cases.

It this regard the protection of the national economy from the adverse consequences of mudflows and floods along with preparedness to cope with droughts and other natural disasters will have a lot of economic, ecologic, demographic and social benefits.

5. Policy and Measures

5.1. Priorities of nature protection policy

The priorities of the state nature protection policy are determined in "The strategy of environmental protection and rational use of natural resources of the Republic of Tajikistan for the period till 2015". This strategy prioritizes the following key problems:

1. Soil degradation;
2. Pollution of water objects;
3. Pollution of atmospheric air;
4. Loss of biodiversity;
5. Waste management.

Considering the importance of global ecological problems and their relation to the state of the local environment, the republic participates in a number of international treaties, including:

- Vienna Convention for the protection of the ozone layer (ratified in 1996);
- Montreal Protocol on substances that deplete the ozone layer and London amendment (1997);
- The UN Convention on biological diversity (1997);
- The UN Convention to combat desertification (1997);
- The UN Framework Convention on climate change (1998);
- Ramsar Convention on wetlands of international importance especially as waterfowl habitat (2000);
- Bonn Convention for the protection of the migratory species of wild animals (2000);
- Aarhus Convention on access to information, public participation in decision-making and access to justice in environmental matters (2001).

5.2. Legislation

One of the basic mechanisms for reduction, inventory and control of greenhouse gas emissions is an adequate legislative base.

With the purpose to conserve natural resources and habitats, to rationally use and restore natural resources, to prevent adverse impacts of anthropogenic activities and to improve the quality of the environment, the Government of Tajikistan in 1994 adopted the Law "On nature protection". This law regulates the ecological requirements to businesses, including prevention of harmful emissions and discharges into the environment, monitoring and control over the use of natural resources and environmental protection.

According to provisions of this law, systematic observations of the climate, establishment and observance of specifications for maximum permissible emissions of harmful substances that affect the climate, and development of targeted ecological programs that provide emission reductions are necessary.

The following legislation that include the requirements to conduct the control over rationing and limitation of harmful emissions into the atmosphere have been developed:

- The law of the Republic of Tajikistan "On atmospheric air protection " (1996)
- The law of the Republic of Tajikistan "On energy industry" (2000)
- The law of the Republic of Tajikistan "On transport" (2000)
- The law of the Republic of Tajikistan "On ecological examination" (planned)

The government in 1993 authorized the definition of payment and its quantities for environmental pollution and waste disposal. If there is a case of harmful emissions and environmental pollution being over the limits, a fine of 10 times more than the normal charge is enforced.

Nevertheless, in sectoral legislation, the mechanisms of reduction and inventory of anthropogenic greenhouse gas emissions and removals have not been enforced. In this connection, it is required that legislation in relevant areas to be adapted to the requirements of the UN Framework Convention and other international environmental treaties and documents accepted by the republic.

5.3. Strategies and programs

In 1996, the Government accepted the State program on public awareness and ecological education of the population of the Republic of Tajikistan till 2000 and prospectively till 2010. The program is aimed at enhancing the level of education and knowledge of the population on environmental issues, including atmospheric air protection.

With the purpose of rational use of natural resources, including maintenance of optimum atmospheric air quality, the Government of the Republic of Tajikistan in 1997 accepted the State ecological program for the period 1998-2008.

In 2000, the Government accepted the National Action Plan on environmental hygiene aimed at, in addition to other measures, protection of the atmosphere from anthropogenic influence and protection of public health with regard to environmental quality.

In 2001, the Government accepted the National program of actions to combat desertification. The program provides a set of measures for the protection and improvement of the state of forests and land resources that will also promote enhancement of natural sinks of carbon in the aspect of climate change mitigation.

The National strategy for the protection of stratospheric ozone layer and phasing out ozone depleting substances has been developed. Some measures of the strategy are being implemented, including those on phasing out of CFCs, which have the potential to destroy the ozone layer and increase the greenhouse effect.

The Republic of Tajikistan joined the UN Framework Convention on Climate Change on January 7, 1998 and accepted its commitments, as the Party not included in Annex I of the Convention.

The National Action Plan for Climate Change Mitigation indicates the priorities and measures to be undertaken by the Republic of Tajikistan to address the problem of climate change, to develop a capacity for further research and analysis of the climate system, its variability and change, to strengthen the international cooperation and joined efforts to reduce greenhouse gas emissions and adapt to climate change. The measures indicated in the National Action Plan serve as a basis for planning and decision making at all state levels and in all relevant sectors.

5.4. Institutional structure

A specially authorized state entity for the rational use of natural resources and environmental protection in the republic is the Ministry for Nature Protection of the Republic of Tajikistan.

The following functions are assigned to the Ministry for Nature Protection:

- State management of nature protection activities in the republic;
- Development and realization of common scientific and technical policies on nature protection activities to be implemented by national ministries and departments;
- Control over the use and protection of lands, surface and ground waters, atmospheric air, flora and fauna, and common minerals;
- Development of long-term state programs on nature protection and rational use of natural resources.

The Ministry has in its structure the special inspectorate for atmospheric air protection, engaged by the control of stationary sources of harmful substance emissions, development of the specifications of maximum permissible emissions and control over the performance of air protection measures.

The departments of the Ministry for Nature Protection develop methodologies, instructions on environmental impact assessment, specifications of environmental quality, including atmospheric air. Also, ministerial departments are engaged in gathering, analysis, publication and dissemination of information about the state of the environment, including the volumes of harmful emissions into the atmosphere and air quality situation.

The ecological examination of the Ministry for Nature Protection is engaged in the validation of economic activities for conformity to nature protection legislation and requirements of environmental quality.

Local committees for nature protection within various regions of the republic, carry out the instructions of the Ministry for Nature Protection with regard to the control of atmospheric air pollution sources and other objects of anthropogenic influence on the environment.

The Main Administration on Hydrometeorology and Environmental Monitoring (Tajik Met Service), housed within the Ministry for Nature Protection of Tajikistan is a coordinating entity responsible for implementation of the UN Framework Convention on Climate Change in the Republic of Tajikistan.

The divisions of the Main Administration on Hydrometeorology carry out the following types of observation and environmental monitoring:

1. Meteorological;
2. Agrometeorological;
3. Upper air;
4. Actinometrical;
5. Hydrological;
6. Environmental pollution monitoring;
7. Special observations (glaciers, floods, avalanches, etc.)

In connection with joining the UN Framework Convention, the Main Administration on Hydrometeorology assumed the following commitments, in cooperation with other governmental institutions and research organizations:

- Research on, and projection of climate change;
- Compilation of national inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases;
- Gathering information about vulnerability assessment to climate change, revealing the indicators and consequences of climatic changes;

- Development and rating of the implementation of measures indicated in the National Action Plan for Climate Change Mitigation, including strategy on GHG emissions reduction and adaptation to climate change;
- Preparation and dissemination of information about the implementation of the UN Framework Convention in Tajikistan;
- International cooperation with UNFCCC Secretariat, Intergovernmental Panel on Climate Change and other appropriate organizations.

The director of Tajik Met Service is the National Focal Point on Climate Change and the chair of the Governmental Workgroup on Climate Change, which is an advisory body with representation from key governmental agencies and ministries related to climate change. The Governmental Workgroup has been established in 1999. Project Steering Committee includes representatives from governmental, academic and non-governmental organizations, and private sector. The roles of the Committee include planning, coordination and prioritizing of climate change activities, partnerships with stakeholders and public awareness. The structure of climate change coordination is shown in the figure 5.1.

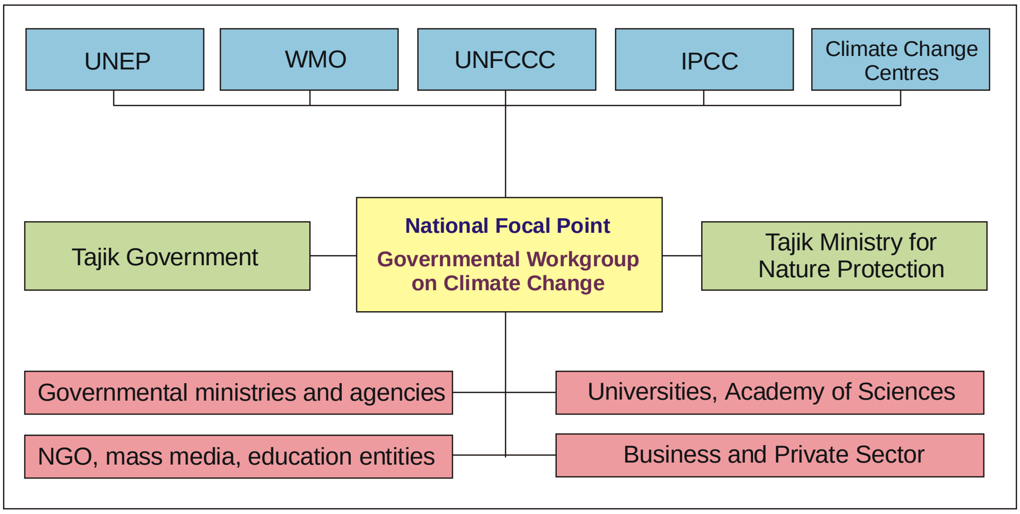


Fig. 5.1.

The list of ministries and departments that have a potential impact on the climatic system includes: Ministry of Energy, Ministry of Transport, Ministry of Industry, Ministry of Agriculture, State Committee on Land Resources, State Forest Authority etc. At present, the policies and measures in the relevant sectors do not consider the climate change problem thus requiring further integration of policies and responsibilities of the abovementioned ministries and departments for effective performance of the national obligations to the UN Framework Convention.

5.5. Rationing and control of emissions

There are about 80 different industries in Tajikistan consisting of more than 1,300 separate enterprises. There are also about 12 thousand agricultural farms, which altogether adversely affect the environment.

Rationing and control of emissions are the determining factors in reducing anthropogenic pressure on the state of the atmospheric air and climate.

The emission rationing mechanisms in the industrial sector are the sanctions of specially authorized entities on nature protection that are issued for a maximum period of 5 years. These sanctions consider the specifics of industrial processes, composition and intensity of emissions, climate peculiarities, as well as geographical and administrative positioning. Other mechanisms are the payments for certified emissions and the penalties for over permitted emissions. At present, some 900 enterprises have certificates for the maximum permissible emissions. However, it should be noted, that GHG emissions are not considered in all abovementioned certificates.

The inventory of emissions of harmful substances into the atmosphere is being conducted by administrations of enterprises, local committees for nature protection and special inspectorate for atmospheric air protection under the Ministry for Nature Protection of Tajikistan. At present, a regular inventory of GHG emissions from stationary pollution sources is not being conducted.

Motor vehicles are the main source of atmospheric air pollution, in particular carbon dioxide, carbon monoxide, nitrous oxides, NMVOC. Most vehicles that operate in the republic are generally old and use poor quality fuel that potentially increases the volume of harmful emissions. A small contribution into atmospheric air pollution from mobile sources in Tajikistan comes from railway transport and aviation.

On an individual level, the owners of motor vehicles carry out the rationing of harmful substance emissions in accordance with specified norms. On an institutional level, administrations of enterprises and nature protection entities implement the rationing of harmful substance emissions. The road police inspectorate, together with environmental protection authorities, carry out selective measuring of the contents of harmful substances in exhaust gases and give instructions for their adjustment. The inventory of harmful substance emissions from mobile sources is conducted on the basis of fuel use. However, a regular inventory of GHG emissions from mobile sources has not been compiled to date.

Oil and gas pipelines are the sources of methane emissions, which occur due to technological imperfections and failures. However, at present, they are not considered by nature protection entities as the sources of atmospheric air pollution.

In the countryside, the sources of atmospheric air pollution are: cattle breeding and poultry, agricultural engineering, application of mineral fertilizers, etc. Emission rationing at agricultural enterprises is practically non-existent, in spite of the significant contribution of agriculture into the total national methane and nitrous oxide emissions.

The Tajik State Forest Authority manages the forest fund of the republic. However, the inventory of GHG emissions from forest fires and burning of biomass has not been conducted.

The Ministry for Nature Protection keeps an account of the formation of solid communal wastes, industrial wastes and wastewater. Nevertheless, the volume of GHG emissions is not considered within the scope of responsibility.

5.6. Environmental impact assessment and ecological examination

The Environmental Impact Assessment (EIA) and ecological examination are the integral elements of planning and realization of all kinds of economic activities, which could directly or indirectly affect the state of natural resources and public health.

The EIA is being conducted by competent institutions and/or by research groups, which have necessary experience in this area and confirmed scientific qualification. The participation of the public in discussion of the EIA results is an important planning process element.

The ecological examination assesses the scientific validity and conformity of planned economic activity to the requirements of environmental quality specifications and nature protection legislation.

The basis for ecological examination is "The Provision on State ecological examination in the Republic of Tajikistan" (1994) that has been developed according to the Law "On nature protection". The conclusion of state ecological examination is obligatory for implementation.

State ecological examination:

- Analyzes and estimates a degree of complex influence of planned activity on the state of the environment and public health;
- Defines completeness, integrated approach and efficiency of provided measures on prevention of emergencies and liquidation of their consequences;
- Rates the expediency and opportunity of conducting a planned economic activity in respect with ecological properties of considered territory;
- Analyzes a social-ecologic public opinion on planned economic activity;
- Prepares objective, scientifically-proved conclusions of ecological examination, timely transfer to relevant institutions that make decisions on implementing the object of the examination and informing interested persons and parties.

The ecological examination, among other issues, takes into account:

- The basic sources of atmospheric air pollution;
- Quality of atmospheric air and climatic parameters;
- Possible damage resulting from planned activity;
- The factors of reduction in the population's quality of life;
- Impacts on the climate and atmospheric air quality, including volume of emissions, concentration of polluting substances, their influence on ecosystems with regard to the distance from the source of emissions;

"The Provision on State ecological examination" defines the objects that subject to ecological examination in the Republic of Tajikistan. Thus, the EIA and state ecological examination are important tools for control and reduction of GHG emissions and mitigation of anthropogenic pressures on ecosystems.

5.7. Priorities in climate change mitigation policy and measures

Climate change mitigation requires complex approach, which involves a set of measures on reduction of greenhouse gas emissions and adaptation to climate change. These measures are targeted at climate change mitigation given that implementation costs are covered by further economic, social and ecological benefits and promote sustainable development.

Reduction of GHG emissions. For the fulfillment of obligations to the UNFCCC (articles 4 and 12 UNFCCC) Tajikistan's National Action Plan includes the following directions of measures on GHG emission reduction and enhancing of carbon natural sinks:

- Enhancement of energy efficiency in relevant sectors of the national economy;

- Application of effective technologies and use of energy sources in the national economy that promotes high rates of economical growth and reduce or limit greenhouse gas emissions;
- Protection and enhancement of natural sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forest management practices, afforestation and reforestation;
- Promotion of sustainable forms of agriculture in the light of climate change considerations;
- Research on, promotion, development and increase used of, new and renewable energies, advanced, innovative, and environmentally sound technologies;
- Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures, which limit or reduce emissions of greenhouse gases.

Response measures are targeted at different levels of implementation and involve all relevant sectors: energy, industry, transport, agriculture, forestry and wastes. Accession to the Kyoto Protocol to the UNFCCC in the perspective is a key factor and necessary condition for successful implementation of national commitments and participation in Clean Development Mechanism of the Kyoto Protocol.

Adaptation. Scientific data confirms, that at present, development and implementation of only measures on greenhouse gas emissions reduction is not sufficient for the prevention of dangerous anthropogenic impacts on the climate system.

Considering Tajikistan's circumstances, adaptation to climate change is as important task in solving climate change problem as reduction of GHG emissions.

The results of vulnerability assessment of natural resources, national economy and public health to climate change confirm that influence of climate factors sometimes is very high, and appropriate adaptation measures could decrease or prevent severe effects of climate change and ensure common preparedness.

The present stage of adaptation strategy includes primary possible adaptation measures, which might be implemented in order to cope with climate change effects and support the sustainable development of the republic.

Important directions of NAP measures on adaptation to climate change include:

- In-depth research on climate change, its impacts on natural resources, national economy, public health and development of specific adaptation measures;
- Improvement of the systematic observation networks and environmental monitoring to revise and renew adaptation measures;
- Improvement of the system of data collection, interpretation and dissemination;
- Enhancement of weather forecasting, climate modeling and early warning systems for minimization of natural disasters risk and preparedness to extreme phenomena;
- Capacity building to strengthen institutional, technical and human resources to promote adaptation and research in fields of climate and hydrological investigations, geographical information systems, environmental impact assessment, protection and re-cultivation of lands, rational use of water resources, conservation of ecosystems, sustainable agriculture, infrastructure development and health protection;
- Implementation of actual projects on adaptation to climate change in priority areas related to rational use of natural resources, development of national economy and health protection.

5.8. GHG abatement options as per sectors

Energy sector. According to expert estimates, energy consumption in Tajikistan will increase by the year 2015 compared to current levels. The trends of greenhouse gas emissions in the energy sector will depend on the comprehensiveness of measures on energy efficiency improvement and GHG emission reduction. There is a large potential for GHG emission reduction in Tajikistan's energy sector, which is estimated as much as 30-60% in comparison with baseline scenario.

The following abatement options in the energy sector can be implemented:

Oil and gas systems:
- Modernization of petroleum storage facilities;
- Modernization of flare facilities;
- Replacement out-of-date gas distributing equipment.

Energy production and use:
- Putting into operation of large hydropower plants, which are currently under projection and/or construction;
- Introduction of small hydropower plants and utilization of renewable energies;
- Improvement of electricity supply and heating networks efficiencies.

Industry and agriculture:
- Use of effective electric motors, mechanisms and drives in all industries;
- Improvement of drying systems in textile industry;
- Improvement of furnaces in metal smelting, with introduction of "know-how" technologies;
- Utilization of heat from clinker production in cement industry;
- Increasing efficiency of irrigation systems, reduction of energy consumption by water pumps and agricultural equipment.

Residential sector:
- Introduction of progressive thermo insulation of households;
- New approach in planning, design and construction of residential and commercial buildings, with increased application of high-tech materials for walls, roofs, windows etc;
- Transition to efficient lighting equipment, in particular luminescent lamps, halogen infrared lamps, automatic systems of street illumination, etc;
- Improvement of heating systems, enhancing conditioning and optimizing the microclimate of residential and commercial buildings;
- Installation of gas consumption monitoring systems.

Transport:
- Optimization of roads, cargo and passenger traffic circuits;
- Introduction of technologies to improve fuel quality in road transport sector aimed at reducing harmful emissions;
- Encouragement of use of low fuel consumption motor vehicles;
- Switching of public transport to alternative fuels, in particular liquefied gas;
- Electrification of railway and development of urban electrified transport;
- Development of alternative transport, including bicycles;
- CO_2 emission reduction amongst light vehicles, which are most popular in the republic, to a level of 120-150 gram CO_2/km;
- Expansion of exhaust emission rationing tools and mechanisms.

It should be noted that potential of renewable energies in Tajikistan is very high. Use of renewable energies would help to solve many environmental problems, including GHG emissions abatement, prevention of forest cuttings, waste utilization etc.

Solar energy. Due to its geographical positioning, Tajikistan is one of the most appropriate regions for applying solar energy. There are 280-330 sunny days a year. The intensity of total solar radiation varies within a year from 280 to 925 MJ/sq.m in piedmont regions, and from 360 to 1120 MJ/sq.m in highlands. According to expert estimates, a typical solar station in Tajikistan's conditions can potentially avoid 0.30-0.35 tonnes of CO_2 a year. Utilization of solar energy available in Tajikistan could satisfy national energy demands by 10-20%.

Wind energy. Mean annual wind speed in Tajikistan varies from 0.8m/sec to 6.0 m/sec at 10 meters above ground. Wind direction and speed greatly depends on the atmospheric circulation and peculiarities of the landscape. The strongest winds blow in highland areas (Fedchenko, Anzob etc) and in the areas where landscape favor to convergence of air flows (Khujand, Fayzabad etc). Mean annual wind speed in these areas reaches 5-6 m/sec. In the open lowlands and wide valleys wind speed reaches 3-4 m/sec. In the locked lowlands mean annual wind speed does not exceed 1-2 m/sec. Although hydropower prevails, application of wind power as a supplementary source of energy is justifiable in certain regions of Tajikistan.

Biogas. Agricultural wastes are potential energy sources. The most promising option of biomass utilization in Tajikistan's conditions is biogas generation by means of anaerobic fermentation of manure. Now, a few experimental biogas generators operate in Tajikistan. In addition, there is the potential opportunity to produce energy by thermo-chemical method of biomass conversion using cotton residues.

Hydropower. Potential hydropower resources of Tajikistan are estimated at around 527 billion kWh a year (not including small rivers). At present, only 5% of this potential is being used. Hydropower plants produce more than 95% of all electricity in Tajikistan (about 15 billion kWh a year). For Tajikistan, in the context of climate change mitigation, small hydropower engineering represents the greatest interest. Opportunities for developing such are available in most of the mountain regions, in particular Central Tajikistan and the Pamirs. Development of small hydropower engineering is an important factor for the improvement of socio-economic conditions and the prevention of forest cuttings, thus reducing wood fuel use for meeting energy demands. Now, there are 20 small hydropower plants in operation. Present generating costs for hydropower are the lowest in comparison with other renewable energies.

Industrial sector. The industrial sector of Tajikistan is responsible for the emissions of such gases as carbon dioxide, perfluorocarbons, sulphur dioxide and others that have a direct and indirect impact on the climatic system and environment. Aluminum smelting contributes the greatest portion of industry-related emissions. In general, the industry is responsible for 20-30% of the national total emissions.

According to expert estimates, CO_2 emissions in the industrial sector will increase up to 1.6 millions tonnes by the year 2015. Perfluorocarbon emissions will considerably increase in aluminum industry if response measures are not undertaken.

The emissions of perfluorocarbons from aluminum smelting greatly contribute to the effect of global warming. The gas CF_4 affects global warming by 6,500 times more than the main anthropogenic greenhouse gas CO_2. Aluminum smelting surpasses in emissions of CO_2-equivalent such sectors as transport, chemical industry etc. Therefore, the reduction of emissions from aluminum smelting is of high priority for climate change mitigation. The reconstruction of gas purification facilities at Tajik Aluminum Plant and computerization of technology are required. The researches on non-carbon anodes are very promising; it will allow avoiding of PFC emissions.

At the "Tajik Cement" enterprise, the transition from "wet" method of cement production to "dry" method in needed. It will save 30% of energy resources and reduce CO_2 emissions. Rehabilitation of gas purification facilities and dust filters are required.

At the "Azot" enterprise (Nitrogen fertilizer plant), utilization of CO_2 that occurs in the process of ammonia production for further use in food and drink industry is possible. Other technological options (incl. converted gas) are under consideration.

Agricultural sector. Methane emissions in agriculture occur as a result of enteric fermentation of agricultural animals, anaerobic decomposition of manure, rice cultivation on irrigated fields, and burning agricultural residues. Nitrous oxide emissions come from agricultural soils as a result of application of organic and mineral fertilizers.

According to baseline scenario, projected increase of the number of cattle and poultry, as well as expansion of rice cultivation on irrigated fields will increase methane emissions to 125% between the present time and 2015. The nitrous oxide emissions will increase 1.7 times in comparison with 1998 levels. The total GHG emissions in CO_2-equivalent in agriculture will reach 3.2 million tonnes or 139% of 1998 levels.

Improvement of agricultural practices in the cattle breeding industry, rational feeding and regulation of the number of animals will promote reducing methane emissions. Use of agricultural biomass for energy generation through the recuperation of methane from manure is very promising option for many rural areas of Tajikistan. The reduction of methane emissions from rice cultivation is possible through the introduction of progressive transplanting method. According to expert estimates, the potential for methane emissions reduction in agricultural sector of Tajikistan makes 10-30%.

The reduction of nitrous oxide emissions requires the improvement of methods of mineral and organic fertilizers application. The options for nitrous oxide emissions reduction include: application of nitrification inhibitors for cotton crops, application of fertilizers by band method, localization of fertilizers in soil etc.

Land use change and forestry. Recently, the reduction of CO_2 removal by soils has been caused by the overall deterioration of land resources and the loss of humus. Deforestation, mainly forest cutting, has become the basic reason for the reduction of annual biomass growth and, consequently, a smaller volume of CO_2 accumulation. In the late 1990s, the volume of carbon accumulation by forests decreased by 35% in comparison with that in 1990.

The following measures in the sector of land use change and forestry can be implemented: combating erosion processes; introduction of tillage technology, which maximize the storage of carbon; prevention of illegal forest cuttings; increased reforestation and afforestation; planting of protective forests along the roads, agricultural fields and in urban areas; protection of forests from pests, diseases and fires; conversion of low-density tree plantations to normal compactness.

Waste. Solid waste disposal sites and wastewater treatment are the sources of methane emission into the atmosphere. The contribution of CH_4 emissions from these sources makes less than 10%. It is established that introduction of waste recycling (metal, paper, plastics etc.) in Dushanbe and Khujand cities can potentially reduce CH_4 emissions by 30-40% by 2015 and decrease primary energy consumption. In addition, there is possibility for generation of biogas from active silt at sewage disposal plants. Although the implementation costs of such measures are high, they will have many benefits for improving environmental conditions and enhancing urban sanitation.

6. Research and Systematic Observation

6.1. Research

The Tajik Met Service conducts observation of the climate system over 100 years. National academic institutions and universities explore the interactions between the economic development and the condition of natural resources. However, the problem of climate change has not been studied in details to date.

In the course of preparation of the First National Communication, experts firstly identified a position of Tajikistan concerning global climate change both in terms of anthropogenic pressures on the climate system and vulnerability to climate change. According to the results of the research, Tajikistan takes 100s place in the world on the volume of greenhouse gas emissions. Per capita GHG emissions in Tajikistan are the smallest compared to other Central Asian countries. Wide use of hydropower resources, low volume of industrial manufacturing and little number of vehicles do comparably low level of GHG emissions.

Based on climate records, a few analyses to detect climate change have been carried out by the Tajik Met Service. The general findings were that temperature records indicated warming trends, especially within urbanized areas, while rainfall data evidence not uniform variations, depending on geographical positioning of the regions.

It is established that extreme weather events and natural disasters annually cause significant damage to many sectors of the national economy including irrigation and hydropower engineering, agriculture and transport. The climate and climate-related factors have a direct impact on a status of public health, occurrence and spread of infectious, vector- and water-born diseases, labor conditions and thermal comfort.

There is strong evidence that climate change led to widespread retreat of most Tajikistan's glaciers and followed by runoff decrease in a few rivers. Expert studies confirmed that glacial cover of Tajikistan would reduce steadily provided that temperature will further rise and precipitation will decrease.

Climate change scenarios were elaborated in cooperation with Azerbaijan Climate Change Center. The climate features simulated by GCMs agree well at global scale. At the regional and local scales, however, the outputs from various GCMs differ significantly. The large range of values of meteorological variables produced by different GCMs make it unwise to use just one GCM to generate climate change scenarios for Tajikistan. Therefore, national experts adopted the approach of using a range of scenarios to assess the impact of climate change on economic activities and natural resources. It is useful to apply a regional climate model nested within a bigger global model. The regional model, which has a finer resolution, is able to incorporate smaller local weather features in mountain conditions of Tajikistan.

The reduction of uncertainties regarding the impacts of climate change on water resources, ecosystems, social systems, and public health is of great importance. Another actual research issue is the enhancing of knowledge about the mechanisms of glacier shearing movements under the impact of climatic and geodynamic factors. Research on the issues of carbon management and forest inventories using satellite photography and geographic information systems is necessary. Future studies in the health sector should apply computer-aided vulnerability models in areas where disease susceptibility is high. Research on mosquito control, predictive vector- and water-born diseases models and heat stress should be prompted as part of an adaptation strategy.

6.2. The rationale of systematic observation network

Long-term systematic observations at national and regional levels are crucial for the monitoring of climate and its changes. The decision in COP4 related to the strengthening of observational network and support for the Global Climate Observing System (GCOS) reiterated the need for long-term systematic observations.

The continuous monitoring of climate change and its impacts form the basis for scientific research for better understanding of the climate system, and mechanisms causing climate change. Study of climate system elements and their dynamics can promote the making of effective and proved economic, technical and social decisions. In this connection, the existing global climate observation networks, including GCOS, require improvement and further development.

The improvement of systematic observation is one of the priorities in research on the global climate system, indicators of climate changes and its adverse consequences. Hydrological and meteorological information is necessary for sustainable agriculture, definition of optimum harvesting dates, protection of crops from hailstones, designing buildings, bridges, roads, canals, ensuring the safety of cargo and passenger traffic, etc. Adequate monitoring and forecasting of severe hydrometeorological events reduce the scale of their adverse impacts and allow the prevention of damage.

6.3. Participation of Tajikistan in international observation networks

Tajikistan has two stations (tab. 6.1.) representing the Global Climate Observing System (GCOS). Tajikistan belongs to the Region II WMO (Asia). The WMO's World Weather Watch involves 10 national stations, including 2 stations that conduct upper air observations. A few national river gauges contribute to the operating of Aral HYCOS.

Table 6.1.

Information on GCOS Stations in Tajikistan

Station Index	Station Name	Latitude	Longitude	Elevation (masl)	Period of observation
38954	Khorog	37º 30'N	71º 30'E	2,077	Since 1898
38933	Kurgan-Tube	37º 49'N	68º 47'E	429	Since 1929

Source: Tajik Met Service

The data from 12 national climate stations, including 2 GCOS stations, are accessible to WMO members and world data centres through Global Telecommunication System. The most perceptive climate stations are Khujand, Khorog, Istravshan and others that conduct observations over 100 years. A few river gauging stations forward the data to the hydrometeorological centres of neighboring states and support the implementation of international and Aral Sea regional projects.

6.4. Operational status of observation network

At present, the hydrometeorological observation network of Tajikistan includes 58 hydrometeorological stations, and 126 hydrological, meteorological and agrometeorological gauges and environmental pollution monitoring points. However, the state of the network does not meet contemporary national and regional demands in hydrometeorological information. The national hydrometeorological service has not enough resources to maintain the network to be able to develop it or keep it in stable operation. Therefore, a number of stations and gauges have reduced or completely stopped environmental observation altogether. Such a situation can be negatively reflected on the quality of climatic information, weather and drainage forecasts etc.

Meteorological observation. Economic reasons have resulted in the reduction of the meteorological observation network, and have been reflected in the deterioration of equipment and quality of observation. For the period of 1991-2002, the activity and coverage of the meteorological observation network in comparison with the 1980s has decreased by 20%. Now, 11 stations out of 58 stations do not operate. The individual stations are temporarily closed because of the absence of specialists. Remote stations are temporarily closed because of financial impoverishment, including unique to the Central Asian region, the meteorological station at the Fedchenko Glacier (Academic Gorbunov). Automatic observation instruments are rarely used. The standard snow cover observations at meteorological stations are carried out in a small volume, and in Tajikistan's conditions, the available data on snow cover is obviously not enough.

Agricultural meteorological observation. Agrometeorological observation is needed to assess the growth, condition and productivity of agricultural crops, temperature and humidity of soils etc. For the last decade the number of stations that conduct agrometeorological observation has significantly reduced from 29 stations and 14 gauges to 21 stations and 8 gauges. The observations are limited on the phases of development of agricultural crops. Aerovisual inspections of pasture vegetation during the last 11 years have not been carried out. The lack of agrometeorological information has had negative effect on agricultural crop forecasts.

Upper air observation. Upper air observation is intended for study of meteorological parameters of the atmosphere at heights up to 30-40 km. Upper air information is used for drawing up of weather forecasts, service of aviation and other sectors. Upper air observation was earlier carried out at 3 stations (Khujand, Dushanbe and Khorog) in 4 standard terms. Since 1996, because of lack of supplies, failure of out-of-date radar-tracking equipment these observations have been terminated at all stations.

Hydrological observation. Hydrological data is needed for studying the hydrological cycle, conducting the state account of waters and water inventory, and the assessment of anthropogenic impacts on the water resources. About 50% of Central Asian water resources are formed in Tajikistan. Therefore, advanced monitoring and forecasting of stream flow is important.

Before, hydrological observation network consisted of 11 stations and 138 river gauges. Now, the number of river gauges and the volume of observation substantially reduced. Lately, there are 89 river gauges in Tajikistan. The average density of existing river gauges on 7 main river basins makes 0.8 gauges per 1,000 sq.km. Low density of river gauges is in the river basins of Syrdarya (0.04), Pyanj (0.33), and Vakhsh (0.52).

Out of 89 river gauges 53 gauges have automatic water level recorders and 46 river gauges measure water discharge. Out of 33 operational river gauges only 14 gauges transfer real-time data systematically. Poor computerization does not allow the prompt process of observational data for the composing of hydrological yearbooks and forecasts, including flood warnings etc.

Other types of observation include environmental pollution monitoring, studying of surface ozone, solar irradiation, glaciers, avalanches, floods, outburst risk on glacial lakes etc. Water quality monitoring covers 21 rivers. Air pollution levels are monitored in 2 cities.

6.5. International cooperation

Tajikistan participates in the regional project on the improvement of water management and hydrological observations in the Aral Sea basin. Within the frames of GEF Aral Sea project, there have been rehabilitated and reequipped 6 river gauging stations that have transboundary value.

Swiss Aral Sea Mission helps to develop the methods of hydrological forecasting and computerized data processing. National hydrologists have attended a series of training courses on this issue. Swiss Government will support establishment and operation of the regional hydrological center in Dushanbe.

Britain Government has given a set of computers with CLICOM software for climate data processing in the frames of WMO's Voluntary Cooperation Programme. LARST low resolution PC station has been granted by Swiss Government. The station demonstrated good practical values and need to be upgraded to higher resolution.

Asian Development Bank (ADB) has assisted in joint development of special hydrological software and database "Hydromet DB", which will facilitate hydrological data processing and statistics compiling. A set of PCs has been granted by ADB for operation of this software and database. The initial study on the linkages between the climatic factors and flood formation has been carried out in the frames of ADB project.

In 2002, six experimental automatic weather stations have been installed in various climatic regions of Tajikistan (high altitudes, cold, temperate and hot areas) with the purpose to assess the efficiency of automatic weather observations in Tajikistan and further increase the automatic observation network. These stations have been granted by USAID in the frames of Central Asian natural resources management project.

The research on climate change and preparation of the First National Communication has been carried out with support from GEF. It was possible to prepare an electronic set of environmental observation data and analyze factual and expected climate changes. The inventories of GHG emissions and vulnerability assessment have been conducted as well.

The experts from Russian Hydrometeorological Service have conducted the trainings on the use of CLICOM software, courses of the improvement of qualification for weather forecasters. The young national specialists are studying at meteorological high schools of Russia.

7. Education and Public Awareness

7.1. System of education and access to knowledge

The education system of Tajikistan includes preschool and out of school educational entities, primary and secondary schools, colleges, universities, postgraduate education centers (improvement of professional skills), and doctorate studies.

"State program on ecological education and public awareness in the Republic of Tajikistan" was launched in 1996. This program is aimed at enhancing ecological education, raising public awareness on environmental matters, including protection of the climate and atmospheric air.

In the school and high school curriculum, a course on geography and ecology is provided. National universities in conjunction with the Tajik Met Service give specialized courses such as meteorology, agricultural meteorology, hydrology, glaciology etc. However, the problem of climate change and anthropogenic pressures on the climate system has not been considered in curriculum to date. Recently, local teachers have been provided with climate change information kits. Development of educational and information materials, retraining of professional staff, and conducting of workshops for teaching staff at schools and universities on climate change problem is of high priority.

7.2. Mass media

Mass media is the major factor in raising public awareness about the state of the environment and creation of ecological vision among the population.

Press, radio and TV are the basic mass media in Tajikistan. More than 250 printed editions are registered in the republic, including 20 countrywide editions. A few editions deal with environmental matters including the ecological bulletin of the Ministry for Nature Protection, the newspaper "Navruzi Vatan" etc.

On the radio, climate change issues started to be reflected with the beginning of preparation of the First National Communication. The leading experts and scientists of the republic were interviewed on radio on emerging subjects.

Public awareness assessment shows that television is the basic source of ecological information. There are TV programs "We and Nature", "Animal World", children's competitions on subjects about nature.

Nevertheless, in the electronic media, the issues of climate change and other environmental concerns do not generally receive much attention and coverage. Fewer still have knowledge about the initiatives being taken at the national and international levels to improve the environment. Thus, the population is insufficiently informed on the problem of climate change. Further development of easy to understand audio-video materials for broadcasting by electronic medias is needed.

7.3. Internet

Access to the Internet in the republic is limited. There are about 2,000 Internet users in Tajikistan. The limited number of Internet users is caused by technical difficulties and high costs. Although, the tendency of growth in the number of Internet users and local providers is obvious.

The distribution of environmental information, including climate change, using Internet resources is a major element in providing access for the global community to information about Tajikistan's circumstances with regard to global warming.

For the first time, the electronic version of the report about the state of the environment in Tajikistan was launched on the Internet in 1998. In cooperation with leading international organizations a few comprehensive information products, which cover climate change issues, were prepared and stored in the World Wide Web:

- The electronic version of the report "Vital maps and graphics on the environment and climate change in the Republic of Tajikistan" to support the process of preparation of the National Action Plan for Climate Change Mitigation (http://www.grida.no/enrin/htmls/tadjik/vitalgraphics/eng/index.htm);
- The electronic version of the report "The state of the environment in the Republic of Tajikistan in 2000" includes information on the state of climate, water and land resources, biodiversity, ozone layer, anthropogenic pressures and response measures (http://www.grida.no/enrin/htmls/tadjik/soe2/eng/);
- Ecological information about Dushanbe, including climate change, atmospheric air quality (http://www.ceroi.net/reports/dushanbe/eng/index.htm).

7.4. NGO activities

Environmental non-governmental organizations play an important role in the formation of public opinion, and ecological education, and have certain potential in solving ecological problems, mainly at a local level.

At present, there are about 40 ecological NGOs in Tajikistan. Some of them are engaged in environmental education and public awareness; another NGOs implement nature protection projects. The efforts of public organizations are targeted at the sustaining ecologically vulnerable territories, the improvement of the sanitation in urban areas, tree planting, the implementation of demonstration projects on renewable energies etc. In the course of preparation of the First National Communication a series of NGO's ecological actions on climate change were supported.

The acceptance by the republic of the Aarhus Convention on access to environmental information opens new prospects for the dialogue between governmental structures and public organizations. However, the problem of climate change has not received due attention in NGO activities. This requires non-governmental organizations to be more active in this environmental field.

7.5. Public participation in the process of NAP preparation

Awareness of climate change impacts and possible mitigation and adaptation solutions must be promoted amongst the public and decision-makers. The process of NAP preparation was inclusive with participation of the representatives from various governmental departments, scientific organizations and the general public. More than 100 qualified experts and scientists contributed to the preparation of the First National Communication. The results of climate change studies were broadly discussed at the national workshops with participation of a public and mass media. National professionals conducted a few meetings and round tables on climate change in the regions of Tajikistan. A series of public awareness assessments were conducted in the period from 2000 to 2002 to reveal specific needs of national provinces and to promote better understanding of climate change problem and mitigation options amongst local authorities and the general public.

8. Capacity building and technology needs

8.1. Problems and constrains

Constraints in the development of climate change scenarios are due to the lack of appropriate computer-aided models. The GCMs outputs do not agree well with real climate data because of local weather peculiarities and mountain conditions. Low level of confidence exists in precipitation scenarios. The projection of extreme weather events was impossible since no models or methods are available.

Constraints in the preparation of national GHG inventory are due to the lack of statistical data, unavailability of methodologies in local languages etc. The lack of local emission factors and insufficient knowledge of specific emission processes (e.g. agricultural soils, forest and soil carbon dynamics, waste dumps, aluminum production, etc.) led to significant potential uncertainties in a few sectors. The absence of reliable statistical data for some categories (e.g. use of HFCs, solvents) confined GHG inventory. Given national and regional specifics, the actual values for Tajikistan's emission factors could be very different from IPCC default values; this circumstance requires laboratory researches. The development of energy database is important to improve the comprehensiveness and accuracy of emission inventories in the "Energy" category. Similarly, in the "Land Use Change and Forestry" category there is a need to conduct precise forest inventory and estimate carbon stocks.

The development of GHG emission scenarios and options for their reduction are important elements of climate change mitigation policy. Some uncertainties in GHG emission scenarios still remain due to the lack of reliable macroeconomic and sectoral scenarios, inadequate access to the technological information, the lack of software etc.

The lack of appropriate methodologies and reliable data are the major constraints in the assessment of vulnerability to climate change. Expert's skills need to be improved. The lack of computer-aided vulnerability models complicates the performance of research tasks in a few sectors (fibrous materials, food production, water resources, health, etc.). National experts recommended further development and deepening of vulnerability studies in priority areas and elaboration of specific adaptation measures.

8.2. Capacity building

The development of highly skilled human resources, particularly in relation to climate modeling, GHG inventory compilation, uncertainty assessment, data quality control, and vulnerability assessment is required. Another important need is the enhancing of policy makers' ability to integrate climate change considerations into sectoral and territorial planning. Increasing public awareness is important for effective implementation of the National Action Plan for Climate Change Mitigation.

Climate modeling requires finer resolution of climate simulation. Also, the models and methods that project extreme weather events are needed. The research on glacier shearing movement should be prompted. It is important to introduce advanced computer-aided climate models and increase specialist's skills on use of those models.

Considerable efforts are still needed to reduce uncertainties in the national GHG emission inventory through in-depth studying of local emission factors, enhancing statistical reporting system, developing energy balance database, improving data quality, unification of units of measurement and coefficients. First, it concerns Energy and LUCF sectors, as well as transport, industry, agriculture etc. The UNDP-GEF regional project on the improvement of national inventories is promising to solve some of revealed problems.

The assessment of vulnerability to climate change requires further in-depth analysis of the risk of diseases occurrence and area of their distribution in the conditions of warmer climate change. It is important to identify linkages between climate change, desertification and biodiversity, and to integrate the results of research into national strategies. There is a need to conduct detailed assessment of vulnerability of water resources to climate change depending on scenarios of agricultural development. Vulnerability of hydropower engineering and transport sector should be further researched. The introduction of computer-aided vulnerability models is needed.

Skills in technology assessment must be developed to enable sectoral experts and decision-makers to identify, select and promote technologies that are feasible and meet the needs of both climate change considerations and socio-economic development. Training of specialists, especially in climate change mitigation options, cost assessment and developing GHG emissions scenarios are required. There is a need to access technological information and develop database on advanced technologies for GHG emissions reduction and adaptation to climate change.

For Tajikistan, the Clean Development Mechanism is one of the main sources of financial-technological assistance for GHG emission reduction and enhancing natural sinks of carbon. In light of this, the acceptance of the Kyoto Protocol and the creation of adequate national capacities are important. Appropriate legislation and rules that promote transfer of reduced volumes of emissions and building institutional capacity for registration and implementation of CDM projects are needed.

8.3. Technology needs

Technological needs of Tajikistan cover a wide range of issues from GHG emissions reduction to adaptation to climate change.

Technologies that promote energy efficiency need to be introduced in all sectors of Tajikistan's economy, particularly industry, agriculture and irrigation, transport and residential sectors. Oil and gas production and storage needs essential update of technologies with respect to environmental protection and minimization of accident risk. Technologies that abate GHG emissions and reduce intensity of harmful emissions (CO, NO_x, SO_2 etc.) should be prompted in manufacturing industry (e.g. aluminum, cement, ammonia) and road transport. The development of renewable energies is very promising option with regard to GHG emission reduction and substitution of wood fuel use.

The agriculture needs technologies that reduce adverse consequences of climate change and abate GHG emissions. The hydropower engineering sector needs technologies that reduce sedimentation processes and minimize the risk of disastrous floods and landslides. Research on, and technologies for landslide, mudflow and avalanche prevention are needed in transport sector.

LUCF sector requires technologies for the detection and quantification of land-based carbon stocks. Technologies that promote sustainable forest management practices, afforestation and reforestation are of the highest interest.

Appropriate technologies for solid communal waste recycling and recovery of methane are essentially needed. It will reduce GHG emissions, decrease primary energy consumption and improve ecological conditions and sanitation of urban areas.

ANNEXES

Annex 1.

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1990, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**19 294.5**	**1 528.0**	**153.6**	**3.8**	**0.7**	**70.3**	**429.6**	**45.5**	**34.7**
1.Energy	**17 729.5**		**48.9**	**0.1**		**70.2**	**247.1**	**43.0**	**34.0**
Î. Fuel combustion	17 729.5		6.3	0.1		70.2	247.1	43.0	34.0
1. Energy and transformation industry	57.5		0.0	0.0		0.0	0.0	0.0	IE
2. Manufacturing industries and construction	5 084.5		0.4	0.0		13.9	3.7	0.5	IE
3. Transport[1)]	4 185.1		0.6	0.0		43.5	201.6	37.8	IE
4. Other[2)]	8 402.3		5.3	0.0		12.8	41.8	4.7	IE
Ò. Fugitive emissions from fuels	NE		42.6	NE		NE	NE	NE	NE
1. Solid fuels	NE		4.8	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		37.8	NE		NE	NE	NE	NE
2. Industrial processes	**1 565.1**		**0.0**	**0.0**	**0.7**	**0.0**	**181.0**	**2.5**	**0.7**
Î. Mineral products	616.9		NO	NO	NO	NE	0.0	0.1	IE
Ö. Chemical industry	164.3		0.0	0.0	NO	0.0	0.9	0.5	IE
ţ. Metal production[3)]	783.9		0.0	NE	0.7	0.0	180.1	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	1.9	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**97.7**	**3.6**		**0.1**	**1.6**	**NE**	
Î. Enteric fermentation	NA		83.5	NO					
Ö. Manure management	NA		10.1	0.0					
ţ. Rice cultivation	NA		4.0	NO					
D. Agricultural soils	NA		NE	3.6					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	1.6	NE	
5. Land-use change and forestry	**0.0**	**1 528.0**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	587.8	NE	NE					
D. ţŞ$_2$ Emissions and removals in soils	IE	940.2	NO	NO					
6. Waste	**0.0**		**7.4**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.8	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.6	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4)]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4)]	92.9								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1991, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**22 568.1**	**1 217.2**	**176.5**	**2.9**	**0.6**	**83.0**	**398.7**	**47.4**	**40.2**
1.Energy	**21 235.3**		**69.5**	**0.1**		**82.9**	**244.2**	**42.0**	**39.5**
Î. Fuel combustion	21 235.3		6.5	0.1		82.9	244.2	42.0	39.5
1. Energy and transformation industry	58.2		0.0	0.0		0.2	0.0	0.0	IE
2. Manufacturing industries and construction	8 278.9		0.7	0.0		22.4	5.2	0.8	IE
3. Transport[1)]	4 910.6		0.6	0.0		49.5	199.4	36.9	IE
4. Other[2)]	7 987.5		5.3	0.0		10.9	39.6	4.3	IE
Ð. Fugitive emissions from fuels	NE		63.0	NE		NE	NE	NE	NE
1. Solid fuels	NE		3.1	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		59.9	NE		NE	NE	NE	NE
2. Industrial processes	**1 422.9**		**0.0**	**0.0**	**0.6**	**0.0**	**152.9**	**5.3**	**0.6**
Î. Mineral products	589.0		NO	NO	NO	0.0	0.0	0.1	IE
Ö. Chemical industry	165.0		0.0	0.0	NO	0.0	0.9	0.5	IE
ţ. Metal production[3)]	668.9		0.0	0.0	0.6	0.0	152.0	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	4.7	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**100.0**	**2.8**		**0.1**	**1.6**	**NE**	
Î. Enteric fermentation	NA		85.9	NO					
Ö. Manure management	NA		10.5	0.0					
ţ. Rice cultivation	NA		3.6	NO					
D. Agricultural soils	NA		NE	2.8					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	1.6	NE	
5. Land-use change and forestry	**0.0**	**1 217.2**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	581.9	NE	NE					
D. ţŞ2 Emissions and removals in soils	IE	635.3	NO	NO					
6. Waste	**0.0**		**7.3**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.8	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.5	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4)]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4)]	86.1								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1992, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**16 211.5**	**1 239.4**	**148.2**	**2.5**	**0.5**	**53.1**	**301.2**	**32.0**	**28.7**
1.Energy	**15 261.1**		**50.3**	**0.1**		**53.1**	**161.0**	**28.0**	**28.3**
Î. Fuel combustion	15 261.1		3.7	0.0		53.1	161.0	28.0	28.3
1. Energy and transformation industry	115.7		0.0	0.0		0.3	0.0	0.0	IE
2. Manufacturing industries and construction	5 321.8		0.4	0.0		14.4	3.2	0.5	IE
3. Transport[1]	3 039.5		0.4	0.0		30.2	134.9	25.0	IE
4. Other[2]	6784.0		2.9	0.0		8.1	22.8	2.5	IE
Ò. Fugitive emissions from fuels	NE		46.6	NE		NE	NE	NE	NE
1. Solid fuels	NE		2.2	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		44.5	NE		NE	NE	NE	NE
2. Industrial processes	**950.4**		**0.0**	**0.0**	**0.5**	**0.0**	**138.7**	**4.0**	**0.4**
Î. Mineral products	278.0		NO	NO	NO	NE	0.0	0.1	IE
Ò. Chemical industry	104.3		0.0	0.0	NO	0.0	0.5	0.3	IE
ţ. Metal production[3]	568.2		0.0	0.0	0.5	0.0	138.1	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	3.6	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**91.2**	**2.4**		**0.1**	**1.5**	**NE**	
Î. Enteric fermentation	NA		77.4	NO					
Ò. Manure management	NA		9.4	0.0					
ţ. Rice cultivation	NA		4.4	NO					
D. Agricultural soils	NA		NE	2.4					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	1.5	NE	
5. Land-use change and forestry	**0.0**	**1 239.4**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	545.6	NE	NE					
D. ţŞ$_2$ Emissions and removals in soils	IE	693.8	NO	NO					
6. Waste	**0.0**		**6.9**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.4	NO		NE	NE	NE	
Ò. Wastewater handling	NA		0.5	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4]	59.0								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding

NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan’s Summary Report for National Greenhouse Gas Inventories 1993, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**10 775.1**	**1 375.5**	**135.8**	**2.4**	**0.4**	**30.3**	**178.1**	**17.0**	**19.1**
1.Energy	**10 170.0**	**0.0**	**37.0**	**0.0**		**30.2**	**75.4**	**13.8**	**18.8**
Î. Fuel combustion	10170.0		1.0	0.0		30.2	75.4	13.8	18.8
1. Energy and transformation industry	1 180.0		0.0	0.0		3.2	0.4	0.1	IE
2. Manufacturing industries and construction	2.352		0.2	0.0		6.4	1.2	0.2	IE
3. Transport[1]	1 199.5		0.2	0.0		12.8	65.5	12.4	IE
4. Other[2]	5 437.9		0.6	0.0		8.0	8.3	1.1	IE
Ö. Fugitive emissions from fuels	NE		36.1	NE		NE	NE	NE	NE
1. Solid fuels	NE		1.7	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		34.3	NE		NE	NE	NE	NE
2. Industrial processes	**605.1**	**0.0**	**0.0**	**0.0**	**0.4**	**0.0**	**101.2**	**3.2**	**0.3**
Î. Mineral products	151.3		NO	NO	NO	NE	0.0	0.2	IE
Ö. Chemical industry	44.3		0.0	0.0	NO	0.0	0.2	0.1	IE
ţ. Metal production[3]	409.5		0.0	0.0	0.4	0.0	100.9	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	2.9	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**92.2**	**2.3**		**0.1**	**1.5**	**NE**	
Î. Enteric fermentation	NA		77.5	NO					
Ö. Manure management	NA		9.9	0.0					
ţ. Rice cultivation	NA		4.8	NO					
D. Agricultural soils	NA		NE	2.3					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	1.5	NE	
5. Land-use change and forestry	**0.0**	**1 375.5**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	490.6	NE	NE					
D. ţŞ$_2$ Emissions and removals in soils	IE	884.9	NO	NO					
6. Waste	**0.0**		**6.7**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.3	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.5	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4]	31.3								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding

NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1994, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**5 613.2**	**2 048.0**	**111.1**	**1.8**	**0.4**	**15.7**	**128.0**	**8.5**	**9.8**
1.Energy	**5 115.7**		**15.2**	**0.0**		**15.6**	**32.0**	**5.9**	**9.5**
Î. Fuel combustion	5 115.7		0.5	0.0		15.6	32.0	5.9	9.5
1. Energy and transformation industry	189.8		0.0	0.0		0.5	0.1	0.0	IE
2. Manufacturing industries and construction	1 003.5		0.1	0.0		2.7	0.6	0.1	IE
3. Transport[1)]	657.7		0.1	0.0		7.1	26.2	5.0	IE
4. Other[2)]	3 264.6		0.4	0.0		5.3	5.2	0.7	IE
Ô. Fugitive emissions from fuels	NE		14.7	NE		NE	NE	NE	NE
1. Solid fuels	NE		1.1	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		13.6	NE		NE	NE	NE	NE
2. Industrial processes	**497.5**		**0.0**	**0.0**	**0.4**	**0.0**	**94.7**	**2.6**	**0.3**
Î. Mineral products	104.3		NO	NO	NO		0.0	0.1	IE
Ô. Chemical industry	20.0		0.0	0.0	NO	0.0	0.1	0.1	IE
ţ. Metal production[3)]	373.3		0.0	0.0	0.4	0.0	94.6	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	2.5	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**89.5**	**1.8**		**0.0**	**1.3**	**NE**	
Î. Enteric fermentation	NA		74.4	NO					
Ô. Manure management	NA		9.9	0.0					
ţ. Rice cultivation	NA		5.2	NO					
D. Agricultural soils	NA		NE	1.8					
F. Field burning of agricultural residues	NA		0.1	0.0		0.0	1.3	NE	
5. Land-use change and forestry	**0.0**	**2 048.0**	**NE**	**NE**					
Ï. Changes in forest and other woody biomass stocks	0.0	446.6	NE	NE					
D. ţŞ2 Emissions and removals in soils	IE	1 601.4	NO	NO					
6. Waste	**0.0**		6.6	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.2	NO		NE	NE	NE	
Ô. Wastewater handling	NA		0.4	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4)]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4)]	20.3								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1995, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	3 646.2	1 657.1	102.6	1.5	0.4	8.8	112.9	6.6	6.3
1.Energy	**3 196.3**		**9.8**	**0.0**		**8.7**	**16.5**	**2.9**	**6.1**
Î. Fuel combustion	3 196.3		0.4	0.0		8.7	16.5	2.9	6.1
1. Energy and transformation industry	242.4		0.0	0.0		0.7	0.1	0.0	IE
2. Manufacturing industries and construction	253.2		0.0	0.0		0.7	0.2	0.0	IE
3. Transport[1]	328.1		0.0	0.0		3.7	12.4	2.3	IE
4. Other[2]	2 372.6		0.3	0.0		3.7	3.8	0.5	IE
Ð. Fugitive emissions from fuels	NE		9.4	NE		NE	NE	NE	NE
1. Solid fuels	NE		0.3	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		9.1	NE		NE	NE	NE	NE
2. Industrial processes	**449.0**		**0.0**	**0.0**	**0.4**	**0.0**	**95.0**	**3.7**	**0.2**
Î. Mineral products	55.7		NO	NO	NO	NE	0.0	0.0	IE
Ö. Chemical industry	33.0		0.0	0.0	NO	0.0	0.2	0.1	IE
ţ. Metal production[3]	361.3		0.0	0.0	0.4	0.0	94.8	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	3.6	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**86.5**	**1.5**		**0.0**	**1.4**	**NE**	
Î. Enteric fermentation	NA		71.3	NO					
Ö. Manure management	NA		9.9	0.0					
ţ. Rice cultivation	NA		5.2	NO					
D. Agricultural soils	NA		NE	1.4					
F. Field burning of agricultural residues	NA		0.1	0.0		0.0	1.4	NE	
5. Land-use change and forestry	**0.0**	**1 657.1**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	428.3	NE	NE					
D. ţȘ2 Emissions and removals in soils	IE	1 228.8	NO	NO					
6. Waste	**0.0**		**6.5**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.1	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.4	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4]	20.1								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding

NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1996, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**2 779.7**	**1 671.3**	**99.6**	**1.5**	**0.3**	**9.0**	**96.0**	**5.5**	**4.6**
1.Energy	**2 414.6**		**11.8**	**0.0**		**8.9**	**13.5**	**2.5**	**4.4**
Î. Fuel combustion	2 414.6		0.2	0.0		8.9	13.5	2.5	4.4
1. Energy and transformation industry	161.2		0.0	0.0		0.4	0.1	0.0	IE
2. Manufacturing industries and construction	538.6		0.0	0.0		1.4	0.3	0.0	IE
3. Transport[1]	429.8		0.0	0.0		4.7	10.4	2.0	IE
4. Other[2]	1 285.0		0.2	0.0		2.3	2.7	0.4	IE
Ŏ. Fugitive emissions from fuels	NE		11.6	NE		NE	NE	NE	NE
1. Solid fuels	NE		0.2	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		11.4	NE		NE	NE	NE	NE
2. Industrial processes	**365.1**		**0.0**	**0.0**	**0.3**	**0.0**	**79.5**	**3.0**	**0.2**
Î. Mineral products	30.5		NO	NO	NO	NE	0.0	0.0	IE
Ö. Chemical industry	27.8		0.0	0.0	NO	0.0	0.1	0.1	IE
ţ. Metal production[3]	306.9		0.0	0.0	0.3	0.0	79.3	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	2.0	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**81.4**	**1.4**		**0.1**	**3.0**	**NE**	
Î. Enteric fermentation	NA		67.2	NO					
Ö. Manure management	NA		9.3	0.0					
ţ. Rice cultivation	NA		4.8	NO					
D. Agricultural soils	NA		NE	1.4					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	3.0	NE	
5. Land-use change and forestry	**0.0**	**1 671.3**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	425.6	NE	NE					
D. ţŞ2 Emissions and removals in soils	IE	1 246.7	NO	NO					
6. Waste	**0.0**		**6.6**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.1	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.4	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4]	20.4								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1997, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**2 853.4**	**1 543.7**	**94.8**	**1.5**	**0.3**	**10.0**	**93.5**	**6.3**	**4.8**
1.Energy	**2 512**		**7.1**	**0.0**		**9.9**	**14.8**	**2.7**	**4.7**
Î. Fuel combustion	2 512.1		0.3	0.0		9.9	14.8	2.7	4.7
1. Energy and transformation industry	23.1		0.0	0.0		0.1	0.0	0.0	IE
2. Manufacturing industries and construction	477.2		0.0	0.0		1.3	0.3	0.0	IE
3. Transport[1)]	458.4		0.0	0.0		5.5	11.6	2.3	IE
4. Other[2)]	1 526.4		0.2	0.0		3.1	2.9	0.4	IE
ð. Fugitive emissions from fuels	NE		6.8	NE		NE	NE	NE	NE
1. Solid fuels	NE		0.2	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		6.6	NE		NE	NE	NE	NE
2. Industrial processes	**0.0**		**0.0**	**0.0**	**0.3**	**0.0**	**75.7**	**3.5**	**0.2**
Î. Mineral products	24.1		NO	NO	NO	NE	0.0	0.0	IE
Ö. Chemical industry	28.4		0.0	0.0	NO	0.0	0.1	0.1	IE
ţ. Metal production[3)]	288.8		0.0	0.0	0.3	0.0	75.5	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	3.4	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**79.5**	**1.4**		**0.1**	**3.0**	**NE**	
Î. Enteric fermentation	NA		65.4	NO					
Ö. Manure management	NA		9.1	0.0					
ţ. Rice cultivation	NA		4.8	NO					
D. Agricultural soils	NA		NE	1.4					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	3.0	NE	
5. Land-use change and forestry	**0.0**	**1 543.7**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	413.6	NE	NE					
D. ţŞ2 Emissions and removals in soils	IE	1130.1	NO	NO					
6. Waste	**0.0**		**6.6**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.1	NO		NE	NE	NE	
Ö. Wastewater handling	NA		0.4	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4)]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4)]	14.7								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Tajikistan's Summary Report for National Greenhouse Gas Inventories 1998, Gg

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	NO_x	CO	NMVOC	SO_2
Total national emissions and removals*	**1 867.3**	**1 486.9**	**90.1**	**1.7**	**0.3**	**9.2**	**95.6**	**6.8**	**2.8**
1.Energy	**1 524.4**		**2.6**	**0.0**		**9.1**	**14.3**	**2.7**	**2.7**
Î. Fuel combustion	1 524.4		0.1	0.0		9.1	14.3	2.7	2.7
1. Energy and transformation industry	0.8		0.0	0.0		0.0	0.0	0.0	IE
2. Manufacturing industries and construction	193.4		0.0	0.0		0.5	0.1	0.0	IE
3. Transport[1)]	533.4		0.0	0.0		6.2	12.2	2.4	IE
4. Other[2)]	796.9		0.1	0.0		2.4	2.0	0.4	IE
Ȍ. Fugitive emissions from fuels	NE		2.5	NE		NE	NE	NE	NE
1. Solid fuels	NE		0.2	NE		NE	NE	NE	NE
2. Oil and natural gas	NE		2.3	NE		NE	NE	NE	NE
2. Industrial processes	**342.8**		**0.0**	**0.0**	**0.3**	**0.0**	**78.4**	**4.0**	**0.2**
Î. Mineral products	13.6		NO	NO	NO	NE	0.0	0.0	IE
Ȍ. Chemical industry	32.0		0.0	0.0	NO	0.0	0.2	0.1	IE
ţ. Metal production[3)]	297.3		0.0	0.0	0.3	0.0	78.2	0.0	IE
D. Other production	0.0		0.0	0.0	NO	0.0	0.0	3.9	IE
3. Solvent and other product use	**NE**			**NE**				**NE**	
4. Agriculture	**0.0**		**80.9**	**1.7**		**0.1**	**2.9**	**NE**	
Î. Enteric fermentation	NA		65.0	NO					
Ȍ. Manure management	NA		9.3	0.0					
ţ. Rice cultivation	NA		6.4	NO					
D. Agricultural soils	NA		NE	1.7					
F. Field burning of agricultural residues	NA		0.1	0.0		0.1	2.9	NE	
5. Land-use change and forestry	**0.0**	**1 486.9**	**NE**	**NE**					
Î. Changes in forest and other woody biomass stocks	0.0	409.9	NE	NE					
D. ţŞ$_2$ Emissions and removals in soils	IE	1 076.9	NO	NO					
6. Waste	**0.0**		**6.6**	**NE**		**NE**	**NE**	**NE**	
Î. Solid waste disposal on land	NO		6.1	NO		NE	NE	NE	
Ȍ. Wastewater handling	NA		0.5	NE		NE	NE	NE	
7. Other (please specify)	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
Memo items[4)]:									
International bunkers	NE		NE	NE		NE	NE	NE	NE
Biomass burning[4)]	5.0								

1) Includes road transportation, railways and civil aviation
2) Includes commercial/institutional, residential, agricultural sectors
3) PFCs actual emissions based on Tier 2 Approach
4) Emissions are for information only and are not totaled
*) Sum of emissions does not very coincide with total national emissions due to rounding
NO - Not occurring
NA - Not applicable
NE - Not estimated
IE - Included elsewhere

Annex 2.

The list of contributing authors of the First National Communication of the Republic Tajikistan under UNFCCC

Editors:	
Karimov U. (Ph.D)	Institute of Mathematics of the Academy of Sciences
Kayumov A. (Ph.D)	Tajik State Medical University
Makhmadaliev B.	Tajik Met Service
Novikov V.	Tajik Met Service
Assistants:	
Azizova Z.	Tajik Met Service
Bravicheva I.	Tajik Met Service
Burukova O.	Tajik Met Service
Davlatov F.	Tajik Met Service
Khakimov B.	Tajik Met Service
Minikulov N. (Ph.D)	Institute of Astrophysics of the Academy of Sciences
GHG Inventory:	
Asoev N. (Ph.D)	Ministry of Agriculture
Bobritskaya L. (Ph.D)	Ministry for Nature Protection
Buzrukov J.	Ministry for Nature Protection
Gaibullaev H. (Ph.D)	State Statistical committee
Gulov A.	State Committee on Land Resources
Karimov U. (Ph.D)	Institute of Mathematics of the Academy of Sciences
Khairulloev R.	Ministry for Nature Protection
Khakdodov M. (Ph.D)	State Industrial Committee
Kirillova T.	State Industrial Committee
Kurbonov E.	State Industrial Committee
Kuropatkina N.	Hydro energy research institute
Leonidova N.	Hydro energy research institute
Norov K.	State Statistical committee
Petrov G. (Ph.D)	Ministry of Energy
Radjabova N.	State Statistical Committee
Rassolko V.	State Statistical Committee
Safaraliev G. (Ph.D)	Ministry of Agriculture
Safarov M.	Ministry of Agriculture
Svinina N.	State Statistical Committee
Ustyan I.	Tajik Forestry Committee
Varnavskaya E.	State Statistical Committee
Mitigation Analysis:	
Abdurasulov A. (Ph.D)	Physical-Technical Institute of the Academy of Sciences
Asoev N. (Ph.D)	Ministry of Agriculture
Azizov B. (Ph.D)	Tajik Technological University
Bobritskaya L. (Ph.D)	Ministry for Nature Protection
Buzrukov J.	Ministry for Nature Protection
Gaibullaeva Z. (Ph.D)	Tajik Technical University
Gaibullaev H. (Ph.D)	State Statistical Committee
Gulov A.	State Committee on Land Resources
Ikromova S.	Ministry of Economy and Trade

Kirillova T.	State Industrial Committee
Korneeva N.	Ministry of Economy and Trade
Juraev S.	Ministry for Nature Protection
Popova R.	Ministry of Energy
Radjabova N.	State Statistical Committee
Ustyan I.	Tajik Forestry Committee

V&A Assessment:

Abdumamadadov S.	Tajik Met Service
Abdusalyamov I. (Ph.D)	Institute of Zoology of the Academy of Sciences
Abdulloev A. (Ph.D)	Institute of Zoology of the Academy of Sciences
Ahrorov A. (Ph.D)	Ministry of Water Management
Alimov O. (Ph.D)	Institute of Astrophysics of the Academy of Sciences
Alikhanova T. (Ph.D)	Ministry of Economy and Trade
Asrorov I. (Ph.D)	Institute of Economy of the Academy of Sciences
Baidullaeva J.	Tajik Met Service
Bokova P.	Tajik Met Service
Darvoziev M. (Ph.D)	Tajik State National University
Dustov S. (Ph.D)	Ministry for Nature Protection
Finaev A. (Ph.D)	Institute of Water Problems of the Academy of Sciences
Issobaev M. (Ph.D)	Institute of Chemistry of the Academy of Sciences
Isufov U.	State Committee on Land Resources
Karimov B. (Ph.D)	Institute of Economy of the Academy of Sciences
Karimov U. (Ph.D)	Institute of Mathematics of the Academy of Sciences
Kayumov A.	Tajik State Medical University
Khakimov F. (Ph.D)	Tajik State National University
Khomidov A.	Tajik Met Service
Kodyrov M. (Ph.D)	Ministry of Transport
Madaminov A. (Ph.D)	Institute of Botany of the Academy of Sciences
Mahmadaliev B.	Dushanbe Committee for Nature Protection
Makievsky P.	Department of Geography and Ecology of the Academy of Sciences
Malysheva E.	Tajik Met Service
Mamaderov U.	Tajik Agrarian University
Mirzahonova N.	Tajik Met Service
Mirzahonov O.	Tajik Met Service
Muhabbatov H. (Ph.D)	Department of Geography and Ecology of the Academy of Sciences
Muhittddinov S.	Tajik Agrarian University
Murtazaev U. (Ph.D)	Ministry of Water Management
Najmuddin B. (Ph.D)	Committee of Afghan Refugees in Tajikistan
Niezov A. (Ph.D)	Tajik State National University
Novikova T.	Ministry of Transport
Popova L.	Tajik Met Service
Raufy A. (Ph.D)	Institute of Economy of the Academy of Sciences RT
Safarov M.	Tajik Met Service
Safarov N. (Ph.D)	Research Laboratory on Nature Protection
Saidova G.	Tajik Met Service
Sattorov M. (Ph.D)	Institute of Mathematics of the Academy of Sciences
Usupova N. (Ph.D)	Tajik Agrarian University
Yablokov A.	Tajik Met Service
Zakirova M.	Ministry of Finance