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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 (H₂O), carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and ozone (O₃) 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.

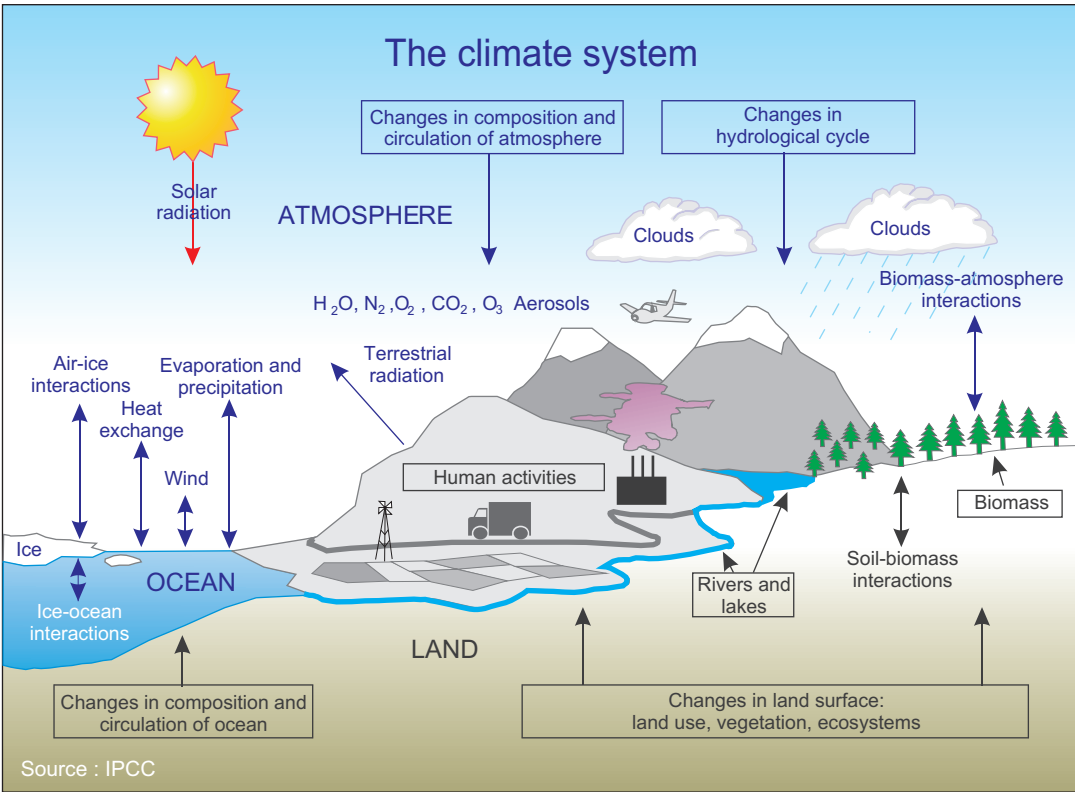


Fig. 1.1.

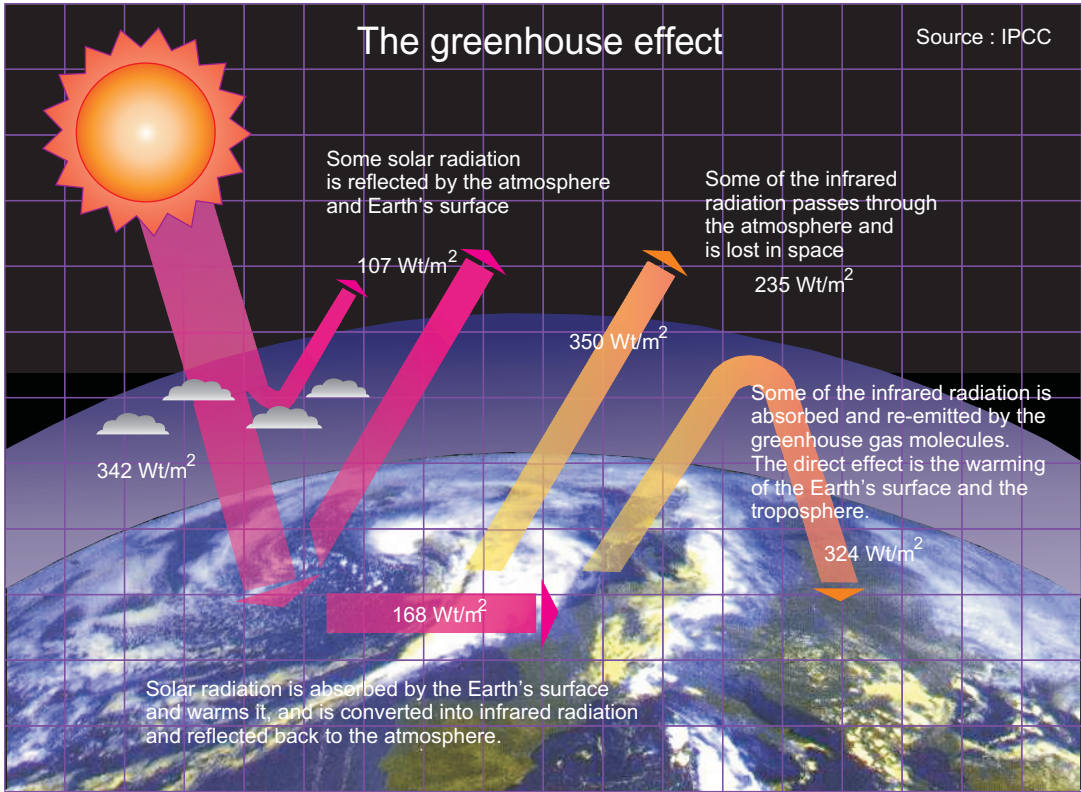


Fig. 1.2.

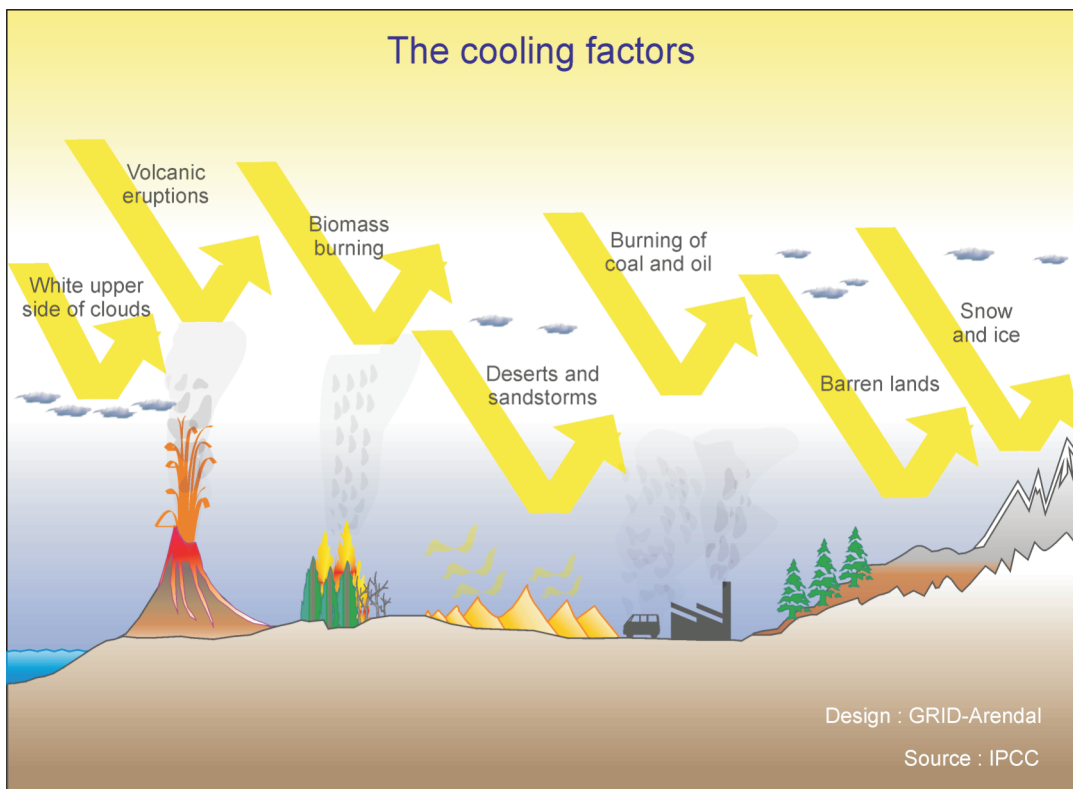


Fig. 1.3.

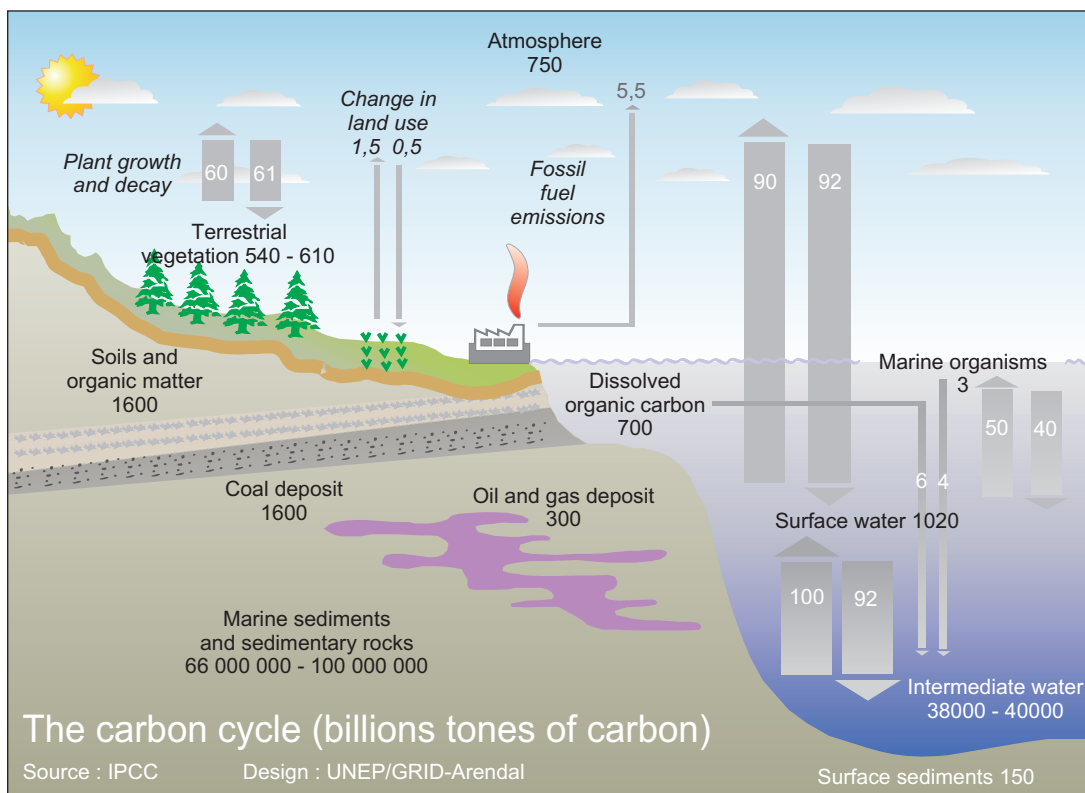


Fig. 1.4.

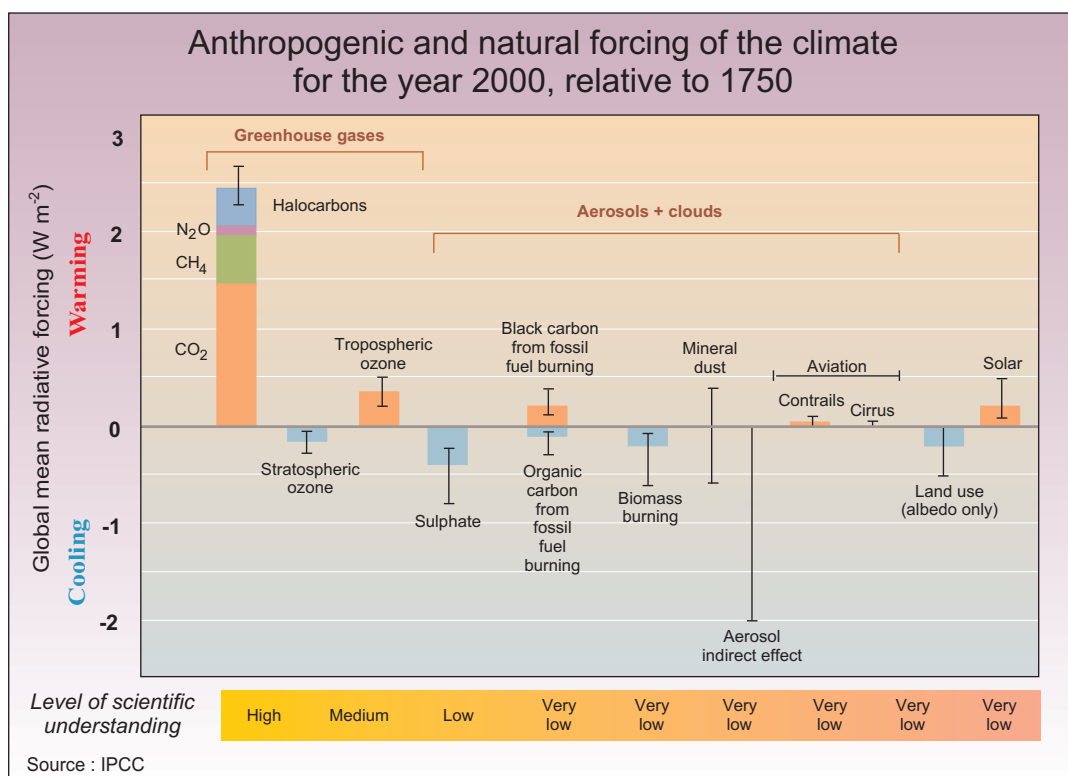


Fig. 1.5.

The gas CF₄ 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 SF₆ is 22,200 times more effective greenhouse gas in comparison with CO₂.

Several chemically reactive gases, including reactive nitrogen species (NO_x), 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 CH₄ 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 CO₂; 0.48 W*m⁻² from CH₄; 0.34 W*m⁻² from halocarbons; and 0.15 W*m⁻² from N₂O (fig. 1.5).

The observed depletion of the stratospheric ozone (O₃) layer from 1979 to 2000 is estimated to have caused a negative radiative forcing (-0.15 W*m⁻²). The total amount of O₃ in the troposphere is estimated to have increased by 36% since 1750, due primarily to anthropogenic emissions of several O₃-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 $-0.2 \pm 0.2 \text{ W} \cdot \text{m}^{-2}$.

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 $0.6 \pm 0.2^\circ\text{C}$ (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.

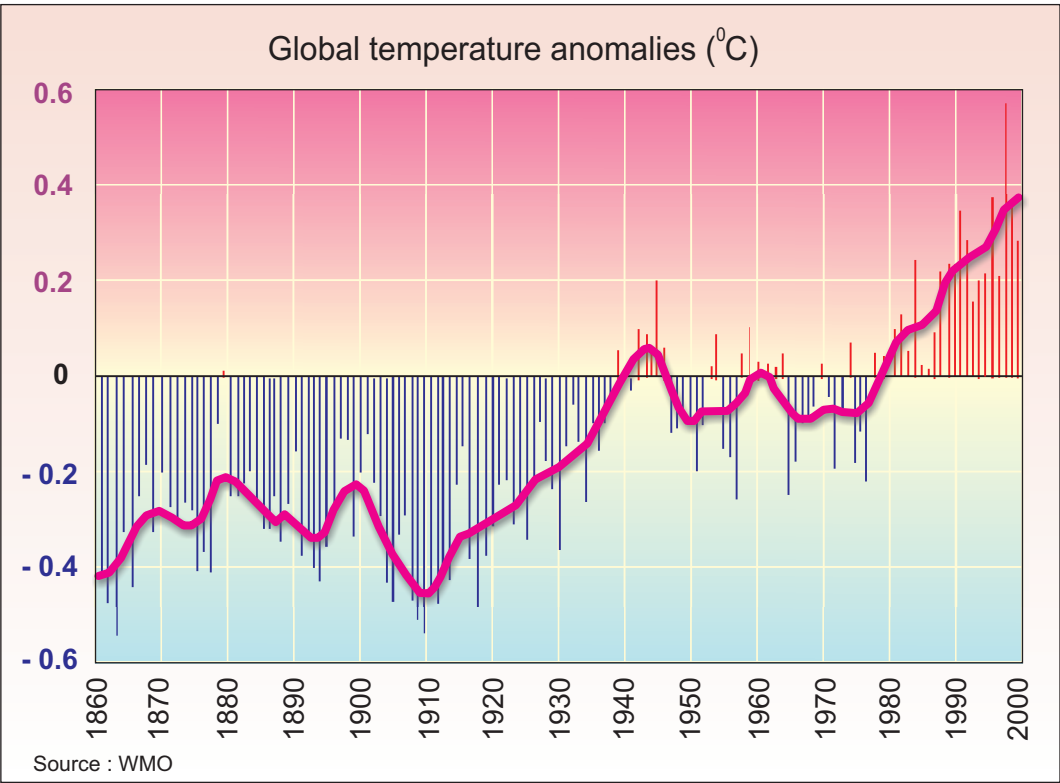


Fig. 1.6.

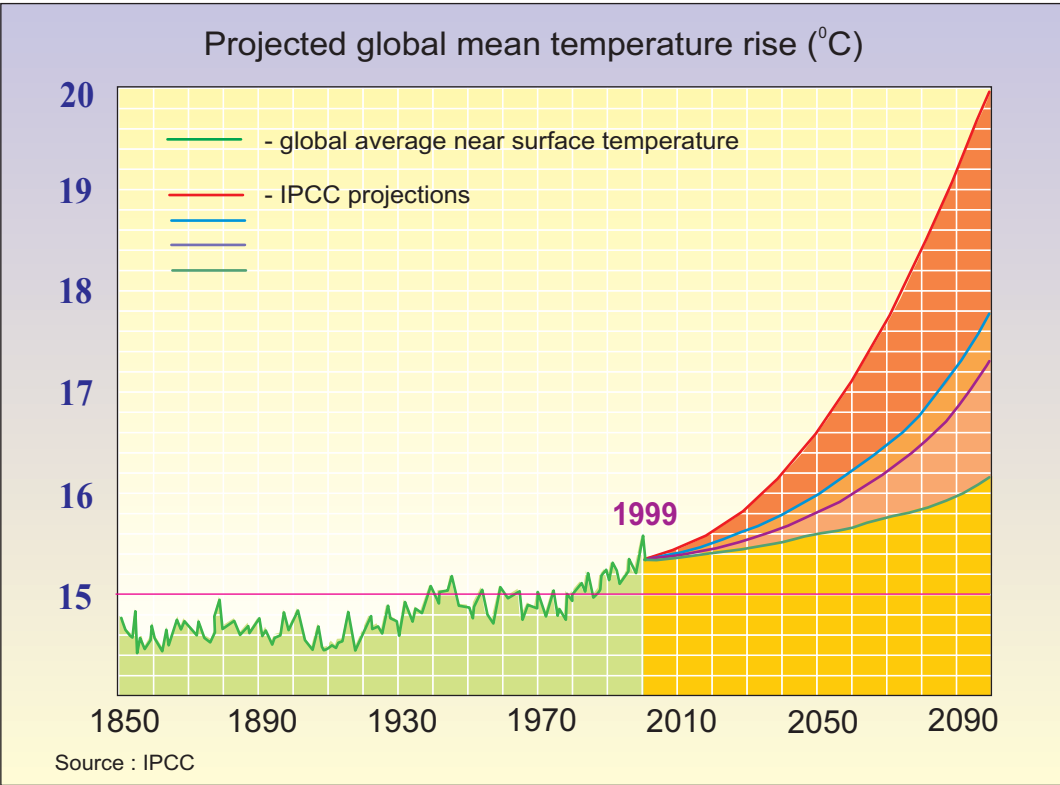


Fig. 1.7.

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 wide 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).

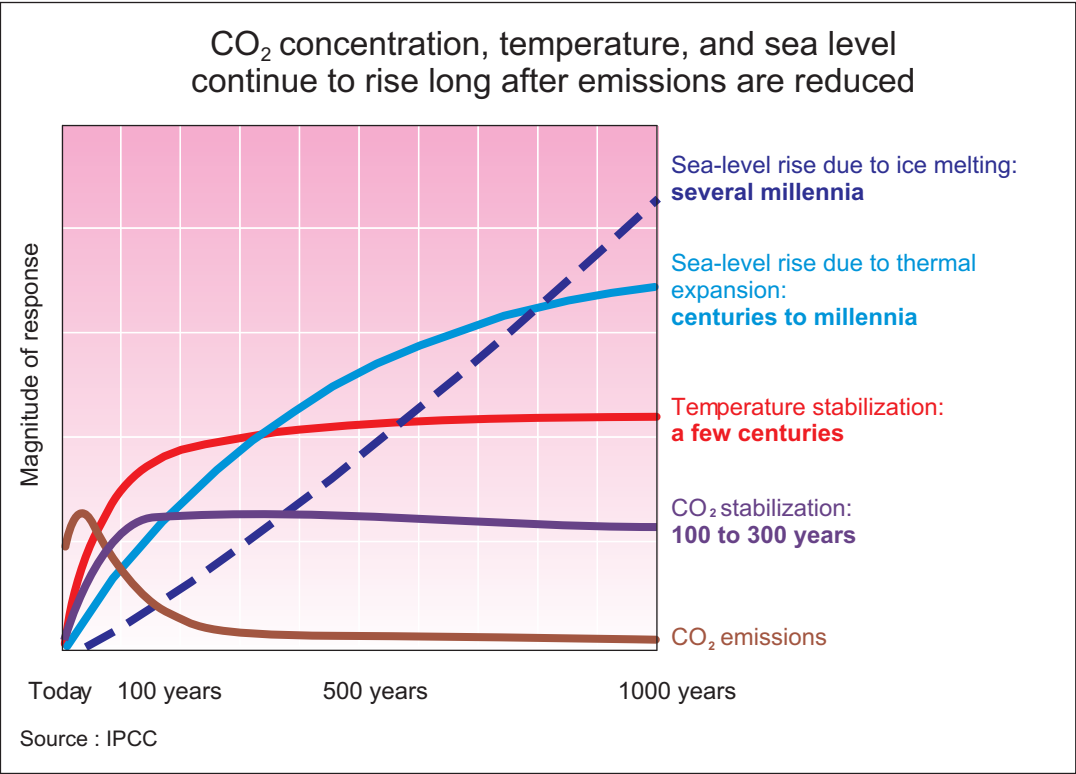


Fig. 1.8.

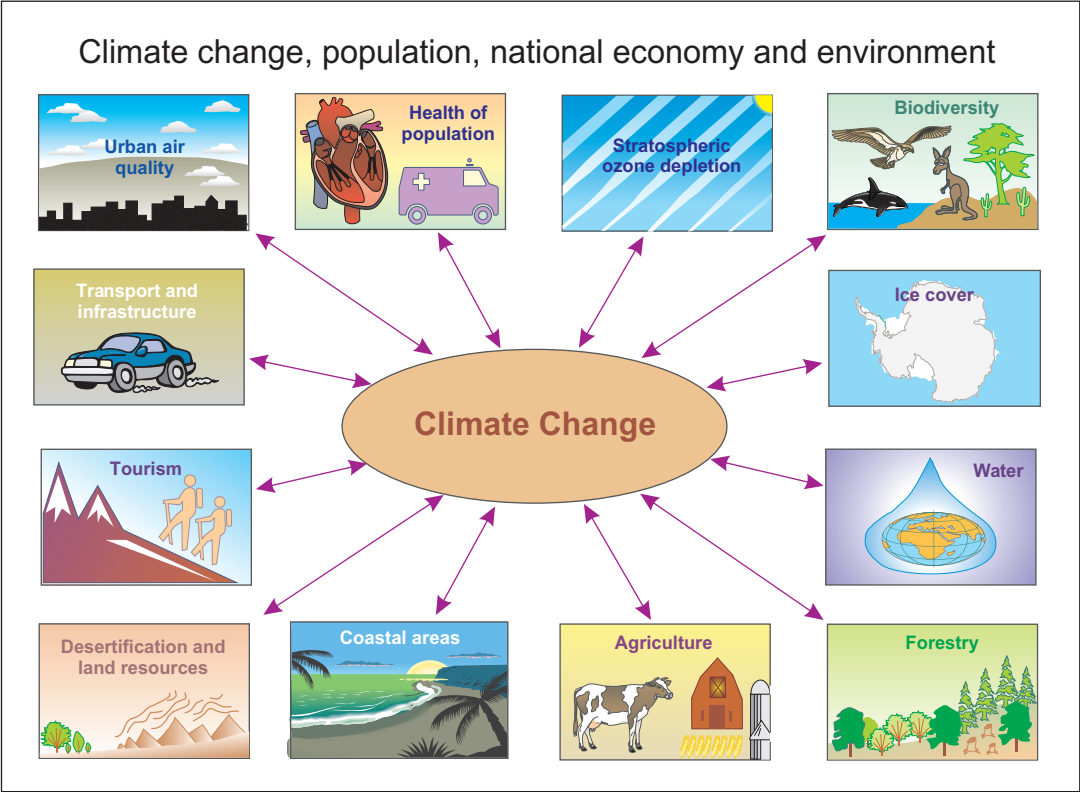


Fig. 1.9.

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

Source : 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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