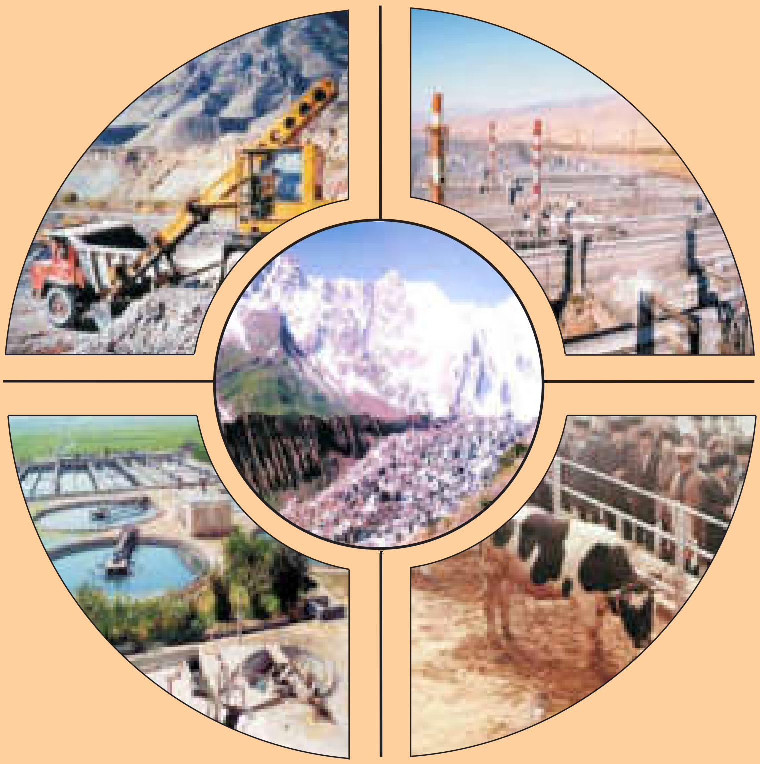
TAJIKISTAN

Main Administration on Hydrometeorology and
Environmental Pollution Monitoring

Ministry for Nature Protection of
the Republic Tajikistan

NATIONAL ACTION PLAN FOR CLIMATE CHANGE MITIGATION



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National Action Plan of the Republic of Tajikistan for Climate Change Mitigation

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

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Preface

Over 100 qualified experts out of whom 30 doctors of sciences from leading ministries and scientific institutions contributed to the preparation of National Action Plan for Climate Change Mitigation. The National Action Plan is prepared in close collaboration with international organizations and represents priorities of the governmental policy on implementation of the UN Framework Convention on Climate change in Tajikistan.

The National Action Plan consists of 12 sections containing the information on climate change scientific basis, anthropogenic pressures, climate change adverse impacts on natural resources, economy and public health as well as response measures on climate change.

The important goal of this National Action Plan is to provide basic information for response measures that will meet the Objective of the UN FCCC, Article 2, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The National Action Plan was discussed in a series of national workshops involving governmental organizations, mass media and international experts. All remarks and recommendations were thoroughly analyzed and elaborated in the course of preparation of the National Action Plan.

We wish to express our appreciation to the Government of the Republic of Tajikistan, GEF, UNDP, UNFCCC Secretariat for providing technical guidance and funding for the preparation of the National Action Plan.

Authors of the National Action Plan would like to express the gratitude to all the national experts, lead authors, review editors, national and international consultants. These individuals have devoted enormous time and effort to produce this document and we are extremely grateful for their commitment to this process that is highly appreciated by the Governmental Working Group on climate change.

Authors of the National Action Plan wish to highlight the continuing efforts made by colleagues from UNEP/GRID-Arendal, UNDP Regional Bureau in Slovakia, UNDP Tajikistan, National Communication Support Programme GEF-UNDP and UNFCCC.

Authors of the National Action Plan are grateful to the governments of the Russian Federation, Uzbekistan and Azerbaijan who have supported their scientists' participation in the research of such new course for Tajikistan as global climate change.

Minister for nature protection *U. Shokirov*

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Summary for Policymakers

I. National circumstances of the Republic of Tajikistan

Tajikistan is situated in Central Asia, between the latitudes 36°40'N to 41°05'N and longitudes 67°31'E to 75°14'E (fig. i). Tajikistan's territory is 143.1 thousand sq.km.

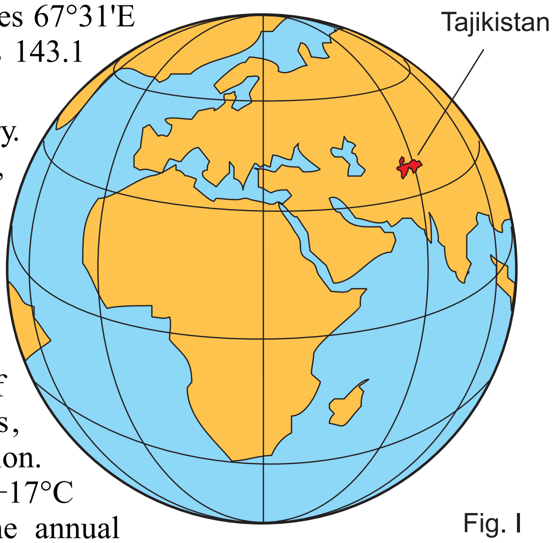

Fig. I

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

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

Due to specific climate and landscape conditions, Tajikistan is considered as the main glacial center of Central Asia. Glaciers regulate river flow and climate, and comprise 6% of the total country area. The largest glacier of Tajikistan is Fedchenko glacier which length exceeds 70 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. The largest rivers are Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, Bartang etc. There are 947 rivers in Tajikistan with the length more 10 km. Total river length is 28,500 km.

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

Forests in Tajikistan occupy an area of 410 thousand hectares. Juniper forests are major national forests and spread on elevations ranging from 1,500 to 3,200 masl. Pistachios are well adapted to hot and dry climate and concentrated in the Southern Tajikistan on the altitudes from 600 to 1,400 masl. Walnut forests grow in Central Tajikistan at the altitudes from 1,000 to 2,000 masl and differ by very demand in terms of soil and climatic conditions. Maple forests occupy essential part of national forests. Poplars, willows, birches, sea-buckthorns and other types of groves are spread fragmentarily.

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

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

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

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

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

Transport is an integral part of the economy in Tajikistan and plays the most significant role in view of the complicated mountainous pattern of the country. The length of paved roads in general use is 13,615 km.

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

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

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

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

II. Climate change trends and scenarios

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

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

During 1961-1990, the increase of 0.7-1.2°C in the annual mean air temperature was observed in the wide valleys of Tajikistan. To a lesser degree, the growth of temperature had taken place in mountain areas by 0.1-0.7°C, and only in the mountains of Central Tajikistan, Rushan and lower reaches of Zeravshan river there was a small decline in temperature of 0.1-0.3°C.

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

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

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

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

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

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

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

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

III. Anthropogenic greenhouse gas emissions and scenarios

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

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

The results of GHG inventory show that most of emissions in Tajikistan were observed in 1991 and amounted to 31 million tonnes of CO_2 without consideration of their removal by natural sinks. The least emissions were observed in 1998 and amounted to 6.3 million tonnes.

The biggest reduction is observed in CO_2 emissions, and the small reduction in emissions of CH_4, PFCs and N_2O.

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

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

CO_2 emissions. In Tajikistan in the period of 1990-1998, the biggest CO_2 emissions were observed in 1991 (22.6 mln tonnes), mainly because of fossil fuels combustion.

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

Most of CO_2 emissions come from:

Fossil fuel combustion in industry, transport and residential sector (82-92%);

Production of cement, lime, aluminum, ferrous metals and ammonia (8-18%).

Because of illegal deforestation, the absorption of CO_2 by forests and other woody biomass has decreased by 35%. Given that in 1990 this indicator was 588 Gg, in 1994 it was only 447 Gg.

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

CH_4 emissions. The biggest volume of CH_4 emissions in the period 1990-1998 in Tajikistan was indicated in 1991 (176 Gg) mainly because of intestinal fermentation, manure management and oil-gas systems. Totally, in the period under review, the volume of methane emissions has decreased more than 40% as a consequence of structural changes in the agricultural sector and decrease in production and consumption of fossil fuels.

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

Rice cultivation, solid waste disposal sites and wastewater treatment processes are the sources of CH_4 emissions. The volume of methane emissions from these sources comprises 10%.

N_2O emissions. The biggest volume of N_2O emissions in the period 1990-1998 in Tajikistan was indicated in 1990 (about 4 Gg); the lowest emission was indicated during 1995-1998 (up to 2 Gg), mainly because of applying mineral fertilizers in agricultural soils. Nitrous oxide emissions in the category "Agriculture" make in different years 97% to 99% of all N_2O emissions.

N_2O emissions from other sources (manure management, burning of agricultural residues) are insignificant. Part of N_2O emissions occurs due to fossil fuel combustion, mainly in transport sector.

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

Since the production of primary aluminum has decreased from 450.3 thousand tonnes in 1990 to 195.6 thousand tonnes in 1998, perfluorcarbon emissions have proportionally decreased by 57%. The biggest volume of perfluorocarbon emissions was registered in 1990 - 0.69 Gg. The least PFC emissions indicated in 1997 - 0.29 Gg.

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

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

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

IV. Climate change impacts on the environment, economy and public health

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

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

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

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

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

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

Agriculture in Tajikistan is at particular risk of severe effects of climate change, where apart from other factors, land degradation and desertification are the typical natural processes.

The most damage to agriculture in Tajikistan is occurred in result of such hydro-meteorological phenomena as:

High temperatures, hot winds and low temperatures;

Heavy rainfalls;

Floods and mudflows;

Strong winds and sandstorms;

Agricultural pests and diseases.

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

Long dry periods together with high temperatures in spring and summer seasons lead to the intensification of desertification processes in Southern and Central Tajikistan. Uncontrolled deforestation conditioned by lack of energy resources lead to catastrophic scales of those processes.

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

Hydropower engineering is relatively stable towards the hydrological cycle fluctuations, however long-term drought and increased suspended solids will negatively affect this economy.

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

As a result of climate warming, vector-born and other dangerous diseases, including malaria will spread significantly.

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

It is very likely that the rise of extreme summer temperatures will lead to higher infant and adult mortality.

In the circumstances, when the climate is changing very rapidly, human adaptation mechanisms are overstrained, and cannot react appropriately, which increases human being's vulnerability. The climate change impact on public health and mortality remains poorly studied both in Tajikistan and in the world. There is a need in further detailed investigations.

Most vulnerable to the climate change is the population in poverty because of absence of necessary resources for coping adverse affects and adaptation.

It should be noted that V&A research has revealed uncertainties that refer to the lack of scientific knowledge and an inadequate system of observations over the climate change indicators and consequences, including ecosystems, public health, etc.

V. Climate change mitigation

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

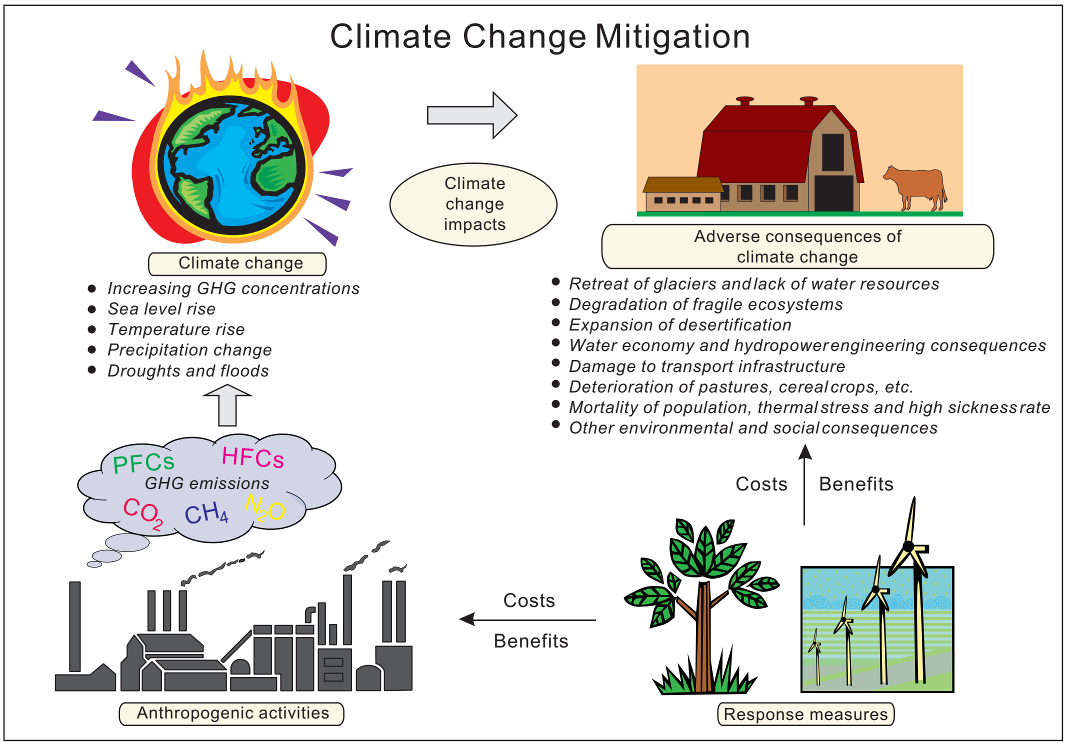

Fig. II

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

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

Application of effective technologies and use of energy sources in the national economy that promotes high rates of economical growth and reduce or limit greenhouse gas emissions;

Protection and enhancement of natural sinks and reservoirs of greenhouse gases;

Promotion of sustainable forest management practices, afforestation and reforestation;

Promotion of sustainable forms of agriculture in the light of climate change considerations;

Research on, promotion, development and increase used of, new and renewable energies, advanced, innovative, and environmentally sound technologies;

Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures, which limit or reduce emissions of greenhouse gases.

Response measures targeted to different levels of implementation and involve all relevant sectors: energy, transport, agriculture, forestry and wastes. Limitation and reduction of greenhouse gases should ensure maximum efficiency and minimum expanses. Joining the Kyoto Protocol to the UNFCCC in the perspective is a key factor and necessary condition for successful implementation of national commitments and participation in Clean Development Mechanism of the Kyoto Protocol.

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

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

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

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

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

Principal directions of adaptation measures include:

Research on climate change, its impacts on natural resources, national economy, public health and development of additional adaptation measures;

Improvement of the systematic observation networks and environmental monitoring to revise and renew adaptation measures;

Improvement of the system of data collection, analysis, interpretation and dissemination among end users;

Enhancement of weather forecasting, climate modeling and early warning systems for minimization of natural disasters risk;

Capacity building to strengthen institutional, technical and human resources to promote adaptation in fields of climate and hydrological research, geographical information systems, environmental impact assessment, protection and re-cultivation of lands, rational use of water resources, conservation of ecosystems, sustainable agriculture, infrastructure development and health protection;

Implementation of actual projects on adaptation in priority areas related to rational use of natural resources, national economy and health protection.

1 Introduction

1.1. Problem background

Climate is usually defined as the statistical description, in terms of the mean and variability of relevant quantities, of a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO).

The key factors determining development and status of the climate are: solar irradiation and its spatial-temporary changes, arrangement of water and land, height of the terrestrial surface, form of the relief and anthropogenic influence.

A variety of climatic conditions in Tajikistan are observed due to high elevations, geographical position and landscape peculiarities, which generate a great deal of interest for studying and modelling climate change on a local and regional scale.

The climatic system consists of five major components: the atmosphere, hydrosphere, biosphere, land surface and the cryosphere, and the interactions between them (fig. 1.1).

The atmosphere is an environment essential for all life on land and sea, upon which the existence of the entire humankind depends.

The anthropogenic effects on the physical and chemical properties of the atmosphere have the potential to directly influence the climatic system.

An important element of the climatic equilibrium of the globe is the greenhouse effect, which maintains the atmosphere of the Earth in a status of thermal balance favorable for existence of animals and plants. The greenhouse effect is responsible for the very existence of life and water on the Earth. It heats the surface of the Earth by 33 degrees and maintains a near-surface temperature of the globe at a level of 15°C above zero. Without the greenhouse effect the average temperature of the surface of the Earth would be -18°C.

The molecules of the greenhouse gases, passing solar radiation, absorb and re-emit reflected long-wave radiation leaving the Earth's surface and the atmosphere, bearing free heat and prevent it from dispersion in space (fig. 1.2). As a result, near-surface temperature of the planet is heated. The increase of concentration of greenhouse gases increases the opacity of the atmosphere with long-wave (infrared) radiation. This is the reason for the Earth-troposphere's increase in temperature, causing an increased greenhouse effect.

Water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as halocarbons, sulphur hexafluoride, hydrofluorocarbons, and perfluorocarbons.

Climate change refers to the significant variation in either the mean state of the climate or in its variability, persisting for an extended period. Climate change may be evoked by natural internal processes, external forcing, or by persistent anthropogenic changes in the composition of the atmosphere or in land use.

The influence of the external factors on a climate can be in generally explained using the radiating influence concept. A positive radiative force such as that produced by increasing concentration of greenhouse gases tends to warm the surface. Conversely negative forcing, which can arise from an increase in some types of aerosols such as sulfate aerosols, tends to cool the surface (fig. 1.3).

Radiative forcing reflects the balance of incoming and outgoing energy in the Earth-atmosphere system and determines what impact this has on the system. Radiative influence depends on the increase of greenhouse gas concentration, radiating properties of these gases and their duration in the atmosphere. It has been established that human activity is responsible for the increase of atmospheric greenhouse gas concentrations and their radiative forcing.

The atmospheric concentration of the main anthropogenic greenhouse gas carbon dioxide (CO_2) since 1750 has increased by 31% and reached 367 ppm. Today's CO_2 concentration has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The rate of CO_2 concentration increase over the past century is unprecedented and now averages 0.4% a year. About three-quarters of the anthropogenic CO_2 emissions to the atmosphere during the past 20 years are due to fossil fuel burning. The rest is predominantly due to land-use change, especially deforestation (fig. 1.4). For the period between 1990-1998 the global CO_2 emissions were estimated at around 6.3±0.4 billion tonnes of carbon a year, for which Tajikistan was responsible for less than 0.1%. Currently the ocean and the land together are taking up about half of the anthropogenic CO_2 emissions.

The atmospheric concentration of methane (CH_4) has increased by 151% since 1750 and continues to increase. These rates of concentration growth are unprecedented. The present CH_4 concentration has not been exceeded during the past 420,000 years. Slightly more than half of current CH_4 emissions are anthropogenic (use of fossil fuels, cattle, rice agriculture and landfills). In addition, carbon monoxide (CO) emissions have recently been identified as a cause of increasing CH_4 concentration.

The atmospheric concentration of nitrous oxide (N_2O) has increased by 17% since 1750 and continues to increase. The present N_2O concentration has not been exceeded during at least the past thousand years. About a third of current N_2O emissions are anthropogenic (agricultural soils, cattle feed lots and chemical industry).

Ozone (O_3) is an important greenhouse gas present in both the stratosphere and the troposphere. The role of ozone in the atmospheric radiation budget is strongly dependant on the altitude at which changes in ozone concentration occur. The change in ozone concentration is also spatially variable. Ozone is formed as a result of photochemical reactions and its concentration is determined by, among other things, CH_4 emissions and polluting substances.

Ozone concentrations respond relatively quickly to changes in the emissions of pollutants. On the basis of limited observations and several modeling studies, tropospheric ozone is estimated to have increased by about 35% since the Pre-industrial Era, with some regions experiencing larger and some with smaller increases.

Concentration of other greenhouse gases having extremely high global warming potential continue to rise in connection with the development of industry and consequently have an influence on the climatic system. Two groups of such gases are halocarbons and perfluorocarbons. These gases are kept extremely long in the atmosphere and are active absorbers of infrared radiation.

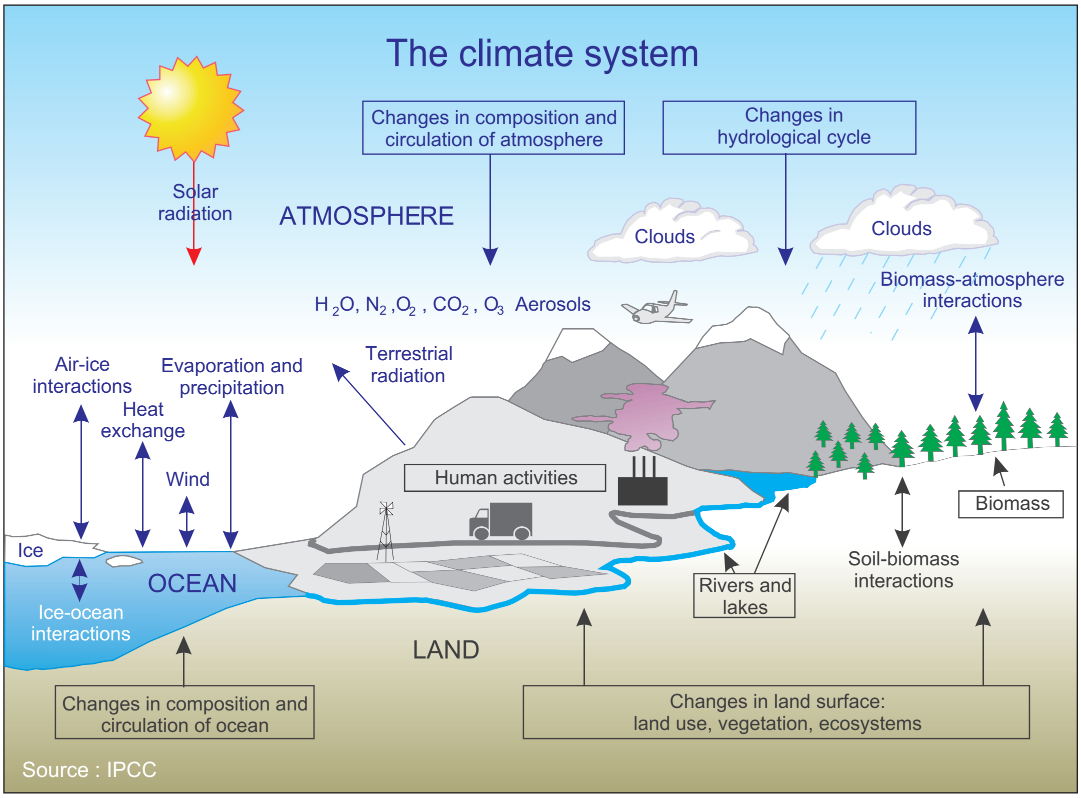
The climate system
Changes in composition and circulation of atmosphere
Changes in hydrological cycle
Solar radiation
ATMOSPHERE
Clouds
Clouds
Biomass-atmosphere interactions
H 2O, N2 ,O2 , CO2 , O3 Aerosols
Air-ice interactions
Evaporation and precipitation
Terrestrial radiation
Heat exchange
Wind
Human activities
Biomass
Ice
OCEAN
Rivers and lakes
Soil-biomass interactions
Ice-ocean interactions
LAND
Changes in composition and circulation of ocean
Changes in land surface: land use, vegetation, ecosystems
Source : IPCC

Fig. 1.1.

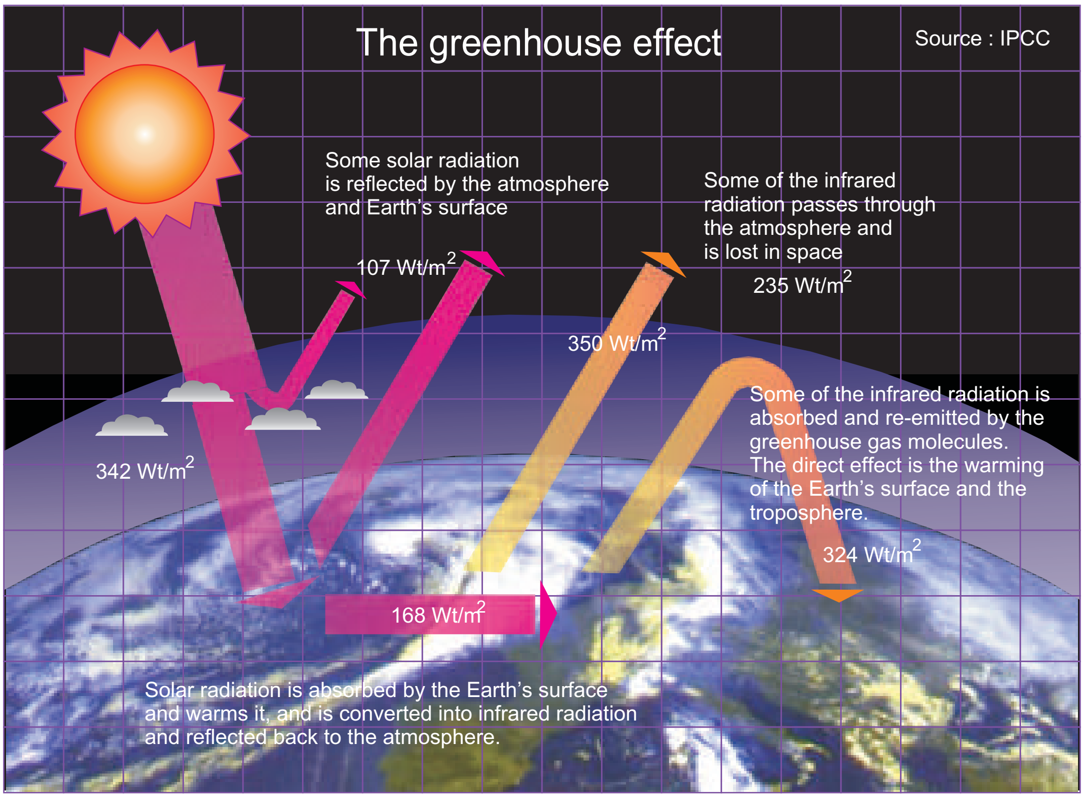
The greenhouse effect
Source : IPCC
Some solar radiation is reflected by the atmosphere and Earth's surface
Some of the infrared radiation passes through the atmosphere and is lost in space
107 Wt/m2
235 Wt/m2
350 Wt/m2
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the Earth's surface and the troposphere.
342 Wt/m2
324 Wt/m2
168 Wt/m2
Solar radiation is absorbed by the Earth's surface and warms it, and is converted into infrared radiation and reflected back to the atmosphere.

Fig. 1.2.

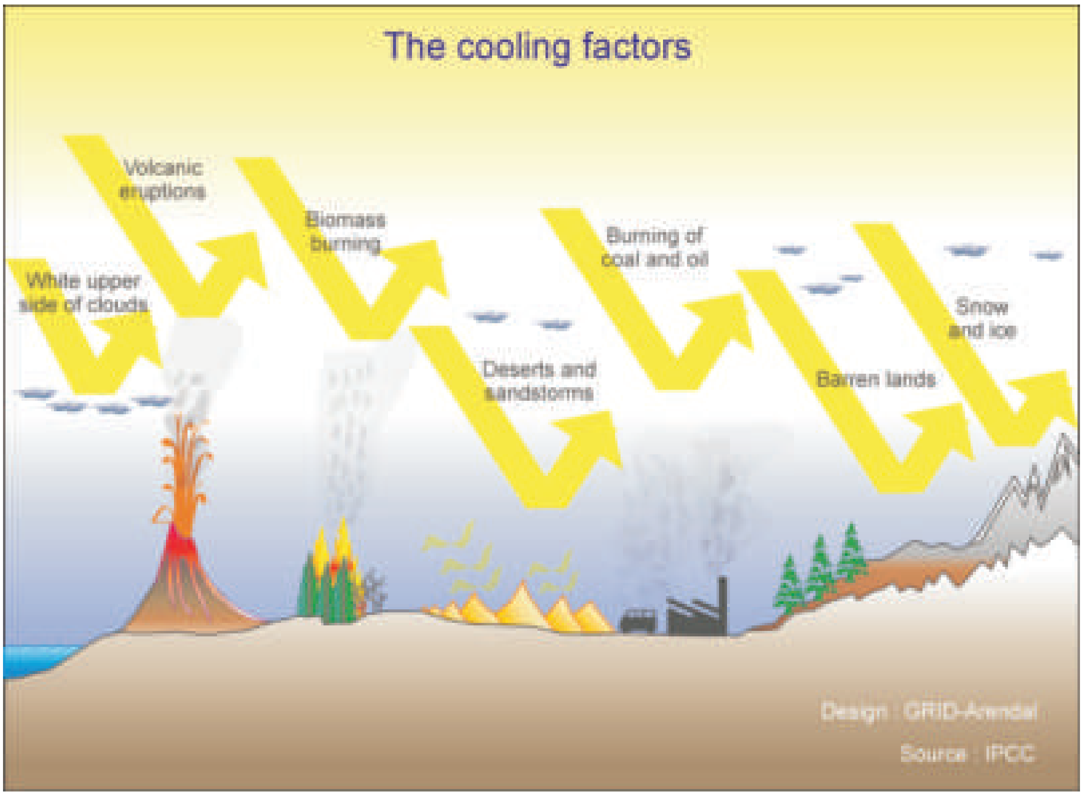
The cooling factors
Volcanic eruptions
Biomass burning
White upper side of clouds
Burning of coal and oil
Snow and ice
Deserts and sandstorms
Barren lands
Design : GRID-Arendal
Source : IPCC

Fig. 1.3.

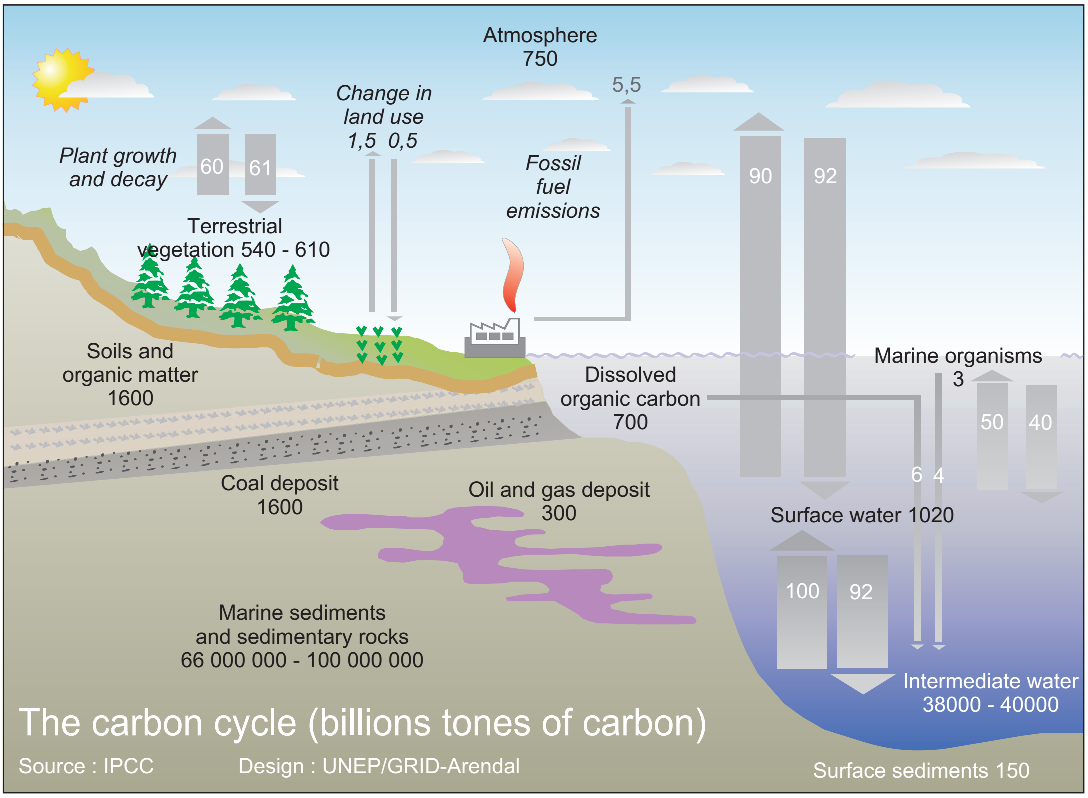
Atmosphere
750
Change in
land use
1,5 0,5
5,5
Plant growth
and decay
60
61
Fossil
fuel
emissions
90
92
Terrestrial
vegetation 540 - 610
Soils and
organic matter
1600
Dissolved
organic carbon
700
Marine organisms
3
50
40
6 4
Coal deposit
1600
Oil and gas deposit
300
Surface water 1020
100
92
Marine sediments
and sedimentary rocks
66 000 000 - 100 000 000
Intermediate water
38000 - 40000
The carbon cycle (billions tones of carbon)
Source : IPCC
Design : UNEP/GRID-Arendal
Surface sediments 150

Fig. 1.4.

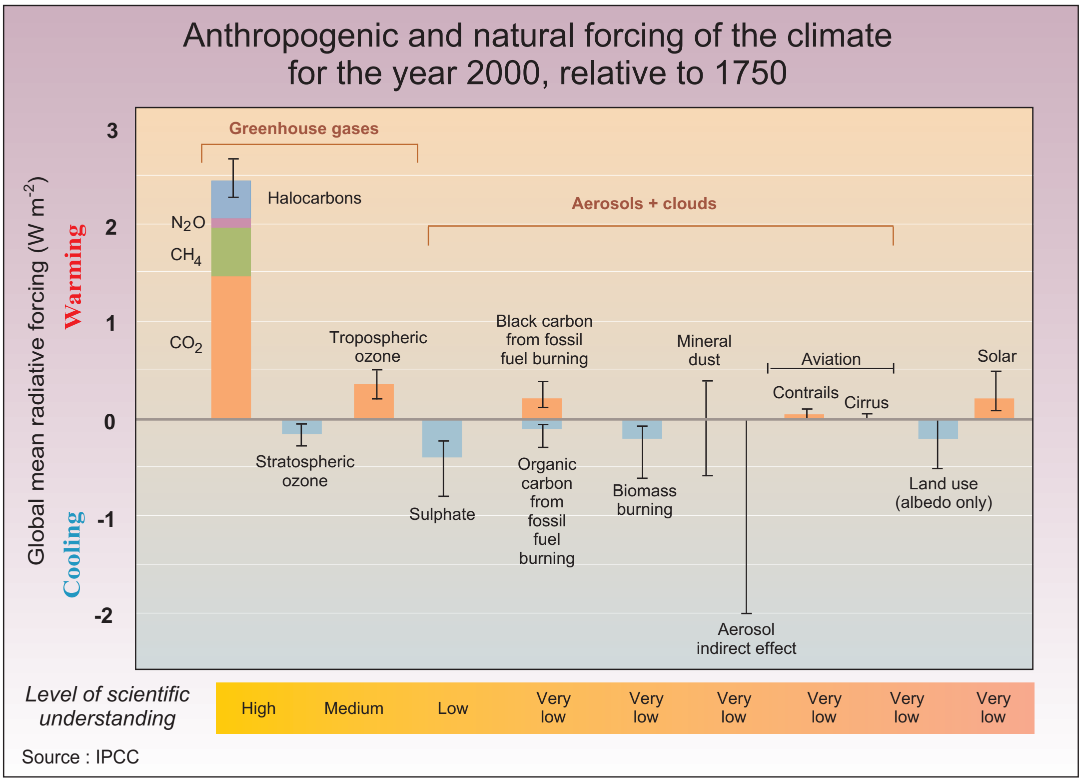

Fig. 1.5.

The gas CF_4 is kept in the atmosphere for a minimum of 50,000 years. It is released by natural sources; however modern anthropogenic emissions exceed natural emissions of this gas by 1000 times or more, and because of this there is an observable increase of its concentration. The gas SF_6 is 22,200 times more effective greenhouse gas in comparison with CO_2.

Several chemically reactive gases, including reactive nitrogen species (NOx), carbon monoxide (CO), and the volatile organic compounds (NMVOC), control, in part, the oxidising capacity of the troposphere, as well as the abundance of ozone. These pollutants act as indirect greenhouse gases through their influence not only on ozone, but also on the lifetimes of CH_4 and other greenhouse gases.

The radiative forcing due to increases of the well-mixed greenhouse gases from 1750 to 2000 is estimated to be 2.43 $W*m^{-2}$, at that 1.46 $W*m^{-2}$ from CO_2; 0.48 $W*m^{-2}$ from CH_4; 0.34 $W*m^{-2}$ from halocarbons; and 0.15 $W*m^{-2}$ from N_2O (fig. 1.5).

The observed depletion of the stratospheric ozone (O_3) layer from 1979 to 2000 is estimated to have caused a negative radiative forcing (-0.15 $W*m^{-2}$). The total amount of O_3 in the troposphere is estimated to have increased by 36% since 1750, due primarily to anthropogenic emissions of several O_3-forming gases. This corresponds to a positive radiative forcing of 0.35 $W*m^{-2}$.

Aerosols have a substantial influence on the radiative balance of the atmosphere and are formed as a result of a set of processes both natural (dust-storm, volcanic eruptions) and anthropogenic (burning of fossil fuels and biomass) character. Direct radiative forcing is estimated to be -0.4 $W*m^{-2}$ for sulphate, -0.2 $W*m^{-2}$ for biomass burning aerosols, -0.1 $W*m^{-2}$ for fossil fuel organic carbon and 0.2 $W*m^{-2}$ for fossil fuel black carbon aerosols. Uncertainties remain relatively large, however.

Changes in land use, deforestation being the major factor, appear to have produced a negative radiative forcing of -0.2 ± 0.2 $W*m^{-2}$.

The combined change in radiative forcing of the two major natural factors (solar variation and volcanic aerosols) is estimated to be negative for the past two decades. This negative influence has balanced some part of the positive influence, which occurred in a result of greenhouse gas concentrations increase.

Greenhouse gas emissions change the concentration of these gases and aerosols in the atmosphere, leading to changed radiative forcing of the climate system. Radiative forcing results in projected increases in temperature and sea level, which in turn will cause impacts on the global hydrological cycle, atmospheric and oceanic circulation.

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

The observed warming over the 20th century is unlikely to be entirely natural in origin. The increase in surface temperatures over the last 100 years is very unlikely to be due to internal variability alone.

The warming over the last 50 years due to anthropogenic greenhouse gases can be identified despite uncertainties in forcing due to anthropogenic sulphate aerosol and natural factors (volcanoes and solar irradiance). The anthropogenic sulphate aerosol forcing, while uncertain, is negative over this period and therefore cannot explain the warming. Changes in natural forcing during most of this period are also estimated to be negative and are unlikely to explain the warming.

In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system. The global average surface temperature has increased over the 20th century by 0.6± 0.2°C (fig. 1.6).

New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely to have been the largest of any century during the past 1,000 years. It is also likely that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year.

On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures (0.1°C per decade). Since 1950 it is very likely that there has been a reduction in the frequency of extreme low temperatures with the smaller increase in the frequency of extreme high temperatures.

Precipitation has very likely increased during the 20th century by 5 to 10% over most mid- and high latitudes of the Northern Hemisphere continents, but in contrast, rainfall has likely decreased by 3% on average over much of the subtropical land areas.

There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century.

The glaciers that have decreased in Tajikistan during this period have contributed to Central Asia's water resource problem, including the Aral Sea crisis.

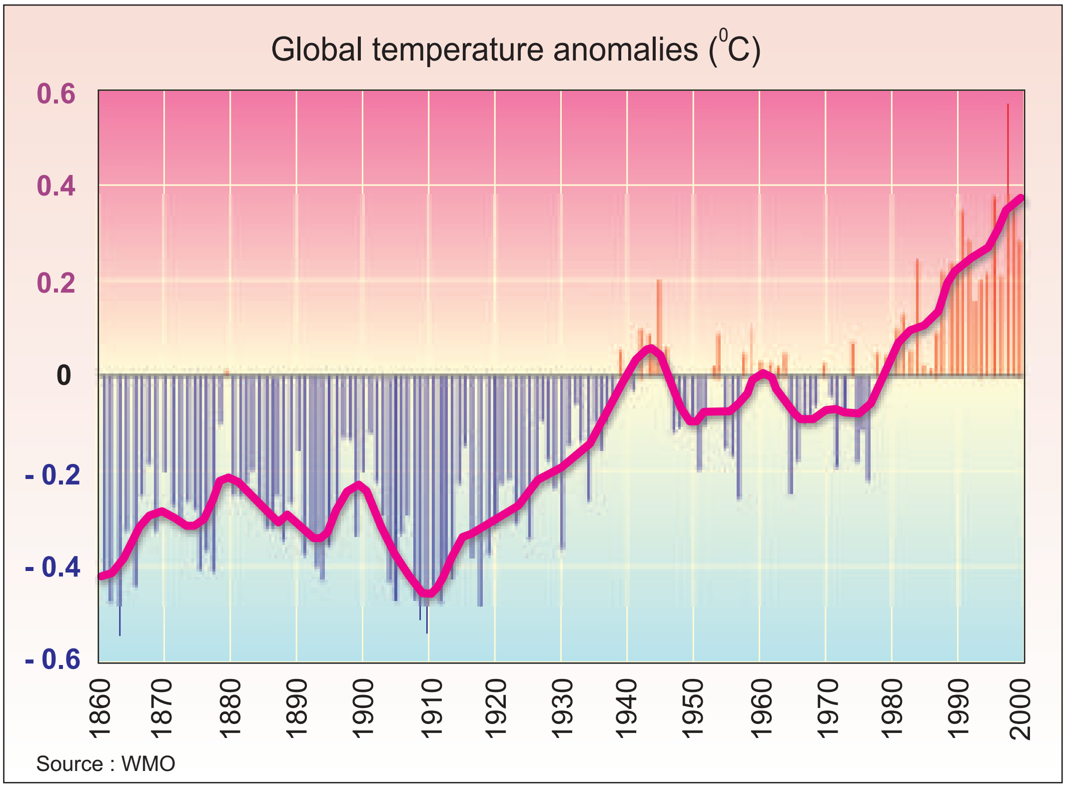
Global temperature anomalies (^{0}C)
0.6
0.4
0.2
0
- 0.2
- 0.4
- 0.6
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Source : WMO

Fig. 1.6.

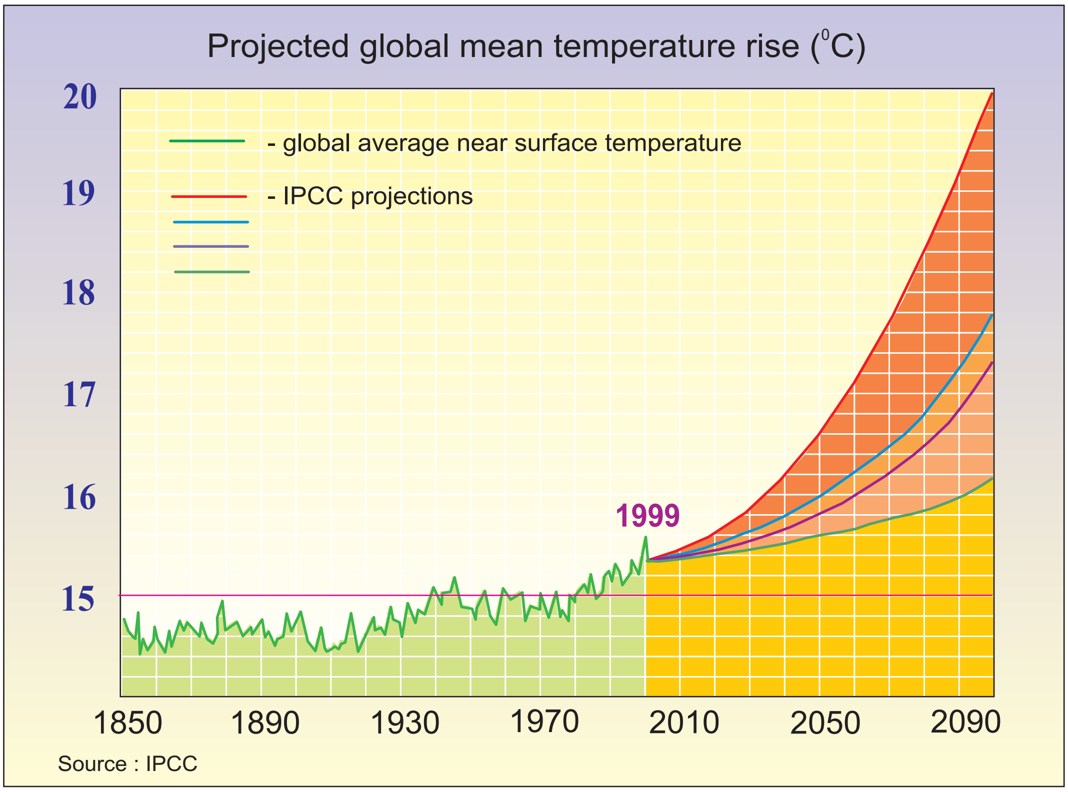
Projected global mean temperature rise (^{0}C)
20
19
18
17
16
15
- global average near surface temperature
- IPCC projections
1999
1850
1890
1930
1970
2010
2050
2090
Source : IPCC

Fig. 1.7.

Satellite data show that there are very likely to have been decreases of about 10% in the extent of snow cover since the late 1960s. Northern Hemisphere spring and summer sea-ice extent has decreased by about 10 to 15% since the 1950s. It is likely that there has been about a 40% decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness.

Based on tide gauge records, after correction for land movements, the average annual rise was between 0.1 and 0.2 m during the 20th century. Global ocean heat content has increased since the late 1950s.

Observed changes in regional climate over the past 50 years have affected many physical and biological processes and systems. There have been observed changes in species distributions, population sizes, migration events, droughts, frequency of disturbances, productivity of and species composition within ecosystems. Frequency of pests and disease outbreaks has also changed. In some regions of Asia and Africa, the combination of regional climate changes and anthropogenic stresses has led to decreased food production and desertification processes.

Human influences will continue to change atmospheric composition throughout the 21st century. The emissions of greenhouse gases change the concentration of these gases and aerosols in the atmosphere, leading to changed radiative forcing of the climate system. Radiative forcing results in projected increases in temperature and sea level, which in turn will cause impacts.

Greenhouse gas forcing in the 21st century could set in motion large-scale, high-impact, non-linear, and potentially abrupt changes in physical and biological systems over the coming decades to millennia, with a wide range of associated likelihoods. Globally averaged surface temperature, and sea level are projected to increase under all IPCC emissions scenarios during the 21st century.

The globally average surface temperature is projected to increase by 1.4 to 5.8°C (fig. 1.7) over the period 1990 to 2100. The projected rate of warming is very likely to be without precedent during at least the last 10,000 year, based on paleoclimate data.

It is very likely that nearly all land areas will warm more rapidly than the global average, particularly those at northern high latitudes in winter. Most notable of these is the warming in the northern regions of North America, and northern and central Asia, which exceeds global mean warming in each model by more than 40%.

Basing on global model simulations and for a vide range of scenarios, global average water vapor concentration and precipitation are projected to increase during the 21st century. At the regional scale, both increases and decreases in precipitation are projected, typically of 5 to 20%. It is likely that precipitation will increase over high latitude regions. Larger year-to-year variations in precipitation are very likely over most areas where an increase in mean precipitation is projected.

Glaciers and ice caps are projected to continue their widespread retreat during the 21st century.

Global mean sea level is projected to raise by 0.09 to 0.88 m between the years 1990 and 2100, for the full range of IPCC scenarios. It will result in flooding of coastal zones and increasing of natural disaster's damage.

In a warmer world the sea level will rise, primarily due to thermal expansion of ocean and loss of mass from glaciers and ice caps. The rise being continued for hundreds of years even after stabilization of greenhouse gas concentrations (fig. 1.8).

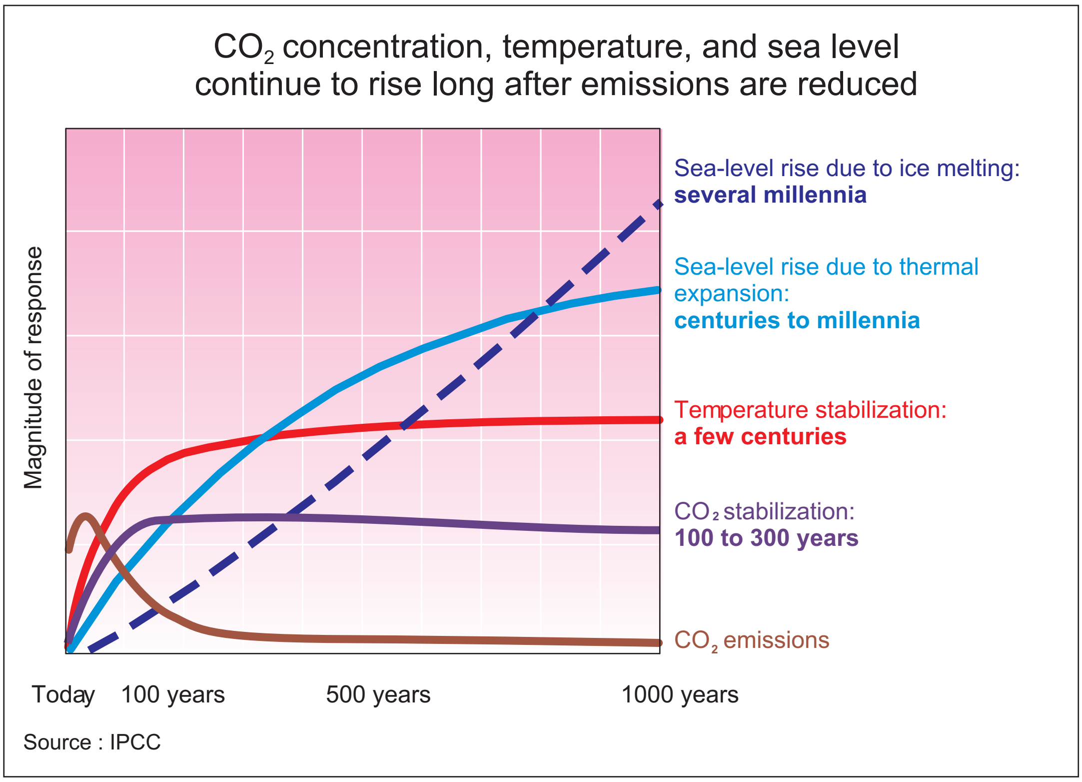
CO2 concentration, temperature, and sea level
continue to rise long after emissions are reduced
Magnitude of response
Sea-level rise due to ice melting:
several millennia
Sea-level rise due to thermal
expansion:
centuries to millennia
Temperature stabilization:
a few centuries
CO2 stabilization:
100 to 300 years
CO2 emissions
Today
100 years
500 years
1000 years
Source : IPCC

Fig. 1.8.

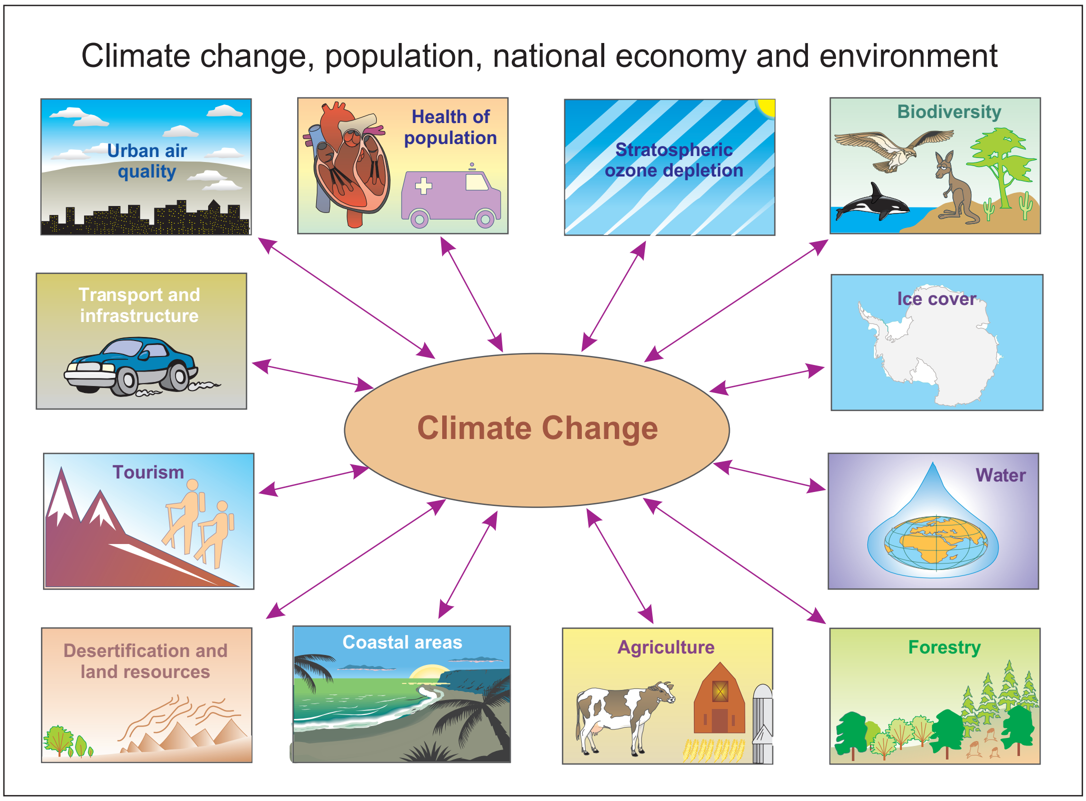
Climate change, population, national economy and environment
Urban air quality
Health of population
Stratospheric ozone depletion
Biodiversity
Transport and infrastructure
Ice cover
Climate Change
Tourism
Water
Desertification and land resources
Coastal areas
Agriculture
Forestry

Fig. 1.9.

Models project that a local warming (annually averaged) of larger than 3°C, sustained for many millennia, would lead to virtually a complete melting of the Greenland ice sheet with a resulting sea-level rise of about 7 m.

The ice sheets will continue to react to climate change during the subsequent several thousand years even if there is a stabilization of the climate. Together, the current ice sheets of the Antarctic and Greenland contain enough water to raise sea level by almost 70 m if there were to melt, so that only small fractional change in their volume would have a significant effect. For warming of more than 10°C, simple runoff models predict that a zone of net mass loss would develop on the ice sheets surface. Irreversible disintegration of the West Antarctic ice sheet (WAIS) would result because WAIS cannot retreat to higher ground once its margins are subjected to surface melting and begin to recede.

The climate change would have both beneficial and adverse consequences on ecosystems, economy and health. Thus, basic attention is given to an estimation and study of adverse consequences of climate change (fig. 1.9).

In a warmer world, the hydrological cycle would become more intense. Global average precipitation is projected to increase. More intense precipitation events (hence flooding) are very likely over many areas. Increased summer drying and associated risk of drought is likely over most mid-latitude continental interiors. Water resources in some regions of the world will increase and in other regions will decrease.

In mountain ecosystems with a rich biodiversity there can be changes in vertical distribution of natural habitats. Some types of forests and pastures will degrade; on the contrary other ecosystem will improve their productivity and condition.

The agriculture in some regions of the world can considerably suffer from climate change. The countries with arid and semiarid climates, which include Tajikistan, are especially vulnerable, where in addition there already occurs land degradation and desertification. In opposite, the influence of climate change probably will not be negative in the countries of moderate and high latitude in the northern hemisphere. The systems most likely to be impacted would include those with scarce water resources.

Freshwater is essential for human health, food production, and sanitation, as well as for manufacturing, other industrial uses and sustaining ecosystems. The water economy will confront with necessity for maintenance lot of water for demands of national economy, especially for irrigation, in view of climate warming and increase of evaporation intensity.

Hydropower engineering is rather stable towards the hydrological cycle fluctuations, however long periods of water shortage and increased amounts of suspended solids will apparently have an adverse effect on this economy.

It is likely that the risk of distribution of infectious and vector-born diseases will increase. Mortality connected with thermal stress will rise as result of warming.

The poorest sections of society appear to be most vulnerable to climate change in view of the absence of necessary survival resources, and the inability to cope with or to adapt to the consequences.

Nevertheless, a number of questions still remain unsolved, that pertain to a lack of scientific knowledge and an inadequate system of observations of climate change. It concerns ecosystems, health issues, etc.

It is possible to note by summarizing what has been stated above, that there is a climate change on a global scale with menacing prospects impacting the environment and humanity in almost every region of the world, especially Tajikistan as it is a small territory that shares experiences almost all climatic zones on the planet. As a result of anthropogenic activity the climate change will likely continue for long time to come. The concentration of anthropogenic greenhouse gases will change depending on the greenhouse gas emissions intensity and the implementation of policies and measures targeted to solve the problem of atmospheric air pollution and emission reduction.

1.2. Tajikistan's commitments to the UNFCCC

Considering the importance of the climate change problem and its adverse impact, Tajikistan continues to take part in the international efforts in solving this problem.

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

The Republic of Tajikistan is a developing country with fragile ecosystems, water resources and agriculture, which are vulnerable to climate change and various natural hazards. Sectors of national economy release greenhouse gas emissions thereby contributing to climate change.

The commitments of the Republic of Tajikistan concerning the UN Framework Convention on Climate Change include:

Formulation and implementation of measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases, and measures to facilitate adequate adaptation to climate change;

Promotion and cooperation in the development, application and diffusion of technologies, practices and processes that control, reduce or prevent greenhouse gas emissions, and in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases;

Cooperation in preparing for adaptation to the impacts of climate change;

Integration of the problem of climate change in social, economic and environmental policies and actions;

Promotion to the international efforts on strengthening systematic observation, potential and opportunities in the field of scientific research related to the climate system;

Promotion and cooperation in the field of information exchange, education, training and public awareness on climate change;

Communication to the Conference of the Parties information related to implementation, in accordance with Article 12, including national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases.

1.3. The process of National Action Plan preparation

In 1999, the Government created a working group with representatives from key ministries and institutions and designated National Focal Point to prepare a National Action Plan for climate change mitigation to fulfill national commitments on UNFCCC.

The document of the National Action Plan (NAP) has been prepared with support from the Global Environmental Facility and the Government of the Republic of Tajikistan. The process of NAP preparation lasted from 2001 to 2002 (tab. 1) and involved more than 100 qualified experts from roughly 30 ministries, institutions, academic and educational entities and public organizations.

Table 1.

The preparation stages of the National Action Plan for Climate Change Mitigation

Date	Events
January 1998	The Republic of Tajikistan joins the UN Framework Convention on climate change
July 1999	Establishment of the Governmental working group and the designation of a National Focal Point to develop National Action Plan on climate change
December 1999	Receive notification from UN FCCC Secretariat and GEF with the intention to support the preparation of the First National Communication on climate change and the National Action Plan
May 2000	Submission of project proposal on the preparation of the First National Communication of the Republic of Tajikistan for GEF approval
August 2000	Arrange initial national workshop on climate change with support from UNDP GEF
October 2000	Sign project document "Enabling the Republic of Tajikistan to Prepare its First National Communication on Climate Change "
October 2000	Conduct the first assessment of public awareness on climate change in the regions of the republic
February 2001	Start implementation of the project on preparation of First National Communication
April 2001	Arrange Project Initiation workshop on preparation of First National Communication
July 2001	Finalize report about climate change and scenarios in the Republic of Tajikistan
August 2001	Finalize report about national GHG inventory of the Republic of Tajikistan
August 2001	Arrange national workshop to discuss the results of climate change research and national GHG inventory
November 2001	Finalize report about assessment of vulnerability of natural resources, national economy and public health to climate change and adaptation measures
December 2001	Arrange National workshop to discuss the results of vulnerability assessment and strategy of adaptation to climate change
January 2002	Finalize report on GHG emissions scenarios and measures for GHG reduction
February 2002	Arrange national workshop to discuss measures on GHG reduction and likely structure of the NAP document
May 2002	Arrange national workshop to discuss the results of NAP preparation and to make decisions on the content of draft NAP document
July 2002	Arrange a meeting with the participation of leading authors to discuss final draft of the NAP document
August 2002	Submission of the document of National Action Plan for Climate Change Mitigation for consideration and approval by Tajik Government

S o u r c e : Tajik Met Service (2002)

Partnerships during NAP preparation and information exchange have been strengthened through a series of national workshops, expert meetings and companies on public awareness in the regions of the republic. Governmental institutions, public organizations, private sector, universities, scientific organizations and mass media have taken part in national workshops on the aspects of the climate change problem.

Adequate access to the resources of the Internet and distribution of climate change information in the national language were implemented. First National Communication along with the summary of results of thematic research has been published. For a better understanding of the climate change problem by the public a series of broadcasts on radio and TV, publications in newspapers, popular books, and brochures were organized.

The following working groups were established and performed designated tasks in the course of NAP preparation:

I. Scientific basis of climate change and scenarios;
II. National inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases and subgroup on verification;
III. Greenhouse gas emissions scenarios and abatement measures;
IV. Assessment of vulnerability of natural resources, national economy and public health to climate change;
V. Adaptation to climate change, measures for optimization of systematic observations and raising public awareness.

The experts from UNFCCC Secretariat and UNDP-GEF together with national consultants have verified the results of research.

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

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2 National Circumstances of the Republic of Tajikistan

2.1. Geographic position

Tajikistan is situated in the south of the Commonwealth of Independent States, within Central Asia, in the center of Eurasia, between 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 700 km from west to the east and 350 km from north to the south. In the north and west, Tajikistan borders on Uzbekistan and Kyrgyzstan, in the south on Afghanistan and in the east on China. The country's perimeter borders total 3,000 km. The territory of the country is divided into 4 administrative regions: Sogd Region, Khatlon Region, Mountain-Badakhshan Autonomous Region and Regions under Republican Administration.

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

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

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 heights exceed 6,000 masl. Thus, the terrain of Western Pamir is mostly rugged. Smooth relief characterizes Eastern Pamir, despite its high elevation above sea level, where wide valleys at elevations of 3,500-4,000 masl prevail. The absolute elevations of Eastern Pamir are high, but local mountains rise only 1,000 to 1,500 m above the valley's floor.

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

2.2. Climatic conditions

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

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

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

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

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

2.3. Glaciers and water resources

Due to specific climate conditions and landscape, Tajikistan is considered the main glacial centre of Central Asia. Glaciers retain huge amounts of water, and regulate river flow and climate. Glaciers and snowfields are the main source of water replenishing the Aral Sea. Glaciers occupy more than 8.0±0.4 thousand sq.km, which is about 6% of the total country area. The most ice cover is observed in the western part of Pamir Mountains.

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

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

1. Upper reaches of the Vakhsh River
Photo by A. Yablokov

Major watersheds of Tajikistan are Syrdarya (North Tajikistan), Zeravshan (Central Tajikistan), Pyanj (Southwest Tajikistan and Pamirs) and blind drainage area of East Pamir. The largest rivers are Pyanj, Vakhsh (photo 1), Syrdarya, Zeravshan, Kafirnigan, Bartang, etc. Most of the rivers in Tajikistan are mountainous; some of them originate at an altitude of more than 3,000 m.

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

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

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

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

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

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

2.4. Forests

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

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

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

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

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

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

2.5. Flora and fauna

Flora of Tajikistan is rich and diverse and includes more than 5,000 species of higher plants, over 3,000 species of lower plants including endemic 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 (photo 2).

2. Middle mountain zone
Photo by I. Abdusalyamov

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

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

2.6. Population

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

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

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

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

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

2.7. Social economic development

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

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

The national unit of currency is the SOMONI, which was introduced as of November 1, 2000. The annual GDP in 1998 was US$ 217.8 per capita.

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

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

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

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

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

Some 533 km of railroads, 13.6 thousand km of asphalt-coated roads run through the country's territory. The total length of national air routes exceeds 53.2 thousand km.

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

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

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

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

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

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

2.8. Energy production and use

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

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

Hydropower resources are abundant and evenly located over the territory of Tajikistan. In terms of hydropower potential, Tajikistan is one of the world leaders. For the time being, only 5% of this potential is being exploited. Hydropower engineering is the base for the electric energy sector of the country. The total capacity of operating power plants comprises 4,412.7 Megawatts, 93% of which is being produced by hydropower plants. Tajikistan's peak energy production was recorded in the early 1990s, when it reached 17-18 billion kilowatt-hours a year (fig. 2.1). At present, this has diminished and on average is 15 billion kilowatt-hours.

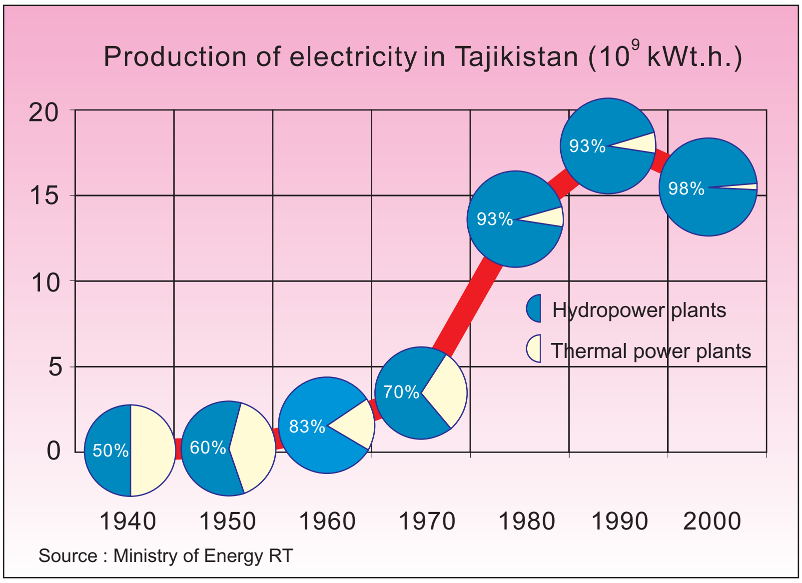

Fig. 2.1.

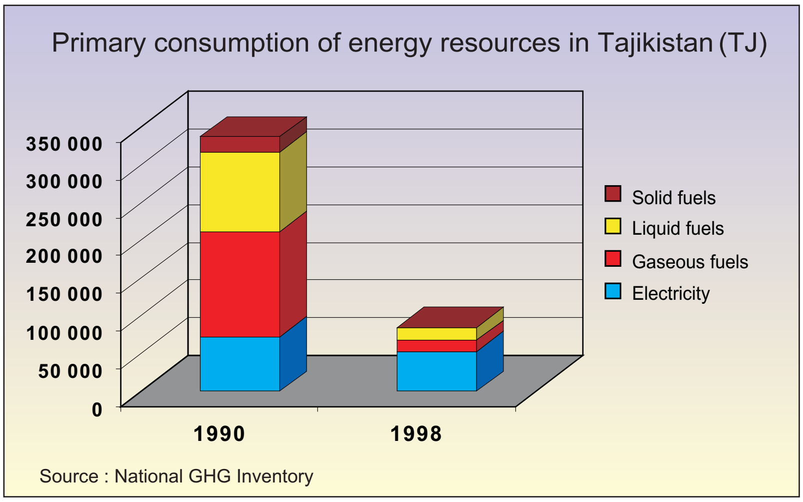

Fig. 2.2.

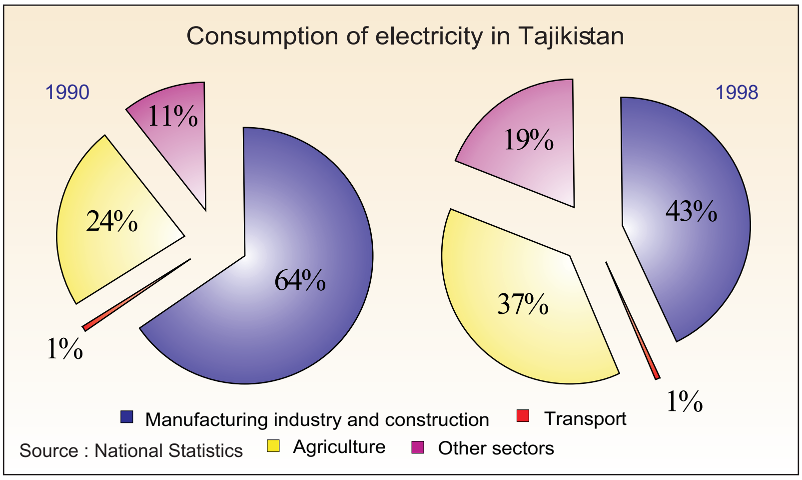

Fig. 2.3.

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

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

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

The structure of primary energy consumption in Tajikistan has significantly changed. During the period between 1990-1998, the consumption of natural gas decreased somewhere between 10 and 15 times, consumption of liquid fuels decreased by 8 times, and the consumption of coal decreased by 400 times (fig. 2.2). The major consumers of energy resources are: the manufacturing industry, construction, motor vehicles and the residential sector.

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

At the same time, there have been substantial changes in the structure of electricity consumption. In 1990, electricity consumption by the manufacturing industry and construction amounted to 11,578 million kilowatt-hours of electric energy, while by 1998 it had decreased to 5,154 million kilowatt-hours. Electricity consumption within the transport sector in the period between 1990-1998 decreased from 158 million kilowatt-hours to 67 million kilowatt-hours. The lack of fossil fuels has been responsible for electricity consumption in residential and agricultural sectors increasing by somewhere between 1.2 and 1.5 times (fig. 2.3).

2.9. Industry

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

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

The major enterprises of metallurgy are; Isfara hydro metallurgic plant, Anzob ore-dressing plant, Adrasman lead-zinc plant, industrial venture Vostokredmet, joint venture "Zeravshan", joint venture "Darvaz" and the industry giant - Tajik Aluminum Plant. The aluminum industry is the main cause for industrial exports and national income. More than 460 thousand tonnes of aluminum was produced in 1989.

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

The construction industry includes the Dushanbe cement plant and other plants producing reinforced concrete, lime products, alabaster, and construction designs. These enterprises are located in all areas of the country. Cement production has decreased from 1.067 million tonnes in 1990 to 17.7 thousand tonnes in 1998 (fig. 3).

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

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

2.10. Agriculture

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

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

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

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

2.11. Land use

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

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

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

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

2.12. Nature protection

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

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

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

3 Climate Change Trends and Scenarios

3.1. Methodology

The analysis of climatic change was primarily focused on the study of changes in surface air temperature, precipitation, snow cover, and extreme hydrometeorological events occurring in the territory of Tajikistan during 1961-1990, and throughout the period of instrumental observation.

Research work on climate change included:

Description of local climate and processes forming it;

Detailed analysis of climatic conditions for the period of 1961-1996 (recommended by WMO as a basis period);

Identification of climate change trends;

Comparison of climatic norms of the base period with the results of leading global climate models (GCMs);

Development and analysis of climate change scenarios assuming a doubled atmospheric CO_2 concentration (2xCO_2) for the period up to 2050.

Nearly 30 meteorological stations located in various climatic zones and altitudes ranging from 300 to 4,200 masl were selected to conduct the analysis.

The development of climate scenarios was conducted together with the Climate Change Center of Azerbaijan using the data received from 10 representative meteorological stations. Modeling was based on the outputs of leading models (GCMs), such as HadCM2, CCCM, GISS, GFD3, UK-89 using climate data for 1961-1990. At almost all stations, the best results regarding temperature and precipitation were with the HadCM2 model.

To fully consider all factors that have an impact on the climate, GCMs include physical processes related to irradiation, photochemistry, thermodynamics, evaporation, condensation, etc. In equilibrium models CO_2 concentration is constant, equal to 1xCO_2, 2xCO_2, 4xCO_2, etc. In dynamic models, CO_2 concentration constantly changes, for instance 1%per annum.

Climate change scenarios were generated by MAGICC-SCENGEN software and based on GHG concentrations in the atmosphere. The resolution of climate modelling was 0.5° latitude and longitude. This software considers 4 basic regions; Tajikistan is included to the Asian region.

National experts have pointed out that the resolution of global climate models does not fully correspond to the complexity of climatic conditions in Tajikistan, where altitude zonation of the climate and precipitation are characteristic and the climate is dependant on the form of landscape. Thus, GCMs cannot be used for high reliability local climate modeling.

3.2. Factors determining the weather and climate in Tajikistan

The climate in Tajikistan is determined by three main factors: solar irradiation, atmospheric circulation, and form of the landscape.

Surface solar irradiation depends on cloud cover, sandstorms, haze, fog, etc. The input of solar irradiation is determined by the processes of global circulation which is mainly a planetary factor. In the complex mountain conditions of Tajikistan atmospheric circulation incurs significant changes, forming local peculiarities. That is why weather and climate in this zone are mostly formed by land surface and atmospheric circulation.

The types of atmospheric circulation in Central Asia, and particularly in Tajikistan, are diverse: cyclonic, anti-cyclonic, frontal and local (mountain-valley, breeze, etc.).

The cyclonic circulation takes place in low-pressure zones, and is characterized by a turbulent anti-clockwise movement of the air from bottom to top. While rising upwards, the air mass expands and cools down adiabatically (1°C/100 m of altitude), and saturates with moisture. Thus, a formation of vast cloud systems and rainfalls constantly occur in the cyclones.

Anti-cyclonic circulation occurs in high-pressure zones, and is characterized by a turbulent clockwise movement of the air from top to bottom. As a result, air mass warms up adiabatically (1°C/100 m of altitude). The warming of air leads to an abrupt decrease of the relative humidity, which in turn, leads to a dissipation of cloud systems, and favors fair weather without rainfall.

Depending on the type of weather, synoptic processes in Central Asia can be classified into four main categories:

A. Cyclonic circulation. There are three basic types of cyclones: the South-Caspian, the Murgab and the Upper-Amudarya. The latter causes snow precipitation throughout Tajikistan, including southern hot lowlands.

B. Cold wave intrusions. According to the areas of origin and direction of movement, cold intrusions are subdivided into three types: western, northwestern, and northern. The most extreme weather deterioration occurs when intrusions follow at the rear of cyclones. Northwestern cold intrusions in the dry season form sandstorms and haze. Northern cold intrusions in the summertime often cause unstable weather on the northern and northeastern slopes of the Turkestan and Zeravshan ranges.

C. The group of synoptic processes causing unstable weather. Three types of processes belong to this group: confining cyclones, wave activities, and the southwestern and southern peripheries of anti-cyclones. Wave-activities are typical for highland areas; they take place in cold frontal partitions. Such a process can continue from several days to one week, accompanied by significant rainfall. When an influx of arctic air masses occurs along the southeastern periphery of anti-cyclones relating to western and northwestern humid intrusions, it is accompanied by widespread rainfall in the winter and springtime.

D. The group of synoptic processes conditioning fair weather. The following processes belong to this group: southwestern peripheries of the Siberian anti-cyclone, thermal depressions, small-gradient fields of decreased or increased air pressure. Thermal depression is typical only for the summer season, and is characterized by very hot hazy weather. In 2000-2001, it played a major role in forming a long-lasting drought in Tajikistan.

3.3. Air temperature

The air temperature in Tajikistan is formed under the influence of different factors. The temperature of the warm period of the year is steadier, whereas in the cold period it depends on the prevalence of intruding air masses from the north or south, as well as their frequency. In the former, the winters are cold, and in the latter, they are warm.

Taking into account the diversity of the climate conditions in Tajikistan, a number of areas with similar geographical conditions have been earmarked to describe the thermal condition of the territory.

Wide valleys and plains at a height of up to 1,000 m are primarily agricultural and cotton growing areas. They cover the southwest part of the republic, Gissar, Vakhsh, lowland Kafirnigan and the Kulyab valley, as well as the Ferghana valley and neighboring districts of the Sogd region.

The summer heats are characteristic to wide valleys and plains when the summer thermal depression is dominant. In summer, clear and hot weather is characteristic, during which the maximum temperature can reach between +43°C and +47°C. The monthly mean temperature of the hottest month (July) lies between +28°C and +30°C (fig. 3.1).

In winter, Tajikistan is under the influence of the Siberian anticyclone. The cold period of the year is characterized by the intrusion of cold arctic air, during which air temperature can be as low as -24°C to -30°C on some days, even in the extreme south of the republic. The monthly mean temperature in the coldest month (January) essentially remains around 0.3-2.5°C, while in the northern part of the republic (Khujand) it falls to 0.3°C below zero (tab. 3.1).

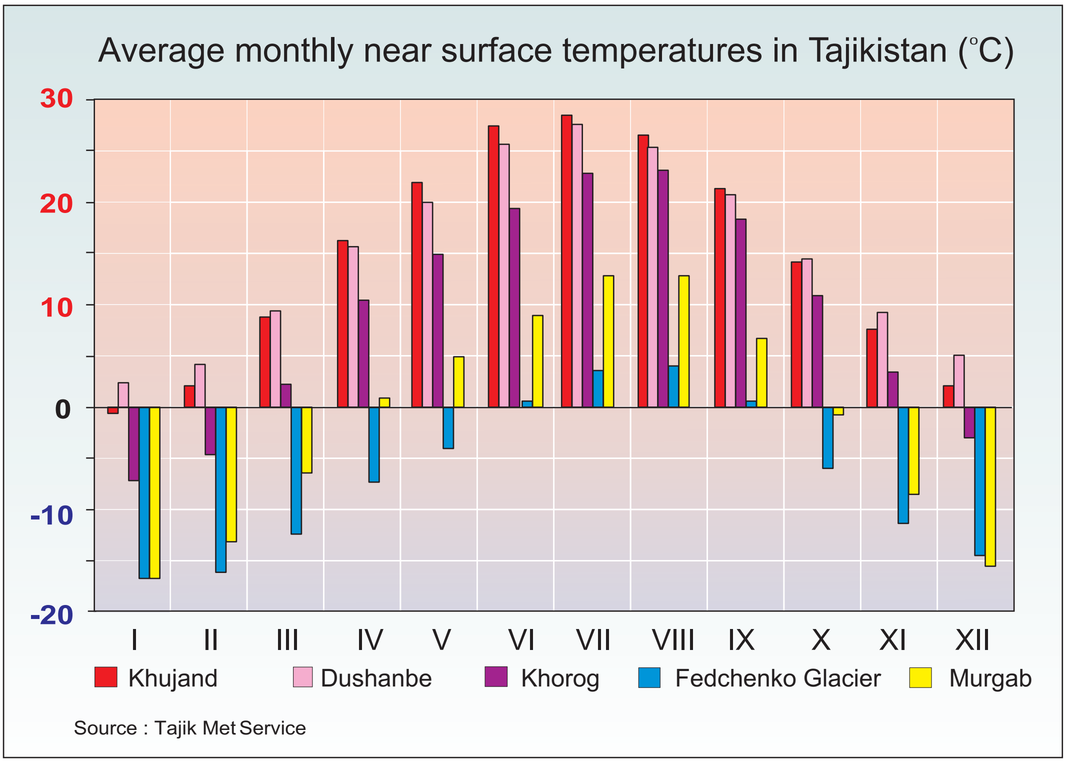

Fig. 3.1.

Table 3.1.

Climatic indicators of air temperature

Station	Altitude (masl)	Average		Absolute average		Absolute		Amplitude	Duration of period	
		Jan	July	Min	Max	Max	Min		>0⁰	<0⁰
Wide valleys and plains										
Aivaj	318	1.8	31.4	-2.4	38.8	46	-22	68	365	0
Khujand*	410	-0.3	28.4	-4.2	36.2	46	-26	72	322	43
Dushanbe*	803	2.1	27.1	-2.8	35.2	43	-27	70	365	0
Transition zone										
Faizabad	1,215	0.3	26.7	-2.8	32.3	41	-21	62	346	19
Khorog*	2,075	-7.1	22.6	-11.7	30.1	38	-27	65	258	107
Madrukasht	2,236	-4.3	18.4	-8.3	25.9	36	-22	58	258	107
Mountain regions										
Ishkashim	2,523	-8.5	19.6	-12.9	26.7	35	-28	63	190	175
Karakul	3,930	-18.2	8.4	-23.2	14.8	24	-46	70	146	219
Fedchenko*	4,169	-17.0	3.5	-19.5	8.5	16	-34	50	0	365

S o u r c e: Tajik Met Service * - revised data

Frequent fluctuations in winter temperature above and below 0°C are typical to this zone. On average the last spring frost for the majority of areas disappears at the end of March, and the first autumn frost starts in the second half of October. The most continuous frost-free periods for the low valleys of Southwest Tajikistan are typically 260 days.

Zeravshan valley and the mountainous areas of Central Tajikistan and Western Pamir form a transitional area from valleys to areas of high altitude up to 2,500 m. As in the previous case, cloudless and dry, but cooler, weather persist here in the summer. For this zone, a consecutive decline in temperature is characteristic, depending on the altitude.

The landscape has a major influence on air temperature. The temperature on the open slopes and mountain passes in the winter months is much higher than in the valleys and closed depressions where strong cooling occurs. During the summertime the opposite occurs.

The mean temperatures in January fluctuate within a wide range: from -1°C in the lower reaches of the Zeravshan valley to -7°C in the mountains of Central Tajikistan. Western Pamir is distinct by quite higher temperatures. Thus, the monthly mean temperature in Kalai-Khum in January is 0.2°C. The absolute minimum reaches -34°C in Tavildara.

The hottest month of the year is July, when the monthly mean temperature changes from 25°C in the Zeravshan valley to 18°C in the mountains of Central Tajikistan. The absolute maximum reaches between +36°C and +40°C.

The first frost is observed in the late October and the final spring frost occurs in the second half of April. The frost-free period in valleys averages to 200 days, decreasing to 150 days at the altitude of 2,500 masl.

The high-altitude areas above 2,500 m include Central and Eastern Pamir, and mountain ranges. The climate of these areas is continental. Rarefied atmospheric conditions in high altitude areas, although causing increased solar irradiation, at the same time cause heat loss. Therefore, temperature fluctuations between winter and summer and from day to night are significant and increase in the east (tab. 3.1).

Eastern Pamir has distinctively severe climatic conditions. Winter is long and cold here. The monthly mean temperature in January ranges from -14°C to -26°C. The absolute minimum is extremely low and reaches -63°C (Bulunkul Lake). Summer is short and cool. The July mean air temperature does not exceed +15°C (Irkht). The absolute maximum varies between +20°C (Fedchenko Glacier) and +34°C (Irkht).

The longest frost-free period has had a duration of 111 days (Irkht), and in a number of the coldest areas (Shaimak, Karakul, Bulunkul, Fedchenko Glacier) there is no frost-free period at all.

3.3.1. Changes in air temperature

The greatest changes in the climate, particularly in air temperature, have taken place in the areas affected by human intervention into environment: urbanization, land development, reservoir construction, etc.

Thus, general warming in the 1930-40s, as a whole, has not had an effect on the climate change in the republic. In the following decade, a decrease in air temperature was observed, and the mid-1950s was one of the coldest times throughout the instrumental observation period of Tajikistan. At that time, air temperature on average was 1-1.5°C lower than normal.

In light of the fact that significant changes in the climate were beginning to be observed since the 1950-60's, as stated by IPCC, and considering that comprehensive meteorological observations had been carried out in Tajikistan during this period, climate change research reviewed every aspect of the annual and seasonal air temperature change for that time.

During 1961-1990, an increase of 0.7-1.2°C in the mean annual air temperature was observed in the wide valleys of Tajikistan. To a lesser degree, an increase in temperature by 0.1-0.7°C had taken place in mountainous and high-altitude areas (fig. 3.2). A small decline in temperature by 0.1-0.3°C was recorded only in the mountains of Central Tajikistan, Rushan and the lower reaches of Zeravshan. In large cities, the growth of near surface temperature was especially significant and reached 1.2-1.9°C (fig. 3.3) that is obviously associated with urbanization (construction of roads, buildings, transport, industry, etc.).

In the zones with irrigated agriculture, such as the newly irrigated Yavan valley, the temperature tended to decrease, especially in summer. In the south (Shaartuz) and north (Khujand) of the republic, the mean annual air temperature has remained the same, which is conditioned by local factors (land development, construction of water reservoir).

During 1961-1990, the warmest year was 1971, when the mean annual air temperature exceeded the norm by 0.7-0.8°C everywhere. The following year of 1972 was the coldest in this period, when the negative deviation of the temperature was 2°C from valley to foothill zones, and 1-1.3°C at high altitudes. Eastern Pamir was an exception, where the coldest year was 1965, when the mean air temperature was 1.2-3.4°C lower than normal.

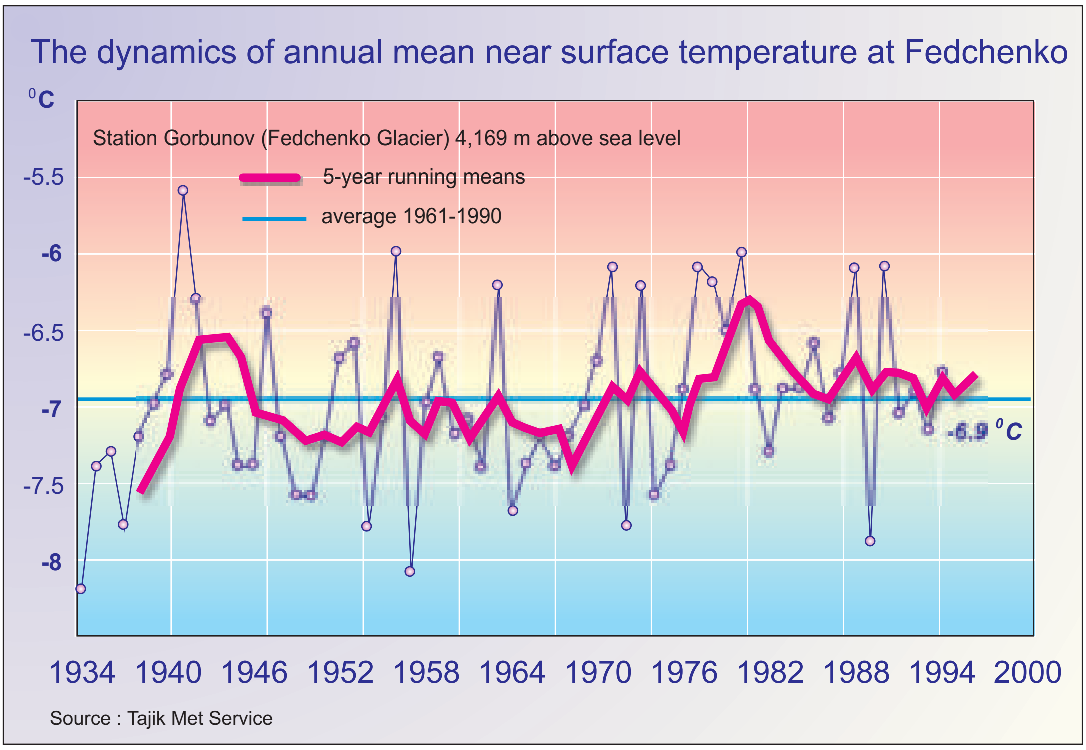
The dynamics of annual mean near surface temperature at Fedchenko
°C
Station Gorbunov (Fedchenko Glacier) 4,169 m above sea level
5-year running means
average 1961-1990
-5.5
-6
-6.5
-7
-7.5
-8
-6.9 °C
1934 1940 1946 1952 1958 1964 1970 1976 1982 1988 1994 2000
Source : Tajik Met Service

Fig. 3.2.

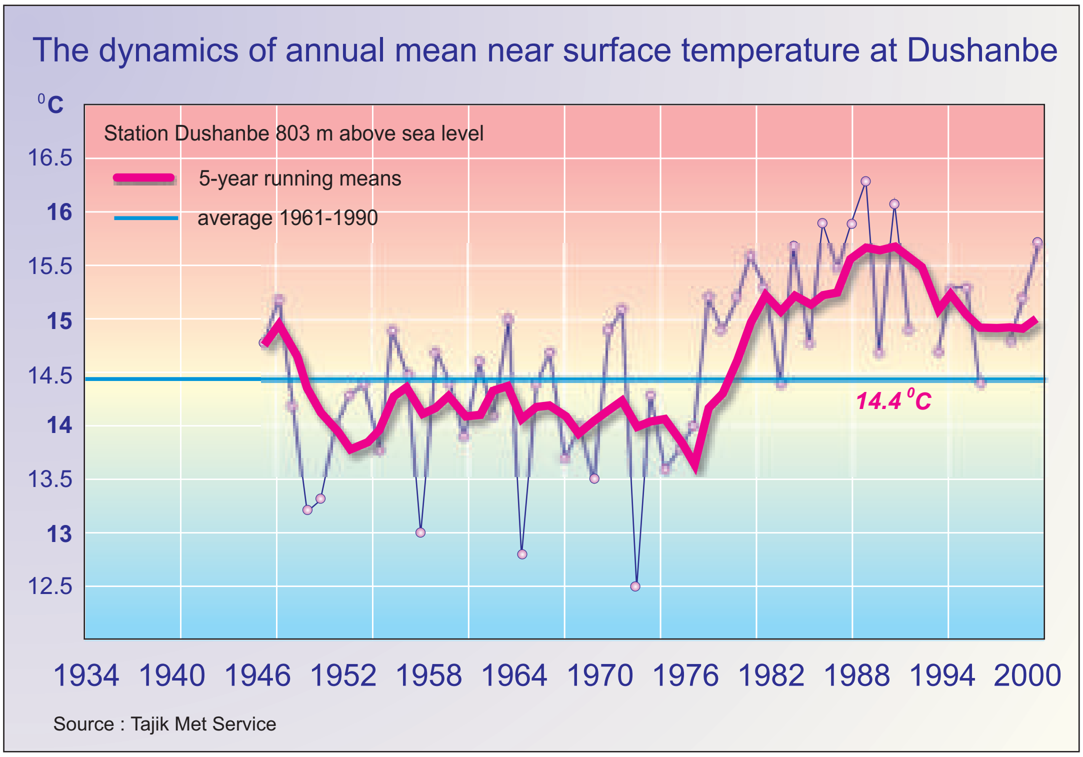
The dynamics of annual mean near surface temperature at Dushanbe
°C
Station Dushanbe 803 m above sea level
5-year running means
average 1961-1990
16.5
16
15.5
15
14.5
14
13.5
13
12.5
14.4 °C
1934 1940 1946 1952 1958 1964 1970 1976 1982 1988 1994 2000
Source : Tajik Met Service

Fig. 3.3.

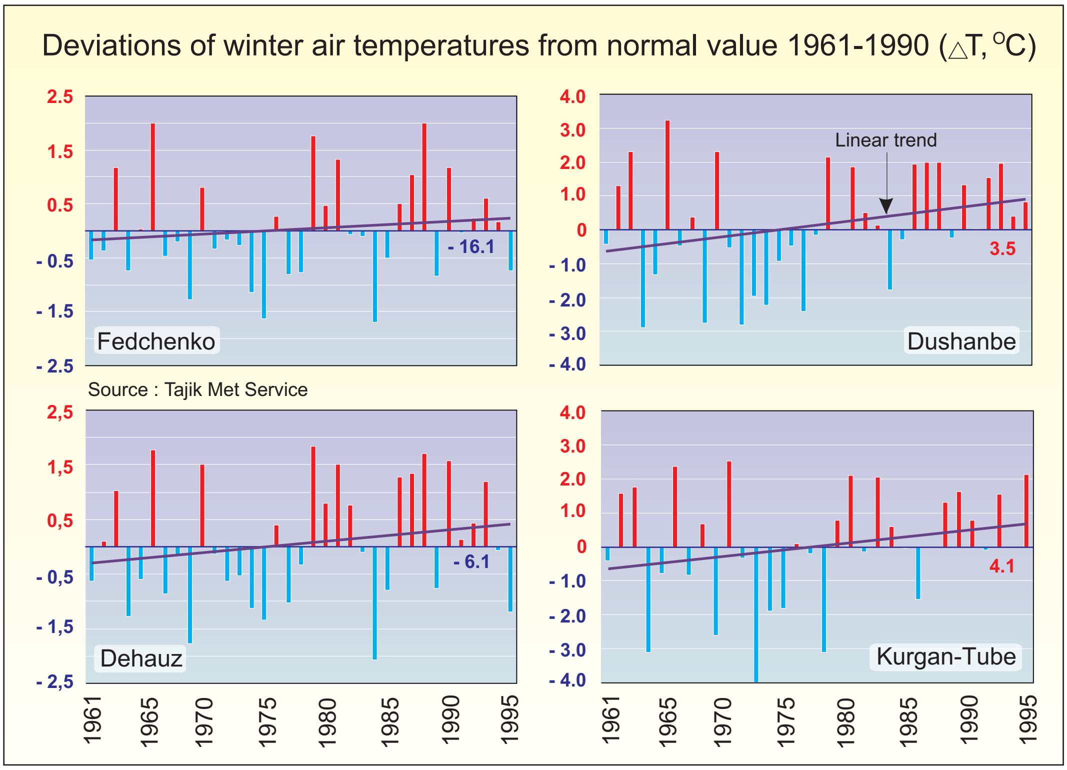
Deviations of winter air temperatures from normal value 1961-1990 (△T, °C)
Fedchenko
- 16.1
Dushanbe
Linear trend
3.5
Source : Tajik Met Service
Dehauz
- 6.1
Kurgan-Tube
4.1
1961
1965
1970
1975
1980
1985
1990
1995

Fig. 3.4.

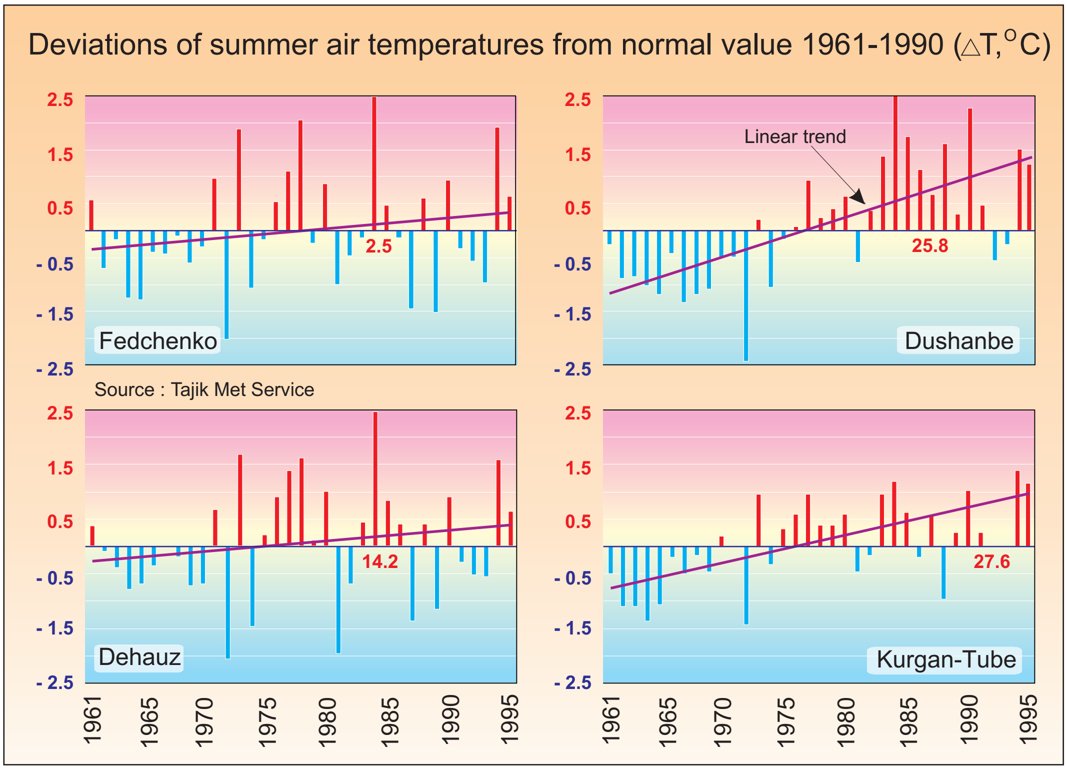
Deviations of summer air temperatures from normal value 1961-1990 (△T, °C)
Fedchenko
2.5
Dushanbe
Linear trend
25.8
Source : Tajik Met Service
Dehauz
14.2
Kurgan-Tube
27.6
1961
1965
1970
1975
1980
1985
1990
1995

Fig. 3.5.

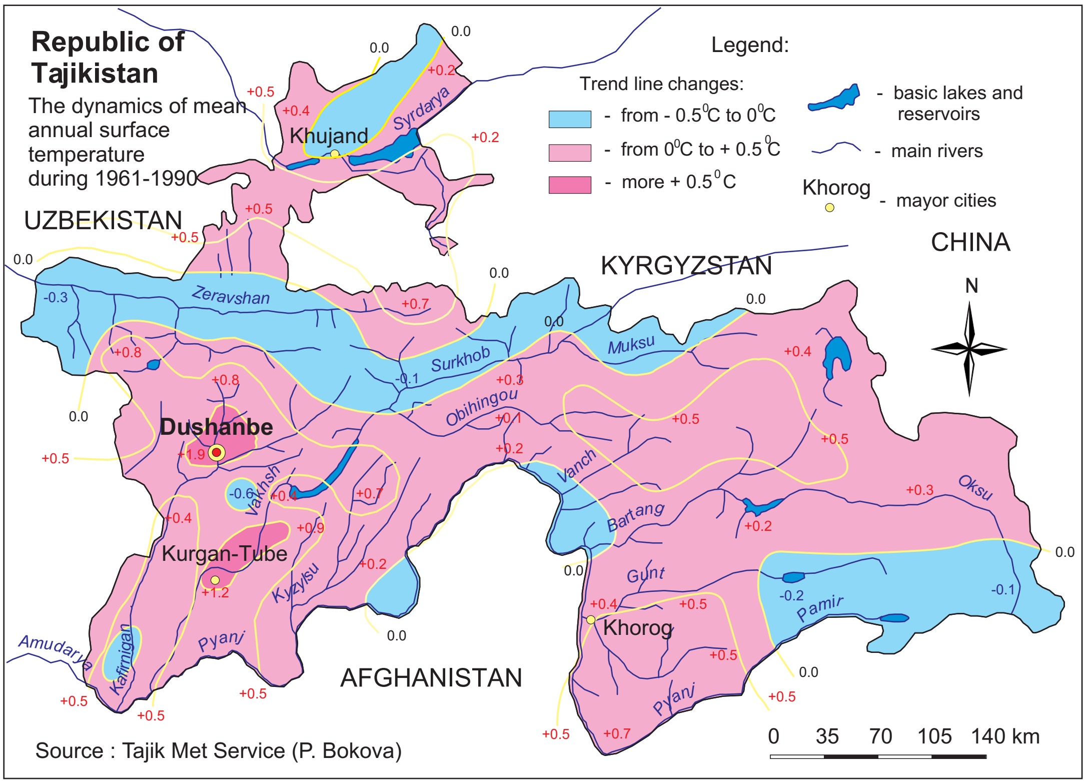
Republic of Tajikistan
The dynamics of mean annual surface temperature during 1961-1990
Legend:
Trend line changes:
- from - 0.5°C to 0°C
- from 0°C to + 0.5°C
- more + 0.5°C
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
N
Khujand
Dushanbe
Kurgan-Tube
Khorog
Syrdarya
Zeravshan
Surkhob
Muksu
Obihingou
Vakhsh
Vanch
Bartang
Gunt
Oksu
Pamir
Kyzylsu
Pyanj
Kafirnigan
Amudarya
0 35 70 105 140 km
Source : Tajik Met Service (P. Bokova)

Fig. 3.6.

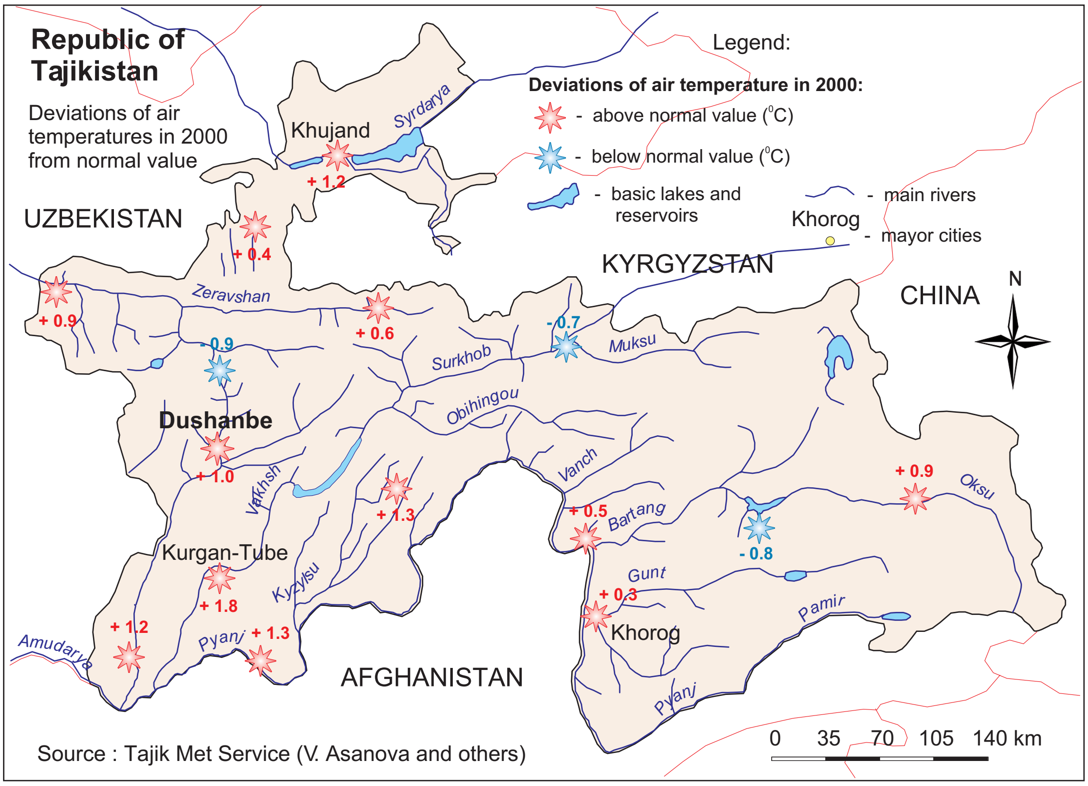
Republic of Tajikistan
Deviations of air temperatures in 2000 from normal value
Legend:
Deviations of air temperature in 2000:
- above normal value (°C)
- below normal value (°C)
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
N
Khujand
Dushanbe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

Fig. 3.7.

The warmest period was observed between 1977 and 1984, and in lowland areas until the 1990s. The temperature at this time exceeded norm by 0.6-1.6°C.

During the period under investigation, the greatest increase in temperature observed for the autumn and winter seasons were by 0.6°C in the valleys and by 0.7°C in the mountains. In the spring and summer seasons the rise of air temperature all over the republic has averaged between 0.1°C and 0.4°C.

The winter period was characterized by an increase in temperature, except for the lower reaches of the Zeravshan, Kulyab and Yavan valleys and Eastern Pamir, where it has decreased by 0.1°C to 0.4°C. The greatest increase in the winter air temperature was observed in Dehauz, Faizabad and Maikhura, as well as in large cities (fig. 3.4).

The spring temperatures in Tajikistan, in general, tend to increase in lowlands, mountains and high-altitude areas by somewhere between 0.2°C and 0.7°C. In a number of foothill areas, irrigated valleys and certain areas of the Pamirs a temperature decline of 0.1°C to 0.7°C has been observed.

Maximum annual temperatures in Tajikistan are usually observed in the summer. It is established that absolute maximum temperatures rise steadily. In lowlands and foothill areas, tendencies of increasing summer temperatures by 0.2-0.8°C are common place (fig. 3.5). In the mountains of Central Tajikistan a small decrease in air temperature by 0.4°C, and by 0.3°C in the south of the republic (Shaartuz) has been observed.

In the republic, particularly in the south and the east of the country, the autumn temperatures average a significant growth of 0.8-1.2°C. Central Tajikistan is probably an exception, as in a number of areas a downward trend has been observed.

The map (fig. 3.6.) shows the information on air temperature change tendencies during 1961-1990. Since the 1990s, the volume of meteorological observation programmes in Tajikistan has decreased considerably. Nevertheless, available data asserts that the 1990s appear to be the warmest decade throughout the period of instrumental observations in Tajikistan, particularly in 1997 and 2000 (fig.3.7).

3.4. Precipitation

Two zones basically determine atmospheric precipitation in the territory of Tajikistan. The dry climate zone covers the valleys of Southwest and Northern Tajikistan, the foothills of the Turkestan range, as well as the extensive high-altitude area of Eastern Pamir (50-300 mm per year). The rest of the territory is classified as a zone of insufficient humidity (up to 900 mm). Exceptions are the windward southern slopes of Gissar range, where a damp climate zone prevails (above 1,800 mm).

The observed distinctions in the distribution of annual precipitation (tab. 3.2) in the territory of the republic are caused, essentially, by the land surface features. The Gissar range resists western and south-west humid air masses and the largest amount of precipitation in the republic (Sioma, Haramkul) at more than 1,500 mm, falls on its southern slopes.

Table 3.2.

Mean annual precipitation in Tajikistan (mm)

Murgab (3,576 m)	Khorog (2,075 m)	Dehauz (2,564 m)	Kalaihumb (1,279 m)	Dushanbe (803 m)	Tavildara (1,616 m)	Haramkul (2,800 m)
75	281	315	502	640	922	1,521

S o u r c e: Tajik Met Service

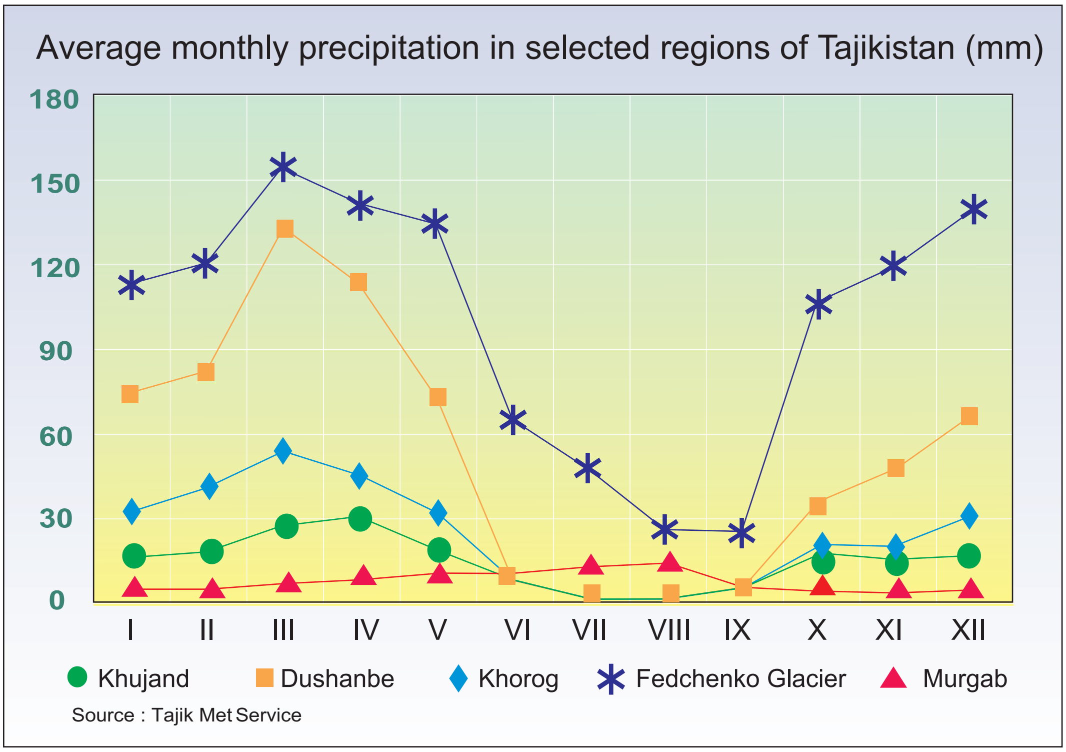
Average monthly precipitation in selected regions of Tajikistan (mm)
180
150
120
90
60
30
0
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
Khujand
Dushanbe
Khorog
Fedchenko Glacier
Murgab
Source : Tajik Met Service

Fig. 3.8.

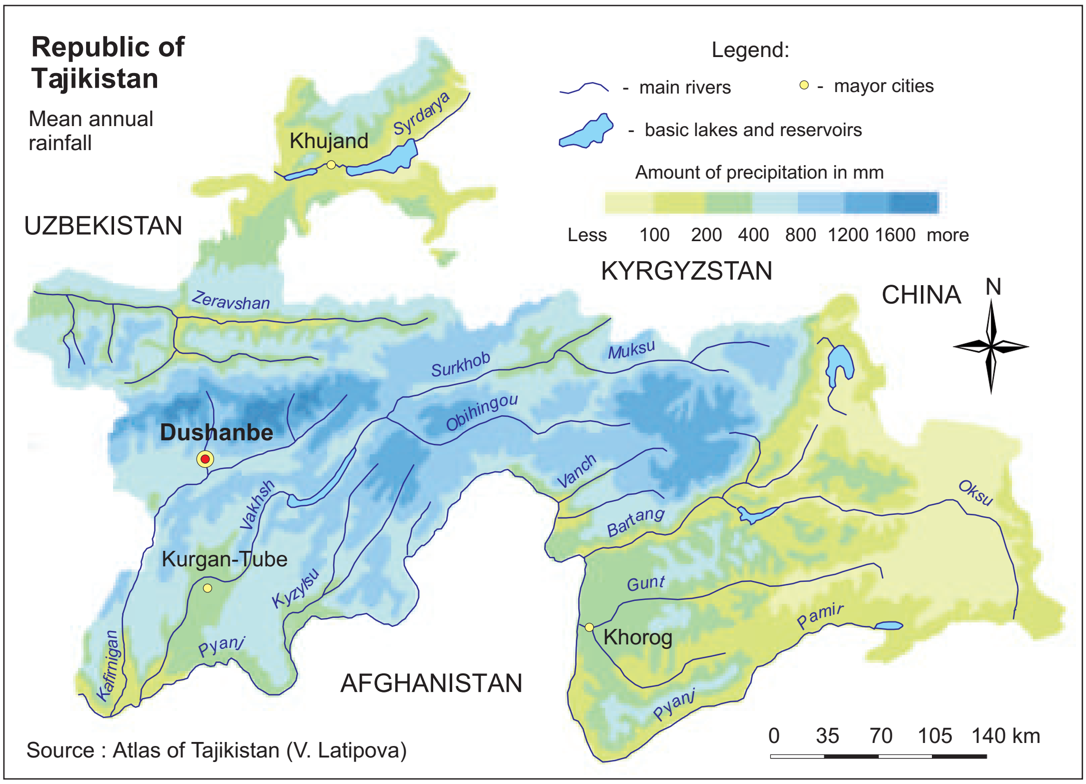
Republic of Tajikistan
Mean annual rainfall
Legend:
- main rivers
- mayor cities
- basic lakes and reservoirs
Amount of precipitation in mm
Less 100 200 400 800 1200 1600 more
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
N
Khujand
Syrdarya
Zeravshan
Surkhob
Muksu
Obihingou
Dushanbe
Vanch
Vakhsh
Bartang
Oksu
Kurgan-Tube
Kyzylsu
Gunt
Khorog
Pamir
Kafirnigan
Pyanj
Pyanj
0 35 70 105 140 km
Source : Atlas of Tajikistan (V. Latipova)

Fig. 3.9.

In spite of the fact that the slopes of all mountain ranges are well-humidified, internal areas of the extensive mountain massifs of Tajikistan, especially deep closed depressions, closed and narrow valleys among mountains, receive little precipitation. For example, in the Surkhob River valley the precipitation is 3 times less than that at the same altitude of the southern slopes of the Gissar range. It is dry in the valley of the Zeravshan River, where the annual precipitation totals between 190 - 340 mm. It is very dry also in southern Tajikistan, where annual precipitation does not exceed 150 - 200 mm (fig. 3.8).

Annual precipitation distribution in various areas of Tajikistan is not uniform. For most of the territory, the precipitation is lowest in the summer months. The maximum precipitation occurs in March to April in the valleys and foothills, and in April to May in high-altitude areas.

The maximum period of rainfall in most of the territory varies within the range of 30-100 mm per month; in some areas within the range of 200-300 mm. In the north of Tajikistan and Eastern Pamir, the precipitation maximum decreases to 12-20 mm per month. The months of minimum precipitation all over the territory usually does not exceed 5 mm, and only in some high-altitude areas reaches 10-20 mm per month (fig. 3.9).

In the foothills of Tajikistan, 15-20% of the annual precipitation falls in the form of snow. The quantity of hard precipitation increases up to 50-70%, with the altitude mounting, and reach the maximum of 85-90% in the Pamirs, including Fedchenko Glacier (100%).

The number of days with precipitation of 0,1 mm and more in the plains vary within the range of 50-80 days, in the foothills 80-100 days, up to about 125 days as the altitude heightens. The least number of days with precipitation is observed in Eastern Pamir - 50 days only.

3.4.1. Changes in precipitation pattern

Atmospheric precipitation is primarily determined by land surface peculiarities and atmospheric circulation. The height and orientation of mountains remarkably affect the strengthening of the cyclone precipitation.

The basic amount of atmospheric precipitation over the territory of Tajikistan is brought in by air masses from the Arctic and Atlantic Ocean, Mediterranean Sea, and the Indian Ocean. The amount of atmospheric precipitation manifests great variability from year to year with the occurrence of very drought-prone or wet periods.

The comparison of abnormal amounts of precipitation with the reoccurrence of latitudinal and longitudinal types of atmospheric circulation indicate the formation of excess precipitation under longitudinal currents, while the deficit of precipitation is observed under the latitudinal currents of air masses.

In 1961-1990, within the mountains of Central Tajikistan, as well as in the valleys of southwest and northern Tajikistan, foothills of Turkestan range and high-altitude areas of Eastern Pamir, a reduction in the amount of annual precipitation of 1-20% has been observed. In the foothills and mountains of the Khatlon region, the reduction in precipitation averages between 6-22% (fig. 3.10).

In Karategin and Darvaz, from the altitude of 1,500 m and higher, the amount of precipitation has increased by 14-18%. In Western Pamir, the increase of precipitation is 12-17%. The greatest increase in precipitation (36%) has been observed on Fedchenko Glacier (fig. 3.10).

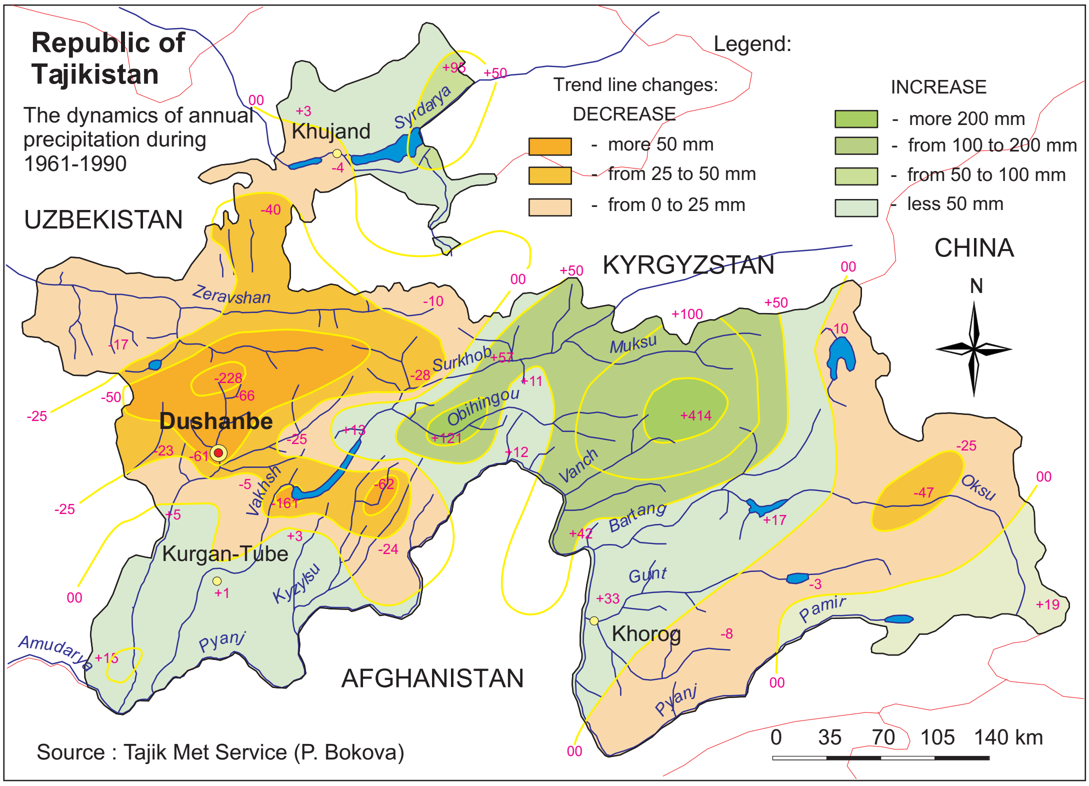

Fig. 3.10.

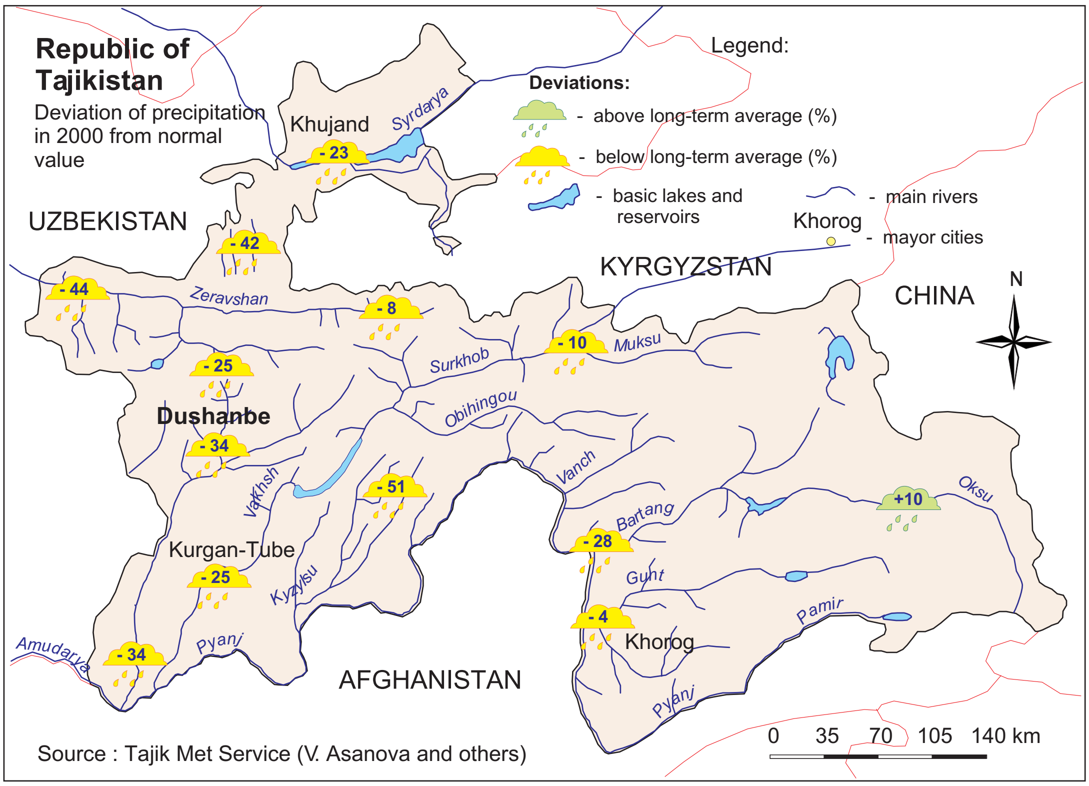

Fig. 3.11.

Overall, the most humid or dry periods were not actually observed during the years 1961-1990. In valleys, there is essentially an alternation between short wet and dry periods. In abnormally humid years, the amount of precipitation exceeds the norm by 50-65%, in Khujand by 60-100%, and in the Kulyab region by 30%. In the driest years, the deficit of precipitation is on average 35-50% below the norm.

Significant annual deviations of precipitation are observed in the mountains. Here, negative deviations are around 10-20% whereas positive changes range from 10-20% in Dehauz up to 50-100% in Murgab. In abnormally humid years, the precipitation ranges from 50 to 100% above average in the upper reaches of Zeravshan and Western Pamir, and sometimes to more than 150% in Eastern Pamir.

Research shows that the precipitation during the cold period of 1961-1990 had increased in the plains and foothill valleys. A small increase in precipitation had occurred in the upper reaches of the Zeravshan River and in Western Pamir. The greatest increase in precipitation (29%) during the cold period was observed on Fedchenko Glacier. In Eastern Pamir, during the same cold period a drastic precipitation reduction was observed, which was likely to have been caused as a result of shading of this area by the mountain ranges.

The warm period is characterized by uneven temporal distribution of precipitation. It is characteristic of this period for the highest levels of precipitation to fall in April and the beginning of May, then drastically reduce; in valleys, precipitation is rarely observed from July till September.

In the warm period of 1961-1990, the lowlands and foothills observed a drastic reduction in precipitation by 6-57%, and the upper reaches of the Zeravshan River by 6%. A remarkable reduction in precipitation during the warm period was experienced in Eastern Pamir (70%). During the same period in higher regions of the same territory (above 1,500 masl), the amount of precipitation increased from 9% to 36%. On Fedchenko Glacier, the precipitation increased by 44%.

The lowlands suffer from lack of rainfall as well as excessive rainfall more often than the mountains. During drier years, precipitation is 30-70% lower than average, and during wetter years precipitation can be 200% and more above average.

The most arid years in Tajikistan throughout the period of instrumental observation were 1944 and 2000, when a precipitation deficit of 30-70% was observed all over the territory, except for high-altitude depressions (fig. 3.11). Unusual drought was reported in Tajikistan during these years. The most humid year was 1969, when precipitation was 1.5 times above the long-term average.

3.5. Changes in snow stock

The depth and duration of snow cover vary considerably over the territory of Tajikistan.

In the southern areas of the republic (Gissar, Vakhsh, Kulyab and low Kafirnigan valleys) and in the northern plains, consistent snow cover is absent in 90% of winters, and in 15% of winters snow cover is not formed at all. Snow cover in the Pamirs stockpiles at elevations between 3,500-4,000 masl and perpetually replenishes itself.

In the mountains, the distribution of snow cover depth is closely connected to land surface peculiarities and atmospheric precipitation. The snow cover reaches greater depths in the areas of maximum precipitation. So, on the southern slopes of the Gissar range, at the area surrounding the Haramkul meteorological station, the maximum depth of snow can exceed 2.5-3 m, while at the same time the average decadal snow depth in Eastern Pamir reaches 4-5 cm, and the maximum is 20 cm (fig. 3.12).

In many areas, as the altitude grows, the depth of snow cover increases. The average biggest decadal snow depth at the altitude of 1,500 masl reaches 40 cm, while at the altitude of 1,850 masl it increases up to 90 cm, and at the altitude of 2,800 masl to 250 cm (Haramkul).

The height of snow cover varies from year to year and can considerably deviate from the long-term average. For example, at the Anzob pass, where the average height of snow cover is 169 cm, it's maximum reaches 264 cm, but minimum - 92 cm.

Mean monthly distribution of the number of days with snow cover in Tajikistan is scattered. In the south of the country and in the Ferghana valley (in the north), the snow cover is less than 20 days annually. To the north and south from the Ferghana valley, in Gissar valley and in Karategin and Darvaz districts the number of days with snow cover gradually increases following the altitude zonation, and reaches a maximum of 244 days at the Anzob pass. In Western Pamir, the number of days with snow cover varies depending on the altitude from 40 to 160 days. In Eastern Pamir, the number of days with snow cover ranges between 40 - 90 days.

For analyzing changes in snow stock in Tajikistan, instrumental observation data received from 17 climate stations was reviewed, including data on the accumulation of greatest snow stocks, snow depth, temperature, and water content in snow.

Water content in the snow bed was taken as the basic characteristic of the snow cover, because this value, combined with snowmelt intensity, determines stream flow in the rivers, magnitude of maximum flow, humidity content in the soils, etc.

In the low-altitude zone up to 1,000 masl, which occupies about 17% of the total territory of the republic, consistent snow cover is not formed; snow falls sporadically and melts quickly. As a rule, the greatest depth of snow in this zone occurs at the end of January and beginning of February and reaches 20-25 cm high. The water content in fresh snow cover is very small and does not exceed 5-10 mm. On average, the number of days with snow cover over the winter period in the south of the republic does not exceed 15-30 days, and in the north, it continues up to 50-60 days.

In the mid-altitude zone of 1,000-2,000 masl, occupying about 11% of the total area of the republic, steady snow cover begins to lie from mid-December until mid-March, and in certain years, there is no formation of constant snow cover at all. The average number of days with constant snow cover, in various areas ranges within 85 to 100. The biggest snow stocks occur in the second half of February.

At the altitudes of 2,000-3,000 masl, occupying about 12% of Tajikistan's territory, constant snow cover is formed at the end of November and beginning of December, and melts, as a rule, at the end of March and beginning of April. Depending on the location, the number of days with snow cover averages between 100 to 135 days. Practically everywhere in this zone, the maximum snow stock is observed at the end of February and beginning of March.

In the high-altitude zone between 3,000 to 4,000 masl, occupying about 50% of the total area of Tajikistan, the accumulation of the biggest snow stocks takes place at the end of March and beginning of April. Constant snow cover is not formed everywhere at these heights. In the Eastern Pamir, the snow can fall throughout the year

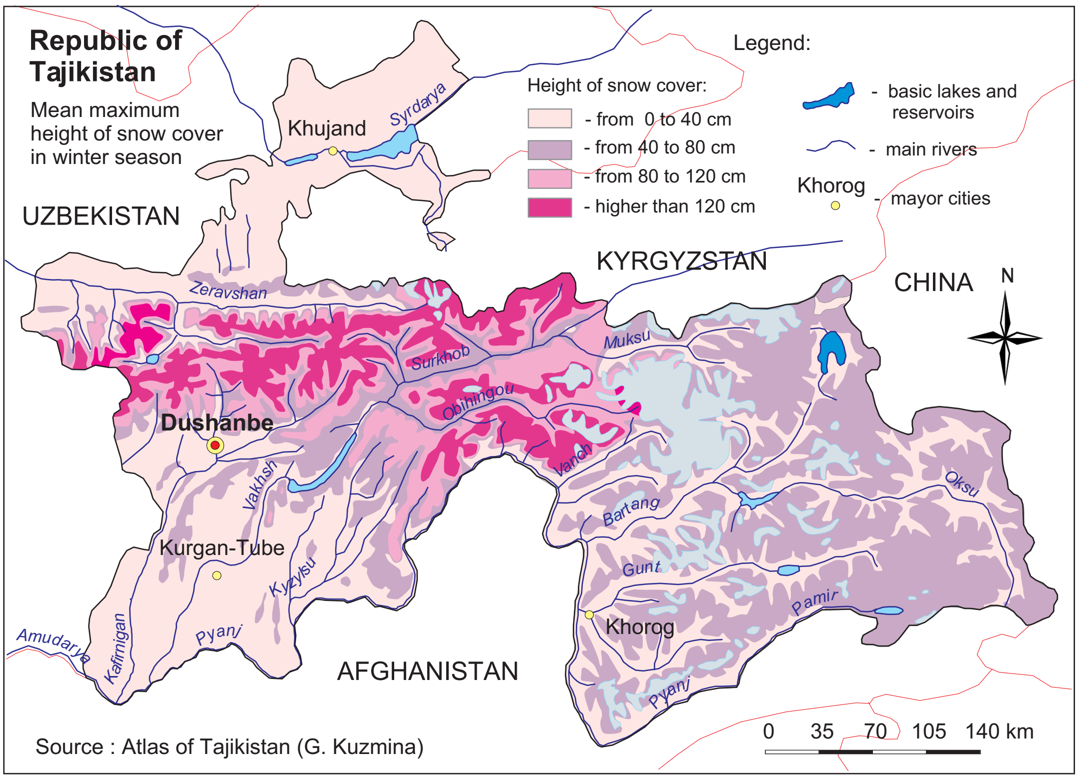

Fig. 3.12.

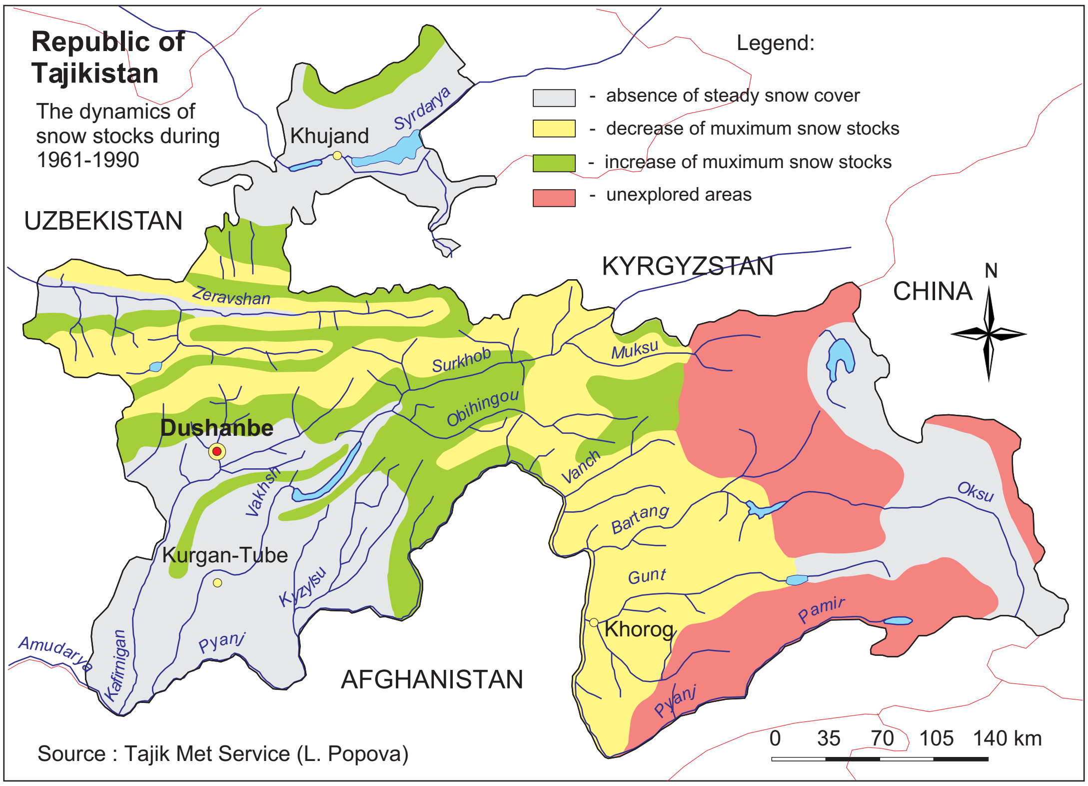

Fig. 3.13.

but in view of climate aridity and small amount of precipitation, the snow cover is less permanent and is quickly blown away. The average number of days with steady snow cover in this zone considerably decreases eastwards from 245 days in Gissar range to 45 in Eastern Pamir.

In the zone above 4,000 masl, occupying around 10% of the territory of the republic, maximum snow stocks begin in the middle of May, and steady snow cover persists perpetually. Glaciers and permanent snowfields cover most of this high-altitude zone.

It has been observed that each type of winter in Tajikistan, in terms of snowfall, corresponds to certain characteristics of atmospheric processes. So, winters with less snow are characterized by the prevalence of anticyclone circulation near the ground. In winters with medium snowfalls, there is an alternation of anticyclone circulation and southern cyclones accompanied by cold intrusions with insufficiently humid air masses. In winters with high snowfalls, the cyclone activity with frequent humid cold intrusions prevails. The number of winters with small snow stocks exceeds by 1.5-2 times the number of winters with high snow stocks.

Winters with the highest rates of snowfalls were reported in 1949-1950 and 1964-1965, when snow stock exceeded long-term averages in 1.5-2 times over 50% of the territory. The winter in 1969 manifested particularly high rates of snowfalls, when throughout the territory of the republic the rates were 2-2.5 times above normal. The winters with low rates of snowfall were in 1955-1963. Beginning from 1964 to 1984, there has been an alternation between winters in terms of snowfall rates. For the period of 1985 to 1990, at elevations of 3,000 masl, snow stocks decreased.

The analysis of changes in water contents in the snow throughout instrumental observation, and separately for the period of 1961-1990s, shows an average increase of 35% in foothills and medium-height mountainous areas of the republic with altitudes of up to 2,000 masl (fig. 3.13). On the contrary, in the zone from 2,000 to 3,500 masl, an overall reduction in maximum snow stock of 35% on average has been observed.

However, the tendency of declining snow stocks in the zone above 2,000 masl is not uniform everywhere. The increase in snow stocks has been observed in mountainous areas of the Khatlon Region (Sanglok, 2,230 masl) and on Fedchenko Glacier (4,169 masl). It is necessary to note that on Fedchenko and in Sanglok since the 1960s, the snow stocks have been in decline.

3.6. Extreme weather events

The study of processes resulting from climate change is based not only on the analysis of air temperature, precipitation and snow cover, but also on extreme weather events (high and low temperatures, sandstorms, heavy snowfall and rainfall, floods, mudflows, avalanches, hailstone falls).

High temperatures. The zone of an adverse thermal regime (equal to and higher than 40°C) covers the entire plain areas of the republic. On the basis of the analysis of observational data, an upward trend of 30% in the number of days with temperature above 40°C has been identified in almost all the plains of the republic. In 1984, a period of 48 days with temperatures above 40°C (fig. 3.14) was observed in Shaartuz. The least number of days with temperatures above 40°C was observed in 1972.

Low temperatures. Daily mean temperatures of air equal and below -10°C are also considered dangerous weather events. The least average number of days in one year with low temperatures is observed in the territory's plains (0.2-0.8 days), although in some years this number increases up to 5-15 days. The greatest reoccurrence of low temperatures is observed in mountainous areas, especially in low depressions, mountain passes, and tops of high mountain ranges. In foothill areas, the average number of days with low temperature changes from 6 to16 days, and in some years, between 25 and 80 days. In general, the number of days within one year with a daily average temperature below -10°C shows a downward trend by 30-50 % (fig. 3.15).

Heavy snowfall and rainfall. Intense precipitation is one of the most dangerous hydrometeorological events in terms of its consequences. The average number of days with intense precipitation in the republic is insignificant and varies from 0.1 to 6 days per year. In some areas, intense precipitation does not occur at all. In some years, for example in 1969, the number of semidiurnal intense precipitation exceeded the average value by 3.5-5.5 times. The maximum number of days with intense precipitation is accounted for mainly in spring months and in summer months in high-altitude areas. During 1961-1990, the number of days with intense hard precipitation tended to reduce. The change in the number of days with intense liquid precipitation is ambiguous. For example, in the Kulyab valley the number of days with intense liquid precipitation increased by 1.5 times. In the area of Dushanbe city, a downward trend of 1.5-2 times was observed.

Hail. Hailstones frequently cause damage to agriculture. The centre of most hail events is located along the Gissar range, primarily in the foothills. The number of days with hail grows as the altitude increases. At the same time, the maximum reoccurrence of hail ranges from 0.7-1 days in lowland areas to 4-8 days in high altitudes. Gissar valley is known for its large frequency of hail events, where the number of days with hailstone averages to 1.9-3.5 days per year. In 1961-1990, the number of days with hailstone in lowland and foothill areas decreased by 60-80%. In mountainous areas, the occurrence of hail has not changed, and in some areas has increased.

Floods. One of the consequences of heavy rainfall is high flood waters, which are observed frequently in the foothills and mountainous areas of Tajikistan at the altitudes of up to 2,000 masl. In high-altitude areas, floods can result from a break-through in temporary lakes. As a rule, high floodwaters are of a short-term nature, but cause huge damage to settlements and the national economy. During the period under research, the highest number of disastrous floods was observed in 1969, 1970, 1985 and 1988. The southeast slopes of Gissar range, northern slopes of Turkestan range and southern slopes of Kuramin range are the areas with greatest flood activity, particularly in the basins of Yakhsu, Varzob, Vakhsh, and Obihingou rivers. As a whole, during 1961-1990, an increase of 50-60% in the number of days with disastrous floods was observed. Between 1991-2000, several disastrous floods were experienced in the republic in 1993 and 1998, which destroyed many sites (Ragun hydropower station dam under construction, roads, houses in Khatlon and Sogd regions) and huge damage was caused.

Avalanches. Basic conditions for the formation of avalanches are slopes with a gradient of 30-50°, snow cover more than 30 cm, and relevant meteorological conditions. In Tajikistan's conditions, the major reason of avalanches is fresh snow formation (60-70%). The biggest recurrence of avalanches has been reported on the slopes with a northern exposition. Most avalanches are observed in February and March. The biggest number of days with avalanches was indicated in 1978, when mass avalanches occurred in all highland areas. It caused traffic jams; many communication and power supply systems were damaged. In 1969, extraordinary avalanche activities were indicated in the Western

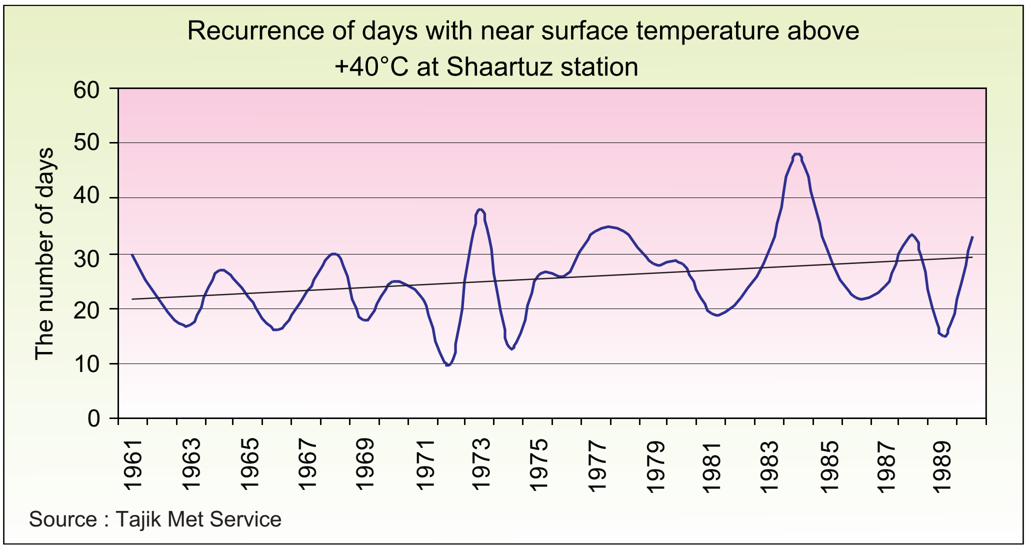

Fig. 3.14.

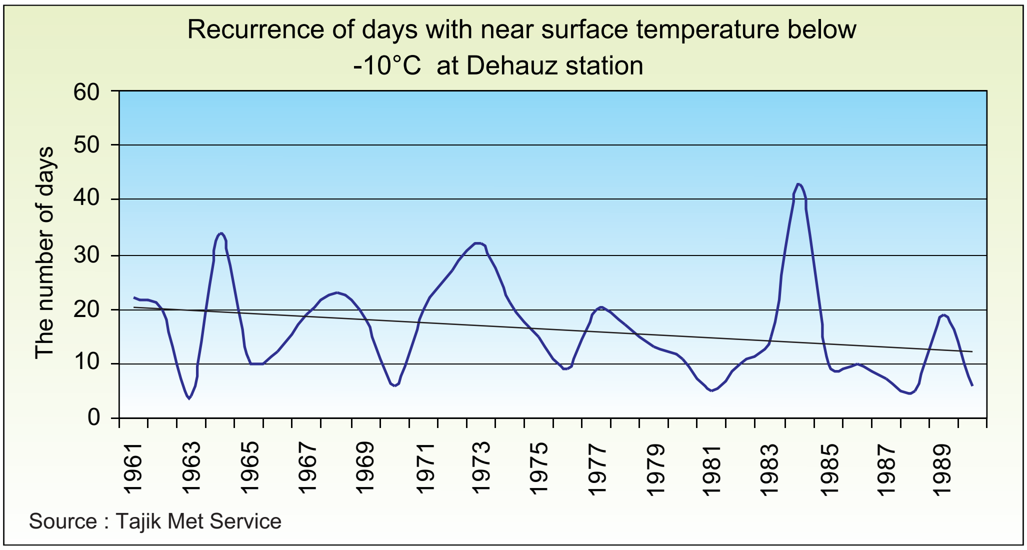

Fig. 3.15.

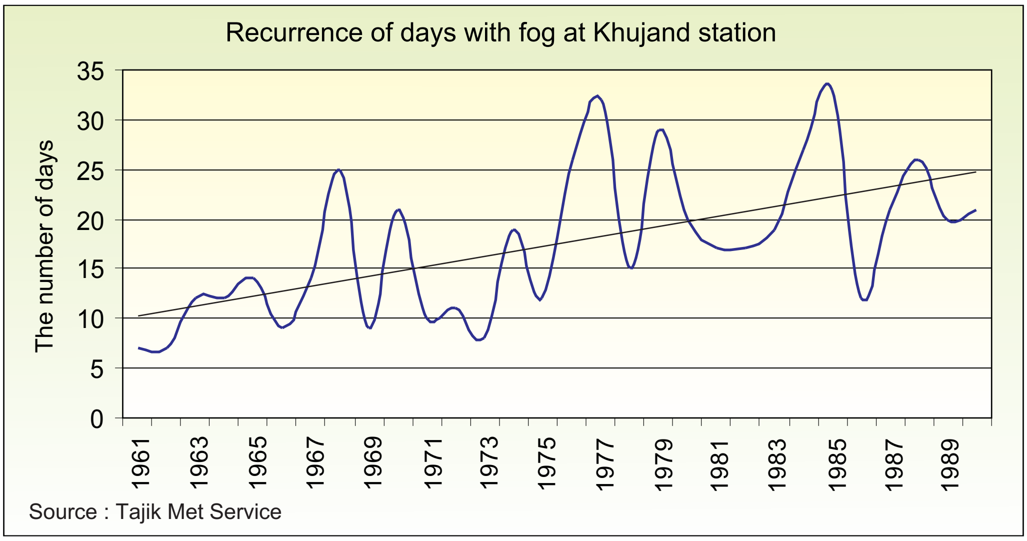

Fig. 3.16.

Pamir. The number of days with avalanches exceeding twice the average was indicated in 1976, 1984 and 1987. In the period of 1961-1990, there was a trend towards an increase of days with avalanches by 50-70%.

Fogs, lasting for more than 24 hours, with a visibility of 50 meters and less, are considered especially dangerous. However, it is a rare phenomenon in Tajikistan. Fogs start in November, reach their peak in December-January, and end in March. The exception is highland areas in the zones of cloud formation, where fogs are permanent. In most areas, total duration of fog does not exceed 50-70 hours a year. On the mountain passes, duration of fogs increases to 1,200 hours a year. Normally, fogs continue for 3-5 hours. In the period of 1961-1990, the number of days with fog increased by 20-50%. In the area of Khujand city, the number of days with fog increased by 80% (fig. 3.16).

Sandstorms are divided into local and frontal types. In the first case, these phenomena cover small areas with dry sandy soils and moderate winds. Such phenomena are frequent in the south of the country. Frontal sandstorms that accompany cold-wave intrusions, rush upwards along the valleys of Kafirnigan and Vakhsh. At the same time a strong wind (18-20 m/sec) along with sandstorm blow for several hours. The biggest number of days with sandstorms is observed in the south of the country and reaches 14 days a year. In the period of 1961-1990, there is a trend towards a reduction in the number of days with sandstorms by 1.5-2 times. However, in the late 1990s, the number of days with sandstorms has increased.

3.7. Climate change scenarios

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

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

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

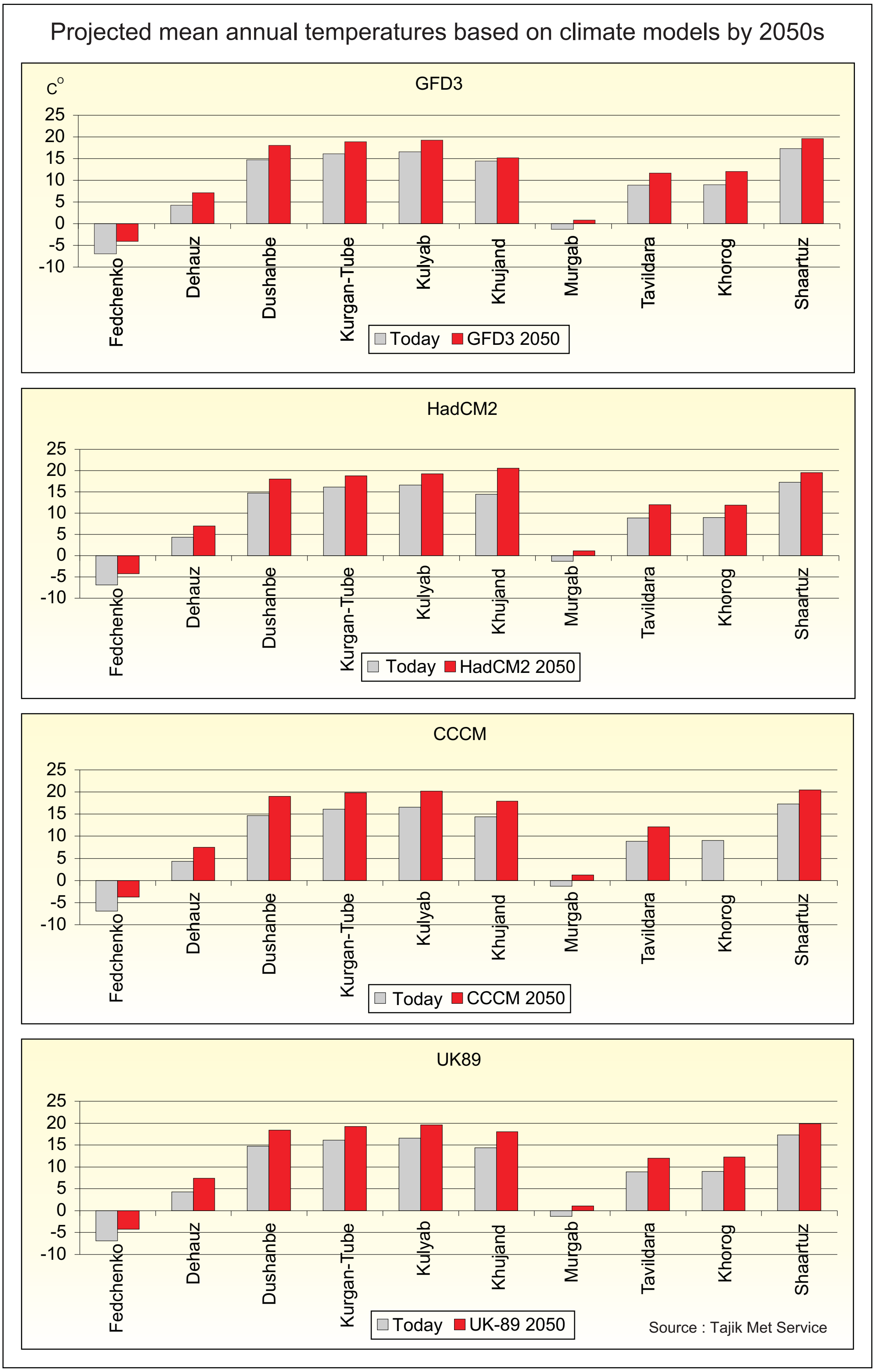
Projected mean annual temperatures based on climate models by 2050s
GFD3
c°
25
20
15
10
5
0
-5
-10
Fedchenko
Dehauz
Dushanbe
Kurgan-Tube
Kulyab
Khujand
Murgab
Tavildara
Khorog
Shaartuz
Today
GFD3 2050
HadCM2
Today
HadCM2 2050
CCCM
Today
CCCM 2050
UK89
Today
UK-89 2050
Source : Tajik Met Service

Fig. 3.17.

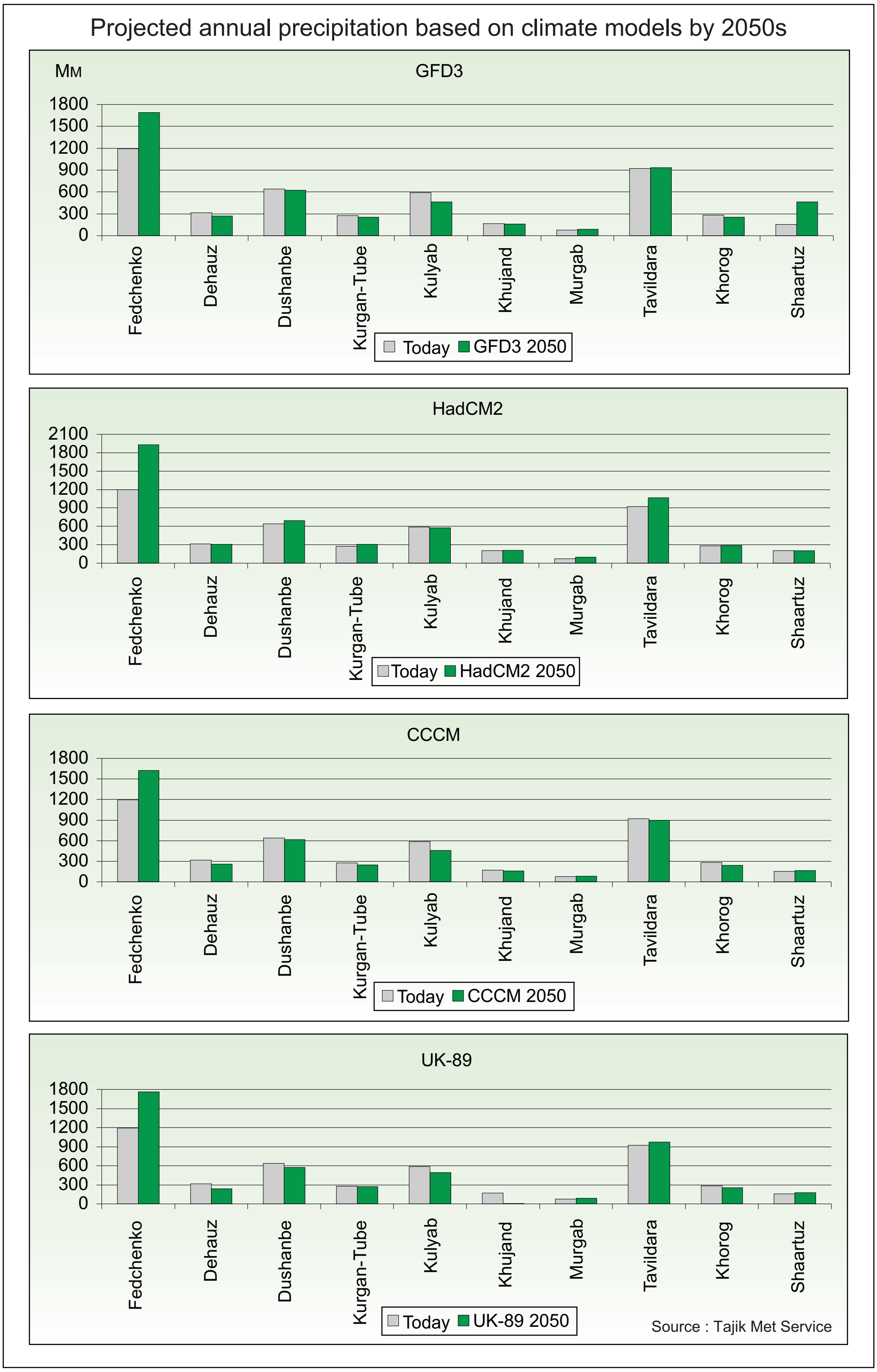
Projected annual precipitation based on climate models by 2050s
Мм
GFD3
1800
1500
1200
900
600
300
0
Fedchenko
Dehauz
Dushanbe
Kurgan-Tube
Kulyab
Khujand
Murgab
Tavildara
Khorog
Shaartuz
Today GFD3 2050
HadCM2
2100
1800
1500
1200
900
600
300
0
Fedchenko
Dehauz
Dushanbe
Kurgan-Tube
Kulyab
Khujand
Murgab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

Fig. 3.18.

On the basis of the models selected, climate change projections were prepared for the period until 2050s, when $2xCO_2$ is expected. The modeling of mean annual temperature scenarios in Tajikistan shows that the interval of expected changes ranges between 1.8-2.9°C. Mean monthly temperature change varies considerably within the models. Thus, according to CCCM the greatest increase in temperature is expected in February-March at the stations of Dushanbe, Kurgan-Tube, Kulyab and Shaartuz, which will reach 4.7-4.9°C. At the same time, HadCM2 shows minimum increase and in summer period - maximum increase of 1.9-2.3°C (fig. 3.17).

According to the models, the change and variability in precipitation for the period until 2050s are even greater than the changes in air temperature. According to UK-89 and HadCM2 models, an increase of 3-26% is expected in most of the regions of the republic is projected. Based on CCCM and GFD3, a decline of precipitation by 3-5% and more is expected (fig. 3.18). There is also significant difference in the seasonal precipitation projections. According to HadCM2, a maximum increase in precipitation of 41-69% is expected in July. Based on CCCM, at the same period the biggest reduction in precipitation of 16-21% is expected.

4 Inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases

4.1. Methodology

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

The main requirement in the preparation of the national GHG inventory is applying a methodology of calculations agreed and adopted in the COP UNFCCC, which allows international comparing of results.

Revised 1996 IPCC Guidelines for the National Greenhouse Gas Inventories, including software IPCC v 1.1 served as the basic documents and methodologies for all GHG emission calculations.

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

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

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

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

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

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

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

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

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

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

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

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

Electronic modules were prepared and submitted to the UNFCCC Secretariat.

Anthropogenic impact on the climate system in Tajikistan

Emissions from energy sector are CO_2, CH_4, N_2O, CO, NMVOC , NO_x, SO_2

Production of heat and electricity at heat power plants
Fossil fuel combustion in manufacturing industry and construction
Fossil fuel combustion in transport sector
Fuel consumption in residential, agricultural and other sector

Emissions from industrial processes are CO_2, PFCs, HFCs, CO, NMVOC, SO_2

Production of aluminum and ferrous metals
Production and maintenance of cooling equipment
Production of ammonia
Production of cement and lime
Production of foodstuffs and beverages

Emissions from agricultural sector are CH_4, N_2O, CO

Enteric fermentation
Manure management
Cultivation of rice on flooded fields
Agricultural soils
Burning of agricultural residues

Land use change and forestry are natural CO_2 absorbers

Changes in forests and other woody biomass
Absorption of CO_2 by soils as a result of 20-year changes in land use
CO_2 emissions as a result of illegal deforestation, biomass burning and soil dehumification

Emissions from waste are CH_4 and N_2O

Decay of organic substances in anaerobic conditions
Communal wastewater purification
Treatment of industrial wastewater

4.2. Tajikistan's contribution to global warming

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

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

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

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

4.3. Total greenhouse gas emissions

Five different gases with direct greenhouse effect considered in Tajikistan's GHG inventory. For comparison of their contribution into total emissions and assessment of their impact on the climate system, IPCC recommends submitting the results of the inventory in both absolute units and in CO_2-equivalent. The latter depends on the global warming potentials (GWP), which consider the radiative influence of greenhouse gases during a certain period, as well as the lifetime of those gases in the atmosphere (tab. 4.1).

Table 4.1.

Global warming potentials for main greenhouse gases for 100 year period

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

Source: IPCC

Some greenhouse gases in view of their physical and chemical properties possess an extremely high GWP. Among those are perfluorocarbons. In light of high GWP, even a small volume of their emissions accounts for a significant CO_2-equivalent value.

The results of calculation show that the greatest greenhouse gas emissions in Tajikistan were observed in 1991; they resulted in 31 million tonnes of CO_2-equivalent, and taking into account absorption in LUCF sector, they amounted in 30 million tonnes of CO_2-equivalent. The lowest volume of GHG emissions was observed in 1998 and resulted in 6.3 million tonnes of CO_2-equivalent. Taking into consideration absorption in LUCF sector, they amounted in 4.8 million tonnes (fig. 4.1)

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

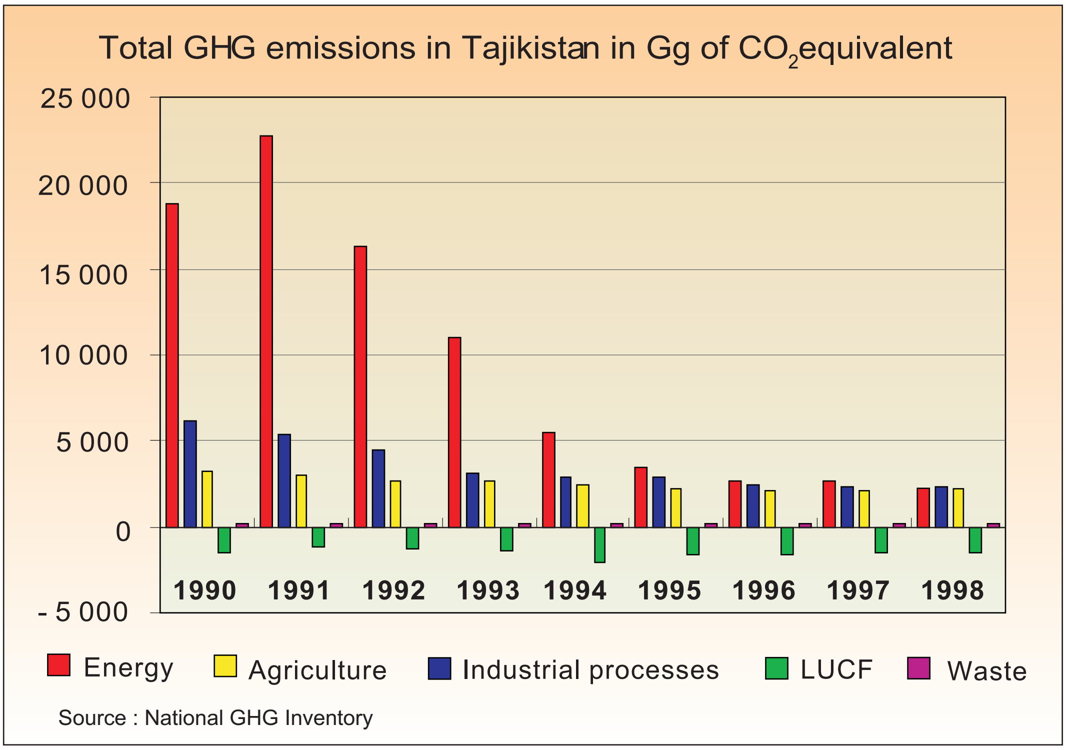

Fig. 4.1.

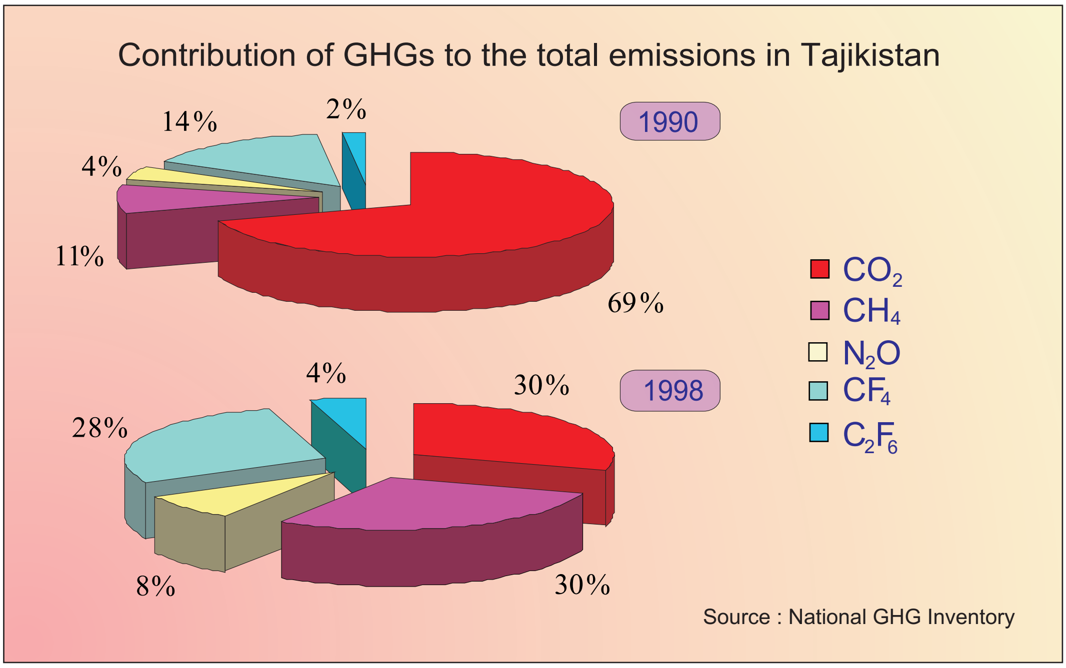

Fig. 4.2.

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

4.4. Per capita greenhouse gas emissions

CO_2 emissions per capita have decreased from 3.8 tonnes to 0.5 tonnes; this index is the lowest in the Central Asian region. At a global level, Tajikistan has the 100th position in terms of specific CO_2 emissions (CDIAC). Given that combustion of fossil fuels is the major source of CO_2 emissions, it should be noted that essential hydropower potential explains the low level of CO_2 emissions for the time being (fig. 4.3).

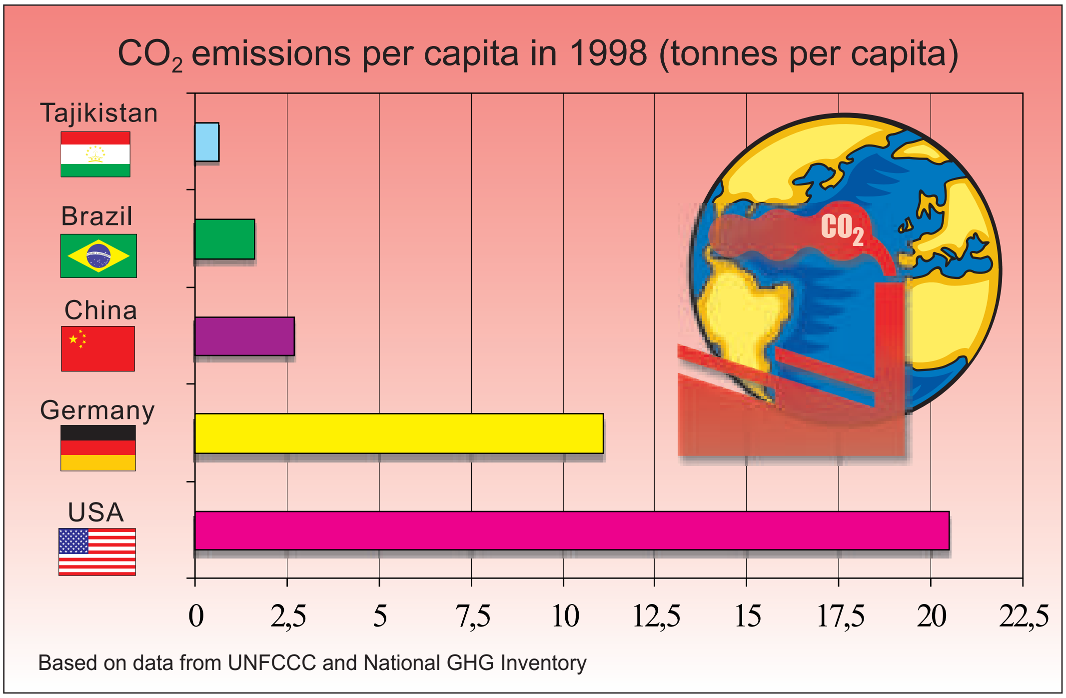

Fig. 4.3.

4.5. Key sources of greenhouse gas emissions

Key source categories of the greenhouse gas emissions in Tajikistan, which aggregate 95% of all emissions during 1990-1998 varied from year to year (tab. 4.2)

Table 4.2.

Key sources of GHG emissions for the period 1990-1998

IPCC category	Greenhouse gas	Contribution
ENERGY, Industry and construction	CO_2	8-27%
ENERGY, Residential sector and other sectors	CO_2	18-33%
ENERGY, Transport	CO_2	8-16%
ENERGY, Oil-gas systems	CH_4	5-10%
INDUSTRIAL PROCESSES, Production of metals	CF_4, C_2F_6	13-32%
INDUSTRIAL PROCESSES, Production of metals	CO_2	2-3%
AGRICULTURE, Enteric fermentation	CH_4	6-19%
AGRICULTURE, Manure	CH_4	1-2%
AGRICULTURE, Agricultural soils	N_2O	4-8%

S o u r c e : National GHG Inventory

4.6. CO_2 emissions

In Tajikistan in the period of 1990-1998, the biggest CO_2 emissions were observed in 1991 (22,658 Gg), mainly because of the combustion of fossil fuels (fig. 4.5).

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

The biggest share of CO_2 emissions are: combustion of fossil fuels, production of cement, aluminum, ammonia and ferrous metals. Insignificant CO_2 emissions occur as a result of soil dehumification.

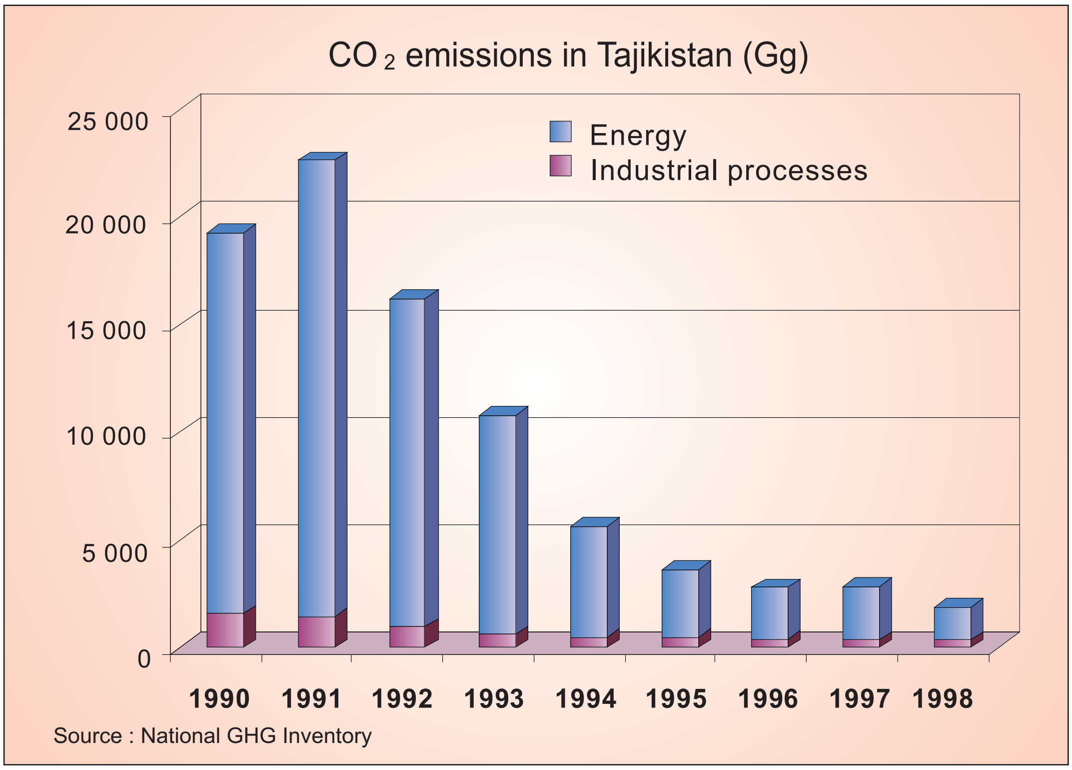

Fig. 4.4.

4.6.1. CO_2 emissions in the category "Energy activities"

In Tajikistan the biggest Co_2 emissions were observed in 1991 at 21,235 Gg, the least in 1998 at 1,524 Gg. The residential sector is a major source of energy-related CO_2 emissions. From year to year, the share of this source amounted to 35-45% of total energy-related emissions. According to expert judgments, this source makes as much as 50% of CO_2 emissions considering unaccounted fuel consumption (wood, coal, etc.).

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

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

There are about 250 thousand vehicles in the country, including 170 thousand individual motorcars. The number of vehicles per capita is 24 cars per 1000 people. The biggest number of individual motorcars per 1000 people is 31 cars in the capital city, Dushanbe.

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

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

4.6.2. CO_2 emissions in the category "Industrial processes"

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

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

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

Production of lime involves several phases including extraction of raw materials, crushing, and screening, decarbonization, lime hydration to dioxide calcium and further transportation, storage and usage. Emission coefficient for lime production constitutes 0.79 tonnes CO_2 per 1 tonne of final product.

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

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

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

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

Distinctive feature of land resources in Tajikistan are:

Domination of non-agricultural lands (68%) among which are glaciers, snowfields, mountains, pebbles, rocky cones, mountain deserts and other unusable lands;

Small areas of forests and bushes (3%);

Most agricultural lands are pastures;

The most valuable parts of available lands are arable, which are being intensively used.

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

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

In the period of 1997-1990s irrigated areas of the Republic of Tajikistan increased to 178.4 thousand hectares as a result of land reclamation (Urtaboz, Tashrabad, Garauty, etc.), which increased arable lands to 150.6 thousand hectares, perennial plantations to 17.5 thousand hectares (tab. 4.3). Land reclamation took place due to fallow lands (53.9 thousand hectares), hayfields (10.2 thousand hectares), pastures (52 thousand hectares) and other lands (110 thousand hectares).

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

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

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

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

Figure 4.3.

Dynamics of area of agricultural lands for the period 1970-1998 (10^3 hectares)

Year	Total land area		All agricultural lands		Including:						
					Arable lands		Perennial plantations	Fallow lands	Hay-fields	Pastures	
	Total	Irrig.	Total	Irrig.	Total	Irrig.	Total	Total	Total	Total	Irrig.
1970	14,254.9	530.7	4,330.5	493.5	772.7	414.4	62.7	73.2	37.3	3,384.6	9.4
1971	14,254.5	539.1	4,328.3	500.5	763.1	422	63.9	73.2	39.2	3,388.9	9.6
1972	14,254.5	547.6	4,369.2	507.8	765.7	428.8	65.6	68.3	38.2	3,431.4	9.7
1973	14,254.5	555.6	4,362	514.2	758.9	432.7	68.3	55.7	37.7	3,441.4	13.9
1974	14,254.5	564.8	4,363.9	523.2	759	439	69.3	49.1	38.8	3,447.7	16.1
1975	14,254.5	578.7	4,373.7	537	755	452.6	71.4	47.3	38.2	3,461.8	15.5
1976	14,259.4	593.3	4,384.8	550.8	761.5	467.1	73.3	42.2	38.7	3,469.1	15.4
1977	14,254.5	603.3	4,385.5	560.4	766.8	477	74.3	37.4	37.7	3,469.3	15.2
1978	14,254.5	612.1	4,385.4	568.5	773.1	485.7	76	36.4	37.2	3,462.7	14.1
1979	14,254.5	620.6	4,387.3	576.4	777.7	494.9	77.8	35.2	36.4	3,460.2	12.5
1980	14,254.5	627.6	4,394.5	583	783.4	502.3	78.2	35.8	35	3,462.1	12.4
1981	14,254.5	637.1	4,388.4	591.5	787.1	510.5	78.3	34.1	34.8	3,454.1	12.8
1982	14,254.5	644.4	4,383.4	598.9	793	518.7	78.6	33.1	34.5	3,444.2	12.5
1984	14,254.5	658.1	4,336.4	610.4	797.6	530.7	81	28.2	31.5	3,398.1	11.4
1985	14,254.5	665	4,374.3	615.5	803.6	536.7	83.4	24.5	31.5	3,431.3	10.3
1986	14,254.5	679.7	4,392.8	628	813.2	550.1	83.6	23.9	31.5	3,439.8	10.0
1987	14,254.5	692.7	4,385.1	639.6	822.9	563.5	85.4	21.9	30.4	3,424.5	7.6
1988	14,254.5	696.1	4,417.1	564.2	822.5	564.3	89.5	23.3	30.3	3,451.6	7.2
1989	14,254.5	705.4	4,415.3	647	819.3	566.3	94.5	22.8	30.1	3,448.6	4.9
1990	14,254.5	709.1	4,431.2	647.4	815	565	99	19.3	27.1	3,470.8	4.2
1991	14,254.5	717.8	4,434.1	653.3	811.2	567.9	103.4	19.7	26.4	3,473.4	4.3
1992	14,254.5	713.3	4,438.8	646.9	808.6	560.2	106.3	19.4	26.3	3,478,2	4.3
1993	14,254.5	714.7	4,480.0	646.8	806.8	558.3	108.6	19.7	26.1	3,518.8	4.0
1994	14,254.5	719.9	4,617.2	647.1	806.2	557.4	111.4	19.2	23.7	3,656.7	2.9
1995	14,254.5	715.1	4,578.5	642.7	801.2	553.3	111.2	19.3	23.7	3,623.1	2.9
1996	14,254.5	718.3	4,585.5	618.4	764.6	525.7	108.0	23.0	23.6	3,666.3	2.9
1997	14,254.5	718.4	4,564.9	616.4	764.4	525.9	105.6	22.9	23.6	3,648.4	2.8
1998	14,254.5	713.6	4,546.1	600.2	734.2	508.7	102.7	26.1	23.6	3,659.5	2.8

S o u r c e : Tajik State Committee on Land Use (2001)

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

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

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

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

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

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

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

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

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

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

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

Juniper forests occupy an essential part of national forests. They are predominant in Northern Tajikistan on the slopes of Gissar, Zeravshan and Turkestan ranges and consist of 3 dominant species: *Juniperus seravshanica, Juniperus turkestanica* and *Juniperus semiglobosa*. The area of junipers with a plenitude of 0.3 and more is 150 thousand hectares (tab. 4.4). Average juniper timber stock makes 21.2 cub.m a hectare.

Pistachio forests are well adapted to the arid hot climate and occupy 78 thousand hectares. As a rule, pistachios (*Pistacia vera*) comprise clean tree plantations or with portions of almond trees (*Amygdalus bucharica*). The pistachios are predominant in southern Tajikistan at an altitude from 600 to 1,400 masl. Pistachios, together with walnut plantations (*Juglans regia*) and almonds are valuable sorts of nuceferous trees.

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

Table 4.4.

Forestlands and timber stock

Type	Total		Including state forest fund	
	Area (thousand hectares)	Timber stock (mln.cub.m)	Area (thousand hectares)	Timber stock (mln.cub.m)
Juniper	150	3.2	122	2.7
Pistachio	78	0.4	74	0.38
Almond	12	0.03	10	0.02
Walnut	8	0.4	3	0.1
Birch	2	0.05	0,4	0.02
Poplar	6	0.2	3	0.1
Willow	4.4	0.06	0.7	0.02
Maple	44	0.6	35	0.5
Elm	1	0.03	0.1	-
Saxaul	8	0.02	-	-
Cherry-plum	2.6	0.03	0.3	-
Bushes	58.4	0.43	7	0.3
Other woody plantations	35.6	0.2	4	0.03
TOTAL	410	5.62	289.5	4.17

S o u r c e: Tajik State Forest Authority (2001)

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

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

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

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

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

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

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

Table 4.5.

Forested area and annual biomass growth

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

Source: National GHG Inventory

Table 4.6.

Reforestation in Tajikistan (thousand hectares)

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

Source: Tajik State Forest Authority (2001)

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

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

Table 4.7.

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

CO_2 sources and sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Change of carbon stock in mineral soils	940	635	713	923	1,658	1,295	1,323	1,210	1,161
Intensively used organic soils (emission)	-	-	- 19	- 38	- 57	- 66	- 76	- 80	- 84
Net land-use	940	635	694	885	1,601	1,229	1,247	1,130	1,077
Forests	588	582	546	491	447	428	425	414	410
TOTAL	1,528	1,217	1,239	1,376	2,048	1,657	1,671	1,544	1,487

Source: National GHG Inventory

4.8. CH_4 emissions

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

In the period under review, the volume of methane emissions has decreased more than 25%, as a consequence of structural changes in the agricultural sector and decrease in fossil fuel production and consumption (fig. 4.5).

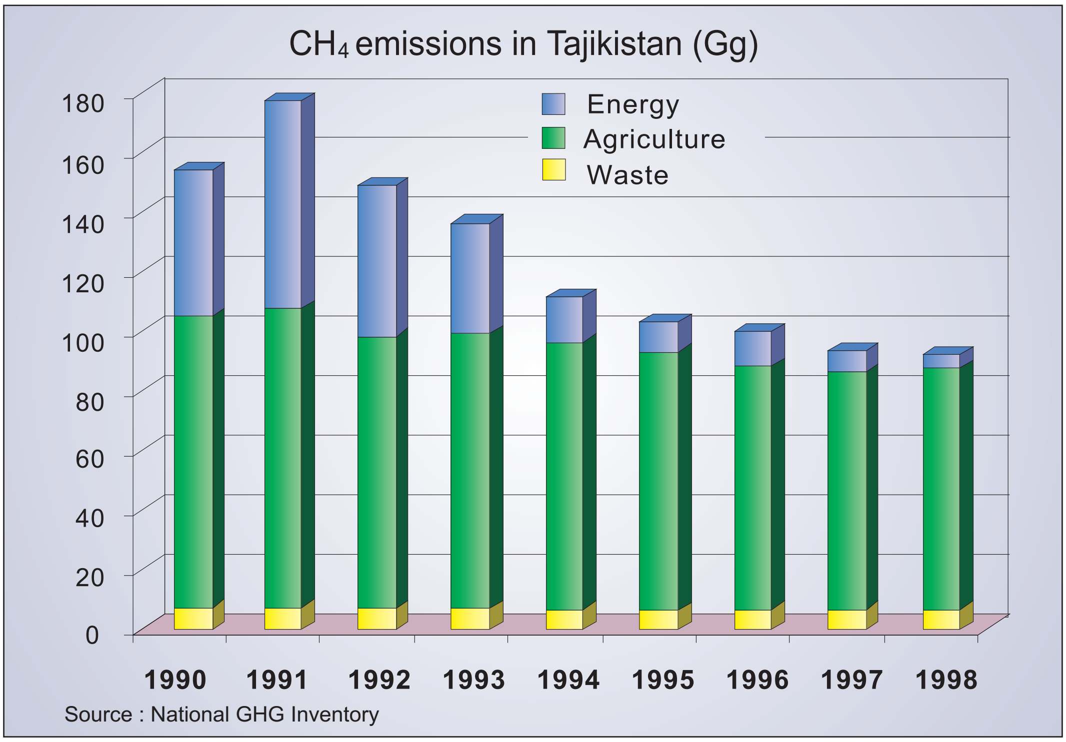

Fig. 4.5.

4.8.1. CH_4 emissions in the category "Agriculture"

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

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

Methane is formed in the process of herbivorous animals' enteric fermentation. The amount of emitted methane depends on the number of animals, breed, age, feeding type, quality and quantity of food, climatic conditions within cattle breeding zones and grazing technologies. It should be mentioned that ruminants produce 97-98% of the total CH_4 emissions from enteric fermentation. Methane emissions from this source have decreased in the period of 1990-1998 from 83 Gg to 65 Gg.

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

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

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

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

4.8.2 CH_4 emissions in the "Energy" category

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

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

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

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

4.8.3 CH_4 emissions in the "Waste" category

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

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

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

There are three basic types of waste disposal sites in Tajikistan:

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

CH_4 emission from solid wastes in Tajikistan for the period of 1990-1998 has not changed significantly from 6.1 to 6.8 Gg, which is conditioned by the dynamics of the urban population, types of dump and morphologic structure of solid communal wastes.

Methane in wastewaters is being formed in aerobic conditions. The amount of organic substances influence methane emission intensity.

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

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

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

4.9. N_2O emissions

The biggest volume of N_2O emissions in the period of 1990-1998 in Tajikistan was indicated in 1990 (about 3.8 Gg); the lowest emission was indicated during 1995-1998 (about 2 Gg), mainly caused by the application of mineral fertilizers; this source account for between 95% and 99% of all N_2O emissions. N_2O emissions from other sources in the category "Agriculture" (manure management, waste) are insignificant (fig. 4.6).

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

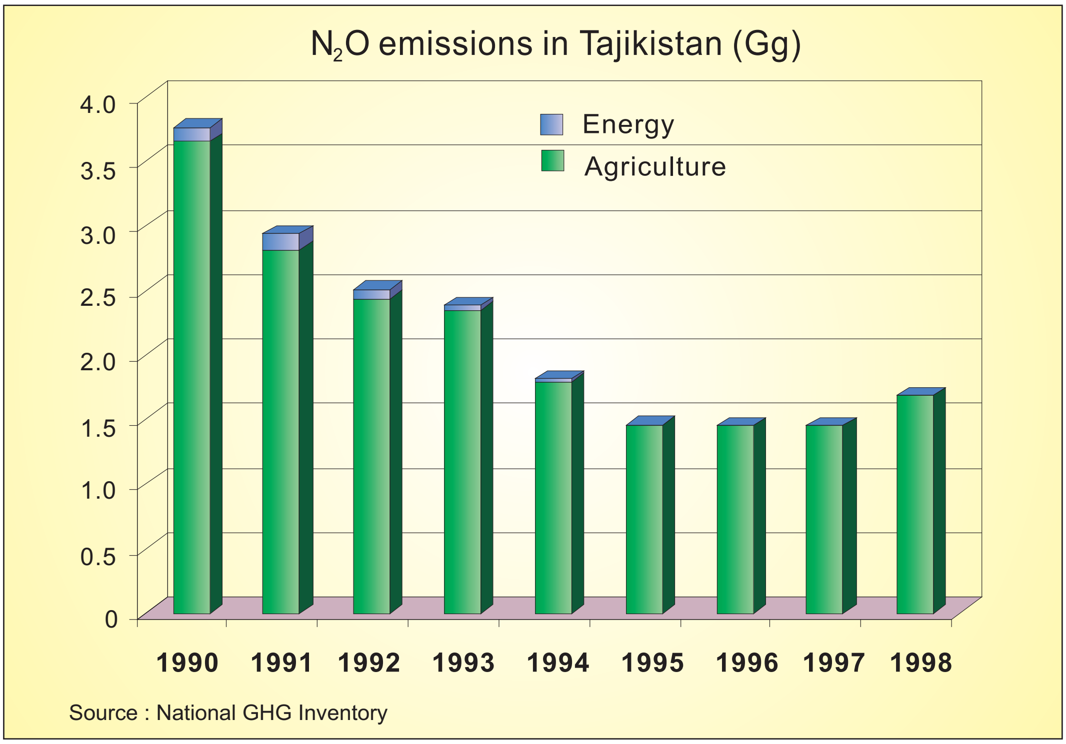

Fig. 4.6.

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

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

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

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

4.10 Emissions of perfluorocarbons

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

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

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

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

Table 4.8.

PFC emissions in aluminum industry (Gg)

Greenhouse gas	1990	1991	1992	1993	1994	1995	1996	1997	1998
CF_4	0.63	0.53	0.48	0.35	0.33	0.33	0.28	0.26	0.27
C_2F_6	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03
CO_2-equivalent	4,647	3,905	3,488	2,551	2,421	2,421	2,096	1,966	2,031

S o u r c e : National GHG Inventory

4.11. Emissions of GHG precursors and SO_2

Anthropogenic activities, along with GHG emissions lead to the emissions of CO, NOx, non-methane volatile organic compounds (NMVOC) and SO_2, which affect both the climate system and environment (fig. 4.7).

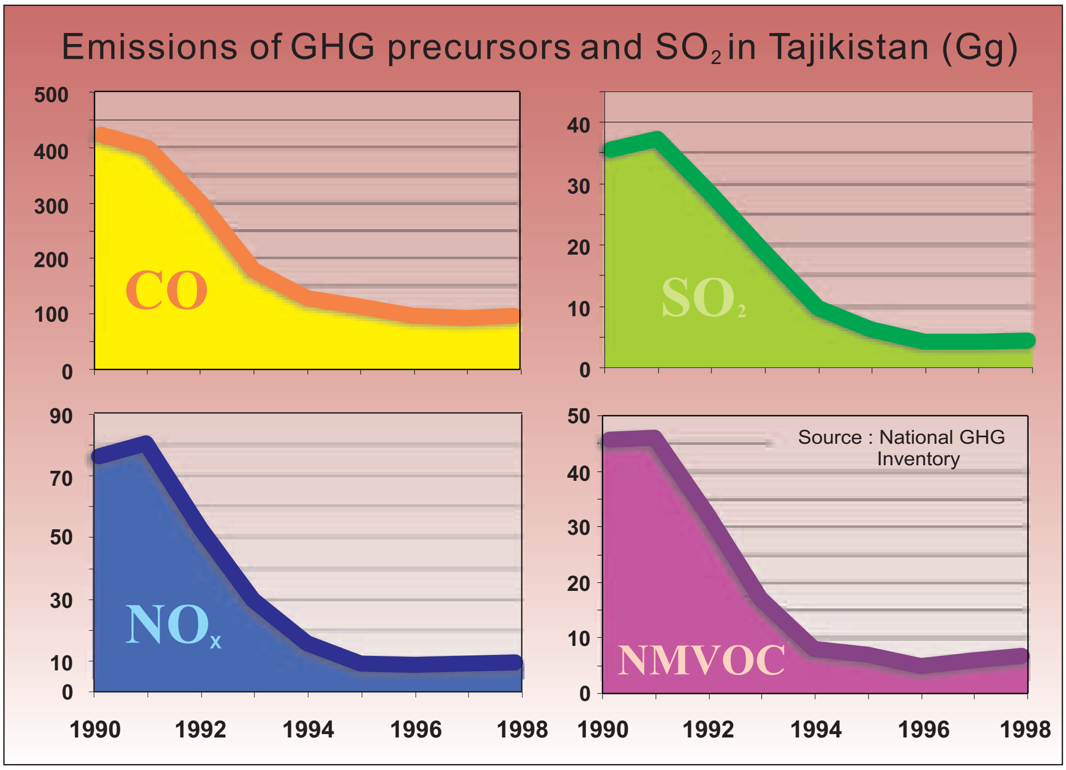

Fig. 4.7.

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

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

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

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

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

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

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

4.12. Uncertainty assessment

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

Table 4.9.

Uncertainty assessment of GHG emissions and removals

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

S o u r c e : National GHG Inventory

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

the low uncertainty group (10-33%),

the middle uncertainty group (33-66%), and

the high uncertainty group (66-100%).

The low level of uncertainty is observed in the category "Energy" (tab. 4.9.). There is a problem of coincidence in energy balance, particularly with natural gas, which causes uncertainty for a few emission sources to the middle level of reliability.

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

A middle uncertainty is observed in the category "Agriculture". Uncertainties in methane emissions from enteric fermentation and manure management are estimated in some years to be low or middle because of the lack of statistical data and possible inaccuracy in emission factors in local conditions. The high level of uncertainty is estimated in N_2O emissions from agricultural soils (tab. 4.9.).

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

5 Scenarios of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases till 2015

5.1. Methodology

The projection of macroeconomic development till the year 2015 has been prepared to determine greenhouse gas emission scenarios.

The scenarios were based both on the national methods, available information and international experience, including IPCC and UNEP recommendations.

All scenarios consider:
State policy priorities in the given sector;
The dynamics of the population number and employment;
The dynamics of GDP and deflator;
The dynamics of capital investments and investment activity;
Energy efficiency of national economy and GDP;

Leading experts and officials from the Academy of Sciences, Tajik Technical University, Tajik Met Service, Ministry for Nature Protection, Ministry of Economy and Trade, Ministry of Agriculture, Ministry of Energy, State Committee on Land Resources, Ministry of Industry, State Forest Authority have taken part in the research.

5.2. GDP and macroeconomics

During the years of independence and the reform of the public and economic system, Tajikistan created the basis for the principles of democratic development. However, the initial reformation period coincided with the economic crisis.

In the period of 1991-1996, GDP decreased by more than 60%. For the period under review, coal production reduced by 23.8 times, petroleum by 5.5 times, gas by 2.4 times, cement production by 21.6 times. A difficult situation has subsequently arisen in the agricultural sector, especially cotton growing and livestock industries.

As a result, the crisis has not only had an economic impact, but also a technological one. General assets have become considerably dated and unsuitable for effective use. With the significant reduction of industrial activity, and a decreased level of concern for energy conservation by the consumer, the energy consumption by manufacturers has increased by more than 4 times. This issue in addition with other factors, has had negative consequences on the state of education, public health services and other social spheres. The economy's decline has led to a deterioration in the quality of life experienced by the population's majority.

The implementation of economic reforms in the country has promoted a decrease of manufacture recession rates and economic stability, reducing the budget deficit. Since 1997, GDP has had consistent positive rates of growth. The economic tendencies in 1997-2001 give the rise to the belief that macroeconomics of the republic will develop in forthcoming years.

According to expert estimates, taking into account the economic development tendencies of the previous years and socio-economic development in the mid-term, GDP could increase by 3.5 times by 2015 in comparison to the level of 2000. Thus, the rates of GDP growth are projected at a level of more than 6% a year (fig. 5.1).

The increased production of petroleum, gas condensate and natural gas is possible under the reconstruction of oil and gas wells. It has been planned to restore and start operating 34 oil and gas wells by 2015, which will allow the production of oil products, including gas condensate, at an annual rate of 80 thousand tonnes, and natural gas up to 265 million cub.m. It would exceed year 2000 production levels by 3.6 and 7.2 times, accordingly. The recommencement of operational oil refining factories will allow processing of crude oil in the republic.

The construction of new oil refining factories with a capacity 500 thousand tonnes, both in the north and the south of the republic, and Khudja Sartez gas-field development for liquefied gas production is supposed. The implementation of these measures will improve the supply of energy resources to the population (fig. 5.2).

It is planned to increase coal production in the republic to a level of 200 thousand tonnes a year by 2015. It is likely that in the long term coal mining will be conducted in a greater volume by open-air method.

According to forecasts, by 2015 the aluminum production in Tajikistan will increase by 1.9 times in comparison with that of 2000 and will exceed the level of 1990.

<u>High industrial parameters in the aluminum industry are planned to be achieved by:</u>

The increase of electrolysis efficiency;

The introduction into operation of conserved electrolyzers and annual repair of operating electrolyzers;

Involving of secondary resources into industrial production (recycling).

The modernization of technology and expansion of the chemical product market will stipulate growth of this branch by 2015, especially ammonia manufacturing. According to expert estimates, the volume of chemical product manufacture will increase 10 times in comparison with 2000 levels and exceed that of 1990.

The republic's agricultural potential can be increased by reforming ineffective collective farms and state farms and replacing them with rental based farms, cooperative societies, associations and joint-stock companies. Now, there are more then 14 thousand large, average and small farms and agriculture organizations in the republic.

<u>The following basic tasks are planned to be achieved within the agricultural sector by 2015:</u>

Complete supply of needed products for the republic, where the capacity for their manufacture is available (vegetables, potatoes, fruit, grapes, etc);

Double 2000 levels of cotton production, rising the production volume to a level of 800 thousand tonnes a year;

Satisfy the needs of the population and the national economy in cereal products to increase grain production to 1.1 million tonnes;

Increase the number of cattle and poultry on average by 15-30%.

Thus, Tajikistan having sufficient agricultural-industrial potential contributes at some level to global climate change. Hence, macroeconomic development forecasts and GHG emission projections are the basis for the development of measures on GHG emission reduction and increased efficiency of resource use (fig. 5.3).

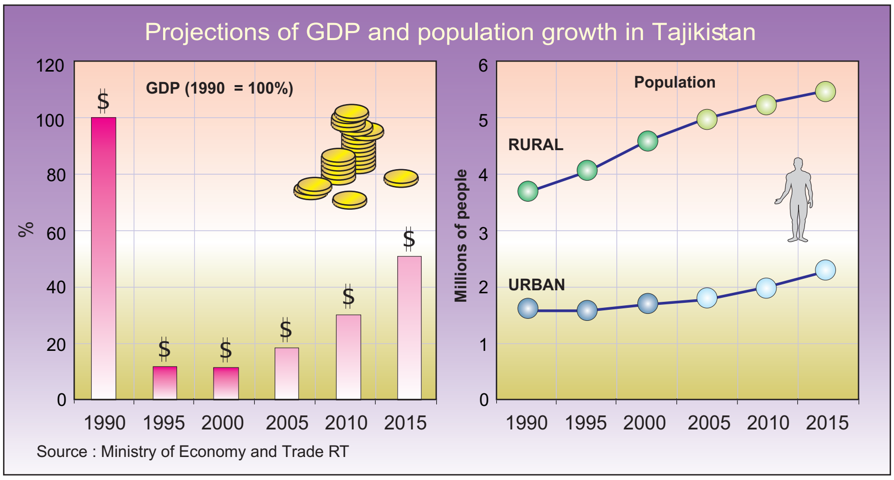

Fig. 5.1.

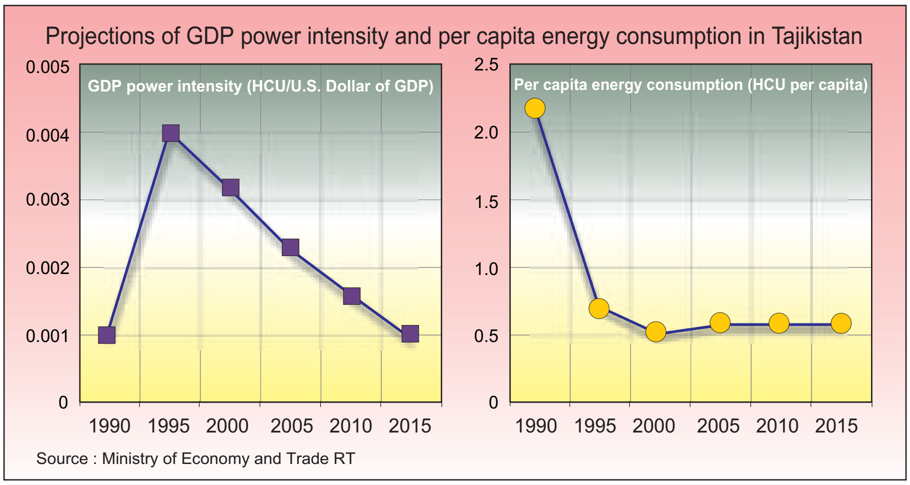

Fig. 5.2.

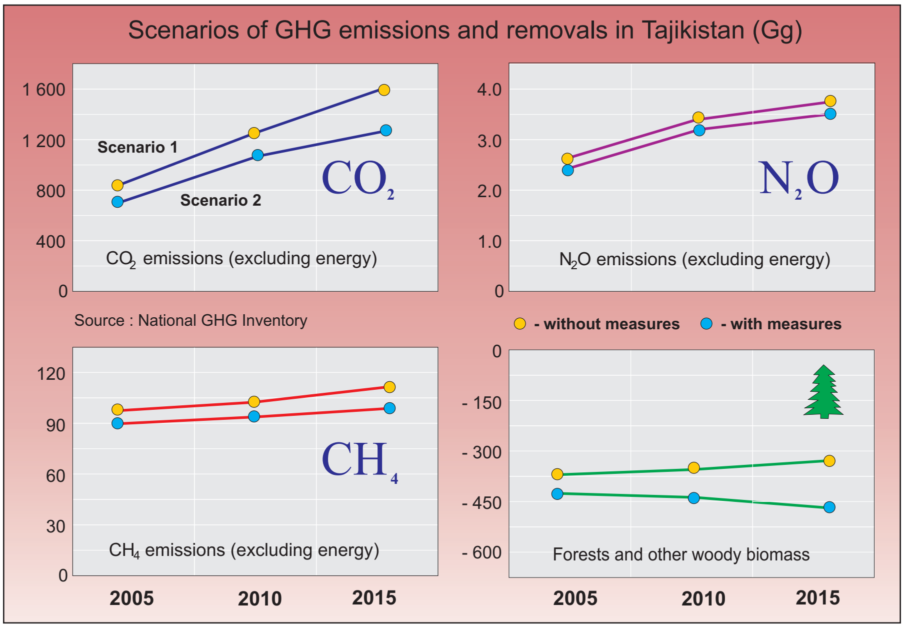

Fig. 5.3.

5.3. Energy sector

According to the national GHG inventory of Tajikistan, the main source of CO_2 emission is anthropogenic activity related to energy production and consumption. The energy sector contributes about 80% of all CO_2 emissions. Most energy-related CO_2 emissions are formed by gaseous fuel combustion, a lesser amount by liquid and an insignificant amount by solid fuel combustion. Most CO_2 emissions occur in residential, industrial and transport sectors.

According to expert estimates, energy consumption levels in Tajikistan will increase by 2015 compared to that of 2000. Taking into account the current level of fossil fuel production cannot meet the country's growing demands, this problem will have to be solved through imports.

The dynamics of GHG emissions in the energy sector will depend on the comprehensiveness of measures on energy efficiency, energy saving and emission reduction. There is a large potential for GHG emissions reduction, which is estimated as much as 30-60% in comparison with the scenario "without measures".

<u>The scenario "without measures" includes:</u>

Maintaining of existing parameters of energy efficiency in sectors of the national economy;

Use of non resource saving technologies;

Wood and coal fuel use in rural (basically mountain) regions;

Excessive natural gas consumption in industry and residential sector caused by the absence of monitoring systems and the ineffectiveness of gas distribution networks;

Use of poor-quality fuel and ineffective internal combustion engines in the transport sector;

Absence of measures on enhancing thermal insulation and climatic comfort in residential and commercial buildings.

<u>The scenario "with measures" (intermediate and optimistic) assumes:</u>

Increase of energy efficiency in all sectors of the national economy;

Energy saving in residential, commercial and other sectors;

Putting into operation of large hydropower plants, which are currently under construction (Sangtuda and Rogun HPPs);

Development and increased use of alternative and renewable energies;

Improvement and optimization of transport infrastructure, including development of electrified transport;

Reduction of GHG emissions in industry, transport, residential sectors, etc.

5.4. Industrial processes

The industrial sector of Tajikistan is responsible for the emissions of such gases as carbon dioxide, perfluorocarbons and others that have a direct and indirect impacts on the climate system and environment. Aluminum smelting contributes the greatest portion of industry-related greenhouse gas emissions.

<u>For the period of 1990-1998, in all industries the observed reduction of GHG emissions was caused by:</u>

Sharp decrease of manufacture volumes;

Damage and secession of technological equipment, in particular ammonia and cement;

Irregular supply of electricity and natural gas.

By 2015, the increase of non-ferrous metallurgy production volumes up to the level of 1990 is projected. By 2015, the chemical industry's ammonia production volumes will exceed the level of 1990 by 1.8 times. Large growth is expected in the textile industry, namely in cotton and raw silk processing. In the field of mechanical engineering it has been planned to develop the industry's potential by manufacturing new kinds of production (automobiles and lorries, electrical engineering etc.), and renewing previously manufactured products. The introduction of metallic waste recycling and technology modernization is planned at the Tajik Aluminum Plant (capacity 100,000 tonnes a year).

According to expert estimates, the increase of GHG emissions in the industrial sector is expected to be caused by:

Restoration and development of the production and processing of minerals, metals, chemicals, machines, textile, food and other goods;

Putting into operation new industrial objects and reconstruction of existing capacities without taking measures on GHG emissions reduction.

According to the above mentioned scenario, CO_2 emissions in the given sector will be increased proportionally to the industrial manufacture volumes and by 2015 will reach about 1.6 millions tonnes. The basic share of CO_2 emissions will be aluminum (44%), cement (23%) and ammonia (18%) production. In comparison with 1990, CO_2 emissions will be 102% by the year 2015. Perfluorocarbon emissions that have very high global warming potential will considerably increase in aluminum industry.

The CO_2 emissions can be reduced by 250 Gg (16%) by implementing reduction measures in comparison to the scenario "without measures", including emissions from cement production by 1.3 times, and ammonia production by 1.7 times.

Great potential on PFCs emission reduction hypothetically exist. Thus, it is possible to reduce PFCs emissions by several times or avoid them at all (non-carbon anode technologies). For precise recording of PFCs emission trends instrumental monitoring is needed.

5.5. Agriculture

Providing projected increase of the number of cattle and poultry, as well as expansion of rice cultivation on flooded fields, the emission of methane without taking measures will increase to 98-100 Gg by 2015. In comparison with the year 1998, the projected methane emission in agriculture will increase to 125% between the present time and 2015, and will equal 1990 levels.

By 2015, the nitrous oxide emission under scenario "with measures" will comprise 3.5 Gg. This will be equivalent to 88% from 1990 levels or 178% from 1998 levels.

According to expert estimates, under the scenario "without measures" the increased application of nitric fertilizers and expansion of agricultural lands will favor growth of nitrous oxide emissions by a factor of 1.7-1.8.

The total GHG emissions in CO_2-equivalent in agriculture will reach 3.2 million tonnes (139% of 1998 levels), of which methane will comprise 64%, and nitrous oxide 36% of aggregated emissions if abatement measures will not be implemented.

Under scenario "with measures", the trend of methane emissions in agriculture will depend on how complete the measures are implemented. The rate of emissions growth under scenario "with measures" will not exceed 0.7-1.1% a year, whereas under scenario "without measures" it will range from 1.2 to 1.6% a year.

5.6. Land use change and forestry

Recently, the reduction of CO_2 absorption by soils has been caused by the overall deterioration of land resources and the loss of soil humus. According to expert estimates, annual wash out of soil humus in rain-feed lands in the republic amounts to about 1 million tonnes. As a result, by 2000, CO_2 emissions from intensively used soils in comparison to the previous period has increased by 4.5 times. Under scenario "without measures", CO_2 emissions in this category would increase up to 300 Gg a year by 2015, and CO_2 removal will further reduce by 30-40% in comparison with the year 2000.

Deforestation, mainly forest cutting, near settlements and in mountainous areas has aggravated the problem of desertification. Furthermore, it has affected surface runoff and the state of biodiversity. Deforestation has become the basic reason for the reduction of annual biomass growth and, consequently, a smaller volume of CO_2 accumulation.

In the year 2000, the volume of carbon accumulation by forests decreased by 35% in comparison with that of the 1990's. The cutting down of fast growing trees and reduction of tree density has triggered this situation. Under scenario "without measures" i.e. without improvement works, sustainable forest management, forestation, reforestation, protection of forests against pests and fires, carbon accumulation will be lowered to 327 Gg by the year 2015, that will comprise only 80% of 2000's level.

5.7. Wastes

Wastes are the sources of methane and other greenhouse gas emissions. In the period of 1990-2000, total methane emission in this sector has decreased by 10%. It has been caused by the abrupt reduction of industrial manufacture volumes and wastewater discharges, and the alteration in the number of urban population and in the system of waste disposal.

Projected urban population growth for the period until 2015 will average 1.5% per annum. Under scenario “without measures” the total methane emission from waste will likely increase. In this way, methane emission from solid communal waste disposal sites will grow by 4-5% in comparison with 1990's level, and emission from communal wastewater will increase by 25%. The expected growth of aluminum and nitrogen fertilizers production will not considerably change the methane emission from industrial wastewater.

Under scenario "with measures", with emphasis on utilization and recycling of solid communal waste, sanitary and ecological conditions will be considerably improved and methane emission will be limited to 2000's level and even lower reduced.

6 Vulnerability of Natural Resources, National Economy and Public Health to Climate Change

6.1. Methodology

The goal of the vulnerability assessment was to analyze the potential impact that climate change could have on today's natural resources and the country's socio-economic situation, and to predict the possible qualitative and quantitative changes for the beginning of the 21st century resulting from global climate changes.

The vulnerability assessment was based on the impact that current conditions and projected models of possible climatic conditions would have on the natural resources and socio-economic development of Tajikistan, these include:

Ice cover;
Surface water resources;
Land resources and desertification;
Pastures;
Ecosystems;
Water economy and hydropower engineering;
Agriculture, including cotton and grain growing;
Transport infrastructure;
Urban air quality;
Public health and recreation.

Research methodologies were based on the UNEP and IPCC recommendations on the assessment of vulnerability to climate change. They include five major stages:

I. Introduction and approbation of vulnerability assessment methods recommended by international scientific organizations;

II. Development and selection of acceptable climate change scenarios for conducting a vulnerability assessment in Tajikistan.

III. Analysis of natural resources and socio-economic development of the Republic of Tajikistan; their linkages with climate conditions in the second half of the 20th century;

IV. Vulnerability assessment, evaluation of the adaptation potential, and projection of possible changes in natural resources and the national economy resulting from global warming in the first half of the 21st century;

V. Assessment and evaluation of measures' costs, development of an adaptation strategy to mitigate the consequences of climate change, and assessment of needs in further research, including systematic observations and public awareness.

National experts from the Academy of Sciences, Ministry for Nature Protection, National meteorological service, Tajik State University, Ministry of Transport, Ministry of Economy and Trade, Ministry of Finance, Agrarian University, State Committee on Land resources, Ministry of Water Economy, Ministry of Health, Ministry of Energy, and others have participated in the vulnerability assessment.

6.2. Ice cover

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

Northern mountain slopes receive the least amount of solar irradiation and therefore they provide better conditions for glacier existence and development. The number of glaciers in all the basins on the northern exposed slopes (north, north east and north west) makes around 65-70% of all those in Tajikistan.

Research of Tajikistan's glaciers started at the end of the 19th century. Since then, a "Catalogue of glaciers" was composed; the regions of ancient ice accumulation were identified; glacier dynamics and formation and melting processes were studied. All this data along with climate change scenarios served as a basis for a vulnerability assessment of glaciers to climate change.

The most ancient glaciations known in Tajikistan took place in the second half of earlier quaternary (about 200 thousand years ago). Its area totalled 29.5 thousand sq.km, which is 3.5 times more than nowadays. Strong glaciations were formed in Eastern Pamir and exceeded today's area of glacial cover in that region by 8 times. In the Gissar-Alai region, glaciers had covered relatively small areas. Few if any glaciers were found on the northern slopes of the Turkestan range and the upper stream of the Varzob River.

The next stage of glaciation in the second half of middle quaternary (about 100 thousand years ago) covered almost all mountain territories of Tajikistan. Its area comprised of 24.8 thousand sq.km. The area of glaciers that covered Western Pamir and Gissar-Alai was 3 times more than today. Thus, Fedchenko Glacier formerly occupied the whole valley of the Muksu River.

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

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

In the Zeravshan River basin, the glacier of the same name retreated by 280 meters during 1927-1961. During 1961-1976, the Zeravshan Glacier retreated by 980 meters. From 1961 to 1991 the Zeravshan Glacier retreated by 1,092 meters. Nowadays, the Zeravshan Glacier is in the process of intensive degradation. The Rama Glacier, located in the same river basin, during 1929-1975 retreated by 320 meters and during 1976-1991 by 356 meters. Recently, the retreat of the Rama Glacier has been very intense.

Small glaciers on the western slopes of the Peter Primus range within the Surkhob River basin melt intensively. On the Alai range's southern slopes, the ice cover decreases much slower, since this is an area of larger glaciers.

The large Garmo Glacier, located in the Obihingou River basin melts intensively. During the 20th century, this glacier shrank by almost 7 km, having lost more than 6 sq.km of its area. At present, on average this glacier retreats by 9 m a year; because of melting its surface caves 4 m a year. The Skogach Glacier, which is located in the same river basin, retreats annually by 11 meters (fig. 6.1). In the period from 1969 to 1986, the glacier lost 98.8 million cub.m, which is 8% of the total mass.

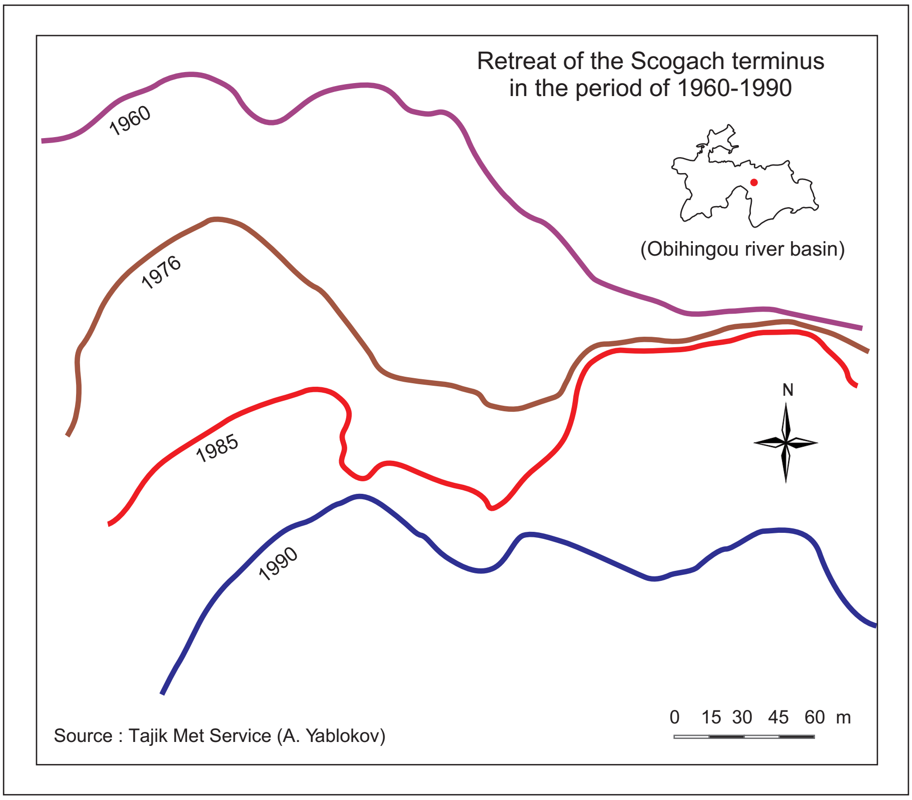

Fig. 6.1.

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

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

Together with glacier retreat, climate change has been responsible for the shearing of certain glaciers. Of 65 surging glaciers (i.e. glaciers that experience a dramatic increase in flow rate, ten to one hundred times faster that its normal rate), located in the Central Asian region, some 35 are located in Tajikistan.

One of the periodically surging glaciers that pose a potential risk, resulting in a glacial lake outburst is the Medvezhi Glacier. This glacier is located in the upper stream of the Abdukagor River (Vanch River left tributary). The length of the glacier is 15.8 km and area is 25.3 sq.km. The upper elevation of the glacier reaches 4,500 masl and the glacier tongue is located at an elevation of 3,000 masl. Between the area of accumulation and ablation there is icefall, which height exceeds 900 meters.

The National hydrometeorological service has been observing the glacier using instrumental tools since the early 1960s. The shearing movements of the Medvezhi Glacier were reported in 1951, 1963, 1973, 1989 and 2001 (photo 3).

In the spring of 1963 the speed of the glacier's movement had increased by a hundred times and reached 50 m a day. The glacier had blocked the Abdukagor River and formed a lake with a volume of 20 million cub.m of water. As a result of the glacial lake outburst a mudflow occurred with a discharge about 2,000 cub.m/sec. Thanks to preventive measures there were no serious destruction of property or people.

A new shearing movement of the glacier happened in spring 1973. An ice dam of 0.5 km width and 150 meters height blocked the valley of the Abdukagor River. This formed a glacial lake that reached a depth of 110 meters holding a volume of 27 million cub.m. As a result from the outburst there was a maximum water discharge exceeding 1,000 cub.m/sec. The water level in the Vanch settlement, situated 90 km away from the glacial lake was raised by 3 m, and in the Kalai-Khum settlement (Pyanj River) by 1.5 m.

As a result of a subsequent movement in 1989 the Medvezhi Glacier lengthened by 1.2 km, the volume of ice transported by the glacier amounted to 80 million cub.m. However, the height and width of the ice dam were less than in previous cases, thus the glacial lake outburst was not disastrous (120 cub.m/sec).

3. Medvezhi Glacier in 2001
Satellite photo by Russian Ac. Sci.

The last pulsation of the Medvezhi Glacier happened in the summer of 2001. The glacier lengthened by 450-600 m and carried 9.6 million cub.m of ice. In April 2001 the speed of glacial movement was 5 m per day; in May the speed of the glacier's movement reached 40 m per day. However, in the end of June the glacier had almost stopped and did not reach the Abdukagor River (remaining distance was 250 m), thus a glacial lake was not formed. It is likely that climate change will intensify the glaciers pulsation.

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

Below is a tentative projection of the glaciation dynamics over the territory of Tajikistan up to 2050. This projection is based on a series of climate change scenarios and the results of authoritative regional studies (fig. 6.2).

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

The area of small glaciers (1 sq.km) on the southern slopes of Gissar range will halve. Hundreds of small glaciers on the right-side slopes of the Surkhob River will disappear. The ice cover in this region will reduce by 15-20%, and the ice volume will decrease by 25-30%. However, some bigger glaciers will remain.

It is likely that in Sangikar, Sorbog and Yarhych basins small glaciers will disappear or significantly shrink. A lesser extent of degradation is likely to be observed in the Koksu basin.

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

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

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

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

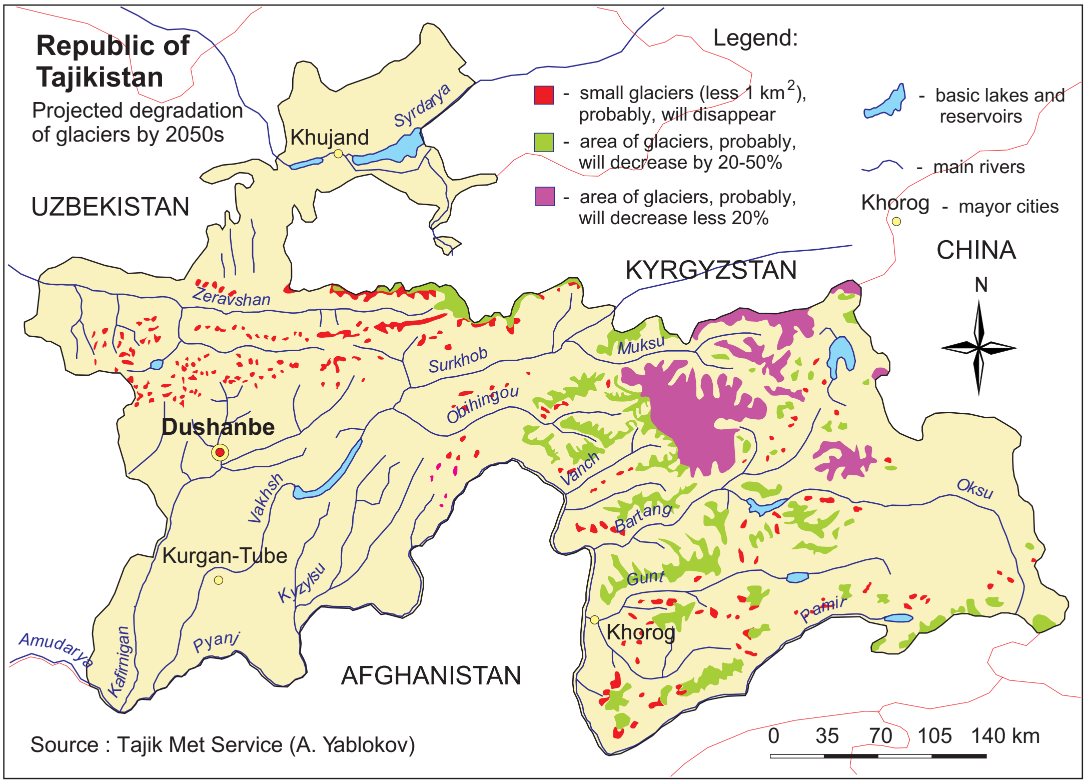

Fig. 6.2.

6.3 Water resources

Up to 80% of stream flow of the Amudarya River that flows into the Aral Sea is formed in Tajikistan (fig. 6.3).

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

In 30 years, the biggest decrease in annual flow has been observed on the Kyzylsu, Zeravshan, Vakhsh and Pyanj rivers (up to 7%). To a lesser extent the flow has also decreased in the Kafirnigan River (up to 3%). In the Eastern Pamir annual river flow changed insignificantly, and slightly increased (0.5-1%) in some regions of Western Pamir (fig. 6.4).

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

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

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

Expected increase of mean annual temperature by 1.8°C (HadCM2) in addition to a higher rate of increase of summer temperatures will cause a decrease of ice cover all over the Gissar-Alai region by 50% and to a lesser degree in the Pamirs (15-20%). Under such conditions glacier feeding of many rivers will reduce by 20-40%, whereas annual flow of the Zeravshan, Kafirnigan, Vakhsh and Pyanj rivers will decrease by 7% (an optimistic assessment). According to projections, a constant increase of temperature by 3-4°C in comparison with today's climate will dramatically shift the area and the volume of glaciers thereby causing catastrophic decline of water resources by 30% and more.

It is likely that a projected increase of precipitation by 14-18 % (HadCM2) will not have significant impact on river flow, since most of the rainfall's water will evaporate and percolate. It is very likely that rainfall will be more occasional and intensive increasing possibility of floods. According to other climate models rainfall will decrease and thereby deteriorate the state of water resources, particularly in Central Tajikistan. On the other hand, glacier and snow melting and an increase of precipitation (TAR IPCC) will result in an increase of runoff in the Pamir mountains (fig. 6.5).

Climate warming by the year 2050 will result in shifting beginning, peak and duration of flood periods. The duration of flood period will expand due to an increase in temperatures. On the rivers with glacier-snow feeding this period will shift 30-50 days, on the rivers with snow-glacier feeding - 15-20 days. Flood peak will shift 15-25 and 7-10 days respectively. On the rivers with snow and snow-rain feeding flood peak will start 25-30 days earlier, and duration of flood period will shorten because of earlier thawing of snow reserves (fig. 6.6).

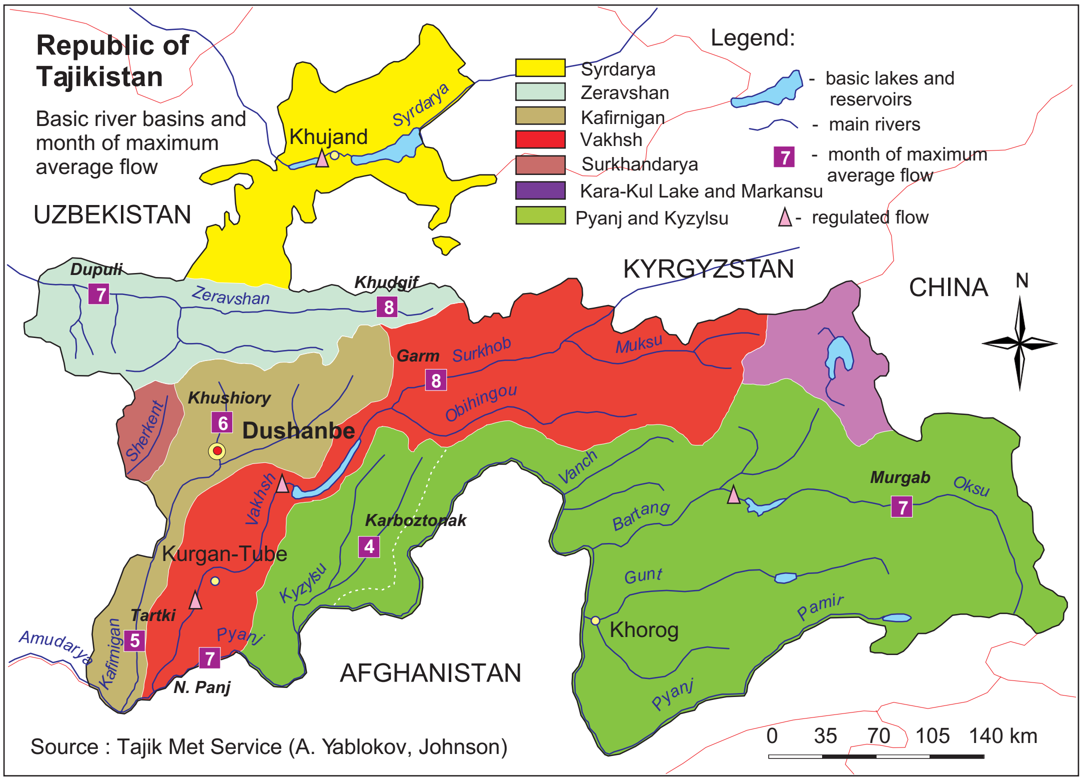
Republic of Tajikistan
Basic river basins and month of maximum average flow
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
Legend:
Syrdarya
Zeravshan
Kafirnigan
Vakhsh
Surkhandarya
Kara-Kul Lake and Markansu
Pyanj and Kyzylsu
- basic lakes and reservoirs
- main rivers
- month of maximum average flow
- regulated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

Fig. 6.3.

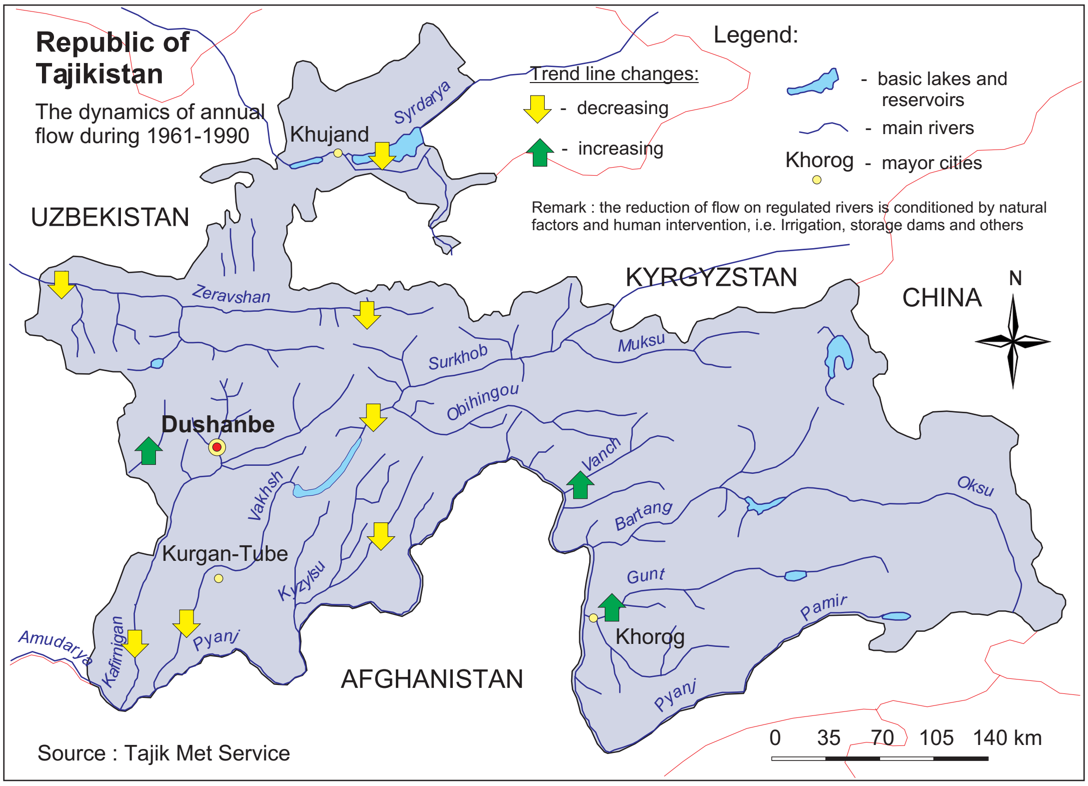
Republic of Tajikistan
The dynamics of annual flow during 1961-1990
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
Legend:
Trend line changes:
- decreasing
- increasing
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
Remark : the reduction of flow on regulated rivers is conditioned by natural factors and human intervention, i.e. Irrigation, storage dams and others
Khujand
Dushanbe
Kurgan-Tube
Khorog
Source : Tajik Met Service
0 35 70 105 140 km

Fig. 6.4.

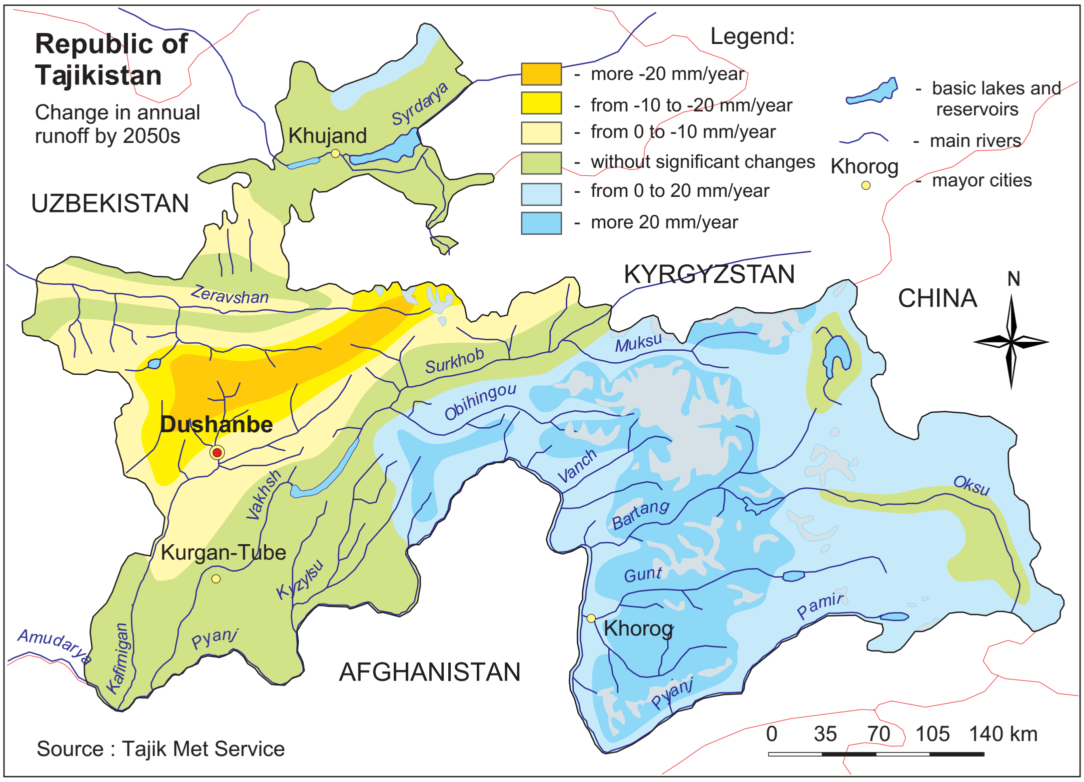
Republic of Tajikistan
Change in annual runoff by 2050s
Legend:
- more -20 mm/year
- from -10 to -20 mm/year
- from 0 to -10 mm/year
- without significant changes
- from 0 to 20 mm/year
- more 20 mm/year
- basic lakes and reservoirs
- main rivers
Khorog - mayor cities
UZBEKISTAN
KYRGYZSTAN
CHINA
AFGHANISTAN
N
Khujand
Syrdarya
Zeravshan
Surkhob
Muksu
Obihingou
Dushanbe
Vanch
Vakhsh
Bartang
Oksu
Kurgan-Tube
Kyzylsu
Gunt
Pamir
Khorog
Amudarya
Kafirnigan
Pyanj
Pyanj
0 35 70 105 140 km
Source : Tajik Met Service

Fig. 6.5.

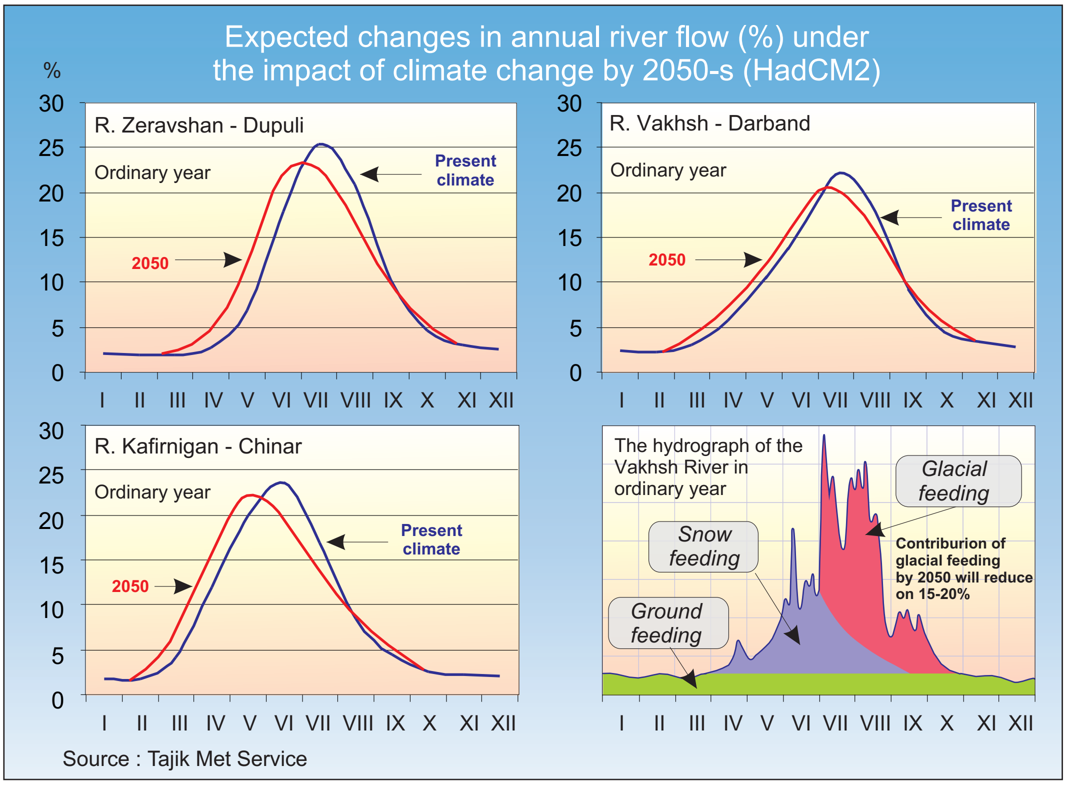
Expected changes in annual river flow (%) under the impact of climate change by 2050-s (HadCM2)
%
30 25 20 15 10 5 0
R. Zeravshan - Dupuli
Ordinary year
Present climate
2050
R. Vakhsh - Darband
Ordinary year
Present climate
2050
R. Kafirnigan - Chinar
Ordinary year
Present climate
2050
I II III IV V VI VII VIII IX X XI XII
The hydrograph of the Vakhsh River in ordinary year
Glacial feeding
Snow feeding
Ground feeding
Contriburion of glacial feeding by 2050 will reduce on 15-20%
Source : Tajik Met Service

Fig. 6.6.

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

6.4. Land resources and desertification

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

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

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

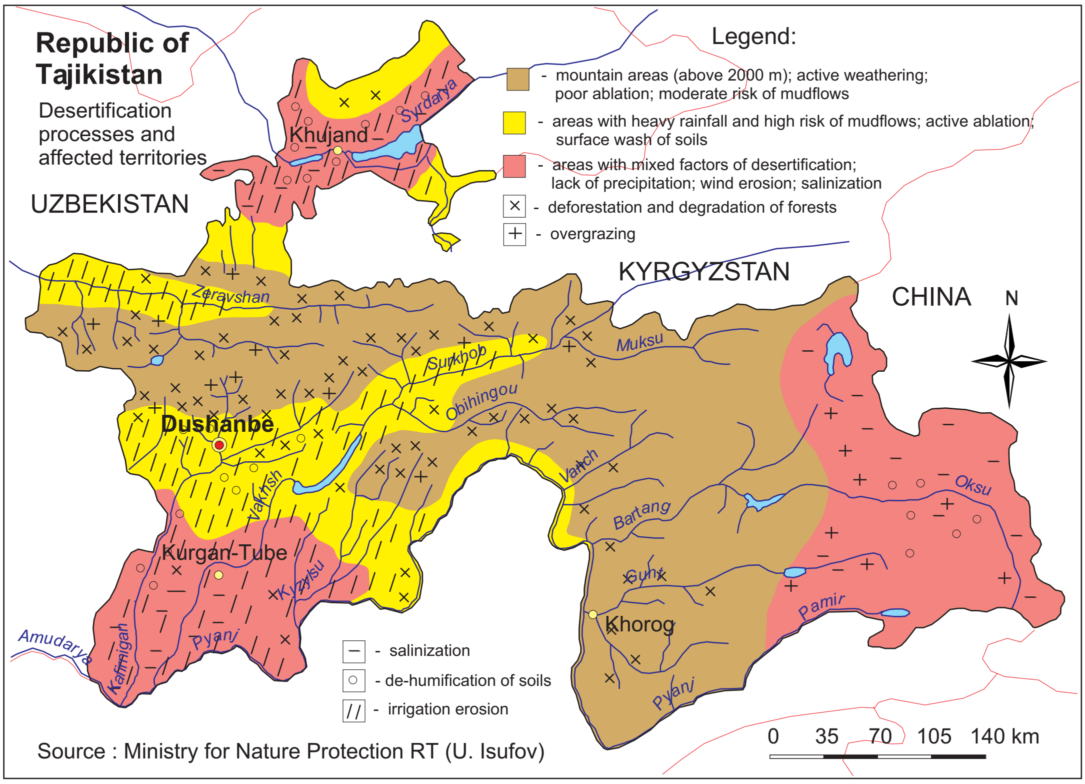

Fig. 6.7.

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

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

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

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

6.5. Pastures

Natural pastures and hayfields occupy a territory of 3.3 million hectares playing an important role in animal husbandry and serving as habitats for many species of flora and fauna. Natural pastures represent a valuable gene pool for the selection and introduction of new sorts of fodder.

Herbal cover of pastures conserves and increases soil fertility, preserves the soil from erosion and enriches the atmosphere with oxygen. The role of pastures is essential in regulating surface runoff, especially in mountain areas. Animal husbandry provides inexpensive production in comparison with stabling.

Low-herb savannoides and desert autumn-winter-spring pastures are situated within the valleys and foothills of Southern and Northern Tajikistan. Tall-herb savannoides prevail in mid-mountainous regions and have a very high productivity. Generally the following types of autumn-winter-spring pastures are dominant in Tajikistan: low-herb savannoides (productivity 250-500 kg/ha); tall-herb savannoides (900-1,400 kg/ha); desert pastures (50-300 kg/ha); cryophilic meadows (500-1,000 kg/ha).

Summer pastures that cover up to 50% of all pasturages are used from mid June till the end of August. Summer pastures are situated in sub-alpine and alpine zones and consist of tall-grass savannoides and steppes (productivity 500-900 kg/ha), meadows (800-1,200 kg/ha), prickly grasslands (300-500 kg/ha) and deserts (50- 300 kg/ha).

According to data from the Ministry for Nature Protection of Tajikistan the total annual mass of fodder in all types of pastures is 1,622 thousand tonnes of dry weight. Of this amount 1,086 thousand tonnes of fodder is on high-mountain summer pastures and 536 thousand tonnes of fodder on low-mountain autumn-winter-spring and all-the-year-round pastures.

However, the productivity of natural pastures is low and continues to decrease as a result of overgrazing, deterioration of pasture diversity, and violation of nature protection legislation, especially on autumn-spring-winter seasonal pastures of Southern Tajikistan. The area of most important winter pastures and hayfields decreases due to land reclamation and their use as arable rain-feed lands. Lately, many pasturelands on mountain slopes have been ploughed, and now used for the cultivation of cereals, where wash out of soils varies from 70 to 4,000 tonnes/ha.

The research shows, that the productivity of pastures greatly depends on climatic conditions during the vegetation period, especially levels of heat and humidity. Projected parameters of climate change have a potential to affect animal husbandry in Tajikistan. The arguments for this can be drawn from analyzing the relationship between precipitation, temperature and productivity of vegetation during the period between 1961 and 1990.

Providing precipitation levels are normal, a temperature rise of 2 to 4°C in February and March decreases winter-spring pasture productivity by 20% and can be reduced by 3 times during dry years. In the mid-mountains, an increase of annual temperature by 1.5-2°C together with normal precipitation leads to a decrease of pasture productivity by 20%. In dry years, a decline in productivity and diversity of ephemeral vegetation can be observed, which has an adverse effect on the pastures (fig. 6.8).

Low pasture productivity due to climatic conditions was reported in 1966, 1970 and 1985. In 2000-2001, pasture productivity decreased due to drought and high temperatures.

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

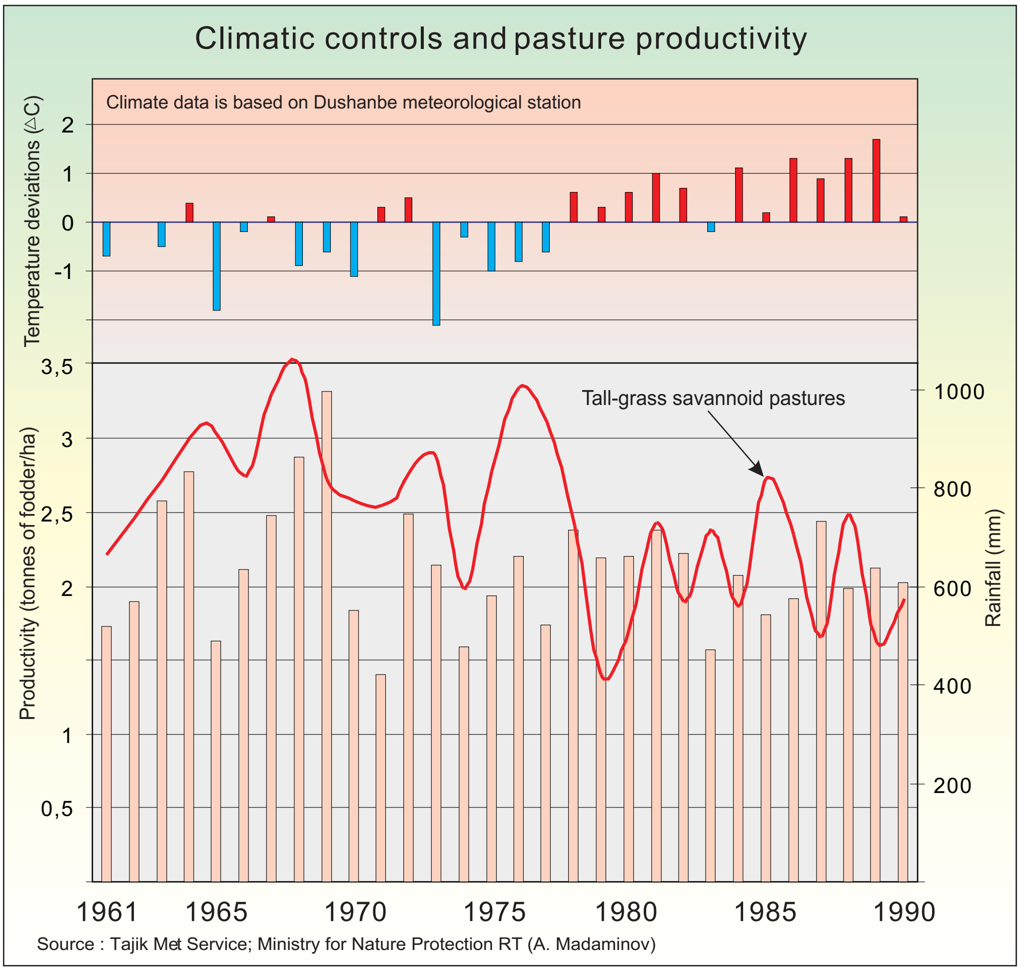

Fig. 6.8.

6.6. Ecosystems

In the conditions of global climate change the understanding and exploring of climate change impacts on productivity and diversity of ecosystems, especially mountain environments of Tajikistan, have great significance and actuality.

Tajikistan's flora is rich and diverse and consists of more than 5 thousand species of vascular plants, more than 300 mosses and about 3 thousand species of low plants inhabiting various ecosystems. Some 850 species of flora are endemics, which can only be observed on the territory of the republic or its neighbouring states.

Forests in Tajikistan occupy an area of 410 thousand hectares. Basic types of forests are: junipers, broad-leaf forests, small-leaf forests, xerophitic light forests, tugai (flood plain) and xerophitic shrub vegetation.

The fauna includes 84 species of mammal, 365 species of bird, 46 species of reptile, 52 species of fish, 2 species of amphibian, and over 10,000 species of invertebrate.

The combination of vertical zonation, land surface, soils and climatic factors give rise to a rich diversity of ecosystems within the relatively small territory of Tajikistan. Ecosystems respond to climate change and the increase of CO_2 concentration in different ways. The state of ecosystems and the changes within them are important indicators of climate change (fig. 6.9).

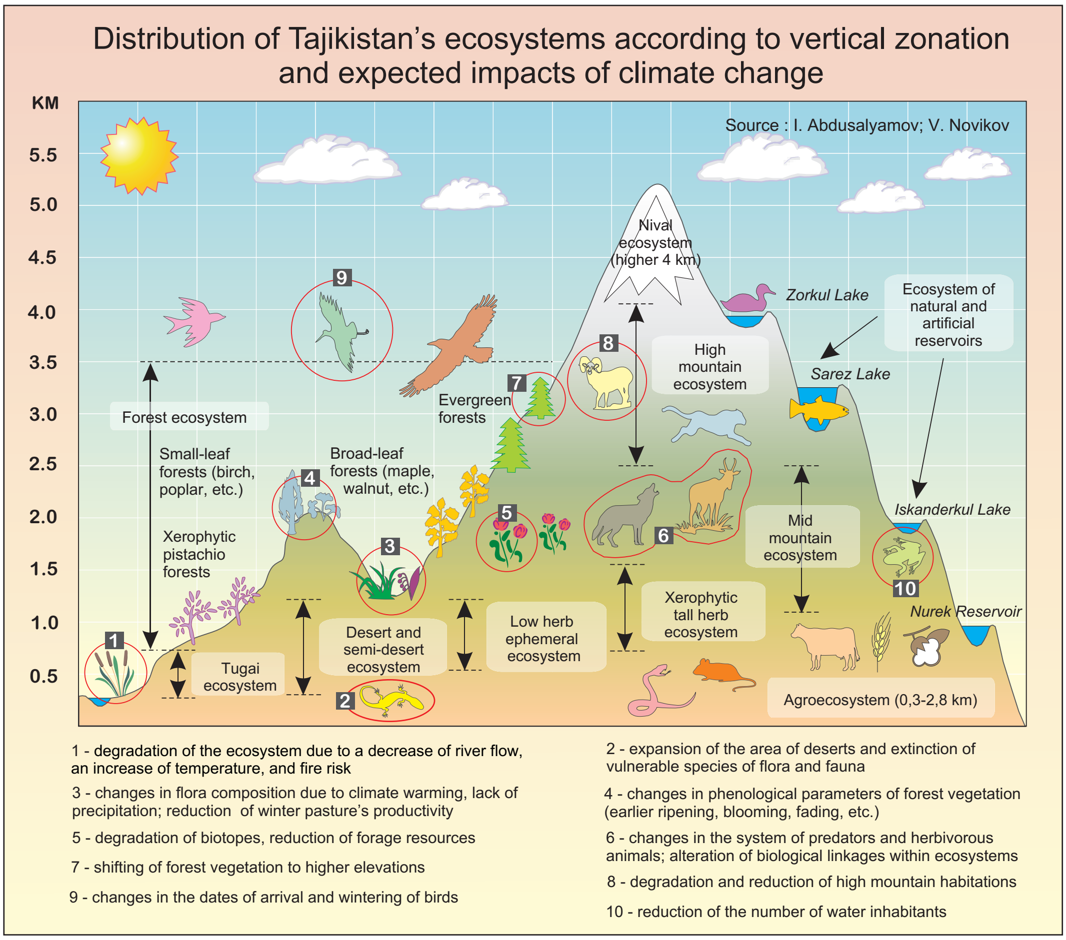

Fig. 6.9.

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

Broad-leaf forests - up to 2.5 km above sea level;
Small- leaf forests - up to 3.8 km above sea level;
Pistachio forests - up to 2 km above sea level;
Heat-loving junipers - up to 3 km above sea level;
Cold-resistant junipers- higher than 3.2 km above sea level.

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

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

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

4. Bukhara red deer
Photo by I. Abdusalyamov

It is very likely that as a result of climate warming the habitats will degrade thereby reducing the number of endangered and rare species of flora and fauna (photo 4). The fauna of high mountain regions is particularly sensitive to climate change. It is likely that birds' migration dates will change and the period of wintering will shift.

Climate warming can destroy the equilibrium within the system of carnivorous and herbivorous, invertebrates and vertebrates. There is no doubt that climate changes will affect water resources and thereby negatively impact habitants of water reservoirs: invertebrates, fishes and amphibians. These changes will take place in various ecosystems as a chain reaction, i.e. each alteration in one type of flora will accordingly cause alterations in other flora and fauna.

6.7. Water economy and hydropower engineering

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

Water economy performs the following main tasks:
Drinking and industrial water supply;
Irrigation of arable lands and pastures;
Maintenance of reservoirs.

Unique hydraulic engineering constructions of Tajikistan are: irrigation systems Vakhsh (4,752 km), Large Gissar (1,864 km), Khojabakirgan (6,472 km), Parhar-Chubeck (1,109 km); dams of Nurek and Baipaza hydropower plants; conduits Vakhsh-Yavan (7.4 km), Yavan-Obikiik (5.2 km) and Vakhsh-Dangara (14 km) irrigate arable lands of Yavan, Obikiik and the Dangara valleys.

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

Considering the projected increase of temperature by 1.8-2.9°C by 2050, the water consumption by vegetation will increase by 1-10%. Taking into account a shortened water volume in the future, water economy will face serious negative consequences, especially irrigation.

In 1990, water withdrawal by agricultural, communal and industrial sectors was 13.9 cub.km while 72% of this amount was used for irrigation. It is likely that water needs for irrigation will rise by 1.0 cub.km by 2010 and will total 15.0 cub.km. Considering the planned expansion of irrigated lands up to 1.5 million hectares, it is estimated that demand in water for irrigation will be 20-22 cub.km a year.

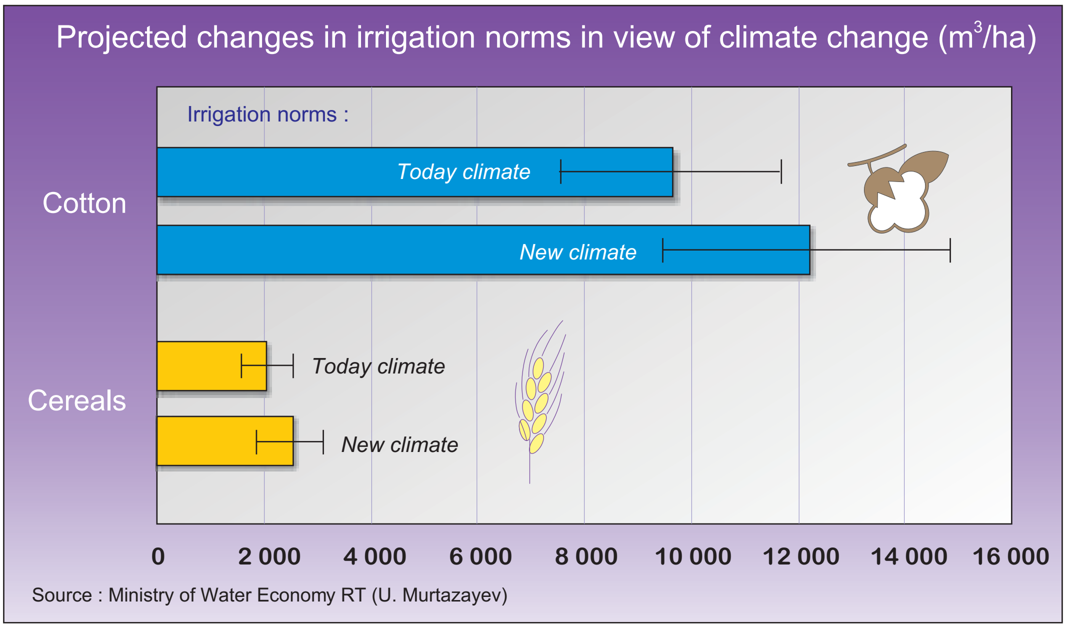

Fig. 6.10.

Projected parameters of climate change will increase the intensity of evaporation from the surface by 5-10%, whereas evapotranspiration of hygrophilous vegetation will rise by 10-20%. This will lead to an increase of irrigation norms (fig. 6.10):

In Khatlon province on cotton - from 7,550-11,700 cub.m/ha to 9,600-14,900 cub.m (27%) using existing technologies;
On wheat - from 1,580-2,530 cub.m/ha to 1,920-3,100 cub.m/ha (22%);
On alfalfa - from 4,220-9,240 cub.m/hectare to 5,820-12,750 cub.m/hectare (38%).

In a number of valleys, the ground water flow can decrease in view of surface water shortage and changes in the precipitation pattern; energy consumption on mechanical water lifting for agriculture will likely increase. Suspended solids in water will magnify because of soil erosion. The process of reservoir sedimentation will be more intensive (fig. 6.11). Low efficiency of irrigation systems (0.65) along with water resources shortage will complicate the water problem in the future.

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

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

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

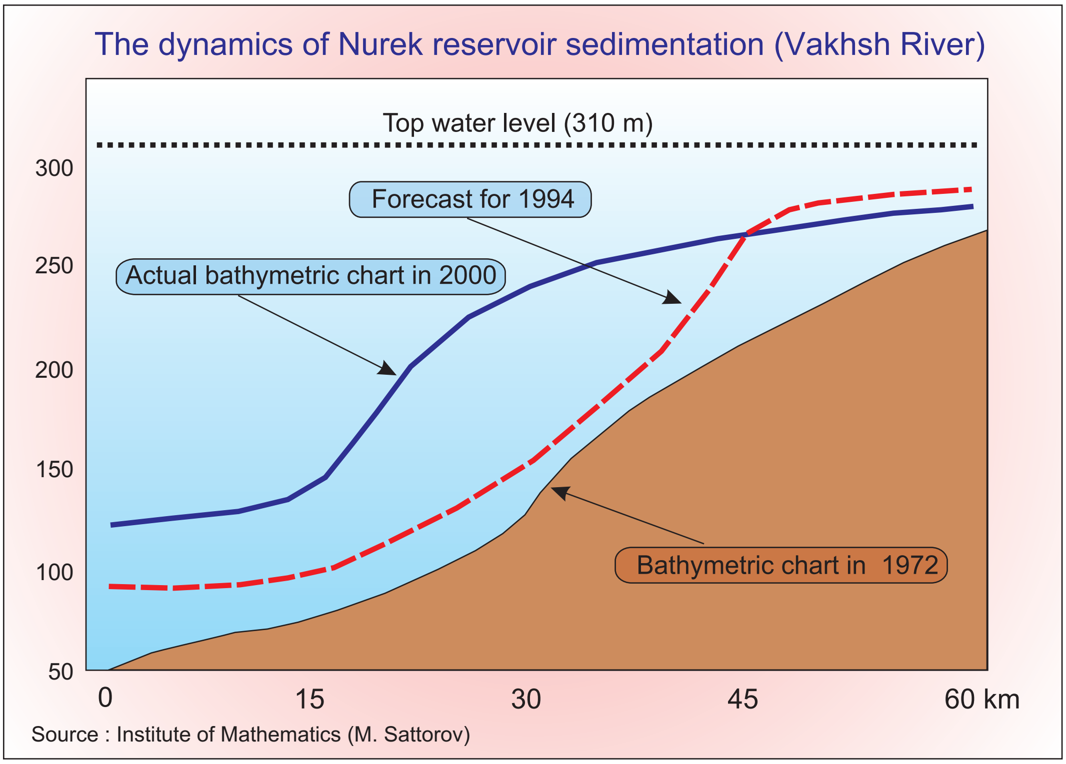

Fig. 6.11.

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

The infrastructure of the Rogun hydropower plant, which is currently under construction, was considerably damaged as the result of a flood in 1993. In March 2002, a massive landslide formed close to the Baipaza hydropower plant as a result of complex geodynamic and climatic factors (heavy rainfalls).

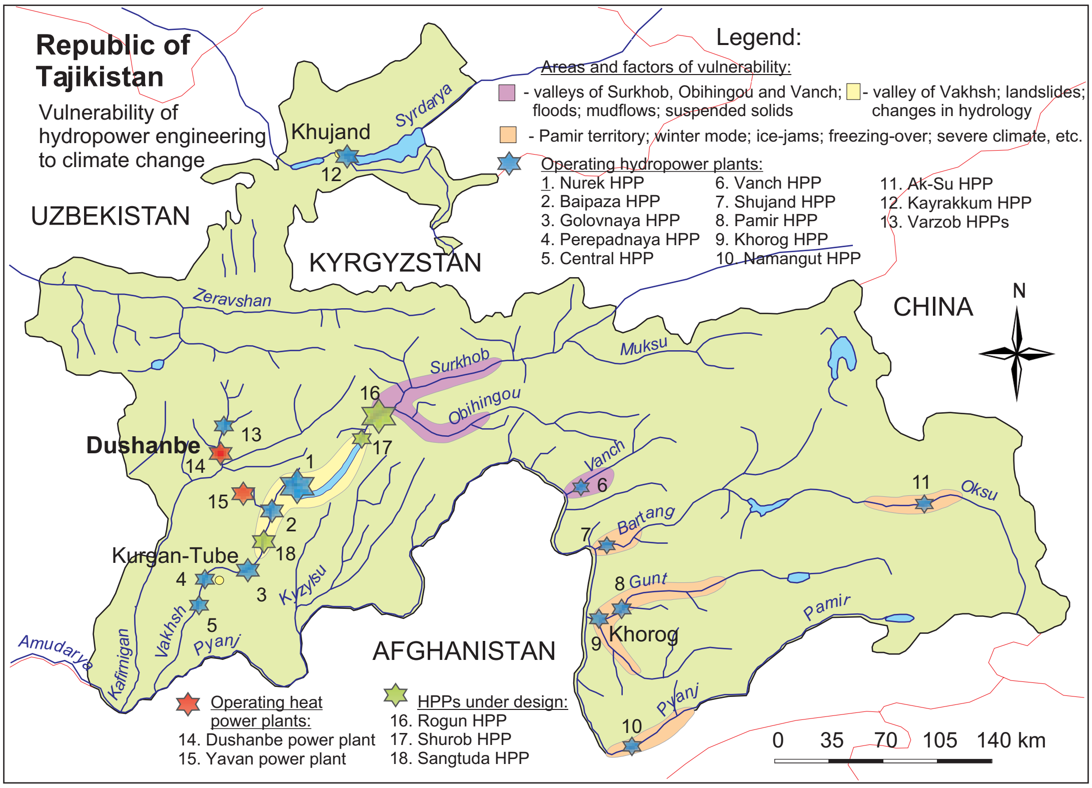

Fig. 6.12.

According to expert evaluations, a 10% increase in precipitation, especially in the regions prone to water erosion, will double the volume of suspended solids in the Vakhsh River, thereby increasing the intensity of sedimentation at the Nurek reservoir (fig 6.11).

On the Surkhob, Obihingou, and Vanch rivers landslide activities, floods and other hydro-meteorological phenomena cause this instability. The formation and outburst of glacial lakes is also potentially dangerous for hydropower facilities in this region. Prompt rise of temperatures and the rapid melting of snow increases the possibility and intensity of floods. The Pamirs are characterized by a harsh climate. Thus, the winter mode here brings bigger influence: ice jams, frazil, alterations of frosts and thaws, etc (fig 6.12).

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

6.8 Agriculture

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

Agriculture is the major sector of Tajikistan's economy, and it is paramount for the sustainable development of the nation. In the last decade, this sector comprised one third of Tajik GDP. Gross agricultural production from 1991-1997 decreased by 53.9%, especially for cattle breeding, its growth only recommenced in 1998.

The share of production by private farms in 2000 increased to 11.7% of the total gross agricultural production. Such a tendency continues now. Managing 61% of

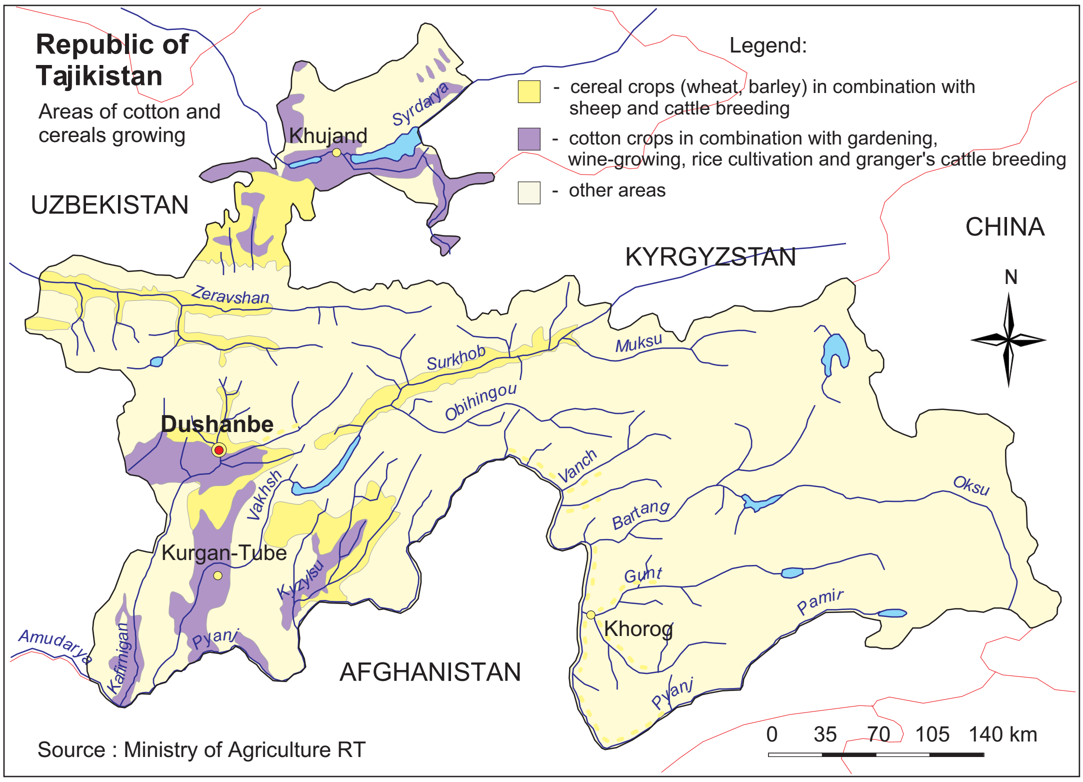

Fig. 6.13.

agricultural lands, agricultural enterprises produce 33.6% of the gross agricultural products, while the population managing just 24.2% of agricultural lands produce 54.7% of the total gross agricultural production. The share of cattle breeding by private farms is 90%.

The main agricultural practices in the republic are cotton growing, gardening, viniculture, melon farming, potato and cereal farming and animal husbandry (fig. 6.13).

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

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

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

The vulnerability assessment includes a quantitative evaluation of the agricultural losses caused by hydro-meteorological disasters in the period of 1991-2000.

The biggest damage occurred as the result of:

High air temperatures, accompanied by hot winds, and low air temperatures;

Heavy rainfalls, flash floods and mudflows;

Hail;

Strong winds and sandstorms;

Agricultural pests and diseases.

During 1991-2000, annual loses of agricultural gross product caused by extreme weather events made up to 1/3 of total losses. As a result of droughts in 2000-2001, the lack of precipitation and small snow stocks the harvest of cereals in comparison with previous years reduced by 10-30%. Hailstones, heavy rainfalls and other extreme whether events in 2002 resulted in significant damage to the agriculture of Tajikistan estimated at tens of millions of somoni, since the preventive and adaptation measures had not been taken.

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

6.8.1. Cotton production

Cotton is cultivated in the Gissar and Vakhsh valleys, Kulyab and Sogd areas. Cotton fields occupy about ¾ of irrigated lands. The Vakhsh valley is the leading area in production of valuable fine-stapled cotton. The cotton productivity depending on areas vary from 1,500 to 4,000 kg per hectare. Cotton is a basic agricultural export product and is widely used in Tajikistan's industry.

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

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

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

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

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

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

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

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

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

6.8.2. Cereals

After independence, development of agriculture became one of the main priorities of Tajikistan, since the country faced the necessity of cereals production increase to ensure food security.

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

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

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

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

Cereal productivity depends on the outreach of agricultural diseases and pests activity. The climatic factors favor the reproduction and spread of pests and different types of diseases. Climate change impacts can lead to the increase in the number of cereal pests and theirharmfulness.

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

6.9. Transport infrastructure

Tajikistan is a mountain country and in view of complicated landscape, motor-roads are the most important part of the infrastructure. The total length of national roads is about 30 thousand km, including 13.6 thousand km with a hard surface.

Road transport covers 90% of internal cargo turnover. In addition to the performance of important economic tasks, road transport plays a vital role in the maintenance of agricultural and social infrastructure. Development of railways in Tajikistan is very limited in territorial respect. There are only 3 isolated segments of the Tajik railway system with a total length of 533 km. Railway transport maintains about 90% of external cargo turnover. Aviation inside of Tajikistan is limited by complicated mountain conditions. In general, aircraft transportation, both internal and external, abruptly declined in the last decade, because of high usage costs and unsatisfactory conditions of the whole country's aircraft system. Water transport is applied insignificantly, basically in the form of small river vessels, barges and ferries on the rivers Pyanj, Vakhsh, Syrdarya and Amudarya.

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

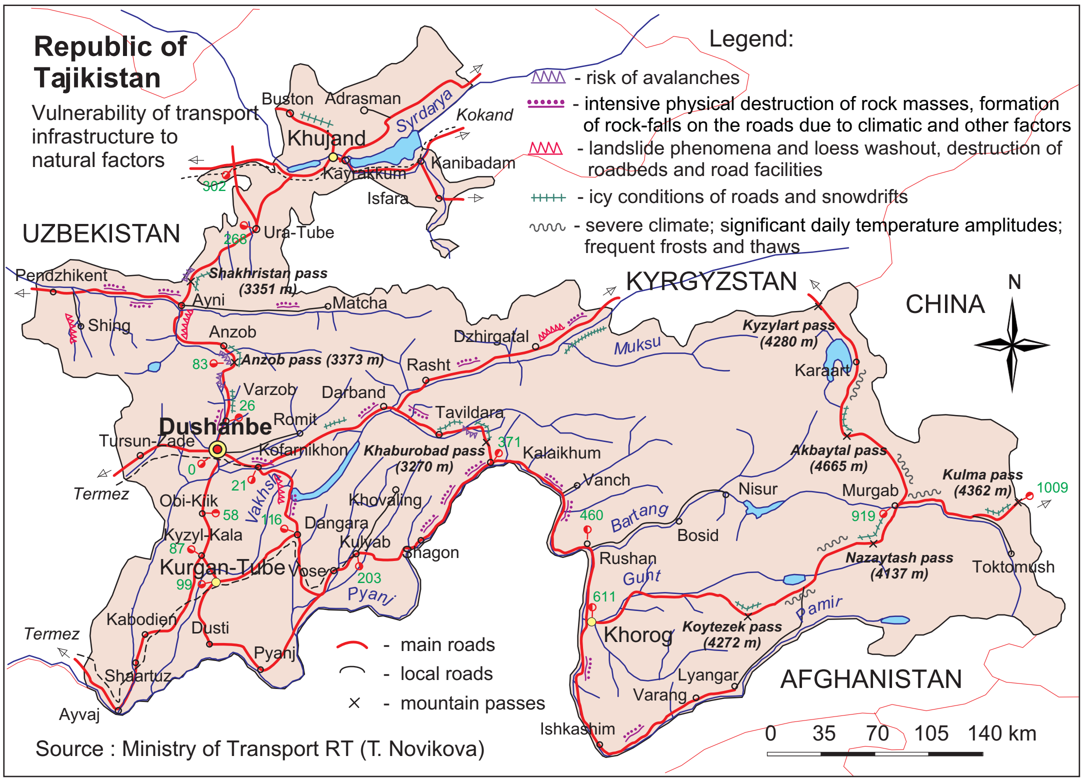

Fig. 6.14.

The development of road transport is limited by unfavorable natural-climatic conditions. High temperatures in the summer season in the valleys and foothills cause infringement of fastness indicators and deformation of road surfaces. Significant daily temperature amplitudes lead to intensive physical destruction of rock masses leading to the formation of rockslides and rock-falls on the roads (fig 6.14).

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

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

Table 6.1

The length of roads under the impact of unfavorable natural conditions (km)

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

S o u r c e : Tajik Ministry of transport (2001)

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

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

6.10. Public health

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

The vulnerability assessment shows that the condition of public health and life expectancy are determined in many respects by climatic conditions in combination with other factors, especially by temperature, and its impacts (fig. 6.15).

It is established that temperature rise in the mountains amplifies the impact of hypoxia, which makes people living in these regions more vulnerable in comparison with those living in valleys; those most vulnerable are older people.

The longevity index reflects the possibility of reaching longevity and practically does not depend on population structure. Climate warming leads to a decrease in the longevity index. In the conditions of a hot climate (lowlands) the longevity index is lower than in moderate and warm climatic conditions (foothills and low-mountains). As the elevation increases and partial oxygen pressure declines, the longevity index substantively decreases. The longevity index in Mountain Badakhshan Autonomous Region in comparison with average national index is two times lower (fig. 6.16).

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

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

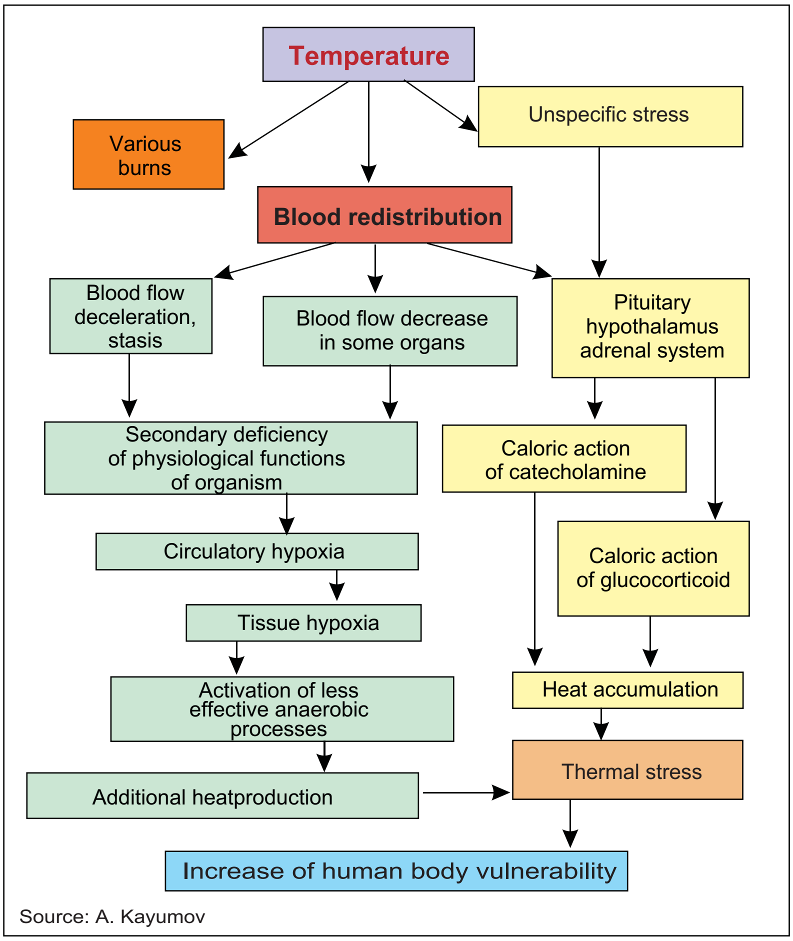

Fig. 6.15.

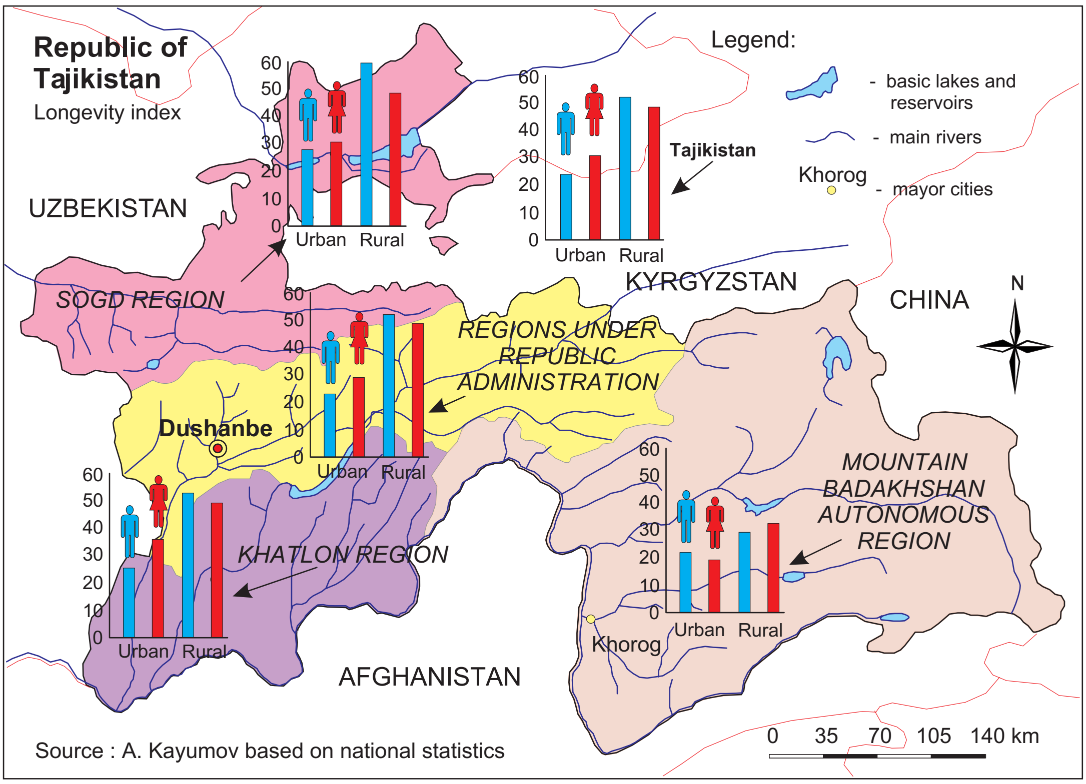

Fig. 6.16.

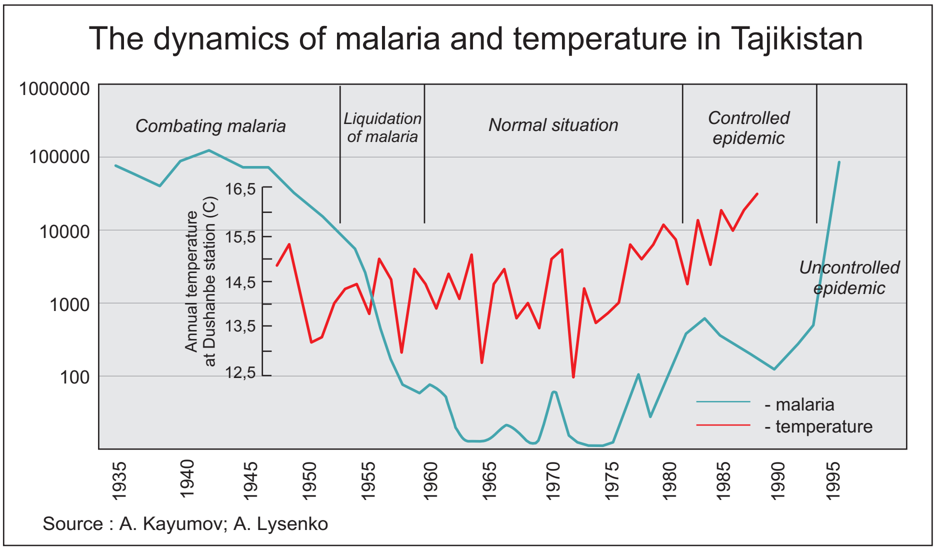

Fig. 6.17.

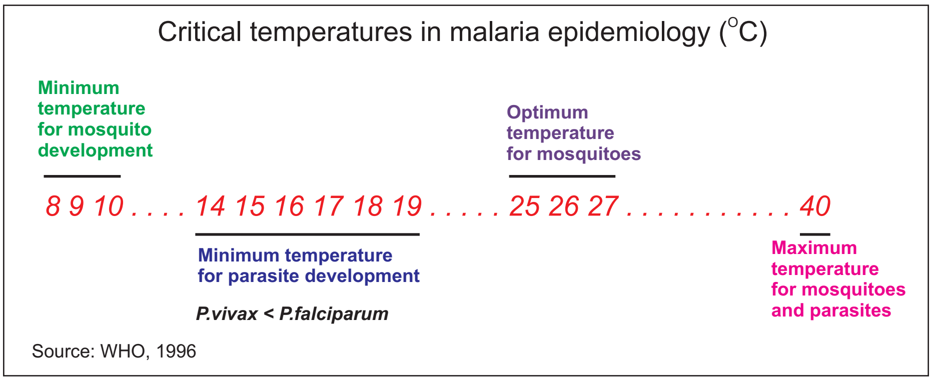

Fig. 6.18.

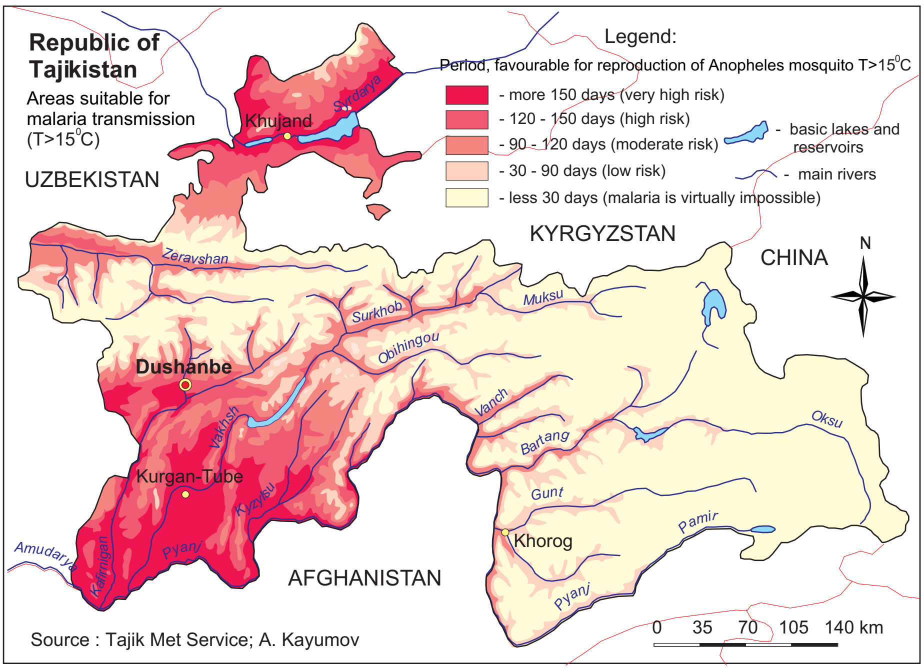

Fig. 6.19.

Research shows that the increase of malaria depends on the temperature of the environment (fig.6.17). The temperature is a limiting factor in malaria epidemiology (fig. 6.18).

Climate warming will cause not only the increase of malaria but will also increase the number of days favorable for reproduction of malaria mosquitoes which in turn increases the possibility of infection turnover by 6-7 times. The zone of potential malaria development in Tajikistan will increase both in the lowlands and highlands up to an elevation of 2,000 masl and more (fig. 6.19).

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

Under the conditions of climate warming the chance of tropical diseases and dangerous infections to spread is very high.

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

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

It is likely that the rise of extreme summer temperatures in hot lowland regions will lead to increased infant and adult mortality.

Research conducted on the base of medical-biological classification of mountain zones has shown that the factors influencing public health are divided into two groups: natural and anthropogenic. Natural factors are temperature, hypoxia and anthropogenic factors are pesticides, mineral fertilizers and industrial emissions prevailing depending on altitude. It is identified, that the climatic factor (temperature) in Tajikistan is a determining factor of public health conditions.

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

6.11. Urban air quality

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

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

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

Anticyclone circulation promotes development of near surface inversion. Under such phenomena the temperature increases with height or remains constant. Inversions are formed predominantly during clear nights by means of cooling near surface air stratum and prevent the vertical movement of pollutants in the atmosphere (fig. 6.20). The rate of increase of gas concentration depends on the height of the lowest inversion level above the source of pollution. This increase of concentration is as high as the source of pollution close to the inversion layer, and as the height of the pollution source is lower. In winter an arctic front favors the stagnation of air movement by means of cooling surface air at heights up to 1.5 km.

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

Dust storms and haze are the major unfavorable meteorological factors. Mean annual duration of haze in Dushanbe reaches 12 days, out of which 7 days with strong haze with visibility of less than 2 km. The record duration of haze was in 2001. Almost every day from June to August, there was a slight haze in Dushanbe. The number of days from June to November 2001 with strong haze was 29 days. When dust content in the air is high, near surface temperature cools by 3-8°C in comparison with clear sky.

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

Increased air pollution is observed in other cities of the republic. Thus, climatic factors impact air quality in urban areas and sometimes it occurs substantially.

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

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

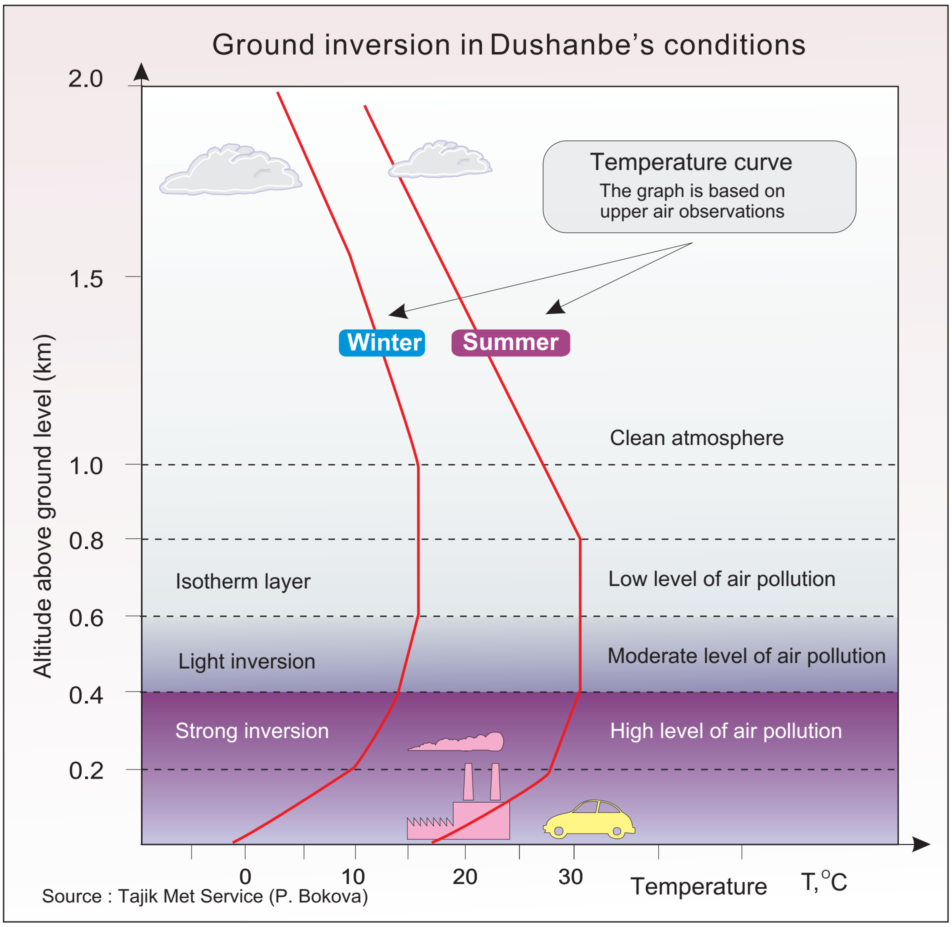

Fig. 6.20.

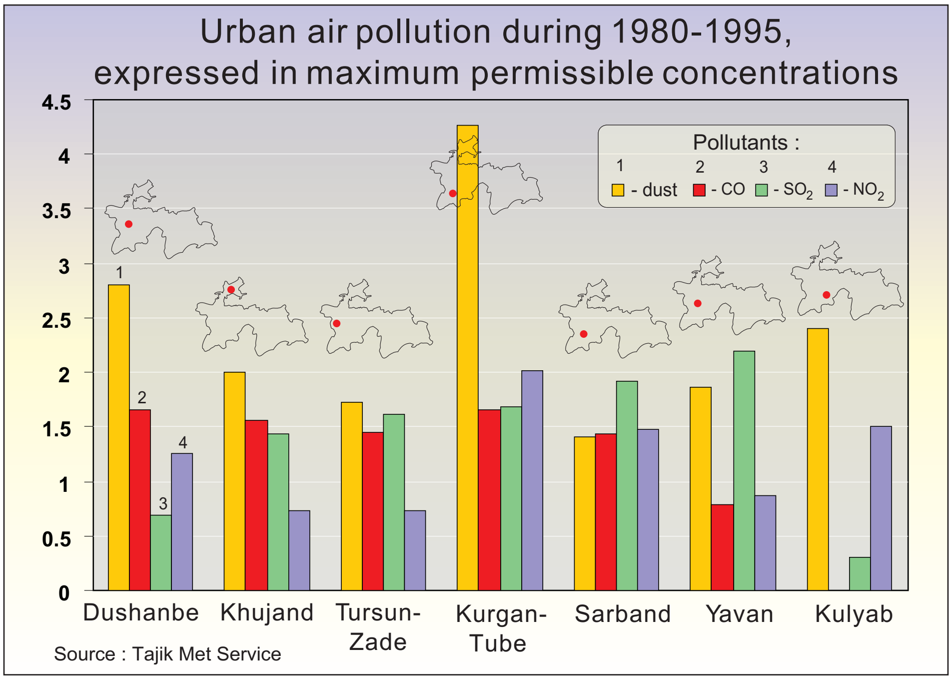

Fig. 6.21.

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

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

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

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

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

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

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

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

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

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

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

The vulnerability assessment shows that Dushanbe and Kurgan-Tube are the most vulnerable to atmospheric air pollution (fig. 6.21). The high level of pollution in these and other cities in many respects is caused by an influence of meteorological factors: rare precipitation in the summer period, calm, large intensity of solar irradiation.

It is likely that human intervention (emissions from vehicles and industries, reduction of green areas) and climate change will increase atmospheric air pollution in most of these cities in the future.

6.12 Winter sports and recreation

Winter sports and recreation, particularly mountain skiing, are widely spread in the areas with long existing snow cover in Tajikistan. The basic mountain-skiing bases are Khoja-Obigarm, Takob, and Rogun and are located at an elevation of 1,500-2,700 masl (photo 5). According to expert judgments, some 8-10 middle and high-mountain plateaus have good prospects for the development of winter sports, including extreme ones (ski-extreme, alpine-ski).

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

5. Safedorak mountain ski plateau
Photo by V. Minaev

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

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

6.13. Climate change adverse consequences

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

An irregularity of Tajikistan's landscape, active tectonic processes, advanced hydrological network, intense precipitation in characteristic areas, and arid climate are

Fig. 6.22.

natural factors causing intensive development of geodynamic processes and the manifestation of disastrous phenomena such as landslides, landslips, snow avalanches, which promote an accumulation of disintegrated rock formations in river channels, and the occurrence of mudflows (fig. 6.22).

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

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

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

High air temperatures lead to rapid snow melting and ice thawing thereby creating conditions for formation of glacial-born mudflows. Sometimes mudflows happen as a result of a glacial lake outburst formed by a surging glacier. At the moment, there are 4 potentially dangerous situations in the Surkhob River basin and 6 in the Varzob River basin.

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

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

7 Policy and Measures

7.1. Priorities of nature protection policy

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

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

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

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

7.2. Legislative measures

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

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

According to Article 15 of the present law, the state nature protection authorities of the Republic of Tajikistan together with state statistical reporting authorities conduct quantitative and qualitative control of natural resources and assess the state of the environment.

According to Article 18 of the present law, a specially authorized entity on nature protection defines the limits of use for natural resources, emissions and discharges of polluting substances into environment, and waste disposal.

Article 25 of the present law regulates the norms of maximum permissible emissions and discharges of polluting substances into the environment.

Article 30 of the present law establishes the standards and ecological requirements that provide specifications of allowable anthropogenic influences on the environment with regard to existing and new technologies.

The state ecological examination, according to Article 33 of the present law is an obligatory measure for protection of the environment. This procedure is being carried out to validate and conform the planned economic activity in accordance with nature protection legislation and the requirements of the environmental quality norms.

Article 46 of the present law regulates the ecological requirements to energy industries, including prevention of harmful emissions and discharges into the environment.

According to Article 52 of the present law, in order to protect the environment from waste pollution, all juridical and physical persons are required to adopt effective measures for observance of norms in generating and disposing industrial and domestic wastes.

Article 53 of the present law adjusts climate protection. According to the requirements of this article, the realization of systematic observations on climate change, establishment and observance of specifications for maximum permissible emissions of harmful substances that affect the climate, and development of long-term ecological programs that provide emission reductions are necessary.

Article 88 of the present law promotes international cooperation in environmental protection.

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

The law of the Republic of Tajikistan "On atmospheric air protection " (1996)

The law of the Republic of Tajikistan "On energy industry" (2000)

The law of the Republic of Tajikistan "On transport" (2000)

Other legislative mechanisms that deal with inventory and control of harmful substance emissions into the atmosphere are the Administrative Code (2000) and Criminal Code (1998) that provide material and criminal liability for infringement of the nature protection legislation.

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

Nevertheless, in the legislation on agriculture, forestry and other economies that have a potential influence on the climate, the mechanisms of reduction and inventory of anthropogenic greenhouse gas emissions and removals have not been enforced. In this connection, it is required that legislation in relevant areas adapt to the requirements of the UN Framework Convention and other international environmental treaties and documents accepted by the republic to their adaptation according to the requirements of the UN Framework Convention and other international environmental treaties and documents accepted by the republic.

7.3. Strategies and programs

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

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

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

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

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

7.4. Institutional structure

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

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

Implementation of complex management of nature protection activities in the republic;

Development and realization of common scientific and technical policies on nature protection activities to be implemented by national ministries and departments;

Control over the use and protection of lands, surface and ground waters, atmospheric air, flora and fauna, and common minerals;

Development of long-term state programs on nature protection and rational use of natural resources.

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

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

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

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

The Main Administration on Hydrometeorology and Environmental Pollution Monitoring under the Ministry for Nature Protection of Tajikistan is a coordinating state entity for implementation the UN Framework Convention on Climate Change.

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

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

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

Research on, and projection of climate change;

Compilation of national inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases;

Gathering information about vulnerability assessment to climate change, revealing the indicators and consequences of climatic changes;

Development and rating of the implementation of measures indicated in the National Action Plan for climate change mitigation, including strategy on GHG emissions reduction and adaptation to climate change;

Preparation and distribution of information about the implementation of the UN Framework Convention in Tajikistan;

International cooperation with UNFCCC Secretariat, Intergovernmental Panel on Climate Change and other appropriate organizations.

The Hail Protection Service carries out a set of measures to reduce the damage to agriculture and industry caused by hailstones.

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

7.5. Rationing and control of emissions

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

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

The basic enterprises of non-ferrous metallurgy of the republic are: Isfara hydro metallurgic plant, Anzob ore-mining plant, Adrasman ore-mining plant, "Vostokredmet", Joint company "Zeravshan", Joint company "Darvaz", and a giant of Tajik industry - the Tajik aluminum plant. The main sources of atmospheric air pollution are the production, transportation and storage of raw materials, and the technological processes involved. The enterprises of non-ferrous metallurgy have the greatest influence on the quality of atmospheric air and the climatic system.

The industry of constructional materials includes Dushanbe cement plant, enterprises of concrete constructions, limestone processing and others. These enterprises are located throughout the territory of the republic. Construction industry gives rise to the emissions of particles, greenhouse gases and aerosols.

The chemical industry of the republic includes the joint-stock company "Azot" (Vakhsh nitrogen fertilizer plant) that produces ammonia and carbamide, Isfara oil refining enterprise, Joint company "Tajikhimprom" (Yavan chemical plant) that produce chlorine-containing materials, and other enterprises. The emissions into the atmosphere come from acid, plastic, mineral fertilizer, petroleum and other products manufacture.

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

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

Motor vehicles are the main source of atmospheric air pollution, in particular carbon dioxide and nitrous oxides. Most vehicles that operate in the republic are being exploited over a long period of time that potentially increases the volume of harmful emissions. A small contribution into atmospheric air pollution in Tajikistan comes from railway transport and aviation.

The rationing of harmful substance emissions in road transport in the private sector is being carried out by the owners of vehicles taking into consideration specified norms of emissions. On an institutional level emission rationing is being implemented by administrations of enterprises and nature protection entities. The road police inspection, together with environmental protection institutions carry out selective control over the contents of harmful substances in exhaust gases and give instructions for their adjustment (photo 6). The rationing of GHG emissions in the transport sector is not being carried out.

The inventory of harmful substance emissions from mobile sources is conducted on the basis of fuel use. However, a regular inventory of GHG emissions from mobile sources has not been compiled.

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

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

6. Testing of harmful substance concentrations in exhaust gases from motor vehicles
Photo by N. Safarov

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

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

7.6. Environmental impact assessment and ecological examination

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

The Environmental Impact Assessment is intended to define and predict the results of human intervention into the environment and the consequences of that influence on public health. The EIA is being carried out with consideration of local environmental conditions and all potential factors of anthropogenic influence on the natural complex, and also expected ecological and socio-economic consequences.

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

The EIA project documentation includes:
1) The purpose and rationale of planned activity;
2) Ways of realization and general description of planned activity;
3) Existing alternatives, including their absence;
4) The detailed report on the state of the environment;
5) The detailed report on socio-economic development;
6) Types and levels of impact on the environment in conditions of normal operation and in cases of extreme situations;
7) Possible changes in the environment and socio-economic consequences caused by these changes;
8) Measures on the reduction and prevention of negative impact on the environment and the reduction of ecological risk;
9) The information on identified gaps and uncertainties, revealed during EIA project Implementation.

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

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

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

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

The ecological examination also considers the description of offered actions to prevent, eliminate, minimize and compensate a negative impact on the environment, including:

The territorial nature protection plans;

The technical decisions on elimination of atmospheric air pollution, secondary use of energy and other resources;

Compensatory measures.

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

Now in the republic a number of industrial enterprises have passed the EIA procedure and the ecological examination. However, measures on environmental protection and directives of state nature protection institutions have not yet been fully implemented.

8 Greenhouse Gas Abatement Strategy

8.1. Strategy's objectives

In order to implement the national commitments to the UN Framework Convention (articles 4 and 12 of the Convention), the Tajik Government provides development, acceptance and realization of measures aimed at addressing the problem of anthropogenic emissions by sources and removals by sinks of greenhouse gases.

Such measures are developed in accordance with long-term national priorities of the Republic of Tajikistan, which include improvement of population well being on the basis of sustainable development, infrastructure enhancing and ecological security. The realization of these measures is a complex task on a nationwide scale and requires the coordinated actions of governmental ministries, departments, non-governmental organizations and the general public.

The strategic objective is to develop a set of effective measures to reduce GHG emissions, enhance the state of carbon natural sinks in the relevant sectors of the national economy, improve energy efficiency, develop renewable energies and reduce fossil fuel consumption.

Based on the appropriate decisions of the Conference of the Parties to the UN Framework Convention, the Government determines the following basic tasks as part of this strategy:

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

Application of effective technologies and use of energy sources in the national economy that promote high rates of economical growth and reduce or limit greenhouse gas emissions;

Protection and enhancement of natural sinks and reservoirs of greenhouse gases;

Promotion of sustainable forest management practices, forestation and reforestation;

Promotion of sustainable forms of agriculture in light of climate change considerations;

Research on, promotion, development and increased use of, new and renewable energies, advanced, innovative, and environmentally sound technologies;

Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures, which limit or reduce the emissions of greenhouse gases.

8.2. Strategy's priorities and frameworks

The selection of measures on limitation and reduction of GHG emissions in relevant sectors is based on expert assessments, specific needs of national ministries, and international avant-garde scientific achievements.

The national and sectoral programs, plans and strategies on environmental protection and socio-economic development of the republic were analyzed to ensure adequate coverage of all influencing factors.

A set of measures of this strategy and its priorities were discussed on a series of meetings for experts involved in relevant fields, round tables and national workshops.

State policy and concrete measures aimed at limitation or reduction of GHG emissions that provide cost efficiency and maximum effect are based on:

Application of economic regulation tools;

Institutional strengthening of structures responsible for realization of nature protection measures;

Implementation of technical measures aimed at direct GHG emissions reduction, improvement of energy efficiency, etc.

The developed measures are focussed on republican, regional, local, and also on sectoral, institutional, public and individual levels.

8.3. Measures on energy efficiency, energy conservation and reduction of GHG emissions in the Energy sector

The analysis of GHG inventory in the Energy sector shows that greenhouse gas emissions in Tajikistan occur mainly as a result of fossil fuel consumption, i.e. fuel use and combustion in transport, residential, industrial and other sectors.

Hence, it is necessary to consider the measures on GHG emission reduction in the Energy sector, first of all in the sphere of fuel consumption. The basic measures in this direction are:

State regulation of rational fuel and energy use in all spheres and on all levels of production and consumption;

Formation of new and improvement of existing legislative bases, and also appropriate structures of management, training and control, which will allow further maximum involvement of tools for GHG emission reduction to minimal possible level. Thus, it is important to maintain the instrumental control over greenhouse gas emissions and electricity consumption in various sectors of the national economy and residential services;

Development and realization of the programs on energy supply improvement at industrial and agricultural enterprises with application of new energy saving technologies, and use of secondary energy and thermal resources for own consumption.

Basing on these principles, in this strategy the following priorities on energy efficiency and GHG emission reduction are determined:

Production, processing, storage and transportation of fuel:

Improvement of ventilating systems in underground mines and utilization of methane;

Modernization of the petroleum storage facilities;

Modernization of the flare facilities;

Outflow reduction in main gas pipelines;

Utilization of excess pressure in main gas pipelines;

Replacement of out-of-date gas distributing equipment;

Accident risk decrease at gas pipelines;

Natural gas clearing efficiency increase with regard to sulphur content and gas dehydrating.

Energy:

- Reconstruction and improvement of electrical networks, substations, transformers and cable production, that can potentially reduce electricity loss of by 30-40%;
- Improvement of thermal systems and insulation of buildings, that can save about 25-30% of energy;
- Introduction of independent heating systems and closed circuit hot water supply;
- Rehabilitation of equipment at large and small hydropower plants;
- Construction of mini and microhydropower plants, especially in remote high-mountain regions with lack and/or deficiency of electricity that will considerably reduce the use of coal and wood fuel for meeting energy demands and will improve social development level .

According to expert estimates, the construction of large hydropower plants such as Rogun hydropower plant, Sangtuda hydropower plant, hydropower installations on the Zeravshan and Kafirnigan rivers with the development of appropriate infrastructure have the greatest potential for CO_2 emission reduction in the Energy sector, which could total 6-9 million tonnes of CO_2 a year in the mid-term prospect. At the same time GHG emission reduction costs are minimal. The increase in the number of large hydropower plants is a priority for the energy sector development in Tajikistan.

However, negative influence from construction and operation of large reservoirs on ecological conditions of surrounding regions (ground water level raising, biodiversity loss, increase of seismic risk) is a cause of concern voiced by scientists and the general public.

Therefore, alongside the construction of large hydropower plants, other activities should be implemented that also have significant effects on both GHG emissions reduction and energy efficiency.

Transport:

- Construction of new and unification of existing roads and communications, in particular tunnels under mountain passes, that can reduce the extent of motorways, improve their quality and reduce fuel consumption by 25-30%;
- Introduction of technologies for improvement of fuel quality aimed at reducing harmful substance emissions;
- Encouragement of use of motor vehicles with more economic gasoline internal combustion and diesel engines;
- Switching of public transport to alternative fuels, in particular liquefied gas;
- Electrification of railway and development of urban electrical transport;
- Development of alternative transport;
- Optimization of cargo and passenger traffic circuits;
- CO_2 emission reduction amongst light vehicles, which are most popular in the republic, to a level of 120-150 gram CO_2/km;
- The control of volume and concentration of exhaust emissions;
- Expansion of the application of exhaust emission rationing tools and mechanisms.

Residential services and commercial sector:

- New approach in planning, design and construction of residential and commercial buildings, with application of high-tech materials for walls, roofs, windows, etc;
- Transition to modern lighting equipment, in particular luminescent lamps, halogen infrared lamps, automatic systems of street illumination, etc;

Improvement of heating systems efficiency, enhancing conditioning and maintenance to microclimate of residential buildings;

Installation of gas consumption control systems and development of advanced consumption norms;

8.4. Promotion of the development of renewable energies

The unique nature-climatic conditions of Tajikistan favor a high potential and diversity for the possible use of renewable energies: solar, wind, biogas, and hydropower.

Most of the population resides in rural areas, and the adequate provision of environmentally friendly energy is a basis for sustainable development of rural and mountain regions, which also ensures a rational use of natural resources. The complex use of non-traditional renewable energies would help to solve many problems of nature protection, including GHG emission abatement and prevention of forest cuttings.

Solar energy. Due to its geographical conditions, Tajikistan is one of the most appropriate regions for applying solar power. There are 280-330 sunny days a year; intensity of solar radiation reaches 1 kW/sq.m and more.

Solar irradiation on a horizontal surface, when the sky is clear, in midday reaches 0.33-0.81 kW/sq.m in the valleys, and 0.46-1.02 kW/sq.m in the mountains. Clouds reduce solar radiation. On average, clouds lower radiation by 32-35% in lowlands and 50% in highlands.

Total solar irradiation is calculated on the basis of incoming and dispersed radiation on a horizontal surface. Total solar irradiation reaches its maximum in May-July. The intensity of total solar irradiation varies from 280 to 925 MJ/sq.m in piedmont regions, and from 360 to 1120 MJ/sq.m in highlands.

Conversion of solar irradiation into electricity is based on the use of photovoltaics. Conversion efficiencies of silicon cells continue to improve with 24.4% efficiency obtained in the laboratory for monocrystalline cells and 19.8% for multicrystalline, though commercial models are only obtaining 13-17% efficiency. Modules currently retail for around US$ 4,000-5,000/kW. Present generating costs are relatively high (US$ 0.2-0.4).

At present, the national Academy of Sciences researches the potential of solar energy use and develops prototypes. According to expert estimates, a typical solar station produced in Tajikistan can potentially avoid 0.30-0.35 tonnes of CO_2 a year.

However, at the moment the high potential of solar energy in Tajikistan remains unutilized. According to estimates of the Physical-Technical Institute, Tajik Academy of Sciences, utilization of solar energy available in Tajikistan could satisfy national energy demands by 10-20%.

Wind energy. Theoretical wind power potential in Tajikistan, according to different estimates, amounts at some 30-100 billion kWh/year, and is comparable with hydropower potential.

Mean annual wind speed in Tajikistan varies from 0.8 to 6.0 m/sec at 10 meters above ground. Wind direction and speed greatly depends on atmospheric circulation and landscape. The strongest winds blow in highland areas (Fedchenko Glacier, Anzob mountain pass, etc.) and in the areas where landscape favor to convergence of air flows (Khujand, Fayzabad). Mean annual wind speed in these areas reaches 5-6 m/sec. In the open lowlands and wide valleys - little bit less (3-4 m/sec). In closed lowlands mean annual wind speed does not exceed 1-2 m/sec.

During the year, the highest wind speeds are observed in spring and winter, under cyclones. The lowest wind speed occurs in summer and autumn. Meteorological observations show that the wind speed 1-5 m/sec has the highest recurrence (70-90%) in most regions. Wind velocities higher than 10 m/sec are rare, and their occurrence does not exceed 10%. In the valleys and intermountain depressions, there are 5-15 windy days per year (Istravshan, Dushanbe, Iskanderkul). In other regions, the number of windy days reaches 40-60 (Khujand, Shakhristan and Anzob passes, glacier Fedchenko etc.).

The use of wind power is promising in some regions of the republic where the wind speed is relatively high (more than 5-6 m/sec at 10 m above ground: Khujand, Kayrakkum, Faizabad, the passes of Khaburabad, Shakhristan, Anzob, and other places). The power of wind can be applied for electricity generation, elevation of water for irrigation, grain grinding etc. Typically wind turbines have a capacity of 250-270 kW. The generating costs depend on mean annual wind speed, and varies within $0.03 (10 m/sec) - $0.12 (5 m/sec).

Although hydropower energy prevails, application of wind power as an autonomous supplementary small-capacity source of energy is justifiable in certain regions.

It should be noted that wind energy production on an industrial scale requires the exploitation of large territories. It is therefore important to conduct research of all related aspects.

Biogas. Agriculture and forestry wastes can become additional power sources by means of generating biogas, whereas raw material would be an effective fertilizer for agriculture. In conditions of large cattle-breeding complexes and poultry factories, totaling 20 in Tajikistan with the number of animals ranging from 400 to 800, it is possible to produce electrical and thermal energy and reduce methane emissions.

Biomass decay leads to the formation of by-products such as methane, liquid methanol, and wood charcoal. The most promising option of biomass utilization in Tajikistan's condition is biogas generation by means of anaerobic fermentation of manure. Such biogas contains both CH_4 and CO_2. Final energy can reach 60-90% of initial energy. The output of gas makes 0.2-0.4 cub.m on 1 kg of dry manure under normal conditions. A biogas generator with a capacity of 1-3 cub.m and daily consumption of about 8 kg of manure produces up to 2 cub.m of biogas. The costs of biomass generator range from US $300 to $600.

In addition, there is the potential opportunity to produce energy by thermo-chemical method of biomass conversion using cotton residues, which is the basic crop in Tajikistan.

Hydropower resources. Potential hydropower resources of Tajikistan are estimated at 527 billion kWh a year. At present, only 5% of this potential is being used. More than 95% of all generated electricity (about 15-18 billion kWh/ year) is being produced by hydropower plants (HPP). Most of the hydropower resources are concentrated on big rivers such as Vakhsh, Pyanj, Obihingou and others, flowing in deep rocky canyons.

For Tajikistan, in the context of climate change mitigation, the greatest interest is represented by small hydropower engineering, opportunities for developing such are available in most of the mountain regions.

According to estimates, the utilization of 10% of hydropower potential of small rivers in mid- and high-mountain regions could provide electricity to 70% of settlements and rural infrastructure that suffer from an energy resource deficit. A feasibility assessment has confirmed the efficiency of micro and small hydropower stations in remote regions.

During wintertime, hydropower plants cannot generate enough power due to water conservation, and harsh climate i.e. ice events etc. In this time the national power supply network is overloaded. Nurek HPP is the biggest in Tajikistan, with an operating capacity of 3,000 MW. During the summer, HPPs produce an abundance of electricity with enough excess water to be used for irrigation. It should be noted that big HPPs and thermal power plants supply electricity to the cities and industrial enterprises. Small settlements in remote regions face lack of electric power.

In rural areas of Tajikistan, annual consumption of electricity comprises 200 kWh, whereas in neighboring countries this indicator rises to 300 kWh. Some 80% of electricity consumption in highland areas is used for lighting. In some places population does not have access to electricity at all: Komarow, part of Romit canyon, highland Matcha, and others. Major energy sources for these regions are wood, coal, and oil products.

At present, development of small hydropower engineering is an important factor for improvement of socio-economic conditions in mountain regions and the prevention of forest cuttings. In the republic, there are some 20 small hydropower stations in operation.

The regions with the greatest prospects for installation of a micro and mini HPP in the Pamirs are middle and high mountain areas, i.e. Kalai-Khum, Vanch, Rushan. Some 20 micro and mini HPPs with total a capacity of 18 thousand kW can be installed here.

Additionally there is an opportunity to install some 100 small HPPs in Karategin region.

The abundant hydropower resources of the Zeravshan river basin are as yet unused, mainly because little investigation to discover the potential for hydropower development of this region has taken place.

Small hydropower stations have several advantages over large ones, these are: smaller capital investment during design, construction and operation, few ecological risks, affinity to the consumers. These are important conditions for a country like Tajikistan.

The costs of small HPPs vary from US $800 to $1500/kW. It is interesting to note that the cost of Nurek HPP was US $300/kW. Present generating costs for hydropower are low (US $ 0.04). The pay back period for a micro HPP is 3-5 years.

On the basis of the above-mentioned analysis, the following measures on development for renewable energies in the national economy and livelihoods of Tajikistan can be identified:

- Development of state policy in the sphere of development of renewable energies and promotion of electricity supply in remote mountain regions;
- Monitoring, zonation and assessment of renewable energies potential;
- Development of a database and access to international databases on renewable energy equipment; selection and application of effective devises for Tajikistan's conditions (mini- and micro hydropower plants, photo-voltaic converters, solar water heating equipment, wind energy turbines, biogas devices);
- Creation of a new and strengthening of existing industrial and research capacities for development, manufacturing and research on efficiency of renewable energy equipment;
- Improvement of legislative mechanisms that promote the development of renewable energies, including energy saving, privileges to the producers and consumers of renewable energy etc.
- Training and preparation of experts in the field of renewable energy, exchange of experience with developed countries' specialists;
- Raising public awareness on the application of renewable energies and demonstration their advantages in comparison with traditional fuels.

8.5. Measures on energy efficiency and GHG emissions reduction in Industrial sector

The limitation and reduction of GHG emissions that occur as a result of industrial processes are possible by updating of existing out-of-date technologies and introducing new modern energy efficient technologies with low parameters of GHG emissions and other harmful gases.

The main greenhouse gases in industry are CO_2 and perfluorocarbons. Additionally there are emissions of such gases as CO, NOx, SO_2 etc. The industry is responsible for 20-30% of all national harmful emissions.

At the Tajik Aluminum Plant all technological installations that emit harmful gases into the atmosphere are supplied with purification systems. Fluoride-containing gases are transported to the fluoride handling room and return for electrolysis after regeneration. The efficiency of existing methods of harmful emission purification makes around 80-90%.

Nevertheless, concerning the climate change problem the Tajik Aluminum Plant represents itself as the main stationary source of pollution. Aluminum smelting leads to the emissions of perfluorocarbons (CF_4 and C_2F_6) in the amount of 1.2-1.4 kg per 1 tonne ofraw aluminum.

The emissions of perfluorocarbons greatly contribute to the effect of global warming. The gas CF_4 affects global warming by 6,500 times more than the main anthropogenic greenhouse gas CO_2. Aluminum smelting surpasses in emissions of CO_2-equivalent such sectors as transport, chemical industry etc. Therefore, the reduction of emissions from aluminum smelting is of high priority for climate change mitigation. The reconstruction of gas purification facilities at electrolysis rooms and computerization of technology are necessary.

At the "Tajik Cement" enterprise the reconstruction of the basic manufacturing process is necessary to incorporate the "dry method" with replacement dust cleaning filters and gas purification facilities. Considering the present status of cement manufacturing, and also taking into account the high recreational potential of the Varzob area, which borders the plant, it is feasible not to restore the plant with former technology, but modernize this industry with new technology. This will considerably reduce energy consumption, water use and emissions of particles. Besides, to decrease ecological pressures it would be advisable to lower the capacity of the plant to 400-600 thousands tonnes of cement a year, and construct a new cement plant of the same capacity in the south of republic, taking into consideration the wind factor.

At the enterprise "Azot" (Vakhsh nitrogen fertilizer plant) it is necessary to complete construction of a biological sewage disposal plant that will reduce GHG emissions from industrial wastewater and solve the problem of communal wastewaters of Kurgan-Tube and Sarband towns. In the long-term, the replacement of copper-ammoniac clearing of converted gas by a more efficient system is necessary, that will reduce CO and CO_2 emissions, prevent copper discharge into surface waters, and save energy.

<u>The measures of energy efficiency in industry include:</u>

Use of highly effective electric motors, mechanisms and electric drives in all industries;

Improvement of drying systems in textile industry;

Improvement of furnaces in metal smelting, with introduction of "know-how" technologies;

Utilization of heat from clinker production in cement industry.

The basic measures on limitation and reduction of CO_2 emissions in industry are:

Modernization of technological machines and equipment in construction sector;

Transition from "wet" method of cement production to "dry" method, where the economy of energy resources up to 30% and essential CO_2 emission reduction is possible;

Reconstruction of gas purification facilities and dust filters at cement plant;

Modernization of gas purification facilities and application of electrolysis protective housings at aluminum plant;

Utilization (compression) of CO_2 which occur in the process of ammonia production for further use in food and drink industry, etc.

The basic measures on reduction of PFC emissions in aluminum industry are:

Computerization of electrolysis process of prebaked anodes;

Research on new technologies of aluminum production on non-carbon anodes that can completely avoid PFC emissions. Such technology at an existing level of scientific research is likely possible for use by 2015-2020.

8.6. Energy efficiency and GHG emission reduction in Agriculture

The CH_4 emissions in agriculture of Tajikistan occur as a result of intestinal fermentation of agricultural animals, anaerobic decomposition of manure, rice cultivation on irrigated fields, and burning agricultural residues.

Advanced scientific knowledge in the field of genetics and experience in agricultural animals selection in Tajikistan is the basis for creation of new breeds, especially cattle, with smaller intensity of intestinal fermentation and methane emission.

Analyzing the technologies of manure storage and use, it is possible to note that there is an opportunity to potentially reduce methane emissions in this sector by 10-20% by applying advanced technologies, including biogas generation.

The last years have been characterized with the substantial growth of rice production and expansion of irrigated rice fields, which are the sources of methane emission.

At the basic rice sowing in the republic, it is usual to crop late growing sorts of rice, and repeated sowing intermediate growing and early growing sorts. From the point of view of methane emission reduction, it is favorable to cultivate the early growing sorts of rice in the basic rice sowing period, but the practice shows, that they are less productive than late growing sorts. Therefore, in Tajikistan late growing sorts of rice are wide spread; its vegetation period takes 130-145 days.

For methane emission reduction in this category, it is necessary to move from a traditional method of rice cultivation to a more progressive transplanting method. The soil-climatic conditions of Tajikistan allow growing rice by this method. This method enables cultivation of two crops a year and reduction of vegetation period, that has huge value in terms of food provision in the conditions of land scarcity and methane emission reduction by 20-30%.

The N_2O emissions occur from agricultural soils as a result of application of organic and mineral fertilizers. Gaseous losses of nitrogen that is contained in fertilizers are formed by nitrification and subsequent denitrification, and are the basic reasons of nitric fertilizers efficiency reduction and N_2O emission.

For reduction of nitrogen losses and increased efficiency of mineral fertilizers application it is necessary to apply them in optimum terms and norms, in accordance with other fertilizers and in combination with a rational system of land cultivation, crop turnover and correct mode of irrigation.

The application of nitrification inhibitors is one of the basic ways for reduction of N_2O emission from agricultural soils, especially cotton crops. Other ways for N_2O emission reduction include the applying of fertilizers by band method, localization of fertilizers in soil and the application of capsule fertilizers.

The basic measures on energy efficiency in agriculture are:

- Application of economic stimulus on energy saving and use of renewable energies;
- Increased efficiency of irrigation systems, reduction of energy consumption by water pumps and agricultural equipment;

The basic measures on GHG emission reduction in agriculture are:

- Improvement of practices in the cattle breeding industry, rational feeding and regulation of the number of animals;
- Use of agricultural biomass for energy generation and the recuperation of methane from manure;
- Enhancing of rice cultivation technology;
- Optimization of agricultural crops location along with improvement of methods and norms of mineral and organic fertilizers application;
- Training of farmers on usage of new methods and technologies.

Implementation of indicated measures will promote GHG emissions reduction, the increase of agricultural productivity with reduction of water consumption, the increase of soil fertility on the basis of introduction of advanced technologies in all sectors of plant growing and cattle breeding. Realization of measures on GHG emissions reduction in agriculture will promote significant savings and reduction of anthropogenic pressures on the environment.

8.7. Enhancing natural sinks of carbon including forests and soils

Agricultural soils, where intensive agriculture is practised, and also forests and other woody biomass are sinks and absorbers of carbon. Degradation and dehumification of soils and forest cutting lead to carbon losses. The dynamics of these processes depends on human activity, management issues, manifestation of erosion processes, extent of soil ploughing, observance of cultivation technology, state of forests and annual volumes of afforestation.

Since the 1990s as a result of forest cuttings and reduction of forestation volumes the absorption of carbon by forests has reduced by 30%. This tendency continues today.

Government measures on the increase of CO_2 absorption in LUCF sector include and can be further aimed at:

Combatting erosion processes, including salinization and swamping;
Supplying of rural population with renewable energies and replacing consumption of wood fuels;
Prevention of illegal forest cuttings;
Reforestation and afforestation;
Planting of protective forests along the motorways and agricultural fields;

Panting of trees in urban areas;
Protection of forests from pests, diseases and fires;
Conversion of low-density tree plantations to normal compactness with the purpose of increasing forest productivity.

The specified measures should be implemented in the context of acting and/or planned national strategies and action plans on rational use of natural resources. In addition to socio-economic and ecological benefits, these measures will promote the effective absorption and accumulation of CO_2.

8.8. GHG emission reduction in the process of waste disposal

Solid waste disposal sites in the cities and sewage disposal plants that treat communal and industrial wastewaters are the sources of methane emissions into the atmosphere. Greenhouse gas emissions, including CH_4, CO_2, non-methane volatile organic compounds, occur as a result of anaerobic decomposition of the organic fraction of wastes and have a negative impact upon the climatic system and local sanitary-ecological conditions.

In Tajikistan the contribution of this emission source makes less than 10% of the total CH_4 emissions, whereas trends of growth are insignificant. Therefore, an acceptance of only technical measures on reduction of CH_4 emissions is not economically feasible because of high costs.

For improvement of ecological and sanitary conditions of the cities, and methane emissions reduction from solid communal wastes, it is necessary to develop capacities on waste recycling in Dushanbe and Khujand cities. The volume of solid communal waste formation in these urban areas makes around 40% of national household wastes, and implementation of specified measures can reduce CH_4 emissions by 30-40% by 2015. One of the feasible measures in ecological regard is the recycling of active silt at sewage disposal plants.

The incineration of solid wastes, including energy co-generation, most of experts recognize as an unfeasible option. On the one hand it does not meet the requirements of national nature protection legislation; on the other hand, it can considerably aggravate the ecological situation in the cities if separation of wastes is not undertaken. Besides, this measure is technologically ineffective; the efficiency of the system reaches only 10-20%.

The basic measures on reduction of methane emissions in the waste sector are:

- Recycling of solid communal wastes in the cities, recirculating of metals, plastics, glasses and paper, which also considerably reduces primary energy consumption;
- Composting of wastes with high contents of organic matter, mainly in small dumps;
- Electricity and thermal energy production on the basis of biogas from active silt at sewage disposal plants;

8.9. Perspectives of adopting Kyoto Protocol to the UNFCCC

At the third session of the Conference of the Parties to the UN Framework Convention, which took place in 1997 in Kyoto (Japan) Kyoto Protocol was accepted. This document obligates developed countries, which are the Parties to the Protocol to reduce by 2008-2012 cumulative greenhouse gas emissions by 5% in comparison with 1990 levels.

For the Parties included into Annex "B" of the Kyoto Protocol, which are developed and transition countries, there are quantitative obligations on the limitation or reduction of GHG emissions. These obligations can be achieved both inside group of developed countries, and with quotations of emissions in developing countries. For developing countries, including Tajikistan, the quantitative obligations on GHG emission reduction are not stipulated. As of June 2002, the Kyoto Protocol was signed by 74 states of the world.

In the Kyoto Protocol, three major mechanisms on implementation of obligations under the UN Framework Convention are specified: (1) joint implementation, (2) emission trading and (3) clean development mechanism.

According to Clean Development Mechanism of the Kyoto Protocol (CDM), Parties not included in Annex I, will benefit from project activities resulting in certificated emission reductions. Developed countries for achieving compliance with their quantified emission limitation and reduction commitments assist Parties not included in Annex I in GHG emission reduction and/or enhancing natural sinks. Activities related to CDM can be implemented on the condition that participants of the project are the Parties to the Kyoto Protocol.

For Tajikistan, Clean Development Mechanism is one of the main sources of financial-technological assistance for implementation of measures on GHG emission reduction and enhancing natural sinks of carbon that were indicated in the National Action Plan. In light of this, the acceptance of the Kyoto Protocol to the UNFCCC is the key factor and necessary condition for successful fulfillment of national commitments under the UNFCCC and participation in Clean Development Mechanism.

<u>For implementation of NAP measures, including investment projects and CDM projects it is necessary to:</u>

- Accept the Kyoto Protocol to the UN Framework Convention on Climate Change;
- Develop appropriate legislation and rules that promote transfer of reduced volumes of emissions, as requested by relevant decisions of the Conference of the Parties to the UNFCCC;
- Build institutional capacity for registration and implementation of CDM projects;
- Strengthen cooperation with the CDM executive board and operational entities that certificate emission reduction;
- Promote sharing of information at private and/or state subjects on issues related to the attraction of investments into CDM projects.

8.10. Cost of measures and potential financial sources

Total cost of strategy implementation is estimated about $US 500 millions, not including large projects. The potential sources of funding could be GEF operational programs, CDM, budgetary funding within the approved limits, and non-budgetary sources.

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9 Strategy of Adaptation to Climate Change, Prevention and Minimization of Its Adverse Effects

9.1. Strategy's objectives

Scientific data confirms, that at present, the simple development and implementation of measures on greenhouse gas emission reduction is not sufficient for the prevention of dangerous anthropogenic impact on the climate system.

According to the decisions of CoP UNFCCC and recommendations of the Intergovernmental Panel on Climate Change, adaptation is considered as an important instrument in solving the problem of climatic change in addition to the reduction of greenhouse gas emissions into the atmosphere.

According to the definition of the Intergovernmental Panel on Climate Change adaptation to climate change refers to adjustment of natural and human systems to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities.

National programs and action plans of Tajikistan on environmental hygiene, desertification, ozone layer depletion, flood management and ecological education confirm the high priority of preventative actions and the reduction of natural disasters' negative consequences caused by climate change.

The results of the vulnerability assessment of natural resources, national economy and public health to climate change, confirm that the influence of climatic factors in Tajikistan sometimes is very high, and appropriate adaptation measures could decrease or prevent negative effects of climate change and ensure general preparedness to this phenomenon.

The present stage of the adaptation strategy mainly includes the identification of primary possible adaptation measures that have to be implemented in order to mitigate climate change effects and support sustainable development of the republic. The next stages of strategy development will include expansion, probation and detailing of adaptation measures.

The strategic objective is to develop a set of effective measures for reducing the vulnerability of natural resources, national economy and public health in the conditions of climate change that promote sustainable development of the country.

<u>The main tasks in the implementation of the strategy are:</u>

Implementation of the scientific research programs on climate change, its impacts on natural resources, economy and public health and development of specific adaptation measures;

Improvement of systematic observation and monitoring network for ensuring timely adjustment of adaptation measures;

Improvement of the data collection system and analysis, interpretation and dissemination of the results among the end users;

Enhancing of the system of forecasting, modeling and early warning on natural disasters, especially catastrophic floods and mudflows;

Building institutional and technical capacity on the issues of adaptation;

Training of personnel in the adaptation-related fields, such as, climate and hydrological research, geographical information systems, environmental impact assessment, protection and re-cultivation of lands, rational water use, conservation of ecosystems, agricultural and infrastructure development, health protection;

Implementation of concrete projects on adaptation in priority fields related to natural resources use, economy development and health protection;

9.2. Strategy's priorities and frameworks

The following criteria were used to elaborate the adaptation measures:

The extent of negative effects of climatic factors, extreme weather events and projected climate changes on the subjects;

The risk for people, public health, economic development, food security, infrastructure, cultural heritage, water resources, land resources, biodiversity;

Cost efficiency etc.

Possible adaptation options depend on the type and the intensity of the climate change impact and include:

1. Loss prevention by taking preventive measures on decreasing the vulnerability of the object under the impact of climate change.
2. Acceptance of the loss and minimization of its effects in cases when the negative influence considered being acceptable in a short term, because the object can stand it without prejudice in a long term.
3. Sharing the loss in a way that the influence will be distributed on bigger territory or on larger population despite of those who were the prime victims of the natural disaster.
4. Change of the type of activity aimed at adaptation to both negative and positive effects of climate change.
5. Change of location in cases when the preservation of activity considered being more important than preservation of its location and migration to those areas where conditions are more appropriate after a climatic change.
6. Recovery, which is targeted on the recovery of the system. This is not exactly adaptation to climate change, because the system is still vulnerable to further climate change impacts.

There are of course, many cases, when climate change can have a positive effect. In these cases the strategy of adaptation assumes benefiting from the positive opportunities.

In accordance with recommendations of the Intergovernmental Panel on Climate Change, the following types of measures were taken into consideration:

Structural/infrastructure measures;

Legal/juridical changes;

Institutional/administrative/organizational measures;

Financial motivation and subsidies;

Economical tools;

Technological tools;

Regulation measures;

Prevention and minimization of natural disasters related to climate variability;

Training;

Scientific research and personnel training.

Measures are targeted on national, local, sectoral, institutional, and individual levels.

9.3. Sustainable use of natural resources and the promotion of their adaptation to climate changes

Water resources

The vulnerability assessment shows that in the mid-term the water resources of Tajikistan within the river basins of Vakhsh, Kafarnigan, Kyzylsu, Zeravshan and others are likely to decrease. In some regions this tendency can be catastrophic. The possible decrease of stream flow in summertime can reach a critical level.

During the last 50 years, global warming has caused glaciers to retreat all over the mountainous regions of Tajikistan. Glacier retreat affects stream flow in the rivers that get their water from glaciers and snow stocks. It is likely that a temperature rise of 2°C would reduce the ice cover by 20% in comparison with today's area.

Therefore, an extraordinary process is taking place, which requires systematic observation needed for the long-term forecasting of stream flow. This process requires:

Routine observation of the representative glaciers;

Space monitoring of glaciers dynamics;

Annual observation of snow in mountain regions in the period from January till May and use of observation's results in forecasting.

There are about 35 periodically surging glaciers that are potentially dangerous because of the formation of glacial lakes and their outbursts. Therefore a complex of measures, including glacier research and application of advanced methodologies, to forecast a catastrophic movement of these glaciers is needed.

The main purpose of scientific support in the field of rational water use and protection is determined by the distinctive role of Tajikistan in the supply of water to the Aral Sea. The priority actions on rational water use and promotion adaptation of water resources are:

Improvement of the system of hydrological observation;

Development of computerized database to effectively handle and distribute hydrological information;

Research on the influence of climatic factors on flood formation;

Development of computer-aided models of hydrological forecasting;

Development of new schemes of land-reclamation in the conditions of climate change;

Development of measures in the field of water resources protection, water and energy saving in the conditions of climate change;

Improvement of payment system related to water resource use;

Development of new, and improvement of existing technical and economical tools on water resource use at national and regional levels.

Land resources

The area of agricultural lands in Tajikistan is very limited; therefore its protection and rational use play an important role. The welfare and living standards of more than 70% of Tajikistan's population directly depends on the condition of lands, which in turn largely dependent on the climatic factors.

The vulnerability assessment shows that climate change (droughts, high spring and summer temperatures, heavy rainfalls, water resources shortage) could trigger erosion and give rise to desert expansion. This would probably have an adverse impact on the agricultural sector of Tajikistan.

In this regard, the following measures of adaptation and minimization of adverse impacts of climate change are identified:

Zoning of territory depending on the extent and type of influence of climatic factors on the condition of lands taking into account its vulnerability to the different forms of erosion;

Setting a selection of soil protection measures for specific landscapes according to the influence of climatic and anthropogenic factors;

Conducting land-reclamation measures, which include crop rotation, soil protection and limiting the ploughing of steep lands that will help to conserve the humus in the soils under the expected conditions of climate change;

Combatting swamping and salinization of soils, including the cleaning and rehabilitation of drain constructions, collectors and pumping stations;

Forest rehabilitation measures in the regions prone to drought and wind erosion. This will promote sand consolidation, reduction of desertification and minimizing the influence of other climatic factors.

Pasturelands

The condition of natural pastures and hayfields in Tajikistan is determined by two key factors: anthropogenic pressure (overgrazing, forest cuttings) and climate impact (droughts, extreme high and low temperatures, hailstones etc).

The vulnerability assessment shows that climate impacts in some years appear to be severe, when pasture productivity reduces by 3 times thus considerably affecting animal husbandry in Tajikistan.

To minimize adverse consequences of climate change now and in the future, the main recommendations on adaptation of pasturelands to climate change are:

Systematic monitoring of pasturelands and forecasting their conditions based on climate models;

Development of a computer-based model "Climate - Pasture Productivity" for different climatic and ecological zones of the republic;

Setting optimal dates and grazing norms, taking into account differentiation by types and productivity conditions of the pastures;

Regulation and optimization of pastureland use;

Selection aimed at drought- and disease-resistance in the current conditions of climate change;

Expanding irrigated pasturelands for using them in dry years;

Creation of additional fodder stocks.

Ecosystems

In Tajikistan, ecosystems play an important role in sustaining the well being of the population in rural and mountain regions. Climate warming, the increase of carbon dioxide in the atmosphere and other factors greatly influence the ecosystems.

Such an influence is expressed in the extinction of species of flora and fauna, deterioration of biotopes, shifting of phenological parameters of vegetation, degradation of tugai woodlands, winter-spring pastures, etc. The impact of anthropogenic and climate factors lead to intensifying the erosion process, altering the conditions of surface runoff because of changing vegetation, that in turn negatively affect stream flow.

According to authoritative expert assessments, the following adaptation measures for Tajikistan's ecosystems can be underlined:

Enhancing scientific understanding of climate change processes that have an impact on ecosystems, with emphasis on nature protected territories;

Monitoring of ecosystems;

Promotion the reasonable use of natural territories with minimization of anthropogenic pressure, especially in industrial and agricultural areas;

Supply the population with adequate energy resources and substitute wood fuels;

Support the natural corridors of migrating species of animals and birds;

Protection of rare and endangered species of animals, plants and their habitats, including prevention of illegal trade and hunting;

Increase of efficiency, improvement of the systematic monitoring, and expanding of some existing nature protection territories with an emphasis on ecosystems vulnerable to climate change;

Obligatory fulfillment of nature protection laws;

Development of rules and managing principles on the protection and rational use of biological resources.

9.4. Adaptation of economies to climate changes

Water economy

The vulnerability assessment of water resources to climate change shows their reduction in the future, therefore adaptation measures of water economy to climate change and its adverse effects were developed. The negative consequences mainly include: the deficit of water for irrigation, increase of irrigation norms, alteration of ground water dynamics, and the deterioration of water quality.

The adaptation measures are chosen in such a way that it would have to be effective and useful in both the conditions of the present climate as well as considering its possible changes in the future. The necessity of its timely implementation will be increasing in the future. The suggested adaptation measures are divided into three categories: technical, public and agricultural.

Technical:

Computerizing a system of water supply based on geographic information systems (GIS);

Increase of irrigation systems efficiency and application of new technologies and types of irrigation and water conservation;

Rehabilitation and reconstruction of irrigation systems for reduction of water losses due to filtration and evaporation;

Support of water saving technologies in industry, agriculture and water supply;

Switching on increased use of closed drainage systems and secondary use of drainage water for irrigation;

Pumping of some strongly mineralized, toxic and irrigation waters into deep reservoirs in order to avoid its percolation into the river water heads and channels;

Adaptation of irrigation modes to the conditions of climate change, including revision of the terms and norms of irrigation;

Construction of water reservoirs in specific agricultural areas to create guaranteed water reserves in dry years and to reduce the risk of floods and mudflows;

Stabilization and strengthening of river beds, where floods and washout are the norm;
Decrease of industrial wastewater volume, that will contribute to the reducing of water ecosystems vulnerability;
Creation and maintenance of transit water-bio-filters for cleaning water from toxic components;
Rehabilitation of drinking water supply systems and wastewater purification facilities to ensure safe water availability in cities.

Public:
Promotion of principles of rational water use and water conservation in mass media;
Public and water consumers participation in terms of water management;
Training of farmers on the principles and technologies on water conservation and rational water use;
Informing public about the intergovernmental relationships between the Republic of Tajikistan and the states of the Aral Sea basin.

Agricultural:
Measures on expanding protected forests on riverbanks;
Advancing the selection of drought-resistant and high productive agricultural crops with a low level water consumption.

Hydropower engineering

Hydropower engineering is fundamental for the economy of Tajikistan. The country currently utilizes no more than 5-10% of its huge hydropower potential. The existing reservoirs operate in the mode of hydropower production and land irrigation. They also play an important role in protection from floods, fish industry development, recreation, industrial and public water supply.

The research proved that big hydropower plants are more susceptible to the influence of climatic factors and changes in water level than small stations. Key factors of vulnerability are extreme floods, mudflows, landslides, severe climatic conditions and reservoir sedimentation.

The adaptation measures for the sustainability of the hydropower sector in the conditions of climate change are determined as follows:
Updating of stream flow characteristics and its extreme values using the most modern scientific data and methods;
Updating and modernization of hydropower systems designs in terms of the capacity and stability of reservoirs;
Optimizing the mode of exploitation, and reducing the sedimentation processes;
Design and construction of special protection structures for all hydropower systems, electricity transmission lines and substations;
Computer-based monitoring of all hydropower systems;
Construction of new hydropower systems and reservoirs, which could provide needed regulation of stream flow fluctuations as well as reducing the negative impact of sedimentation within existing reservoirs.

Agriculture

The vulnerability assessment shows that agricultural production mostly depends on climatic conditions and its variations. The crops grown in Tajikistan are based on irrigated and rain-feed agriculture. The territory of the irrigated lands and the state of rain-feed lands might worsen in the case of a water resource shortage and climate change. Widespread desertification requires a total reform of the whole system of agricultural production in the conditions of climate change. Moreover, the impact of extreme weather events in some cases is catastrophic and can be responsible for 30-40% of all losses in agriculture.

Due to the alarming results of the vulnerability assessment of agriculture, in this strategy the following common adaptation measures have been determined as follows:

Modernization of logistical base in agriculture;

Development of scientific and technical support of agricultural sector, including long-term forecasting;

Conducting a series of agro-technical and land-reclamation measures to improve sowing areas;

Rationalization of crop rotation combined with agricultural machinery application, appropriate use of chemical and biological methods against insects;

Measures on the prevention of salinization and swamping, as well as water and wind erosions;

Securing the financial sustainability of households and insurance in agriculture.

The increase in a level of adaptation for the cotton industry to the climate change requires:

Creation and introducing of fast growing, heat and disease-resistant sorts of cotton;

Prediction and timely prevention of harmful insects episodes and cotton diseases;

Introduction of effective cotton sorts rotation in cotton growing zones, where it is vulnerable to climate change;

Increase of cotton irrigation efficiency based on water saving technologies, that will assist in protection of soil from erosion.

The increase in a level of adaptation for the grain industry to the climate change requires:

Creation and introducing local sorts of cereals, which are sustainable to unfavorable climate conditions;

Selection of new drought and diseases-resistant sorts of cereals along with the support of private seed-growing;

Maintenance of guaranteed grain stocks;

Increase efficiency of cereal crops protection regarding diseases and insects, and forecasting the chance of their occurrence depending on climate conditions.

The increase in a level of adaptation for the cattle breeding industry to the climate change requires:

Strengthening of forage reserves;

Expanding of pasturelands, allowed for private use with an increased level of control;

In addition to state veterinary services, to promote the development of private veterinary services and to implement a set of measures on disease reduction.

Transport infrastructure

Transport infrastructure plays an important role in the economic development of the country. In Tajikistan, climate impact on the condition of roads is significant and contributes to the destruction of roads and bridges. Floods, avalanches, severe climate conditions (cold winter and hot summer) also destroy the roads.

Priority tasks of transport infrastructure adaptation to climate change are the creation of new standard norms during the stages of designing, construction and maintenance of the roads depending on climate conditions.

National plans of road construction should be implemented with consideration of the environmental and climatic impacts. While making decisions on road construction it is necessary to consider the factor of climate variability in different mountain regions.

The measures on promoting sustainability of the transport sector to climate change have been determined as follows:

Improvement of existing and development of new standards in the transport sector taking into account vertical zonation and climate characteristics;

Classification of road and climate indicators depending on land surfaces;

Differentiation of regional requirements to the paving characteristics according to the altitude and vertical zonation of the climate;

Research of microclimate specifics in the off road side for justification of technical norms;

Justification of road strength properties taking into account the climate factors;

Research on the impact dynamics of the unfavorable natural phenomenon on mountain roads with the purpose of construction of additional protecting structures and strengthening mountain slopes;

Monitoring of dangerous geological phenomenon on the roads and consideration of extreme weather events in the process of road construction and exploitation.

9.5. Preparation, prevention and minimizing the risks of natural disasters

The vulnerability assessment shows that natural disasters, including catastrophic floods, mudflows and landslides caused by climatic factors are a major reason of human and financial losses on an annual basis.

The main tasks in the conditions of climate change are the development of adaptation measures to minimize the risk of natural disasters for the population and economy:

Improvement and rehabilitation of the existing hydrometeorological network with the development of advanced forecasting and early warning systems, flood management and other extreme weather events (with the upgrading density of stations up to 1/1,000 sq.km);

Modernization of the system of gathering, processing, analysis, interpretation and distribution of the information, including the development of dynamic databases, geographic information systems and computer-based models of formation and influence of floods and other extreme weather events;

Development and implementation of a set of measures on natural disasters management, with special emphasis on local public awareness and local authorities participation;

Improvement of forecasting and early warning systems, including expanding in the areas of accuracy, high reliability of forecasts on floods and other extreme whether events;

Planning, designing and implementation of pilot projects, aimed at creation, strengthening and development of resources and structures.

Planning of technical and non technical measures of protection from floods;

Improvement of preparedness of population and appropriate governmental departments in the event of natural disasters and providing rescue equipment;

Reduction of flood impact risk, especially in the areas with undeveloped infrastructure and populated by poor groups of people. Allocation of residential and business premises in safe areas is an important measure in this program.

9.6. Adaptation measures for enhancing public health in the conditions of climate change

The vulnerability assessment stated that the climate plays an important role in the dynamics of morbidity and mortality. The change of climate, especially temperature, causes a misbalance not only on different hierarchical levels of the biosystem but also between those levels. Only adaptive measures to the negative influence of the external environment will allow the improvement of health and an increase in life expectancy of Tajikistan's population (fig. 9.1).

Common adaptation measures can be directed to:

Increase socio-economical and sanitation-educational levels of the population;

Arrange seminars and round tables on "Climate change and public health" for the representatives of all categories of society, ministry officials and decision makers;

Develop an educational program on "Climate change and public health" for medical students;

Develop an unified computer database on climate change related to the state of public health on a regional and nationwide level;

Establish an interdepartmental scientific-information center "Man and Climate" (fig. 9.2) that will allow the monitoring of factual changes in health related to climate conditions and also develop targeted measures of adaptation;

Improve nature protection legislation, public health protection laws and its implementation control; introduce effective legislative, administrative and technical measures for control and monitoring;

Develop and improve individual and popular methods of research in terms of adaptation and develop integral indicators, characterizing adaptation to the conditions of climate change;

Increase the sustainability of the human body through consumption of medication that promotes adaptation (preferably herbs).

The vulnerability assessment shows that an 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 (*Anopheles*).

Adaptation measures on reduction of malaria must include:

Illness prevention

Reduction of illnesses and mortality

Reduction of infection

Malaria elimination

Measures for the prevention of malaria should include:

Introduction of Gambusia to reservoirs and rice fields containing malaria

Insecticide treatment

Purification of irrigation channels and drainage systems

Marsh drainage

Use of individual mosquitoes nets

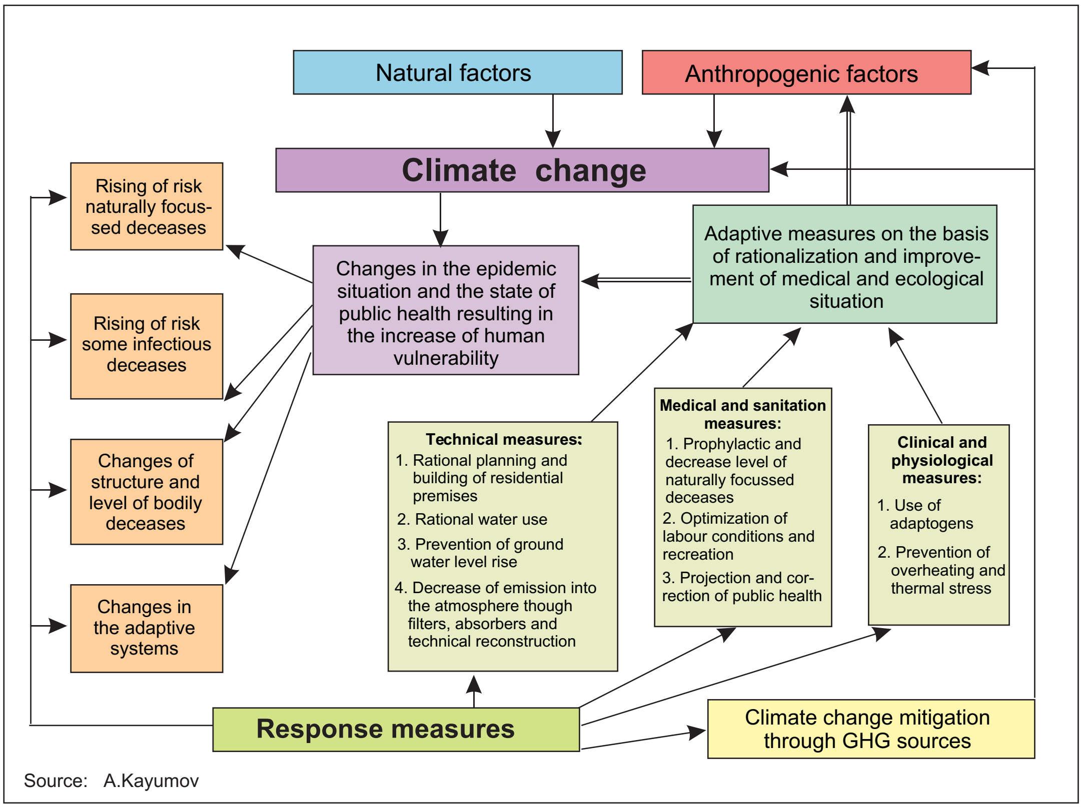
Natural factors
Anthropogenic factors
Climate change
Rising of risk naturally focus-sed deceases
Rising of risk some infectious deceases
Changes of structure and level of bodily deceases
Changes in the adaptive systems
Changes in the epidemic situation and the state of public health resulting in the increase of human vulnerability
Adaptive measures on the basis of rationalization and improve-ment of medical and ecological situation
Technical measures:
1. Rational planning and building of residential premises
2. Rational water use
3. Prevention of ground water level rise
4. Decrease of emission into the atmosphere though filters, absorbers and technical reconstruction
Medical and sanitation measures:
1. Prophylactic and decrease level of naturally focussed deceases
2. Optimization of labour conditions and recreation
3. Projection and cor-rection of public health
Clinical and physiological measures:
1. Use of adaptogens
2. Prevention of overheating and thermal stress
Response measures
Climate change mitigation through GHG sources
Source: A.Kayumov

Fig. 9.1.

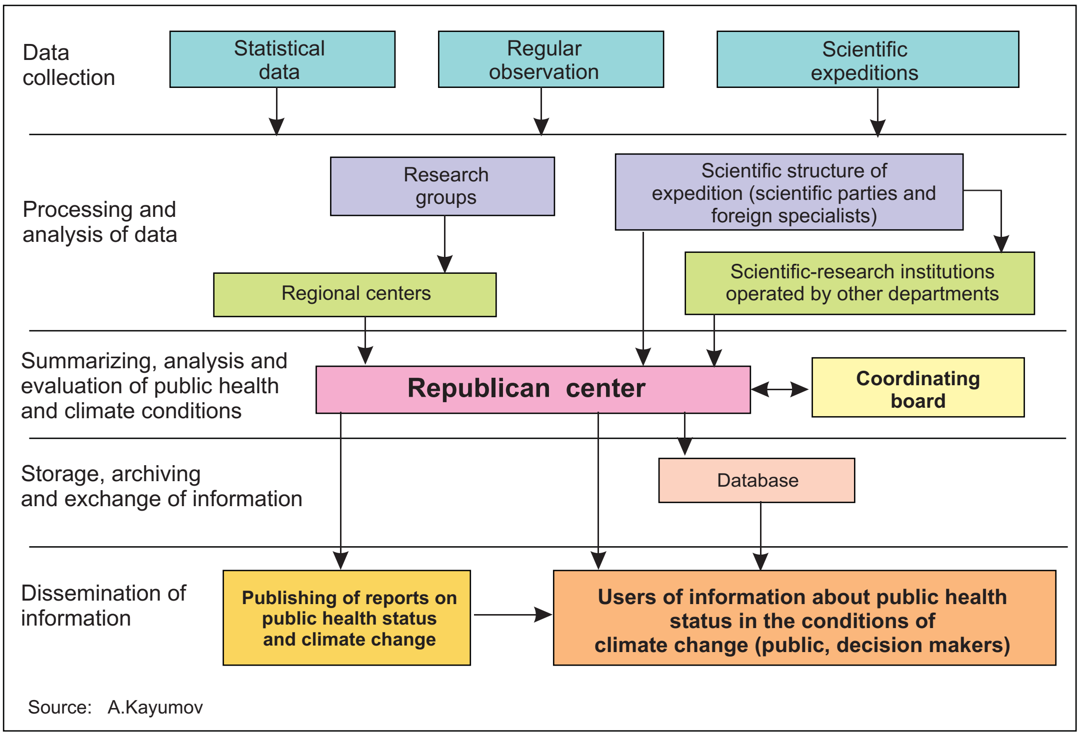
Data collection
Statistical data
Regular observation
Scientific expeditions
Processing and analysis of data
Research groups
Scientific structure of expedition (scientific parties and foreign specialists)
Regional centers
Scientific-research institutions operated by other departments
Summarizing, analysis and evaluation of public health and climate conditions
Republican center
Coordinating board
Storage, archiving and exchange of information
Database
Dissemination of information
Publishing of reports on public health status and climate change
Users of information about public health status in the conditions of climate change (public, decision makers)
Source: A.Kayumov

Fig. 9.2.

Besides vector-born diseases, which are dangerous for public health, there are other diseases such as typhoid, salmonellosis, dysentery and others with the inherent spring-summer, summer and summer-spring timing.

Weakening of sanitary control over the water quality in the conditions of climate change can potentially increase the risk of these infections spreading, especially in rural areas, where the population does not have sufficient access to safe drinking water.

Within a set of measures on prevention of intestinal infections it is necessary to consider:

Securing the population with quality drinking water; disinfecting sewers; sanitary cleaning of public transport, urban and rural settlements, industrial and agricultural objects;

Enhancing microbiological, chemical and physical control of ground and surface waters.

More than 60-80% of workdays in July-August in valleys and mountains, especially southern Tajikistan, air temperature exceeds 28°C. Labor in such conditions causes many functional changes in the human body resulting in a high pulse rate and frequent breathing, increase of body dehydration, temperature and thermal stress of human beings that negatively affects working capacity and human health.

For maintenance of working capacity and health protection in the conditions of such a hot climate and to reduce thermal stress in summertime it is necessary to:

Introduce the work schedules that avoid peak daytime temperatures;

Use the premises with regulated microclimate;

Drink regularly;

Consider the possibility of providing additional rest periods during work on a hot day and revise appropriate legislation.

Town planning in Tajikistan was originally carried out without consideration of the hot climate; especially the impact heat can have on public health. As a result, morbidity and mortality increase, especially among children and aged people. Existing residential and public buildings do not fully secure rational use of landscape and microclimate conditions in town planning, which reduces comfort. Urbanization intensifies the problem of exhaust gases, noise, vibration and overheating.

Adaptation measures to reduce thermal stress in respect to town planning are considered as important options in improving health in the conditions of climate warming. To achieve this goal at present and in the outlook it is necessary to consider:

Landscape characteristics and altitude;

Orientation of mountains and valleys towards the cardinal points;

Duration of days within the hot season where overheating occurs;

Amplitude of near surface temperature fluctuations between average maximum and average minimum (day and night time) in summer and winter seasons;

Day and night wind speeds during the summer season.

Thus, with regards to the improvement of urban environments and enhancing comfort it is necessary to develop new architectural typology that secure necessary adaptation potential in a changing climate.

9.7. Immediate adaptive measures in case of climatic catastrophes

In recent years, the number of climatic catastrophes has been increasing, especially floods and droughts. The unpredictability of these events makes them difficult for adaptation.

It is estimated that if medical support could be timely provided at the locality of the incident then mortality could be decreased by 20%.

During the last decade from 1991 to 2000, more than 90% of the victims of natural disasters who died were the result of extreme meteorological and hydrological phenomena.

For the improvement of preparedness and minimization of negative consequences from possible climatic catastrophes, it is necessary to conduct regular training on emergencies, liquidation and development of exact cooperation mechanisms between local and central authorities, rescue services and populace.

In initial hours after a natural disaster event, the population should be provided with the following information:

1. What to do to be safe.
2. Location of food, water and medical supply distribution centers.
3. Operation of army, fire services, professional rescue personnel and others.

It is important to divide the responsibility of medical personnel accordingly:

Urgent surgery;

Sorting of victims depending on their condition;

Solving epidemiological and hygiene problems for the organization of water supply, temporary living and food supply;

Conducting medical and sanitary assessment (sanitary-epidemiological, sanitary-chemical and sanitary radiation).

9.8. Food security and struggle against the drought consequences

The problems of land degradation and water supply shortage decrease contemporary agriculture's productivity and threaten the food security.

Sufficient supply of food in Tajikistan, especially in rural areas, is strongly linked to environmental conditions and climate impacts.

Adequate nutrition favors normal growth and development of the human body, increases disease resistance and working ability. These factors as well as other social conditions allow wide adaptation possibilities of the human body to the changing climate conditions.

The problem of food security becomes evident when internal supply is insufficient for the needs of the population demands, as a result of climatic and other impacts.

In the 1990s, the food supply in Tajikistan was not sufficient to provide the minimum level of calories and proteins. Accordingly, adaptation possibilities of the human body have decreased and caused the high level of population's vulnerability in a condition of climate warming. The droughts associated with increasing poverty and reduction of agricultural sector's efficiency, extremely intensified the food security problem.

Therefore the strategy determines the following adaptation measures aimed at food security improvement:

Stimulation of economic growth that will contribute to adequate food security;

Elimination of poverty, especially within communities, which are more vulnerable to climate change;

The rural areas, where more than 70% of the country's population reside and provide about 90% of food production, assistance and support are needed in the development of effective and rational methods in agriculture, acceptable for the conditions of climate change and high risk of climatic catastrophes;

Development of private farms with differentiation of agricultural production.

9.9. Reduction of anthropogenic pressures in urban areas

Research shows that the cities of Tajikistan are vulnerable to the impact of meteorological factors (wind mode, atmospheric circulation, dust storms, temperature, solar irradiance). It results in the increase of pollutant concentrations in the atmosphere caused by anthropogenic emissions, the rise of air temperature and its subsequent adverse influence on urban environments and public health.

Projected climate change will likely intensify the impact of meteorological factors, because the feature of urban architectural composition promotes the rise of temperature by 2-3°C in comparison with the countryside.

The lack of sufficient street ventilation leads to the increase of atmospheric pollutant suspension and promotes the formation of heat islands.

In respect to the adaptation of the urban environment to climate change important measures for the improvement of air quality and urban ecology in general are:

Zoning of vulnerable urban territories to facilitate acceptance of adequate and effective adaptation measures and to ensure appropriate urban design and construction in the conditions of climate change;

Environmental impact assessment for large enterprises that have the potential to effect the urban environment and determine how much their operation adds stress on the local environment;

Enhancing of nature protection control on industrial technologies, processes and overall performance of air protection measures on stationary pollution sources;

Minimization of unorganized pollution sources;

Optimization and improvement of urban road surfaces and designs for reduction of fuel consumption and GHG emissions, and construction of by-pass roads to diminish vehicle's pressure in the central part of the cities;

Control on fuel quality and harmful substance concentrations in exhaust gases;

Prohibition of open waste burning in urban areas to reduce emissions of persistent pollutants and greenhouse gases, including solid communal wastes and foliage that contains toxic substances;

Inventory of urban tree plantations and development of measures that enhance their efficiency in terms of air quality;

Increase of public participation when implementing the urban environment improvement measures.

9.10. Costs of measures and potential financial sources

The general estimated cost of strategy implementation is about US$ 500 million. The potential resources for the funding of adaptation measures could be the projects of international support by Global Environmental Facility programs and Adaptation Fund, investment projects, part of CDM projects, budgetary funding within the approved limits, and non-budgetary sources.

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10 Optimization of the Systematic Observation and Promotion Research in the Aspect of Climate Change

10.1. The rationale for improvement and development of systematic observation network

Systematic and in-depth observations of climate are needed to improve understanding of the global climate system, and mechanisms causing climate change. Study of climate system elements and their dynamics can promote the making of effective and proved economic, technical and social decisions. In this connection, the existing global climate observation networks, including GCOS, require improvement and further development.

The improvement of systematic observation is determined by the UN Framework Convention (Article 5) as one of the priorities in research on the global climate system, indicators of climate changes and its adverse consequences.

Hydrological and meteorological information is necessary for sustainable agriculture, definition of optimum harvesting dates, protection of crops from hailstones, designing buildings, bridges, roads, canals, ensuring the safety of cargo and passenger traffic, etc. Control and forecasting of extreme weather events reduce to an extent the scale of their adverse impacts and allow the prevention of damage.

10.2. Main tasks and structure of hydrometeorological service

The network of hydrometeorological observations in Tajikistan has been developing basically for the satisfaction of the national economy's needs in hydrometeorological information, with the purpose of planning activities and making decisions on risk and damage reduction that is caused by adverse hydro-meteorological phenomena.

Hydrometeorological monitoring includes systematic observation of local hydrometeorological conditions, as well as collection, processing, analysis, generalization of information, and forecast production.

Main tasks of the hydrometeorological service are:

- Supply targeted organizations with information on hydrometeorological conditions in the places of observation, both real-time and archive data;
- Warning of targeted organizations about dangerous and spontaneous atmospheric phenomena;
- Supply data for hydrometeorological forecasts, and prevention of extreme weather events;
- Accumulation and generalization of objective data about the hydrometeorological condition of the territory of the republic.

For performance of the designated tasks, the hydrometeorological service should have the appropriate organizational structure and optimum observational network.

The structure of the hydrometeorological service includes a central management body, specialized divisions on services of observation network, gathering, processing, transfer and storage of hydrometeorological information, regional centres, network of hydrometeorological stations and gauges (fig. 10.1).

10.3. Participation of Tajikistan in international observation networks

Tajikistan has two stations representing the global climate observing system (GCOS). Tajikistan belongs to the Region II WMO (Asia). The World Weather Watch (WWW) WMO involves 10 Tajikistan's stations, including 2 stations that conduct upper air observations (tab. 10.1).

Climatic data by means of "CLIMAT" telegrams are transferred daily via channels of Global Telecommunication System (GTS). Since 2001, Tajikistan transfers in GTS channels the data from 12 stations, including 2 GCOS stations, which are accessible to WMO and world data centres.

Table 10.1.

Meteorological stations which participate in the system of the international exchange

Station	Coordinates	Attitude	GCOS	WWW	IHN CIS
Dushanbe	38°33'NL 68°47'EL	800 masl		+	+
Isambay	38° 03' 68° 21'	563			+
Istravshan	39°54' 69°69'	1005		+	+
Isfara	40° 08' 70° 36'	873		+	+
Kulyab	37°55' 69°47'	659		+	+
Kurgan-Tube	37°49' 68° 47'	429	+	+	+
Lahsh	39 ° 17' 71° 32'	1998			+
Parhar	37°29' 69°23'	448		+	+
Penjikent	39° 30' 67° 36'	1015			+
Pyanj	37° 14' 69° 05'	363		+	+
Khovaling	38°21' 69° 59'	1468			+
Khorog	37° 30' 71° 30'	2077	+	+	+
Khujand	40° 13' 69° 44'	427		+	+
Shaartuz	37°19' 68° 08'	380		+	+

S o u r c e : Tajik Met Service (2002)

Because of financial difficulties two WWW stations are temporarily closed. Three stations do not transfer data because of communications damage. The most perceptive WWW stations are: Khujand, Khorog and Istravshan that have been conducting observations since the end of the 19th century.

The interstate hydrometeorological network of CIS (IHN CIS) is intended to exchange the data of meteorological, upper air, hydrological and other observations necessary for preparation of hydrometeorological forecasts and warning about dangerous hydrometeorological phenomena. The observations of that network in Tajikistan consist of 14 meteorological stations, 11 hydrological gauges on rivers, lakes and reservoirs.

10.4. Operational status of observation network and measures for improvement

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

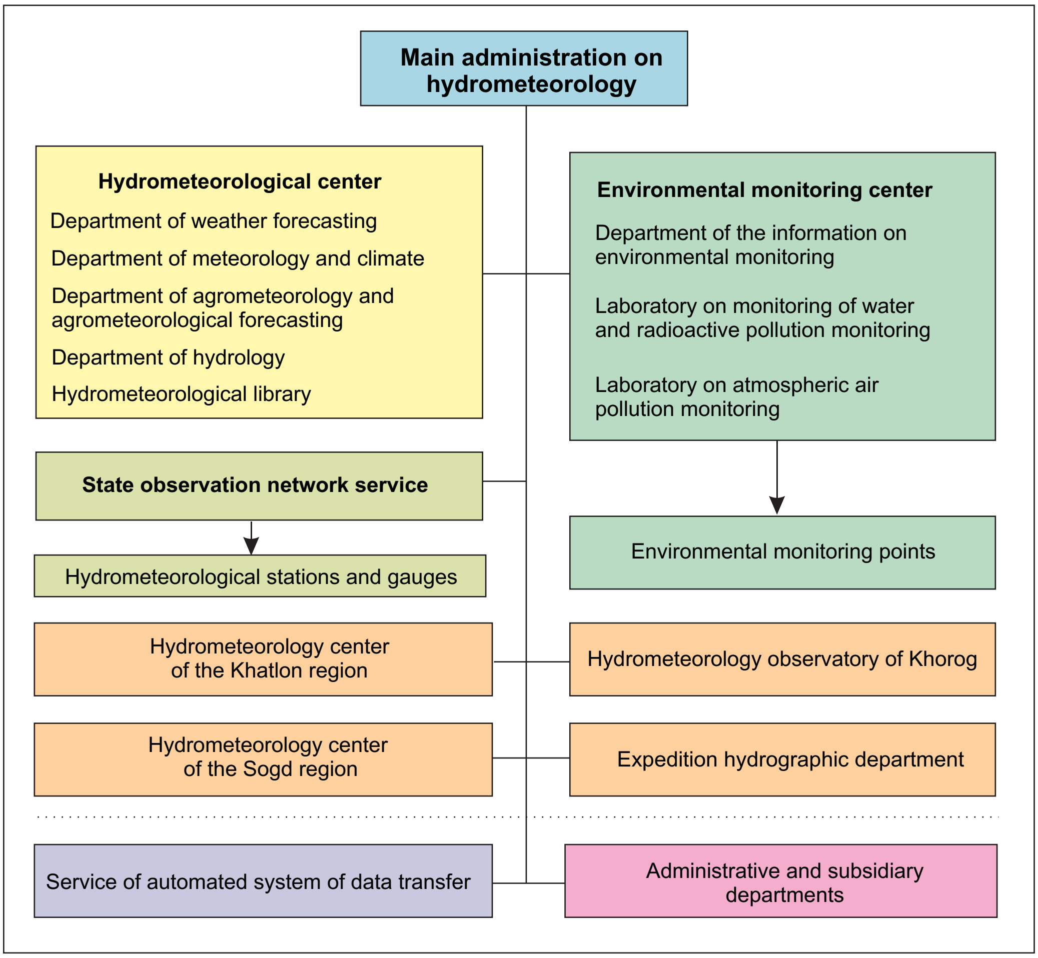

Fig. 10.1.

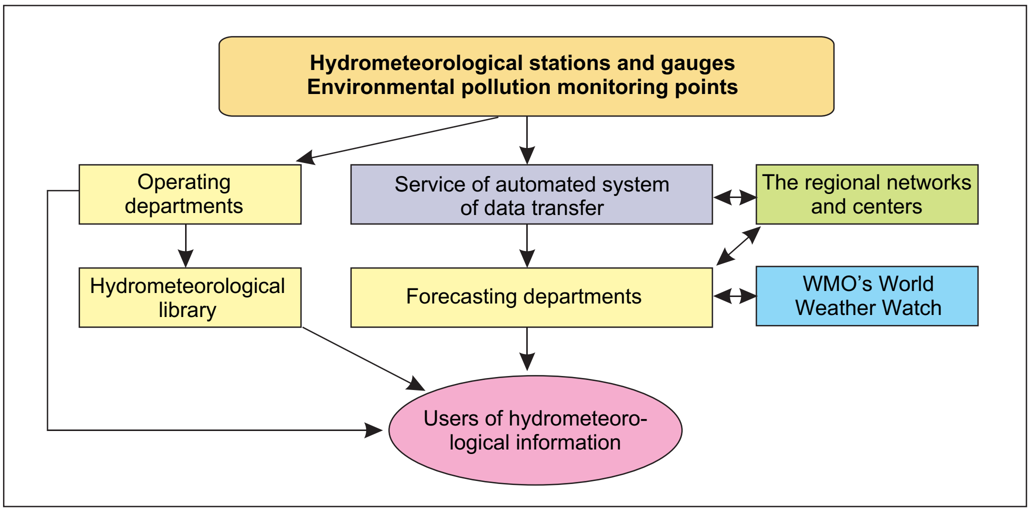

Fig. 10.2.

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

The national hydrometeorological service does not have enough resources to maintain the network to be able to develop it or keep it in working order. Therefore, a number of stations and gauges have reduced or completely stopped observation altogether. The majority of stations are equipped with out-of-date devices and instruments, and in the last decade, the updating of the network with modern equipment has not been conducted. The difficulty with using outdated equipment and ensuring appropriate accuracy of measurements, results in deterioration of data quality and its reliability.

Such a situation can be negatively reflected on the quality of climatic information, weather and drainage forecasts, including floods and other dangerous phenomena. This situation interferes with the development of research on climate change, its impacts and integration of Tajikistan into the global observation network.

The development and implementation of measures to optimize the observation network, conserve the most important points of observation, minimize expenses, and ensure its conformity to the modern requirements in terms of management, technical conditions and distribution of information among consumers is required. This will allow Tajikistan's contribution to the global observation network in the given region.

There is a need to develop the National program on optimization of systematic observation network.

10.4.1. Meteorological observation

During the whole period of meteorological observation in Tajikistan, more than 80 stations and 20 gauges have been opened. The individual stations were departmental, intended for a short number of specialized researches.

The meteorological observation in the republic is carried out 24/7 and includes the measurements of temperature, humidity, air pressure, temperature of soil, precipitation, definition of cloud type and quantity, meteorological range of visibility, direction and speed of wind and various types of atmospheric phenomenon. Current weather information is provided to the republican hydrometeorological center. The data transmission is carried through the Ministry of Communications and own communication facilities (radio stations).

Economic reasons have resulted in the reduction of the meteorological observation network, and have been reflected in the deterioration of equipment and materials.

For the period of 1991-2002, the activity and coverage of the meteorological observation network in comparison with the 1980s has decreased by 20 %.

Now, 11 stations out of 58 stations do not operate. The individual stations are temporarily closed because of the absence of specialists. Remote stations are temporarily closed because of financial impoverishment, including unique to the Central Asian region, the meteorological station named after Academic Gorbunov on the Fedchenko Glacier (4,168 masl).

The situation has resulted in part of the Sogd region and some areas of Southern and Central Tajikistan no longer being observed meteorologically.

The data on snow cover in aggregate with real-time information on intensive rainfalls are the basis for short-term and mid-term water level forecasting and flood warnings. The standard snow cover observations by meteorological stations are carried out in small volume. In difficult mountain conditions of the republic, the available data on the dynamics of snow cover and its water equivalent is obviously not enough. Automatic precipitation gauges are absent in remote regions.

The lack of instruments at some stations forced to stop observations of extreme temperatures of air and soil, the height of clouds, wind and visibility. There are difficulties with observational data entry and sending of observation reports to the Main administration of hydrometeorology in the required time frames.

Observation and recording of initial data by automatic means are practically not used. There is a small number of devices, which record on paper the data on air temperature, pressure, relative humidity, intensity of precipitation, sunshine duration, however this does not solve the problem, as this data then needs to be processed manually.

To improve and develop the national meteorological observation network and enhance participation in the Global Climate Observing System and interstate hydrometeorological observation network of CIS, it is necessary:

- To maintain an existing network of meteorological stations, taking into account, that there are long-term observations on climate, the observations are conducted under the multi-purpose programs and the data of many stations are directly used by national economy of the republic;
- To pay special attention to high-mountainous meteorological stations that have a valuable use for weather and water level forecasting and study of global climate change;
- To research and analyze the information on network optimization and to prepare appropriate recommendations, including methods, tools of observation and location of observation points;
- To restore the destroyed gauges and stations and to carry out repair services and residential premises at acting observation points;
- To get missing devices and equipment for separate stations, and to ensure their installation and appropriate operation;
- To carry out check and calibration of all types of devices and equipment used and to conform with international standards;
- To expand the network of snow gauges and equip with devices for automatic measurement of snow cover thickness and its water equivalent, and also expand the network of automatic precipitation gauges with real-time data transfer to hydrometric stations or directly to the hydrometeorological center;
- To develop a network of automatic weather stations, especially in remote regions, for reduction of gaps in scientific knowledge and improvement of forecasting of weather conditions and natural disasters, including floods;
- To promote equipment of a network by automatic observation devices;
- To ensure the steady mechanism of observational data transfer.

10.4.2. Agrometeorological observation

Agrometeorological observation is being carried out to assess the development, growth, status and productivity of agricultural plants, temperature and humidity of soils. Aerovisual observations are used for definition of pasture productivity.

The network of agrometeorological observation for the last decade has undergone significant changes. Like this, in the year 1988 agrometeorological observation was carried out at 29 stations (including 2 specialized) and 14 gauges, by the year 2001 its number was reduced to 21 stations and 8 gauges, from them on 7 points agrometeorological observation has not been conducted. The observations are limited only on the phases of development of agricultural crops and local meteorological conditions. The reports from the network do not arrive in time. Aerovisual inspections of pasture vegetation during the last 11 years have not been carried out. The lack of agrometeorological information has had negative effect on forecasts of phenology and productivity of agricultural crops.

The last agrometeorological directory was issued in 1987. Since then no agrometeorological directories have been composed.

Taking into account the large importance of agrometeorological observation for conducting sustainable agriculture in climate change conditions and the high value of instrumental observations on the phenology of vegetation that is a characteristic indicator of climate change it is required:

- Restoration of observation network, especially in the areas vulnerable to extreme weather events and to projected climate change;
- Supply the observation network with necessary devices and equipment;
- Introduction of advanced forecasting techniques and modeling of herbal productivity;
- Renewal of cost-efficient aerovisual and land observations of pasture vegetation;
- Access to satellite observation system (monitoring of vegetation and soil cover) and use of computer-aided means for decoding and processing of satellite information;
- Development and introduction of effective mechanisms of interaction with the consumers of agrometeorological information and encouragement of development of a network of volunteers in rural areas, especially in droughty plains and in mountains.

10.4.3. Upper air observation

Upper air observation network is intended for study of meteorological parameters of the atmosphere at heights up to 30-40 km. Upper air information is used for drawing up of weather forecasts, service of aviation and other sectors, analysis of atmospheric processes.

Upper air observation was earlier carried out at 3 stations (Khujand, Dushanbe and Khorog) in 4 standard terms. Since 1996, because of lack of supplies, failure of out-of-date radar-tracking equipment these observations have been terminated at all stations.

Alongside with radio sounding of the atmosphere, there were also balloon observations (direction and speed of wind up to height of 12 km) at 9 stations being carried out. Now these observations are not being conducted.

Taking into account the importance of upper air data for weather forecasts and air navigation the following measures are necessary:

- Renewal of radio sounding of the atmosphere in the republic, with perspective expansion of upper air observation network;
- Supply of existing upper air stations with modern equipment and supplies, sufficient for continuation of systematic observations;
- Renewal of balloon observations at aviation meteorological stations.

10.4.4. Actinometrical observation

The network of actinometrical observations is intended for obtaining data about solar irradiation over the territory of the republic.

Out of 5 sites of actinometrical observation, 2 stations are working (Gissar and Kayrakkum). Absence of systematic equipment calibration (that had previously carried out in Crimea and Uzbekistan) potentially reduces the accuracy of actinometrical observations. In connection with change of structural subordination, observational data is not duly processed and simply recorded on paper.

For restoration and development of actinometrical network, with the purposes of more detailed study of solar irradiation it is necessary to:

Calibrate the equipment according to internationally recognized standards at stations currently in use;

Renew the actinometrical observation in the south of the republic (Kurgan-Tube) and at the high-mountain station named after Academic Gorbunov (Fedchenko glacier) with the installation of new equipment;

Create conditions for observational data processing in the Main Administration on hydrometeorology of Tajikistan in cooperation with Main Geophysical Observatory named after Voekov (St. Petersburg, Russian Federation).

10.4.5. Hydrological observation

The hydrological observation network is intended for gathering data about the state of inland water objects. Hydrological data is necessary for studying spatial-temporary regularity of the hydrological cycle; conducting the state account of waters and water inventory; control of water balances and water resources of separate watersheds and the assessment of anthropogenic impacts on the water resources.

In Tajikistan, where 50% of water resources of Central Asia originate, the exact control, analysis and forecast of stream flow is important. The average density of existing gauges on 7 basic river basins makes 0.8 gauges per 1000 sq.km. It is optimum on the rivers Shirkent, Kafirnigan, Zeravshan, Kyzylsu. Low density of river gauges are in the basins of Syrdarya (0.04), Pyanj (0.33), Vakhsh (0.52). In addition, many river gauges within these basins do not operate.

The river gauging network conducts the following types of observations: water level and water discharge, water temperature, ice thickness, chemical composition of water, suspended sediment concentrations, currents and choppiness on lakes and reservoirs.

Until the 1990s, hydrological observation was carried out at 11 stations and 138 river gauges. The hydrological forecasts were made daily, for one decade, for one month, and for vegetation period on 5 river watersheds. A hydrological yearbook was regularly issued. At the end of the 1990s, the number of river gauges and the volume of observations had substantially reduced (tab. 10.2).

Table 10.2.

The number of river gauges

Observation	1975	1980	1985	1990	1995	2001
Planned	104	132	138	138	97	97
Actual	104	132	138	107	61*	89*

S o u r c e : Tajik Met Service (2002)   * - limited programme of observations

In view of the lack of finances, necessary equipment and instruments have not been obtained. Poor computerization does not allow the prompt process of observational data for the composing of hydrological yearbooks. Lack of specialists is a problem too. The last hydrological yearbook was issued in 1991. Yearbooks for the following years are in the process of compilation.

On all operational gauges, the volumes of observation have reduced. The observation of evaporation from water surface is carried out only at one station. Out of 53 automatic water level recorders, only 4 installations operate effectively. 46 river gauges measure water discharge. Hydrological observational data arrives irregularly.

The status of the Kairakkum hydrological observatory (formerly leading scientific and methodical center) has downgraded to a standard gauging station. Observations on the small rivers with a length between 10-25 km have not been conducted for a long time.

For the rehabilitation and development of the hydrological observation network, in the aspect of forecast improvement, enhancing of water resources management and participation in the Global Hydrological Cycle Observing System (HYCOS), the following measures are necessary:

- Feasibility assessment of gauges' location and functionality of hydrological observation network and development of recommendations on improvement;
- Restoration of river gauges that were damaged by floods and other natural disasters, and changing of location of some observational points;
- Renewal of temporarily closed hydrological gauges;
- To pay special attention to hydrological observation points that have a large value for transboundary water resources control and high value of observations for the study of the hydrological cycle of the Aral Sea basin, including flood and stream flow forecasting;
- To get missing equipment and instruments for separate stations, and to ensure their installation and appropriate operation;
- Restoration to full capacity land and aerovisual observations over formation and water content of snow cover in mountains;
- To develop the network of automatic hydrological gauges and early warning systems, especially in river heads that are prone to floods and in remote mountain regions with a stable river channel for steady functioning of equipment;
- To replace equipment of the network by automatic observation instruments, including automatic water level recorders;
- To ensure the steady mechanisms of observational data transfer from gauges to regional stations and further to the Main Administration on Hydrometeorology.

10.4.6. Surface ozone observation

Surface ozone observation in Tajikistan is carried out in Dushanbe and includes the measurements of ozone concentrations in the lower atmosphere. Earlier, observational data were transferred for the verification and processing to Russian Federation. Now, because of absence of finances the data is stored at Dushanbe station as the hand-written tables of observations.

During the last years, surface ozone observation is not carried out because of absence of special tables for data processing, equipment damage and the lack of specialists.

Surface ozone observation represents the large importance for assessing atmospheric air quality and climate change study. In this connection, it is necessary to:

Renew observations at Dushanbe station;

Expand surface ozone observation network, with introduction of new equipment, including stratospheric ozone layer (land observations and TOMS);

Create conditions for computer processing and storage of observational data in the Main administration on hydrometeorology of Tajikistan.

10.4.7. Environmental pollution monitoring

The environmental pollution monitoring center using the data from special stations assesses atmospheric air pollution, surface water quality, soil and radiating conditions. The center provides a lot of organizations with archive, real-time information and forecasts on the state of environmental pollution and its likely consequences, and generalizes observational data in the form of reports and yearbooks. The center informs appropriate ministries and departments about extremely high levels of environmental pollution.

Till the 1990s, surface water pollution monitoring has been carried out on 46 rivers, 6 lakes and 1 reservoir, and the concentration of some 40 organic and inorganic polluting substances have been measured.

From 1994 till 1997, surface water pollution monitoring has not been carried out. From 1998, the observations were renewed and carried out on 21 rivers, with measuring of about 20 polluting components.

Till 1990s, the radiometric observations were carried out on 27 stationary points. Now measurement of gamma and beta activity of fall-out is being carried out at 16 stationary points. The selection of tests of radioactive aerosols, which are falling-out on the surface within a day, is not carried out.

Earlier, the measurements of concentrations of toxic chemicals in soils have been carried out at 25 points. Since 1994, the measurements are not carried out because of failure gas chromatograph, lack of finance for the delivery of tests to laboratory and necessary chemical supplies.

Till 1990, atmospheric air pollution observation has been carried out in 7 cities of Tajikistan on 21 stationary points for 21 harmful substances, including heavy metals. Some 7 air pollution observation points were functioning in Dushanbe, in Tursun-Zade - 3 points, Kurgan-Tube - 3 points, Yavan - 2 points, Kulyab - 1 point, Khujand - 3 points, Sarband - 1 point. Air pollution monitoring on the base of mobile laboratory "Atmosphere-2" has been implemented using the method of emission source monitoring with the purpose of more detailed study of local atmospheric air pollution.

In 1993-1997, the number of observational points and the volume of observation were reduced. Now observation on atmospheric air pollution in the republic is being carried out only in the cities of Dushanbe and Kurgan-Tube on 5 stationary points under the reduced program. The existing devices and equipment have the large deterioration and became morally outdated.

Taking into account the large importance of environmental pollution observation for the control of emissions of greenhouse and other harmful gases, and environmental impact assessment it is necessary to:

Optimize the location of environmental pollution monitoring points;

Restore the extent, volume and quality of environmental pollution monitoring;

Calibrate used devices and equipment and to ensure conformity of data quality to international standards;

Equip the network with a new automated devices, supply materials and spare parts for used devices;

Introduce into the atmospheric air quality monitoring program the measurement of greenhouse gas concentrations and rating intensity of atmospheric air emissions from stationary sources;

Launch CO_2 concentration measurements in mountains at an altitude of 2,000 masl or higher, ensuring maximal remoteness from GHG emissions sources;

Introduce modern methods of environmental pollution forecasting and yearbooks compiling.

10.4.8. Specialized observation

The hydrographic expedition department is carrying out hydrographic research of river basins, special study of various hydrological phenomena and processes (glacier mode, snow cover distribution, river-stream processes, inspection, forecasting and mapping of avalanches, floods phenomena, outburst risk on glacier lakes), snow measuring expeditions in mountains, geodesic activities on glaciers. The forecast of avalanche and flood risk covers the period from December till July. Forecasting methods developed by hydrographic expedition department are used for avalanche warning and possible Medvezhi Glacier shearing movements.

The situation with snow observations in mountains has worsened since 1990 (tab. 10.3). The exact water resources assessment of the region on present time and forecast for prospect cannot be done without it. Annual inventory of avalanches and mudflows is not compiled.

Table 10.3.

Expeditions of hydrographic department

Expeditions	1990	2001
1. Inspection of glaciers (the number)	18-20	3-4
2 (a). Inspection of glacial lakes with outburst risk, land	3-4	0-1
2 (b). Inspection of glacial lakes with outburst risk, aero visual	10-15	0
3. Inspection of avalanches (the number of basins)	15-18	2-3
4. Inspection of mudflows (the number of basins)	10-15	2-3
5. Routing snow surveys (the number of basins)	3-4	2
6. Aero visual observation of snow cover	15-18	2
7. Inspection of remote snow scales	15-18	2-4
8. Inspection of stations and points	8	2
9. Opening of total precipitation gauge	36	0

Source: Tajik Met Service (2002)

The instrumental regular observations of glacier mode, snow cover, floods and avalanches in the aspect of climate change are a basis for development of indicators and improvement of climate change consequences projection.

Restoration and development of the specialized observations requires:

Optimization of the system, methods and routes of observations in light of climate change considerations;

Completion of the hydrographic expedition department by specialists and equipping of the department with modern tools of measurements, expedition equipment and data processing systems;

Restoration the extent and volume of snow cover observations with regard to its formation and water content, including land, aerovisual and satellite methods;

Development of observation system on a glaciers mode and dynamics;

Renewal of observations on glacial lakes and objects with outburst risk;

Improvement of mudflow and avalanche observation and forecasting.

10.5. The system of data collection, processing, dissemination, and measures for improvement

The system of data gathering, processing and distribution is a basis for weather forecasts, dangerous hydrometeorological phenomena warnings and planning of measures in national economy, especially in the conditions of climate change. Therefore, accuracy, efficiency, completeness and format of information are the important factors for effective implementation of measures that indicated in the National Action Plan for Climate Change Mitigation.

10.5.1. Data collection, transmitting and regional exchange

The long-term practice of gathering and distribution of real-time hydrometeorological information has generated a sustainable system that takes into account geographical features and an existing level of telecommunication systems development. For the transfer of hydrometeorological information, stations and observation points depending on local conditions are equipped with various communication facilities: telephone, telegraph, radio. In addition, hydrometeorological service exchanges the information coming from stations and points of the Ministry of Water Economy and Ministry of Energy.

The interconnection method is used for the hydrological information gathering. The regional stations carry out the gathering of the reports from the river gauges within the appropriate region by an own communication facility, and completed reports are transferred further in the format of bulletin through the Ministry of Communications of Tajikistan.

The observation automation level in Tajikistan is low. Observers measure most parameters (hydrological and meteorological) manually with the further recording in special book. Then, the data is coded and transferred by communication facilities to the center of information processing (fig. 10.2).

The communication center ensures the operations of the automated system of data transfer and engaged in gathering and distribution of hydrometeorological information in the zone of its responsibility.

The gathering and distribution of hydrometeorological information is carried out through the Ministry of Communications using telephone, telegraph and radio communications. Tajikistan is connected to the main meteorological telecommunications network through the regional center in Tashkent and the World Data Center in Moscow, however the channel speed is very low.

The network of international and regional hydrometeorological information exchange includes 25 stations (SYNOP, CLIMATE, HYDRO). The reception of weather maps is done by the system TV-INFORM-METEO, which does not function now in a view of high cost. Therefore, the Internet is being used as an alternative option. The observational data from neighbouring countries comes through the World Data Center in Moscow.

Tajik Met Service in Dushanbe carries out regular 24/7 receptions, primary processing and synoptic interpretation of analog information from polar-orbital satellites such as NOAA and geostationary satellite such as METEOSAT. The images from METEOSAT are represented as photosnapshots. Tajik Met Service uses the results of synoptic interpretation of satellite information for support of atmospheric processes synoptic analysis and weather forecasts.

The radio communication equipment now has became out-of-date and do not provide a necessary level of information interchange.

The stations that transmit the information through telephone lines, experience difficulties in view of damage of communication lines and disconnects as a result of debts.

The basic problems of existing data gathering system are high cost for transfer of the telegrams, plenty of mistakes during preparation and transfer of telegrams from stations, absence of the feedback with significant number of stations and gauges.

Alternative of existing data gathering system is the transition to new computer technologies that will allow automating data gathering process. It is essential to lower its cost and to improve data quality within the time. For this purpose, it is required to:

- Ensure repair and restoration of operation of existing information transfer means throughout the observation network;
- Pay special attention to those stations and gauges which are included in regional and global observation networks and to ensure computer-aided reception-transmitting equipment and to create stable channels of communication;
- Establish in the central communication center the computer-aided meteorological telecommunication system that provides automatic gathering, verification and distribution of the meteorological information, both inside republic, and in the regional and world meteorological telecommunications centers;
- Ensure the system autonomy of transfer and information interchange;
- Install the satellite system of high-resolution picture transmission (HRPT), with the purpose of the increase of weather forecasts reliability and completeness, monitoring of environmental pollution, snow stocks assessment, observation of vegetation, water resources and glaciers dynamics.

10.5.2. Data processing

Before, the mechanized data processing and spatial control were carried out in the Central Asian Regional Computer Center in Tashkent. Since 1997, with infringement of interdepartmental connections all observational material is unprocessed and is stored on paper carriers. The absence of automatic data processing and control now is one of the complex problems that require paramount decisions.

Practically all observation materials are being processed manually, and only small portion is entered onto electronic carriers. Therefore, there is a large delay in publication of meteorological and hydrological yearbooks.

The storage conditions on paper carriers in hydrometeorological library correspond a little to established requirements, and there is a risk of irrevocable loss of observation materials.

The improvement and automation of the system of data processing, control and storage requires:

Introduction of computer-aided system of weather forecasting and stream flow projection on the basis of satellite digital information and land observations, especially in mountain regions.

Supply the Tajik Met Service's specialized departments dealing with information with the computers, networks and software for processing and archiving of observation materials;

Development of hydrometeorological and environmental pollution database with advanced mechanisms of spatial-temporary control and forms of data presentation.

Priority directions are:

a) Improvement of an existing database (DB) on meteorology "CLICOM", including the information on meteorological stations and gauges, air temperature, precipitation, other meteorological parameters, phenomena and extreme values. Integration of "CLICOM" with other software for preparation of meteorological yearbooks. Visualization of meteorological information using GIS-technologies.
b) Improvement of an existing database (DB) on hydrology "Hydromet DB", including the information on hydrological stations and gauges, measured and calculated water discharge, water temperature and other hydrological parameters, phenomena and extreme values. Optimization of "Hydromet DB" for preparation of state water inventory and hydrological statistics. Visualization of hydrological information using GIS-technologies.
c) Development (obtaining) and installation of DB "Snow cover" that include the information on the specialized snow cover observations, precipitation, height of seasonal snow border, water content in snow, etc.
d) Development (obtaining) and installation of DB "Glaciers" that include the information on the catalogue of glaciers, data on aero and satellite photographing of glaciers.
e) Development (obtaining) and installation of DB "Avalanches" that include information on avalanche monitoring stations, measured characteristics of the avalanches throughout the period of instrumental observation.
f) Development (obtaining) and installation of DB "Mudflows" that include information on mudflow risk, the large mudflows passage possibility and historical information about catastrophic floods.
g) Development (obtaining) and installation of DB "Environmental pollution" that include the information on pollution of atmosphere, soil, surface waters, etc.

10.5.3. Data dissemination

The consumers of hydrometeorological and environmental information are:

Mass media and general public;

State authorities;

Energy industries;

Civil aviation;

Rescue services;

Transport;

Agriculture;

Hydropower engineering;

Construction;

Residential services;
Public health services;
Other services.

<u>The consumers are provided with:</u>
Real-time data of systematic observation at stations and gauges;
Meteorological, hydrological, agricultural and special forecasts, and warnings on projected extreme weather events;
Long-term data and hydrometeorological averages.

<u>The ways of data distribution to the consumers:</u>
Daily hydrometeorological bulletin;
Broadcasting of weather forecasts through mass media. Central TV and radio stations broadcast weather forecasts and warnings on extreme weather events;
Data transfer through teletype, telephone, facsimile;
Granting access to the information in a reading room of hydrometeorological library;
Calculations of weather averages and specific data according to consumer orders.

Tajik Met Service prepares weather forecasts for one day, and subsequent 3-5 days, one month. Water level forecasts on basic rivers are being prepared for one decade, month, quarter, and vegetation period (April-October). Agrometeorological forecasts include projections of vegetation phenology and productivity.

Daily hydrometeorological bulletin includes weather forecast for coming day subsequent 3-5 days and warning on possible dangerous hydrometeorological phenomena. Besides, the bulletin includes the data recent hydrometeorological conditions and atmospheric pollution in the main cities of the republic.

Decade agrometeorological and hydrological bulletins and monthly meteorological weather forecasts are being issued.

There are agreements with various departments on data exchange. Altogether, the hydrometeorological center serves 18 governmental organizations. The population is notified on expected weather through mass media, including radio, TV, and press.

Currently, the dissemination of climate change information is basically focussed on scientific research centers and governmental organizations.

The results of weather analysis and forecasts are being distributed through communication channels to the hydrometeorological centers of neighbouring countries.

For increasing the efficiency of distribution of hydrometeorological information distribution, it is expedient to switch on commercial data use and to considerably expand the use of computers for electronic data distribution, including Internet.

10.6. Human resources and measures for improvement

Impoverishment of hydrometeorological service and severe economic situation in the republic has led to the leaving of many professionals and absence of young specialists. For the last decade, almost all staff has been completely renewed. At present time, there are a lot of vacancies that adversely affect the status of hydrometeorological observations in Tajikistan.

Now there is a crucial question on the preparation of professionals. At Tajik State National University the chair of meteorology is organized, however because of weak technical base there is no opportunity of preparation of professionals in agrometeorology, actinometrical observation, upper air observation, and radio transmission.

In the Main Administration on hydrometeorology, there is deficiency of specialists in weather forecasting, hydrology, agrometeorology, and PC operators. Availability of personnel on the observation network cause certain concern. Many observers at stations have no special education, for the chiefs of stations within several years the workshops and courses of improvement of qualification were not carried out. There are large difficulties in the training of specialists in agrometeorology and upper air observation.

In general, the completeness of staff makes 64%. The completeness of engineering personnel in hydrometeorology makes 37%, in meteorology - 64 %, in hydrology - 67%, in chemistry - 48%, in communications - 81%. Few employees have no special education. However, retraining and improvement of professional skills of experts on the base of the Tajik Met Service, specialized centers of Russian Federation and Central Asia are being carried out at possible extent.

For the strengthening human potential, it is necessary to train the specialists (synoptic, hydrologists, climatologists) in hydrometeorological high schools and services abroad. It is necessary to arrange a series of trainings for observers at hydrometeorological stations, to ensure experience exchange and to promote training courses on development and introduction of new forecasting methods, interpretation of digital satellite information, operation of hydrometeorological equipment, enhancing climate change research.

10.7. International cooperation

International cooperation and participation of Tajikistan in regional projects promotes improvement and development observation network.

Tajikistan participates in the regional project on improvement of hydrological observations in the Aral Sea basin.Within the framework of GEF Aral Sea project there are have been rehabilitated and reequipped 6 river gauging stations.

Swiss Mission on Aral Sea helps to develop the methods of hydrological forecasting.Britain Government has given computers with CLICOM software for climate data processing in the frameworks of WMO voluntary cooperation programme. Asian Development Bank has assisted in development of software and hydrological database "Hydromet DB".

In 2002, the first experimental automatic weather station has been installed in Dushanbe with the purpose to assessment the efficiency of automatic weather observations in Tajikistan. The station has been granted by USAID Central Asia environment project.

The research on climate change and preparation of First National Communication has been carried out with GEF support.

Within the framework of international cooperation there are have been research on relationship between climatic factors, desertification processes and flood formation.

Hydrologists have attended the trainings on hydrological forecasting and data processing. The experts from Russian Hydrometeorological Service have conducted the trainings on the use of CLICOM software, courses of the improvement of qualification for weather forecasters. The young experts are sent to study at meteorological high schools of Russia.

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11 Enhancing the Education System, Training of Specialists and Raising Public Awareness on the Problem of Climate Change and Its Adverse Consequences

11.1. Introduction

The increase of public awareness and enhancement of knowledge on climate change problems, anthropogenic pressures on the climatic system and its adverse consequences, has great value for increasing the efficiency of NAP implementation and the development of new state policy directions in the area of climate change.

The development and implementation of measures aimed at education and public awareness on climate change problems, improvement of public access to information on climate change, training of scientific, technical and managerial personnel are important national commitments to the UNFCCC (Article 6).

In the long term, it is required to develop an appropriate program based on an in-depth study of the national needs to improve the existing system of ecological education, and raising public awareness on climate change.

11.2. System of education and access to knowledge

The education system of the Republic of Tajikistan has a public character and is carried out by specially authorized state departments.

The education system includes preschool and out of school educational entities, primary, secondary and high schools, lyceums, gymnasia, technical colleges, technical schools, universities, and also institutes and other postgraduate education centers (improvement of professional skills), masters and doctorate studies.

In the republic there is an advanced network of educational entities, however the potential of pedagogical staff, the financing of education and deterioration of the logistical base do not promote adequate knowledge acquisition in some areas of the republic.

With the purpose of enhancing ecological education and raising public awareness, the "State program on ecological education and public awareness in the Republic of Tajikistan to the year 2010" was launched in 1996. This program is based on state policy in the category of ecological education and is aimed at forming public ecological thinking, and the active social position of citizens as environmental defenders (fig. 11.1).

In courses at comprehensive schools, there are educational subjects in which the conditions of climate formation, basic climatic factors and their value for natural resources are considered. In the high school curriculum, a course on ecology and environmental protection is provided, and separate subjects include climate studies, synoptic meteorology, glaciology, hydrology, agricultural meteorology, general hygiene, ecology of transport etc. However, in these subjects the questions related to the problem of anthropogenic pressures on the climate and adverse consequences of climate change are notconsidered.

11.3. Mass media

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

Press, radio and TV are the basic mass media in the republic. Some 259 printed editions are registered in the republic, including 20 countrywide editions, out of which 85 are published regularly. The separate editions dealing with ecological issues include the ecological bulletin of the Ministry for Nature Protection, the newspaper "Navruzi Vatan", and newsletters by ecological NGOs.

The national broadcasting has three channels; transmissions from the neighboring countries also are received everywhere. On the radio, climate change issues started to be reflected with the beginning of the preparation of the First National Communication and National Action Plan for Climate Change Mitigation. The leading experts and scientists of the republic were interviewed on the radio on emerging subjects.

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

Nevertheless, climate change problems in mass media are propagandized in insufficient volume, and that is a direct consequence of the lack of appropriate information and misunderstanding of the urgency of this problem.

In spite of the fact that environmental protection topics are periodically covered in the mass media, the population of the republic is insufficiently informed on climate change problems. This circumstance breaks the process of public involvement in climate change mitigation and prevents access to reliable information about climate change.

11.4. Internet

Access to the Internet in the republic is rather limited. Internet network users number about 2 thousand in Tajikistan with dial-up and dedicated access.

The limited number of users is caused by technical difficulties and high installation and use costs. However, the formation of new Internet companies has promoted the improvement of access to the global network and the decrease of service costs.

The distribution of ecological information, including climate change, using the Internet resources is a major element in providing access for the global community to information about Tajikistan's circumstances and exchange of knowledge.

For the first time, the electronic version of the report about the state of the environment in the Republic of Tajikistan was launched on the Internet in 1998. Cooperation with leading international organizations on environmental protection, including UNEP, allowed the creation of more satisfactory and effective digital information products:

The electronic version of the report "Vital maps and graphics on the environment and climate change in the Republic of Tajikistan" in support of the National Action Plan (http://www.grida.no/enrin/htmls/tadjik/vitalgraphics/eng/index.htm)

The electronic version of the report "The state of the environment in the Republic of Tajikistan in 2000" includes information on the state of climate, water and land resources, biodiversity, ozone layer, anthropogenic pressures and response measures (http://www.grida.no/enrin/htmls/tadjik/soe2/eng/)

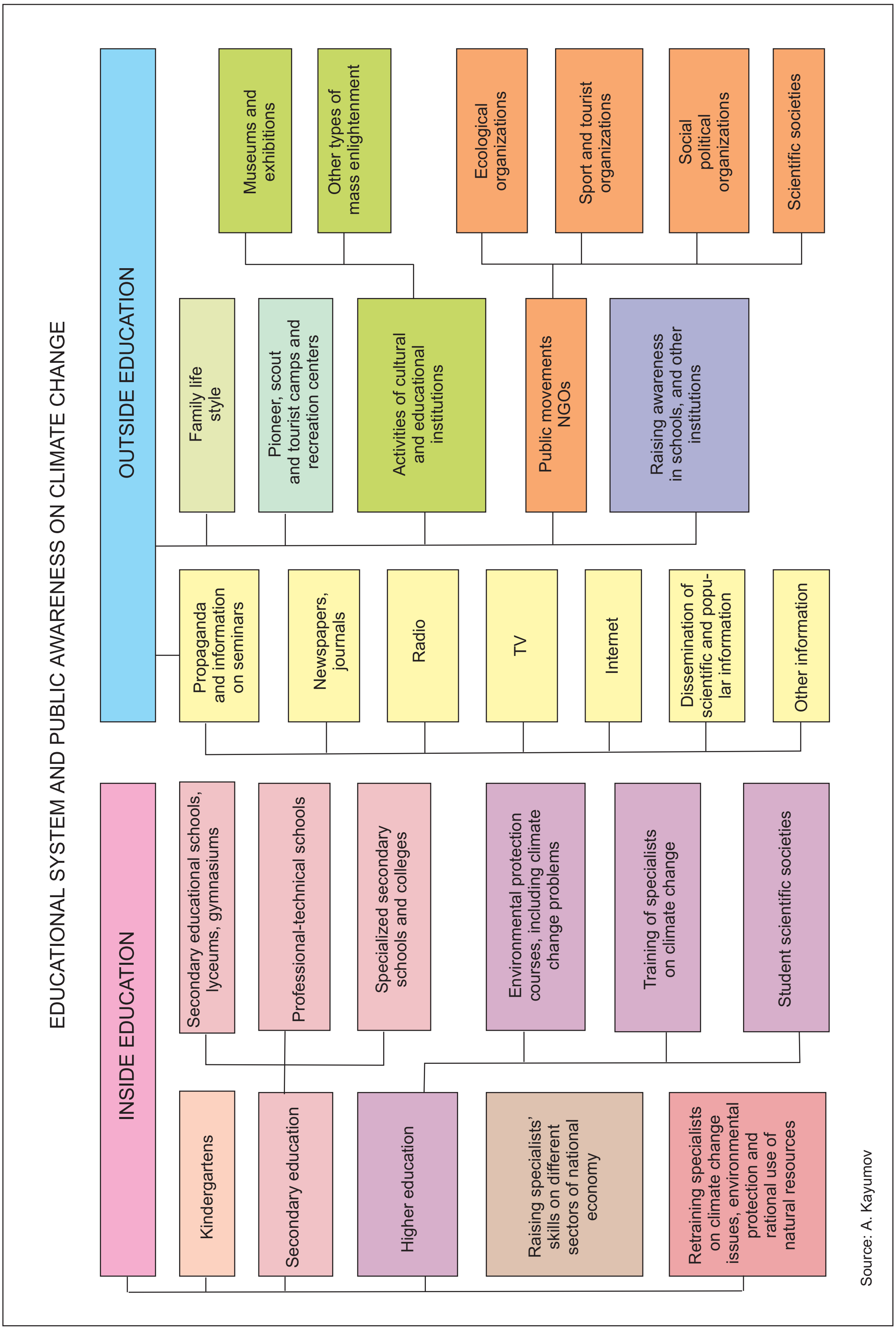
EDUCATIONAL SYSTEM AND PUBLIC AWARENESS ON CLIMATE CHANGE
INSIDE EDUCATION
OUTSIDE EDUCATION
Kindergartens
Secondary education
Higher education
Raising specialists' skills on different sectors of national economy
Retraining specialists on climate change issues, environmental protection and rational use of natural resources
Secondary educational schools, lyceums, gymnasiums
Professional-technical schools
Specialized secondary schools and colleges
Environmental protection courses, including climate change problems
Training of specialists on climate change
Student scientific societies
Propaganda and information on seminars
Newspapers, journals
Radio
TV
Internet
Dissemination of scientific and popu-lar information
Other information
Family life style
Pioneer, scout and tourist camps and recreation centers
Activities of cultural and educational institutions
Public movements NGOs
Raising awareness in schools, and other institutions
Museums and exhibitions
Other types of mass enlightenment
Ecological organizations
Sport and tourist organizations
Social political organizations
Scientific societies
Source: A. Kayumov

Fig. 11.1.

Ecological information about Dushanbe, including climate change, atmospheric air quality (http://www.ceroi.net/reports/dushanbe/eng/index.htm).

The Tajik Met Service has developed electronic versions of the reports about climatic anomalies in the Republic of Tajikistan in 2000 and data on long-term meteorological observations on GCOS stations in Tajikistan. The materials of national workshops on climate change were recorded on electronic disks.

11.5. Public ecological movement and organizations

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

At present there are about 40 ecological NGOs in Tajikistan. Some of them are engaged in ecological education and public awareness; other NGOs implement nature protection projects. The efforts of public organizations are targeting the clearing of ecologically vulnerable territories, the improvement of the sanitary urban state, tree planting, and the realization of demonstration projects on renewable energies etc.

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

11.6. Scientific research and publications on climate change

Scientific research on climate change is not only the basis for the formation of knowledge, but also for policy-making and public opinion.

The activity of research organizations has promoted in-depth study of nature-climatic conditions of Tajikistan and edition of a number of fundamental publications.

In the period of 1960-1980, the climate directory of Tajikistan, the atlas of Tajikistan, with maps and graphics of climatic conditions, monographies and collections of scientific research were issued.

The publications on ecological problems provide:

- The scientific bases, in which the new scientific achievements and results are stated;
- Monitoring data, including information about the state of the environment and related trends;
- Data about negative impacts on the environment, technologies for the reduction of harmful emissions into the atmosphere;
- Reports of scientific conferences and workshops

The analysis of publications by types has shown that the greatest number of publications (60%) are devoted to scientific researches on ecological problems, 25% of publications include monitoring data.

Some publications reflect the regularities of climatic conditions formation and hydrometeorological phenomena over the territory of the republic and Central Asian region; other publications characterize the dynamics of water resources, glaciation and their linkages with climatic factors. The publications about harmful substance emissions are connected with the analysis of their impacts on natural resources and public health.

However the climate change problem, in its contemporary understanding, is not considered in almost all publications. Modifications in the climate directories, methodical manuals, cartographical production is required. There are new opportunities for the study of the climate change problem, using computer-aided models, and international methodologies issued by IPCC and UNEP.

The growth of the number of publications in 2000-2002 was a direct result of conducting scientific researches on the climate change problem, arranging workshops, conferences etc.

Since the beginning of the preparation of the First National Communication and National Action Plan on Climate Change, it was possible to carry out purposeful scientific research and analysis of anthropogenic impacts on the climate change. Within this framework, national experts and scientists have prepared an inventory of GHG emissions and conducted the vulnerability assessment to climate change; a summary and collection of the reports about climate change, the monography "Climate change and its impacts on human health" have been published. More than 150 maps and graphics on various aspects of climate change in Tajikistan have been prepared.

11.7. Public awareness on climate change

In the course of the National Action Plan preparation, workshops with participation of government, scientists, and representatives from regions, mass media and NGOs have been dedicated to various aspects of the climate change problem. The workshops have promoted the creation of uniform opinion on the importance of the climate change problem and its adverse consequences for the republic and world community.

At governmental level a better understanding of the climate change problem has allowed the creation of preconditions for the integration of this problem into policy planning, and at public level this has promoted the creation of a good basis for the realization of accepted measures.

A series of public awareness assessments were conducted in the period from October 2000 till March 2002. The representatives of republican regions, people of various ages and occupations took part in interviews.

The analysis of assessment results shows that the population is insufficiently informed on climate change problems. First of all, it concerns the anthropogenic pressures on the climate system, climate change trends and its adverse consequences.

<u>Such a situation is conditioned by several factors:</u>

- Information on climate change is covered insufficiently in the mass-media and public organizations in view of the novelty of this problem for Tajikistan;
- There are no subjects about climate change and anthropogenic pressures on the climate system in the school and high school curriculum;
- The middle management (heads of local governments, enterprises) is insufficiently informed on the climate change problem;
- Popular brochures and books on the subject are not being published, and the Internet is still inaccessible to the majority of the population.

11.8. Enhancement of the education system, training of specialists and raising public awareness on climate change and its adverse consequences

The basis for effective implementation of the National Action Plan is the support and understanding of climate change by decision-making officials, scientists and the general public. In this area, training of personnel and public awareness on climate change are paramount. Such measures can be implemented on the basis of the existing education system and mass-media, and also through the creation of new structures.

11.8.1. Legal issues

In 1996, the government of Tajikistan developed the "State program of ecological education and public awareness in the Republic of Tajikistan to the year 2010".

However, in this document the raising of public awareness on climate change is not stipulated. In the mass media and the educational system, the climate change problem is not sufficiently covered.

For the creation of a basis for effective implementation of measures, it is necessary to accept the legislative acts for propagation and improvement of public awareness on climate change, reduction of GHG emissions and adaptation to climate change through the Ministry of Education, the mass-media, local governments and enterprises.

11.8.2. Institutional frameworks and interdepartmental cooperation

For gathering, analysis and distribution of the climate change information on national and international levels, and effective implementation of the National Action Plan, the establishment of an Information Center on Climate Change and the designation of a national focal point for the implementation of Article 6 UNFCCC are necessary.

<u>The basic tasks of such a center would include:</u>

- The gathering and analysis of the best available national and international data on climate change, consequences of these changes, and measures for the prevention of the adverse effects of climate change and providing adequate adaptation;
- The development of a directory of organizations and persons engaged in the implementation of Article 6 UNFCCC, and strengthening partnerships;
- Informing the state authorities and public about the latest results of scientific research on climate change issues;
- Methodical support of activities by ministries, departments and mass-media on the development of educational programs, publication of educational and information materials on climate change;
- Assistance in preparation of scientific personnel through graduate and postgraduate studies on climate change;
- Conducting training and workshops for educational institutions, mass media and heads of local governments and industries on climate change problems, including measures on GHG emission reduction and adaptation;

It is expedient to disseminate knowledge in the area of climate change on the basis of the existing educational system, the mass-media, local governments and industries. The sources of knowledge are the information center, the Main Administration on Hydrometeorology of the Ministry for Nature Protection, the Academy of Sciences, high schools, research institutes, etc. The Ministry of Education prepares the educational curriculum, and the educational institutions introduce them in the process of training; mass-media issues publications and popular radio and television programmes. The local governments and enterprises carry out thematic workshops on climate change.

11.8.3. Enhancement of the education system and training

The key factor in the improvement of climate change coverage in the education system is the preparation and retraining of school and high schools teachers, and inclusion in the appropriate educational curriculum aspects of climate change, i.e. anthropogenic impacts on the climatic system and their consequences for natural resources, the economy and the population.

<u>The basic measures on the improvement of the education system and the training of personnel in the areas related to climate change, include:</u>

- Development of educational materials, retraining of professional staff, and conducting of workshops for teaching staff at universities and colleges on the climate change problem;
- Development of the curriculum for schools and high schools with the purpose of the introduction of climate change issues in educational plans;
- Inclusion of a brief description of processes resulting in climatic changes and their consequences into secondary school and high school courses on ecology, physics, chemistry, geography, biology, hygiene;
- Inclusion of the description of the economic consequences of climate change, assessment of economic damage from natural disasters and the analysis of cost-efficiency of the projects and measures on GHG emission reduction and adaptation into the courses on economy at universities;
- Introduction at the meteorological faculty of special courses focusing on the study of natural and anthropogenic processes influencing the climatic system, indicators of climate change and methods of climate projection using computer models and instrumental research;
- Development and publishing of study materials on climate change problems at physics-technical, geographical, medical, agricultural and economic faculties of universities;
- Development of visual educational materials, posters and slide presentations aimed at the popular explanation of the climatic system and greenhouse effect, natural and anthropogenic impacts on the climate, and the consequences of climatic changes;
- Preparation and distribution of study materials on climate change for voluntary follow-up study at schools and universities;

11.8.4. Informing communities and the mass-media

Reliable information on climate change covered in the mass-media is aimed at the improvement of public understanding in view of the urgency of the climate change problem, so as to support the implementation of measures on reduction of GHG emissions and adaptation.

<u>The measures targeting the propagation of climate change problem in mass-media and public awareness include:</u>

- Conducting workshops for the mass-media on methods of popularization of scientific knowledge and effective forms of dissemination of information on climate change;

- Development of radio and television programmes about the reasons for global climate change, observed and expected consequences of climate changes, sources of anthropogenic pressures on the climatic system and measures on GHG emission reduction and adaptation;
- Cooperation with international organizations and assistance in preparation of the information for the Internet, enabling public access to the World Wide Web;
- Popular publications on climate change in republican and local newspapers;
- Popular lectures and workshops at industrial enterprises about the reasons and consequences of climatic changes, the role of industry in the deterioration of the ecology and climate and mitigation measures;
- Arranging workshops and round tables for the heads of local governments (khukumats, jamoats) and other local authorities on climate change and concrete measures, which are specified in the National Action Plan and can be successfully implemented in local conditions for climate change mitigation, including the use of renewable energies, vehicle emissions reduction, prevention of forest cuttings and promotion to rational use of natural resources;
- Publication and distribution of brochures covering aspects of climate change problems and measures for climate change mitigation, including the translation of international information to local languages;
- Conducting activities on public awareness in the regions, attracting the meteorological stations staff and local governments for popular explanation of climate change problem, and measures promoting the reduction of anthropogenic pressure on the climate in local conditions, with the emphasis on the application of renewable energies, the reduction of emissions, and the conservation of forests etc;
- Regular assessment of public awareness on climate change aimed at an evaluation of the efficiency of undertaken measures on public awareness and the development of additional measures.

Non-governmental public organizations can promote the improvement of public awareness through:

- Cooperation with governmental departments on the implementation of the National Action Plan for Climate Change Mitigation;
- The development and use of interactive methods in the education of young people on climate change issues, and youth participation in planning, and the development and implementation of measures;
- Arranging thematic workshops and round tables on climate change, with the participation of leading experts and the scientific community.

12 Preparation of the National Greenhouse Gas Inventory

12.1. State statistical reporting used in the preparation of GHG inventory, and existing constraints

At present, there are 237 forms for statistical reporting on all sectors of the national economy in the republic. The periodicity, timeframes and forms of state statistical reporting are affirmed and financed by the Government of the Republic of Tajikistan.

The republic operates the system of environmental reporting at state and departmental levels. The Governmental Order N°500, December 29, 2000 authorizes appropriate forms of statistical reporting.

The State Statistical Committee, the Ministry for Nature Protection and its structural divisions are the basic owners of environmental data.

Form 2-KS provides data on capital investment into environmental protection and rational use of natural resources. This form contains information on specific measures to be implemented by planned or existing businesses.

Reporting form 2-TP-air (atmospheric air protection) provides information on emissions from industrial enterprises, energy and transport. It is prepared annually by the ministries and departments of the republic and contains data on stationary sources of air pollution, quantity of caught, utilized and released polluting substance emissions into the atmospheric air. The national methodology of emission calculation is different from the international one; thus, the data on the volume and composition of emissions are strongly underestimated. The reporting does not contain the data on GHG emissions. Also, there are no data on mobile sources of pollution, including motor vehicles.

Reporting form 2-TP-water (water resources protection) provides information on the use of water resources, and discharges of wastewater from industrial enterprises and households. Since 1996, the given reporting has not been compiled.

In the energy sector, annual reporting form 6-TP provides information on the functioning of hydro- and thermal power engineering, 23-N (internal) and annual reporting form 24-Energy deals with the electricity balance of the economy, and energy capacities. Fuel and energy balances of Tajikistan have not been compiled for the last 11 years. Forms 3-SN, 4-SN, 11-SN and their annexes cover the issues of fuel stocks in the hands of the consumers and suppliers, fuel remainders, fuel use, thermal energy and electricity. There is also report 1TeP - on thermal energy supply, and 1-GAS - on gaseous fuel.

In the transport sector, annual reporting form 1TRShOS reports on transport operations, and reports 1-KF and 11-SN provide information on fuel use, thermal power and electricity consumption in transport.

In the industrial sector, there are monthly reporting forms 1-P, 3-P, and annual reporting forms 29-APK, 1-KMChP that provide information on industrial production.

Reporting forms 9-Sh and 29-Sh contain data on the application of mineral fertilizers, agricultural crop productivity etc. Reporting forms 24-Sh, and 7-Sh contain data on cattle breeding and cattle inventory. The reporting form on rice cultivation called 7-Sh includes data on the cropland area. Reporting forms 1-zag, 3-zag, 7-zag, 8-zag, 9-zag, 11-zag, and 21-zag provide information on the status of agricultural production manufacturing and cattle breeding. The parameters of the financial status of households, fuel stocks and agricultural machines, and the overall status of farms are reflected in such reporting forms as 8-Sh, 6-mech, 1-farmer, 1-Hn, 2-Hn.

On forest resources there is a monthly reporting form 1-LH "Report on implemented activities", annual reporting form 3-LH "Report on sanitary forest cuttings", 5-LH "Flora and fauna" that deal with the state of flora and fauna in nature protected areas.

Reporting form 4-Sh provides information on land use. Institutional reporting includes information about land resources, their quality, area, and rehabilitation activities.

The inventory of the formation and disposal of solid communal wastes, as well as agricultural wastes is not conducted.

In the course of national GHG inventory preparation for the period 1990-1998, the weakness of the statistical reporting system, particularly the lack of activity data and their accuracy, has been revealed. In all existing reporting forms, there is no information on GHG emissions.

The basic problem of statistical information is the absence of data on energy balance by sectors of energy consumption and by types of fuels. It considerably complicates the preparation of a greenhouse gas inventory in the category "Energy activities" and causes large potential uncertainties in calculations, whereas energy-related activities are the largest source of GHG emissions and its precursors in the republic.

The experts marked the necessity for the improvement of existing statistical reporting, introduction of new or alternative reporting forms to improve the quality of data, and the completeness of GHG inventory in the next stages, and to introduce a regular inventory in accordance with relevant articles of the UN Framework Convention.

In this connection, there is a necessity for the development and implementation of measures aimed at the solution of the above mentioned problems.

The priority directions of measures are recommended by the ministries and departments and included into the National Action Plan. Other measures can be elaborated and implemented in the light of new considerations and needs for the improvement of national and international methodologies for preparation of anthropogenic greenhouse gas emission inventories.

12.2. Regular preparation of the national GHG inventory

In accordance with national commitments to the UN Framework Convention, including the preparation and submission of a GHG inventory for consideration by the Conference of the Parties, the Government intends to implement the following measures:

- To improve the legislation in the area of the preparation of national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases;
- To establish within the existing institutional framework the entity on preparationG of GHG inventory;
- To improve and unify the state statistical reporting system that is used in the course of preparation of the national GHG inventory, within the frameworks of measures indicated in the National Action Plan;

- To find opportunities for adequate application of international GHG inventory methodologies, including their translation to local languages and training of experts on their use;
- To reconsider national methodologies on emission calculation and adapt them in conformity with the IPCC recommendations;
- To develop a database on the sources, volumes and components of greenhouse and other gases emissions in comparable formats;
- To create adequate conditions for selection and attraction of qualified personnel on relevant sectors of the inventory;
- To ensure a necessary level of financing the activities related to the process of inventory preparation;
- To train and retrain the personnel, and arrange the exchange of experience to improve the quality of the inventory.

12.3. Study of local emission factors

In the course of the national GHG inventory preparation, the experts have revealed some discrepancies in regional emission factors recommended by IPCC for separate sectors that influence the quality of the inventory and its international comparability.

In Tajikistan, the research and inventory of greenhouse gas emissions by sources and removal by sinks has not been carried out before. In this connection, a few potentially high uncertainties on emission factors exist.

The following measures can be determined for the initial study of local emission factors:

- Scientific research on natural and anthropogenic processes influencing GHG emissions;
- Instrumental monitoring of GHG emissions, especially large emission sources;
- Expert assessments of local emission factors and international cooperation for unification of the inventory results with regional data.

Priority sectors for the study of local emission factors are:

a. Aluminum production (perfluorocarbon emissions);
b. Transport (GHG emissions and its precursors);
c. Cattle breeding (intestinal fermentation and manure management);
d. Plant growing (agricultural soils and rice cultivation);
e. Forestry (change of carbon stocks in forests and other woody biomass);
f. Land use (change of carbon stocks in soils);
g. Waste (solid communal waste and wastewaters);
h. Oil and gas systems and coal production (fugitive emissions).

12.4. Collection of information on response measures

At the present stage, the national inventory of anthropogenic emissions by sources and removal by sinks of greenhouse gases does not include information on the response measures aimed at the reduction of polluting substance emissions into the atmosphere. This is caused by a few objective factors:

- Absence of rationale and the lack of experience in gathering and assessment of such information, which is worsened by the formerly existing system of emission inventories;

- Absence of uniform format, rules, procedures and a system of communication about response measures;
- Absence of a coordinating body and institutional base for gathering and analysing the appropriate information;
- Lack of economic interest at ministerial, departmental and private sector levels in communication about response measures on GHG emission reduction.

Taking into account the importance of information on response measures, which is required for policy planning and preparation of subsequent National Communications on climate change it is necessary:

- To develop a consistent format, rules and procedures of communication of information about response measures on GHG emission reduction with respect to national circumstances and relevant COP decisions;
- To create a competent coordinating body responsible for gathering and analysing such information and disseminating it;
- To develop a system of provision of economic incentives to the ministries and departments that declare their response measures on GHG emission reduction in accordance with a consistent format, rules and procedures;
- To oblige the ministries and departments to declare, according to the consistent format, rules and procedures, their response measures on GHG emission reduction;
- To take into consideration the efficiency of GHG emission reduction measures already undertaken in the course of the preparation of national inventory and the development of GHG emission scenarios.

12.5. Solving the problem of comparability and improving data quality

Expert analysis shows that in the existing practice of national GHG inventory compilation, there are problems of data comparability, including statistical reporting, in respect of the distinction of units of measurement and translation factors.

The important condition for national GHG inventory preparation is the high quality data utilization. Some initial data contain factors of uncertainty that reach significant values and influence inventory results. It requires further specification and submission of information about uncertainty factors for initial data.

For the improvement of initial data quality and their comparability at state and departmental statistical reporting levels it is necessary:

To unify the units of measurement and translation factors, according to the IPCC recommendations, to the extent the framework of national legislation allow;

At all levels of initial data gathering to estimate their quality and reliability, with the application of mathematical analysis methods;

To ensure high accuracy of data processing and an adequate level of their final presentation;

To take into account specific needs of the regions for material maintenance and the financing of activity related to the initial data gathering and analysis, considering the economic circumstances and their geographical positioning;

To increase a level of expert proficiency in terms of initial data gathering, reliability and primary analysis.

12.6. Regional exchange of information and collaboration with world data centers

The comparison of national GHG inventory results with international information sources shows the distinction of characteristic quantitative parameters of emissions and the scope of considered sectors. It is caused by:

- The use of various information sources, which are more aggregated at international level;
- Not complete scope of categories of greenhouse gas emissions and removals;
- Application of local emission factors, which do not coincide with regional and other factors, recommended by IPCC.

For ensuring the uniformity of methodological approach, the use of adequate information sources and best national inventory data comparability with the world data centers, the implementation of the following measures is expedient:

- Improvement of regional information exchange with national centers on climate change engaged in GHG inventory preparation, and the development of dialogue between the experts in appropriate sectors;
- Submission of inventory updates and new data on GHG emissions to the UNFCCC Secretariat in a compatible electronic format, recommended by IPCC for the Parties not included in Annex I of the Convention;
- Strengthening cooperation with world data centers, such as the UNFCCC Secretariat, the International Energy Agency, the World Resources Institute, the Carbon Dioxide Information Analysis Center, on issues representing mutual interests;
- The training of national experts at the world data centers engaged in the preparation of the GHG inventories.

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ANNEXES

Annex 1.

Matrix of measures

The measures of the National Action Plan for Climate Change Mitigation are focused on the state level of implementation with regard to relevant sectors and regions. These measures are aimed at fulfillment of the UN Framework Convention on Climate Change in Tajikistan to support sustainable development of the country.

The matrix represents institutional and organizational frameworks for implementation of measures identified in the National Action Plan for Climate Change Mitigation, and mainly includes activities on strengthening of potential in appropriate sectors and technical measures.

The measures which do not have a direct effect, from the point of view of climate change mitigation, but have a potential for improvement of climate change processes understanding, development of systematic observations, public awareness raising and GHG emission inventory are represented as conceptual directions of measures in the National Action Plan.

The matrix consists of two parts: (1) Measures on GHG emissions reduction and improvement of the state of carbon natural sinks, and (2) Measures on adaptation to climate change and prevention (minimization) of its adverse consequences.

Matrix's measures are selected on the basis of priorities developed by the national experts, in accordance with IPCC methodological documents and decisions of the CoP UNFCCC. The priorities primarily take into account cost-efficiency, potential of GHG emissions reduction (carbon removal) or improvement of considered object's or sector's adaptation capacities. The industrial, socio-economic and ecological benefits are the important indicators of measures outputs.

The measures identified in the matrix are numbered according to a sequence of the appropriate sections of the National Action Plan; the identifiers of sectors (WR, EN, etc.) are placed, in which the implementation of measures is planned; the numerical indexes (1,2,3 etc.) reflect the type of measures. The abbreviation is mentioned below.

The structure of the matrix includes section "Measure name", where the basic direction or rationale of the measure is specified; section "Measure description and composition" defines the basic stages and kinds of activity within the framework of the given measure. Section "Expected results" represents the balance of outputs, which can be drawn from measure implementation, including direct effect and accompanying benefits. Section "Financing and performance" specifies the potential sources and financing mechanisms for implementation of measure, including (i) budgetary sources, (ii) off-budget funds on nature protection, (iii) technology transfer and investments, (iv) international financial mechanisms on UNFCCC implementation, and (v) internal resources and voluntary obligations.

Depending on authorities and functions of state entities and/or other businesses, in section "Executive authorities" a set of organizations is determined, which assigned to implement and/or assess efficiency of National Action Plan measures.

Timeframes for measure implementation depends on an urgency of measure, availability of necessary resources and volume of measure. The first stage of implementation of Tajikistan's commitments on the UN Framework Convention is limited by the year 2010. While identifying the timeframes of measures, developers of National Action Plan recognized that in the light of new findings in relevant scientific, technical and economic areas, the need for improvement of measures and elaboration of new measures would emerge.

Abbreviation and indexes used in the matrix of measures of the National Action Plan for Climate Change Mitigation:

Type of measures:

1 - Regulation;

2 - Technical;

3 - Training;

4 - Demonstration;

5 - Voluntary obligation;

6 - Research;

7 - Complex;

8 - Information;

9 - Cross-sectoral.

Financing and Performance:

I - budgetary sources;

ii - off-budget funds on nature protection;

iii - technology transfer and investments;

iv - international financial mechanisms on UNFCCC implementation;

v - internal resources.

Sectors, in which greenhouse gas reduction and enhancing of carbon natural sinks is planned:

EN - Heat power engineering and electricity production;

OG - Oil and gas systems;

CO - Coal mining;

MIC - Manufacturing industry and construction;

TR - Transport;

RI - Residential and Institutional Sectors;

AG - Agriculture;

LUF - Land Use Change and Forestry;

WS - Waste Disposal;

RE - Renewable Energies;

Sectors, in which adaptation to climate change and prevention (minimization) its adverse consequences is planned:

WR - Surface water resources;
LR - Land resources and desertification;
AG - Agriculture;
WE - Water economy;
HP - Hydropower engineering;
ECO - Ecosystems;
TR - Transport infrastructure;
PH - Public Health;
EWE - Extreme Weather Events.

(1) Measures on greenhouse gas emissions reduction and improvement of the state of carbon natural sinks

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
1	*	9	Revising of existing policy and measures aimed at prevention of air pollution and improvement of air quality control for climate change mitigation	Improvement of existing and development of new legal bases in relevant sectors, including energy, transport, industry, agriculture, forestry and waste disposal for the support of UNFCCC implementation in Tajikistan. Development of greenhouse gas emissions control and rationing system, and assessment of carbon removal and accumulation by natural sinks. Expansion of EIA and ecological examination application. Assessment of air protection efficiency and drawing of baselines for large emissions sources. Introduction of the system of payments for greenhouse gas emissions and penalties for above permitted emissions.	The basis for effective realization of policy and measures for climate change mitigation	i, v	2002-2005	Parliament Ministry for Nature Protection Other ministries
2	*	1,9	Creation of conditions for joining the Kyoto Protocol and its subsequent implementation	Informing the Tajik Government, relevant ministries and departments about the expediency of joining the Kyoto Protocol. Realization of preparatory action on adoption of Kyoto Protocol. Acceptance of appropriate legislative documents related to transfer of reduced volumes of emissions. Creation of institutional base for registration and realization of projects related to greenhouse gas emission reductions. Information exchange between private and/or state subjects on issues related to investment attraction and CDM projects realization.	Joining Kyoto Protocol, attracting investments and realization of CDM projects	i, iv, v	2002-2005	Parliament Ministry of Economy Ministry for Nature Protection
3	EN	2	Development of capacities on hydroelectricity production	Construction of new large, medium and small hydropower plants. Rehabilitation of units at operational large and small hydroelectric power plants.	Significant potential GHG emission reduction	i, iii, v	2003-2010	Ministry of Energy Hydro Energy Institute Company "Barki Tojik" Ministry of Industry

Nº	Sector	Type of measure	Measure name	Measure description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
4	EN	2	Optimization of electricity transmission networks	Reconstruction and improvement of electricity transmission networks, substations, transformers.	Reduction of electricity losses, stability of electricity supply	i, iii, v	2003-2010	Ministry of Energy Company "Barki Tojik" Ministry of Industry
5	EN	2	Heat loss reduction and ensuring of heat supply stability	Improvement of heating system efficiency and thermal insulation of buildings. Introduction of heat supply independent systems and closed hot water supply circuits.	Saving up to 25-30% energy	i, v	2003-2010	Ministry of Energy Local governments
6	CO	2,6	Promotion to rational methods of coal deposits development	Improvement of ventilation systems at underground coalmines and utilization of the accompanying gas (methane). Increase of coal deposits development by the open way.	Reduction of CH_4 emissions, increase of coal production safety	i, iii, v	2003-2008	Tajikangisht
7	OG	2,6	Improvement of technologies in oil and gas systems	Modernization of the oil storage facilities. Modernization of the flare facilities. Utilization of superfluous pressure and reduction of outflow in the main gas pipelines. Replacement of out-of-date gas distributing equipment.	Reduction of CH_4 emissions, reduction of gas losses, ecological safety of oil and gas pipelines	i, iii, v	2003-2010	Company "Naftrason" Tajik Committee on Oil and Gas
8	OG	2	Increase of gaseous fuel quality	Increase of natural gas clearing efficiency with regard to sulphur containing elements and gas draining, mainly within southern gas fields.	Reduction of sulphur emissions	i, iii, v	2003-2008	Company "Naftrason" Tajik committee on Oil and Gas
9	MIC	8	Capacity building on development and application of new industrial technologies that promote reduction of GHG emissions	Assessment of industry needs in new technologies. Development of database on new industrial technologies. Elimination of barriers for effective implementation of NAP measures and investment (pilot) projects. Creation of system on development and realization of CDM projects and technology transfer. Integration of NAP measures into sectoral development programs.	The basis for planning and effective realization of measures and projects on GHG emission reduction and energy-efficiency	i, iv, v	2002-2005	Tajik Met Service Ministry of Industry
10	MIC	1,8	Introduction and promotion of new industrial technologies.	Creation of economic stimulus on introduction of new industrial technologies. Raising awareness of industrial company managers about technological methods on GHG emissions reduction.	Expeditions introduction of new technologies with small GHG emissions	i, ii, v	2003-2005	Ministry of economy Ministry of industry Tajik Met Service

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
11	MIC	2	Reconstruction of cement production technology at "Tajik Cement" company	Transition from existing technology to dry method of cement production. Replacement of dust filters and gas purification facilities.	Reduction of CO_2 emissions by 300-500 Gg, raw material and energy resources saving, decrease water consumption, GHG emissions reduction and minimization of dust and particles	iii, iv, v	2003-2008	Ministry of Industry "Tajikcement"
12	MIC	2	Reconstruction of ammonia production technology at company "Azot"	Replacement of copper-ammonia converted gas-clearing system by more perfect system. CO_2 utilization in ammonia production for further use in food-processing industry.	Reduction of CO_2 emissions on 300-500 Gg, raw material and energy resources saving, reduction of harmful influence on the environment	iii, iv	2003-2008	Ministry of Industry Joint-Stock Co "Azot"
13	MIC	2	Increase of atmospheric air protection measures efficiency at Tajik Aluminum Plant	Modernization of gas purification facilities and dust filter installations. Installation of protective housings at electrolyzers. Optimization of tree plantations sanitary zone.	Reduction of harmful gas emissions into the atmosphere and their influence on the environment	ii, iii, iv, v	2003-2005	Ministry of Industry Ministry for Nature Protection Tajik Aluminum Plant Academy of Sciences
14	MIC	2	Enhancing of aluminum production technology at Tajik Aluminum Plant	Computerization of electrolysis of prebaked anodes. Development and introduction of aluminum production "know-how" technology using non-carbon anodes (in the mid-term outlook).	Significant PFCs emission reduction, electricity saving	iii, iv, v	2003-2005 2005-2010	Ministry of Industry Academy of Sciences Tajik Aluminum Plant

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
15	MIC	2	Improvement of metal production technologies	Modernization and rising efficiency of ferrous metals melting processes. Introduction of energy saving technologies in ferrous and non-ferrous metals smelting. Replacement of existing cupola furnaces to electrical furnaces in metal smelting industries.	Reduction of CO_2 emissions, energy saving	iii, iv	2003-2010	Ministry of Industry Administration of enterprises
16	MIC	2	Effective energy supply in industry	Use of high efficient electric motors, mechanisms and drives in all industrial sectors. Utilization of heat from technological processes.	Energy resources saving	iii, v	2003-2010	Ministry of Industry Administrations of enterprise
17	TR	1	Introduction and development of “clean transport” program	Analysis of situation by region, transport type and road conditions. Development of measures for control and reduction of greenhouse gas emissions from vehicles. Informing of relevant stakeholders on the program and its introduction.	Reduction of CO_2 emissions from vehicles, improvement of air quality	i, ii, v	2003-2005	Ministry for Nature Protection Ministry of Transport Road Police Inspectorate Transport companies Local governments
18	TR	1,2	Regulation and control of the volume and harmful substance concentrations in exhaust gases	Development of new harmful substance concentration standards by transport types and nature-climatic zones of the republic. Organization and expansion of control points to monitor harmful substance concentration and their equipment with modern gas-analyzers. Licensing of activities dealing with harmful emission adjustments and its wide introduction on the base of maintenance stations and transport enterprises all over the territory of the republic. Wide application of existing harmful substance concentration rationing mechanisms.	Limitation of CO_2 and other pollutant emissions, improvement of air quality, especially in urban areas	i, ii, iv, v	2003-2010	Ministry for Nature Protection Road Police Inspectorate
19	TR	1	Optimization of transport operation	Prohibition of vehicle operation with significant excess of harmful substance concentration standards, especially in ecologically vulnerable and densely populated territories. Rehabilitation of road traffic management automated system in Dushanbe city.	Limitation of CO_2 emissions and reduction of anthropogenic pressure	i, v	2003-2010	Ministry for Nature Protection City governments Road Police Inspectorate
20	TR	2,7	Enhancing of road conditions and road optimization	Increase of paving quality on the main roads. Reduction of road length through the construction of tunnels under mountain passes and new roads.	Significant reduction of GHG and	i, iii, iv	2003-2010	Ministry of Transport Road Police Inspectorate

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				Optimization of cargo and passenger transportation. Removal of freight transportation from the central part of large cities and creation of non-transport zones.	polluting substances emissions, traffic safety, reduction of costs and time of transportation			City governments
21	TR	1,2,5	Improvement of fuel quality	Ensuring of imported fuel ecological control. Introduction of technologies on manufacture of high-quality fuel at local oil refining enterprises. Increase of fuel purification efficiency in terms of sulphur-containing elements.	Reduction of SO_2 and other harmful emissions, engine working resource enlargement	i, iii, v	2003-2010	Ministry for Nature Protection Company «Naftrason» Oil products producers
22	TR	2	Development of electrified types of transport	Electrification of the railway. Expansion of public electrical transport network.	Reduction of ecological pressure	i, iii, v	2003-2010	Ministry of Transport City governments
23	TR	2,6	Development of alternative types of transport	Development and approbation of hybrid vehicles. Development of bicycle manufacturing and creation of appropriate infrastructures (bicycle tracks, parking, service centers, etc.). Creation of economic stimulus for use of alternative types of transport and ensuring the ability of population for their purchase.	Reduction of CO_2 emissions, improvement of urban environment and public health	i, iii, iv	2003-2010	Ministry of Industry Ministry of Transport Road Police Inspectorate
24	RI	2	Rational energy use in residential sector	Installation of gas and other fuel, and electricity monitoring systems. Transition to modern lighting equipment, including luminescent lamps, halogen infra-red lamps, automatic street illumination systems. Improvement of heating, ventilation and conditioning systems. Use of solar and electricity saving water heaters. Development of new energy consumption norms in residential sector.	Reduction of GHG emissions, energy savings, residential and commercial premises comfort improvement	i, iii, iv, v	2003-2008	Tajik gas Ministry of Energy
25	RI	2	New approach in planning, design and construction of residential and commercial	Use of high-tech materials for walls, roofs, windows, heating systems and conditioning for improvement of living comfort in buildings. Application of new architectural typologies in city-planning to mitigate heat waves.	Energy and resources saving, effective utilization of land surface, reduction	i, iii, iv	2003-2010	Committee on Architecture and Construction Ministry of Industry

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
25	RI	2	New approach in planning, design and construction of residential and commercial buildings	Use of high-tech materials for walls, roofs, windows, heating systems and conditioning for improvement of living comfort in buildings. Application of new architectural typologies in city-planning to mitigate heat waves. Orientation of buildings with respect to land surface, sunlight and wind direction for comfort enhancing and energy saving.	Energy and resources saving, effective utilization of land surface, reduction of thermal stress	i, iii, iv	2003-2010	Committee on Architecture and Construction Ministry of Industry
26	AG	7	Capacity building in the introduction and development of know-how, technologies and realization of projects in agriculture that promote GHG emission reduction	Assessment of agriculture needs in new technologies. Development of database on new technologies in agriculture. Elimination of barriers for effective implementation of NAP measures and investment (pilot) projects. Creation of system of development and realization of CDM projects and technology transfer.	Basis for planning and effective realization of measures and projects on GHG emission reduction, energy efficiency	i, iv, v	2002-2005	Tajik Met Service Ministry of Agriculture
27	AG	3,8	Introduction and promotion of new agricultural technologies	Training of farmers and experience exchange on use of new technologies and demonstration of their advantages. Preparation and retraining of experts on progressive technologies in agriculture that reduce GHG emissions.	Adequate skills of experts for introduction of new technologies	i, ii, iv, v	2003-2008	Ministry of Agriculture Tajik Agricultural University
28	AG	2	Recuperation of methane from manure	Transfer (obtaining) of technology, creation and introduction of biogas generators at large cattle-breeding farms.	CH_4 emission reduction, energy co-generation	iii, iv	2003-2010	Ministry of Agriculture Ministry of Industry
29	AG	2	Optimization of cattle breeding and manure storage	Regulation of fodder ration and the number of animals. Construction of typical farms and automation of cleaning, storage and handle of manure. Reconstruction of manure catch-pits.	CH_4 emission reduction, enhancing of cattle breeding productivity, utilization of manure	i, iii, iv, v	2003-2010	Ministry of Agriculture

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
30	AG	2	Improvement of rice cultivation technology	Introduction of rice sorts with smaller vegetation period and high productivity adapted for local soil-climatic conditions. Application of progressive method of transplanting rice cultivation.	Reduction of CH_4 emissions, harvesting two rice crops a year	i, iii, v	2003-2010	Ministry of Agriculture
31	AG	2	Rationalization of nitric fertilizers application methods	Introduction of strip entering of mineral fertilizers. Application of capsulated fertilizers.	Reduction of N_2O emissions, effective use of nitric fertilizers	i, iii	2003-2010	Ministry of Agriculture
32	AG	2	Enhancing of energy efficiency in agriculture	Introduction of pumping stations with smaller energy consumption. Increase of agricultural machine use and fuel use efficiencies. Use of economic stimulus for energy saving and application of renewable energies.	Electric and fuel saving, development of renewable energies	i, iii, v	2003-2010	Ministry of Agriculture Ministry of Water Economy
33	LUF	2	Introduction, development capacity building in technological know-how and realization of projects in forestry	Assessment of forestry needs in new technologies. Development of database on forest resources, forest activities and carbon accumulation potential. Elimination of barriers for effective implementation of NAP measures and investment (pilot) projects. Creation of the system on development and realization of CDM projects. Integration of NAP measures with sectoral development programmes. Training of specialists and experience exchange on introduction of new technologies that promote sustainable forestry management.	Basis for planning and effective realization of measures and projects on carbon absorption and accumulation increase	i, iv, v	2002-2005	Tajik Met Service Tajik State Forest Authority
34	LUF	2,6	Reforestation	Research on, and approbation of, highly productive and drought-resistant forest species. Increase of forest seeding and planting in the volume at least 4 thousand hectares a year, with expansion up to 5 thousand hectares a year in the long-term prospect. Conversion of low-density tree plantations to minimally acceptable (normal) density and promotion to natural reforestation.	Increase of carbon accumulation by forests and other woody biomass, enlarging forested area of the republic	i, ii, iv, v	2003-2010	Tajik State Forest Authority

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
35	LUF	2	Shelterbelt forestry	Planting of field protection forests on irrigated and rain-feed lands using fast growing tree species in the volume at least 450-500 hectares a year.	Increase of carbon accumulation, prevention of wind erosion	i, ii, iv, v	2003-2010	Ministry of Agriculture Tajik State Forest Authority
36	LUF	2	Afforestation on lands, which were not covered by forest at least during the last 50 years	Territorial planning for optimum allocation of forest plantations. Development of plantation cultivation of traditional and new forest (tree) species. Afforestation on non-forest lands. The increase of acclimatization and sustainability of newly planted forests.	Enlarging forested area, increase of carbon accumulation by forests, woody biomass and soils	i, ii, iv, v	2003-2010	Tajik State Forest Authority
37	LUF	1,2	Protection and rational use of forest resources	Adequate supply of rural population by alternative energy resources that could replace wood fuel consumption. Prohibition of illegal forest cuttings. Effective protection of forests from wreckers, diseases and fires. Forest resources control using space monitoring and geographic information systems.	Reduction of fire risk and resulting carbon losses, sustainable forestry and monitoring	i, ii, iii, v	2003-2010	Tajik State Forest Authority Ministry for Nature Protection Ministry of Energy Local governments
38	LUF	1,2	Increase of carbon absorption by soils and combat of dehumification	Research on biological methods for soil fertility increase. Development of sandy and stony soils and increase of their biological activity. Combat of erosion processes and salinization (for carbon absorption increase) and swamping (for reduction of greenhouse gas emissions). Prohibition of steep slope use and promotion of slope terracing.	Increase of carbon absorption by soils, reduction of GHG emissions, minimization of land degradation	i, iii, v	2003-2010	State Committee on Land Resources Ministry of Water Economy
39	WS	2	Waste utilization	Introduction of solid communal waste separation in the places of their accumulation. Creation of capacities on solid communal waste processing in urban areas. Generation of biogas from active silt from sewage disposal plants. Recycling (secondary use) of metals, plastics, paper	Reduction of CH_4 emissions, improvement of urban ecological conditions and sanitary-hygienic status	i, iii, iv, v	2003-2010	City governments Tajik Municipal Service

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				and glass on the basis of existing capacities. Preventing (prohibition) of non-authorized waste burning in cities and other settlements. Finalization of construction of biological sewage purification facilities in Sarband town.				
40	WS	1	Promotion of waste utilization and reduction of waste accumulation volume	Establishment of waste accumulation norms, rules of waste disposal and utilization. Creation of economic stimulus on introduction of solid communal waste separation in the places of its accumulation and subsequent recycling.	Reduction of CH_4 emissions, reuse of materials	i, ii	2003-2005	Ministry for Nature Protection Ministry of Economy and Trade State Statistical Agency
41	RE	2,6	Capacity building on development of and increased use of renewable energies	Development of the database and promotion of access to international databases on renewable energy devices. Selection, analysis and introduction of devices able to work effectively in conditions of Tajikistan. Creation of new and strengthening of existing industrial and research potential for development, manufacturing and research on renewable energy devices efficiency. Training of specialists in the field of renewable and alternative energies. Exchange of experience with developed countries. Rising public awareness on application of renewable energies.	Formation of scientific, technical and human potential on the development of effective devices on renewable energy utilization	i, iv, v	2003-2008	Tajik Met Service Ministry of Energy Academy of Science
42	RE	2,6	Small rivers hydropower resources development	Assessment the small rivers hydropower potential use within areas suitable for installation of mini- and micro hydropower plants. Construction of mini- and micro hydropower plants, especially in remote mountain regions with absence and/or deficiency of electricity and other energy resources. Local electrification. Establishment of appropriate infrastructure and economic stimulus for stable operation of objects.	Reduction of CO_2 emissions associated with reduced use of coal and wood fuels, improved social development level	iii, iv	2003-2010	Tajik Met Service Ministry of Energy Local governments

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
43	RE	2,4,6	Solar energy use	Assessment of potential and revealing of barriers on solar energy use in the republic. Obtaining (transfer) of technologies, designing and installation of devices, on solar energy conversion to thermal and electrical energy based on technological and economic feasibility. Establishment of appropriate infrastructure and economic stimulus for stable operation of devices.	Reduction of CO_2 emissions, replacement of fossil fuel use, improved environmental conditions and living standards	iii, iv	2003-2010	Tajik Met Service Ministry of energy Academy of science Local governments
44	RE	2,4,6	Wind energy use	Assessment of potential and revealing of barriers on wind energy use in characteristic areas of the republic. Obtaining and installation of wind turbines based on ecological, technological and economic feasibility. Establishment of appropriate infrastructure and economic stimulus for stable operation of objects.	Improved living standards of rural regions, environmental protection	iii, iv	2003-2010	Tajik Met Service Ministry of Energy Academy of Science Local governments
45	RE	2,4,6	Biogas energy use	Construction and installation of biogas generators at farms. Promotion of wide application of biogas generators.	Reduction of CH_4 emissions	iii, iv, v	2003-2010	Ministry of Energy Academy of Science Local governments

(2) Measures on adaptation to climate change and prevention (minimization) of its adverse consequences

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
1	WR	6,8	Research on water resources and enhancement of hydrological forecasts in the conditions of climate change	Improvement of hydrological observation and monitoring of glaciers. Introduction of computer-aided models on hydrological forecasting. Development of irrigational forecasting methods and substantiation of irrigational modes.	Truthful information on the hydrological cycle, new forecasting methods	i, iii	2002-2008	Tajik Met Service Water Resources Research Institute GIPROVODHOZ
2	WR, WE	1,3,7	Promotion of protection and rational use of water resources	Specification of existing and development of new legislative base in water use sector for support of adaptation measures. Increase of economic mechanisms efficiency on regulation of water resources use and protection. Introduction of administrative-geographical water resource management concept based on territorial division principles. Statistical control of water resources use. Development of effective measures on prevention of anthropogenic water resources pollution. Encouragement of water saving technologies use in industry, agriculture and communal water supply. Attraction of public and water users to water management, distribution and water saving issues. Training of farmers on water saving technologies and rational water use methods.	Protection and rational use of water resources, water management based on hydrographical-administrative principle	i, v	2003-2008	Parliament Ministry of Water Economy Ministry for Nature Protection Ministry of Agriculture Ministry of Economy and Trade State Statistical Agency Academy of Science
3	WR, WE, LR	2,4,5	Rational water use in agriculture in conditions of climate change	Automation of water control, distribution and consumption system using GIS technologies. Improvement of existing superficial irrigation methods, including micro-furrow and night-time irrigation. Introduction of progressive irrigation methods, including discrete, in-soil, drip irrigation, sprinkling. Leveling of agricultural fields. Rehabilitation and modernization of irrigational systems.	Increase of irrigational system efficiency, reduction of water loss by evaporation and filtration, adaptation of irrigational	i, iii, v	2003-2010	Ministry of Water Economy Ministry of Agriculture Tajik Agricultural University

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				Transition to increased use of closed drainage network and reuse of cleaned drainage waters. Correction of irrigation modes for agricultural crops based on climate change projections. Introduction of drought-resistant and high-productive agricultural crops with minor water consumption.	modes to climate change, sustainability of agriculture in the conditions of climate change			
4	WR, WE	2,5	Improvement of water quality	Introduction in industry closed water use cycle. Reduction of industrial polluted wastewater discharge into surface watercourses. Partial pumping of strong mineral, toxic returnable and drainage waters into deep underground layers. Creation and maintenance of transit water reservoirs acting as biofilters for cleaning of water from toxic impurities through water vegetation. Modernization of drinking water supply systems and communal wastewater purification systems in urban areas. Improvements of physical and chemical control over tap water quality.	Improvement of water quality, reduction of water ecosystem vulnerability, reduction of sedimentation and minimization of accident risk at water-pipes	i, iii, v	2002-2010	Ministry for Nature Protection Ministry of Industry Ministry of Health Ministry of Water Economy Local governments Tajikistan Municipal Services
5	WE	2	Engineering regulation of stream flow and river-beds	Building of reservoir cascade for effective flow regulation. Stabilization and fortification of those parts of river- beds that vulnerable to mudflows and high floods, using engineering structures. Expansion of coast protective afforestation.	Increase of stream-flow regulation, creation of guaranteed water reserves for drought years and flood risk minimization	i, iii	2002-2010	Ministry of water economy Company "Barki Tojik" Hydro Energy Project Tajik State Forest Authority
6	WR	8	Information support of measures on water resources protection	Propagation of rational water use and water saving principles and methods in mass media. Informing of population on the interstate water relations of Tajikistan in climate change conditions.	Public support of measures on rational water use and conservation	i, ii, v	2002-2005	Academy of Science Ministry for Nature Protection Tajik Met Service Mass Media NGOs

N°	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
7	HP	2,6	Optimization of hydropower engineering operation in conditions of climate change	Specification of river-flow characteristics and its extreme values in view of modern scientific data and methods for upgrading of hydropower instalations. Modernization of working hydropower equipment in new conditions for increase of water discharge capacities (flood-control outlets). Optimization of existing reservoirs operation mode and specification of their working characteristics. Reduction of sedimentation processes. Realization of computer-aided monitoring on all energy system structures.	Effective operation of hydropower objects, reduction of sedimentation	i, iii, v	2002-2005	Company "Barki Tojik" Hydro Energy Project Tajik Met Service
8	HP	2	Realization of preventive measures in hydropower engineering	Designing and construction of special protective structures for all hydropower units, power transmission lines, and substations. Construction of new hydropower units and reservoirs.	Flow regulation in conditions of water level changes and fluctuations	i, iii	2003-2010	Company "Barki Tojik" Hydro Energy Project Ministry of Water Economy
9	LR	6,8	Capacity building on land resources protection and rational use	Zoning of territory based on the extent and type of climatic influence on the state of land resources in view of their possible degradation. Development for particular landscape zones the complex of soil protecting measures depending on climatic and anthropogenic influences in conditions of changing climate.	Truthful information on the state of land resources in connection with climate change, basis for realization of measures on soil protection in conditions of climate change	i, v	2002-2005	State Committee on Land Resources Ministry of Agriculture State Institute on Land Projection GIPROZEM
10	LR	2,5	Promotion of land resources adaptation to climate change	Implementation of agro- and forest amelioration measures, including application of crop turnover, soil protecting processing, restriction of steep slope ploughing and forest planting on abrupt slopes. Terracing and planting of fast growing winter- and drought-resistant trees and bushes on abrupt slopes. Clearing and restoration of drainage structures,	Conservation of humus layer in conditions of climate change, sand fixing, reduction of desertification,	i, v	2003-2010	State committee on land resources Ministry of agriculture Ministry of water economy Local governments Tajik State forest authority

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				collectors and ameliorative pump stations. Forest amelioration in the areas prone to droughts, hot winds and wind erosion. Conducting of agrometeorological observations necessary for the definition of climate influence on the state of soils and agricultural plant productivity.	desertification, minimization of adverse climate impacts on land resources			
11	AG	1,6	Capacity building on sustainable agricultural management	Improvement of existing and development of new legal base in agricultural sector. Strengthening of institutional structures and interdepartmental cooperation. Development of database on new technologies in agriculture. Development of scientific research on: a) preservation of gene pool; b) selection of agricultural sorts and animal breeds resistant to adverse environmental factors; c) effective agricultural protection methods in climate change conditions; d) optimization of basic agricultural crop location on the basis of new agro-climate zoning.	New mechanisms and scientific substantiation for effective realization of measures on agriculture adaptation to climate change	i, v	2002-2006	Parliament Ministry of Agriculture Academy of Science
12	AG	2,4	Optimization of agricultural practices in the conditions of climate change	Introduction of progressive technologies of agricultural crops cultivation, including sub-film seeding and transplanting. Modernization of logistical agricultural base. Development of scientific and technical maintenance of agriculture, including long-term forecasting. Realization of complex agro-technical and amelioration measures for optimal structure of sowing areas considering climate change. Rationalization of crop turnover in combination with complex mechanization, chemical application and use of biological methods to combat agricultural pests. Ensuring of household financial stability and insurance in agriculture.	Sustainable logistical base and methods of agriculture, adapted crop turnover	i, iii, v	2003-2008	Ministry of Agriculture Ministry of Finance Ministry of Economy Ministry of Water Economy Tajik Insurance Company Tajikistan Agricultural University

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
13	AG	2,6	Promotion of cotton growing adaptation to climate change	Selection and introduction of early-maturing disease- and heat-resistant cotton sorts with high fiber quality. Forecasting and timely warning of cotton pests and disease occurrences. Development of effective timeframes for sort shifting in cotton growing zones, where cotton is vulnerable to climate change. Increase of cotton irrigation efficiency on the basis of water saving technologies.	New sorts of cotton adapted to climate change, reduction of water use for cotton irrigation	i, iv, v	2003-2008	Ministry of Agriculture Ministry of Water Economy Academy of Science Tajikistan Agricultural University
14	AG	2,6	Promotion of cereal production adaptation to climate change	Selection and introduction of local cereal sorts, resistant to adverse climatic conditions. Selection of new drought- and disease-resistant cereal sorts with encouragement of private seed growing. Prevention and creation of reserve grain stocks. Increase of cereal protection efficiency from pests and diseases and forecasting of agricultural pests spread depending on climatic conditions.	New cereal sorts adapted to climate change	i, iv, v	2003-2008	Ministry of Agriculture Academy of Science Tajikistan Agricultural University
15	AG	2	Promotion of cattle breeding adaptation to climate change	Sustaining of forage reserves. Creation of reserve forage stocks. Preventive measures and minimization of cattle disease risk. Reconstruction of farms for reduction of cattle's thermal stress.	Sustainable cattle breeding in the conditions of climate change	i, iv, v	2003-2008	Ministry of Agriculture Tajik Institute of Cattle Breeding Academy of Science
16	AG	6	Capacity building on study of pasture adaptation to climate change	Zoning of pasturelands on the degree of their vulnerability to climate change. Development of computer-aided model "Climate - pasture productivity" including the forecast of pasture conditions. Establishment of optimum cattle grazing timeframes and norms, with regard to the types and state of pastures.	Truthful information on the state of pasturelands in connection with climate change, grazing time and norms appropriate in new climatic conditions	i, iv, v	2003-2005	Academy of Science Tajikistan Agricultural University Tajik Met Service

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
17	AG	2	Promotion of natural pasture adaptation to climate change	Regulation and optimization of pasture use. Selection aimed at drought-, pest- and disease-resistant fodder crops. Expansion of fodder crops area on irrigated land for their further using during the drought years.	Sustainable usage of fodder lands in climate change conditions	i, iv, v	2003-2008	Ministry of Agriculture
18	ECO	1,6	Capacity building on promotion of ecosystems adaptation to climate change	Scientific research on climate change impact assessment and projection with regard to ecosystems condition and productivity based on reference nature sites (reserves, natural parks). Development of climate change impacts on ecosystems database. Monitoring of ecosystems based on altitude zonation and climate-geographical areas. Revealing of fragile ecosystems and those vulnerable to climate change and the components of those ecosystems, especially rare and disappearing species. Development of targeted measures on promotion of ecosystems adaptation to Climate Change. Improvement of monitoring in nature protected territories, for definition of climate change indicators.	Basis for planning of measures that promote ecosystem adaptation	i, iv, v	2003-2008	Tajik Met Service Tajik State Forest Authority Academy of Science
19	ECO	2	Promotion of complex and rational use of natural resources and territories (ecosystems)	Improvement of nature protection legislation. Minimization of anthropogenic influence in industrial and agricultural areas. Maintenance and protection of nature corridors for migrating animals and birds. Protection of rare species of animals and plants, vulnerable to climate change. Creation of new nature protected territories within the revealed fragile ecosystems and ecosystems vulnerable to climate change.	Adequate conditions for ecosystems adaptation to climate change, reduction of anthropogenic pressures on ecosystems and their fragmentation	i, ii, iv, v	2003-2010	Ministry for Nature Protection Tajik State Forest Authority Academy of Science
20	TR	6,7	New approach in planning and construction of	Perfection of old and development of new standards in transport sector in view of vertical zonation and climatic features.	Adaptation of roads and transportation to	i, iv, v	2003-2005	Ministry of Transport

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
			roads in conditions of climate change	Differentiation of regional requirements in paving properties according to site altitude and vertical climatic zonation. Substantiation of road strength properties in view of climatic factors. Research on adverse natural phenomena influences on roads.	climate change conditions			
21	TR	2	Realization of preventive measures in transport sector	Additional control and installation of protective designs (avalanche galleries, portholes, etc). Measures on mountain slope stability increase. Monitoring of dangerous geological phenomena on road sites. Consideration of extreme weather events in the course of road exploitation and designing of new roads.	Transportation safety, stability of roads under extreme weather events impacts	i, iii, v	2003-2008	Ministry of Transport
22	PH	3,8	Increase of sanitary - educational level of population on climate change issues	Arranging of workshops and round tables with participation of NGOs and local authorities on the problem of climate change and its impact on public health. Propaganda in mass-media the climate change problem and associated risks of infectious and vector-born diseases distribution. Propaganda of healthy lifestyle through development of physical training, sports and recreational tourism. Development of program for high school students "Climate change and human health ".	Increase of efficiency of preventive measures and increased public participation in realization of preventive measures	i, iv, v	2003-2005	Ministry of Health Tajik State Medical University Tajik Agricultural University
23	PH	1,6	Capacity building on study of adaptive processes and development of measures on mitigation and minimization of adverse climate change impacts on	Development of new and improvement of existing legislative, administrative and technical measures. Analysis of situation and elimination of barriers for effective implementation of NAP measures. Creation of interaction mechanisms and subsequent establishment of interdepartmental scientific-information center "Man - Climate". Development of database on climate change and associated public health status.	Data on public health associated with climate change, targeted adaptation measures and human body stability increase, reduction of	i, ii, iv, v	2002-2008	Parliament Ministry of Health Tajik State Medical University

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
23	PH	1,6	public health	Development of integrated parameters that characterize public health status in climate change conditions, for taking adequate adaptation measures. Development and introduction of effective adaptogens in climate change conditions.	morbidity, temporary loss of working abilities, and mortality			
24	PH	2,8	Reduction of malaria risk in the conditions of climate warming	Analysis and drawing up of possible malaria spread forecasts. Public awareness raising and social mobilization of population for reduction of reproduction and spread of malaria mosquitoes sites (man-made reservoirs and marches, rice fields etc.). Revealing and medical treatment of the patients and parasite carriers. Inter seasonal and seasonal chemical prophylactics. Combating malaria vectors: a. Application of gambusia in malaria reservoirs and rice fields b. Disinfection by insecticides c. Cleaning of irrigational channels and drainage systems d. Drainage of marches e. Promotion to use of individual means of protection from mosquitoes	Reduction in the number of malaria mosquitoes, disease prevention, reduction in the number of parasite carriers, reduction of morbidity and mortality	i, iv, v	2003-2008	Ministry of Water Economy Ministry of Health Tajik State Medical University
25	PH	2,6,8	Prophylactics of infectious diseases, including extremely dangerous and tropical infectious diseases in the conditions of warmer climate	Improvement of a set of measures on infectious diseases prevention in new climatic conditions. Supply of good-quality drinking water to population. Cleaning of household wastewaters. Strengthening of sanitary-hygienic control in urban and rural resident areas. Strengthening of microbiological, chemical and physical control on surface and ground waters. Forecasting of infection occurrence and spread. Reduction in the number of potential choleric reservoirs.	Reduction of risk of illnesses and mortality of the population, improvement of forecasting, prevention and distribution of infections, acceptance of adequate measures	i, iii, iv, v	2002-2008	Ministry of Health Tajik State Medical University Tajikistan Municipal Services

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				Development of databank on cholera cases in the neighboring countries. Struggle against insects and rodents, which are the basic infection distribution sources. Strengthening of combat against primary and secondary centers of plague. Increase in a level of public awareness on prevention infectious diseases outbreaks.				
26	PH	1	Rationing of working day in hot period	Introduction of the work schedules that avoid peak daytime temperatures. Use of premises with regulated microclimate. Observance of drinking regime. Improvement of labor legislation on issues connected to work in hot climate.	Reduction of thermal stress, morbidity and mortality, increase of labor productivity	i, v	2003-2005	Ministry of Health Local Governments
27	PH	2	Improvement of urban microclimate in conditions of warmer climate	Zoning of urban territories with regard to their vulnerability to climate change and updating of territorial development plans. Design and orientation of buildings aimed at overheating reduction. Increase of green areas and raising their efficiency on the basis of selection and planting of characteristic sorts of trees. Expansion of fountain network on the basis of water saving technologies. Regular wet cleaning of roads for dust reduction. Reforming of municipal services (water supply, drainage systems, power supply) taking unto account warmer climate.	Comfort increase, reduction of thermal stress, improvement of urban environments	i, iii, v	2003-2008	Ministry of Health Tajikistan Municipal Services Committee of Architecture and Construction Local governments
28	PH	1,2,8	Ensuring of food safety in conditions of warmer climate	Reduction of poverty, especially within communities, which are more vulnerable to climate change. Encouragement of effective and rational methods of agriculture development, acceptable in conditions of climate change and high risk of climatic catastrophes and extreme weather events.	Reduction of morbidity connected with use of infected and poor-quality food products, providing the	i, iii, v	2002-2005	Ministry of health Ministry of agriculture Tajikistan municipal services

Nº	Sector	Type of measure	Measure	Description and composition	Expected results	Financing and performance	Timeframes	Executive authorities
				Development of private farms with differentiation of agricultural production. Strengthening of institutional structures on control and monitoring of food quality. Strengthening of control on imported food quality. Raising public awareness on food safety and hygiene.	population with balanced and high quality food, that will promote human adaptation abilities			
29	EWE	6	Improvement of extreme weather events observations and forecasting	Zoning of territory according to the degree of susceptibility to extreme weather events in view of climate change. Improvement of hydrometeorological observation system, data processing and forecasting, especially in the areas with increased extreme weather events risk (see Section 10 of the National Action Plan). Obtaining (transfer) of technologies for computer-aided climate modeling and methods extreme weather events formation. Research on influence of climatic impacts on flood formation.	Truthful information on EWE display in characteristic areas, increase of EWE forecasting accuracy**,** scientific data on flood formation mechanisms	i, iii, v	2002-2005	Tajik Met Service
30	EWE	1,2,7	Increase of preparedness to, and risk reduction of extreme weather events	Strengthening of interdepartmental partnerships in the field of extreme weather events forecasting and improvement of early warning systems. Conducting regular training and development of precise interaction mechanisms for authorities, emergency services and population in case of extreme weather events occurrence. Location of residential and public buildings in safe places. Development and implementation of a complex of measures on extreme weather events damage reduction. Development and implementation of technical and non-technical measures of protection from floods. Provision of rescue equipment to the appropriate authorities and services. Development of a complex of sanitary-hygienic and anti-epidemiological measures in case of EWE occurrence.	Improvement of EWE monitoring, early warning of population and authorities about EWE, prevention and reduction of damage from EWE	i, iii, v	2003-2010	Tajik Met Service Ministry of Emergency Ministry of Water Economy Ministry of Health

Appendix 2.

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**19 294.5**	**1 528.0**	**153.6**	**3.8**	**0.7**	**429.6**	**70.3**	**45.5**	**34.7**
1. Energy	**17 729.5**	**0.0**	**48.9**	**0.1**		**247.1**	**70.2**	**43.0**	**34.0**
A. Fuel combustion	17 729.5		6.3	0.1		247.1	70.2	43.0	34.0
1. Energy and transformation industry	57.5		0.0	0.0		0.0	0.0	0.0	
2. Manufacturing industries and construction	5 084.5		0.4	0.0		3.7	13.9	0.5	
3. Transport[1]	4 185.1		0.6	0.0		201.6	43.5	37.8	
4. Other[2]	8 402.3		5.3	0.0		41.8	12.8	4.7	
5. Biomass burning[3]	92.9								
B. Fugitive emissions from fuels	0.0		42.6			0.0	0.0	0.0	0.0
1. Solid fuels			4.8						
2. Oil and natural gas			37.8			0.0	0.0	0.0	0.0
2. Industrial processes	**1 565.1**	**0.0**	**0.0**	**0.0**	**0.7**	**181.0**	**0.0**	**2.5**	**0.7**
A. Mineral products	616.9					0.0		0.1	
B. Chemical industry	164.3		0.0	0.0		0.9	0.0	0.5	
C. Metal production	783.9		0.0		0.7	180.1	0.0	0.0	
D. Other production	0.0					0.0	0.0	1.9	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture	**0.0**		**97.7**	**3.6**		**1.6**	**0.1**	**0.0**	
A. Enteric fermentation			83.5						
B. Manure management			10.1	0.0					
C. Rice cultivation			4.0						
D. Agricultural soils				3.6					
F. Field burning of agricultural residues			0.1	0.0		1.6	0.1		
5. Land-use change and forestry	**0.0**	**1 528.0**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	587.8							
B. CO_2 Emissions and removals in soils	0.0	940.2							
6. Waste			**7.4**	**0.0**		**0.0**	**0.0**	**0.0**	
A. Solid waste disposal on land			6.8						
B. Wastewater handling			0.6	0.0					

1 – including road transportation, railways and civil aviation;
2 – including commercial/institutional, residential, agricultural sectors;
3 – CO_2 emissions from biomass are not included into total emissions;
* – sum of emissions does not very coincide with total emissions due to automatic rounding

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**22 568.1**	**1 217.2**	**176.5**	**2.9**	**0.6**	**398.7**	**83.0**	**47.4**	**40.2**
1. Energy	**21 235.3**	**0.0**	**69.5**	**0.1**		**244.2**	**82.9**	**42.0**	**39.5**
A. Fuel combustion	21 235.3		6.5	0.1		244.2	82.9	42.0	39.5
1. Energy and transformation industry	58.2		0.0	0.0		0.0	0.2	0.0	
2. Manufacturing industries and construction	8 278.9		0.7	0.0		5.2	22.4	0.8	
3. Transport[1]	4 910.6		0.6	0.0		199.4	49.5	36.9	
4. Other[2]	7 987.5		5.3	0.0		39.6	10.9	4.3	
5. Biomass burning[3]	86.1								
B. Fugitive emissions from fuels	0.0		63.0			0.0	0.0	0.0	0.0
1. Solid fuels			3.1						
2. Oil and natural gas			59.9			0.0	0.0	0.0	0.0
2. Industrial processes	**1 422.9**	**0.0**	**0.0**	**0.0**	**0.6**	**152.9**	**0.0**	**5.3**	**0.6**
A. Mineral products	589.0					0.0	0.0	0.1	
B. Chemical industry	165.0		0.0	0.0		0.9	0.0	0.5	
C. Metal production	668.9		0.0	0.0	0.6	152.0	0.0	0.0	
D. Other production	0.0					0.0	0.0	4.7	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**100.0**	**2.8**		**1.6**	**0.1**		
A. Enteric fermentation			85.9						
B. Manure management			10.5	0.0					
C. Rice cultivation			3.6						
D. Agricultural soils				2.8					
F. Field burning of agricultural residues			0.1	0.0		1.6	0.1		
5. Land-use change and forestry	**0.0**	**1 217.2**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	581.9							
B. CO_2 Emissions and removals in soils	0.0	635.3							
6. Waste			**7.3**	**0.0**		**0.0**	**0.0**	**0.0**	
A. Solid waste disposal on land			6.8						
B. Wastewater handling			0.5	0.0					

1 – including road transportation, railways and civil aviation;
2 – including commercial/institutional, residential, agricultural sectors;
3 – CO_2 emissions from biomass are not included into total emissions;
* – sum of emissions does not very coincide with total emissions due to automatic rounding

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**16 211.5**	**1 239.4**	**148.2**	**2.5**	**0.5**	**301.2**	**53.1**	**32.0**	**28.7**
1. Energy	**15 261.1**	**0.0**	**50.3**	**0.1**		**161.0**	**53.1**	**28.0**	**28.3**
A. Fuel combustion	15 261.1		3.7	0.0		161.0	53.1	28.0	28.3
1. Energy and transformation industry	115.7		0.0	0.0		0.0	0.3	0.0	
2. Manufacturing industries and construction	5 321.8		0.4	0.0		3.2	14.4	0.5	
3. Transport[1]	3 039.5		0.4	0.0		134.9	30.2	25.0	
4. Other[2]	6784.0		2.9	0.0		22.8	8.1	2.5	
5. Biomass burning[3]	59								
B. Fugitive emissions from fuels	0.0		46.6			0.0	0.0	0.0	0.0
1. Solid fuels			2.2						
2. Oil and natural gas			44.5			0.0	0.0	0.0	0.0
2. Industrial processes	**950.4**	**0.0**	**0.0**	**0.0**	**0.5**	**138.7**	**0.0**	**4.0**	**0.4**
A. Mineral products	278.0					0.0		0.1	
B. Chemical industry	104.3		0.0	0.0		0.5	0.0	0.3	
C. Metal production	568.2		0.0	0.0	0.5	138.1	0.0	0.0	
D. Other production	0.0					0.0	0.0	3.6	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**91.2**	**2.4**		**1.5**	**0.1**		
A. Enteric fermentation			77.4						
B. Manure management			9.4	0.0					
C. Rice cultivation			4.4						
D. Agricultural soils				2.4					
F. Field burning of agricultural residues			0.1	0.0		1.5	0.1		
5. Land-use change and forestry	**0.0**	**1 239.4**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	545.6							
B. CO_2 Emissions and removals in soils	0.0	693.8							
6. Waste			**6.9**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.4						
B. Wastewater handling			0.5	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**10 775.1**	**1 375.5**	**135.8**	**2.4**	**0.4**	**178.1**	**30.3**	**17.0**	**19.1**
1. Energy	**10 170.0**	**0.0**	**37.0**	**0.0**		**75.4**	**30.2**	**13.8**	**18.8**
A. Fuel combustion	10170.0		1.0	0.0		75.4	30.2	13.8	18.8
1. Energy and transformation industry	1 180.0		0.0	0.0		0.4	3.2	0.1	
2. Manufacturing industries and construction	2.352		0.2	0.0		1.2	6.4	0.2	
3. Transport[1]	1 199.5		0.2	0.0		65.5	12.8	12.4	
4. Other[2]	5 437.9		0.6	0.0		8.3	8.0	1.1	
5. Biomass burning[3]	31.3								
B. Fugitive emissions from fuels	0.0		36.1			0.0	0.0	0.0	0.0
1. Solid fuels			1.7						
2. Oil and natural gas			34.3			0.0	0.0	0.0	0.0
2. Industrial processes	**605.1**	**0.0**	**0.0**	**0.0**	**0.4**	**101.2**	**0.0**	**3.2**	**0.3**
A. Mineral products	151.3					0.0		0.2	
B. Chemical industry	44.3		0.0	0.0		0.2	0.0	0.1	
C. Metal production	409.5		0.0	0.0	0.4	100.9	0.0	0.0	
D. Other production	0.0					0.0	0.0	2.9	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**92.2**	**2.3**		**1.5**	**0.1**		
A. Enteric fermentation			77.5						
B. Manure management			9.9	0.0					
C. Rice cultivation			4.8						
D. Agricultural soils				2.3					
F. Field burning of agricultural residues			0.1	0.0		1.5	0.1		
5. Land-use change and forestry	**0.0**	**1 375.5**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	490.6							
B. CO_2 Emissions and removals in soils	0.0	884.9							
6. Waste			**6.7**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.3						
B. Wastewater handling			0.5	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**5 613.2**	**2 048.0**	**111.1**	**1.8**	**0.4**	**128.0**	**15.7**	**8.5**	**9.8**
1. Energy	**5 115.7**	**0.0**	**15.2**	**0.0**		**32.0**	**15.6**	**5.9**	**9.5**
A. Fuel combustion	5 115.7		0.5	0.0		32.0	15.6	5.9	9.5
1. Energy and transformation industry	189.8		0.0	0.0		0.1	0.5	0.0	
2. Manufacturing industries and construction	1 003.5		0.1	0.0		0.6	2.7	0.1	
3. Transport[1]	657.7		0.1	0.0		26.2	7.1	5.0	
4. Other[2]	3 264.6		0.4	0.0		5.2	5.3	0.7	
5. Biomass burning[3]	20.3								
B. Fugitive emissions from fuels	0.0		14.7			0.0	0.0	0.0	0.0
1. Solid fuels			1.1						
2. Oil and natural gas			13.6			0.0	0.0	0.0	0.0
2. Industrial processes	**497.5**	**0.0**	**0.0**	**0.0**	**0.4**	**94.7**	**0.0**	**2.6**	**0.3**
A. Mineral products	104.3					0.0		0.1	
B. Chemical industry	20.0		0.0	0.0		0.1	0.0	0.1	
C. Metal production	373.3		0.0	0.0	0.4	94.6	0.0	0.0	
D. Other production	0.0					0.0	0.0	2.5	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**89.5**	**1.8**		**1.3**	**0.0**		
A. Enteric fermentation			74.4						
B. Manure management			9.9	0.0					
C. Rice cultivation			5.2						
D. Agricultural soils				1.8					
F. Field burning of agricultural residues			0.1	0.0		1.3	0.0		
5. Land-use change and forestry	**0.0**	**2 048.0**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	446.6							
B. CO_2 Emissions and removals in soils	0.0	1 601.4							
6. Waste			6.6	0.0		0.0	0.0	0.0	0.0
A. Solid waste disposal on land			6.2						
B. Wastewater handling			0.4	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**3 646.2**	**1 657.1**	**102.6**	**1.5**	**0.4**	**112.9**	**8.8**	**6.6**	**6.3**
1. Energy	**3 196.3**	**0.0**	**9.8**	**0.0**		**16.5**	**8.7**	**2.9**	**6.1**
A. Fuel combustion	3 196.3		0.4	0.0		16.5	8.7	2.9	6.1
1. Energy and transformation industry	242.4		0.0	0.0		0.1	0.7	0.0	
2. Manufacturing industries and construction	253.2		0.0	0.0		0.2	0.7	0.0	
3. Transport[1]	328.1		0.0	0.0		12.4	3.7	2.3	
4. Other[2]	2 372.6		0.3	0.0		3.8	3.7	0.5	
5. Biomass burning[3]	20.1								
B. Fugitive emissions from fuels	0.0		9.4			0.0	0.0	0.0	0.0
1. Solid fuels			0.3						
2. Oil and natural gas			9.1			0.0	0.0	0.0	0.0
2. Industrial processes	**449.0**	**0.0**	**0.0**	**0.0**	**0.4**	**95.0**	**0.0**	**3.7**	**0.2**
A. Mineral products	55.7					0.0		0.0	
B. Chemical industry	33.0		0.0	0.0		0.2	0.0	0.1	
C. Metal production	361.3		0.0	0.0	0.4	94.8	0.0	0.0	
D. Other production	0.0					0.0	0.0	3.6	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**86.5**	**1.5**		**1.4**	**0.0**		
A. Enteric fermentation			71.3						
B. Manure management			9.9	0.0					
C. Rice cultivation			5.2						
D. Agricultural soils				1.4					
F. Field burning of agricultural residues			0.1	0.0		1.4	0.0		
5. Land-use change and forestry	**0**	**1 657.1**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0	428.3							
B. CO_2 Emissions and removals in soils	0	1 228.8							
6. Waste			**6.5**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.1						
B. Wastewater handling			0.4	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**2 779.7**	**1 671.3**	**99.6**	**1.5**	**0.3**	**96.0**	**9.0**	**5.5**	**4.6**
1. Energy	**2 414.6**	**0.0**	**11.8**	**0.0**		**13.5**	**8.9**	**2.5**	**4.4**
A. Fuel combustion	2 414.6		0.2	0.0		13.5	8.9	2.5	4.4
1. Energy and transformation industry	161.2		0.0	0.0		0.1	0.4	0.0	
2. Manufacturing industries and construction	538.6		0.0	0.0		0.3	1.4	0.0	
3. Transport[1]	429.8		0.0	0.0		10.4	4.7	2.0	
4. Other[2]	1 285.0		0.2	0.0		2.7	2.3	0.4	
5. Biomass burning[3]	20.4								
B. Fugitive emissions from fuels	0.0		11.6			0.0	0.0	0.0	0.0
1. Solid fuels			0.2						
2. Oil and natural gas			11.4			0.0	0.0	0.0	0.0
2. Industrial processes	**365.1**	**0.0**	**0.0**	**0.0**	**0.3**	**79.5**	**0.0**	**3.0**	**0.2**
A. Mineral products	30.5					0.0		0.0	
B. Chemical industry	27.8		0.0	0.0		0.1	0.0	0.1	
C. Metal production	306.9		0.0	0.0	0.3	79.3	0.0	0.0	
D. Other production	0.0					0.0	0.0	2.0	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**81.4**	**1.4**		**3.0**	**0.1**		
A. Enteric fermentation			67.2						
B. Manure management			9.3	0.0					
C. Rice cultivation			4.8						
D. Agricultural soils				1.4					
F. Field burning of agricultural residues			0.1	0.0		3.0	0.1		
5. Land-use change and forestry	**0.0**	**1 671.3**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	425.6							
B. CO_2 Emissions and removals in soils	0.0	1 246.7							
6. Waste			**6.6**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.1						
B. Wastewater handling			0.4	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**2 853.4**	**1 543.7**	**94.8**	**1.5**	**0.3**	**93.5**	**10.0**	**6.3**	**4.8**
1. Energy	**2 512**	**0.0**	**7.1**	**0.0**		**14.8**	**9.9**	**2.7**	**4.7**
A. Fuel combustion	2 512.1		0.3	0.0		14.8	9.9	2.7	4.7
1. Energy and transformation industry	23.1		0.0	0.0		0.0	0.1	0.0	
2. Manufacturing industries and construction	477.2		0.0	0.0		0.3	1.3	0.0	
3. Transport[1]	458.4		0.0	0.0		11.6	5.5	2.3	
4. Other[2]	1 526.4		0.2	0.0		2.9	3.1	0.4	
5. Biomass burning[3]	14.7								
B. Fugitive emissions from fuels	0.0		6.8			0.0	0.0	0.0	0.0
1. Solid fuels			0.2						
2. Oil and natural gas			6.6			0.0	0.0	0.0	0.0
2. Industrial processes	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**75.7**	**0.0**	**3.5**	**0.2**
A. Mineral products	24.1					0.0		0.0	
B. Chemical industry	28.4		0.0	0.0		0.1	0.0	0.1	
C. Metal production	288.8		0.0	0.0	0.3	75.5	0.0	0.0	
D. Other production	0.0					0.0	0.0	3.4	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**79.5**	**1.4**		**3.0**	**0.1**		
A. Enteric fermentation			65.4						
B. Manure management			9.1	0.0					
C. Rice cultivation			4.8						
D. Agricultural soils				1.4					
F. Field burning of agricultural residues			0.1	0.0		3.0	0.1		
5. Land-use change and forestry	**0.0**	**1 543.7**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	413.6							
B. CO_2 Emissions and removals in soils	0.0	1130.1							
6. Waste			**6.6**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.1						
B. Wastewater handling			0.4	0.0					

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

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	PFCs	CO	NO_x	NMVOC	SO_2
Total national emissions and removals*	**1 867.3**	**1 486.9**	**90.1**	**1.7**	**0.3**	**95.6**	**9.2**	**6.8**	**2.8**
1. Energy	**1 524.4**	**0.0**	**2.6**	**0.0**		**14.3**	**9.1**	**2.7**	**2.7**
A. Fuel combustion	1 524.4		0.1	0.0		14.3	9.1	2.7	2.7
1. Energy and transformation industry	0.8		0.0	0.0		0.0	0.0	0.0	
2. Manufacturing industries and construction	193.4		0.0	0.0		0.1	0.5	0.0	
3. Transport[1]	533.4		0.0	0.0		12.2	6.2	2.4	
4. Other[2]	796.9		0.1	0.0		2.0	2.4	0.4	
5. Biomass burning[3]	5.0								
B. Fugitive emissions from fuels	0.0		2.5			0.0	0.0	0.0	0.0
1. Solid fuels			0.2						
2. Oil and natural gas			2.3			0.0	0.0	0.0	0.0
2. Industrial processes	**342.8**	**0.0**	**0.0**	**0.0**	**0.3**	**78.4**	**0.0**	**4.0**	**0.2**
A. Mineral products	13.6					0.0		0.0	
B. Chemical industry	32.0		0.0	0.0		0.2	0.0	0.1	
C. Metal production	297.3		0.0	0.0	0.3	78.2	0.0	0.0	
D. Other production	0.0					0.0	0.0	3.9	
3. Solvent and other product use	**0.0**			**0.0**				**0.0**	
4. Agriculture			**80.9**	**1.7**		**2.9**	**0.1**		
A. Enteric fermentation			65.0						
B. Manure management			9.3	0.0					
C. Rice cultivation			6.4						
D. Agricultural soils				1.7					
F. Field burning of agricultural residues			0.1	0.0		2.9	0.1		
5. Land-use change and forestry	**0.0**	**1 486.9**	**0.0**	**0.0**		**0.0**	**0.0**		
A. Changes in forest and other woody biomass stocks	0.0	409.9							
B. CO_2 Emissions and removals in soils		1 076.9							
6. Waste	**0.0**		**6.6**	**0.0**		**0.0**	**0.0**	**0.0**	**0.0**
A. Solid waste disposal on land			6.1						
B. Wastewater handling			0.5	0.0					

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Annex 3.

List of abbreviations and units of measurements

Abbreviations:

CDIAC	Carbon Dioxide Information Analysis Center
CIS	Commonwealth of Independent States
EIA	Environmental Impact Assessment
EWE	Extreme weather events
FAO	Food and Agricultural Organization of the United Nations
GCOS	Global Climate Observing System
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic information system
GWP	Global warming potential
HPP	Hydropower plant
HRPT	High Resolution Picture Transmission
IPCC	Intergovernmental Panel on Climate Change
NAP	National Action Plan for climate change mitigation
NGO	Non governmental organization
NMVOC	Non-methane volatile organic compounds
Tajik Met Service	National Hydro-Meteorological Service of Tajikistan
TAR	IPCC Third Assessment Report (2001)
TOMS	Total Ozone Measurement System
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
WMO	World Meteorological Organization

Chemical symbols:

CH_4	methane
CO	carbon oxide
CO_2	carbon dioxide
N_2O	nitrous oxide
NOx	nitrogen oxides
PFCs	perfluorocarbons
SO_2	sulphur dioxide

Units:

°C	Celsius degree
cal	calorie
cub.m	cubic meter
cub.m/s	cubic meter per second

cub.km	cubic kilometer
g	gram
Gg	gigagram = 1 000 tonnes
ha	hectare
J	joule
kW/h	kilowatt hour
kW/h/m^2	kilowatt hour per square meter = 3,6 MJ/m^2
Kg	kilogram
KJ	kilojoule
Kcal	kilocalories
km	kilometer
m	meter
masl	meters above sea level
mm	millimeter
m/s	meters per second
MW	megawatt = 1000 000 watt
ppm^{-1}	parts per million by volume
ppbv^{-1}	parts per billion by volume
sq.m	square meter
TJ	terajoule = 1000 000 000 000 joule

Annex 4.

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Annex 5.

List of publications, statistical data and archive sources used in the process of National Action Plan preparation

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