2008

THE SECOND NATIONAL COMMUNICATION OF THE REPUBLIC OF TAJIKISTAN UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE



The Government of the Republic of Tajikistan

The State Agency for Hydrometeorology
Committee for environmental protection under the Government
of the Republic of Tajikistan

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Dushanbe 2008

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The Second National Communication of the Republic of Tajikistan has been prepared in accordance with the UNFCCC Articles 4.1 and 12.1 on the basis of the Guidance for non-Annex 1 Convention Parties (2003).

The national institution responsible for preparation of the Second National Communication is the State Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan, in coordination with key ministries and agencies.

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Ministry of Agriculture of the Republic of Tajikistan
Ministry of Energy and Industry of the Republic of Tajikistan
Ministry of Transport and Communications of the Republic of Tajikistan
Ministry of Economic Development and Trade of the Republic of Tajikistan
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Committee for Environmental Protection of the Republic of Tajikistan
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INTRODUCTION

The Republic of Tajikistan acceded to the UN Framework Convention on Climate Change in 1998 and ratified the Kyoto Protocol on the 21st of October, 2008. In accordance with the UNFCCC commitments, the Republic of Tajikistan prepared its First National Communication (FNC) on climate change and Phase 2 of the FNC on capacity building in priority areas of economy in 2001-2002, and developed the National Action Plan for climate change mitigation, being a strategic document of the country on climate change issues.

The Second National Communication of the Republic of Tajikistan under the UN Framework Convention on Climate Change summarizes the up-to-date information on climate change issues in Tajikistan, the process of UNFCCC implementation, and presents the general and specific data on climate change. The major objective of this Communication is to inform the Convention Parties, as well as decision-makers, specialists and public at large of the most urgent issue of humanity climate change; the way it is reflected in Tajikistan, small mountainous country of Central Asia, the source of fresh water resources and valuable biodiversity for the whole region; as well as of its contribution to the cause of climate change and of the interventions undertaken to mitigate its adverse impacts.

Despite the fact that the Second National Communication is an original document, it should be viewed in the context of previous research on climate change. Moreover it is recommended to refer to the sources and reports of the working groups of experts which served as a basis for preparation of this Communication, and are available at the Centre on Climate Change Research of the State Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan.

The results of research conducted within the preparation framework of the Second National Communication revealed that a lot of priorities of the country on climate change mitigation are mainly related to the development of hydropower, adaptation measures for vulnerable communities and systems, research and climatic observations, being of local, regional and global importance.

The main chapters of the Second National Communication were discussed at the workshops and working meetings during 2005-2008, with participation of representatives from more than 15 ministries and agencies, public at large and international organizations. More than 50 experts, scientists and staff of different organizations and public associations participated in preparation of this document.

The editorial group of the Second National Communication expresses its gratitude to:

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CONTENTS

CONTENTS

INTRODUCTION

Global and regional context

The last decade appeared to be the warmest for the last 150 years at the global scale, and surface air temperature of our planet increased almost by 1°C (Fig. 1). According to evaluations made by the Intergovernmental Panel on Climate Change (IPCC), such change in climate occurred and might even intensify, mostly due to anthropogenic activities.

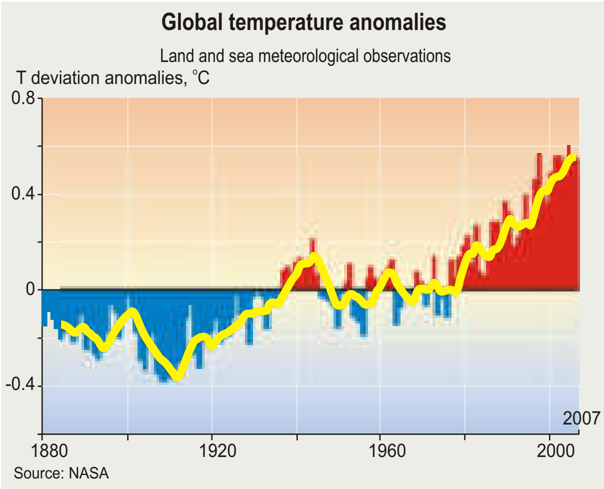


Fig. 1

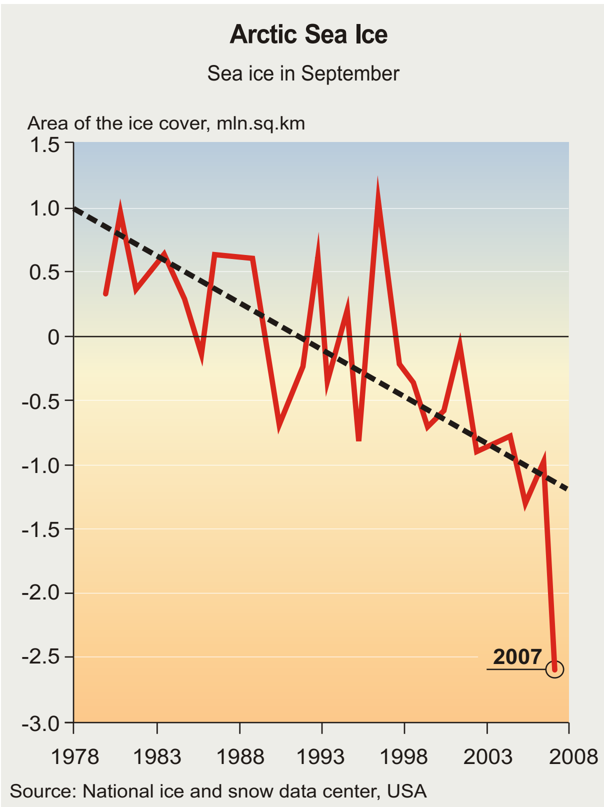


Fig. 2

There are a number of records that during last fifty years an anthropogenic impact on climate considerably increased, largely due to emissions of greenhouse gases (GHG) into atmosphere and deforestation. During the period of 1970-2004 global emissions of greenhouse gases increased by 70%, and concentration of CO_2, a major greenhouse gas, increased up to 380 ppm (in 19 century this number constituted 280 ppm). Ongoing increase of GHG emissions contributes into global warming.

Climate change has a considerable impact on the number of territories of our planet, i.e. the Arctic, the Antarctic and Central Asia. According to the data of satellite measurements, ice cover in the Antarctic Ocean has been constantly decreasing, and reached its minimum in 2005-2007 (Fig. 2). The similar trend is observed in other seas, situated closer to Tajikistan, within the Central Asian region. The decrease in freezing period and total reduction of winter ice cover is observed in the north of the Caspian Sea during the last decade (Fig. 3). Within the Aral Sea basin the local impact on microclimate is observed due to considerable drying of the sea, and global warming impact.

The trend towards increase of temperature is explicit in the neighboring Central Asian countries, e.g. in Uzbekistan and Kazakhstan (Fig. 4-5).

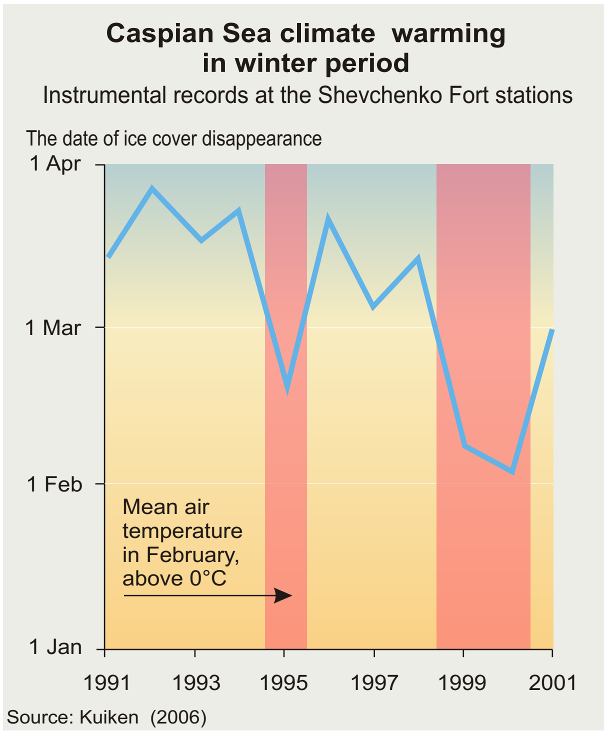


Fig. 3

The glaciers in the Central Asian mountains and in other regions of the world considerably reduced and are melting (Fig. 6-7). As a result there is a risk that climate change might induce shortage of water, adversely impact ecosystems, food security and health.

The interrelation of disaster frequency and scale with climate change trends was stressed at the Dushanbe International Water Forum in June 2008. Indeed more and more large-scale sudden floods, mud flows, droughts, pest outbreaks, fires, etc. are associated with the climate change impacts.

At the global level there are research programmes, political and technical interventions on climate change mitigation established and operational, however it is far from sufficient. All nations around the world and all people should come together to save the planet. Within the context of international negotiations in Poznan and Copenhagen Tajikistan is committed to contribute to the achievement of the UNFCCC goals and objectives.

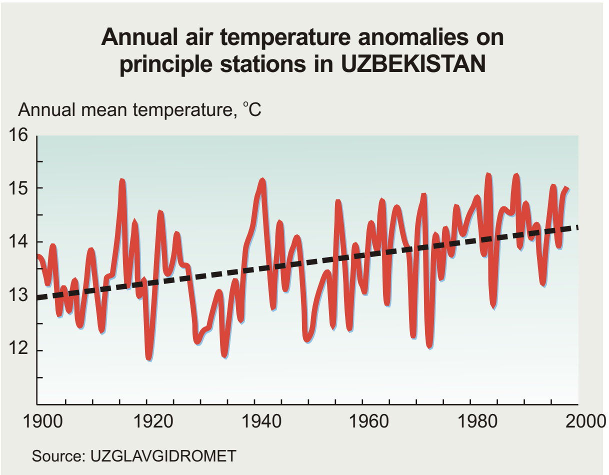
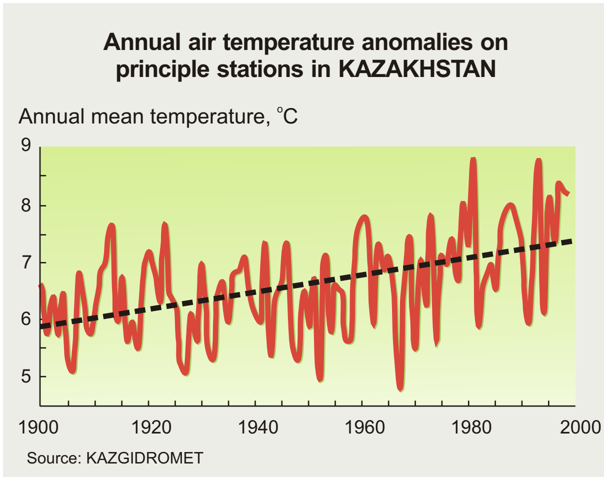


Fig. 4



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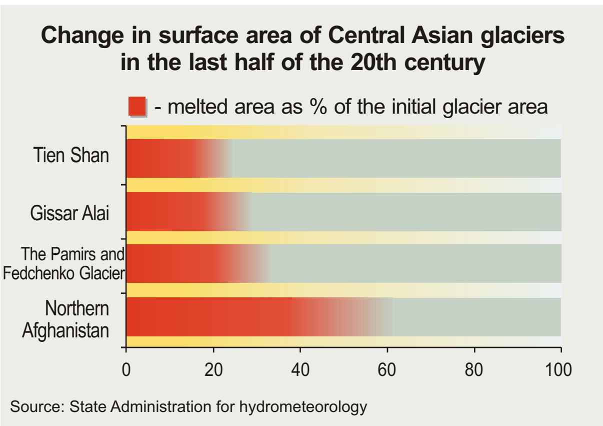


Fig. 6

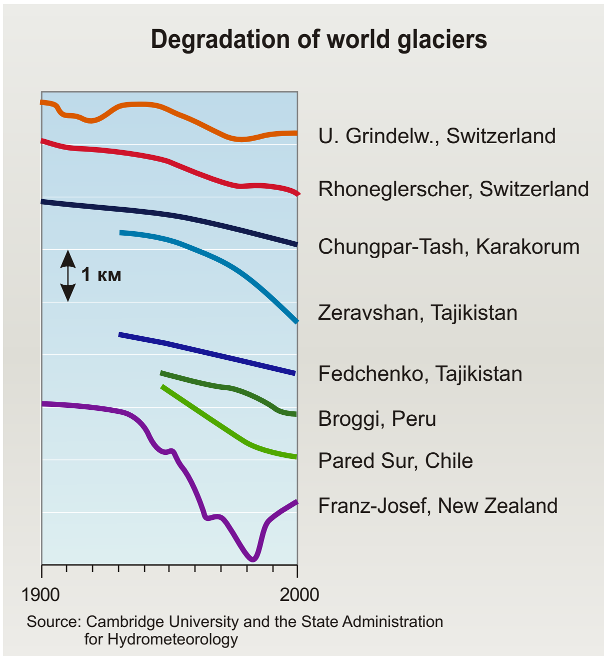


Fig. 7

1. NATIONAL CIRCUMSTANCES

1.1. Geographic profile

Tajikistan is situated in the mountainous part of Central Asia, between the latitudes 36°40'N-41°05'N and latitudes 67°31'E-75°14'E.The area of Tajikistan is 143.1 thousand sq. km, stretching for 700 km from the west to the east and for 350 km from the north to the south. In the north and west, Tajikistan borders with Uzbekistan and Kyrgyzstan, in the south it borders with Afghanistan and in the east - with China. The perimeter borders of the country extend to 3,000 km.

Mountains occupy about 93% of its terrain (Foto 1.1).; with about half of the territory situated at an altitude above 3,000 masl. The absolute heights vary from 300 to 7,495 masl. As for geography of Tajikistan, the 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, Gindukush and Tian Shan adjoining the territory of the republic. Such geographical position is favorable for the great diversity of environmental and climatic conditions.

The characteristics of the mountainous relief are quite peculiar. In the north lie the Ferghana valley and the Kuramin range, in the west the country is covered by low hills and irrigational plantations. The central region of the republic is occupied by the Kuhiston mountain ranges. To the east there is Pamir, the most severe and mountainous region of Tajikistan (the highest peak "Ismoil Somoni" is located at 7,495 masl).

Foto 1.1. Upper reaches of Varzob river.

The western Pamir includes high mountain ranges separated by deep river valleys. The valleys are located at elevations of 1.700-2.500 masl, while the mountain range elevates at the height of over 5.000-6.000 masl. Topography of the Eastern Pamir is rather smooth, despite its higher absolute elevation above the sea level. Due to severe climatic conditions, only high-mountain deserts prevail in the Eastern Pamir.

1.2. Climatic diversity

Aridity, abundance of heat and significant inter-annual variability of almost all climatic elements are the main predominant characteristic for Tajikistan's climate.

Climate in Tajikistan covers a wide range of air temperature, humidity conditions, precipitation and intensity of solar radiation. The annual mean temperature, depending on the elevation of the area, vary from +17°C and above in the south, to -6°C and lower in the Pamirs.

Extreme maximum is observed in July, while extreme minimum is evident in January. The Eastern Pamir is known for its drastic climate, where absolute minimum temperature can reach -63°C. In the south, on the contrary, maximum surface air temperature can exceed +47°C. Therefore, the diapason of extreme air temperatures can amount to 100°C. The annual precipitation in lowland hot deserts of the northern Tajikistan and cold mountain deserts of the eastern Pamir averages from 70 to 160 mm, while in central Tajikistan precipitation can exceed 1.800 mm a year.

Annual duration of 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 and southwest Tajikistan, Gissar and Zeravshan valleys.

1.3. Abundance and diversity of natural resources

1.3.1. Glaciers and water resources

Due to specific orography and climatic conditions, Tajikistan is considered the main glacial centre of

Central Asia. Glaciers are the wealth of Tajikistan, they are not only retaining water, but also regulating river flows and climate. Glaciers and permafrost are the main source of water replenishing the Aral Sea river basins. Every year the melting of snow and glaciers contribute several cub.km of fresh water to the main river basins of the country. Glaciers occupy more than 8.4 thousand sq.km, which is about 6% of the total country area. The bulk of ice cover is observed in the Pamir mountains (Fig. 1.1.).

The largest valley glacier of the region is the Fedchenko Glacier. Its length exceeds 70 km, width - 2 km, and maximum ice thickness - 1 km. The volume of glacier itself with tributaries is 140 cub.km. It originates on 6200 masl with its terminus stretching for 2910 masl. It is estimated that Tajikistan enumerates with 8 thousand of glaciers with 7 out of them having the length of 20 km.

Rivers of Tajikistan are the main sources of water replenishing the Aral Sea. They provide neighboring areas with water for irrigation and power generation.

There are several largest river basins in the republic: Syrdarya (Northern Tajikistan), Zeravshan (Central Tajikistan), Pyandj (South-Western Tajikistan and Pamir), closed basin of the lakes of the Eastern Pamir. The largest rivers are Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, Bartang. Most of the rivers in Tajikistan are of mountainous origin.

There are 947 rivers in Tajikistan with the length more 10 km. Total river length is 28,500 km. The annual surface runoff reaches 30-45 l/sec/sq.km in highlands, whilst in lowland deserts and high mountain regions it amounts to 1 l/sec/sq.km. The annual river flow is about 53 cub.km. Most of the water resources are formed in the basins of Pyandj and Vakhsh rivers. During flood season, when snow melts intensively and heavy rainfall occurs (April-August), the rivers carry a lot of suspended solids, which can exceed 5kg/cub.m (Amudarya and Kysylsu river).

The 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; it leads to the destruction of road facilities,

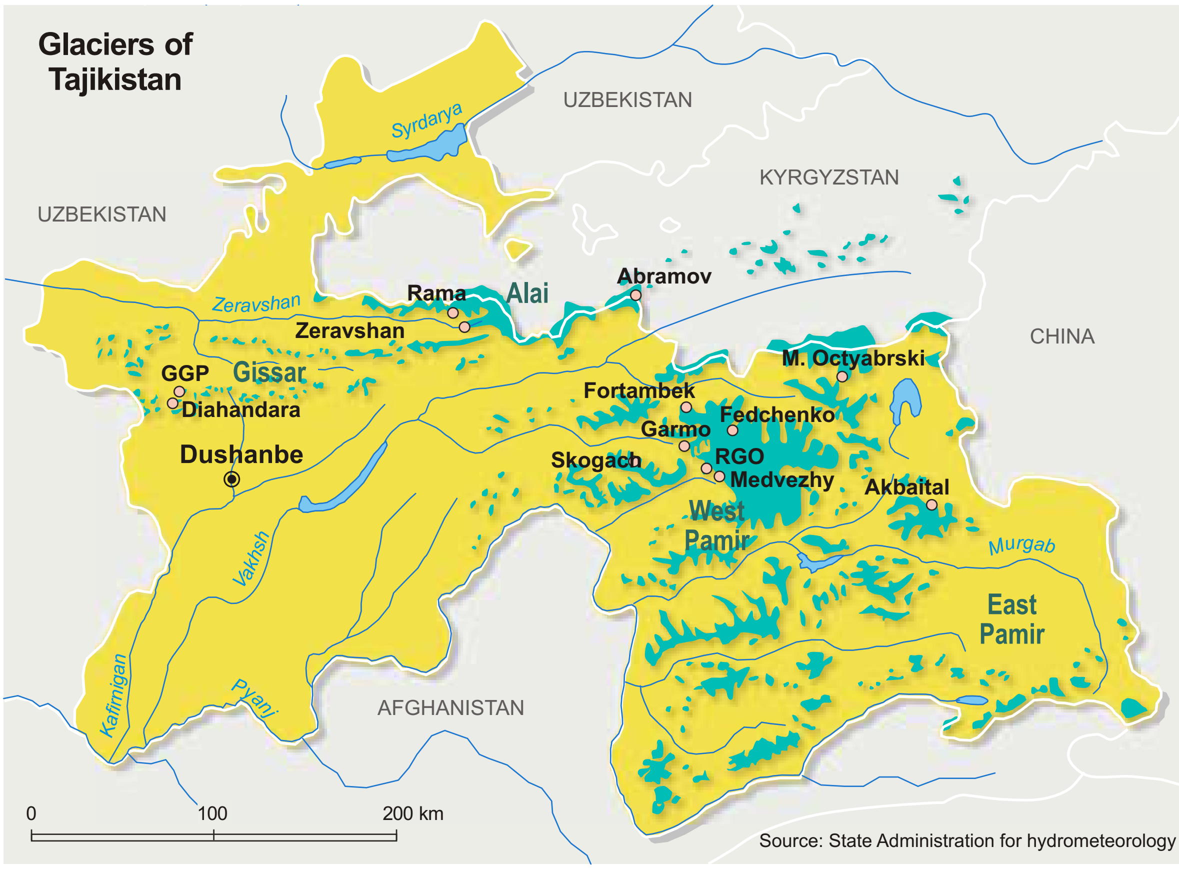


Fig. 1.1.

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. The largest salt-water lake in Tajikistan is Karakul located in the Eastern Pamir, with total area 400 sq.km. The deepest freshwater lake in Tajikistan is Sarez, which was formed as the result of a powerful earthquake and rockslide within the Bartang River canyon in 1911. ; The depth of the lake exceeds 400 m, whereas its volume accumulates 17 cub.km of fresh water. . Other big lakes are Iskanderkul, Zorkul, Yashilkul. In addition to natural lakes there are artificial reservoirs Kairakkum, Nurek, Farkhad and others.

1.3.2. Biological diversity and natural ecosystems

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 and rare species.

Tajikistan as a typical mountain country is unique with its high-altitude flora distribution and its geographic isolation. Some 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.

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 to the high mountains.

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

1.3.3. Forests

Forests in Tajikistan are state property referred to as "group of primary forests, which means that all forestry activities are aimed at forest expansion and improvement. The role of forests in Tajikistan is essential. Forests are needed as accumulators of moisture for soil protection, regulators of climate, and sources of food, botanical and medicinal raw materials.

At present, the total area of the state forest reserves is 1.8 million hectares; some 23% of them are under tree plantations. Significant part of the forest terrain (about 1 mln.ha) was transferred to grasslands for the long-term use. Forests in Tajikistan occupy an area of 410 thousand hectares with percentage of forest land constituting 3% only. The dendroflora is presented by 268 tree and shrub species.

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

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 the 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. The latest years observe significant growth in development of private forest planting, which provides the household and construction sector with industrial timber and wood.

1.4. Population and employment

The population of the republic constituted 7215.7 thousand people as of 1 January 2008; over 70% of the country's total population live in rural areas. The population increase constitutes from 1,5 to 3,5% per annum. Native inhabitants of the country are Tajik people, who comprise 80% of the total population. The state language in Tajikistan is Tajik. Russian is the language of international communication.

During the period of 2000-2005 human resources in Tajikistan increased by 20% and constituted 4 mln. people, however currently the growth in employment significantly lags behind the growth of workforce. It resulted in the intensive increase of seasonal labour migration of the local people abroad. It is estimated that in 2007-2008 the total number of local migrants comprised 800 thousand or 1 million of people, who transfer more than 1 USD billiard of their salaries to home country (Fig. 1.2).

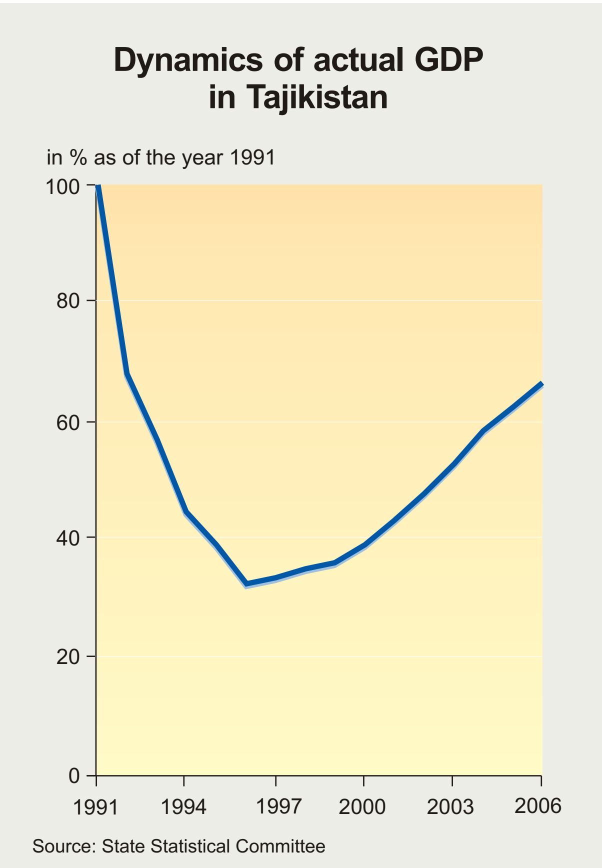


Fig. 1.2.

1.5. Economic development

1.5.1. Industry

Industry is one of the main sectors of Tajikistan's economy. The prevailing subsector in the industrial production is non-ferrous metallurgy (51-45%), light industry (13-22%), food manufacturing industry (16-15%), flour-and-cereals industry (7-8%), etc.

The enterprises of non-ferrous metallurgy are: Isfara hydrometallurgy plant, Anzob ore-dressing and processing enterprise, Adrasman lead-and-zink enterprise, PO "Vostokredmet", JSC "Zeravshan", JSC "Darvaz", and Tajik Aluminum plant, the giant of Tajik industry. Aluminum production is the major source of export and foreign currency income of the country; its volumes of production accelerate each year. The volume of aluminum production constituted around 270 thousand tons in 2000; this indicator increased by 40% in 2007.

The chemical industry mostly includes JSC "TajikAzot" producing ammonia and carbamide, and JSC "TajikHimProm" producing chloride-bearing products, hydrate sodium, lime and food salt. Since 2001 production volumes at JSC "TajikAzot" considerably increased due to complete reconstruction and modernization of the plant, introduction of automated management systems. The peak of production during last years was observed in 2005 at 88,1 thousand tons production output. However, shortage in energy supply triggers the further development of the production growth of the enterprise. Besides, financial constraints and unsatisfactory condition of the infrastructure at JSC "TajikHimProm" are among serious concerns of the industrial decline of the enterprise, which had to operate below limited productive levels.

The industry of construction materials includes Dushanbe cement plant, as well as enterprises of reinforced concrete structures, non-metallic, limestone, gypseous, cementing materials, located all over the country. It should be noted that the volume of cement production considerably increased last years, due to the demand for construction materials.

1.5.2. Energy

Tajikistan is rich in hydropower capacity, which is mainly focused on Vakhsh and Pyanj rivers. In terms of hydropower potential, Tajikistan is one of the world leaders. For the time being, only 5% of this potential is being exploited (Fig. 1.3).

The biggest hydropower plants of Tajikistan are: Nurek hydropower plant with 3,000 MW capacity, Baipaza hydropower plant 600 MW, Kayrakum hydropower plant with 126 MW capacity, Pamir hydropower plants: GES-1 and GES-2, etc. Presently, the hydropower plants of the country contribute 98% of the total energy capacity of the country. Small hydropower plants have favorable prospects as well. At present, their total capacity is about 30 MW. After modernization and renovation of the current HPPs increase of the electricity power will amount to 18 billion kWh per year, whereas launch of the new large-scale HPPs will double this number. The exploitation of the HPPs for the energy generation mostly explains relatively small greenhouse gas emissions in the country.

Several new huge hydropower plants are under planning and construction: Rogun hydropower plant with production capacity at 3,600 MW, Sangtuda-1 HPP - 670 MW (the second aggregate was launched in July 2008, the absolute construction will be completed in 2009) and Sangtuda-2 HPP - 220 MW. However, despite of favorable prognoses of energy development, energy crises hits the country during autumn-winter period, causing serious constraints for all households and enterprises. Out-of-date energy facilities, seasonal shortage of the resources as well as growing energy needs and lack of technological innovations are among crucial reasons for the current situation.

Tajikistan is relatively poor in deposits of fossil fuels. In total, 18 deposits of oil and gas (Kanibadam, Airitan, Niyazbek, Kichikbel) and over 40 deposits of coal (Nazaraylok, Shurab, Fan-Yagnob) are explored in Tajikistan. 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. Currently, 15-30 thousand tons of coal is mined annually, whereas 15-20 years ago this value found 0.5-1 million tons (Fig. 1.4.).

Heat power stations, currently operating in Dushanbe city, is mostly based on gaseous and fuel oil, whereas other coal-functional stations (Yavan station and others), are no longer active. The potential of alternative renewable sources of energy, for instance, solar power and biofuel is quite big, however the lack of infrastructure, low awareness and purchase ability limit their widespread use.

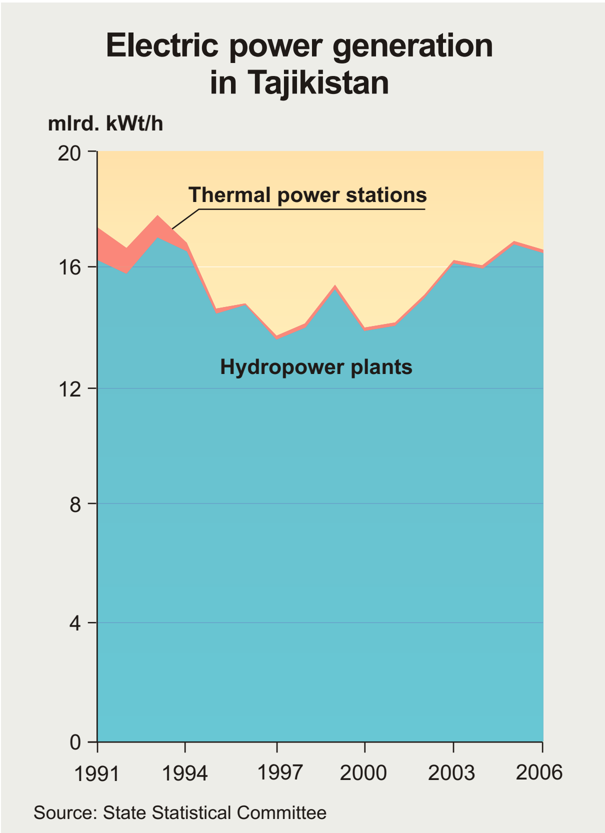


Fig. 1.3.

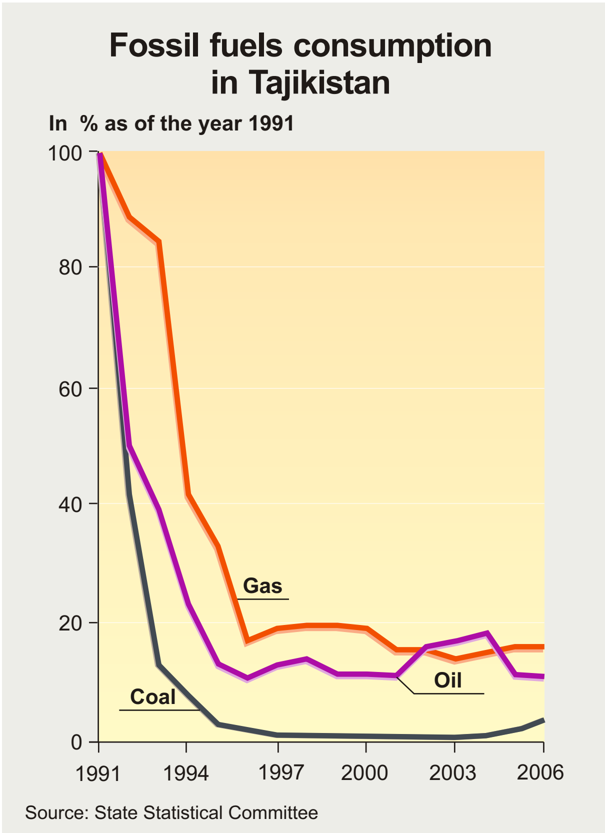


Fig. 1.4.

1.5.3. Agriculture

Agriculture is the most important sector of the economy in Tajikistan influencing the perspectives of sustainable development of the country. The population employment in agriculture constitutes 70%, while the share of agriculture into GDP is about 25%. Most agricultural ventures are either privatized or incorporated into collective farms.

Cotton, cereals, potatoes, vegetables, melons, fruit and grapes are cultivated in the country. Major agricultural fields are occupied by the cotton (production: 400-500 thou tons per year) and cereals (0.8-1 mln.tons per year). The animal husbandry is also developed in the country due to availability and diversity of pastures. It comprises livestock and small cattle. In 2006 the national livestock included 4671 thou cattle heads.

1.5.4. Transport

Transport is one of the major infrastructure sectors in Tajikistan. Its particular role is determined by the complex mountain relief of the area, and in most cases, by considerable remoteness of residential settlements and industrial objects. Currently the transport system of the country includes railroads of wide gauge with total length of 500 km, 13,5 thousand km of automobile roads of general use, including 12,5 thousand km of roads with hard coating.

There is a considerable progress in restoration and construction of roads, connecting the main regions of Tajikistan: construction of the road Dushanbe-Pamir and tunnels under the Anzob and Shahristan mountain passes are in progress. It is expected that completion of these project will enable a year-round transport circulation and communication. Moreover, it is planned to renovate the road between Dushanbe city and the Kyrgyz Republic that will facilitate enhancement of the transportation networks and strengthen market relations of the neighboring countries.

1.5.5. Tourism

The alpine landscapes, diversity of natural ecosystems and climatic conditions of Tajikistan attract tourists from around the world, facilitating the development of tourism in the country. The mountaineering is characteristic to suburbs of Dushanbe and adjoining districts (Varzob, Karatag, Shirkent, Romit gorges), and for Kuhistan (Turkestan, Zeravshan and Gissar mountain ranges, Pairon, Marguzor, Alaudin lakes, Iskanderkul lake). Cultural tourism is more typical for the northern Tajikistan (ancient cities like Pendjikent, Khujand, Ura-Tyube and its historical sites) Alpine climbing are popular in the Fann mountains, Matcha range and the Pamirs.
The downhill skiing is also well known in Tajikistan. It is mainly developed within Khoja-Obi-Garm, Takob and Rogun resorts, which located on 1500-2000 masl. The resorts with medicine water springs, such as Garm-Chashma, Djilandi, Obi-Garm, Shaambary, Zumrad are popular as well.

1.6. Environmental protection

Consequently the activities dealing with environmental protection in Tajikistan are acquiring particular importance. By now the Government of Tajikistan adopted more than 30 laws and bylaws in the area of nature protection, developed 10 national environmental programmes and national action plans. There are national and regional centres on environmental issues, established and being established with attraction of international and civil society organizations.

The Committee for Environmental Protection under the Government of the Republic of Tajikistan is a central organ of executive authority, conducting its activities in line with the integrated state policy on environmental protection, forestry, protected areas, hydrometeorology, rational use of natural resources, and conducts the state control over environmental protection and use of natural resources. The major priorities among the Committee's activities are: protection, restoration and rehabilitation of forests and natural monuments, rational use of flora and fauna, control over: protected areas and tourist routes, water resources, air, minerals, norms of environmental and biological security, etc.

2. INVENTORY OF GREENHOUSE GAS EMISSIONS AND SINKS

2.1. Structure and process of greenhouse gas inventory

The institution charged with responsibility to prepare and conduct inventory of greenhouse gases (GHG) is the State Agency for Hydrometeorology, which establishes links with the UNFCCC Secretariat and National Communication Support Programme.

In accordance with thematic areas of the national GHG inventory, the group of experts is subdivided into five sub-groups, and quality monitoring and evaluation, as well as technical data processing (maps, graphs, databases) teams.

The information required to evaluate GHG emissions/sinks is provided by the statistical data of state agencies, including the State Statistical Committee, Committees for Land Management and Forestry, Customs Committee, and specialized companies and enterprises (energy: "Barqi Tojik", transport: State Enterprises "Tojikiston" and"Rohi Ohani Tojikiston", fuel: JSC "Naftrason", State Enterprise "Tajik Gas", waste: State Enterprise "Hodjagii Manzili Kommunali"). For separate categories of GHG inventory the data of UN FAO is applied.

While preparing GHG inventory for the Second National Communication, experience and databases of the First National Communication, and regional project on enhancing the quality of national GHG inventories in the countries of the Eastern Europe, Caucasus and Central Asia were taken into account.

The stage of inventory process included:

1. Approval of the Team Leader of the intersectoral group on GHG inventory, responsible for conducting inventory within the framework of the Second National Communication.
2. Identification of goals, objectives and methodologies of GHG inventory considering the newest directives of the UNFCCC and IPCC.
3. Stakeholder assessment and establishment of links with key partner organizations: State Statistical Committee, Ministry of Energy and Industry, etc .
4. Selection of leading experts and conducting the inception workshop to discuss methodologies, work plan, data sources and expected results. Assessment of budgetary and technical capacities.
5. Preparation of the GHG inventory strategy at the national level.
6. Preparation and collection of additional documents and information by the Team Leader, experts upon advice of international experts and consultants.
7. Calculation of GHG emissions/absorption.
8. Quality control and writing up a report on national GHG inventory.
9. Presentation and discussion of the preliminary results of the national GHG inventory at the workshop.
10. Archiving data for the use during next GHG inventories and process description.

2.2. Methodology

The major guidance and calculation methodologies used in the preparation of the national GHG inventory are those agreed and adopted in the COP UNFCCC, recommendations of the UNFCCC expert groups, materials of National Communications of other countries and, mainly, the 1996 and 2006 IPCC Guidance for the National Greenhouse Gas Inventories, including software UNFCCC v. 1.3.

In accordance with the IPCC guidance, Tajikistan's inventory covers anthropogenic greenhouse gas emissions by sources and removals by sinks comprising of 9 gases with direct and indirect greenhouse effect during the period of 1999-2003 and the data of previous inventory covering the period of 1990-1998 were re-checked.

Gases with direct greenhouse effect include: carbon dioxide, methane, nitrous oxide, 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 is considered as a gas advancing the formation of anthropogenic aerosols.

For comparison of the contribution of greenhouse gases 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 CO_2-equivalent. The latter depends on the global warming potential (GWP), which consider the radiative influence of greenhouse gases during a certain period, as well as the lifetime of those gases in the atmosphere.

The state statistical data and intraministerial data on each category considered in the national inventory served as a basis for all calculations of greenhouse gas emissions. The units of measurement used for assessment of GHG emissions are gigagram (Gg) and terrajoule (Tj).

The GHG emissions related to production, storage, distribution and combustion of fossil fuels were studied under the category "Energy". The data on production, use, as well as coefficient of reduction, coefficients of carbon emissions and fractions of oxidized carbon were used in calculations. The coefficients of reduction on coal and natural gas were applied in the same way as in the neighbouring CIS countries with analogous territorial conditions. The coefficients of caloric netto-values were applied in accordance with the IPCC recommendations, the coefficients of the IPCC emission factors were adopted as default. The key constraint in assessment of emissions under this category is the lack of energy balance in the Republic of Tajikistan since 1990 (during the whole period of independence), particularly the lack of account on consumption of fuels in transport and industrial sectors, inconsistency and lack of data in sector data, inaccessibility of statistical data under several categories (number of vehicles, import of fuel, etc.).

The GHG emissions which occur as a result of physical-chemical processes of industrial production were calculated under the category "Industrial processes". Activities such as the manufacturing of ammonia, aluminum, steel, iron, cement, and lime, as well as production processes involving sodium were included into this category. The industrial activities related to production and use of halogen containing gases (chlorofluorocarbons, HCFC-22, halogens, etc.) were not considered as they are subject to account in accordance with implementation of Montreal Protocol on substances depleting the ozone layer. The constraints due to inaccessibility of data, similar to those mentioned under the category "Energy" were faced under this category as well.

The GHG emissions related to animal husbandry, rice cultivation, combustion of agricultural residues and nitrogen cycle in agricultural soils were studied under the category "Agriculture". In view of restructuring of the agricultural sector and insufficient statistical account for GHG inventory in animal husbandry and plant cultivation, the results under this category are of high level of uncertainty.

Under the category "Land use change and Forestry" calculations covered two types of activities, including forest planting and land management.

Emissions of methane from solid wastes and wastewater purification are calculated under the category "Waste". Solid wastes in rural areas were not taken into account, in view of their dispersion over the territory, as well as their temporary storage on small non-managed pits with insignificant quantities of methane emissions.

The methodology of Level 1 based on the use of generalized initial data was applied in all calculations.

In accordance with the IPCC recommendations, specific forms, worksheets and tables were used in order to enhance archiving of inventory results. The base year of the second national GHG Inventory was 2000.

2.3. Contribution of Tajikistan to global warming

In 2003 the global emissions of CO_2 major anthropogenic greenhouse gas resulting from oil, gas and coal combustion as well as industrial process and deforestation totaled 25 billion tons. Every year the total amount of the global GHG emission increases by around 1 billion tons. As a result, CO_2 concentration in the atmosphere grows by 0.5%. In the year 2008 it comprised 385 ppm.

Due to the increase of GHG concentration, the mean air temperature of the planet increased by 0.6 0.92 CO_2 during the last 100 years. The major contributors to the GHG emissions are developed countries, including the USA, Canada, Japan and Europe as well as intensively growing developing countries, such as India and China. In 2008 concentration of the CO_2 emissions in China turned the country into the world's first leader. Russia and the Ukraine also make significant contribution to the global warming. Due to the competent estimations (CO_2 per capita) of the USA Oakridge National Laboratory, Tajikistan is placed as number 159 out of 211 countries of the

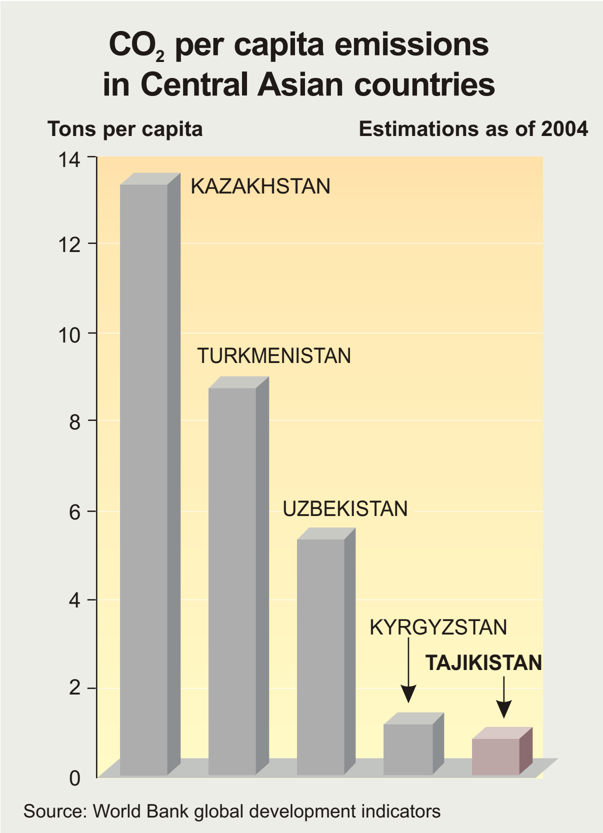


Fig. 2.1.

world, with Kyrgyzstan neighboring to 143. Out of the Central Asian countries, the share of Tajikistan in total emissions constitutes 2-3%, (Fig. 2.1) and mainly explained by the considerable use of hydropower, relatively small number of transport, restructuring of the industry and agriculture. More than 98% of the national energy is produced by the hydropower plants, which do not contribute to CO_2 emissions. Moreover, it is estimated that the expected perspectives of the energy increase through currently operating heat power stations (Dushanbe and Yavan) will not exceed 5% as of the total amount of the energy produced. Therefore, since GHG concentration per capita in Tajikistan is 5 times less than a mean global value, its contribution to the global warming is relatively insignificant, At the same time, there is a considerable potential to obtain the optimum balance between GHG emissions and sinks at the national level (climatic neutrality) and to reduce the GHG emissions.

2.4. Major sources of greenhouse gas emissions

The major emission sources are the sources that contribute to the aggregate of 95%of GHG emissions in CO_2 equivalent during a certain period, usually per annum.

Identification and analysis of GHG emission sources enable detection of priority sectors and categories for enhancement in assessing emissions, developing strategies for GHG emission reduction, and mitigation of the adverse impact on climate.

In 2000-2003 the major sources of GHG emissions (Table 2.1) included: (i) agriculture (livestock, fertilizers), (ii) energy (fuel combustion), and (iii) industry (production of primary aluminum).

Table 2.1

Key emission sources

SECTOR	IPCC Emission Category	Gas
Agriculture	(Direct and indirect emissions) Agricultural areas	N_2O
Agriculture	Enteric fermentation of the domestic animals	CH_4
Energy	Housing and communal services	CO_2
Industrial processes	Aluminum production	PFCs
Waste	Solid waste pits	CH_4
Energy	Industry and construction	CO_2
Industrial processes	Aluminum production	CO_2
Energy	Transport: motorized vehicles	CO_2
Agriculture	Emissions from manure and compost	CH_4
Agriculture	Rice cultivation	CH_4
Energy	Other sectors: Agriculture	CO_2

2.5. Total greenhouse gas emissions

According to the inventory for 1990-2003, the highest GHG emission levels were observed in 1990, and reached 25543 Gg (more than 25 million metric tons) in CO_2-eqv, taking into account the absorption of 23627 Gg. The lowest GHG emissions were observed in 2000 at 7396 Gg of CO_2-eqv, considering absorption of 5518Gg. The maximum decrease of the GHG in CO_2-eqv was observed in the energy sector (from 17 to 2.5 mln.tons), whereas the minimum decrease went for agricultural sector (from 5 to 4.3 mln. Tons). The increase in the GHG emissions is observed starting from 2000 due to the economic growth and increase in transportation and cargo-and-passenger transportation. Currently, the emission level constitutes 35-40% as of the year 1990 level (Fig. 2.2).

For the last 15 years, the structure of the greenhouse gas emissions was significantly changed. In 1990 the energy sector contributed 67% of total emissions in CO_2-eqvand agriculture 20%, followed by industrial processes and waste sector with 10% and 3% respectively. In 2003-2005, due to the overall trend to decrease of GHG emissions in all economic sectors, the ratio of the sectoral emissions changed. By the year 2003, the contribution of the energy sector from the fuel combustion in amounted to 27% only, whereas, the share of the agricultural sector increased by almost 50% as of the total emissions. .

The total amount of GHG emissions is mainly due to CO_2 with 69% (1990) and 32% (2000), CH_4 with 14% (1990) and 32% (2000), and N_2O respectively with 12% (1990) and 25% (2000). The least impact on the total GHG emissions CO_2-eqvwas from the perfluorocarbons with 4% and 8% in 1990 and 2000 respectively.

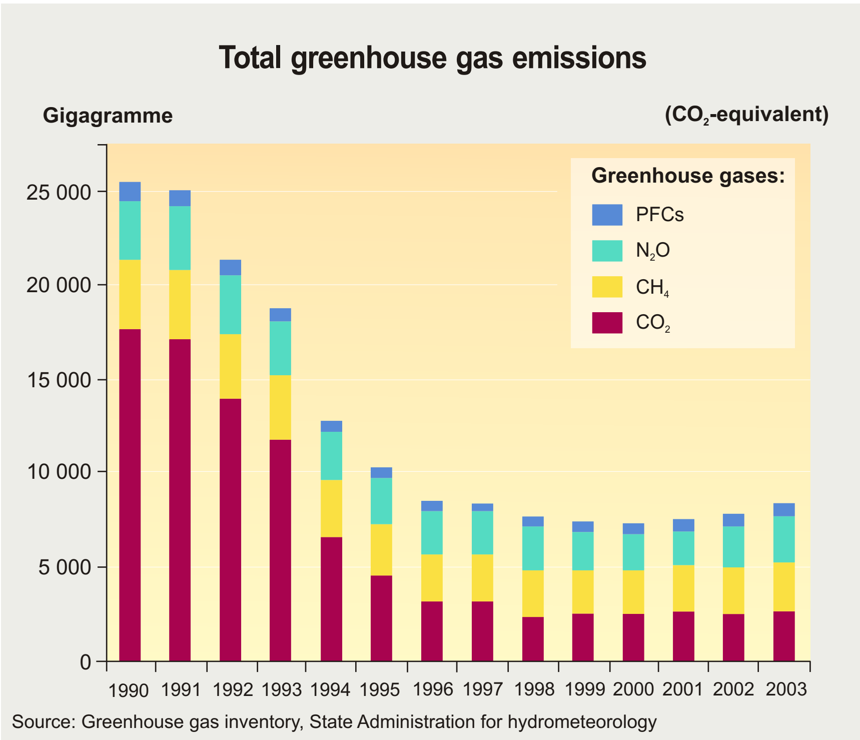
2.6. Dynamics of greenhouse gas emissions by key sectors

2.6.1. Energy

In various time periods the input of the greenhouse gases into "Energy" sector ranged from 27 to 67% of total annual emissions in CO_2-eqv. In 2003 emissions in the sector amounted less than 15 % from the year 1990 level (Fig. 2.3).

2.6.2. Industrial processes

The contribution of the 'Industrial processes' sector to the total GHG emissions fluctuated from 7 to 16 % in CO_2-eqv. In 2003 the sectoral emissions decreased by 50% as compared to the year 1990 level (Fig. 2.3).



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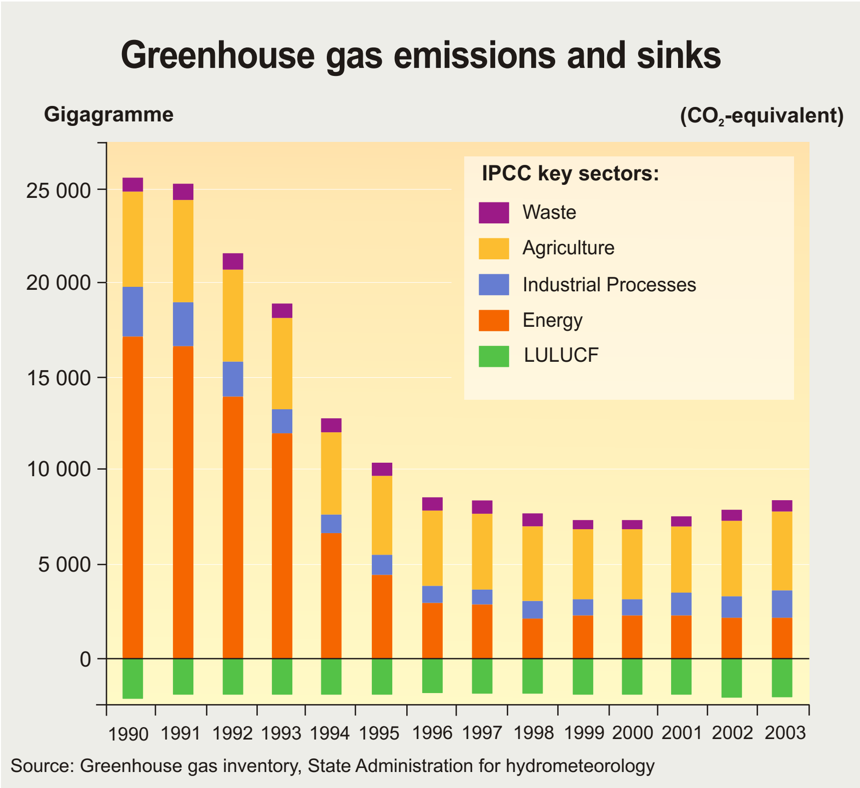


Fig. 2.3.

2.6.3. Agriculture

The contribution of GHG emissions in the 'Agriculture"' sector varied from 20 to 50 % in CO_2-eqv (Fig. 2.3). Starting from 2000, the sector has become one of the key GHG emission sources, with 85% of the year 1990 level reached in the year 2003. This is caused by the significant economic development and decrease of the fossils fuels use and combustion.

2.6.4. Waste

For the whole reporting period the "Waste" sector contributed the least input to the greenhouse gas emissions and amounted to 3-9% in CO_2-eqv. In 2003 the sectoral emissions comprised 70 % of the year 1990 level (Fig. 2.3).

2.6.5. Land use, land use change and forestry (LULUCF)

For the last decades the LULUCF sector has seen the decrease in CO_2 absorption by the forested areas. However, the insignificant growth of CO_2 absorption was seen since the year 2000. In 2003, the stocks composed 8% as of the year 1990 level. The net land use sink has seen an insignificant growth, reaching 8-10% as of the year 1990 level (Fig. 2.3).

2.7. Dynamics of greenhouse gas emissions by key gases

2.7.1. CO_2 emissions

The major sources of CO_2 anthropogenic emissions in Tajikistan are energy (fuel mining, combustion, transportation and use), and industrial processes (cement and aluminum production). Fig. 2.4 shows the dynamics of the cement production. During 1990-2003, the maximum emissions were observed in 1990 (17971 Gg) mostly due to the fuel combustion, and the major absorption volume of 1929 Gg was observed in 1990 and 2003. Overall, during the independency period the total CO_2 emissions decreased by 5-7 times mostly due to the reduction of fossils combustion by transportation sector and households (Fig. 2.5). Starting from 1996, CO_2 emissions were equal to the CO_2 absorption, amounting to 2000 Gg.

Key sources of the CO_2 emissions in the energy sector include:

- Fossil fuel mining (coal, natural gas) and energy production (heat power stations);
- Combustion and use of the fuel in industry and construction;

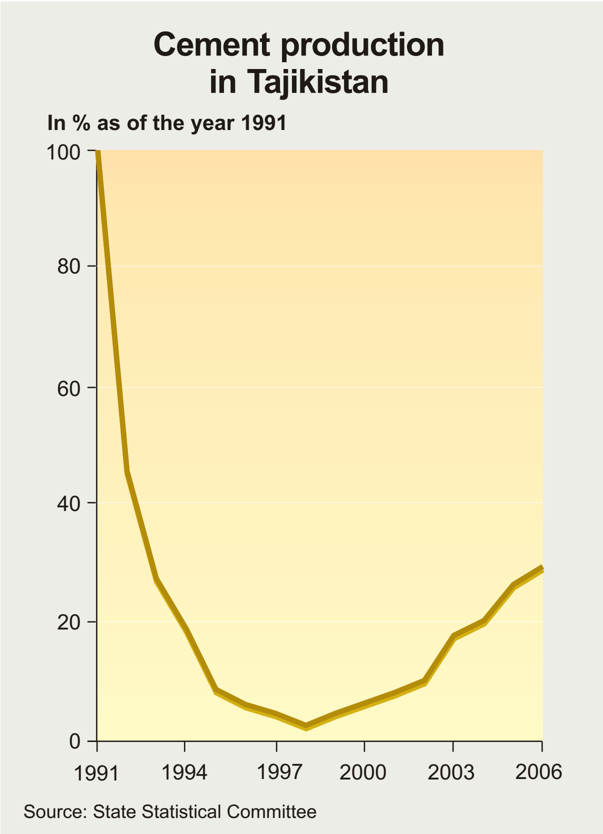
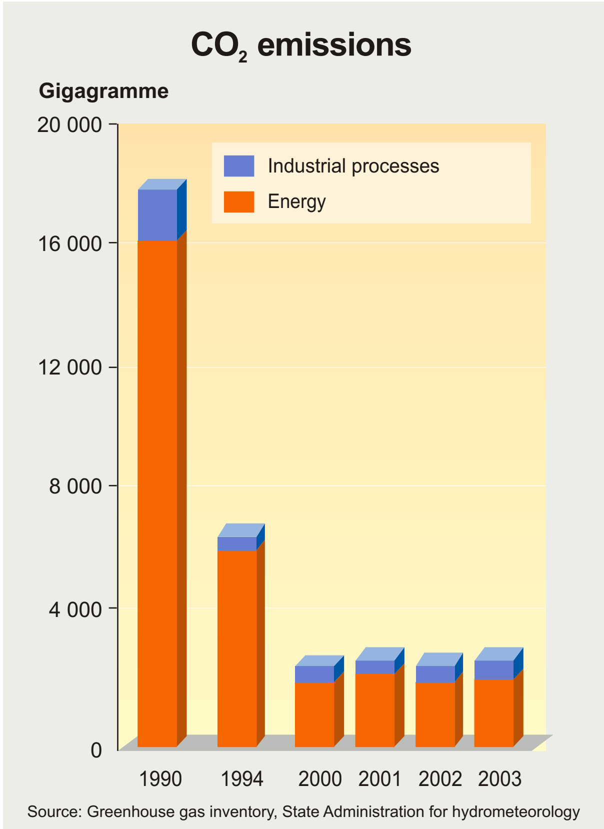


Fig. 2.4.



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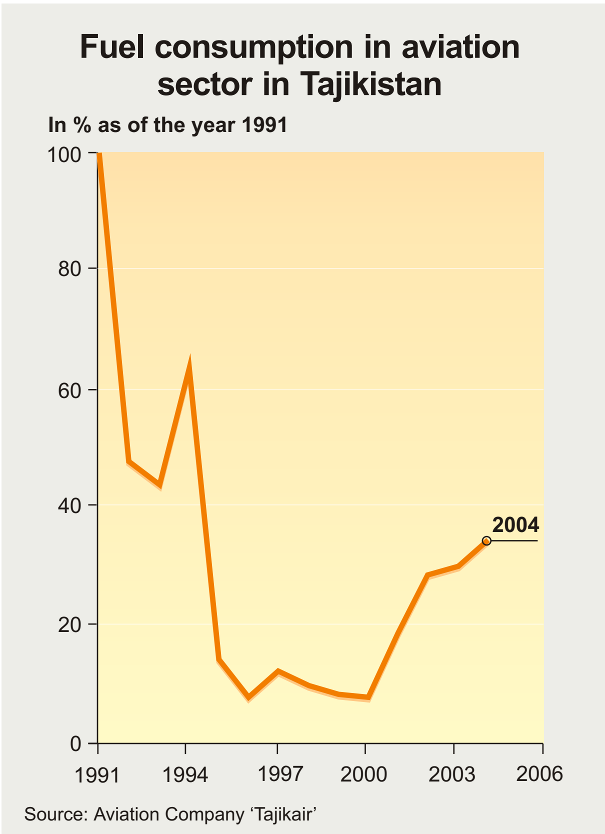


Fig. 2.6.

- Use of the fuel in the transport sector (road, air, railway);
- Other sectors, namely, household and communal services and agriculture.

The CO_2 emissions in the transport sector constituted 30% and 10% in 1990 and 2000 respectively, mainly due to road transportation. The number of road vehicles on gas considerably increased, especially in towns, thus setting conditions for trend of GHG emission reduction. The share of emissions from air transport increased from 9% (1990) to 12% (2000). It is expected that this rate will continue due to an increase of air passenger traffic (Fig. 2.6).

It is worth to point out that major sources of CO_2 emissions in the 'Energy' sector are household and communal sector and agriculture. This is mainly due to the fact that more than 70% of population lives in the rural areas, extensively uses fossil fuel, agriculture being the major source of employment and constituent of GDP. That is why the contribution of abovementioned sectors into the total CO_2 emissions under this category is quite considerable, constituting 40% (1990) and 70% (2000).

The contribution of the industrial sector to the CO_2 emissions is mainly driven by the fossil fuel combustion (especially natural gas) and release of the CO_2 concentration as a result of the chemical processes.

The major sources of CO_2 emissions in the 'Industrial processes' are: aluminum, cement and ammonia production, and, to less extent, cast-iron, lime production and use of sodium ash.

The maximum level of emissions were observed in 1990 and constituted 1.5 mln. tons, the minimum level of emissions were observed in 1997 and constituted 350 thousand tons, mainly due to the production decrease. However, since 1998 an increase by 5-20% in CO_2 emissions is observed. In 2003 the sectoral emissions reached to 628 thousand tons with the major share of the metal production (50% in 1990 and 80% in 2003).

2.7.2 Absorption of CO_2 emissions and carbon sinks

The main sinks of CO_2 emissions in Tajikistan are observed in the category "Land use, land use change and forestry" (LULUCF). The following changes in the economy facilitate absorption of CO_2:

- Increase of the forestsed areas and other wood biomass reservoirs;
- Conversion of forests and pastures;
- Dynamics of the proper use of the lands.

Despite the initial trend towards reduction in CO_2 absorption capacity, one can observe stabilization and even increase in capacity during last years, being the result of: land reform and changes in the land management and land use priorities, strengthened control over land use and increased afforestation for landscape gardening. The accumulation rate of CO_2 emissions by the woody and shrubby plants tended to decrease until the period of 1999-2000. However, since 2001 a slight

The wood losses in forestry is mainly caused due to unauthorized deforestation, which was aggravated by the ceased delivery of coal, gas, and other energy resources supply since 1992. The forests located close to the settlements and forest shelter belts were especially damaged.

The increase of forest area is by sowing and afforestation. The afforestation works constituted 2.3 thousand ha in 2003, which made up 50% of the 1990 level.

The area of agricultural lands increased by 198 thousand ha in 2003, being 4% of the year 1990 level. This increase was due to conversion of pasture lands into agricultural lands. At the same time the area of other agricultural lands decreased by 95 thousand ha.

2.7.3. CH_4 emissions

The main sources of methane emissions in Tajikistan are under 'Agriculture' (76% in 2003) and "Waste" (18% in 2003). The insignificant quantity of methane emissions is observed under 'Energy' sector (coal mining). The methane emissions in 2003 equaled to 70% of the year 1990 level (Fig. 2.7).

CH_4 emissions in the agricultural sector is mostly due to enteric fermentation of the domestic animals (83% in 2003), manure waste (12% in 2003) and rice cultivation (more than 5% in 2003). Such tendency of the methane emissions is mainly contributed by the relative growth of the livestock (Foto 2.1) and food demand (Fig. 2.8).

The deficiency of productive pastures, considerable decrease in forage production and financial constraints of farmers deter active development of livestock and husbandry and facilitate reduction of greenhouse gas emissions in this sector (up to 85% in 2003 as of 1990). The decrease in the amount of CH_4 emissions in rice cultivation is also observed, primarily due to the decrease of agricultural lands. The total area under rice cultivation constituted about 20 ha in 2000, and by 2003 this area reduced by 20%.

The CH_4 emissions under the 'Waste' sector are mainly due to the disposal tips of solid municipal wastes and waste waters. Taking into account that the number of managed disposal tips in the republic in 1999 reduced from 5 to 3, the number of non-managed deep disposal tips reduced from 12 to 7 (on both types of disposal tips methane emissions are more intensive), the data on GHG emissions was corrected accordingly. The total number of disposal tips reduced from 70 to 52, while increase in wastes generation constitutes around 1-2% per annum.

It is estimated that the losses of the natural gas (mainly methane) in baseline and local pipelines amount to 30%, which is equal to the electricity losses. However, due to the decrease of the natural gas supply and lack of the competent data, the

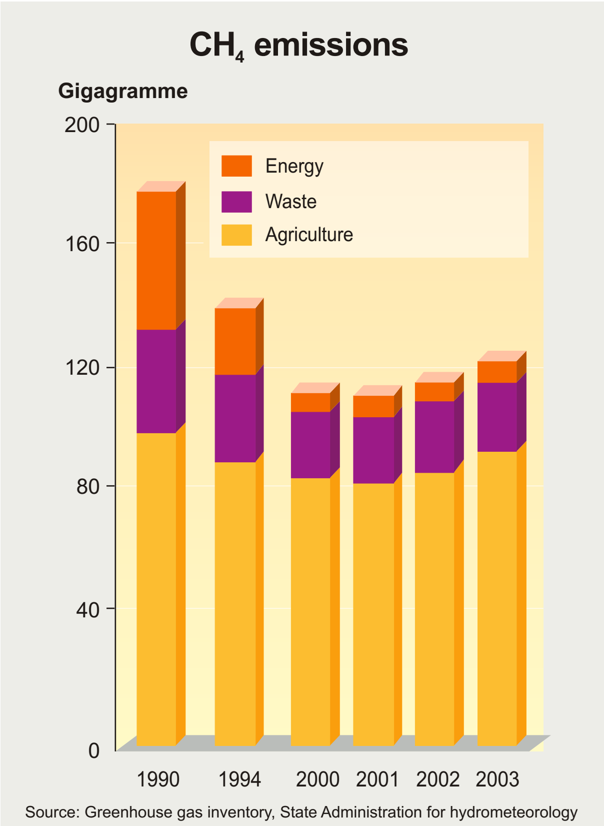


Fig. 2.7.

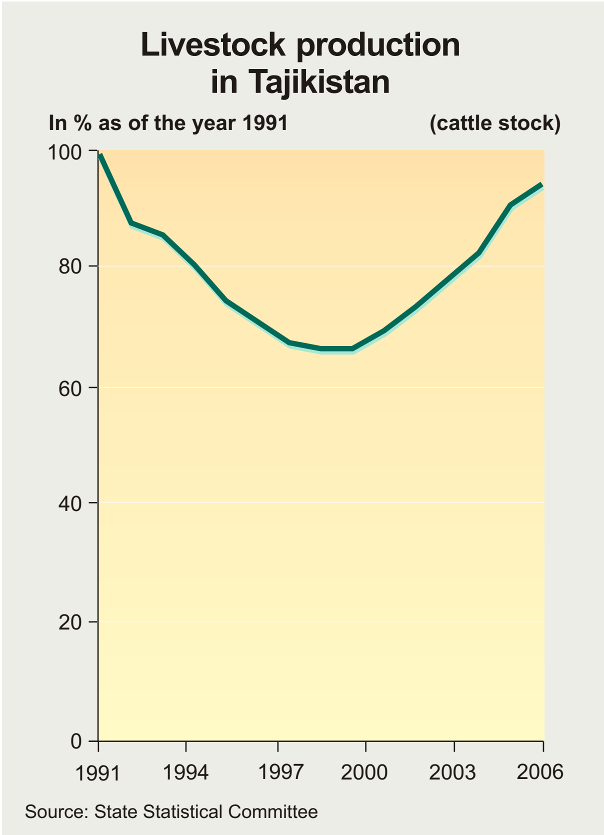


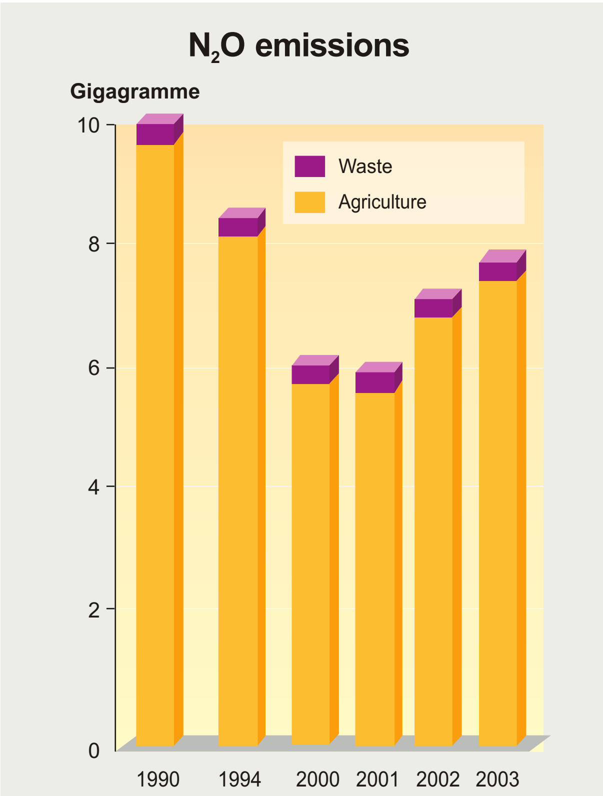
Fig. 2.8.

Foto 2.1. Pasturing livestock in Khatlon region.

sectoral contribution to the methane emissions is relatively low. Input of the coal industry, on the contrary, is rather higher, although the volumes of the coal mining significantly reduced if compared with the Soviet period.

2.7.4. N_2O emissions

The absolute emissions of nitrous oxide are negligible; however their high global coefficient of the global warming (in CO_2-eqv) is rather substantial. In general, N_2O emissions are observed in the categories "Agriculture" (96%) and "Wastes" (4%). In agriculture, N_2O emissions occur in cultivated soils (application of organic and nitrogen mineral fertilizers) and in animal manure. During the period of 1990-2003, GHG emissions in this category varied from 10 to less than 6 thousand tons and since 2000 there was a trend to the increase of N_2O emissions (Fig. 2.9).



Source: Greenhouse gas inventory, State Administration for hydrometeorology

Fig. 2.9.

2.7.5. Perfluorocarbons emissions

In Tajikistan the emissions of perfluorocarbons (CF_4 and C_2F_6) occur during the production of aluminum at Tajik Aluminum Plant. Although the amount of emissions of perfluorocarbons are negligible, their contribution into greenhouse effect is the most significant one taking into account the coefficient of global warming. During the period of 1990 to 2000 the amount of CF_4 emissions reduced from 0,14 to 0,7-0,8 thousand tons, however the amount of emissions increased during the last years due to the increase of the production volumes. There is a trend towards reduction of specific emissions of fluorocompounds and other pollutants per unit of production due to ecological activities.

2.7.6. Indirect greenhouse gas emissions

The major sources of indirect greenhouse gas emissions are originated due to fossil fuel combustion and industrial processes. During the period of 1990-2003 emissions of GHG precursors and SO_2 decreased by 5-8 times, similarly to the tendencies of the total GHG emissions.

2.8. Uncertainty assessment

"Uncertainty" characterizes the level of dispersion and possible deviations of data in comparison with true value. The information on uncertainty enables identification of the priority measures for more accurate assessment of emissions in further inventories and account of the information on uncertainty while planning for GHG emission reduction. The final uncertainty is a combination of uncertainties in coefficients of emissions and uncertainties in data on activities.

The uncertainties are subdivided into three basic groups. The low level of uncertainty (considerably high level of reliability) is at ≤ 10 per cent of uncertainty, medium level of uncertainty is at 10 to 50 per cent, high level of uncertainty (low level of reliability) is at ≥ 50%.

In general, the uncertainty of the current inventory is assessed as medium, at the same time, for some sectors under the 'Industrial processes' sector the uncertainty level is low, while for other categories ("Agriculture", LULUCF, "Waste") the uncertainty is relatively high. Due to the lack of energy balance the uncertainty level of GHG inventory in the 'Energy' sector is medium with regard to the best available data (Table 2.2).

Table 2.2

Uncertainties, according to expert evaluations

Source	Gas	Uncertainty (%)	Uncertainty level
Energy		25	Medium
Electricity	CO_2 CH_4 N_2O SO_2	15	Medium
Industry and construction	CO_2 CH_4 N_2O SO_2	20	Medium
Agriculture	CO_2 CH_4 N_2O SO_2	20	Medium
Transport	CO_2 CH_4 N_2O SO_2	30	Medium
Housing and communal sector	CO_2 CH_4 N_2O SO_2	20	Medium
Commercial sector	CO_2 CH_4 N_2O SO_2	10	Medium
Industrial processes		30	Medium
Cement production	CO_2, SO_2	6	Low
Lime production	CO_2	9	Low
Sodium production	CO_2	8	Low
Ammonium production	CO_2, CH_4, SO2, CO	3	Low
Iron and steel production	CO_2, CO	10	Low
Aluminum production	CF4, C2F4, CO_2, CO, SO_2, NO_x	30	Medium
Agriculture	CH_4, N_2O	80	High
Animal husbandry (enteric fermentation)	CH_4	35	Medium
Animal husbandry (manure and compost)	CH_4, N_2O	20	Medium
Rice cultivation	CH_4	100	High
Pasturing	N_2O	20	Medium
Application of fertilizers	N_2O	30	Medium
LULUCF	CO_2 (absorption)	60	High
Land use	CO_2	60	High
Forestry	CO_2	60	High
Waste	CH_4, N_2O	80	High
Solid domestic waste pits	CH_4	80	High
Domestic sewage	CH_4, N_2O	80	High
Industrial sewage	CH_4, N_2O	80	High

3. VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

3.1. Climate change indicators and trends in the Republic of Tajikistan

Results of the research show that the ground air temperature in the most districts and high altitude zones of Tajikistan is increasing, however, the change in atmospheric precipitations is uneven due to geographic and climatic diversity of the territory of the country. Analysis of the changes of mountain snow reserves reveals various trends depending on the altitude of the snow bedding.

Data from 30 stations for the period 1940-2005 and period of observation were used in studying the dynamics of ground air temperature and precipitation. The stations were selected according to orographic and climatic district groups, as well as according to altitude zones (submountain districts until 1000 masl, mountain districts from 1000 to 2500 m, high altitude areas above 2500 m). To assess changes in snow stock, the data from 15 stations was analyzed.

Glaciers may also serve as characteristic indicators for inter-annual weather variability in the mountains and long-term climatic changes. The trends and state of glaciations in Tajikistan with relation to the climate change are explored in detail in following chapters.

3.1.1. Changes in surface air temperature

The increase of air temperature in the plain regions of Tajikistan constituted, on the average, 0.1-0.2ºC in a decade. The biggest increase for 65 year period is noted in Dangara (1.2ºC) and Dushanbe (1.0ºC), for the rest of the territory it constitutes 0.5-0.8ºC, in Khujand it is 0.3 ºC (Fig. 3.1). Insignificant increase of temperature in Khujand is most probably related to the development of irrigation and building of the Kayrakkum water reservoir, which rendered cooling effect. The increase of annual mean temperature in the mountainous areas constituted 0,3-0,5ºC in 60 year period, except separate isolated canyons where the trends are less notable or negative. The biggest increase of annual mean temperature in the

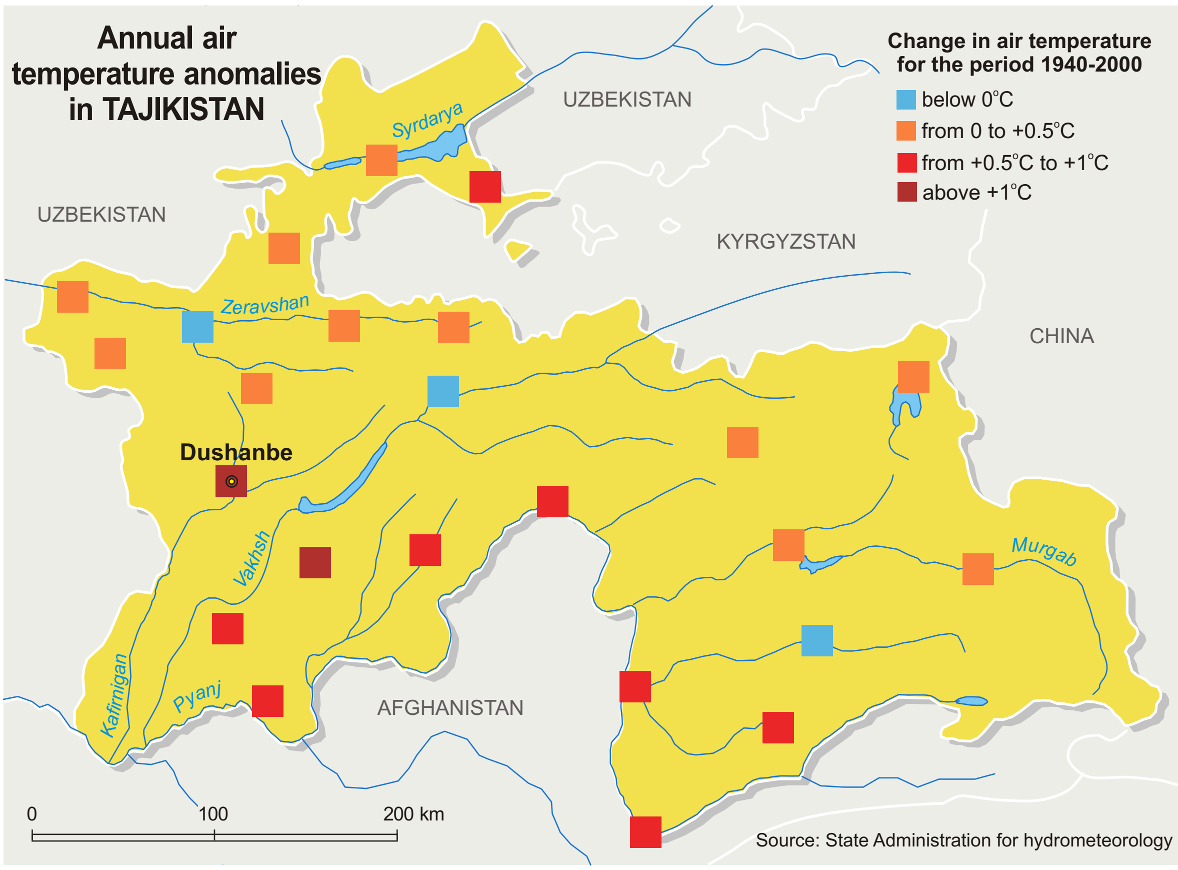


Fig. 3.1.

mountainous zone (1.0°-1.2°C) was observed in Khovaling, Faizabad and Ishkashim. In altitudinal zones (more than 2500 masl) the increase of temperature on average constituted 0.2-0.4°C and up to 0.6°C in Djavshangoz. The fall of temperature (-1.1°C) during this period is noted in the kettle of Bulunkul Lake which could be related to the characteristic features of climate in the Eastern Pamir.

Analysis of surface air temperature changes per each month reveals a trend to warming during the cold season of the year, especially in November-December, reaching 1-3°C. The trend to temperature fall was observed at all high altitudes in February, March, May, June and October. In springs in some sub-mountainous and mountainous areas trend to cold spells prevails (0.1-0.2°C).

The analysis of changes of the extreme air temperatures indicated the dynamics of increase of the maximum annual and seasonal temperatures. The mean maximum temperature increased by 0.5-1.0°C. The minimum mean temperatures also increased, especially in autumn, by 0.5-2.0 °C with some exceptions in high-mountain regions (-0.1°C). In the number of areas the minimum mean temperatures decreased. Generally, the dynamics of increase of the minimum mean temperature advances the dynamics of increase of the maximum mean temperature almost everywhere (Fig. 3.2).

With warming of climate the duration of frost-free period increased. The stable transition above and below 0° is noted earlier in spring and later in autumn. In different areas the duration of frost-free period increased by 5-10 days. Thus, for instance, in the upper reaches of Zerafshan river (Dekhavz station) the period with temperature above 0° earlier in 1941-1960s was observed starting from the 23rd of March to the 15th of October; currently it covers the period of the 20th of March to the 20th of October.

3.1.2. Changes in atmospheric precipitation patterns

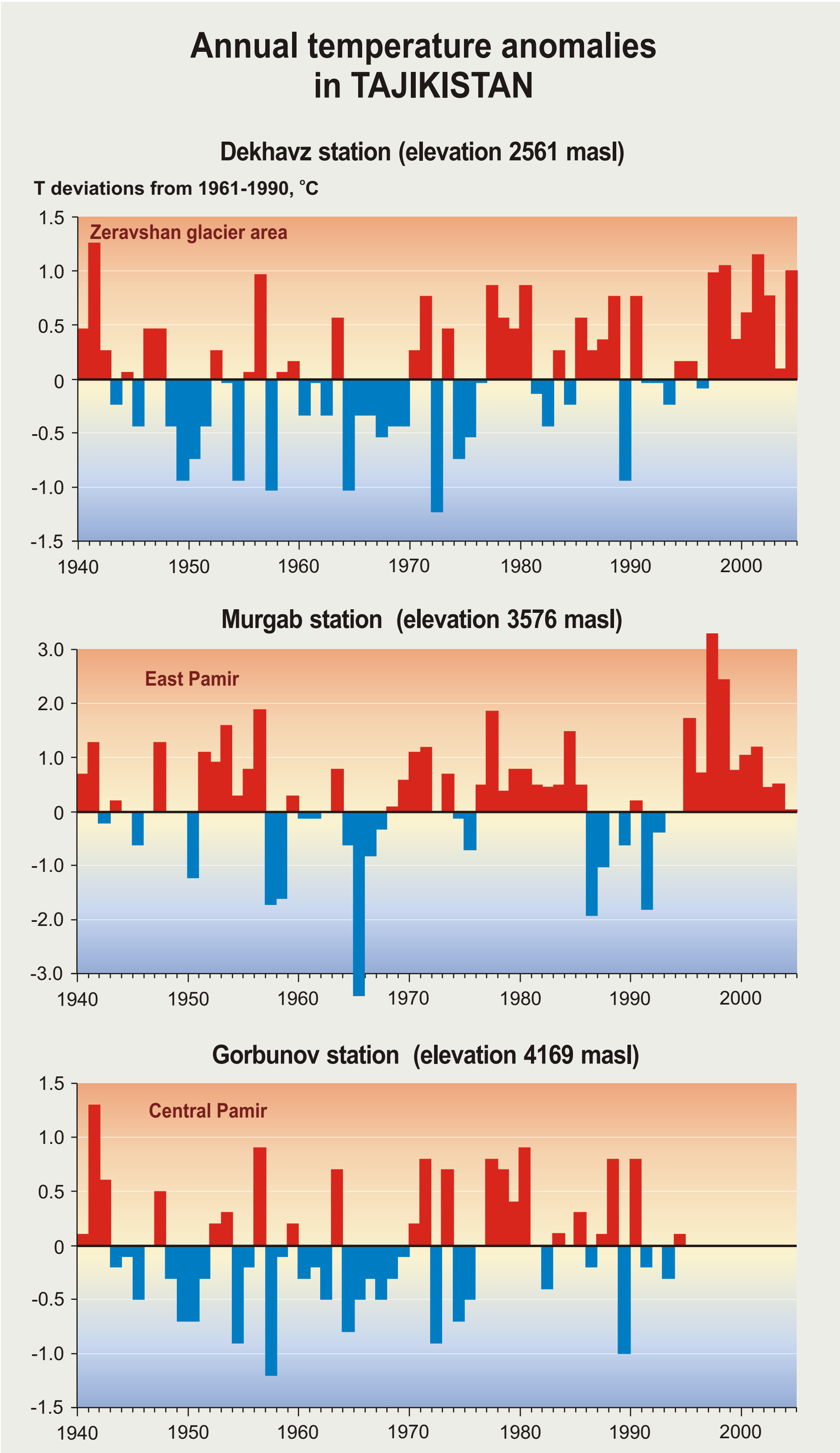
The amount of atmospheric precipitations is mostly determined by the global atmospheric circulation and hydrological cycle, as well as orographic features of the area. The considerable fluctuations in time and space were detected while analyzing the changes of annual amount of precipitation; and a number of very dry and very humid periods were defined.

During the period studied the driest decade for all altitudinal zones was from 1941 to 1950. The periods of dry weather alternated with the period of humid weather up to 1990, with a trend to the increase of the amount of precipitations. After 1990 the rainiest period was in 1998-1999; and the following period of 2000-2001 was the driest one, the drought spread almost on the whole territory of the country. The irregularity and intensity of precipitations increased and this trend is expected to continue in the future. Such trend is also supported by the numerical models. Not only the amount and intensity of precipitations, but also the number of days with precipitations changed (Fig. 3.3).

The analysis of the annual precipitation patterns displays an insignificant increase of the annual amount (by 8% on average) on the territory up to 2500 m and insignificant reduction (by -3%) in the mountainous areas. The most considerable increase in the annual amount of precipitations occurs in summer and autumn in the area up to 2500 m (by 37-90%), mainly caused by the increase in precipitation intensity. The increase in the number of days with precipitations from 0 to 5 mm during the period under observation is registered in the Tajik part of the Fergana Valley (Khujand, by 42 days), which might be due to the impact of the Kairakkum water reservoir (moisture condensation). In general, the number of days with precipitations has decreased in the country (particularly in Iskandarkul, by 48 days).

Taking into account the mountainous relief of the territory of Tajikistan, distribution of precipitations and their long-term changes vary. Thus, the amount of precipitations in the Eastern Pamir (mountainous plateau with elevation of 4,000-6,000 masl.) reduced by 5-10%, and in Murghab by 44% (Fig. 3.4). The similar trend of the reduction of precipitations occurs in the southern lowland areas of the republic (Kurghan-Tyube, Shaartuz).

In the Central Tajikistan (Fedchenko, Kalaikhumb, Rasht, Faizabad, Khushyori) the precipitations increased by 5-10%. The increase of precipitation by 20% is observed in the submountain areas of the southern Tajikistan (Dangara, Kulyab). In the mountains of the northern Tajikistan (Madrushkat, Shahristan) the amount of precipitation increased by 5-30%, with exception of high mountains. In Tajik part of Ferghana valley (Istaravshan, Khujand, Isfara)



Source: State Administration for hydrometeorology

Fig. 3.2.

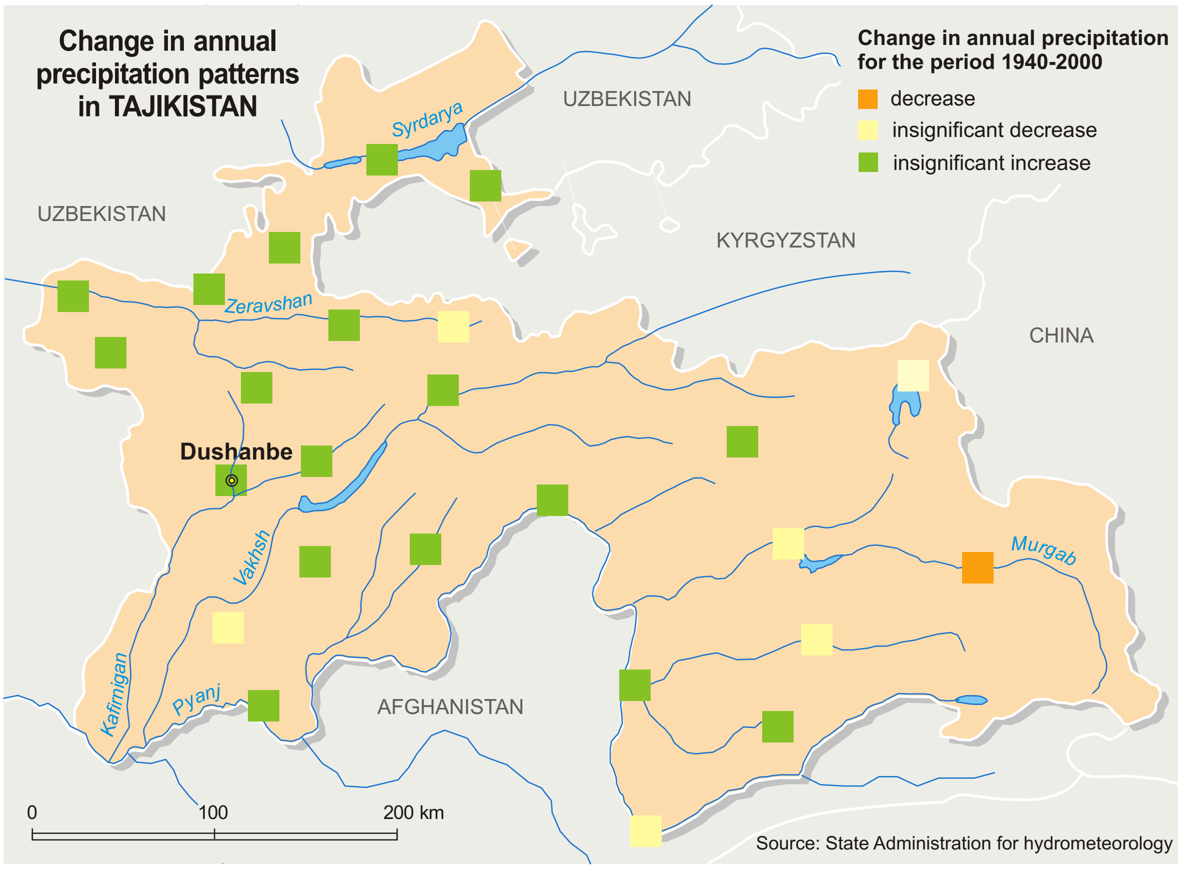


Fig. 3.3.

there is a slight increase in precipitations, on average by 5-10%. The considerable increase, as well as the reduction of atmospheric precipitations by 30-45% is observed in the isolated mountainous areas (mountainous passes, blind canyons), where the impact of local microclimate is significant.

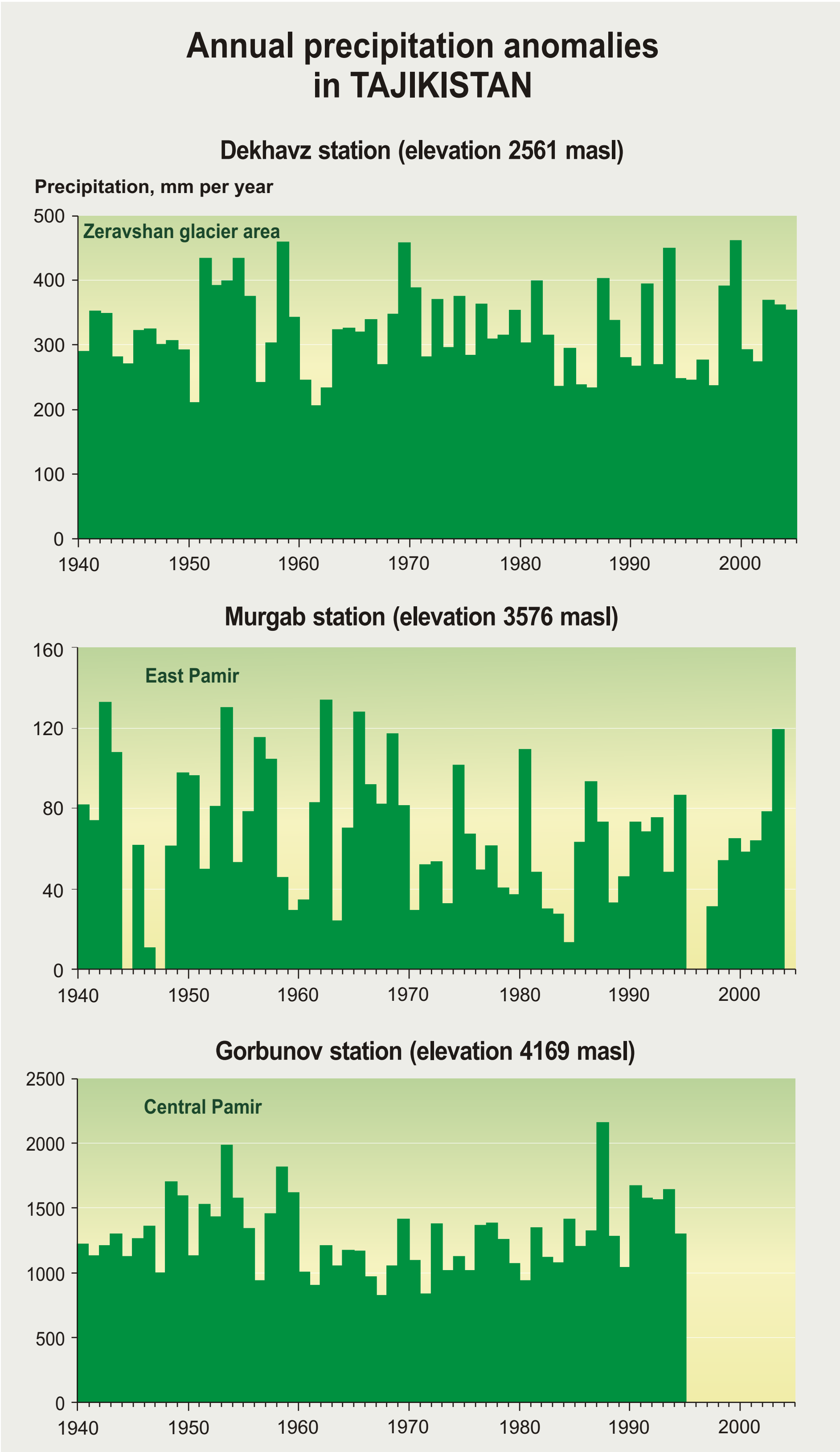
Extensive increase in temperature with fragmented increase and reduction of precipitations contributes to aridity of climate in many areas covered by mountainous forests and under agricultural cultivation.

3.1.3. Dynamics of snow stock

The snow stock in the conditions of mountains in Tajikistan plays a crucial role in water levels of rivers and hydrological cycle. One of the characteristics of the snow cover are reserves of water in the depth of this cover, as the snow cover, together with intensiveness of melting of snows determines the flow of water in the rivers, size of snowmelt flood and reserves of moist in the soils.

During the cold period the solid precipitations form 35-60% of their total amount in plain areas of the country; in the foothills and mountainous areas solid precipitations constitute 45-80% of their total amount, and in high mountains this Fig. reaches up to 100%. There is no stable snow cover in high-mountainous zone up to 1000 m, it snows occasionally and snow melts quickly. In high-mountainous zone of 1000-2000 m the snow cover lies, mainly, from December to the middle of March (85-100 days in average). In the zone of 2000-3000 m the snow cover lies from the end of November-beginning of December till the end of March-beginning of April; the number of days with snow cover is 100-135. In the high-mountainous zone of 3000-4000 m the stable snow cover is not formed everywhere. In the Eastern Pamir it can snow in any season, but due to arid climate and small amount of precipitation the snow cover in this area melts quickly. The average number of days with snow cover in this zone decreases, as one goes to the East: from 245 days in the Gissar mountain range to 45 days in the Eastern Pamir. The zone higher than 4000 m is a zone of permanent snow and ice.

The snow stock varies greatly from year to year and it also depends on the elevation of area. The



Source: State Administration for hydrometeorology

Fig. 3.4.

continuous period with little snow was observed in 1970-1984 (in some regions until 1900) in the high-mountainous part of river basins, while in the foothill areas, on the contrary, this period was characterized by big snow stocks. It is explained by frequent occurrence of the south-west cold air intrusions, which causes an excess amount of precipitation in the foothill areas. The winter of 2007-2008 was characterized by prevailing low surface air temperature and slow speed of seasonal warming, while general reserves of snow stock by the beginning of vegetation period constituted 60-80% for the main river basins. This situation directly affected the water availability in the rivers and subsequently, sectors of the economy (irrigation and hydropower industry).

3.1.4. Extreme weather events and their variability

Climate change considerably impacts not only basic climatic characteristics (temperature, precipitations, snow cover), but intensity extreme weather events as well (extreme temperatures, fogs, dust storms, haze, strong winds, heavy precipitations, thunderstorms, hail, mud flows, avalanching).

Extremely-high temperatures. With increase of maximum temperatures the number of days with temperature equal to +40ºC or over increases (Fig. 3.5). The highest temperatures for the studied period were observed in the southern Tajikistan in 1944 and in 1997, when the daytime temperature was +45-47ºC. The number of days with temperature equal to 40ºC or over increased in the most flat areas of the country, with exception of those territories where development of land and construction of reservoirs took place.

Dust storms and haze. Dust storms are distributed unevenly on the territory of Tajikistan and mainly are observed in the southern deserts and semi-deserts (especially in Shartuz). Haze is most frequently observed in dry summer-autumn period. The maximum number of days with haze occurred in 1971; in Dushanbe it constituted 80 days, in Kurgan-Tyube - 94 days. In November 2007, drastic dust storm covered the southern and central parts of the country until the elevation of 3 km with the visibility rate 50-100 m. During the days with intensive dust storm precipitation of dust particles amounted to 100 thou tons per day. For the last 15 years the number of days with dust storms and haze reduced 2 times against the preceding period. This is likely caused on the one hand, by intensive development and irrigation of land prone to the dust storm formation, and on the other hand, by the reduction of the north-west fronts.

Avalanches. Avalanches are common phenomena in the high mountains of Tajikistan. Fearing the danger of avalanching, the traffic is stopped every winter on Dushanbe-Khujand highway, which is considered to be the most important one, as well as on the other roads. The avalanching took a toll of 46 lives during 2003-2006 (mostly local inhabitants and passengers). A number of avalanches were observed in winter of 2007-2008, when snow piles blocked the motorway connecting the central and northern Tajikistan, damaged the infrastructure and resulted in numerous fatalities (Foto. 3.1). According to the expert evaluations, increase or reduction of the danger of avalanching is connected to the increase or decrease of atmospheric temperature and the amount of solid precipitation in the zone of 1500 masl. and more.

Heavy rainfalls. The number of days with precipitations of 5 mm and more increased in the most areas, especially in the central mountainous zones. The number of days with heavy precipitations (30 mm per day) increased in the foothill areas and Gissar valley. It should be noted that, along with increase of rainy days (Fig. 3.6), the number of snowy days reduced.

Thunderstorms. The biggest number of days with thunder was observed in the Central (Dushanbe, 43 days in 1954) and Southern (Kurgan-Tyube, 24 days in 1963) Tajikistan. However for the last 15-25 years the number of thunderstorms considerably decreased (Fig. 3.6). As far as in the central and southern Tajikistan thunderclouds are often formed prior the intrusions of cold arctic air fronts, reduction of days with thunder indicates the decrease of cold winds. In the Pamir highlands thunders are very rare.

Hails. During the period of 1941-1970 hails rather often occurred on the whole territory of Tajikistan (Fig. 3.6). Hails, as large as walnuts, were observed in May 1966 in Gissar Valley, Darvaz and Karategin. Many cotton fields, agricultural crops were damaged, animals and birds died as a result of hail. Starting from 1970 the number of days with hail decreased. If during the period of 1941-1970 the

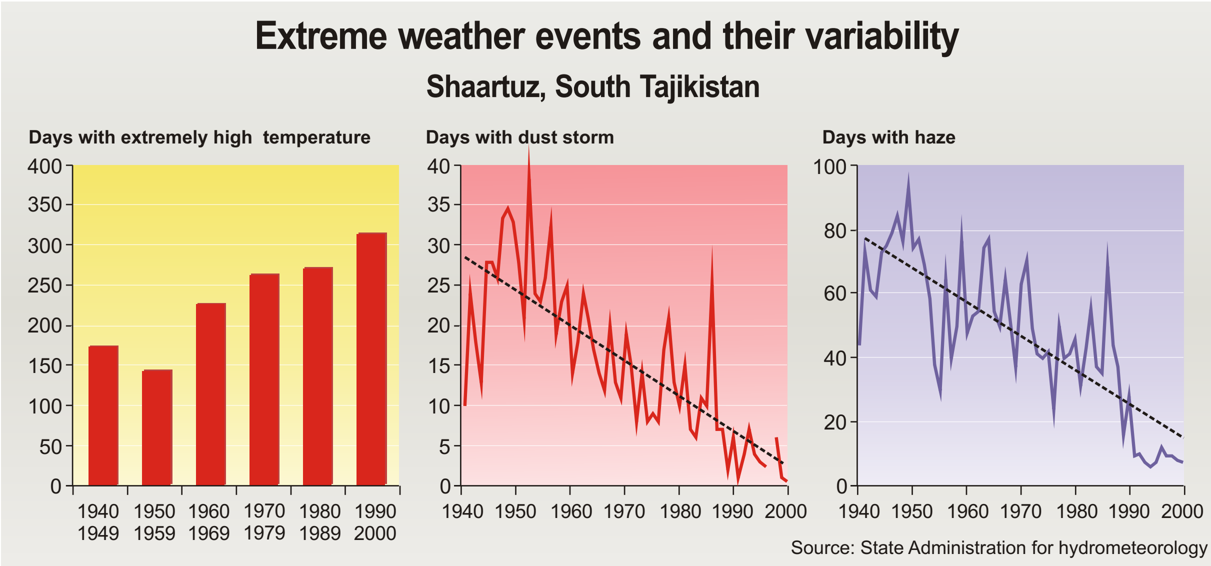


Fig. 3.5.

Foto 3.1. Avalanche consequences in 2007.

average number of days with hail in Gissar Valley was 24, in 1971-1990 hailing frequency decreased almost two times and constituted 14 days. The occurrence of hails reduced even more in 1990-2005 due to the drought of 2000-2001. In general, reduction of the number of days with hailing observed is due to the decrease of cold air intrusion stimulating hail formation and hailfalls.

Strong wind. The densely populated territories of Tajikistan are generally characterized by mild winds; strong winds are often observed only in the bottlenecks of valleys (Khudjand). Winds at a speed 20 m/s are annually observed in the Northern Tajikistan and Eastern Pamir, southern regions of the republic (Shartuz, Nizhni Pyandj) and mountainous passes. In the Central Tajikistan such winds are observed in Faizabad. Winds at a speed 30 m/s are observed only on Anzob pass. The analysis on frequency of days with strong wind and meteorological practice show that the number of days with the western wind reduces (along with the decrease of days with dust storm), and the number days with winds of the eastern direction (east, north-east) increases.

The reduction of the number of the western and south-west winds is related to the reduction of active cold-wave intrusions. The increase of the eastern, south-east winds indicate that the number of cases with intrusion of tropical air into Tajikistan increases.

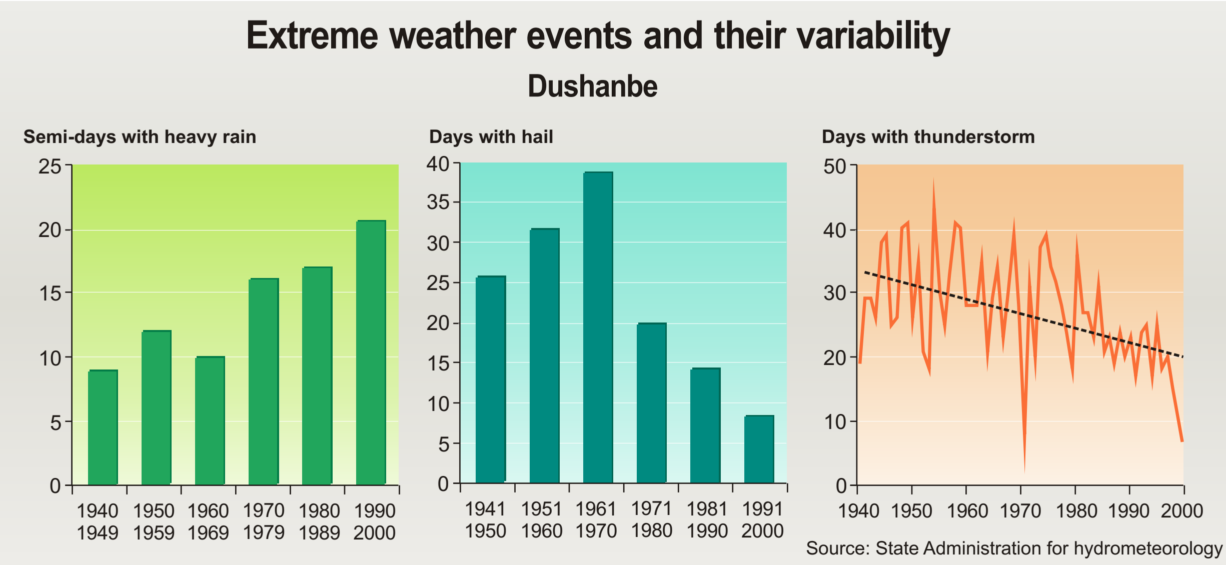


Fig. 3.6.

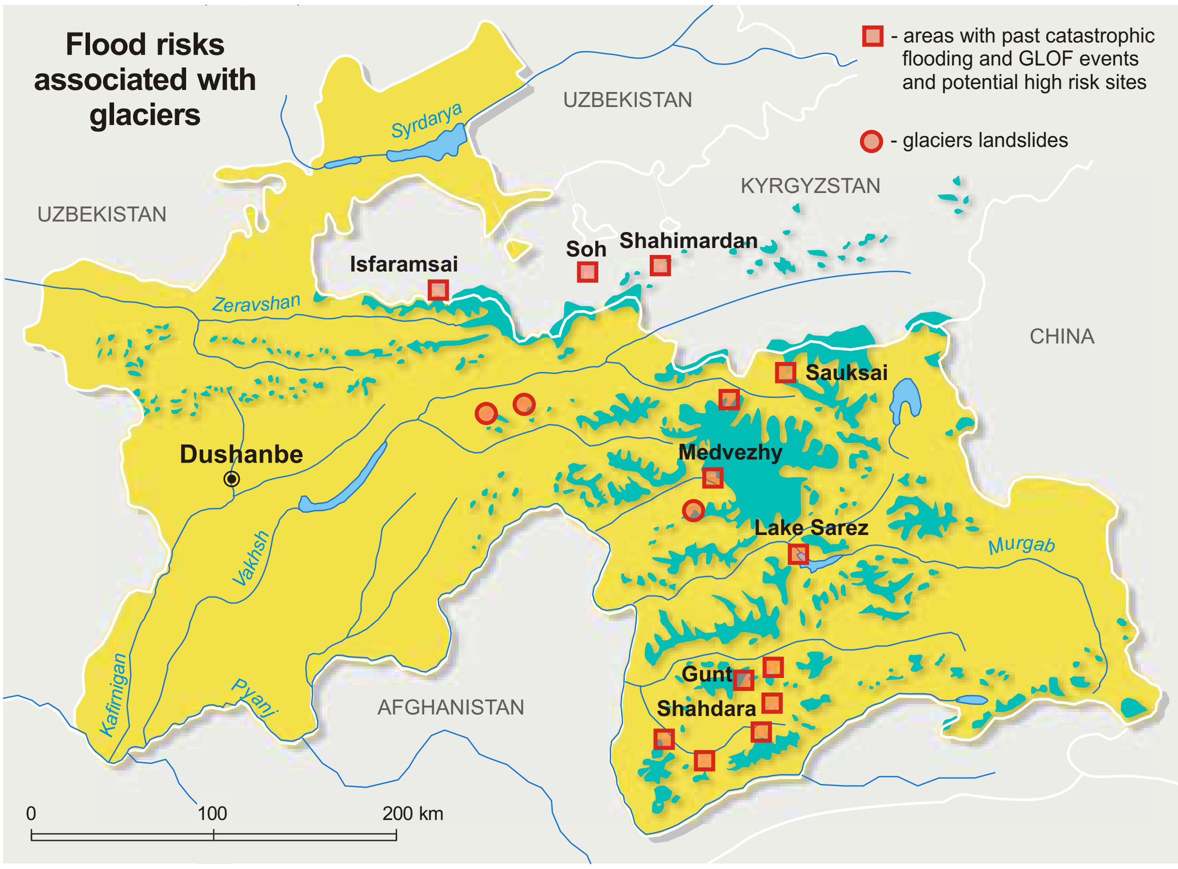
Fogs. Fogs are rare phenomena in Tajikistan. For the last 10-15 years there is a trend in the increase of the number of foggy days in the Tajik part of the Fergana Valley (Khujand). This is probably due to the influence of regional circular processes in the atmosphere providing for advection of warmth over radiative-chilled air.

Mud flows and glacial lakes outburst. According to observation data, the period of 1998-1999, along with the year 1969, was the rainiest one. The amount of mud flows occurring as a result of heavy precipitations significantly increased. The mud flows of spring 1998 destroyed 7 thousand houses and took lives of more than 130 people. There were almost no mudflows in the arid period of 2000-2001. Floods which occurred in Zerafshan river basin in 2002, 2003 and 2005 washed away houses, infrastructure, and caused human fatalities. Due to the increasing rate of summer temperatures in the mountains, there is a risk of mud flows of glacial origin because of fast melting of snow (Fig. 3.7). In 2001 another motion of Medvezhiy glacier was observed. It occurred without creating a glacial lake, which in the past had caused dramatic floods alongside the Vanj river. In 2007 RGO glacier considerably retreated which might have resulted in blocking the Vanj river and creation of a glacial lake. The breakthrough of the glacial lake and mud flood in Roshtkala district of Pamir in 2005 resulted in 25 human fatalities and damage to property.

3.1.5. Dynamics of aridity and droughts

Drought is one of severe meteorological phenomena and in its extreme occurrence it can cause a significant damage to property. According to evaluations the drought of 2000-2001 in Tajikistan was the most devastative natural disaster for the last decade (Fig. 3.8). In lowland arid regions of the Amudarya river basin (e.g. Karakalpakstan), the access to water reduced by 2 times with many agricultural field crops and households being limited the resources. This caused many catastrophic consequences to the economy and local residents. In light of climate warming, the drought assessment and regular analysis plays a crucial role in long-term prediction of the drought years and ecological cooperation. At present the greater part of the territory of Tajikistan is included into arid and scantily moistened zone. Only separate mountainous areas are situated in the moistened climate zone. Particularly arid territories of the country are the Eastern Pamir, lowland areas of Sogd Oblast and southern Tajikistan (there annual amount of precipitation is less than 100-150 mm). In summer arid conditions are predominant almost on the whole territory of the republic.

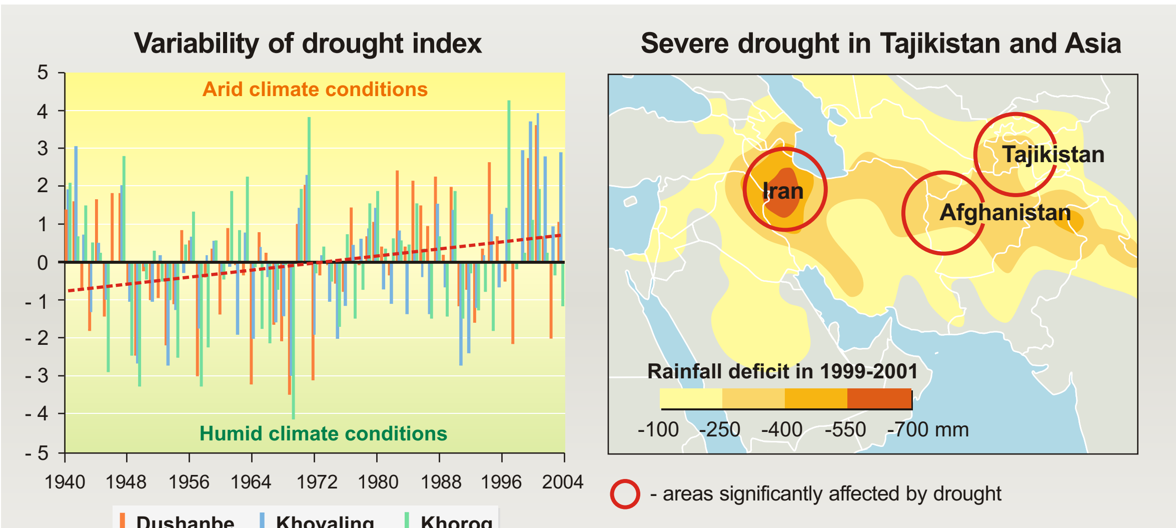
As a rule, absolute droughts are observed as separate hotbeds, and severe ones embrace big territories. During the period studied (60 years) in eight cases the droughts simultaneously covered the



Source: State Administration for hydrometeorology

Fig. 3.7.

whole territory of the country (in 1940, 1947, 1956, 1971, 1980, 1988, 2000 and 2001). Especially severe droughts were in 1971, 2000 and 2001. In 2007 the summer and autumn period witnessed extreme lack of atmospheric precipitation, which caused soil drought. The southern regions of the country and Gissar valley, where the greatest number of years (15-19) with average and severe droughts are observed, particularly suffer from droughts. Therefore, it is prognosticated that droughts in Tajikistan will occur more intensively and frequently in future.



Source: State Administration for hydrometeorology

Fig. 3.8.

3.1.6. Climate change forecasts

The previous models of the global climate change (IPCC 2001) to some extent underestimated the prognosis of the temperature increase for the perspective of 50-100 years. The most recent assessments of IPCC (2007) show that increasing global emissions of GHG will facilitate the increase of temperature for 2-6ºC depending on intensiveness of emissions and geographical position of regions. Even if GHG emissions stabilized at the year 1990 level, increase of global temperature by 0.6-1ºC will be unavoidable. It is considered that increase of temperature beyond 2ºC will be having mainly adverse consequences for the environment and ecosystems, economy and public health.

Within the framework of the First National Communication the scenarios were elaborated on the basis of HadCM2, CCCM, GISS, GFD3 and UK- 89 global models using the reference period of 1961-1990, by 10 representative stations situated in different climatic zones and altitudinal belts of Tajikistan. Further the justification analysis of the data received with actual values for the period of 1991-2005 was carried out.

The comparative analysis of actual mean temperature for 15 years period of with model data shows that all models give conservative values. There are significant differences in precipitation forecast between actual and model parameters. The same model can reasonably prognosticate the temperature and, at the same time, give considerable inaccuracy in precipitation forecast for the same station. The key drawback of global models is their incapacity to take into consideration the local mountainous peculiarities of climate formation predominant in Tajikistan.

In order to give a more accurate evaluation of climate change trends untill 2030, with the use of modern computational modeling facilities the model ECHAM4/OPYC3 (Potsdam Institute for climate impact research, Germany) was applied. This model takes into account the response of regional climate to global warming and the impact of two factors: fluctuations of global climatic parameters (turbulence, wind speed, temperature, atmospheric humidity, etc.) and geographical peculiarities (topography, area elevation above sea level, etc.)

According to the model ECHAM4/OPYC3 statistical estimations, the increase of mean annual temperature by 0.2-0.4ºC (0.1-0.2ºC in decade) is expected in most areas of Tajikistan by 2030 in comparison with the period 1961-1990,; this trend coincides with tendencies predominant in the country for the last 15-20 years. The maximum increase of temperature is expected in winter: by 2ºC and higher. In some areas the reduction in precipitation can be observed (Eastern Pamir, south lowlands), whereas in others (Western Pamir) one can witness just the contrary. The different distribution of precipitation of such kind is related to the significant spatial fluctuation of atmospheric precipitation and impact of topography which intensifies it and causes more uncertainty in forecasting of precipitations expected on the territory of the republic in the long-term prospect (Fig. 3.9).

3.2. Impact of climate change on natural resources

3.2.1. Glaciers

Glaciers of Tajikistan occupy about 6% of the territory of the country and play an important role in forming Amudarya River, the biggest water "artery" of the Central Asia and Aral Sea Basin (Fig. 3.10). In the region, which is characterized by arid climatic conditions, continuous impacts of climate change may trigger the glacial volumes and water flow and availability, which plays a vital role in the water supply for the downstream regions and countries. Annually melting of the glaciers in Tajikistan brings 10-20% of water into the flow of the large rivers; during dry and hot years this number can reach 70%. Water has a crucial importance for agriculture, hydropower engineering and other economic sectors of Tajikistan. Moreover, water resources formed in Tajikistan are utilized mainly by the countries situated downstream. Therefore issues concerning the state of glaciers and water level in the rivers, and climate change impact on them, are of importance for the whole Central Asian region.

The warming rates in the high altitude areas of Tajikistan, particularly Pamir, Zeravshan and Pamir-Alai correspond to the regional and global trends and cause significant changes of glaciers, one of the most vulnerable ecosystems. The impact assessment showed that during the whole period of instrumental observations (since 1930s), the glaciations area of Tajikistan decreased by around 1/3 (Fig. 3.11)

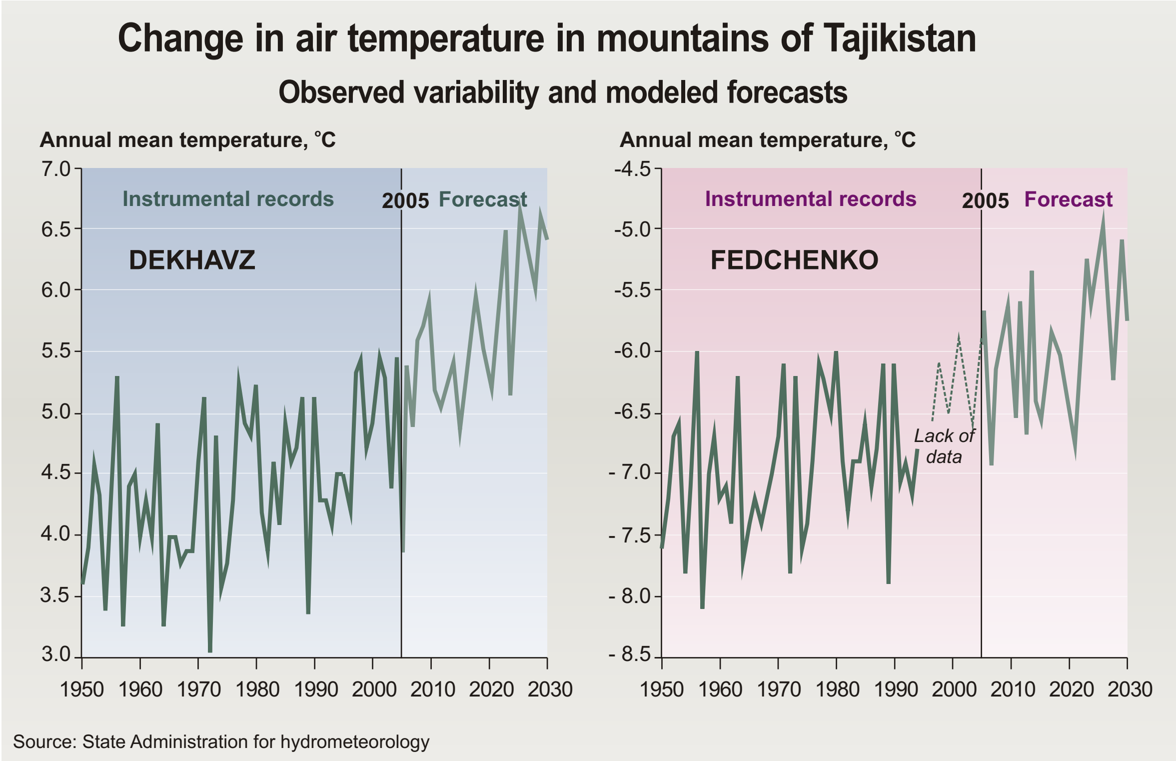


Fig. 3.9.

Northwest Pamir. The system of the Fedchenko glacier lost the thinnest and side parts of its tributaries, whereas; the main accumulated glacial mass decreases much slower (Fig. 3.12). Remote observations showed that within the period 1966-2000 the system of Fedchenko Glacier reduced for 44 sq.km, i.e. 6% of the total area. Later on, glaciological research of 2006 revealed that the average rate of the retreat comprised 16 m/year (Fig. 3.13). It is estimated that presently, the surface of the glacier in the bottom part sank for 50 meters in comparison with 1980, i.e. the glacier "growing thin". Moreover, the terminus of the glacier retreated for 1 km since 1933 (Fig. 1.13). The degradation of other glaciers: Fortambek, Sugran, Mushketov also took place in the Muksu river basin; as well as glaciers in upper reaches of Sauksay and Balyandkiik. In 20th century Bolshoi Saukdara glacier where Sauksay originates from, retreated for 2 km. Almost all other glaciers in Sauksay upper reaches are of surging type that's why it is difficult to consider their degradation.

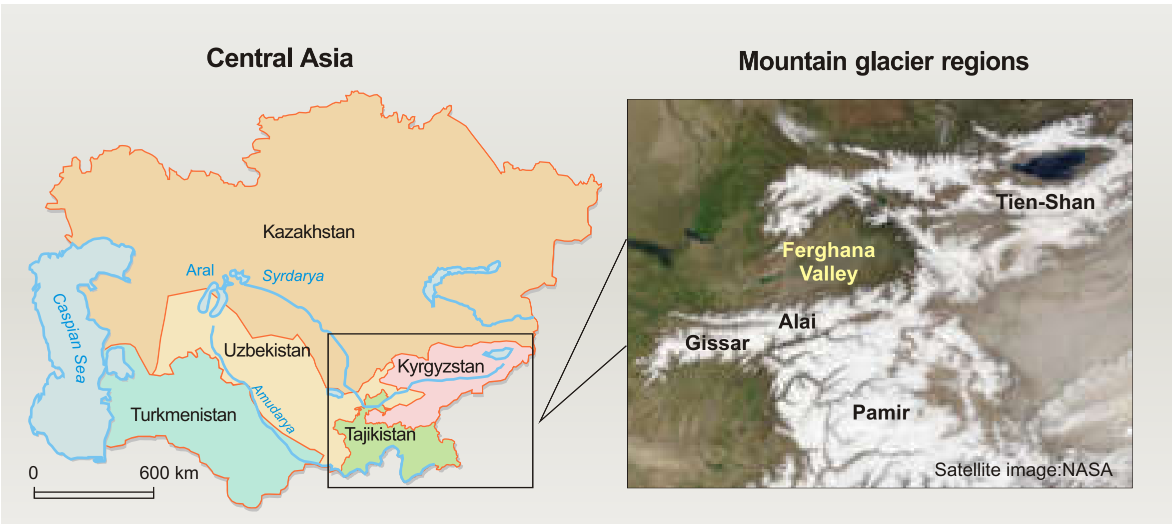


Fig. 3.10.

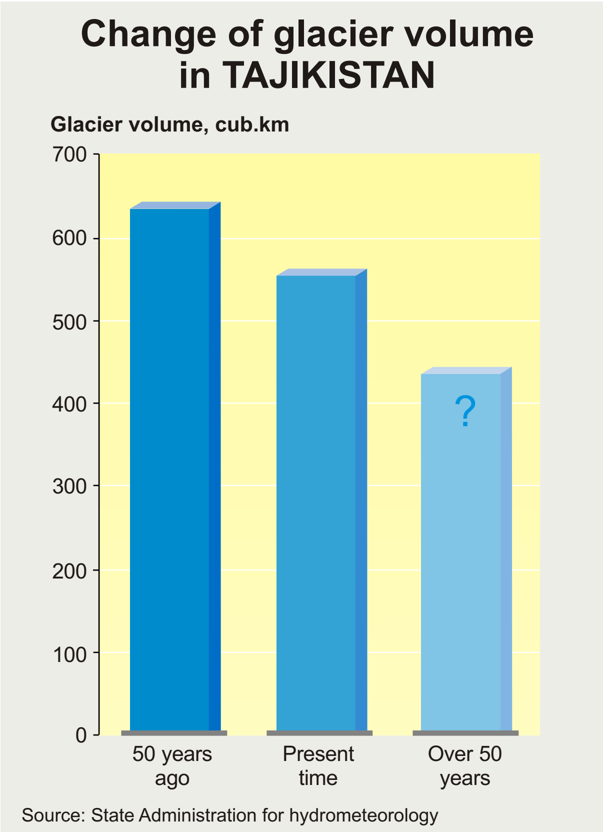


Fig. 3.11.

Western Pamir. During the last 50 years the glaciations area in the basin of Vandj river reduced by more than 25-30%. During glaciological observations in 2005 it became evident that Medvezhiy, surging glacier, retreated from Abdukagor river by 70-80 meters; its surface sank greatly, and large gaps appeared around its two protrudent ice cliffs meaning that more ice melts than comes in from the top accumulation zone of the glacier, i.e. meaning that the glacier "reduced".

Eastern Pamir. In view of more severe and cold climate the glaciations degradation in the Eastern Pamir takes place less intensively than in all other mountainous areas of the country. According to the observations of 2005 Akbaital glacier tongue located not far from Akbaital pass retreated for 15 m. since 1986, and its right edge retreated for 40 meters. Average intensity of retreat constitutes, as before, 1-2 m. per year. The five small glaciers within the area of the Lake Sarez are by now completely disappeared. During the second half of the last century all glaciers of the Murghab river basin depleted by 30-40%.

Obihingou river basin. For the last years the Garmo glacier dramatically sank and is morained with continuum retreat , and breakage into pieces and blocks. From 1932 (when the first mapping data of the glacier occurred) to 2007 it retreated for 7 km long, which is the most significant retreat among the largest glaciers of Central Asia (retreat speed:100 m. per year). The evidence of Garmo retreat, which has been observed in the beginning of the 20th century, is shown on the Fig. 3.14. The Skogach glacier is significantly degrading in the bottom part, however no changes are observed in its upper reaches. Batrud glacier situated nearby retreated by approximately 1 km, and the maximum degradation rates for both glaciers were observed last years (Fig. 3.15).

Left bank of the Pyanj River. On the left bank of Pyanj glaciers are situated in Afghani Badakhshan (mountain ranges of Safedi-Khirs, Kuhi-Lal, etc.), Gindikush and Vakhan mountain range. Left-bank river inflows constitute up to 15-20% of the annual flow of Pyanj. Afghanistan is situated southward of Tajikistan, therefore, degradation of glaciers in Afghanistan is more intensive. According to evaluations made in 1950s the glaciation area in Afghanistan was 4240 sq. km; by 1985 it reduced for 1000 sq. km and at present glaciations degradation exceed 50%.

Gissar-Alai. The Gissar-Alai glaciers vary in degradation depending on the elevation, exposition and relief; but as a whole a trend for area reduction by 1% per year is observed. In summer 2006 the glaciological expedition examined some glaciers of Gissar mountain range. It was found out that Yakarcha, a small glacier in Varzob tributaries, almost did not change for the last 18 years, the GGP glacier in Iskanderkul basin retreats by 3 m. per annum, and the Diahandara glacier (1 sq.km) in Karatag upper reaches totally disappeared. Only traces of moraines and dust are left instead.

If the present rate of the glaciers degradation is retained, one will witness many small glaciers of Tajikistan totally disappeared in 30-40 years. Glaciations degradation can affect mainly river regimes of Zeravshan, Kafirnigan, Karatag, Obihingou. The glacial area can reduce, in comparison with the present, by 15-20%, and water stocks by 80-100 cub.km. But still large glaciers and glacial knots will be retained. It is expected that the glacial inflow to the Pyanj, Vakhsh and generally, Amudarya River will probably increase (due to

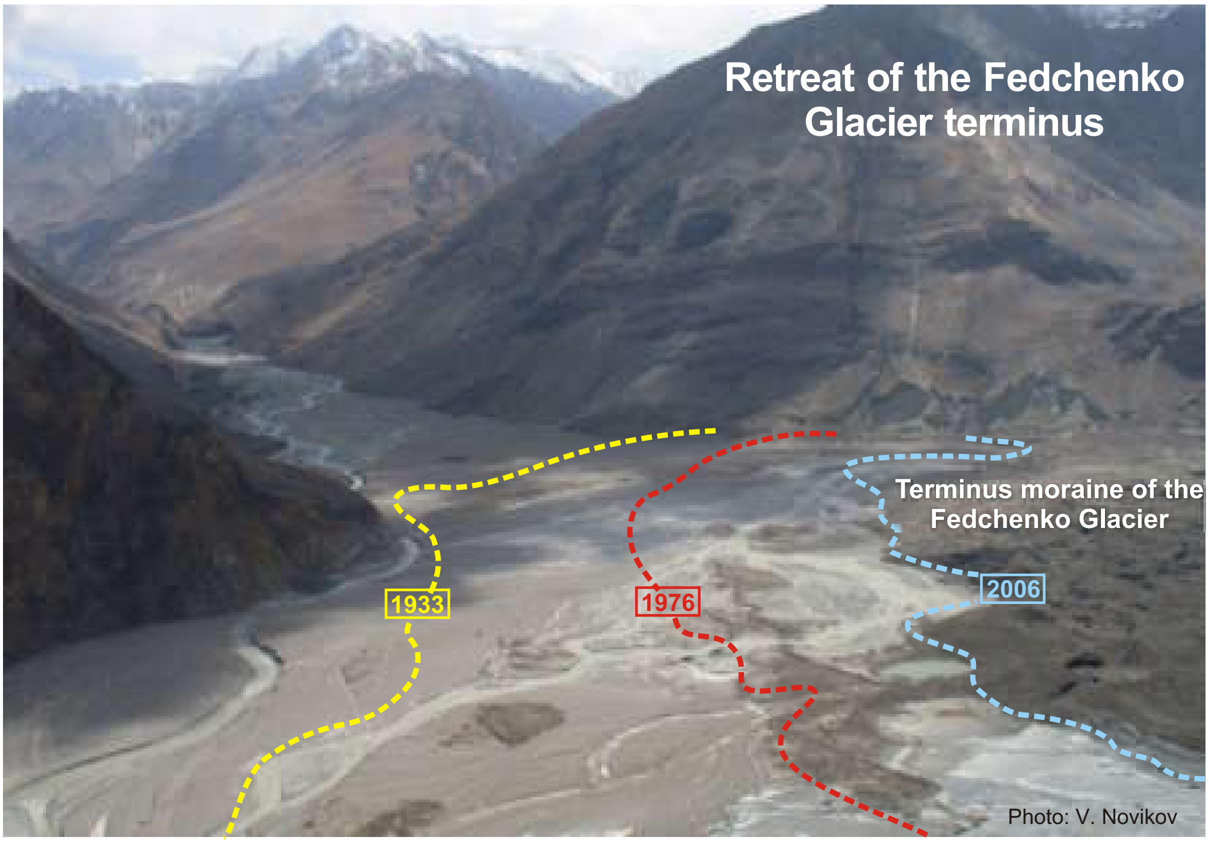
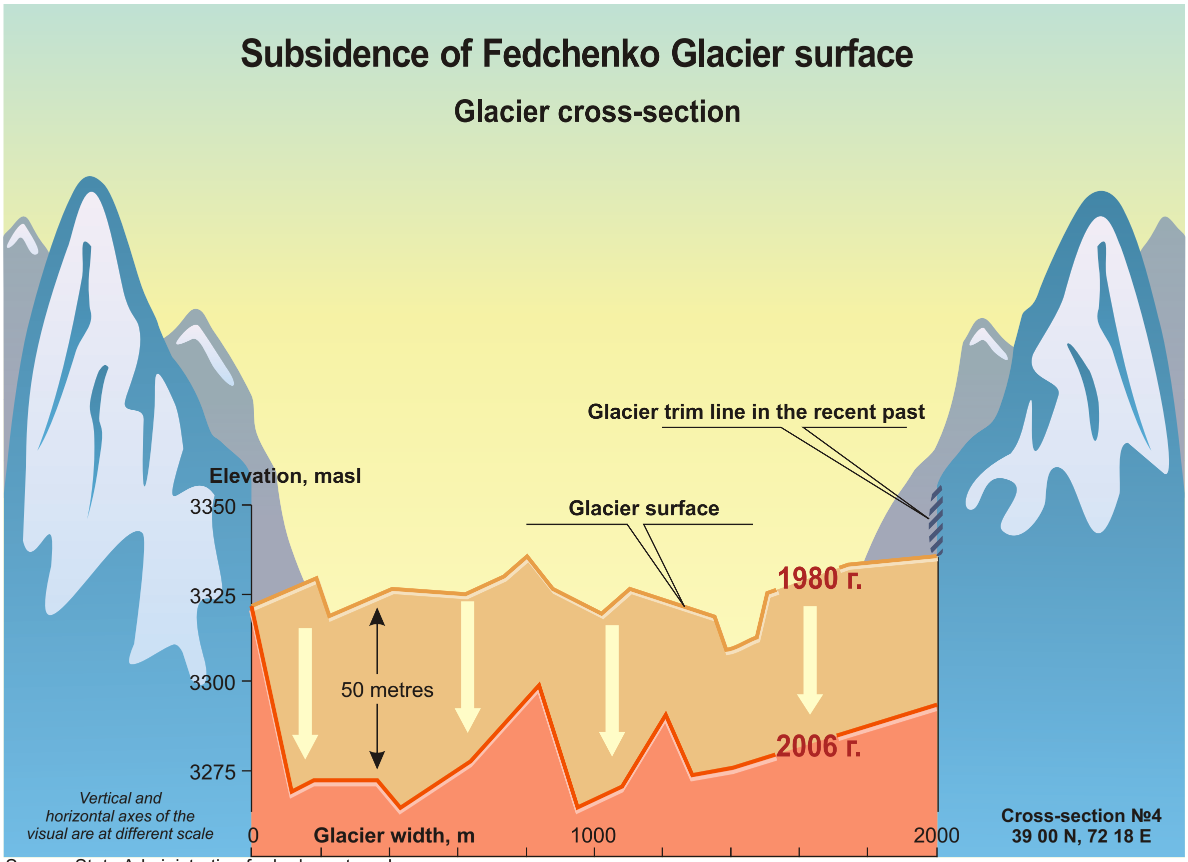


Fig. 3.12.

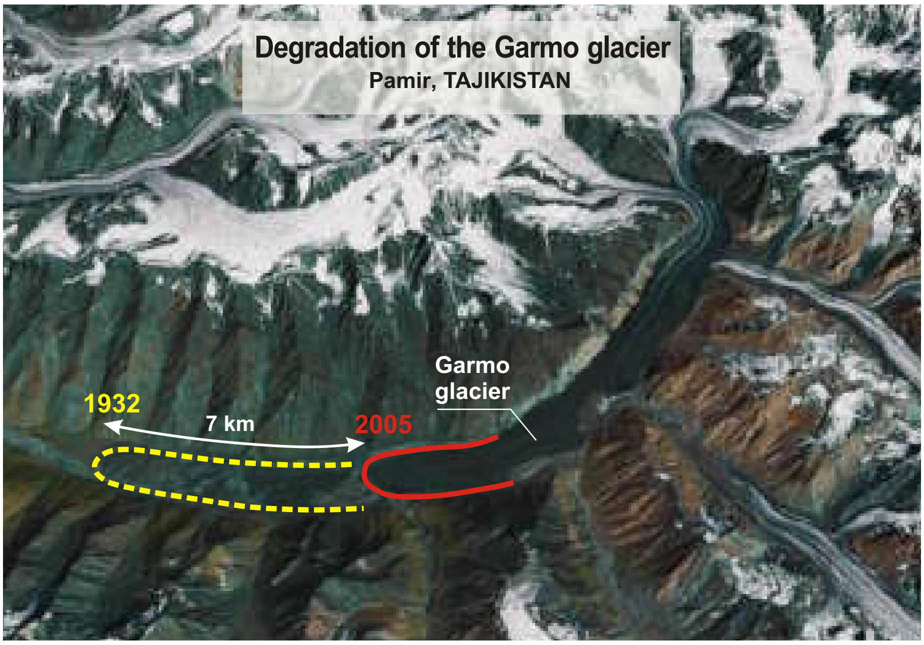


Source: State Administration for hydrometeorology

Fig. 3.13.

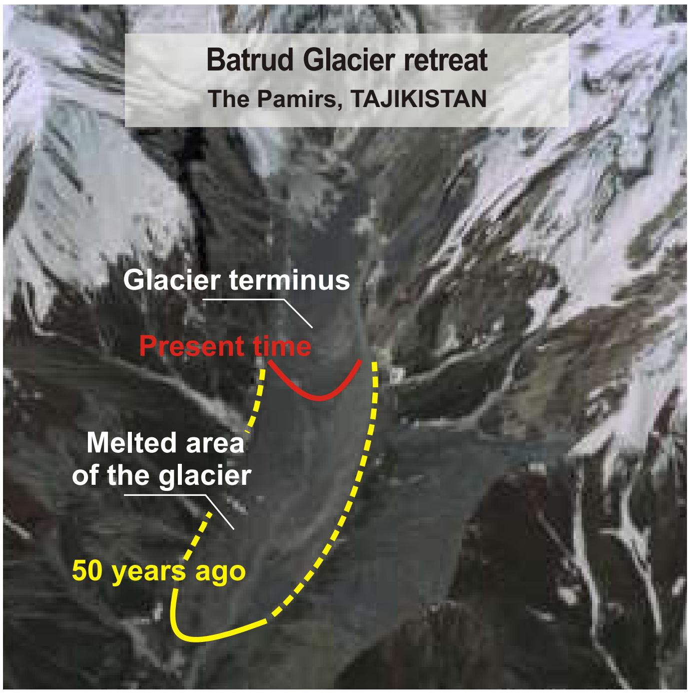
intensive melting of mountain glaciers), and then, in the long-term perspective, dramatically decrease due to the glacial deficit. Adverse impact of climate change on hydrological regime of the vital rivers of Tajikistan can have serious consequences for the definite ecological communities at local and regional scales.

Due to climate warming the freezing period will reduce in high mountainous lakes: they will freeze over later and melt earlier. Taking into account the degradation of glaciers and decrease of atmospheric precipitation the surface water flow will probably reduce and, accordingly the area of Rangkul, Shorkul, Sasikkul lakes in the Eastern Pamir can reduce as well. Increasing rates of the glaciers and snow melting in summer is most probably continue, which will cause the risks of the glacial lake outburst in high mountains. As a result they could lead to potential



Source: Tajik Agency on Hydrometeorology   Image: Google Earth

Fig. 3.14.



Source: State Administration for hydrometeorology   Satellite image: Google Earth

Fig. 3.15.

mudflows and floods. Other glacial lakes, due to their natural filtrations and surface evaporation, are far likely cause any significant hazards. However, accumulation of the melting water in the body of glaciers as well as in the bottom side, increases the capacity of their retreat, collapse and degradation.

3.2.2. Water resources

The large river basins of Tajikistan differ by the elevation of water encatchment, degree of glaciations, river inflow conditions (Fig. 3.16). The rivers of various nutrition types have two periods in their annual flow: spring-summer overflow and autumn-winter low water. Around 60-90% of annual flow runs through during overflow period.

Upon consideration of river flow dynamics by decades the general trend of flow decrease was disclosed in the period of 1971-80 in the rivers of snow-ice nutrition type by 11-14% and in the rivers of snow-rain nutrition type by 8-21%. During the next decade of 1981-90 the flow volume in the rivers of ice-snow nutrition slightly decreased (by 1-10%); the flow volume in the rivers of snow-ice and snow-rain nutrition increased (by 5-25%). The average annual flow volume for the period of 1990-2000 increased in comparison with the previous decade due to increased precipitation (particularly in 1990-93 and 1998-99), air temperature and intensive melting of snow and glacial reserves. The period of 2000-2001 was characterized by the regional drought. The later decades witnessed relatively limited accumulation of snow reserves in high mountains.

Remote observations showed that since 1983 the upper stream of the Amudarya river basin had been witnessing significant decrease in atmospheric precipitation. The periods of 1992093, 1995, 1998-99 are among a few exception cases. However, independent estimations of the Hydrometeorological services of Tajikistan and Uzbekistan made clear evidence that the increase of water availability in the Amudarya river is unlikely to link climate change processes. On the contrary, it is expected that global warming will facilitate the decrease of the river runoff by 5-15% in the long-term future.

Hydrological observations of the vital rivers of Tajikistan showed that inter-annual fluctuations of the river runoff increased with prevailing dynamics of the surface flow reduction. However, the decrease in regular hydrological observations since 1994 and data gaps for the last years make serious challenges to produce unambiguous research results on the state and rate of the water resources.

The Vakhsh river, where major hydropower plans, reservoirs and irrigation infrastructure are located, witnesses decrease of the of the water flow during the period when lesser amount of snow accumulates on glaciers; alternatively, it increases with increase in snow stock. However melting of glaciers is still more important for the Vakhsh flow than melting of snow (Fig. 3.17). Water flow in the Varzob river, which is most significant for Dushanbe water supply, is closely linked with snow stocks and precipitation patterns in high mountains.

Analysis of water content in rivers (Dagana station) and climatic fluctuations in the high-mountainous zone of Varzob river basin (Anzob pass station) displayed a trend to river flow reduction as a consequence of decreases in snow stock. This was especially evident in the latest decades (Fig. 3.18). However, in the last 5 years the water flow in the basin was stabilized, sometimes being even higher. Taking into account that the intensity of rains increased, an opposite trend is observed on Yakhsu river (south stream), which is mainly of snow-rain inflow type and is situated in the south of Tajikistan. On Yakhsu the flow increased predominantly due to

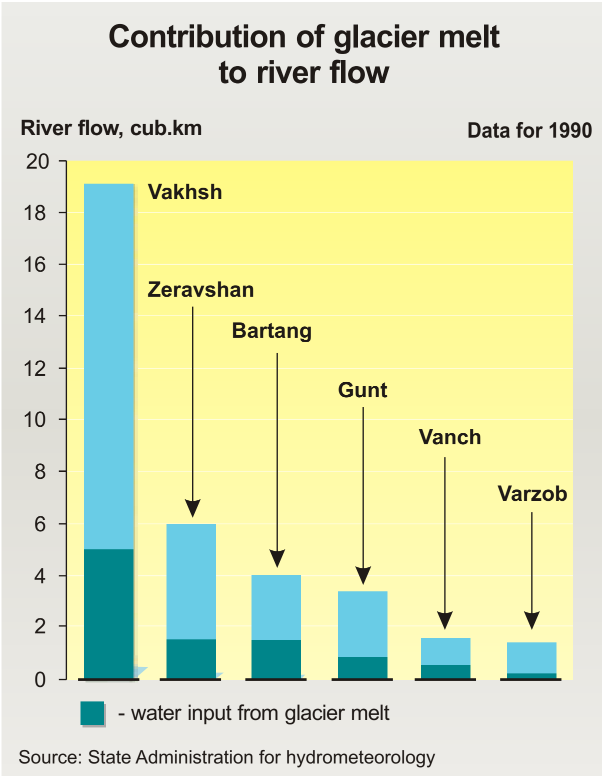


Fig. 3.16.

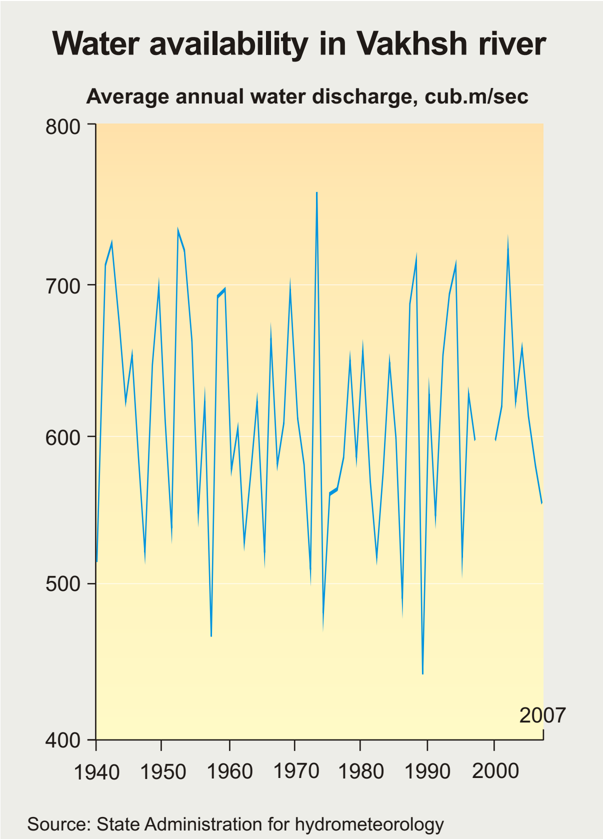


Fig. 3.17.

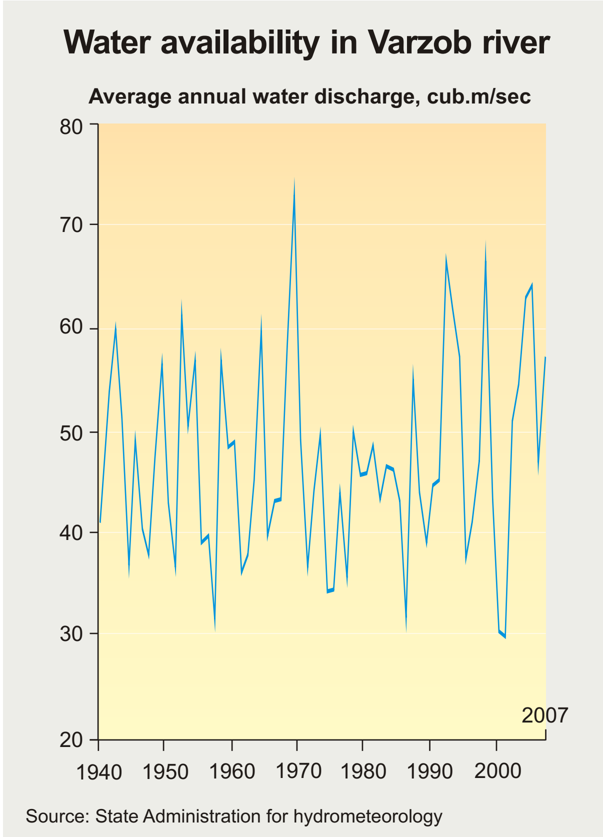


Fig. 3.18.

intensification of floods in spring. On the contrary, in 2008 the river flow in summer considerably reduced, resulting in water shortages experienced by farming areas in the lower reaches of the river.

Fluctuations of water level in the largest altitudinal closed Lake Karakul in Tajikistan (modern estimations of the area: 400 sq.km) are linked with climate change in the Eastern Pamir (Fig. 3.19). The increase of water level occurs, though precipitations reduce; such increase of water level takes place with intervals for 120 years already. The increase of water level is the result of water inflow into the lake due to the increase of atmospheric temperature in summer, melting of ice mound in the Valley of Muzkol River and glaciers. As a result of this increase of water level a peninsula in the central part of the lake was separated by a channel and turned into an island. The comparative analysis of bathymetric and cartographic lake survey indicates the increase of water level in the lake by 10 meters starting from 1880 (researches of Shemanovsky and Dankov). Since 1969, when hydrometeorological service started instrumental observations of the lake, up to 1990, the increase of the water level constituted more than 2 meters. The limited observation data for the recent years reveals the highest water level. In 1977 the area of Karakul Lake constituted 379 sq. km, and in 2007-2008 400 sq. km.

The nature and paleoclimatic investigations (samplings of bottom sediments, littoral deposits and adjoining glaciers) to determine the long-term climatic fluctuations were conducted on Karakul lake within the framework of expedition devoted to the International Polar Year in Tajikistan in July 2008.

The reduction of the area and water level is observed on small closed mountainous lakes of the Eastern Pamir: Bulunkul, Shorkul, Rangkul and Tuzkul. This fact is supported by field observation data for high mountainous ecosystems of Pamir as well lake ecosystems. Reduction and drying up of lakes has a significant impact on natural cycles. Thus migrations and breeding colonies of bar-headed geese on above mentioned lakes are observed much rarer in comparison with the past.

The level of the Lake Sarez in the mountains of the Western Pamir, containing 17 cubic km of fresh water and notorious for possible failure of its natural dam, remains stable and relatively increases in spite of the extending filtration from the lake and reduction of

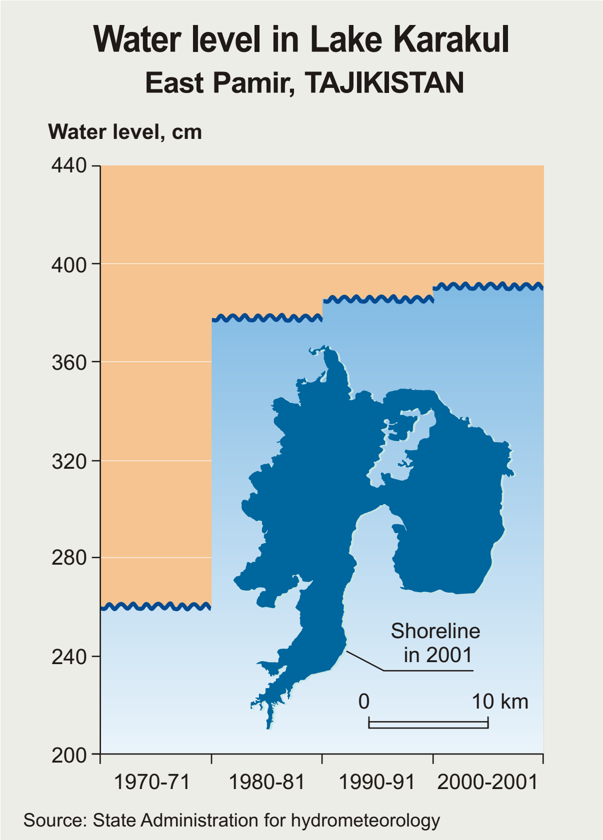


Рис. 3.19.

precipitation in the upper reaches of the basin (Fig. 3.20). The threat of the dam failure of the Lake Sarez is posed both by uncontrolled filtration processes and by overflow over the debris crest resulted from possible slope failure and wave formation. The highest water levels in the lake since its formation in 1911 and stabilization in the 1940s were observed in 1994 and 2005. Seemingly, melting of glaciers and increasing surface flow are the significant factors for increase of the water level (Fig. 3.21). For the last 50 years the area of glaciers reduced for as much as 20% in the water course of the lake basin. However taking into account the lack of data on hydrological regime of the lake it is difficult to give a comprehensive evaluation of fluctuations of the lake levels and reasoning behind.

The water level slightly increased during the last 50 years in the Lake Iskanderkul of the Central Tajikistan. Such phenomenon is probably caused by the increase of surface flow. Field surveys of the glaciers in the basin of the lake in 2006 showed their considerable retreat, which will, undoubtedly, influence the water inflow at present and in the future.

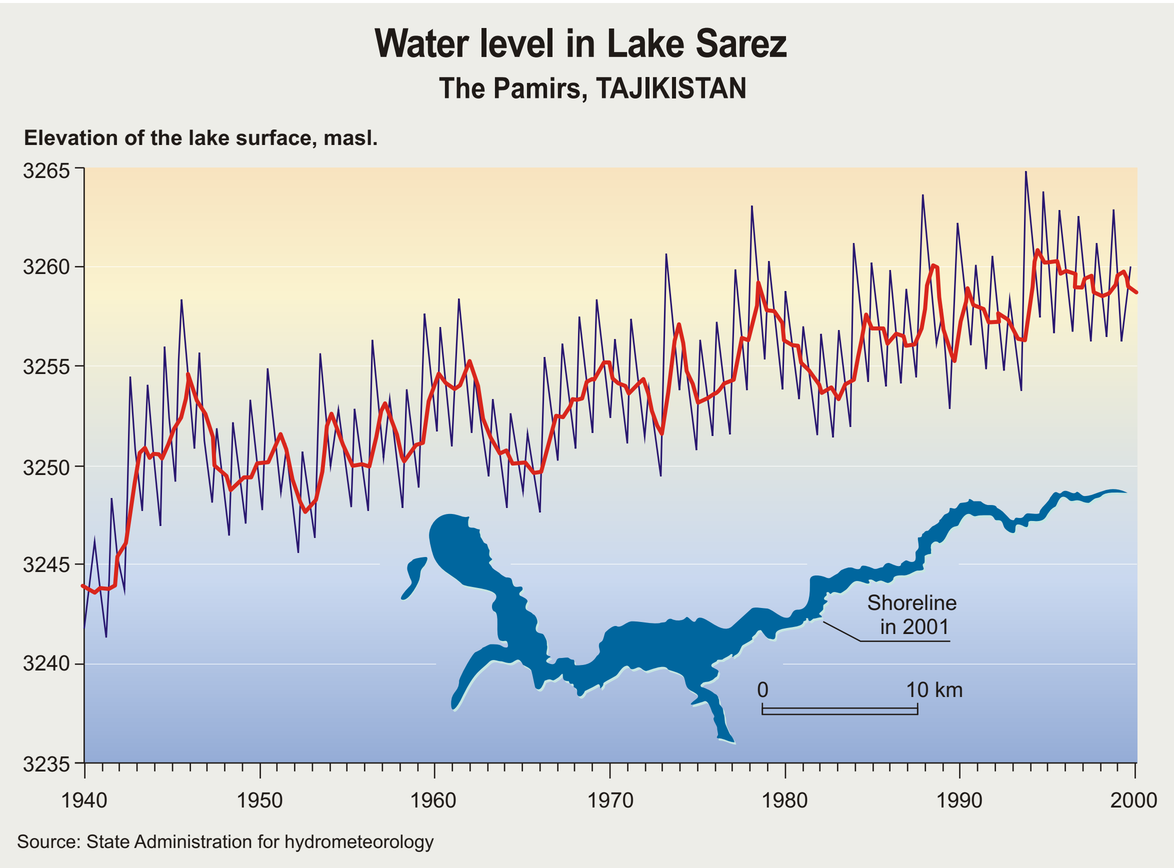


Fig. 3.20.

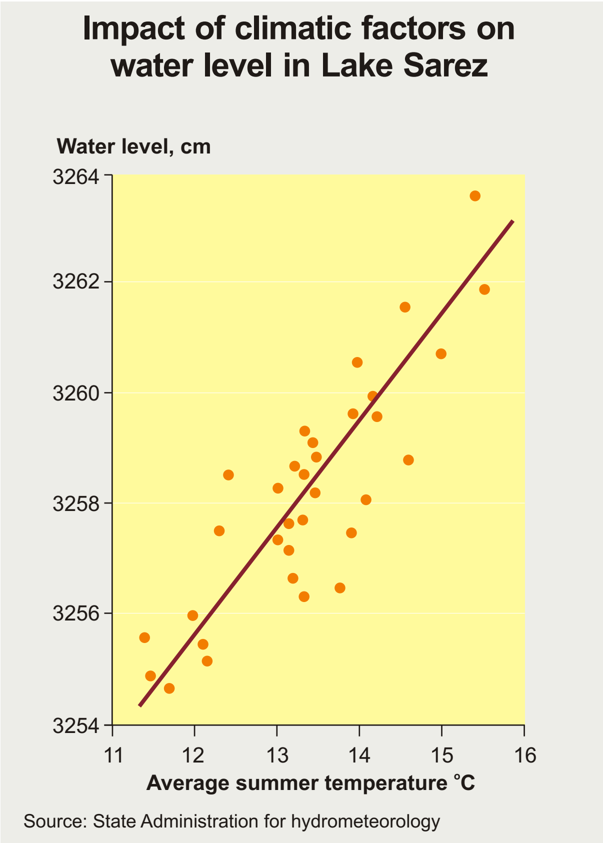


Fig. 3.21.

3.2.3. Natural ecosystems and forest resources

Tajikistan as a mountainous country has a unique mountainous fauna greatly influenced by glaciations of Pamir-Alay and climate change during glacial and interglacial epochs. The diversity of ecosystems in Tajikistan provides unique opportunities to research climate change in various altitudes and climatic zones of the country.

The most sensitive climate change environmental indicators were selected and analyzed with application of long-term observation data, making use of international research practices: 1) high altitude ecosystems and rare species of flora and fauna, 2) outbreaks of insect populations (pests and alien species), 3) water ecosystems and ichthyofauna, 4) forest resources.

3.2.4. Natural ecosystems and species

Out of five natural ecosystems Tajik Depression, Badakhshan, Gissar-Alay, Western Tien Shan and Central and Eastern Pamir, reviewed in the assessment of the fauna vulnerability to climate change, the last three relate to the most vulnerable ones.

Impacts of climate change on the fauna can be exemplified by reduction of habitats and extinction of Marmota menzbieri population, endemic of the Western Tien Shan, high altitude area of the Kuramin Range, in 1980-90s. The usual habitats of this marmot were high altitude meadows, with many snowy areas and springs, providing moist to the surrounding vegetation in summers, these big rodents feed upon. Warming of the climate caused melting of the snowy patches, being one of the main reasons for extinction of Marmota menzbieri population in the Northern Tajikistan.

The climate change differently impacts various groups of the insects. It is possible that current climate change will cause extinction of some species, shrink the areas of their distribution, and influence numbers of generations and lifecycle. Climatic fluctuations in many ways determine an outbreak in the insect population and their lifecycle. It was noted that habitats of some poorly adapting families of endemic representatives of butterflies such as Appolo can shrink due to climate aridity and increase in the area of semi-savanna ecosystems.
Fishes are very vulnerable to the climate change impacts such as increase of temperature in the water reservoirs and changes of hydrological regime. Some species of fishes are especially sensitive to changes of the environment. It influences their spawning areas and migration routes. Increase of temperature in the water reservoirs can negatively impact the existence of such cold- loving species like Amudarya trout and coast rainbow trout (Salmo gairdneri), Siberian peled, etc. The water temperature above +28°C causes their mass death and cease in reproduction. The water temperature is of great importance for spawning as well. The spawning of many valuable fish species is adversely affected by high temperature and deficiency of water.

The thermal regime of the Nurek water reservoir on the Vakhsh River, the largest reservoir in Tajikistan, depends on fluctuations of water levels, temperature of environment and water content. The water in the reservoir warms up in March, with surface water temperature increasing from 12-13°C to 25-28°C in July-August. The water in the reservoir reaches its highest levels in April-October and decreases in November-March, down to 60 meters. From the moment the reservoir was filled in (1973-1982) up to

now the composition of fish yield changed significantly: common marinka (Schizothorax) constituted 40% till 1977, Samarkand khramulya (Varicorhinus) dominated (up to 60%) during 1977-1984, and by 2002 yield of these fish species reduced to 9-19% only. They were extinct due to invasion by alien species. One of the main reasons for reduction of the population of fish species which is valuable commercially in the Nurek water reservoir is a sharp increase in the stripy bystranka (Alburnoides) population. There is an assumption that water warming in the Nurek reservoir caused unfavorable ecological conditions for cryophilic (cold-loving) fish species. Increase of temperature in the rivers, as well as flow changes can have a significant impact on population of trout and its migration routes.

Changes in weather significantly influence the populations of pest insects, and insects-carriers of dangerous infections. The mass outbreaks in the population of some pest species, for example of cotton worm, are observed during last years. In 2003-2005 an increase in the number of cotton worms caused reduction of the cotton harvest for up to 50% within the area exceeding 36 thousand hectares in the southern districts of Tajikistan (Kumsangir, Parkhar, Hamadoni). In 2000-2007 the area infected by locust (*Dociostaurus maroccanus*) increased from 16 thousand to 85 thousand hectares in the southern districts of Tajikistan.

The resilient species of animals are resistant to climatic changes, alien invasive species being of special interest. Several cases of adverse impact of the alien invasive species on the local fauna are observed in Tajikistan, when an increasing number of the alien species oppressed rare and endangered local species of flora and fauna with small area of habitats. Global warming coupled with change in their habitats can deteriorate this situation even more.

3.2.5. Forest resources

Out of five natural ecosystems Tajik Depression, Badakhshan, Gissar-Alay, Western Tien Shan and Central and Eastern Pamir, reviewed in the assessment of the fauna vulnerability to climate change, the last three relate to the most vulnerable ones.

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The climate change differently impacts various groups of the insects. It is possible that current climate change will cause extinction of some species, shrink the areas of their distribution, and influence numbers of generations and lifecycle. Climatic fluctuations in many ways determine an outbreak in the insect population and their lifecycle. It was noted that habitats of some poorly adapting families of endemic representatives of butterflies such as Appolo can shrink due to climate aridity and increase in the area of semi-savanna ecosystems.

One of the best indicators of climate change in the natural habitat of the deciduous forests is walnut trees *(Circassian walnut)*. Deciduous forests are located on the elevations of 1.2-1.5 masl in the Central Tajikistan with relatively humid climatic conditions. In the southern Tajikistan, where pistachio forests are predominant, Bukhara almond trees *(Amygdalus)* remain the most susceptible to climatic fluctuations. In riparian forests of the "Tigrovaya Balka" nature reserve the indicator species is bloomy poplar (Asiatic poplar), reacting on moist shortage in the soil and soil salinity. Juniper forests with the age of 500 years old and more serve as an indicator of long-term climatic fluctuations.

One of the most important indicators of forests is their density. With an average norm of 0.5-0.6 in 1990, share of the plantations with average density constituted 50%, but by 2007 it reduced to 20%. The main reason, first of all, is an adverse anthropogenic impact (cutting trees, stock grazing, and increase in the number of forest pests). According to expert evaluations, there is a trend to constant decrease of the forest wood reserve. If in 1990 it constituted 1.3 m^3 per person, in 2003 it equaled only 0.9 m^3 per person. The forest restoration activities are not enough for full-fledged restoration of the woodlands.

The total area of protected areas constitute 3.1 million hectares (22% of the territory of the country), out of it 2.6 million hectares are part of the Tajik

National Park, 173.4 thousand hectares are divided between four strict nature reserves, 313.26 thousands hectares belong to 13 nature reserves (zakaznik) and 6.8 thousand hectares constitute two natural parks. The protected areas with primeval ecosystems serve for research of climate change impact at the various altitudes and climatic zones of the country (Foto 3.2).

The increase of areas infected by pests is observed during last years (Table 3.1). The main pests of the wood species are: Turkestanian moths, pistachio seed worms, seedworms and silkworms. The walnut plantations suffer from marsoniosis of leaves and fruit pests, saxauls - from powdery mildew. The outbreaks of pest populations of the forest species have become frequent with increase of temperature. These outbreaks considerably reduce accumulation of carbon by the forest plantations. Statistical data shows that the forest areas infected by pests have increased throughout Tajikistan several times during last years. Many of the forests need urgent protective measures to be undertaken.

The forests of the southern Tajikistan are characterized by proneness to fires, especially during hot periods of the year (Table 3.2).. Pistachios, almond trees and tugai forests are those mostly endangered by the fires. During dry and hot years the risk of forest fires dramatically increases. These fires affect significant areas of forest plantations causing catastrophic damages. The main reason of forest fires is of anthropogenic character. The map (Fig. 3.22) illustrates the level of vulnerability of the forest resources to climate change.

The extreme weather events have an adverse impact on the forest plantations. For instance, in 2003 185 km forest roads were destroyed, 50 thousand planting stocks of forest nurseries damaged, 9 thousand fruit and forest trees damaged with total yield loss of the harvest constituting almost 70%, due to natural phenomena. As a result the total losses constituted 1.2 million somoni, while the annual state budget for the forestry sector was 600 thousand somoni.

The cold winter of 2007-2008 was a trying ordeal for the population and forestry of Tajikistan. The severe cold along with a shortage of electricity, gas and

Foto 3.2. Forest resources in Varzob valley .

Table 3.1

Area of pest outbreaks and forest diseases (thousand, ha)

Time period	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total affected area	13,9	11,2	11,3	10,4	12,1	13,9	13	6,1	10	12,2	45	115	117,8	123	120
Including leaf beetles	4	4	4	4	4	4	4,1	4	6	5,7	40	110	115	118	115
Response measures	8,7	6,5	6,6	6,8	6,9	6,5	6,1	6,5	6,5	4,5	5,6	7,4	7,5	7,8	8

Source: Committee for environmental protection

Table 3.2

Data on forest fires for the forestry fund of the Republic of Tajikistan

Indicators	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of fires	-	1	2	1	1	-	3	5	4	4	2	-	-	4	1
Area, thousands of ha	-	4	4	4	4	-	4,1	4	6	5,7	40	-	-	118	115

Source: Committee on Environmental Protection

other energy sources, forced the population to cut trees in the mountainous forests alongside the channels and settlements.

The continuous frosts heavily affected subtropical fruit varieties such as figs, and lemons, ornamental hardwood and softwood species (coniferous trees) even in the southern areas of the country (Shaartuz, Pyanj and Vakhsh districts). The persimmon trees, pomegranate trees and grapes were damaged almost everywhere in the country. The young plantings (5-7 years) of Eldar Pine, including those in the forest nurseries of the entire country, were severely damaged as well. Overall damage to the forestry of the country, caused by extreme climatic conditions, constituted above 2 mln. somoni. Many of the fruit plantations were restored by undertakiing appropriate measures in spring.

Zoning of forest areas in Tajikistan to climate change vulnerability

Source: State Administration for Hydrometeorology (K. Odinaev, A. Kayumov)

Fig. 3.22.

3.2.6. Land resources

The specific conditions of Tajikistan contributing to degradation processes in the soil cover are: semi-arid climatic conditions, high variability in the amount of precipitations, and considerable area of lands under degradation.

Water erosion and wind erosion of soils are observed in the Eastern Pamir and in the Northern and Southern Tajikistan. In the Central Tajikistan the soils are especially prone to water erosion due to heavy precipitations and rugged topography. The irrigational erosion is widely spread in the newly irrigated areas of valleys.

The nitrification ability of grey desert and brown soils is more pronounced if the temperature is around 20°C, but if the temperature is below 10°C or above 40°C the accumulation of nitrates in soils almost stops. The optimal temperature for nitrification of soils located at high altitudes constitute 10°C and increase of temperature to 20°C and more leads to dramatic reduction of the nitrification processes, and if the temperature increases above 40°C this process stops. Therefore climate warming can have an adverse impact, first of all, on soils located at high altitudes.

Irrigation as a whole more considerably impacts dehumification of typical sierozem (grey-brownish) soil compared with cinnamonic soil. Annual losses of humus on yearly-plowed dry tillage of cinnamonic soil constitute 3%, and on virgin soils the humification equals dehumification.

As a result of the erosion processes (Foto 3.3) the upper, most fertile horizons of the soils get destroyed causing establishment of ravines (gorges), which cause, in their turn, not only decrease in yields, but also reduction of agricultural lands.

Foto 3.3. Salinization of irrigated soils in South Tajikistan.

The sierozem (grey-brownish) soils formed on thick strata of aeolian soils are most vulnerable, since they are prone to subsidence if under irrigation, which, in its turn, hinders further irrigation of submontane lands. The biological activity of soils increases under impact of irrigation at high surface air temperature, and it boosts the dehumification processes thus decreasing fertility. This phenomenon is observed mostly on newly irrigated lands. With intensification of climate aridity, expansion of desertification processes poses a real risk to agriculture and requires measures to be taken.

The total area of saline soils and lands (solonchak) in the country constitutes 100-120 thousands hectares mainly spread in the south and north of the country. Due to salinity of lands, the country experiences losses of 100 thousand tons in cotton yields and other agricultural products, reducing the quality of these products as well.

3.3. Impact of climate change on economic development

3.3.1. Water resources and management

Tajikistan consumes about 20% of the water amount formed within the country or 10% of the average perennial flows of the rivers of the Aral Sea Basin (Table 3.3). Almost 40% of the water returns as a discharge and collector-drainage water. The specific consumption rate of water per person in Tajikistan constitutes about 1900 m^3 a year, which is less than the average world Fig. (2600 m^3 a year).

Introduction of the water tariffs, reduction of production volumes, change in the structure of and areas under agricultural crops, deterioration of the land reclamation status, availability of vacant irrigated lands and deficiencies in irrigation systems are major reasons for reduction of water consumption from 13.7 km^3 to 12.6 km^3 (8%) for the last 15 years. Currently the state of water consumption in the country is as follows: irrigated farming - 94%, household and agriculture water supply 3.2%, industry 2%, fishery sector 0,5% and other sectors 1%.

The efficiency coefficient of irrigation systems in the country as a whole is 55%, whereas farm-irrigational system capacity is 60%.. The watering norms fluctuate between 12 and 17 thousands m^3/ha (average irrigation norm of net weight in the country is 9 thousand m^3/ha, efficiency coefficient of irrigation systems 0.63-0.65 and accordingly, of the head water supply point for irrigation constitutes 14.5 thousand m^3/ha) depending on agricultural areas.

The dominating method of watering of the agricultural crops in Tajikistan is watering along furrows (98% of the total irrigation area), suitable for the level of mechanization of the agriculture. For rice, flooding irrigation is used on the area of about 12

Table 3.3

Water using on river basin and streams

Water carriers and consumption	2000	2001	2002	2003	2004	2005	Average for six years
1. Amudarya river basin, including:	9262,4	9256,6	9263	9475,2	9505,3	6867,7	8938,4
Pyanj	2556,4	2554,8	2556,5	2615,1	2623,4	1572,7	2413,2
Vakhsh	3334,5	3332,3	3334,6	3411	3421,9	3014,9	3308,2
Kafirnigan	3038,1	3036,1	3038,2	3107,9	3117,7	1909,2	2874,5
Surhandarya	314,9	314,7	314,9	322,1	323,2	370,9	326,8
Zeravshan	333,4	333,2	333,5	331,6	332,7	169,3	305,6
Kashkadarya	5,56	5,55	5,56	5,09	5,7	2,0	4,0
2. Syrdarya river basin, including:	2186,8	2185,6	2186,9	2237,1	2244,1	2934,2	2329,1
Isfara	288,7	288,5	288,6	295,3	296,2	387,3	307,4
Isfana	3,5	3,5	3,5	3,4	3,4	4,7	3,7
Streams	1160,1	1135,2	1195,2	1186,8	1190,5	522,3	1065,0
Total:	12609,3	12577,9	12664,9	12899,1	12940	9971,3	12277,1

Source: Ministry of agriculture

thousands ha (less than 2% of the total irrigation area), and drip irrigation is applied as an experiment, on the limited area (100 hectares) in the Sogd Oblast. The watering by sprinkling machines is not used due to high power input required.

Payment for water supply is collected from users at the level of 60% from tariff set and only one third of it is paid by money, the rest is paid by various agricultural products, i.e. on the way of barter. During 1992-2004 the funding for maintenance of irrigation systems constituted only 10% of the norm. Currently the length of irrigation channels between farms constitute 6 thousands km, out of which 39% are tiled with concrete or built as ferroconcrete flumes, while the total length of the irrigation network within agricultural sector constitutes 28 thousand km, out of which 35% are tiled with concrete, built as flumes and pipes. The total length of collector-drainage network constitutes about 11.5 thousand km, out of which about 4 thousand km are represented by blind drains in the internal network.

Such technical status of the channels between the farms and within the farms enables for water saving in irrigation. With increase of the efficiency of interfarm irrigation network by 10%, water saving will constitute around 1,0-1,4 bln. m^3, and extensive introduction of water-saving technologies will enable water-savings increase up to 2-2,5 bln. $m^3$of water.

It is expected that around 50% of needs in agricultural products will be covered through increase of crop productivity and increase of efficiency in agriculture, while the rest through allocation of additional land and water resources for farming. Hence, in order to satisfy increasing demand in food, it is planned to reclamate around 400 thousand irrigated lands in the nearest 15 years, involving 7 billion m^3 of water. To implement these plans, significant financial investments and labor will be required. Moreover, out of 718 thousand ha of irrigated lands under cultivation now, around 20% experience water shortage, and about 850 million m^3 of water is required annually, to supply this water demand. Thus, the reclamation of additional land and consumption of additional water is an open issue at this stage.

The assessment of climatic changes (surface air temperature, atmospheric precipitations, air humidity) on the territory of the country indicates a trend to warming, and the change in evaporability capacity is of particular importance for the water sector. During the last 30 years the area with

maximum seasonal evaporability extended, especially in summer and autumn, serving as an evidence of the increase in climatic aridity. The decrease of water level in some rivers is observed at the background of decrease in water reserves of glaciers and reduction in the amount of snow cover in the mountains. Also the irregularity of precipitations and river flows increased.

It is expected that biological needs of plants in water will increase for 1-10%, when the average annual temperature increases by 1.0-2.0◦C by 2030. According to forecasts, the amount of water in many rivers fed by snow, rain and glaciers will reduce in summer, thus the irrigated agriculture will experience shortage of water as well.

In the number of the areas underground water reserves can decrease due to reduction of surface water and precipitations. Accordingly, power inputs required for pumping up water by machines will also increase. Besides, due to increase of continuous rains, washout of soils and increase in rates of erosion processes, as well as increase of water turbidity in the rivers is expected, resulting in large depositions and drifts in the irrigation channels, basins, pump stations and sedimentation basins. The existing low efficiency coefficient of the irrigation systems, coupled with water shortage, can further deteriorate water related issues.

The need in cheap and clean energy constantly increases. The need in construction of hydropower stations and reservoirs increases in order to provide the required amount of water to the consumers, especially during dry periods. Considering climate change and socio-economic development trends, if new mechanisms and approaches in the area of integrated water resources management are not developed and introduced into practice, water-energy issues can aggravate not only in Tajikistan, but also within entire Central Asia. In this context the issue of financing technical maintenance is of great importance to provide water supply to consumers.

The vulnerability assessment of the hydropower sector to the climate change was mainly conducted on the Vakhsh River. The assessment revealed that changes in water level of the river for the last 70 years had insignificant impact on operational objects of hydropower. However, as a result of flood in 1993, the infrastructure of the Roghun hydropower station, which is currently under construction, was significantly damaged, while in 2002, a landslide damaged the Baipaza hydropower station dam. According to expert assessments, increase of precipitations only by 10% in the areas prone to water erosion can double the volume of sedimentation washed into the Vakhsh river, increasing accumulation of mud in the river.

Climate warming and increased risks of floods and mudflows raise serious concerns in relation to outbreaks of water-borne diseases. Currently only 52% of the population utilizes tap water, whereas the remaining 48% utilizes water directly from the rivers, channels, small irrigation networks and other water sources. Efficiency of the water treatment facilities does not exceed 40%, only 15% of the population uses sewerage system. Therefore, there is an urgent need to address this issue.

It should be noted that with increase of air temperature and intensive snow melting in spring, the frequency in occurrence of floods and mud flows increases as well. For example, a catastrophic flood caused by heavy precipitations, melting snow and temperature increase occurred on the river Pyandj in Khamadoni District in summer of 2005. The water table in the dam of the Chubek head reached 4 meters instead of usual 0.5-1 m, and water discharge increased by 3-5 times. As an evidence of extreme temperature increase, there were large blocks of ice moving with the flow alongside the river on the first day of flood, being a rare phenomenon for the Pyandj river basin. This 2005 flood resulted in considerable damage to the water economy and other infrastructure along Tajik-Afghan border costing about 50 million USD. The catastrophe attracted the attention of the authorities of both states and of international organizations: presently, a complex project on natural disasters risk management is being implemented.

3.3.2. Agriculture and agrobiological diversity

Agriculture in Tajikistan is the most important sector of the economy and source of population employment. This sector provides for about 25% of GDP of the country. The priority areas of agriculture are cotton cultivation, gardening, potato and grain crop cultivation, as well as animal husbandry. The total area of agricultural lands constitutes 4574 thousands ha, or 32 % of the total area of the country, with 739 thousand ha of arable land.

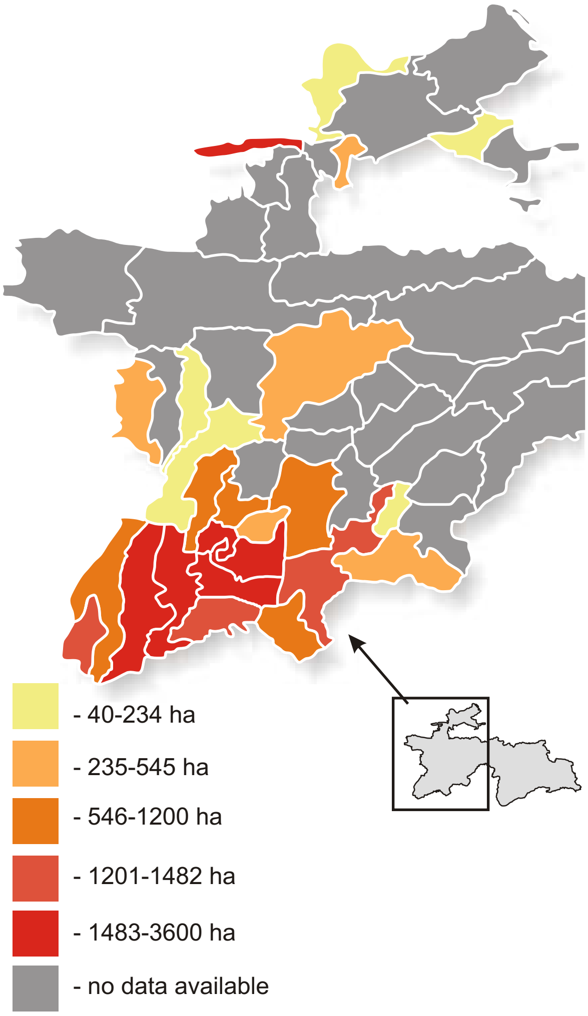
Heavy rains, high waters caused by mud flow, high air temperature accompanied by droughts, strong winds and dust storms, frosts and extreme cold temperature are those hydrometeorological phenomena causing the biggest damage to the agriculture (Table 3.4). The impact of climatic factors is observed in spring when precipitations cause formation of soil crust, wash out of crops, irreparable damage to agricultural products, particularly cotton. As for hail, it damages plants breaking the stems, thus reducing the quality and amount of yields.

To the bigger extent, crop yield depends on the choice of sowing time, properties of soils and temperature. Extremely high air temperatures and droughts suppress the development of plants, result in fires and contribute to desertification processes, reduce amount of waters to be used for agriculture, altogether causing economic losses. Low yields of cotton (14.1centner/ha) occurring in Tajikistan in 2000, were, most probably, related to drought which stroke significant parts of Central Asia in 2000-2001. The yield of grain crops during this period reduced in number of regions with irrigated farming by 30-40%.

The provision of food security, specifically production of grain and potato crops, is of strategic importance for the country. The yield in 2007 constituted of more than 1 mln. tons of wheat and 500 thousand tons of potato, which does not satisfy the needs of the country.

The pressure on agriculture, especially in the form of extreme hydrometeorological phenomena, will increase (Fig. 3.23). The greatest concerns are called by duration of droughts and outbreak of pests, which, as a rule, are of regional scale.

Replanting cotton crops in Tajikistan



Source: Ministry of agriculture (M. Ormonov), State Administration for Hydrometeorology (A. Kayumov)

Fig. 3.23.

Table 3.4

Extreme weather events losses

Name	Unit	Time period						
		1999	2000	2001	2002	2003	2004	2005
Cereal crops	Area thousand, ha	26,6	154,9	3,6	8,4	10,5	2,9	5,0
	Monet. loss, thous. TJS	1839,8	51035,3	1524,1	6767,9	3814,4	1724,8	2826,6
Cotton crops, including replanting	Area thousand, ha	13,4	11,6	3,2	12,9	16,8	3,2	6,4
	Monet. loss, thous. TJS	1526,0	3157,9	971,3	3365,7	3560,9	1117,8	5965,3
Total:	Area thousand, ha	81,3	268,1	343,3	39,1	50,5	12,0	19,4
	Monet. loss, thous. TJS	14294,8	87282,0	198937,4	31810,5	15538,0	7513,8	16370,7

Source: Ministry of agriculture

Taking into consideration that Tajikistan is one of the key centres for genetic diversity, and local population mostly depends on natural resources for food (fruits and berries of wild tree specied, productive pastures, medicinal plants), impact of climate change can increase the load and result in reduction of services provided by natural resources. Further research on impact of climate change on agrobiodiversity and adaptation measures need to be undertaken.

Apart from hydrometeorological factors, the yields of cotton, grain crops and potato in the country are impacted by:

- Large areas of irrigated lands managed by collective enterprises with old technical base;
- Debts of restructured farms transferred to the newly organized dekhkan farms;
- Lack of knowledge among farmers and rural population on their rights and privileges, best practices, market economy and technical progress;
- Shortage of necessary materials, micro-credits, property and resources to increase agricultural productivity;
- Lack of information and advisory centers.

Therefore climate change adaptation measures in agriculture should be integrated into sectoral reforms at national and local levels.

3.4. Impact of climate change on human health

The correlation assessment of the public health status and impact of climatic factors was conducted within the framework of the Second National Communication. The data on malaria and other infectious and non-infectious diseases, related to the hydrometeorological factors, were précised, and reproductive health sector was analyzed.

The dramatic increase of temperature and severe drought of 2001-2002 became key factors contributing to the increased death rates among population. The research revealed that, on average, annual death rates increased by 2500 people during the period from 2001 to 2003, with prevailing, although unequal, trend in the hot and moderate climatic zones. For example, population living in the Khatlon region with hot arid climate suffered more (mortality rates per 1100 people increased) than population living in the districts of the republican subordination (moderate climate).

Malaria was stopped as a mass disease in Tajikistan in 1956 and was eliminated in 1960. However, due to climate warming, starting from 1980 increase in the number of malaria cases was observed, reaching its peak in 1990-2000. It should be noted that temperature is a limiting factor in distribution of malaria. In Tajikistan the optimal temperature for reproduction of the main malaria carriers (An. superpictus, An. pulcherrimus) is +25°C to +30°C. It is known that probability of malaria outbreaks, when the source is available, is "high", if the number of the days with the average daily temperature above 15°C constitutes 120-150 days a year, and "very high" if this number is above 150 days. The vulnerability assessment shows that the increase of the mean annual temperature by 2-3°C would cause an increase in the number of days favorable for the reproduction of malaria mosquitoes. Hence, increase of the seasonal duration of "effective infections" up to 6-7 months, results in 6-7fold infection turnover. In such case, the number of infected people can reach more than 100-150 thousand people.

Apart from transmissible diseases, such diseases like typhoid fever, partiph and other salmonelloses, dysentery, amoebiasis, lambliasis, helminthosis etc. with characteristic spring-summer, summer and summer-autumn seasonality are observed. The infectious diseases with fecal and oral transfer mechanism get spread through the causative agents getting into food and water. It is worth to note that natural disasters increase the risk of spreading of causative agents of these infectious diseases.

Impact of the heat waves due to climate warming is very likely to increase mortality rates among the vulnerable groups, including children and elder people. Dramatic increase of temperature and severe drought of 2001-2002 became one of the key factors of the death tall among the population. The results of the research, which were based upon international studies made clear evidence that the "adverse affect" usually stands long behind the pressing event. For example, affect of the drought of 2000-2001reached its peak in 2003. Therefore, the research revealed that the death rates on average increased by 2500 people annually in the period from 2001 to 2003, with prevailing, although unequal, trend in the hot and moderate climatic zones. For example, the population living in the Khatlon region, hot arid climate, suffered more (increase in mortality rates per 1100 people) than the population, living in the

districts of the republican subordination, moderate climate, (increase in mortality rates per 700 people). The latter estimations were accounted for 1000 people, which comprised 50 for the districts of the republican subordination and 63.5 for the Khatlon region.

Reproductive health of women in the conditions of climate change is also interconnected with peculiarities of hot climate in Tajikistan. The analysis shows that frequency of birth in summer period is higher than in winter. Deliveries are more frequent in July: the number of births constitutes 17-22% of total annual number of births (2000-2004). During winter months the lowest rate of births is registered in February: the number of births constitutes 12%-17% of total annual number of births (2000-2004). Overall, miscarriages happen more frequently in winter than in summer. On the contrary, late births prevail in summer periods. The birth pathologies both in winter and summer of 2001 reached the maximum in comparison with other years. There might be a correlation with severe drought and abnormally high air temperature prevailing in that very same period. The children born with low weight have a high share in the infant death ratio specifically during hot period of the year.

3.5. Adaptation needs and priorities

3.5.1. Adaptation of natural ecosystems to climate change

The adverse impact of climate change on ecosystems and biodiversity will be critical if its destructive consequences are not mitigated and timely adaptation measures are not implemented. It is proposed to pay more attention to the monitoring indicators of climate change, support and expand the network of protected areas, develop the transborder ecological corridors and cooperate with neighboring countries of Central Asia.

To preserve, reproduce and improve food value of local commercial fishes (common marinka, Samarkand khramulya and Amudarya trout), the number of some alien fish species need to be regulated in the water reservoirs of the country.

The integrated system of plant protection and pest control with considerable economic effect is widely acknowledged in the practice of fighting pests in agriculture during last decades. The scale of chemical treatment in the agricultural sector can be reduced by 5-6 times. Therefore, it is necessary to support this direction and renovate monitoring on early warning practices.

3.5.2. Adaptation of forest resources to climate change

The vulnerability analysis of the forest resources to the climate change showed that the forest plantations mostly suffer from fires and increased number of pests resulting from high temperatures and droughts. Moreover, shortage of energy resources force local people to intensively cut and use the woods, leading to decrease of biomass reserves in the forests.

The efficiency of adaptation measures depends on adequately planned activities with consideration of vulnerability of the forestry to climate change; these activities are to be particularly directed at strengthening the protection of forests from fire, protection of plantations from pests, provision of necessary activities on restoration of forests, measures on preservation of flora and fauna species. The increase of forest biomass will also contribute to the reduction of greenhouse effect due to increased absorption of carbon. Taking this into consideration, development of private and communal forestry will have favorable perspectives in future. The adverse impact of natural disasters and erosion of soils might be reduced as well through planting and cultivating forests.

3.5.3. Adaptation of land resources to climate change

Breeding of agricultural crops resistant to drought and salinity considerably restrains destructive impact of droughts. To protect soils and to raise productivity of the lands affected by erosions in the dry zones, the method of ploughing across the slopes is to be used. The surface of the soil is closed entirely by additional bio-mass (clover crops, permanent legumes grasses etc.), reducing the risks caused by high temperature and droughts. It is appropriate to cultivate the lands situated on the slopes of 12-35 degrees by terracing and developing gardens and grape plantations on these terraces. The strip cropping on the slopes using higher norms of organic and mineral fertilizers is advisable. Adaptation measures to reduce soil aridity in the conditions of climate change are to be directed

at regulation of water-physical properties of the soils. It is important to provide for infiltration of the precipitation waters into the lower horizons of the soils through under-winter ploughing, which establishes reserves of moisture in soils. It is possible to get high yields of grapes, fruits and additional hay for the stock without considerable tilling in the zone of brown calcareous soils on the slopes from 8 to 30 degrees while forming meadows and watering them.

The most effective adaptation methods in farming are that of sprinkling and drip irrigation, enabling to optimize watering norms for the crops when droughts and shortage of water occur. To reduce the rates of organic matter decomposition, prevent its mineralization and dehumification, the use of organic fertilizers (manure, weed remains, lucern layers, green fertilizers) on the topsoil is advisable. To improve the state of gypsiferous soils (prevailing in Kurgan-tube zone), the biologization of soil formation processes is to be applied, increasing productivity of soils and farming crops by 1.5-2 times.

3.5.4. Adaptation of water resources to climate change

In order to save water while irrigating agricultural lands, water consumption levels is to be reduced, norms are to be enhanced; water losses during filtration and discharge, as well as losses in irrigation system are to be reduced. Thus, planning and introduction of water saving activities is required. Therefore planning and introduction of water-saving adaptation interventions through increase of the efficiency of intra-farm network and inter-farm channels due to application of pipe and tray-type sprinklers and anti-filtration lining of channels.

It is advisable to conduct activities regulating the river flow through construction of dams and diametrical dikes, channel dredging and flow straightening works, with the aim to direct the water flow into one course, thus protecting the settlements, agricultural lands and communication infrastructure from washouts and floods. The construction of small water reservoirs, mud flow reservoirs and watercourse reservoirs might also contribute to protection. The efficiency of adaptation measures to protect from floods constitutes around 40 mln. USD (based on the example from an area located on the river bank of Pyandj, in Hamadoni district.

3.5.5. Adaptation of agriculture to climate change

The vulnerability assessment reveals that reduction of agricultural productivity is observed in some areas experiencing increase in temperature and decrease in precipitation. The most effective adaptation methodology in these climatic conditions is additional watering, especially in the areas with sandy soils and deeply located ground waters. It can help to sustain productivity and sustainability of cotton cultivated during summer period in the southern Tajikistan usually lacking atmospheric precipitations. To reduce agricultural losses from adverse impact of climatic factors, it is necessary to strengthen material and technical base of the farms, undertake anti-erosion measures, conduct bank protection works, establish forest protection zones, provide antihail systems, etc.

The least vulnerable to climate warming are cotton fields in Khatlon and Sogd regions, where productivity to lesser extent depends on climatic factors, but is determined by agro-technical factors and availability of water for irrigation. Cotton is more resistant to high surface air temperature and soil salinity as opposed to other crops (potato and grain crops), therefore it is more profitable to grow cotton in hot conditions of valleys.

The current state of potato cultivation requires adopting immediate measures on appropriate organization of potato seed cultivation, selection of new productive varieties resistant to pests and adapted to specific agro-ecological areas of Tajikistan. In order to get high yields, it is important to introduce intensive technological cultivation of grain crops based on effective use of available technical resources and application of best practices.

To provide for food security in the country it is necessary to develop and maintain the minimum basket of goods, physiological norms of nutrition on all food products per capita, with an account of national peculiarities, by gender and age. It is also advisable to implement the measures on reduction of the internal food market dependency upon import through enhancing the competitiveness of national goods and maintaining the state policy of sound protectionism.

To achieve this, the system of state procurement on several types of agricultural products should be

developed and introduced, and the volume of internal production of the major food products at the level of not less than threshold value, in accordance with nutrition standards should be provided.

3.5.6. Adaptation of human health to climate change

The vulnerability assessment shows that an increase of the mean annual temperature would likely cause an increase in the number of days favorable for the reproduction of malaria mosquitoes. The choice of the activities combating malaria carriers has to be conducted based on the knowledge of biology and ecology of malaria mosquito species, which live in the given locality, types of sites, where anti-mosquito activities will be implemented. Various hydro-technical, physical and biological methods need to be used against mosquito.

While assessing vulnerability of the women's reproductive health to climate change, it was revealed that the indicators of women's health during hot periods of the year become worse. Thus it is necessary to raise awareness of medical workers of all the levels on peculiarities of the course of pregnancy and deliveries in hot climate conditions and to improve existing programs on enhancement of maternal and infant health, taking into consideration climate change factors.

Taking into consideration that fact that number of pathological pregnancies and deliveries among women who live in hot climate conditions can increase, it would be appropriate to review the issue of establishment of a specialized center for provision of qualified regular medical check-up of the health state among mothers and children after pathological pregnancies and deliveries.

In accordance with WHO recommendations (Bonn 2008), scientific potential to research the impact of climate change on human health should be developed, and adaptation measures to significantly reduce maternal and infant death rates, as well as death rates among population in general, should be elaborated.

4. POLICY AND MEASURES ON CLIMATE CHANGE

4.1. Perspectives on participation of the Republic of Tajikistan in the global agreements on reduction of GHG emissions and adaptation to climate change

The Republic of Tajikistan adopted the UN Framework Convention on Climate Change (UNFCCC) in 1998, with obligations of a non-Annex 1 country and ratified the Kyoto Protocol in 2008.

Since the Republic of Tajikistan signed and ratified the UNFCCC, the country prepared and provided to the Conference of Parties the First National Communication on Climate Change informing the Parties of the Convention of the trends in GHG emissions, vulnerability of the environment, national economy and human health to the global climate change, as well as of measures, both planned and undertaken, on climate change mitigation.

At the same time, the Republic of Tajikistan prepared the National Action Plan for climate change mitigation approved by the Decree № 259 of the Government of the Republic of Tajikistan, as of 6 June 2003. The National Action Plan identifies the major directions and priorities of the state policy on reduction of GHG emissions and adaptation to climate change.

Taking into account the need in investments for nature protection activities, introduction of new technologies and reduction of GHG emissions, the National Action Plan sets forth the need and expediency to sign and ratify the Kyoto Protocol to the UNFCCC.

While researching the perspectives of the Kyoto Protocol implementation in the Republic of Tajikistan back in 2005, key ministries and agencies supported signing and ratification of the Protocol.

The Government of the Republic of Tajikistan (Majlisi Namoyandagon Majlisi Oli) made a resolution to ratify the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) on the 21th of October, 2008.

Participation in the Kyoto Protocol will enable Tajikistan, the country in transition, to benefit from the Clean Development Mechanism CDM (Article 12 of the Kyoto Protocol) and implement CDM projects.

One of the main objectives of the CDM is to attract funds for projects contributing to the sustainable development of the country. Therefore, it is expected that project proposals submitted for funding by CDM will not only contribute to the reduction of GHG emissions into the atmosphere, but also facilitate the socio-economic development of the country, as well as provide for rational use of natural resources.

Priorities of the CDM projects include:

- Increase of energy efficiency in households and industrial sector;
- Development of renewable energy sources;
- Shift to cleaner fuels;
- Increase of energy efficiency in transport sector;
- Enhancement of agricultural practices and disposal of organic wastes.
- Reforestation.

Therefore, flexibility mechanisms under the Kyoto Protocol will enable Tajikistan to attract investments into projects on: modernization of energy sector, energy efficiency in housing and communal sector and industry, and forestry.

It is important to point out that Republic of Tajikistan will also access other benefits of the Kyoto Protocol. There are a number of them, such as benefits in social sector, i.e. decrease in the rates of respiratory and other diseases resulting from air pollution, reduced vulnerability of natural resources and adaptation to climate change.

Since Tajikistan has a huge potential for development of small hydropower, there is a possibility to attract investments for development of renewable energy within CDM. It is estimated that if existent capacity in small hydropower (18 billion kWh) is utilized in Tajikistan, it can lead to reduction of 5-6 mln. tons of CO_2 emissions per year. Additional socio-economic benefits are: increased employment opportunities for local population and better access to energy, especially in rural areas.

4.2. Reduction of GHG emissions in energy consumption sector

4.2.1. Renewable sources and large-scale hydropower

The geographic position and favorable climatic conditions of Tajikistan open good opportunities to for the development and use of the renewable energy sources. Several dozens of projects on construction of small scale HPPs supported by financial contributions of different donors were implemented in Tajikistan during the last decade. Back in 1990s "Barqi Tojik" constructed 7 hydropower stations with capacity from 70 to 630 kWh, while during the same period 12 small scale hydropower stations with capacity from 30 to 100 kWh were constructed in Gorno-Badakhshan Autonomous Oblast with support from the Aga Khan Foundation. However due to the lack of technical maintenance most of these HPPs are not operational at the moment. Other international organizations made a valuable contribution to the development of small-scale hydropower stations with capacity of 10-13 kWh. Additionally, within the framework of ADB projects, 2 small-scale HPPs with capacity 100 and 200 kWh were constructed as well. Until 2015 it is planned to construct 70 small scale hydropower stations in total, with total capacity of more than 80 thousand kWh.

A series of biogas facilities with capacity 0.5-6 kWh, developed by the Institute of Physics and Techniques under the Academy of Sciences were installed in Kafirnigan and Kulyab. At the same time, the solar collectors are successfully utilized by households. It is observed that the local people both in urban and rural areas become more flexible with the use of small-scale renewables, namely, solar photovoltaic sources, solar stoves and boilers, and biofuel. This is considered as one of the solutions to address the problem of energy shortage.

Development and maintenance of current large-scale hydropower plants at the Vakhsh River as well as additional construction of new ones (with regard to all stakeholders' opinion) open good opportunities for the clean energy supply. This will significantly increase the capacity of the country in energy exporting and enable to minimize greenhouse gas emissions, resulting from the operation of the heat stations. It is expected that newly constructed HHP capacities enter into operation in 2010-2015.

Along with the development of the hydropower potential, the country can succeed in energy saving techniques through improvements in household and agricultural practices, as well as in industrial and transport sectors. The following sections will discuss more detailed narratives.

4.2.2. Transport

For the latest years Tajikistan witnesses a significant increase in number of vehicles, especially passenger cars. Annually this number grows by 15 thousand cars, which leads to increasing demand of the fuel. As a result, the combustion of the fuel greatly contributes to the total amount of greenhouse gas emissions. However along with the increasing rate in the number of vehicles, there is a tendency towards increased consumption of other types of fuel, specifically natural and liquefied gas. One of the main advantages of the gaseous fuel are cost effective prices and environmentally-friendly use.

It is known that the unsatisfactory state of the roads leads to additional fuel demand and causes greenhouse gas emissions. Therefore, in order to improve the transportation network and communication a lot of investments are attracted for construction and rehabilitation of automobile roads in Tajikistan. The following automobile roads were constructed and rehabilitated with the use of modern asphalt pavement during the period of 2000-2006: Murghab-Kulma and Shagon-Zigar, being part of the Great Silk Road and reaching the state border with the People's Republic of China, highways Dushanbe-Kurgan Tyube-Dangara-Kulyab and Dushanbe-Varzob. The construction of tunnels and access lanes is going on. The future projects on modernization of roads are: rehabilitation and reconstruction of the roads Aini-Pendjikent the border with Uzbekistan, Kulyab-Kalaihumb, Kurgan Tyube-Dusti, construction of the tunnel "Shar-Shar".

Alongside with the automobiles, public transportation (especially electrified one) and bicycles is being developed with zero GHG emissions. The modernization and expansion of the fleet of trolley buses (by more than 150) facilitates the reduction of GHG emission rates in the transport sector.

According to the expert prognoses, the number of vehicles will increase, consequently the rates of GHG emissions will increase as well. Therefore the potential possibilities of transport infrastructure to reduce GHG emissions should be supported, namely: transition to liquefied gas and/or biofuel, development of bicycle infrastructure and public transportation, modernization and reconstruction of roads with asphalt pavements, planting trees and shrubs along the roads.

4.2.3. Housing and communal services

The main area causing GHG emissions in the housing sector is the use of energy for household needs. However the depreciation and wear-and-tear of housing stock, irrational use of electricity and low coefficient of energy efficiency are key factors contributing to the GHG emissions.

The assessment of energy efficiency of the houses in rural areas reveals that its low coefficient is due to the inappropriate geographic position of the houses while under construction, lack of rational system of house heating, use of wood-burning stoves with low efficiency, as well as inefficient of thermal protection of external and internal components of buildings. The main causes of low energy efficiency in urban households are: use of monolithic or ferroconcrete stoves which do not conform to heat insulation requirements and lack of central heating causing increased loads for electricity power.

Expert assessments show that implementation of the large-scale activities on energy saving and integration of the energy-efficient technologies will enable to increase the energy efficiency by 20-40%. Additionally, widespread use of renewable energy sources, especially solar potential, will provide the local citizens with additional sources of hot water and heat.

4.3. Reduction of GHG emissions in the industrial sector

4.3.1. Tajik Aluminum Plant

The Tajik Aluminum Plant (TadAZ) is one of the giant industrial enterprises in Tajikistan being the hugest energy carrier in the country. Its nominal production capacity amounts to 500 thousand tons of aluminum per annum. The peak of production observed in 1989 with 456 thousand tons of aluminum produced. In 2007, after a relatively short break in production capacity, Tajik Aluminum Plant stepped into the level of 420 thou. tons per year, significantly increasing its productive potential.

In order to improve the state of environment and ecological indicators, the administration of the plant applied a series of preventive measures to avoid entrance of the emissions and other pollutants into the atmosphere: modernization, reconstruction and strengthening the capacities of gas cleaning installations, pipe laying, equipping the laboratory with state-of-the-art equipment, regular afforestation and landscape gardening. The envisaged activities facilitated to the reduction of GHG emissions and other pollutants into the atmosphere.

It is expected that the further enhancement of technical and technological state of the enterprise will planned in the future, namely: modernization of anodic mass and electrolysis production technologies, introduction of modern automated management systems, rehabilitation of dust cleaning systems, reconstruction of gas escape collectors of electrolysis, capital reconstruction of ventilation and aspiration systems of the enterprise, etc. All these measures will undoubtedly reduce adverse impacts of the GHG emissions onto environment and improve ecological situation,

4.3.2. JSC TajikAzot

JSC Joint Enterprise "TajikAzot" (former Vakhsh nitrogen fertilizer plant) is the biggest enterprise of chemical industry producing mineral fertilizer (carbamide) for the needs of agriculture. The nominal production capacity of the enterprise for synthetic ammonia is 123 thousand tons and for carbamide is 180 thousand tons. The peak in production of ammonia (121thousand tons) was reached in 1981, of carbamide (192thousand tons) in 1985. Later on, the economic decline and acute energy shortages dramatically limited the productive capacity of the enterprise.

With the establishment of joint Tajik-Cyprus enterprise (JSC Joint Enterprise TajikAzot) in 2001, fettling of methane and carbon dioxide converters was conducted, compressors and sulfur compound gas treating devices were installed, and modern automated management systems were introduced, enabling rehabilitation of both technological lines

and set up the production. In parallel, the enterprise implemented ecological improvements, which favorably addressed the reduction of greenhouse gas and other pollutants emissions. For example, the year of 2005 witnessed 88.1 thou.tons of carbamide with ammonia competitive reduction by 26% as compared with maximum permissible concentrations.

4.3.3. JSC "Tajikhimprom"

The main product produced by the JSC "Tajikhimprom" is hydrate of sodium and other chlorine containing products. Like in many other enterprises, economic crisis and obsolete tehnical and technological facilities were among few crucial factors of the decline of the Tajikhimprom's production; and as a result caused significant reduction of the pollutant emissions into the atmosphere. However, it is expected that the plant will accumulate its productive capacity in nearest future. The latter can be achieved through enhancement of the partnership with international counterparts. Presently, capital and extensive repairs, which assumes integration of modern technologies is in progress.

4.4. Enhancement of the state of natural carbon sinks

The results of the GHG inventory reveal that after the 1990s a trend to reduction of the potential capacity of the forests in CO_2 absorptionis observed. . Since 2000 the rate of CO_2 absorption amounts to 90% as of the year 1990. One of the main reasons for destabilization forest capacity is massive deforestations due to energy crises, minimization of afforestation volumes and inefficient activities on forest protection.

At the same time, the interest for establishment of nurseries and cultivation of forest plants among dekhkan farms and leaseholders are favorable factors for increase in the amount of wood biomass. More than 268 thousand seedlings were planted at the Victory Park of the capital of republic and "the green circle" around Dushanbe was rehabilitated these last years. The large scale afforestation works were conducted close to Nurek reservoir, in Karategin, Kurgan-Tyube, Pyandj, Shaartuz and Asht regions, with priority made towards landscape gardening and river shore protection, development of anti-erosion capacity of soils. Activities planned within the framework of fire precaution and protection of forests from pests outbreaks and diseases, alongside with obligatory activities on afforestation and conservation of species diversity of flora and fauna will strengthen the capacity of carbon sinks on the one hand, and will significantly enhance the state of the environment and natural resources, on the other hand.

4.5. National policies on sustainable development and environmental protection policy

4.5.1. Existing legislative and regulatory mechanisms

One of the basic mechanisms for the 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 state of environment, the Law "On nature protection" was adopted by the Government of Tajikistan in 1994. This law regulates the organization, monitoring and control over the use of natural resources, and environmental protection, including the atmosphere.

The by-laws, regulating requirements on conducting control over emission rates, are:

- Law of the Republic of Tajikistan on Protection of Atmosphere (1996);
- Law of the Republic of Tajikistan on Energy (2000);
- Law of the Republic of Tajikistan on Transport (2000).

Other normative-legal acts, which determine responsibility for violation of the environmental legislation, include: the Administrative Code of the Republic of Tajikistan and the Criminal Code of the Republic of Tajikistan.

The order of determining fees and fines for polluting the environment and storing wastes into the nature was approved by the Government of Tajikistan in 1993. In case of violating the limits of emissions and pollution, a 10-fold fine is collected for the damage caused.

Nevertheless, mechanisms of control over reduction, account of emissions and absorption of anthropogenic greenhouse gases are not determined in the legislation on agriculture, forestry and other sectors, having potential impact on the climate. In this regard, it is necessary that these mechanisms conform to the requirements of the UNFCCC and other multilateral environmental agreements and programs ratified by the country.

4.5.2. National strategies and programmes

The State Program on Environmental Awareness-Raising and Education of the Population of Tajikistan until 2000 and 2010 (in perspective) was approved in 1996. The program envisages raising educational level and awareness of the population on environment issues, including protection of the atmospheric air.

In 2000 the Government adopted the National Action Plan for Hygiene of the Environment, which stipulates activities for protection of the atmosphere from the adverse impact of anthropogenic factors and preservation of public health taking into account the state of environment.

In 2001 the Government adopted the National Action Program to Combat Desertification. The Program envisages for a complex of measures directed towards protection and enhancement of the state of forests and land resources, which will also facilitate addressing the issues of climate change due to the increase in the number of carbon sinks.

In 2003 the Government of the Republic of Tajikistan approved the National Action Plan for Climate Change Mitigation envisaging for a set of measures directed towards reduction of GHG and improvement of the state of natural carbon sinks, adaptation to the climate change, optimization of systematic observations, improvement of the education (information) system, training of personnel and awareness-raising, as well as development of the cadastre of emission points and carbon sinks.

In 2005 the Government adopted the State Program on Development of Protected Areas for 2005-2015 and the State Program on Development of Forestry and Hunting for 2006-2015, stipulating for a series of reorganizations to improve nature protection and forestry management.

In 2006 the Government approved the National Action Plan for Environmental Protection, envisaging various activities on protection of environment, which are harmonized with the economical, social and ecological objectives.

The Complex Program on use of the renewable energy sources in Tajikistan for 2007-2015 was approved by the Government in 2007. The program envisages a set of activities aimed at establishment of production base and infrastructure for extended use of renewable energy sources, i.e. solar radiation, energy of wind, biomass, small rivers, and geothermal sources.

The National Strategy on the protection of stratospheric ozone layer and phasing out ozone depleting substances has been developed as well. 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.

Considering the importance of global ecological problems and their relation to the state of environment, the country is a party to the number of international treaties, including:

- Vienna Convention for the protection of the ozone layer (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).

4.6. Implementation progress of the National Action Plan for climate change mitigation

The assessment of the implementation progress of the National Action Plan for climate change

mitigation (NAP) showed that the main economic branches of the national economy generally succeed in mitigation measures, namely focusing on:

- Development of the renewable energy sources (construction of the small-scale hydropower plants),
- Integration of the modern technologies on climate change mitigation and greenhouse gas reduction
- Reafforestation and improvement of the natural carbon sinks, as well as raising public awareness on climate change

Presently, construction of small-scale hydropower plants ("Kuhiston", "Cheptura", "Artuch", "Tutak") with 500 kWh capacity is under progressive development. Additionally, it is expected that more than 70 small-scale HPPs will be constructed until 2015 with total capacity of more than 79 thou kWh. In parallel, the Academy of Sciences of the Republic of Tajikistan conducts regular studies on capacity assessment of renewable energy sources in different districts of the republic and develops new models of equipment on reorganization and use of alternative sources of energy in households and enterprises.

The industrial enterprises of the Ministry of Energy and Industry conducted a number of activities on renovation and replacement of old equipment and transfer to newer and cleaner production technologies. The activities on reconstruction of aspiration systems, replacement of gas flues and drip pockets on gas purification scrubbers, enhancement of electrolytic cell closures facilitated reduction of non-managed emissions at Tajik Aluminum Plant. Introduction of automated management systems into production processes within JSC "TajikAzot" also contributed to the reduction of carbon dioxide emissions.

In order to manage natural disaster risks and facilitate adaptation in the water economy sector a number of shore protection activities were conducted on the main rivers of Tajikistan. The construction of new water reservoirs, training walls, as well as conduction of channel dredging works are planned for protection of settlements, infrastructure and agricultural lands from destruction and flooding. At the same time, enhanced water saving technologies are developed for irrigation of agricultural lands in the forest areas with subsidence soils.

4.7. National and regional projects on climate change

The implementation of the EU project "Technical Assistance to Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in relation to their commitments to the UNFCCC" enabled capacity building to develop legislative and legal frameworks for implementation of the CDM projects (Clean Development Mechanism), enhanced technical base in conforming to the standard procedures of CDM, as well as helped to develop recommendations on enhancing institutional and technical capacity of Tajikistan for ratification and implementation of the Kyoto Protocol of the UN Framework Convention on Climate Change.

The CIS and Eastern Europe countries are considered as main stakeholders of the UNDP-GEF project "Capacity Building to Improve Quality of GHG Inventory". The priority directions of the project were: strengthening institutional capacity to collect, process and archive data, establishment of sustainable process of GHG inventory and enhancement of technical base, methodologies and guidelines. The project facilitated improvement of the quality of preparation of the national inventories, transfer of knowledge and exchange of experience, development of partnerships between participant countries.

The CARE International project "Adaptation of Rural Population to Climate Change in Tajikistan" (2005-2007) aims at strengthening the institutional and technical capacity of the local jamoats (rural administration) to deal with consequences of climate change, to improve social and economic efficiency and well-being of the households. The target group of the project consisted of the population of three jamoats, which were located in the different altitudes and climatic zones of Varzob valley. Practical activities of the project included: demonstration of energy efficiency of bio-fuel stoves, tree planting and educational workshops and trainings on raising awareness of the population on the climate change issues and its adverse impacts.

In 2005-2007 a series of field trips and expeditions to high-mountain zone of the country to study the state of the glaciers and glacial lakes were undertaken. In July 2008 in the framework of the scientific-research project on paleoclimate research of the Lake Karakul and Pamir-Alai glaciers has been initiated by the

Berlin University in cooperation with Tajikgidromet and UNEP. As a result a new dataset on ancient and current climate change trends was collected.

One of the main objectives of the regional assessment project "Public comprehension of the climate change problem in Tajikistan and Kyrgyzstan" is to assess public understanding of climate change and its adverse impacts on natural resources and agriculture, as well as to analyze national policy to address climate change and access to information. Goal groups included rural population of the neighboring countries. During the project, a number of activities on raising awareness on climate change, such as seminars, trainings and media-tours implemented.

4.8. Participation of the Republic of Tajikistan in the international negotiations on climate change

Tajikistan, as a Party to the UNFCCC, participates at the international and regional processes on climate change. Since the UNFCCC ratification, the representatives of the country participate at the annual Conferences of the Parties (COP) and its subsidiary organs, where policy decisions on efficient implementation of the Convention and Kyoto Protocol are concluded. Starting from 2006, Tajikistan is a chair to the CACAM regional group (Caucasus, Central Asia, Moldova and Albania), negotiating the regional interests at the meetings with the UNFCCC Secretariat.

Republic of Tajikistan is a member of the Compliance Committee under the Kyoto Protocol of the Conference of Parties since its establishment, participating at the regular meetings of the Kyoto Protocol. (REVISE)

The Forum of Designated National Authorities (DNA) was established in order to enable participation of non-Annex I Parties in the negotiation processes under the Kyoto Protocol and Clean Development Mechanism (CDM). The meetings within DNA forum facilitate exchange of information and experience among countries and foster discussions on emerging issues with the CDM Executive Board. Tajikistan contributes to the development of scientific research on assessment of climate change, its adverse impacts and recommended measures on GHG emission reduction through participation of country representatives at regular meetings of working groups of the Intergovernmental Panel on Climate Change (IPCC).

The impact of climate change on human health has become an issue of global concern. In order to enhance awareness among policy-makers and climate change experts, the report on climate change impact on human health developed with significant input and valuable recommendations from the representatives of Tajikistan was presented at the first meeting conducted by the World Health Organization (Bonn, Germany, 2008). REVISE

Tajikistan develops international relations on climate change issues with some scientific research institutions, namely with Potsdam Institute for Climate Impact Research and Berlin University of Frei.

4.9. On the way to climate neutrality

Climate neutrality is a modern concept aimed to reduce or compensate GHG emissions of individuals, enterprises and countries as a whole, thus reducing impact on global warming. The process of climate neutrality starts with calculating the carbon footprint of each and every activity, i.e. GHG emissions caused by activities. These activities can be very diverse: traveling in a car, use of heating system, pumping irrigation, organizing a conference and associated energy consumption, paper consumption, or industrial production. Once the amount of GHG emissions is calculated, achievement of climate neutrality can be facilitated by different protective measures, from planting trees, switch to renewable energy sources or other alternative fuels, to compensating carbon emissions in third countries and through specialized companies and projects. Climate neutrality is of particular importance both at national and individual levels. The countries of Europe and Asia declared their long-term commitments to climate neutrality through implementation of specific policies in this area. The UNEP Guidance on climate neutrality (Kick the Habit), released in June 2008, outlines the steps and actions in this area.

There is a great potential for Tajikistan to achieve climate neutrality, both in energy and forestry sectors (also for neutralizing emissions of other countries and global businesses), as well as in other areas. Undoubtedly, special attention should be paid to this issue by heads of state agencies and local administrations, local businesses and public at large.

5. RESEARCH AND SYSTEMATIC OBSERVATIONS

5.1. Development of systematic observations on nature and climate

For many years national hydrometeorology services around the world conduct surface, upper-air and spacecraft observations of weather, water and climate. The current and expected trends of global warming are known owing to the systematic observations, forecasts and synoptic analyses facilitating to the timely planning of adaptation measures and development of new mechanisms for reduction of GHG emissions.

Development of hydrometeorological observation network in Tajikistan started with establishment of Tajik hydrometeorological committee in 1926. Alongside with systematic observation of weather, water and climate, Tajik hydrometeorological service conducts assessments of climate change and forecasts, analyses of recurrence of extreme hydrometeorological events, surveys of mountain glaciers and glacial lakes.

Large scale field and aerovisual observations conducted by the specialists of the Agency for Hydrometeorology on glacial lakes (Sarytag and Karatag river basins, etc.) recently revealed a considerable retreat and degradation being an evidence of global warming. The research data served as a basis for update of data on glaciations state in the country and region, and contributed into preparation of scientific publications, articles and illustrated electronic books on climate change in Tajikistan.

5.2. Participation of the Republic of Tajikistan in the international observation networks

Tajikistan has two stations representing the global climate observation system (GCOS). Tajikistan belongs to the Region II WMO - Asia. The World Weather Watch of the WMO involves 10 Tajikistan's stations, including 2 stations that conduct observations within upper atmospheric layers.

Climatic data by means of "CLIMAT" telegrams are transferred daily via channels of Global Telecommunication System (GTS). Since 2001, Tajikistan transfers the data from 13 stations into GTS channels, among them are 2 GCOS stations, which are accessible to WMO and world data centers.

Because of financial constraints two WWW stations are temporarily closed and another three stations do not transfer data because of damage in communications. The most promising WWW stations are: Khujand, Khorog and Istravshan where observations are conducted since the end of the 19th century.

The interstate hydrometeorological network of CIS (IHN CIS) is intended to exchange the data on meteorological, aerological, hydrological and other observations necessary for preparation of hydrometeorological forecasts and warnings on dangerous hydrometeorological phenomena. The meteorological observations of this network in Tajikistan are provided by 18 stations, and hydrological observations are provided by 11 gauges on rivers, lakes and reservoirs.

5.3. Current state of hydrometeorological observation network and needs for enhancement

The hydrometeorological observation network spreads over all regions and altitudinal belts of the territory of Tajikistan, which at present includes 57 hydrometeorological stations, and 96 hydrological, meteorological, agrometeorological observation and environmental pollution monitoring points. However, due to lack of financial support and investments, one can observe the reduction of the observation network in the last decades: the number of hydrometeorological stations reduced by 20%, the number of gauges reduced by 36%, the number of environmental pollution monitoring points reduced by 80%. The recession in the number of observations over weather, water and climate considerably deteriorates the quality and quantity of the information provided.

Meteorological observations include the measurements and qualitative assessments of meteorological elements and phenomena, such as air temperature and humidity, atmospheric pressure, wind, cloudiness, precipitation, fogs, snowstorms, thunderstorms, visibility, etc. At present the state of meteorological observation network is unsatisfactory: out of 57 stations 8 are temporarily closed, many monitoring points lack devices and equipment, the volume of implemented works, as well as the timelines and quantity of efficient data transmission significantly reduced.

Agrometeorological observations assess the development, growth, productivity of agricultural crops, temperature of topsoils and humidity of soils. Currently the network of agrometeorological observations includes 24 stations (out of them 2 specialized ones) and 7 gauges. The observations are not conducted on these 7 monitoring points due to the lack of specialists in agricultural meteorology, and some agriculturally developed areas are not covered by agrometeorological observations.

Aerological observations aim to study the meteorological parameters of the atmosphere at heights up to 30-40 km. This information is used for elaboration of weather forecasts, aviation and other sectors, analysis of atmospheric processes. Aerological observations were conducted at 3 stations (Khujand, Dushanbe and Khorog). However, since 1996, these observations are terminated at all stations because of lack of supplies, failure of out-of-date radar-tracking equipment.

Hydrological observations study the hydrological cycle of regular inventory of water and water cadastre, assess an anthropogenic impact on water resources. In Tajikistan, where 50% of water resources of the Central Asian region is formed, an accurate analysis and forecast of the flow is particularly important.

An average density of existing gauges within 7 major river basins constitutes 0,8 gauges per thousand square kilometers. The low density of hydrological observation points is observed in the Syrdarya (0.04), Pyandj (0.33) and Vakhsh (0.52). Presently, the hydrological network includes 75 river and 6 lake observation points. Observations of the water runoff are undertaken at 48 gauges only.

Other observations include monitoring of environmental pollution, study of the upper ozone layer, solar radiation, glaciers, avalanches, floods, descent of glacier lakes, etc. The monitoring of water quality covers 21 rivers. The level of air pollution is analyzed in two cities.

A considerable progress in the development of Tajik hydrometeorology service is driven by signing the Programme for rehabilitation of hydrometeorological stations and hydrological observation points for the period 2007-2016, which envisages equipping significant hydrometeorological station and gauges, and complete rehabilitation of environmental pollution observation network.

5.4. Cooperation development and capacity building at the National Hydrometeorology Service

The significant contribution into capacity building of Tajik hydrometeorological service is made by the Swiss Agency for Development and Cooperation (SDC) which supports the projects of the national hydrometeorological services of the Central Asian countries. The SDC project supported rehabilitation, equipping, and in some cases even construction of over a dozen meteorological and hydrological stations.

It is worth mentioning that a considerable progress is made in automation of hydrological data processing. Prior to the introduction of the HydroPro software the hydrological information was processed manually. It facilitates capacity building in automation of data management, reduces workload, as well as minimizes error probability. Along with existing methods of hydrological forecasting a swiss-american mathematical model was introduced and already demonstrated efficiency in use.

Another issue of particular importance in the development of the national hydrometeorological service is the automation of meteorological data processing. In order to enhance the automated patterns in the initial processing of the regime meteorological information, and to minimize errors the last model of PERSONA MIS/MIP system was introduced and training provided by the specialists of Russian hydrometeorology service (RosGidroMet). Along with modernization of automated systems for hydrometeorological data processing, the satellite forecasting developed considerably. Within the framework of the WMO Voluntary Cooperation Programme (VCP) the Chinese hydrometeorological service donated satellite equipment FENGYUNCast to Tajik hydrometeorological service.

It is expected that the network of hydrometeorological observations, which currently is in poor

operational condition, will be rehabilitated on the Pyandj river basin, within the framework of the Asian Development Bank (ADB) project on disaster risk management within the Pyandj River. In accordance with the project implementation plan, it is envisaged that necessary technical equipment will be provided to the stations and observation points, database will be established and modeling approach in the flow forecast will be utilized.

The modernization and automation of hail-suppression service is also under way: technical equipment and spare parts to anti-hail installations are regularly replaced. Within the framework of the programme for rehabilitation and equipping the hail-suppression service, a meteorological radar set in Gissar was rehabilitated and modernized, enabling to observe meteorological processes and notify on storms. In spring of 2008, due to modern observation methodologies, 24 cases of hail were prevented, saving agricultural productivity. In the future, systematic observations of the environment and climate, along with the new enhanced methodologies on active coercion over meteorological processes will enable to increase the number of artificial precipitation in some agricultural areas being of great use in conditions of global warming and aridity of climate.

Currently the World Bank conducts an assessment of the state (infrastructure, forecasting and data transmission methodologies) of the national hydrometeorological services in Europe and Central Asia, including Tajikistan. It is expected that outcomes of the research will define the next stages for enhancement and modernization of current activities of the national hydrometeorological services, and will determine practical benefits of the World Bank investments into development of cooperation and hydrometeorological data exchange between neighboring countries.

It should be pointed out that young specialists of the Tajik hydrometeorological service participate in the international conferences, seminars, courses and trainings in different areas of hydrometeorology, thus strengthening its capacity and professionalism. In this area, significant changes are driven by the WMO, UNFCCC, UNEP, regional meteorological training centers, national hydrometeorological services of Russia, China, Korea, Iran, India, Japan and Central Asian countries, etc.

6. EDUCATION AND AWARENESS-RAISING

6.1. Courses on climate change, ecology and meteorology within educational system

The current educational system in the republic is of four levels, consisting of pre-school and secondary education, vocational training, college and higher education. Along with other compulsory subjects, such courses as environment, ecology, geography and physics are taught at secondary schools; and at the university (both humanitarian and technical) level education there are departments of physics, meteorology, and environmental protection. The department of the public healthcare of the Tajik State Medicine University delivers lectures and talks on climate change and human health. However there is no special compulsory course on climate change within educational system by now. To fill in this gap, there are electives on climate change at schools and universities; illustrated books, demonstration CDs and movies are distributed as teaching material among teachers and pupils.

6.2. Public participation in knowledge exchange and awareness-raising

Presently the issue of climate change attracts attention of public and media. There are more than 40 non-governmental organizations registered in the Republic which conduct different activities on environmental awareness-raising with climate change being one of the hot topics. A number of non-governmental organizations implement separate small-scale demonstration projects on climate change, conduct surveys, distribute magazines and bulletins, participate in public events promoting rational use of natural resources and reduction of GHG emissions. Along with this, the issue of climate change is widely discussed in media (press, TV and radio). Awareness-raising among media representatives is one of NGO activities as well: trainings, round-tables, debates and media tours are conducted for media workers to raise their awareness on climate change issue.

6.3. Internet and climate change resource center

The modern world where information technologies evolve day-by-day, offers a unique set of communication means which facilitate information search. The number of Internet uses increases in Tajikistan, too: if in 2003 their number totaled 2 thousand people, currently the number of Internet users increased up to 70-100 thousand people. The number of Internet service providers increases as well, covering more and more remote areas of the country. With the aim to raise public awareness and understanding on climate change issues and measures, undertaken by the Republic of Tajikistan in response to the UNFCCC obligations; a web-page on climate change related projects is created and regularly updated. During the project implementation period, a number of e-information CDs were produced, namely:

- CD with illustrations and graphs named "Global warming and glaciers of Tajikistan;
- CD with popular scientific information named "Climate change and its consequences for Tajikistan";
- E-digest with survey materials for general public and media.

The information in hard copies is also available to general public. The library of resource and climate change resource centre is operational and regularly updated since 2001. The library includes different categories of information: popular scientific (national and international research papers), specific (UNFCCC, UNEP methodologies, etc.), general (articles, curricula, etc.). If necessary, visitors of the resources information centre can consult the materials posted in Internet, talk to local experts.

In general, the assessment shows that these last five years the public awareness in climate change issues increased: in cities and towns by 10-15%, in comparison with 2003; in rural areas by 10% (due to lack of access to communication and information means).

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Abbreviations, acronyms and units of measurement

Abbreviations:

AN RT	Academy of Sciences of the Republic of Tajikistan
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
CoES	Committee on Emergency Situations
CIS	Commonwealth of Independent States
DRS	Districts of republican subordination
EF	Efficiency Factor
EIA	Environmental Impact Assessment
EWE	Extreme Weather Events
FAO	UN Food and Agriculture Organization
GBAO	Gorno-Badakhshan Autonomous Oblast
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gases
GIS	Geographic Information System
GCOS	Global Climate Observation System
GosKomStat	State Committee on Statistics
GWP	Global Warming Potential
HPP	Hydropower Plant
HRPT	High Resolution Picture Transmission
IPCC	Intergovernmental Panel on Climate Change, established by WMO and UNEP in 1988
JSC	Joint Stock Company
JV	Joint Venture
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MinEconomy	Ministry of Economic Development and Trade
MinFin	Ministry of Finance
MinProm	Ministry of Industry
MinSelKhoz	Ministry of Agriculture
MinTrans	Ministry of Transport
MinVodKhoz	Ministry of Land Reclamation and Water Resources
MinZdrav	Ministry of Health
MPC	Maximum permissible concentration
NAP	National Action Plan for climate change mitigation
NCSA	National Capacity Self-Assessment for global environmental management
NHMS	National Hydrometeorology Service
NII	Scientific Research Institute
NMVOC	Non-Methane Volatile Organic Components
NGO	Non-governmental organization
RT	Republic of Tajikistan
SANIGMI	Central Asian Scientific Research Institute on Hydrometeorology
SC	State Company
SA	State Agency
SUAE	State Unitary Aviation Enterprise
SUE	State Unitary Enterprise
TadAZ	Tajik Aluminum Plant
TajikHydroMet	State Agency on Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan

TAU	Tajik Agrarian University
TASHN	Tajik Academy of Agricultural Sciences
TAR IPCC	IPCC Third Assessment Report published in 2001
TOMS	Total Ozone Measurement System
TSMU	Tajik State Medical University
TPP	Thermo Electric Power Plant
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

Chemical formulas:

CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
N_2O	Nitrous oxide
NOx	Nitrogen oxides
PFCs	Perfluorocarbons
SO_2	Sulphur dioxide

Units of measurement:

°C	Celsius degree
bln	billion
bln^{-1}	per-unit volume concentration of gas evaluated in billion proportions
cal	Calorie
ccal	kilocalorie
gr	Gramme
ha	Hectare=10.000 square meters
J	Joule
kg	kilogramme
KJ	kilojoule
kWh	kilowatt per hour
kWh/m^2	kilowatt per hour per square meter = 3,6 MJ/m^2
km	kilometer
m	Meter
masl	Meters above sea level
mln.	million
mln^{-1}	per-unit volume concentration of gas evaluated in million proportions
mm	millimeter
m/sec	Meter per second
m^2	Square meter
m^3	Cubic meter
m^3/sec	Cubic meter per second
MW	MW megawatt = 1,000,000 watts
sec	second
t	ton
TJ	Terrajoule = 1000. 000. 000. 000 joules
t.o.e.	tons of oil equivalent = 29 308 KJ = 0,7 tons of oil equivalent

Annex 1

Key sources of GHG emissions in 2000 in Tajikistan

Country	Tajikistan					
IPCC category	Sector	Subsector	Gas	Emission in CO^2-eqv.	Total contri-bution, %	Estimations %
Total				**7324,49**		
4.D	**Agriculture**	**Agricultural soil**	N_2O	1760,30	24,03	24,03
4.A	**Agriculture**	**Enteric fermentation**	CH_4	1404,93	19,18	43,21
1.A.4	**Energy**	**Residential and communal sectors**	CO_2	1238,40	16,91	60,12
2.C	**Industrial process**	**Aluminum production**	PFCs	615,96	8,41	68,53
6.A	**Waste**	**Solid waste disposal on land**	CH_4	427,57	5,84	74,37
1.A.2	**Energy**	**Industry and construction**	CO_2	412,52	5,63	80,00
2.C	**Industrial process**	**Aluminum production**	CO_2	403,74	5,51	85,51
1.A.4	**Energy**	**Agriculture**	CO_2	228,96	3,13	88,64
4.B	**Agriculture**	**Manure management**	CH_4	208,83	2,85	91,49
4.C	**Agriculture**	**Rice cultivation**	CH_4	167,33	2,28	93,77
1.A.3	**Energy**	**Road transport**	CO_2	161,20	2,20	95,98
6.B	**Waste**	**Wastewater handling**	N_2O	81,8	1,1	97,1
4.B	**Agriculture**	**Manure management**	N_2O	42,2	0,6	97,7
1.A.3	**Energy**	**Railway transport**	CO_2	36,2	0,5	98,2
2.B	**Industrial process**	**Ammonia production**	CO_2	29,1	0,4	98,6
2.A	**Industrial process**	**Cement production**	CO_2	27,3	0,4	98,9
1.A.3	**Energy**	**Air transport**	CO_2	27,0	0,4	99,3
6.B	**Waste**	**Wastewater handling**	CH_4	14,1	0,2	99,5
1.A.1	**Energy**	**Stationary source**	CO_2	9,5	0,1	99,6
2.A	**Industrial process**	**Lime production**	CO_2	8,8	0,1	99,7
2.C	**Industrial process**	**Metal production**	CO_2	5,7	0,1	99,8
1.B.1	**Energy**	**Fugitive emission from coal industry**	CH_4	2,6	0,0	99,9
4.F	**Agriculture**	**Burning of agricultural residues**	CH_4	2,6	0,0	99,9
1.A.4	**Energy**	**Private sector**	CH_4	2,3	0,0	99,9
4.F	**Agriculture**	**Burning of agricultural residues**	N_2O	1,0	0,0	99,9
2.A	**Industrial process**	**Sodium consumption**	CO_2	0,7	0,0	99,9
1.A.4	**Energy**	**Private sector**	N_2O	0,7	0,0	100,0

ANNEX 2: Summary tables of greenhouse gas emissions and removals by sinks
Tajikistan: Greenhouse Gas Inventory in 1990, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**23628**							
Total national emissions and removals by key gases	**17 695**	**-1 916**	**175**	**10**	**74**	**533**	**59**	**34**
1. Energy	**16 114**	0	**44**	**0**	**73**	**289**	**54**	**27**
A. Fuel combustion	16 114		2	0	73	289	54	27
1. Electricity	59		0	0	0	0	0	0
2. Manufacturing industries and construction	4 801		0	0	13	3	0	8
3. Transport	4 776		1	0	43	271	51	6
4. Other	6 478		1	0	17	15	2	13
B. Fugitive emissions from fuel	0		42		0	0	0	0
1. Solid fuels			5		0	0	0	0
2. Oil and natural gas			37		0	0	0	0
2. Industrial Processes	**1 582**	**0**	**0**	**0**	**1**	**242**	**5**	**7**
A. Mineral products	633				0	0	0	0
B. Chemical industry	164		0	0	0	1	1	0
C. Metal production	784		0	0	1	241	0	7
D. Other production	0		0	0	0	0	4	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**99**	**10**	**0**	**2**	**0**	**0**
A. Enteric fermentation			85					
B. Manure management			10	0			0	
C. Rice cultivation			4				0	
D. Agricultural soils				9			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	2	0	
5. Land use change and forestry[1]	**0**	**-1 916**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-590						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-36						
E. CO_2 emissions and removals in pastures	0	-1 290	0	0	0	0		
6. Waste			**33**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			31		0		0	
B. Wastewater handling			2	0	0	0	0	
CO_2 emissions from biomass burning	**93**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1991, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**23191**							
Total national emissions and removals by key gases	**17 134**	**-1 895**	**177**	**11**	**75**	**444**	**49**	**32**
1. Energy	**15 701**	0	**42**	**0**	**74**	**239**	**44**	**26**
A. Fuel combustion	15 701		2	0	74	239	44	26
1. Electricity	58		0	0	0	0	0	0
2. Manufacturing industries and construction	4 366		0	0	12	3	0	7
3. Transport	4 755		1	0	46	221	41	6
4. Other	6 522		1	0	17	15	2	12
B. Fugitive emissions from fuel	0		41		0	0	0	0
1. Solid fuels			3		0	0	0	0
2. Oil and natural gas			38		0	0	0	0
2. Industrial Processes	**1 433**	**0**	**0**	**0**	**1**	**204**	**5**	**6**
A. Mineral products	599				0	0	0	0
B. Chemical industry	165		0	0	0	1	1	0
C. Metal production	669		0	0	1	203	0	6
D. Other production	0		0	0	0	0	5	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**102**	**10**	**0**	**2**	**0**	**0**
A. Enteric fermentation			87					
B. Manure management			11	0			0	
C. Rice cultivation			4				0	
D. Agricultural soils				10			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	2	0	
5. Land use change and forestry[1]	**0**	**-1 895**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-567						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-38						
E. CO_2 emissions and removals in pastures	0	-1 291	0	0	0	0		
6. Waste			**33**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			31		0		0	
B. Wastewater handling			2	0	0	0	0	
CO_2 emissions from biomass burning	**87**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1992, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**19492**							
Total national emissions and removals by key gases	**14 074,0**	**-1 889,2**	**164,1**	**9,9**	**53,4**	**346,0**	**33,2**	**28,1**
1. Energy	**13 124,0**	0,0	**40,9**	**0,1**	**52,6**	**159,1**	**29,2**	**22,8**
A. Fuel combustion	13 124,0		1,3	0,1	52,6	159,1	29,2	22,8
1. Electricity	116,0		0,0	0,0	0,0	0,0	0,0	0,0
2. Manufacturing industries and construction	3 997,0		0,3	0,0	10,9	2,5	0,4	7,1
3. Transport	2 957,0		0,4	0,0	28,7	145,7	27,0	4,0
4. Other	6 053,0		0,6	0,0	13,0	10,9	1,8	11,7
B. Fugitive emissions from fuel	0,0		39,7		0,0	0,0	0,0	0,0
1. Solid fuels			2,1		0,0	0,0	0,0	0,0
2. Oil and natural gas			37,5		0,0	0,0	0,0	0,0
2. Industrial Processes	**950,0**	**0,0**	**0,0**	**0,0**	**0,7**	**185,3**	**4,0**	**5,4**
A. Mineral products	278,0				0,0	0,0	0,1	0,1
B. Chemical industry	104,0		0,0	0,0	0,0	0,5	0,3	0,0
C. Metal production	568,0		0,0	0,0	0,7	184,7	0,0	5,2
D. Other production	0,0		0,0	0,0	0,0	0,0	3,5	0,0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**93**	**9**	**0**	**2**	**0**	**0**
A. Enteric fermentation			78					
B. Manure management			10	0			0	
C. Rice cultivation			4				0	
D. Agricultural soils				9			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	2	0	
5. Land use change and forestry[1]	**0**	**-1 889**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-558						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-39						
E. CO_2 emissions and removals in pastures	0	-1 292	0	0	0	0		
6. Waste			**30**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			28		0		0	
B. Wastewater handling			2	0	0	0	0	
CO_2 emissions from biomass burning	**60**		**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

Tajikistan: Greenhouse Gas Inventory in 1993, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**16858**							
Total national emissions and removals by key gases	**11 826**	**-1 898**	**161**	**10**	**41**	**226**	**20**	**24**
1. Energy	**11 217**	0	**39**	**0**	**41**	**89**	**16**	**20**
A. Fuel combustion	11 217		1	0	41	89	16	20
1. Electricity	1 187		0	0	3	0	0	2
2. Manufacturing industries and construction	2 538		0	0	7	1	0	5
3. Transport	1 401		0	0	13	70	13	2
4. Other	6 092		1	0	18	17	3	12
B. Fugitive emissions from fuel	0		38		0	0	0	0
1. Solid fuels			2		0	0	0	0
2. Oil and natural gas			36		0	0	0	0
2. Industrial Processes	**608**	**0**	**0**	**0**	**1**	**135**	**3**	**4**
A. Mineral products	155				0	0	0	0
B. Chemical industry	44		0	0	0	0	0	0
C. Metal production	409		0	0	1	135	0	4
D. Other production	0		0	0	0	0	3	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**93**	**9**	**0**	**2**	**0**	**0**
A. Enteric fermentation			78					
B. Manure management			11	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				9			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	2	0	
5. Land use change and forestry[1]	**0**	**-1 898**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-552						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-40						
E. CO_2 emissions and removals in pastures	0	-1 307	0	0	0	0		
6. Waste			**29**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			28		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**31**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1994, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**10933**							
Total national emissions and removals by key gases	**6 694**	**-1 887**	**140**	**9**	**22**	**165**	**9**	**15**
1. Energy	**6 196**	0	**21**	**0**	**22**	**37**	**7**	**11**
A. Fuel combustion	6 196		1	0	22	37	7	11
1. Electricity	190		0	0	0	0	0	0
2. Manufacturing industries and construction	1 598		0	0	4	1	0	3
3. Transport	1 144		0	0	11	30	5	2
4. Other	3 265		0	0	7	7	1	6
B. Fugitive emissions from fuel	0		21		0	0	0	0
1. Solid fuels			1		0	0	0	0
2. Oil and natural gas			20		0	0	0	0
2. Industrial Processes	**498**	**0**	**0**	**0**	**1**	**127**	**3**	**4**
A. Mineral products	104				0	0	0	0
B. Chemical industry	20		0	0	0	0	0	0
C. Metal production	373		0	0	1	127	0	4
D. Other production	0		0	0	0	0	2	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**90**	**8**	**0**	**1**	**0**	**0**
A. Enteric fermentation			75					
B. Manure management			10	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				8			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	1	0	
5. Land use change and forestry[1]	**0**	**-1 887**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-521						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-40						
E. CO_2 emissions and removals in pastures	0	-1 326	0	0	0	0		
6. Waste			**28**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			27		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**20**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1995, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**8473**							
Total national emissions and removals by key gases	**4 668**	**-1 877**	**129**	**8**	**15**	**150**	**5**	**12**
1. Energy	**4 222**	0	**15**	**0**	**15**	**21**	**4**	**8**
A. Fuel combustion	4 222		0	0	15	21	4	8
1. Electricity	244		0	0	1	0	0	0
2. Manufacturing industries and construction	1 039		0	0	3	0	0	2
3. Transport	465		0	0	5	14	3	1
4. Other	2 474		0	0	7	6	1	5
B. Fugitive emissions from fuel	0		14		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			14		0	0	0	0
2. Industrial Processes	**446**	**0**	**0**	**0**	**1**	**127**	**1**	**4**
A. Mineral products	52				0	0	0	0
B. Chemical industry	33		0	0	0	0	0	0
C. Metal production	361		0	0	1	127	0	4
D. Other production	0		0	0	0	0	1	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**86**	**7**	**0**	**1**	**0**	**0**
A. Enteric fermentation			71					
B. Manure management			10	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	1	0	
5. Land use change and forestry[1]	**0**	**-1 877**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-492						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-41						
E. CO_2 emissions and removals in pastures	0	-1 344	0	0	0	0		
6. Waste			**28**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			27		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**17**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1996, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**6654**							
Total national emissions and removals by key gases	**3 206**	**-1 883**	**119**	**8**	**13**	**126**	**6**	**8**
1. Energy	**2 840**	0	**7**	**0**	**12**	**17**	**3**	**5**
A. Fuel combustion	2 840		0	0	12	17	3	5
1. Electricity	211		0	0	0	0	0	0
2. Manufacturing industries and construction	730		0	0	2	0	0	1
3. Transport	418		0	0	4	11	2	1
4. Other	1 481		0	0	6	6	1	3
B. Fugitive emissions from fuel	0		7		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			7		0	0	0	0
2. Industrial Processes	**366**	**0**	**0**	**0**	**0**	**106**	**3**	**3**
A. Mineral products	31				0	0	0	0
B. Chemical industry	28		0	0	0	0	0	0
C. Metal production	307		0	0	0	106	0	3
D. Other production	0		0	0	0	0	3	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**83**	**7**	**0**	**3**	**0**	**0**
A. Enteric fermentation			69					
B. Manure management			10	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 883**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-482						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-40						
E. CO_2 emissions and removals in pastures	0	-1 361	0	0	0	0		
6. Waste			**29**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			28		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**18**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1997, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**6622**							
Total national emissions and removals by key gases	**3 326**	**-1 873**	**116**	**7**	**16**	**124**	**7**	**8**
1. Energy	**2 984**	0	**7**	**0**	**15**	**20**	**4**	**5**
A. Fuel combustion	2 984		0	0	15	20	4	5
1. Electricity	25		0	0	0	0	0	0
2. Manufacturing industries and construction	644		0	0	2	0	0	1
3. Transport	501		0	0	5	12	2	1
4. Other	1 814		0	0	8	7	1	3
B. Fugitive emissions from fuel	0		7		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			7		0	0	0	0
2. Industrial Processes	**342**	**0**	**0**	**0**	**0**	**101**	**4**	**3**
A. Mineral products	25				0	0	0	0
B. Chemical industry	28		0	0	0	0	0	0
C. Metal production	289		0	0	0	101	0	3
D. Other production	0		0	0	0	0	3	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**80**	**7**	**0**	**3**	**0**	**0**
A. Enteric fermentation			66					
B. Manure management			9	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 873**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-479						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-39						
E. CO_2 emissions and removals in pastures	0	-1 355	0	0	0	0		
6. Waste			**29**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			28		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**9**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1998, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**5875**							
Total national emissions and removals by key gases	**2 499**	**-1 861**	**114**	**8**	**15**	**127**	**8**	**7**
1. Energy	**2 156**	0	**4**	**0**	**15**	**20**	**4**	**4**
A. Fuel combustion	2 156		0	0	15	20	4	4
1. Electricity	10		0	0	0	0	0	0
2. Manufacturing industries and construction	500		0	0	1	0	0	1
3. Transport	543		0	0	6	13	2	1
4. Other	1 104		0	0	8	7	1	2
B. Fugitive emissions from fuel	0		3		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			3		0	0	0	0
2. Industrial Processes	**343**	**0**	**0**	**0**	**0**	**105**	**4**	**3**
A. Mineral products	14				0	0	0	0
B. Chemical industry	32		0	0	0	0	0	0
C. Metal production	297		0	0	0	105	0	3
D. Other production	0		0	0	0	0	4	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**81**	**7**	**0**	**3**	**0**	**0**
A. Enteric fermentation			65					
B. Manure management			9	0			0	
C. Rice cultivation			6				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 861**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-464						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-38						
E. CO_2 emissions and removals in pastures	0	-1 360	0	0	0	0		
6. Waste			**29**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			28		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**3**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 1999, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**5590**							
Total national emissions and removals by key gases	**2 621**	**-1 854**	**108**	**7**	**12**	**141**	**7**	**8**
1. Energy	**2 236**	0	**5**	**0**	**12**	**15**	**3**	**4**
A. Fuel combustion	2 236		0	0	12	15	3	4
1. Electricity	12		0	0	0	0	0	0
2. Manufacturing industries and construction	418		0	0	1	0	0	1
3. Transport	454		0	0	5	10	2	1
4. Other	1 353		0	0	6	6	1	3
B. Fugitive emissions from fuel	0		5		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			5		0	0	0	0
2. Industrial Processes	**385**	**0**	**0**	**0**	**0**	**123**	**4**	**3**
A. Mineral products	24				0	0	0	0
B. Chemical industry	15		0	0	0	0	0	0
C. Metal production	346		0	0	0	123	0	3
D. Other production	0		0	0	0	0	4	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**82**	**6**	**0**	**3**	**0**	**0**
A. Enteric fermentation			65					
B. Manure management			10	0			0	
C. Rice cultivation			7				0	
D. Agricultural soils				6			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 854**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-452						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-37						
E. CO_2 emissions and removals in pastures	0	-1 365	0	0	0	0		
6. Waste			**21**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			20		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**4**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 2000, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**5519**							
Total national emissions and removals by key gases	**2 540**	**-1 878**	**112**	**6**	**9**	**158**	**5**	**8**
1. Energy	**2 064**	0	**6**	**0**	**8**	**10**	**2**	**4**
A. Fuel combustion	2 064		0	0	8	10	2	4
1. Electricity	9		0	0	0	0	0	0
2. Manufacturing industries and construction	363		0	0	1	0	0	1
3. Transport	224		0	0	2	6	1	0
4. Other	1 467		0	0	5	4	1	3
B. Fugitive emissions from fuel	0		6		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			6		0	0	0	0
2. Industrial Processes	**475**	**0**	**0**	**0**	**1**	**144**	**4**	**4**
A. Mineral products	37				0	0	0	0
B. Chemical industry	29		0	0	0	0	0	0
C. Metal production	409		0	0	1	144	0	4
D. Other production	0		0	0	0	0	3	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**85**	**6**	**0**	**3**	**0**	**0**
A. Enteric fermentation			67					
B. Manure management			10	0			0	
C. Rice cultivation			8				0	
D. Agricultural soils				6			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 878**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-473						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-37						
E. CO_2 emissions and removals in pastures	0	-1 367	0	0	0	0		
6. Waste			**21**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			20		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**4**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 2001, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**5759**							
Total national emissions and removals by key gases	**2 766**	**-1 882**	**112**	**6**	**11**	**181**	**9**	**9**
1. Energy	**2 267**	0	**7**	**0**	**10**	**23**	**4**	**4**
A. Fuel combustion	2 267		0	0	10	23	4	4
1. Electricity	13		0	0	0	0	0	0
2. Manufacturing industries and construction	566		0	0	2	0	0	1
3. Transport	400		0	0	4	19	4	1
4. Other	1 289		0	0	5	4	1	3
B. Fugitive emissions from fuel	0		7		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			7		0	0	0	0
2. Industrial Processes	**499**	**0**	**0**	**0**	**1**	**155**	**5**	**4**
A. Mineral products	43				0	0	0	0
B. Chemical industry	9		0	0	0	0	0	0
C. Metal production	448		0	0	1	155	0	4
D. Other production	0		0	0	0	0	5	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**83**	**6**	**0**	**3**	**0**	**0**
A. Enteric fermentation			67					
B. Manure management			10	0			0	
C. Rice cultivation			6				0	
D. Agricultural soils				6			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	3	0	
5. Land use change and forestry[1]	**0**	**-1 882**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-476						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-37						
E. CO_2 emissions and removals in pastures	0	-1 369	0	0	0	0		
6. Waste			**21**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			21		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**4**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 2002, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**6043**							
Total national emissions and removals by key gases	**2 594**	**-1 913**	**115**	**7**	**11**	**189**	**8**	**9**
1. Energy	**2 024**	0	**6**	**0**	**11**	**20**	**4**	**4**
A. Fuel combustion	2 024		0	0	11	20	4	4
1. Electricity	49		0	0	0	0	0	0
2. Manufacturing industries and construction	563		0	0	2	0	0	1
3. Transport	514		0	0	5	16	3	1
4. Other	897		0	0	5	4	1	2
B. Fugitive emissions from fuel	0		5		0	0	0	0
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			5		0	0	0	0
2. Industrial Processes	**570**	**0**	**0**	**0**	**0**	**165**	**4**	**5**
A. Mineral products	67				0	0	0	0
B. Chemical industry	28		0	0	0	0	0	0
C. Metal production	475		0	0	0	165	0	5
D. Other production	0		0	0	0	0	4	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**87**	**7**	**0**	**4**	**0**	**0**
A. Enteric fermentation			72					
B. Manure management			11	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	4	0	
5. Land use change and forestry[1]	**0**	**-1 913**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-497						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-38						
E. CO_2 emissions and removals in pastures	0	-1 379	0	0	0	0		
6. Waste			**22**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			21		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**4**		**0**	**0**	**0**	**0**	**0**	**0**

Tajikistan: Greenhouse Gas Inventory in 2003, Gg

Greenhouse Gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOCs	SO_x
Total national emissions and removals by sinks (CO_2-eqv)	**6560**							
Total national emissions and removals by key gases	**2 768**	**-1 929**	**122**	**8**	**11**	**189**	**7**	**9**
1. Energy	**2 140**	0	**7**	**0**	**11**	**12**	**2**	**4**
A. Fuel combustion	2 140		0	0	11	12	2	4
1. Electricity	25		0	0	0	0	0	0
2. Manufacturing industries and construction	655		0	0	2	0	0	1
3. Transport	304		0	0	3	6	1	1
4. Other	1 156		0	0	7	6	1	2
B. Fugitive emissions from fuel	0		7		0	0	0	0
1. Solid fuels			1		0	0	0	0
2. Oil and natural gas			6		0	0	0	0
2. Industrial Processes	**628**	**0**	**0**	**0**	**0**	**171**	**4**	**5**
A. Mineral products	95				0	0	0	0
B. Chemical industry	39		0	0	0	0	0	0
C. Metal production	494		0	0	0	171	0	5
D. Other production	0		0	0	0	0	4	0
3. Solvents and other product use	**0**			**0**			0	
4. Agriculture			**93**	**7**	**0**	**5**	**0**	**0**
A. Enteric fermentation			77					
B. Manure management			11	0			0	
C. Rice cultivation			5				0	
D. Agricultural soils				7			0	
E. Savannas burning			0	0	0	0	0	
F. Burning of agricultural residues			0	0	0	5	0	
5. Land use change and forestry[1]	**0**	**-1 929**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stock	0	-496						
B. Conversion to forests and pastures	0	0	0	0	0	0		
C. Wastelands		0						
D. CO_2 emissions and removals in soils	0	-38						
E. CO_2 emissions and removals in pastures	0	-1 396	0	0	0	0		
6. Waste			**22**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposals on land			21		0		0	
B. Wastewater handling			1	0	0	0	0	
CO_2 emissions from biomass burning	**4**		**0**	**0**	**0**	**0**	**0**	**0**