

## 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.

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.

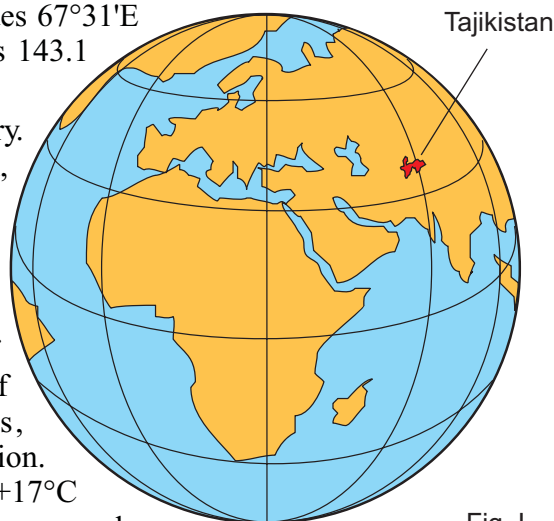


Fig. 1

**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 than the observed changes during the 20th century. It is likely that increase of temperature will be essential in the warm period of a year and in some regions 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<sub>2</sub>, 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<sub>2</sub> 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<sub>2</sub> emissions, and the small reduction in emissions of CH<sub>4</sub>, PFCs and N<sub>2</sub>O.

CO<sub>2</sub> 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<sub>2</sub> emissions nowadays and in the outlook.

**CO<sub>2</sub> emissions.** In Tajikistan in the period of 1990-1998, the biggest CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> by soils increased from 932 Gg in 1990 to 1,436 Gg in 1998. Emission of CO<sub>2</sub> 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<sub>4</sub> emissions.** The biggest volume of CH<sub>4</sub> 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<sub>4</sub> emissions in different years comprises 5-35%.

Rice cultivation, solid waste disposal sites and wastewater treatment processes are the sources of CH<sub>4</sub> emissions. The volume of methane emissions from these sources comprises 10%.

**N<sub>2</sub>O emissions.** The biggest volume of N<sub>2</sub>O 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<sub>2</sub>O emissions.

N<sub>2</sub>O emissions from other sources (manure management, burning of agricultural residues) are insignificant. Part of N<sub>2</sub>O 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<sub>4</sub> comprises the biggest part of emissions (91%); the smallest part is C<sub>2</sub>F<sub>6</sub> (9%).

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

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<sub>2</sub>-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.

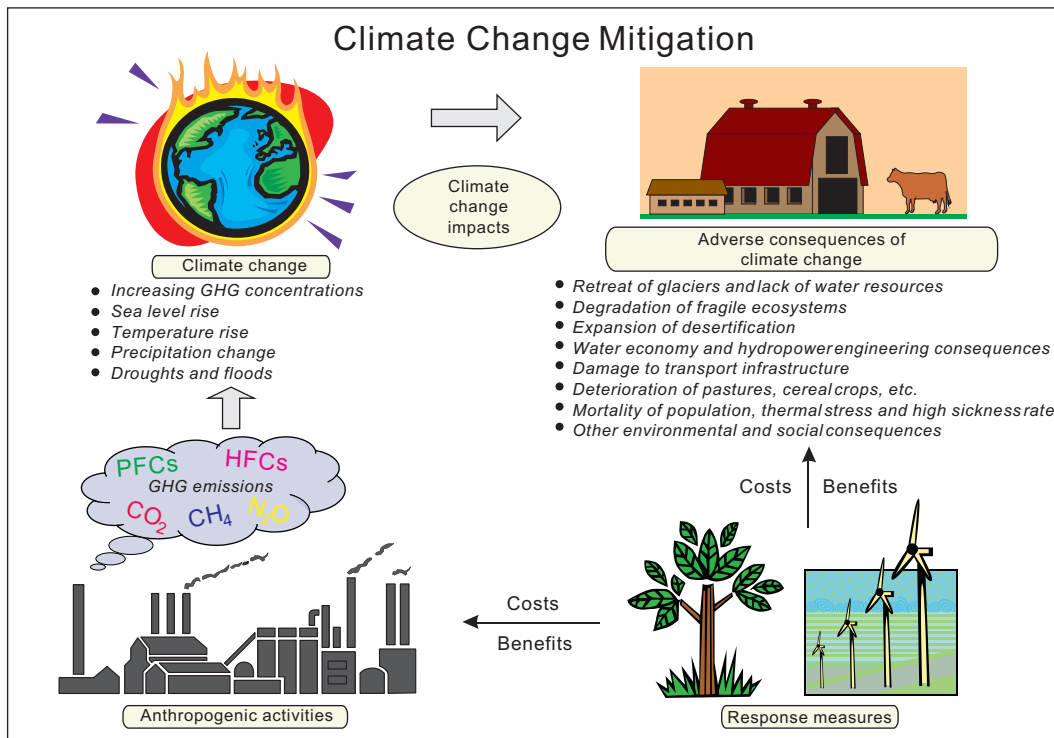


Fig. II

**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.