UN environment programme



# Atlas
## of environmental change

# Republic of Tajikistan

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# ATLAS
# OF ENVIRONMENTAL CHANGE



# REPUBLIC OF TAJIKISTAN

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Russian Academy of Sciences
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## Foreword: Atlas of Environmental Change for the Republic of Tajikistan

The Atlas of Environmental Change of the Republic of Tajikistan has been developed using global, regional and national datasets spanning six decades, drawing both on historical information and the latest satellite technology. It provides detailed information on the republic's environment, focusing on terrestrial and aquatic ecosystems.

The information contained within the Atlas can assist the Republic of Tajikistan to monitor the environment, report in accord with its Multilateral Environmental Agreements (MEAs) as well as assist in producing data for its national state of environment reporting. The Atlas also provides a solid evidence base for policy and decision-makers to manage environmental issues sustainably.

The Atlas' data is made available to the Government through a GeoPortal so it can be continually used and updated based on national priorities.

The environmental changes impacting our world today are evident in the Republic of Tajikistan. Over the past sixty years, the average annual temperature in the country has increased by 1.2°C, compared to a global average of 0.6°C, and this rise is expected to accelerate in the coming decades. On average, 500 to 600 natural disasters are registered per year, 90 per cent of which are events such as flooding, earthquakes, mudslides, rockfalls and avalanches. Between 2020 and 2023, 1,826 natural disasters occurred, resulting in the loss of more than 100 lives and causing economic damage exceeding US $30 million.

The modern-day glaciers of Tajikistan contain about 845 km³ of water - seven times the average annual flow of all rivers draining into the Aral Sea basin. Due to climate change, the volume of glaciers in the country has significantly decreased which, in recent decades, has led to an increase in river runoff. However, by 2050, with a potential increase in the average air temperature of 2.0°C from current levels, runoff in the Amu Darya river basin would likely decrease by about 30 per cent compared to the previous decade's average. This could increase pressure on water resources both within the country and across the Central Asian Region.

Water resources are the backbone of Tajikistan's energy sector, with up to 93 per cent of electricity generated by hydropower plants. Policies which support greater local stewardship and transboundary cooperation, such as Integrated Water Resource Management (IWRM), have been proven to help manage water effectively.

Tajikistan is a global biodiversity hotspot and has the highest species density per unit area among the countries of Central Asia. In 1991, PAs accounted for only 3.58 per cent of the country's territory, however, by 2023, this had increased to 21.58 per cent.

This biodiversity richness makes Tajikistan's forests a key natural resource despite their relatively small area. The main challenges for local forests are linked to unregulated economic activities, a situation worsened by a general shortage of forest products in the country. In this context, engaging local communities in the joint management and protection of forests is of particular importance.



***Arnold Kreilhuber***

Regional Director
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# Foreword



The «Atlas of Environmental Changes in the Republic of Tajikistan» was developed as part of the project «Capacity Development and Technology Transfer for Improving the Generation and Use of Data and Information to Support Environmental Monitoring in Central Asia,» funded by the Government of the Russian Federation and the United Nations Environment Programme (UNEP).

The Atlas was developed under the coordination of the Committee for Environmental Protection under the Government of the Republic of Tajikistan, in collaboration with scientific specialists from Moscow State University and the Institute of Geography of the Russian Academy of Sciences, and highly qualified specialists from relevant ministries and agencies of the Republic of Tajikistan.

This publication is based on global and national data covering long-term observations, using both historical information and the latest satellite sensing technologies. The Atlas provides a comprehensive picture of how climate change and human activity impact the landscapes, ecosystems, and natural resources of Tajikistan. It serves as an informational, cartographic, and scientific reference publication for specialists in various fields, government officials, university professors and students, and a wide range of readers interested in the state of Tajikistan's environment. The Atlas is a reliable tool for developing environmental policy based on reliable data, facilitating informed decision-making in environmental conservation.

I express my sincere gratitude to the Government of the Russian Federation and UNEP for their financial, scientific, and technical support in developing the «Atlas of Environmental Changes in the Republic of Tajikistan.»

*Sheralizoda Bakhodur Akhmadjon*

*Chairman of the Committee for Environmental Protection under the Government of the Republic of Tajikistan*



# Executive Summary

The project to create digital atlases of environmental change in Central Asia for three target countries – Kyrgyzstan, Tajikistan and Uzbekistan – aims to harmonize national statistical systems for use in the preparation of national reports in accordance with international standards to the secretariats of four key environmental global agreements – the United Nations Convention to Combat Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention on Biological Diversity (UNCBD) and Sustainable Development Goals (SDGs) pertaining to water and life on land. This is important because harmonization of approaches to data collection and processing contributes to the fulfillment of international obligations in the field of environmental protection by these countries.

For Tajikistan, as is the case for all Central Asian countries, the state of water resources is a key factor in sustainable development as agriculture, a vital economic activity, is irrigation-based. In Tajikistan, the water sector is being reformed based on the principles of IWRM, where the main basins have been identified and the decision made that these should be managed by basin-based organizations with the support of public basin councils. The influence of local communities will also be strengthened through the organization of Water Users Associations. However, targets 6.1 and 6.2 are especially critical, since access to safe water supplies and sanitation within the republic is currently insufficient. This is demonstrated by the fact that almost a third of the rural population (28 per cent) uses water from open and unprotected sources, which causes high risks of infectious diseases.

Tajikistan is a typical Central Asian country with very limited land resources for agricultural production and limited potential to expand its irrigated land area. All objectives related to SDG 15.3, which pertain to land management, are complex and not supported by up-to-date statistics, a situation that prevents unambiguous assessments of trends in crop area dynamics, productivity and carbon balances in soils of different land cover classes, including pastures, which are under excessive pressure due to the unregulated growth of livestock numbers.

Tajikistan, again like all countries in the region, has limited forest resources. A situation that became apparent in the compilation of this atlas is that data from global sources on Tajikistan's forest area and biomass stocks in forest ecosystems differ significantly from published national statistics and, therefore, the latter cannot be used as the only source for assessing trends and planning actions for sustainable forest management. Therefore, regular national forest inventories using harmonized definitions, and methodologies are essential to unambiguously determine trends in forest area and their condition.

The relative floristic and faunistic richness of Tajikistan is due to its complex mountainous relief, pronounced vertical belt, the physical separation of its mountain ranges, latitudinal climate transformation and the presence of islands of relict flora and fauna. In this context, the main threats to the republic's biodiversity include: habitat loss and degradation due to agricultural and infrastructure development; illegal logging; excessive and uncontrolled grazing in forests and natural pastures as well as poaching, including so-called 'organized' trophy hunting. Despite some 21.58 per cent of the republic being classed as protected areas (PAs), the lack of clear boundaries and enforcement does not allow these risks to be satisfactorily mitigated.

Tajikistan recognizes climate change as a major cause of the increased frequency and severity of natural disasters. Under the Paris Agreement, Tajikistan has committed to supporting vulnerable populations by implementing policies and measures to mitigate and adapt to climate change. National statistics on casualties and economic losses show a weak correlation with the number of recorded emergencies, which emphasizes the random nature of natural disasters and their unpredictability. Under these conditions, prevention programmes, including the resettlement of residents from areas at greatest risk, may be justified despite the high social and economic costs.

## Abbreviations

AGB –Aboveground plant biomass
and Environment Protection
CAFC – Central Asia Forest Cover
CCI – Climate Change Initiative
CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora.
CMIP – Coupled Model Intercomparison Project
ECE – Economic Commission for Europe
ESA – European Space Agency
FAO – Food and Agriculture Organization of the United Nations FSC–Forest Stewardship Council
GEF – Global Environment Facility
GLIMS – Global Ice and Measurements From Space
GSOCM – FAO Global Soil Organic Carbon Map
IBA – Important Bird and Biodiversity Area
IPCC– Intergovernmental Panel on Climate Change
IUCN– International Union for Conservation of Nature
IWRM– Integrated Water Resources Management
KBA – Key Biodiversity Areas
LDN – Land Degradation Neutrality
MGCI – Mountain Green Cover Index
OSM – OpenStreetMap
PEFC–Programme for the Endorsement of Forest Certification SDGs – Sustainable Development Goals
SFM – Sustainable Forest Management
SOC – Soil Organic Carbon
UNCBD – United Nations Convention on Biological Diversity UNCCD – United Nations Convention to Combat Desertification UNDP –United Nations Development Programme
UNECE – United Nations Economic Commission for Europe
UNEP – United Nations Environment Programme
UNEP-WCMC – UN Environment Programme World Conservation Monitoring Centre
UNFCCC – United Nations Framework Convention on Climate Change WDPA – World Database of Protected Areas
WMO – World Meteorological Organization
WUA – Water User Association
WUE – Water Use Efficiency
WUEMoCA – Water Use Efficiency Monitor in Central Asia
WWF – World Wildlife Fund

## Main sources of spatial data

**Climate Change**
ECMWF ERA5
Climatology lab TerraClimate database
Local Climate Zones (LCZ)
CHELSA
CHPclim

**Settlements and Infrastructure**
High Resolution Settlement Layer
LandScan Population Data
POMELO Model Population Density Maps
WSF – World Settlements Footprint
OSM – Open Street Map
Topographic maps of the General Staff of the USSR

**Water Resources**
Global irrigation areas (2001 to 2015)
Global surface water dynamics 1999–2021
HydroSHEDS
WRI Aqueduct 4.0
Water Information System of the Water Resources Service

**Land Resources**
GLC_FCS30D Global 30-meter Land Cover Change Dataset (1985–2022)
ESA CCI-LC
ESA WorldCover 2021 (10m)
Global Land Cover and Land Use Change, 2000–2020
GlobCover Global Land Cover
GISD30: global 30-m impervious surface dynamic dataset from 1985 to 2020
Global Soil Salinity Maps (1986–2016)
Global 2010 Bare Ground (30 m)
Bare Earth's Surface Spectra 1980–2019
Global cropland expansion in the 21st century
GIMMS Normalized Difference Vegetation Index 1982–2022
FAO Global Map of Irrigated Areas

**Forest Resources**
Global Forest Change
ETH Global Sentinel-2 10m Canopy Height
Global 2010 Tree Cover
Forest Landscape Integrity Index
EOWEB (DLR) Treecover
Tree Canopy Change (1982–2016)
Global Forest Carbon Fluxes (2001–2022)
Central Asia Forest Cover

**Biodiversity**
The World Database on Protected Areas (WDPA)
BERI v2: Bioclimatic Ecosystem Resilience Index
BHI v2: Biodiversity Habitat Index
Biodiversity Intactness Index (BII)

**Natural Disasters**
Global georeferenced Database of Dams
Global large flood events
Global Landslide Catalog
Geocoded Disasters (GDIS) Dataset (1960 – 2018)
USGS Global Earthquake dataset

# Table of Contents


**Foreword** ..... **3**

**Executive Summary** ..... **5**

**Abbreviations** ..... **6**

**Main sources of spatial data** ..... **6**

**1.1.Introduction** ..... **8**

1.1.Project Objectives ..... 9

1.2.Target Audience of the Project ..... 9

1.3.Methodology and Data Sources ..... 11

1.4.Geoportal and Spatial data ..... 13

**2.2.Drivers of Change** ..... **14**

2.1.Climate Change ..... 15

2.2.Demography and Infrastructure Development ..... 38

**3.3.Water Resources** ..... **42**

3.1.Key Aspects ..... 43

3.2.General Characteristics ..... 43

3.3.Progress towards the SDGs ..... 56

3.4.Responses ..... 62

**4.4.Land Resources** ..... **68**

4.1.Key Aspects ..... 69

4.2.General Characteristics ..... 69

4.3.Progress towards the SDGs ..... 75

4.4.Responses ..... 78

**5.5.Forest Resources** ..... **84**

5.1.Key Aspects ..... 85

5.2.General Characteristics ..... 85

5.3.Progress towards the SDGs ..... 89

5.4.Responses ..... 92

**6.6.Biodiversity** ..... **94**

6.1.Key Aspects ..... 95

6.2.General Characteristics ..... 95

6.3.Progress towards the SDGs ..... 100

6.4.Responses ..... 108

**7.7.Natural Disasters** ..... **118**

7.1.Key Aspects ..... 119

7.2.General Characteristics ..... 119

7.3.Progress towards the SDGs ..... 129

7.4.Responses ..... 132

**Литература** ..... **139**



# Introduction

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### 1.1. Project objectives

This Atlas has been developed under the project 'Capacity development and technology transfer to improve the generation and use of data and information in support of monitoring the environment in Central Asia', implemented by the United Nations Environment Programme (UNEP) in cooperation with the Faculty of Geography of Lomonosov Moscow State University (MSU) and the Institute of Geography of the Russian Academy of Sciences (IGRAS), with financial support from the Russian Federation (https://atlascentralasia.com/). As the name of the project suggests, its goal is to increase the scientific and technical capacity of Central Asian government agencies responsible for the environment to monitor, assess and sustainably manage their respective terrestrial and aquatic ecosystems as well as their countries' natural resources, including those of a transboundary nature, by increasing access to global sources providing real-time information.

The proposed format of this tool, namely an online digital environmental atlas (the Atlas of Environmental Change in Central Asia), aims to harmonize national statistical systems for use in the preparation of national reports to the secretariats of four key environmental global agreements – UNCCD, UNFCCC, UNCBD and SDGs related to water, and life on land – in accordance with international standards.

### 1.2. Target audience of the project

The target audience of this project is primarily policymakers and/or decision-makers, particularly those endowed with a measure of authority and responsibility for the consequences of any adopted and implemented environment-related management action plans. Among the targeted decision-makers are those responsible for the preparation of national reports within the framework of various international initiatives, such as the aforementioned Rio Conventions and the agreement on the SDGs adopted by the international community in 2015. This project's analysis of published national environmental reports has shown that the quality of national reports is largely determined by the reliability of the data used, and these data are often drawn from global resources or national sources whose quality is unclear. Furthermore, the set of indicators used by individual countries from global sources and cartographic images varies considerably, even among neighbouring countries of a given region, which makes it difficult to compare them with each other in terms of environmental status and trends.

This atlas is dedicated to the Republic of Tajikistan, where The last national atlases of Tajikistan in traditional (paper) format were published during the Soviet era. The importance of this project lies in addressing the existing challenges of collecting, updating, and processing geospatial information on the state of the environment within the republic, as there is currently no unified methodology for collecting and presenting Tajikistan's spatial environmental data. In particular, there is a lack of consistency in information on the system of PAs

across national and international reporting systems, as well as regarding data on degraded lands. Compounding this informational bottleneck is the fact that institutional archives are only partially digitized, meaning, for example, that the Committee on Environmental Protection only has electronic versions for the last five years. Furthermore, the water cadastre needs to be updated as the last one was done in 2009, while the republic's forest inventory work covers only 14 of more than 40 forestry, with the last complete forest inventory in Tajikistan being carried out in 1988.

One of the important tasks of the project is to analyse the differences in indicator definitions used in international and national sources. In some cases, this discrepancy in definitions was deliberately created during the so-called nationalization of the SDGs, where some national definitions were retained from the Soviet system of statistics. Although the Forest Code, adopted in 2011, contains an international definition of «forest,» Tajikistan's national forestry statistics remain based on the Soviet definition of a forest as «a natural complex dominated by tree communities of one or more species growing densely and forming more or less closed stands of more than 0.1 hectares.» (see section 5.3). National legislation also uses the term «forest lands» to refer to «lands covered and not covered by forests, but designated for forest restoration and forest management.» Both last definitions differ from the wording adopted in international documents, which leads to disagreement between national statistics and international sources regarding the estimates of forested areas and their dynamics

.



*The old railway in the gorge*

The inconsistency of data from national and international sources proved to be the most serious problem in the present project's implementation. Many indicators found in national sources are incomplete or unreliable due to the uncertain methodologies of their derivation. Spatial information and cartographic data are either unavailable or outdated, while there is little systematic monitoring of ecosystems in the country. Most national assessments on land use and land cover change, degradation of cropland, pastures, forests and other types of ecosystems, as well as water quality, lack a clear methodological basis. In this assessment report, several global datasets were tested at the national level, and significant discrepancies were found between them and national indicators. At the same time, global data sources do, in some cases, show significant discrepancies with respect to the same indicators. This made the verification of the results of global data resources particularly important for the project, where an inherent goal was to analyse the quality of data on the state of the environment in the Republic of Tajikistan made available in national, international and scientific publications.

### 1.3. Methodology and data sources

At the first stage of this project, the indicators of the target countries' progress in implementing the SDGs and progress in accord with the key global Rio Conventions (UNFCCC, UNCCD, UNCBD) were identified. These indicators were then used to determine what would be the thematic content of the electronic atlases available via a Geoportal.



*Yurts, Eastern Pamir*

Five thematic areas with 44 related indicators and sub-indicators were selected: water (14), land (7), forests (7), biodiversity (11) and natural disasters (5). In addition to the five thematic areas, it was decided that the atlases would present data on climate change and population dynamics as the main drivers of environmental transformation in these countries.

All the selected indicators were approved for use by key stakeholders during an online meeting on 27 May 2021. During the workshop held on this date, representatives of UNEP, IGRAS and MSU presented the concept of the project, in particular, the methodology for the development of the electronic atlas 'Changes in the Countries of Central Asia'. Additionally, the attendees determined the technological requirements of providing access to the atlas' content and announced a series of training seminars for interested participants from partner countries on the collection and processing of thematic geospatial data based on the IGRAS platform.

It is expected that the information collected for this project, obtained through the analysis of global and macro-regional databases and spatial information, will be particularly important given the shortage of national indicators. Global environmental data sources provide information obtained in a uniform manner and make it possible to compare situations in different regions and countries within the same region. In addition, global data sources are regularly updated, which makes it possible to identify temporary changes in the territory of the targeted republics. The use of these global data sets provides an opportunity for each targeted country to improve and develop a system of national statistics on the state of its environment by better ensuring the correctness of its indicators. Nevertheless, the utilized global sources still needed to be verified regarding the national, local spatial and statistical data they provide where the quality of the information related to the selected thematic areas and indicators was checked for consistency and reliability. To do so, this project used a multi-tiered approach, similar to the one adopted in the SDG manual, albeit modified to allow for the limited availability and reliability of environmental statistics in the target countries *(Table 1)*. In optimal cases, the results obtained from global databases correspond with national data; in case of discrepancy, preference is given to global sources.

Mapping of water-related SDG indicators requires delineating basic layers, such as water bodies, irrigation canals,

*Table 1. Quality Levels of Source Data*

| Quality Level of initial data | Definition |
|---|---|
| Level 1.<br>(poor data quality) | Global/regional data sources that do not provide information on the temporal trend of the phenomenon under consideration and do not correspond to national estimates. |
| Level 2.<br>(medium data quality) | Global/regional data sources that provide information on the temporal trend of the phenomenon under consideration but do not correspond to national estimates. |
| Level 3.<br>(good data quality) | Global/regional data sources that correspond to national estimates but do not provide information on the dynamics of the phenomenon under consideration. |
| Level 4.<br>(high data quality) | Global/regional data sources that provide information on the temporal trend of the phenomenon under consideration and are consistent with national estimates. |

### 1.3. Methodology and data sources

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*The Lost Fortress*

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Mapping of water-related SDG indicators requires delineating basic layers, such as water bodies, irrigation canals, hydrological and administrative boundaries. The first three of these can be derived using the HydroLAKES, HydroRIVERS and/or HydroBASINS global datasets, while information regarding administrative boundaries is obtained from the National Focal Points. A complete set of SDG water indicators related to basin management, water availability and water use efficiency can be derived from the global HydroSHEDS and the Water Use Efficiency Monitor in Central Asia (WUEMoCA) regional dataset. The quality of the data for these indicators was determined as level 2 according to the above *Table 1*. Water safety indicators depend entirely on existing national statistics on wastewater treatment, sanitation and water pollution.

SDG indicators for land resources provided by global data include land cover change and carbon stocks. There is a lack of national spatial data in the target countries to verify global land cover products (ESA Copernicus and CCI), so the quality of data available for the Land Cover Change indicator has been categorized as level 2. The UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) dataset matches well with aggregated national carbon stock data, however, it does not provide information on their dynamics, leading to the quality of data related to the indicator being classed as level 3.

The SDG indicators on forest resources include forest area, forest types, forest aboveground biomass stocks and the Mountain Green Cover Index. There are no up-to-date forest inventory data for Tajikistan that meet international standards and global databases show significantly lower forest cover than national statistics due to the inclusion of vast areas of bushy land in the latter. As such, the data quality for the Forest Types indicator in Tajikistan should also be classified as level 2[2]. The European Space Agency dataset (ESA Copernicus

1 Tier Classification for Global SDG Indicators (2019) Tier Classification of SDG Indicators_11 December 2019_web.xlsx (un.org).

2 Santoro M. (2018). GlobBiomass – global datasets of forest biomass. PANGAEA, https://doi.org/10.1594/PANGAEA.894711.



*The M34 highway*

-CCI) provides an estimate of forest aboveground biomass for 2010 that is comparable with national indicators. The data quality for this indicator in Tajikistan can be classified as level 3. The Mountain Green Cover Index is provided by the UNSDG Open Data Centre, however, national statistics related to this index are not available, resulting in the data for this indicator being classified as level 2.

Information on PA boundaries is contained in the World Database on Protected Areas (WDPA) database, which is regularly updated and includes all Category I and II PAs in Tajikistan but does not include many Category III or IV PAs. In addition, the boundaries of PAs in the WDPA database do not always correspond to the official boundaries. Therefore, the quality of data for the SDG indicator on biodiversity should be categorized as level 2.

Most of the maps presented in the atlas are based on global resources and a large proportion of them can be verified with national data, i.e. the maps are level 3 in terms of quality. Prospects for SDG mapping are related to further improvement of these resources towards verification at regional, national and local levels, as well as the provision of data on temporal changes in the state of the environment (as required to meet level 4 data quality). The project envisages further development of the information base, which will be presented on a separate geoportal and made available to partners from the target countries.

### 1.4. Geoportal and spatial data

An important outcome from this project, which increases the potential for the practical use of the Atlas, is the creation of a Geoportal which contains spatial data concerning climate change, water deficit, conservation of forest ecosystems and biodiversity issues as well as disaster management data within Tajikistan. Such Geoportals are an important tool for a wide range of government agencies and institutions involved in nature resources management, environmental protection, risk management and area planning.

In the Republic of Tajikistan, these government agencies and institutions include the State Committee for Environmental Protection and the Ministry of Hydropower and Water Resources (for monitoring the state of natural resources and developing environmental protection measures); the Committee for Emergency Situations (CES) and Civil Defence (for analysing and forecasting risks associated with natural and man-made disasters, taking into account the location of risk recipients); the Ministry of Agriculture and the Agency for Land Reclamation and Irrigation (for water management); and the Ministry of Agriculture and the Agency for Land Reclamation and Irrigation (to manage water and land resources and assess the impact of climate change on these resources); the Agency for Forestry (to monitor the state of forest ecosystems, biodiversity and develop measures for their conservation and restoration); the Ministry of Economic Development and Trade (to develop strategies for socio-economic development by taking into account spatial data and the potential uses of various areas).

The Geoportal can also be used by research institutes and universities to assist with their scientific research, model natural processes and develop recommendations for sustainable development.

Using global and national sources, the Geoportal includes more than 320 vectors and more than 140 raster layers derived from the analysis of remote sensing data and the digitization of thematic maps available at the Institute of Geography of the Russian Academy of Sciences.

The Geoportal is built on the Geonode platform, the main features of which are:

- Effective data management: Geoportal managers can readily update data, delete data that are no longer relevant and upload new spatial data.
- Clear visualization: Allows user-friendly interactive displays of maps and layers as well as the creation of clear legend systems.
- Facilitates customized spatial analysis: Can perform basic data operations such as layering, filtering by attributes, performing spatial analysis and creating new thematic maps.
- Promotes the integration and exchange of data: Data published on the Geoportal can be integrated with other geographic information systems and other Geoportals of various departments operating within the Tajikistan Republic.

The functionality of the Geoportal allows users to undertake a wide range of tasks, including assessing the vulnerability of given areas to climate change; monitoring of water resources; analysing changes in an area and/or the state of forest ecosystems; monitoring of the state of agricultural ecosystems; identifying areas where there is an increased probability of natural disasters occurring and assessing the risks associated with these events.

A more detailed description of the Geoportal's functionality and examples of how it can be used to undertake typical tasks are given in the Geoportal User Manual.



*View of the Hissar fortress*

# Drivers of Change



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## 2.1. Climate Change

Climate change in Central Asia is a significant factor in the ongoing transformations of the region's aquatic ecosystems and resources, terrestrial ecosystems and biodiversity as well as its agriculture and settlement systems. Central Asia, already one of the driest regions in the world, is experiencing rising temperatures and changing precipitation patterns that are leading to increased water shortages, landscape aridization and threats to the region's unique fauna and flora. The agricultural sector faces increased unpredictability and changes in agroclimatic characteristics during the growing season, which creates heightened risks for food security and the lives of rural communities.

The territory of Tajikistan is located at the junction of several powerful atmospheric circulation processes. One is the westerly transfer associated with the North Atlantic Oscillation (NAO) while the second is the southeasterly transfer associated with the Southern Oscillation (ENSO)[1]. A pronounced negative phase of the NAO leads to an increase in precipitation in Central Asia brought by western cyclones in the winter-spring period. A weakening of the NAO leads to the strengthening of the Siberian anticyclone in winter. Cold waves from the Arctic reach the territory of southwestern Tajikistan while the mountains bordering the country to the north and east promote the retention of cold air masses. Strong manifestations of ENSO are accompanied by an influx of warm air in winter and an increased probability of droughts in Tajikistan. In summer, when these air masses are not in an active phase, another important atmospheric process manifests, namely a thermal depression, which is facilitated by the proximity of deserts to the high mountains and results in clear skies with dry and hot weather.

The climate of Tajikistan is sharply continental and is characterized by significant daily and seasonal fluctuations in weather conditions. At the same time, the large amplitude of altitudes, in combination with a very complex relief structure, causes the formation of unique regional variants of the continental climate *(see map 'Climate types')*. Under these circumstances, air temperature fluctuates greatly at different altitudes and within regions. As such, the country is characterized by large contrasts in temperature conditions in almost all seasons of the year, particularly between the lowest lying areas (with altitudes below 1000 m) in the north and south of the country and the highland (above 3500 m) eastern regions *(see maps 'Air temperatures in April'; 'Air temperatures in July' and 'Air temperatures in October')*. For example, in the south, in the Shakhritus district (Khatlon region), the temperature in winter can rise to +22°C, while in the Pamir Mountains, in the area of Lake Bulunkul, it can drop to -63°C *(see map 'Air temperatures in January')*[2].

The Pamirs form a high-mountain desert where the

1 Kurbonov N.B. (2022) On the issue of climate change in Tajikistan in the context of global warming. Bulletin of the Pedagogical University (Natural Sciences) (in Russian) No. 3 (15). Pp. 22-32.

2 Mergili et al. (2011) Changes in the glacial and periglacial environment of the European Alps and the Central Asian mountains and their socio-economic implications: A comparison. In Proceedings of the Innsbruck. Conference, November 21–23, 2011. Wien.

average annual air temperature is -1°C. Vast areas of the 'Roof of the World' lack heat resources for productive agriculture, as shown by the distribution of the sum of active temperatures *(see map 'Sum of active temperatures for a period of stable average daily temperature above 10°C')* and the region has no stable period with temperatures above 10°C. The main agricultural regions are located in the south (the Vakhsh and Panj valleys), in the centre (the Gissar oasis) and in the north (Fergana) of the country, where the sum of active temperatures exceeds 4000°C. In the Zeravshan river valley, the sum of active temperatures is typical for a moderately warm climate (3000–4000°C). The differences between the northern and southern irrigation areas are determined by a longer growing season in the latter (defined by the temperature transition through 5°C) (*see maps 'Date of stable transition of average daily air temperature through 5°C in spring' and 'Date of stable transition of average daily air temperature through 5°C in autumn'*), as well as lower risks of spring and autumn frosts *(see maps 'Average dates of last spring air frosts' and 'Average dates of first autumn air frosts')*. On flat cultivated lands, the frost-free period is relatively long and lasts about 250 days, whereas the Eastern Pamirs are characterized by the absence of a frost-free period, since ground frosts are observed all year round[3]. Indeed, it is estimated that permafrost covers more than 84 per cent of the Pamirs, which typically rise to an altitude of over 3000 m, and snow may fall even in summer and remain on the ground for several days[4].

The precipitation regime in Tajikistan is dominated by macroregional atmospheric processes. The highest amounts of precipitation fall in the spring months in the valleys and foothills, where typically 50 to 70 mm fall per month, while in the highland areas, April and May have the highest precipitation. In summer, due to the geographical location of Tajikistan and its remoteness from the main frontal zones, most air masses do not bring significant precipitation, especially to the plains where, on average, less than 5 mm falls per month *(see Fig. 1)*. In the summer, a season deficient in precipitation, melting glaciers become the main source feeding into rivers.

The average annual precipitation in Tajikistan is approximately 690 mm with its distribution being mainly influenced by relief. Depending on the altitude and the location of the mountain ranges, the amount of precipitation each region receives varies greatly where, for example, the Eastern Pamirs less than 100 mm annually, while the Vakhsh river valley in the south receives 500 to 600 mm and the southern slopes of the Gissar Range typically receive more than 2000 mm *(see map 'Precipitation')*. The vertical gradient of precipitation is about 40 mm per 100 m-1 of the altitude[5]. At altitudes above 5000 m, humid air almost completely loses its moisture supply. The insignificant amount of precipitation falling in the Eastern Pamirs (40–140 mm with a long-term average of about 76 mm) is explained by its location in the shadow of the high ridges of the Western Pamirs. Due to the dry air that passes over these ridges, snow that would normally fall and melt simply evaporates in the Eastern Pamirs. With extremely low precipitation and temperatures, the plateau and mountains of the Pamirs are distinguished by high levels of illumination and intense solar radiation (up to 1751 kWh/m²/year), which many experts consider as offering potential for the development of solar energy *(see map 'Duration of sunshine per year')*[6]. In the conditions present throughout the Eastern Pamirs, woody vegetation cannot develop, meaning the only locally available natural fuel is the sparsely growing dwarf shrubs *(Krascheninnikovia ceratoides, Artemisia spp.)*.

Meteorological observations for the period from 1940 to 2020 show a trend towards an increase in average annual temperatures of 0.1 to 0.2°C per decade and an increase in the number of days when the temperature exceeds 40°C. In mountainous (forest and shrub-steppe) regions, an increase in temperature of 0.3 to 0.5°C per decade was recorded, while in the alpine zone, the increase was 0.2 to 0.4°C. However, in general, trends towards increasing temperatures are less pronounced at high altitudes than at lower altitudes (see Fig. 2). Tajikistan's temperature trends by season do not show large differences with winter and spring temperatures being on average 0.1 to 1.1°C and 0.1 to 1.3°C higher than normal per decade, respectively, and autumn temperatures in mountainous areas 0.6 to 1.1°C above average[7].

3 Mirzokhonova S.O. (2021) The impact of climate change on the hydrological regime of the Panj River basin. candidate's dissertation Monographiya_Mirzokhonova-S.O..pdf. (in Russian)
4 Mergili et al. , 2011.
5 Normatov I, Normatov P. (2020) Climate change impact on hydrological characteristics and water availability of the Pamir Mountain Rivers. Proc, IAHS. 383. Pp. 31–41.
6 Zandler et al. (2016) Scenarios of Solar Energy Use on the «Roof of the World»: Potential and Environmental Benefits. Mountain Research and Development, 36. 3. Pp. 256-266.
7 Fourth... 2022.

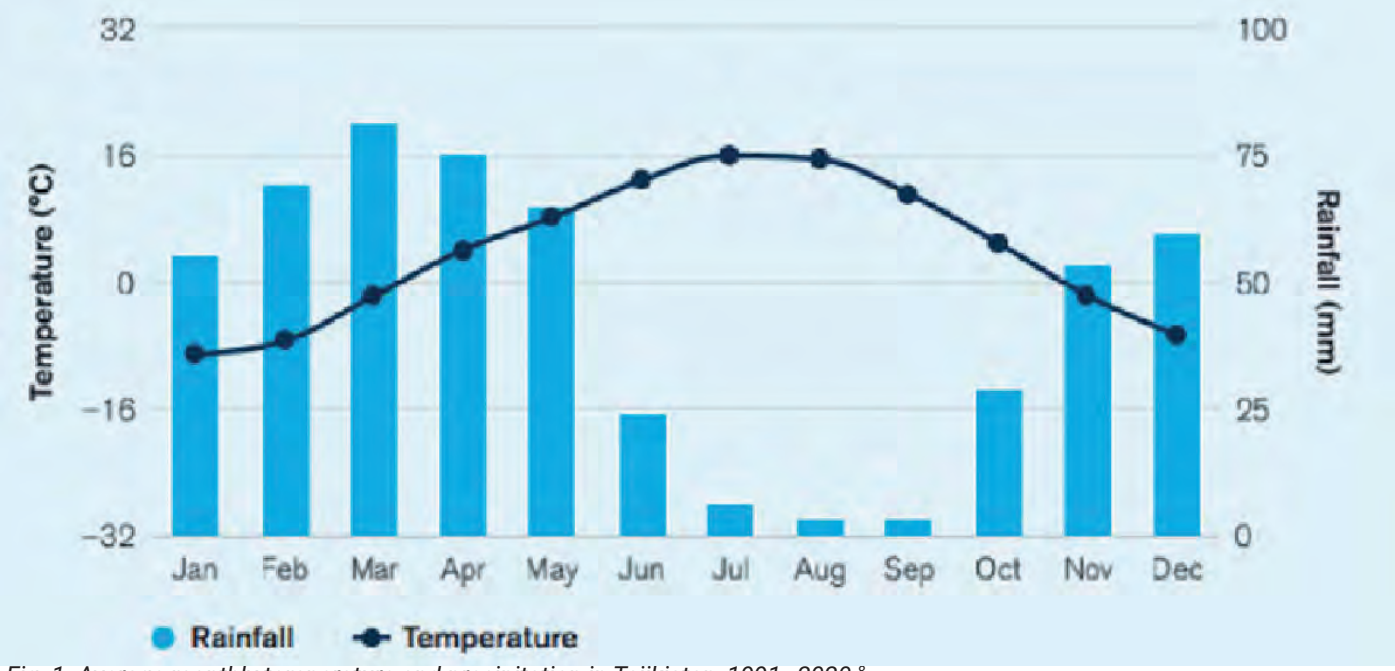



*Fig. 1. Average monthly temperature and precipitation in Tajikistan, 1991–2020.*[8]

8 Mergili et al. , 2011.

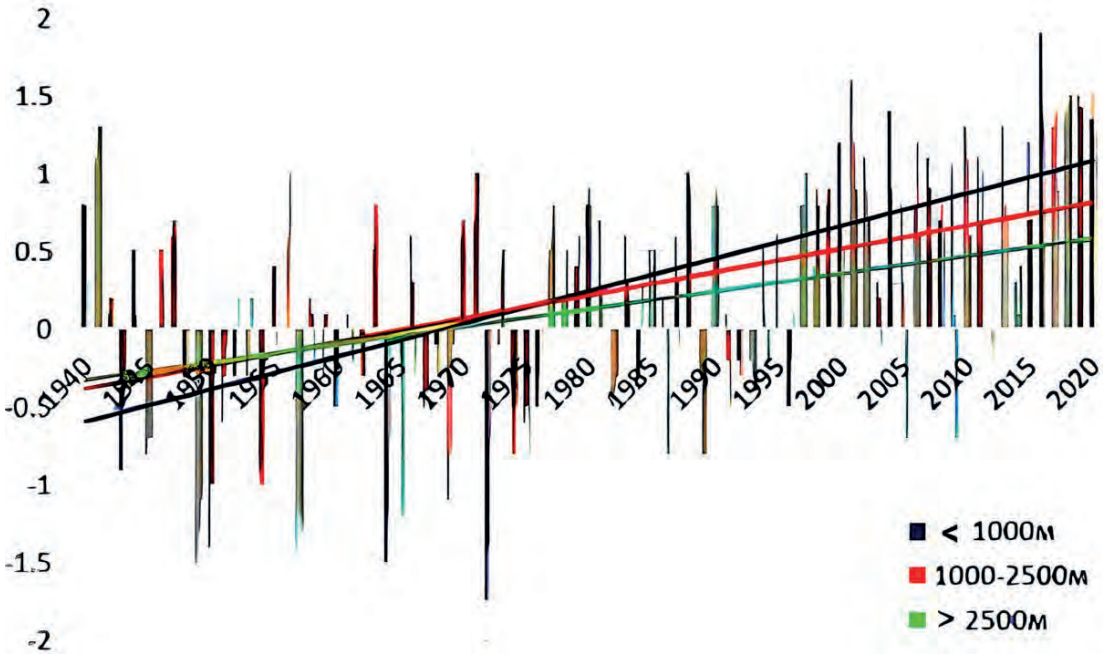



*Fig. 2. Trends in changes in average annual air temperature (relative to average values) in the mountainous regions of Tajikistan, depending on altitude.*[9]

9 Fourth National Communication of the Republic of Tajikistan under the UN Framework Convention on Climate Change. (2022) Dushanbe. 232 P.

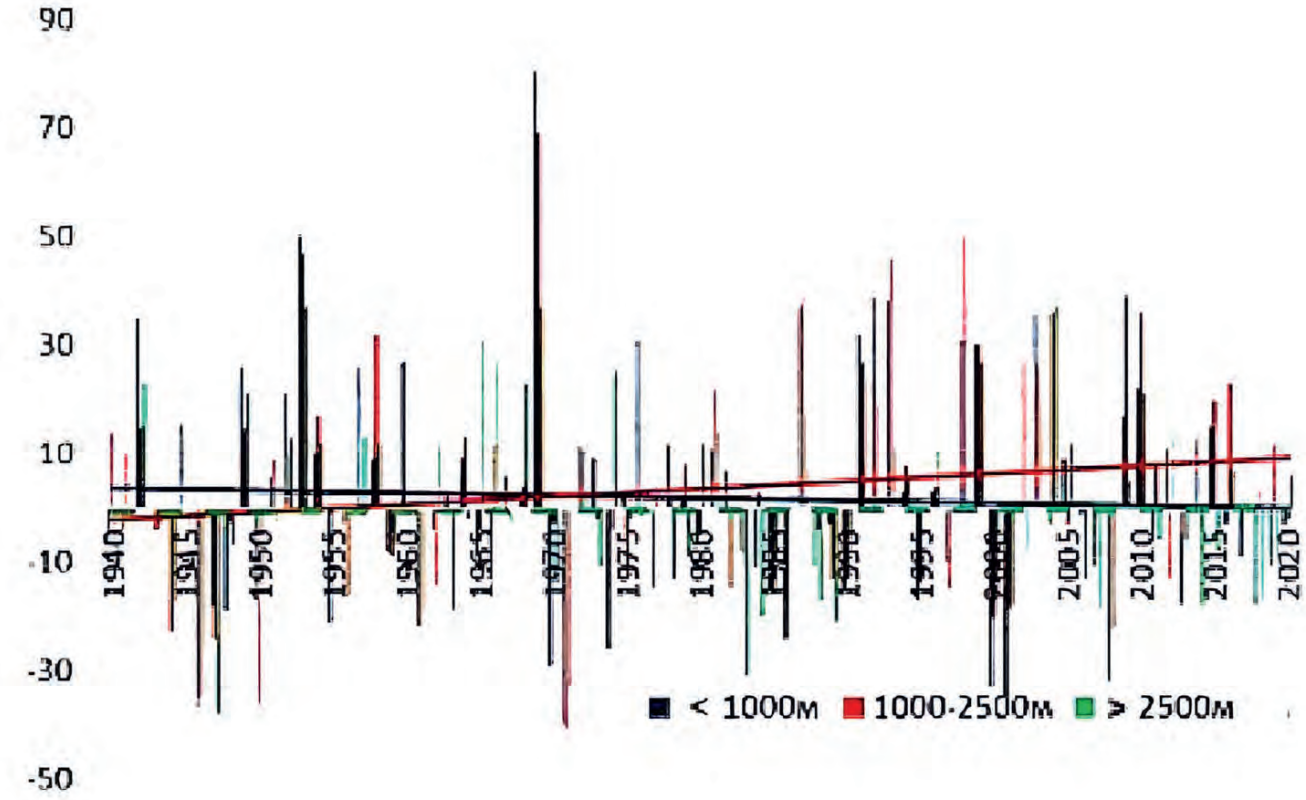



*Fig. 3. Trends in average annual precipitation (relative to average values) in the mountainous regions of Tajikistan depending on altitude, 1940–2020.*[10]

10 Fourth.., 2022.

Since the 1990s, the increase in average annual temperature has intensified to averages of 0.7 to 1.0°C per decade, with the most prominent increases evident in most of western Tajikistan, including both its valley and mountain landscapes *(see maps 'Trend of average annual air temperature, 1960–2023' and 'Trend of average annual air temperature, 1990–2023')*.

No pronounced trends in average annual temperature were revealed in the Pamirs *(Table 2)*. Here, the temperature trend had positive values only in certain months, namely April, November and December. In some geographic depressions, a decrease in temperature was even observed where, in the Lake Bulunkul basin for example, a decrease in average annual temperature of 1.1°C in the period from 1940 to 2005 was recorded[11]. In this respect, there is a similarity with the highland regions of Kyrgyzstan, where negative trends in average annual temperatures are also observed in some depressions.

The accelerating temperature increases over the past 30 years compared to the period 1960–2023 are characteristic of the summer season *(see maps 'Warm season air temperature trend, 1960–2023' and 'Warm season air temperature trend, 1990–2023')*. A comparison of these maps shows that, for example, in recent decades, the Fergana Valley has 'caught up' with the southern regions of Tajikistan in terms of warming rates. Furthermore, it is apparent that since the 1960s, the maximum temperatures have increased to the greatest extent in the south of the country in the agricultural oases *(see map 'Maximum air temperature trend, 1960–2023')*. Indeed, the southwestern Khatlon region can be seen to be experiencing the greatest changes in most climatic indicators in the country *(see Table 2)*.

Precipitation trends in Tajikistan are rather negative, especially in the southern agricultural regions of the country *(see maps 'Precipitation trend, 1960–2023' and 'Precipitation trend, 1990–2023')*. However, these trends are weakly expressed both in the lowlands and in the highlands *(see Table 2)*. A trend toward a slight increase in precipitation is typical for altitudes of between 1000 and 2500 m but is also weakly manifest *(see Fig. 3)*. Although no significant changes in the thickness of snow cover and snow lines were found, this does not allow the assumption that changes in river runoff in the spring period are due to this factor. The year-to-year variability of solid precipitation effectively masks possible trend changes in snow cover *(see maps 'Snow cover in 2001', 'Snow cover in 2010' and 'Snow cover in 2023')*.

The combination of accelerating rises in air temperature in the warm season and low summer precipitation, which shows a weak negative trend, should lead to an exacerbation of climatic water deficits in the river valleys where the country's main irrigated agricultural areas are located *(see maps 'Climate water deficit trend, 1960-2023' and 'Climate water deficit trend, 1990-2023')*. In this context, the processes of exacerbated water deficits are more pronounced in the Vakhsh and Pyanj river valleys *(see map 'Climate water deficit in 2023')*.

According to the Climate Vulnerability Monitor, Tajikistan is classified as a country "severely vulnerable to climate change now and in the near future (up to 2030)" . This means that the country's economy is closely linked to climate-sensitive sectors, and the limitations of its adaptive capacity due to the country's natural features seriously complicate the development and implementation of strategies to reduce risks and increase resilience to climate change. The same assessment is given to the Kyrgyz Republic, but, for example, Uzbekistan is recognized as less vulnerable to climate change.

The Intergovernmental Panel on Climate Change's global circulation models for 2050 relative to 2010 show that average annual air temperature is likely to increase from −0.6°C to 1.1°C in the Panj river basin, from 3.5°C to 5.0°C in the Vakhsh river basin, and from −2.6°C to −0.9°C (2050) in the Pamir glaciation zone. Maximum and minimum daytime air temperatures will also increase. Permafrost, which is currently estimated (according to a model developed for the Swiss Alps) to cover 84 per cent of the Pamir area, could shrink by 40 per cent by the end of the century with a temperature increase to 4.0°C .

During the period 2010–2040, there will be a gradual increase in average annual precipitation, with the exception of the lower parts of the Vakhsh and Pyanj river valleys. However, these projected changes in precipitation will be quite insignificant (from −2 per cent to +7 per cent), even the already low-precipitation Pamirs *(see Table 2)*, against the background of an increase in average temperatures of 2°C. This is because the latter will remain the main driver of negative climate change and will lead to an increased risk of drought due to higher levels of evaporation and early snowmelt. For example, by the mid-21st century, the densely populated Fergana Valley is projected to see an increase in precipitation of 10 mm but an increase in evaporation of at least 70 mm. These modelling results are generally confirmed by the air temperature and precipitation forecasts for 2040 presented in the atlas *(see maps 'Expected change in air temperature by 2040' and 'Expected change in precipitation by 2040')*. Higher values for temperature change, some 2.5°C for the lower reaches of the Vakhsh and Panj Rivers (in the Khatlon region) and 2.6 to 2.7°C for the Zeravshan and Syr Darya (Sughd region) river valleys, are explained by the different base period (1970 to 2000) used for calculating trends in the atlas.

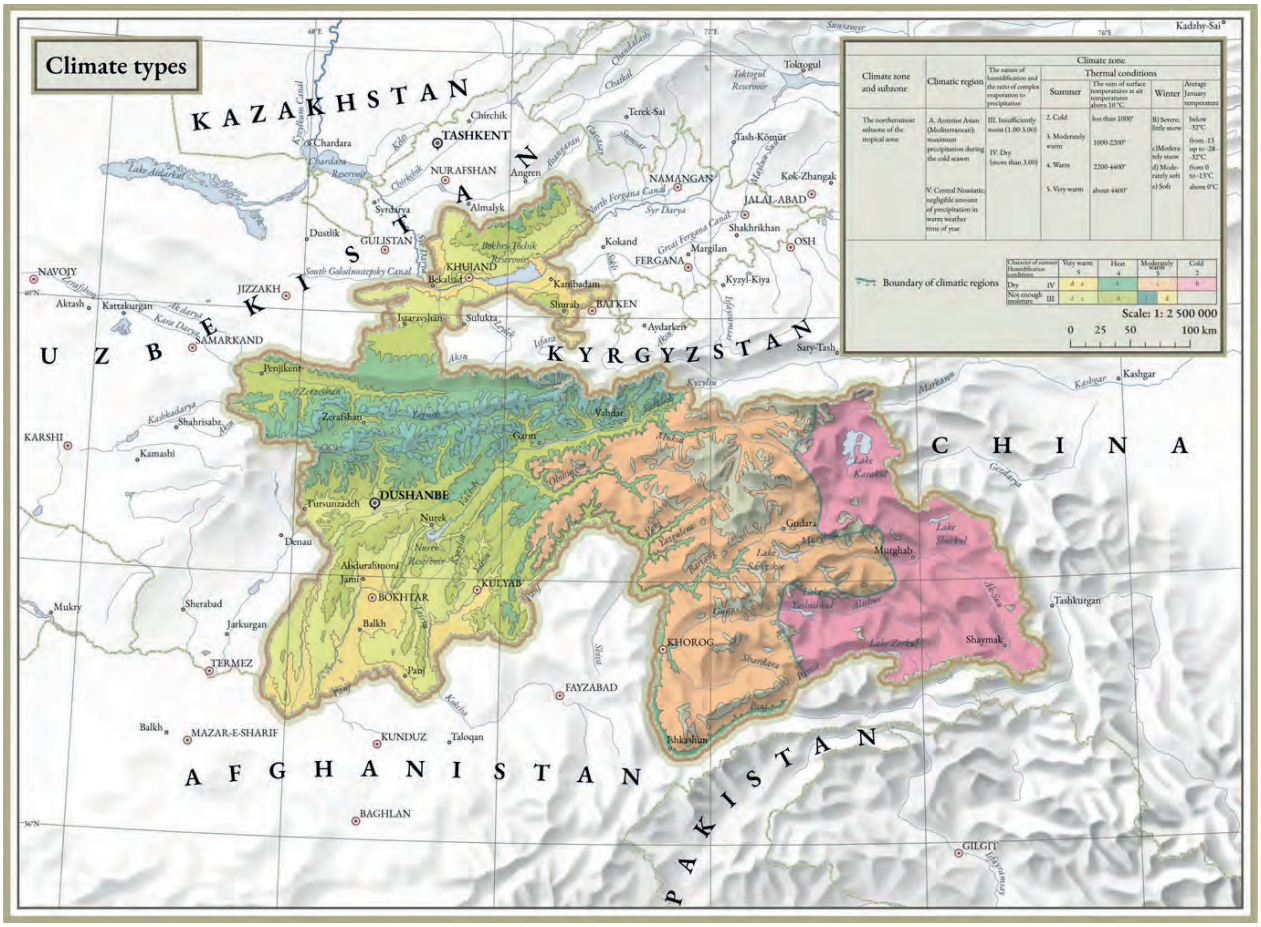


*A donkey carrying a huge load of hay on its back. Western Tajikistan*

11 Kurbonov...,2022.

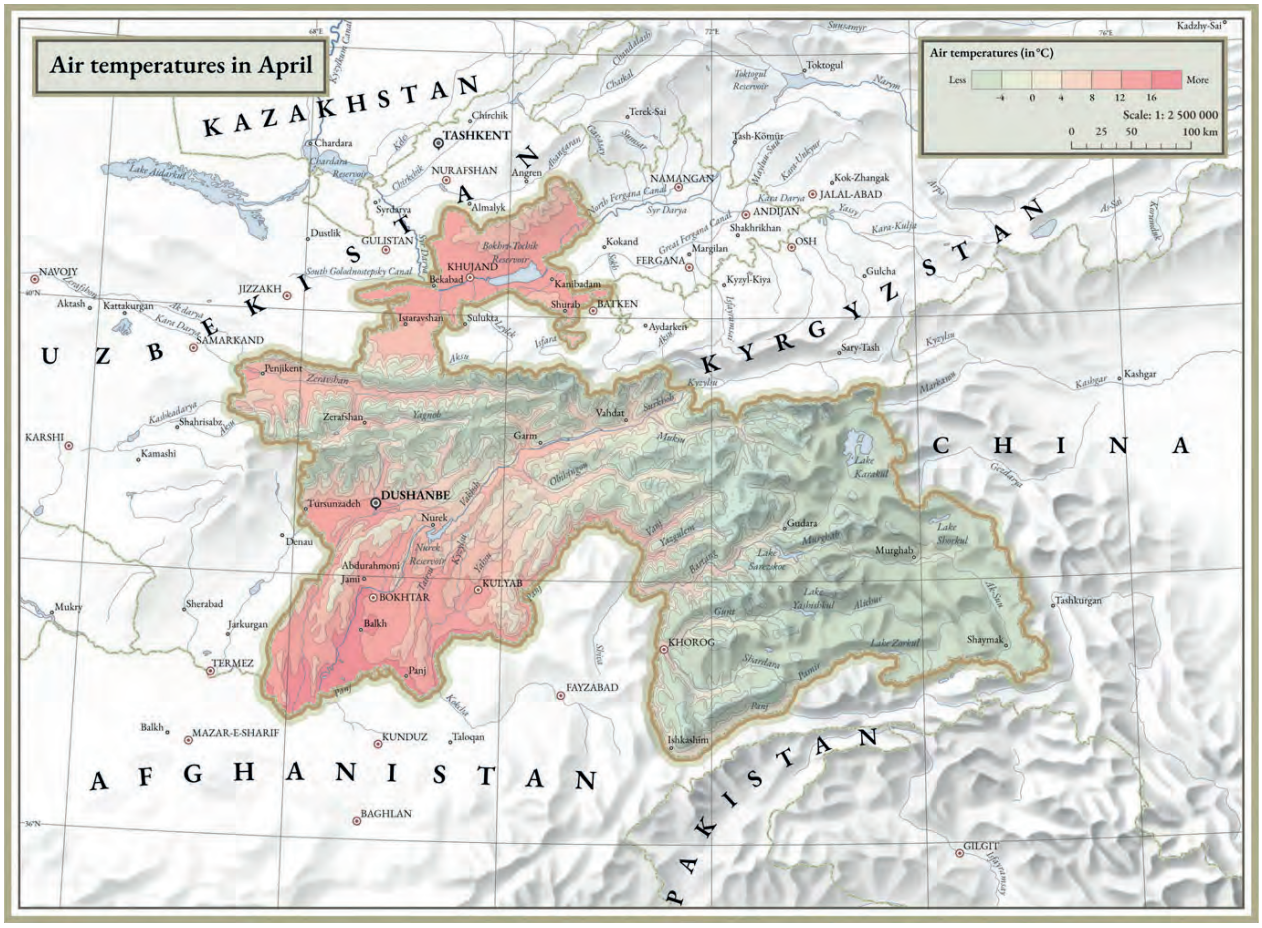
*Table 2 Trends in climate indicators in Tajikistan and its region*

| Indicator | Trends | | |
|---|---|---|---|
| | National average | Maximum | Minimum |
| Trend in average annual temperatures (1960–23), °C per year | 0.021 | 0.047 (Khatlon region) | 0.005 (GBAO) |
| Trend in average annual temperatures (1990–23), °C per year | 0.036 | 0.048 (Khatlon region) | 0.005 (GBAO) |
| Trend in summer temperatures (1960–23), °C per year | 0.029 | 0.03 (Khatlon region) | 0.010 (GBAO) |
| Trend in summer temperatures (1990–23), °C per year | 0,042 | 0,073 (Khatlon region) | 0.022 (GBAO) |
| Trend in maximum temperatures (1960–23), °C per year | 0.024 | 0.027 (Sughd region) | 0.020 (GBAO) |
| Trend in maximum temperatures (1990–23), °C per year | 0.039 | 0.055 (Khatlon region) | 0.030 (GBAO) |
| Average annual precipitation trend (1960–23), mm per year | -0.169 | 0.086 (GBAO) | -0.800 (Dushanbe) |
| Average annual precipitation trend (1990–23), mm per year | -0.750 | -0.053 (GBAO) | -2.200 (Dushanbe) |
| Trend in climate water deficit (1960–23), mm per year | 0.227 | 0.919 (Khatlon region) | -0.034 (Sughd region) |
| Trend in climate water deficit (1990–23), mm per year | 3.070 | 6.329 (Khatlon region) | 0.000 (GBAO) |
| Projected temperature increases by 2040, °C per year from the baseline period (1970–2000) | 2.502 | 2.695 (Sughd region) | 2.358 (GBAO) |
| Projected changes in precipitation by 2040. Percentage of the baseline period (1970 – 2000) | 3.468 | 8.847 (Sughd region) | -1.497 (GBAO) |

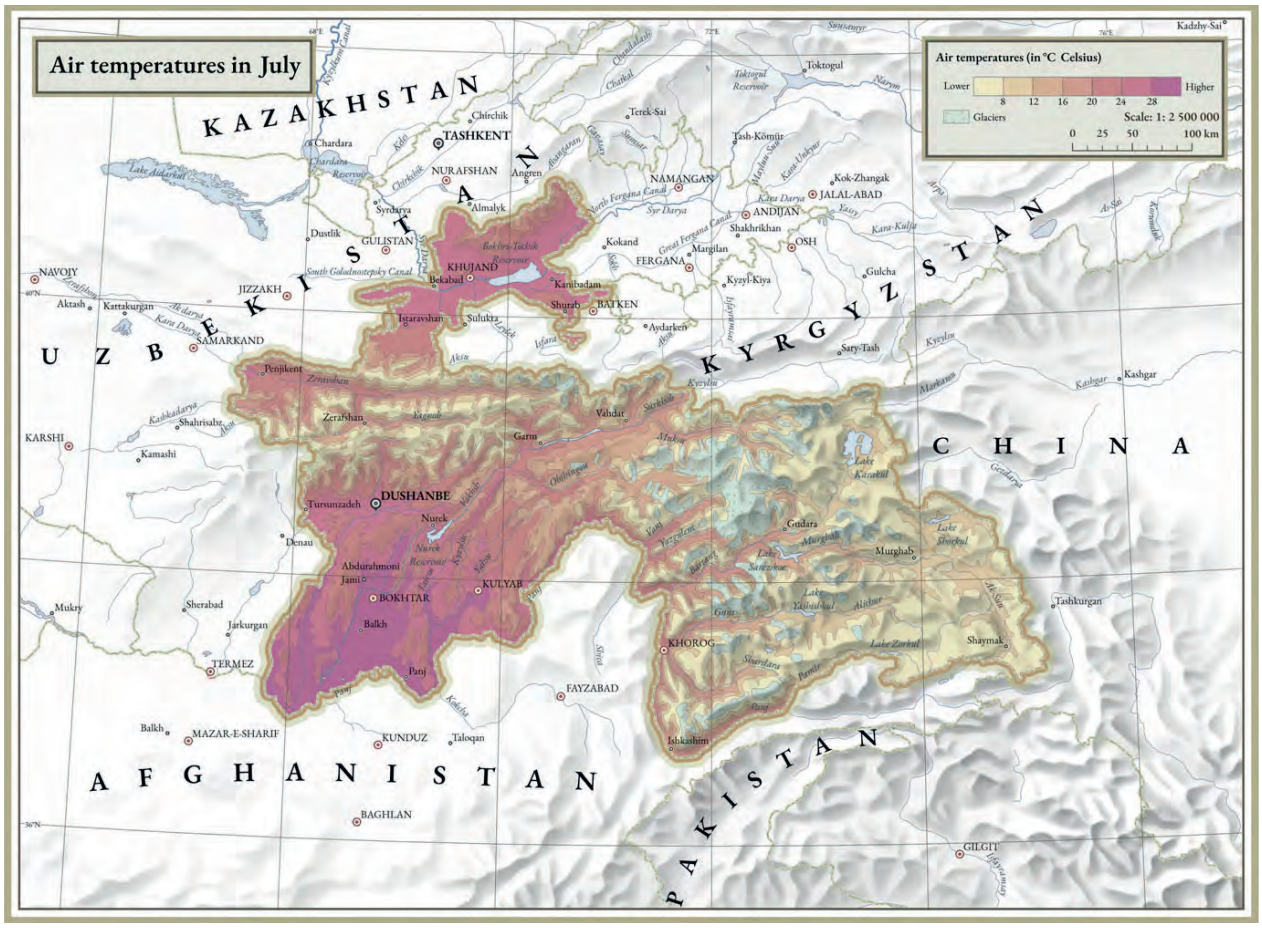



Updated global Köppen-Geiger classification with unprecedented one km resolution and temporal coverage from 1980 to 2016. Based on three air temperature datasets (WorldClim V1 and V2 and CHELSA V1.2) and four precipitation datasets (WorldClim V1 and V2, CHELSA V1.2 and CHPclim V1). Vegetation is simultaneously presented as a 'crystallized, visible climate', which is reflected in the characteristics of the zones.[12]

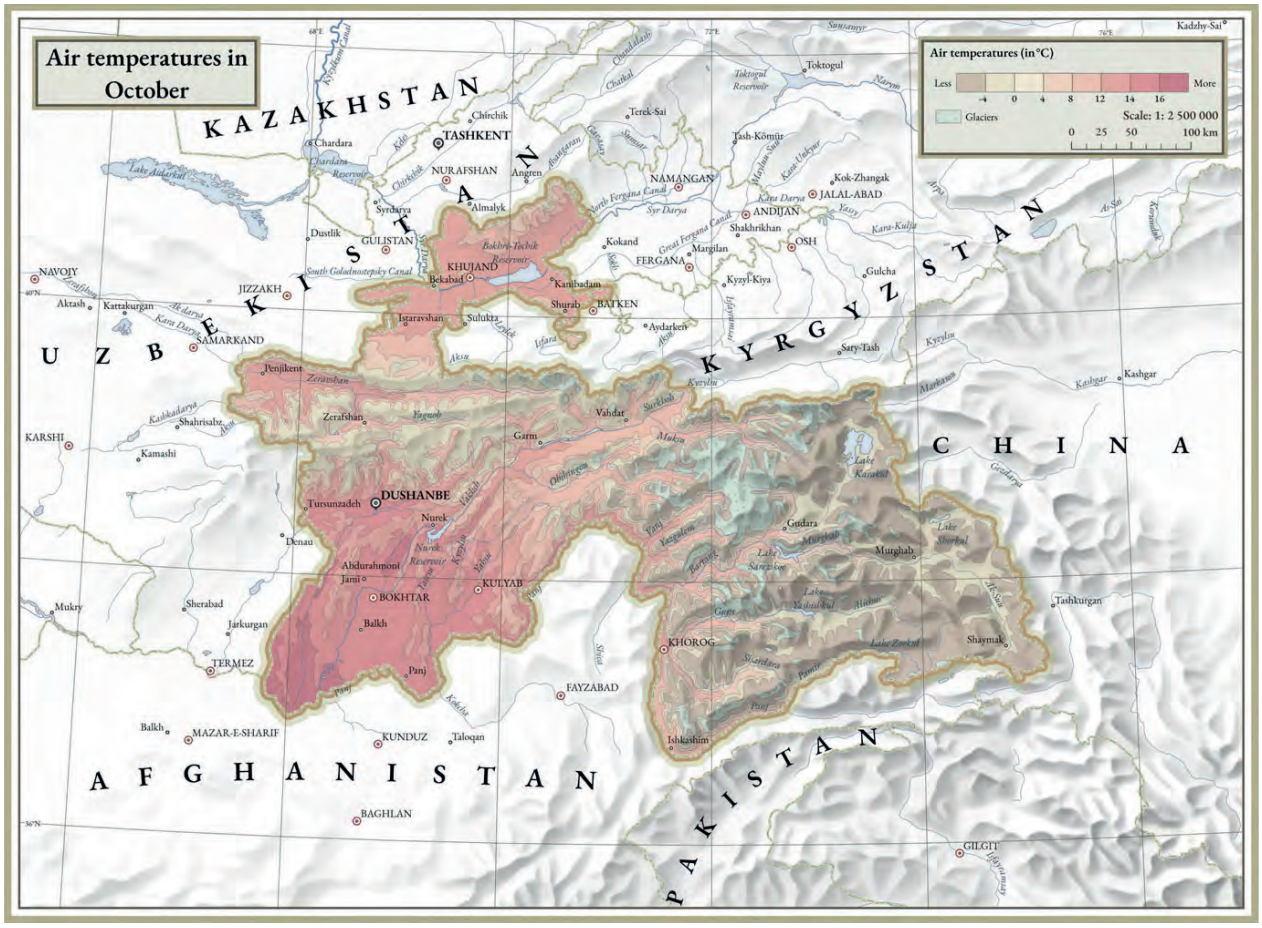
12 Beck et al. (2018) Wood: Present and future Köppen-Geiger climate classification maps at 1-km resolution, Nature Scientific Data.




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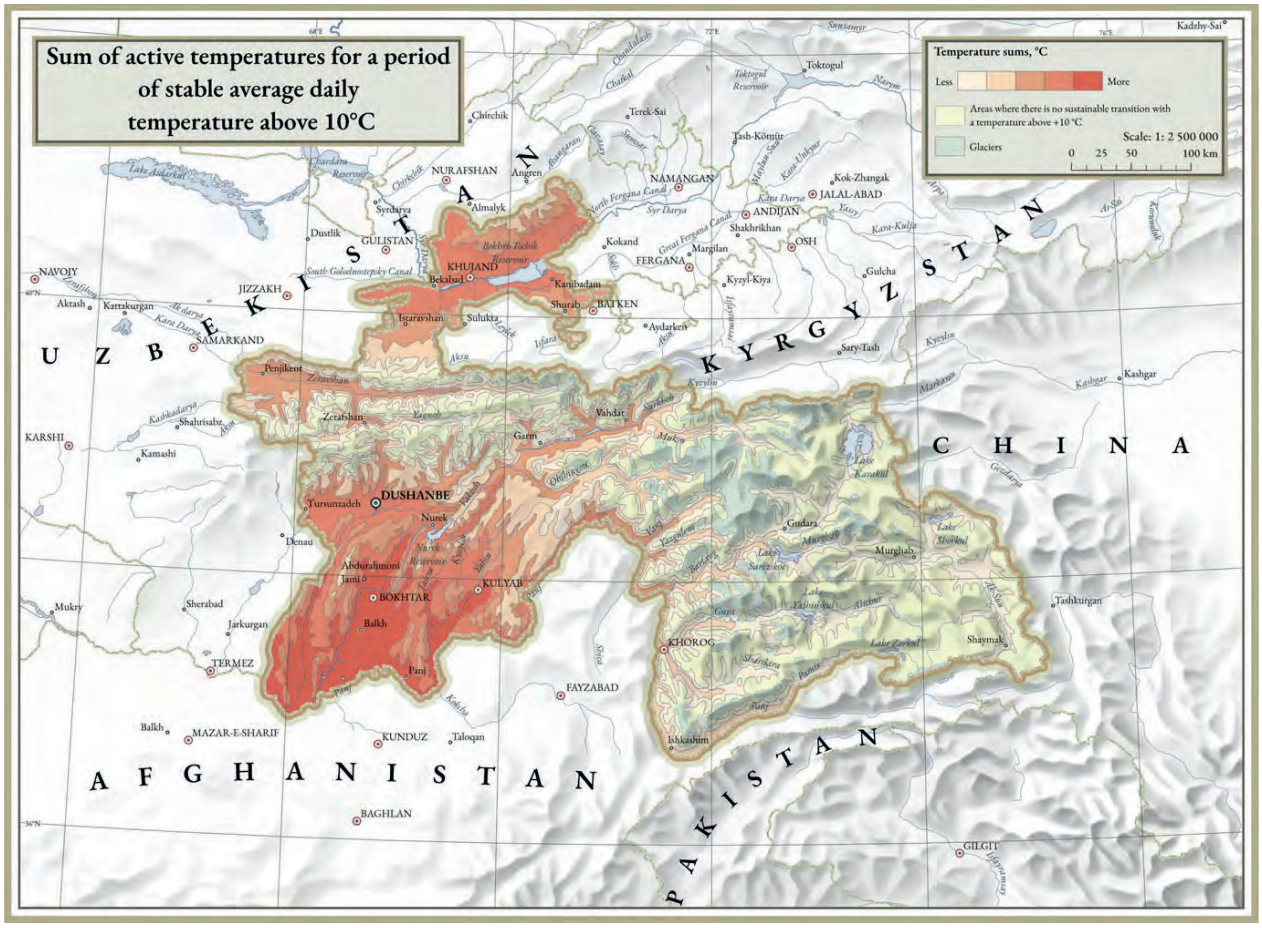

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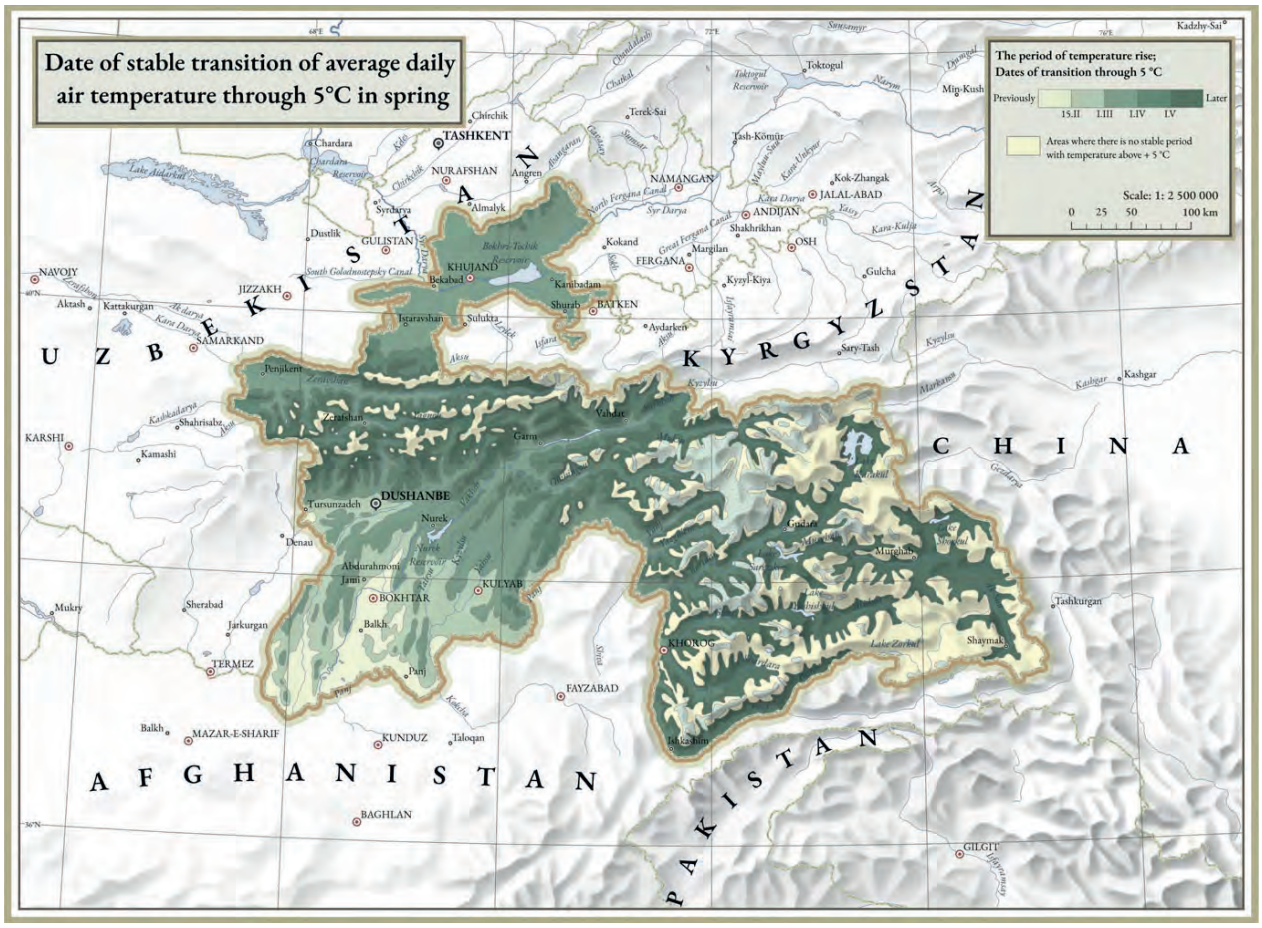

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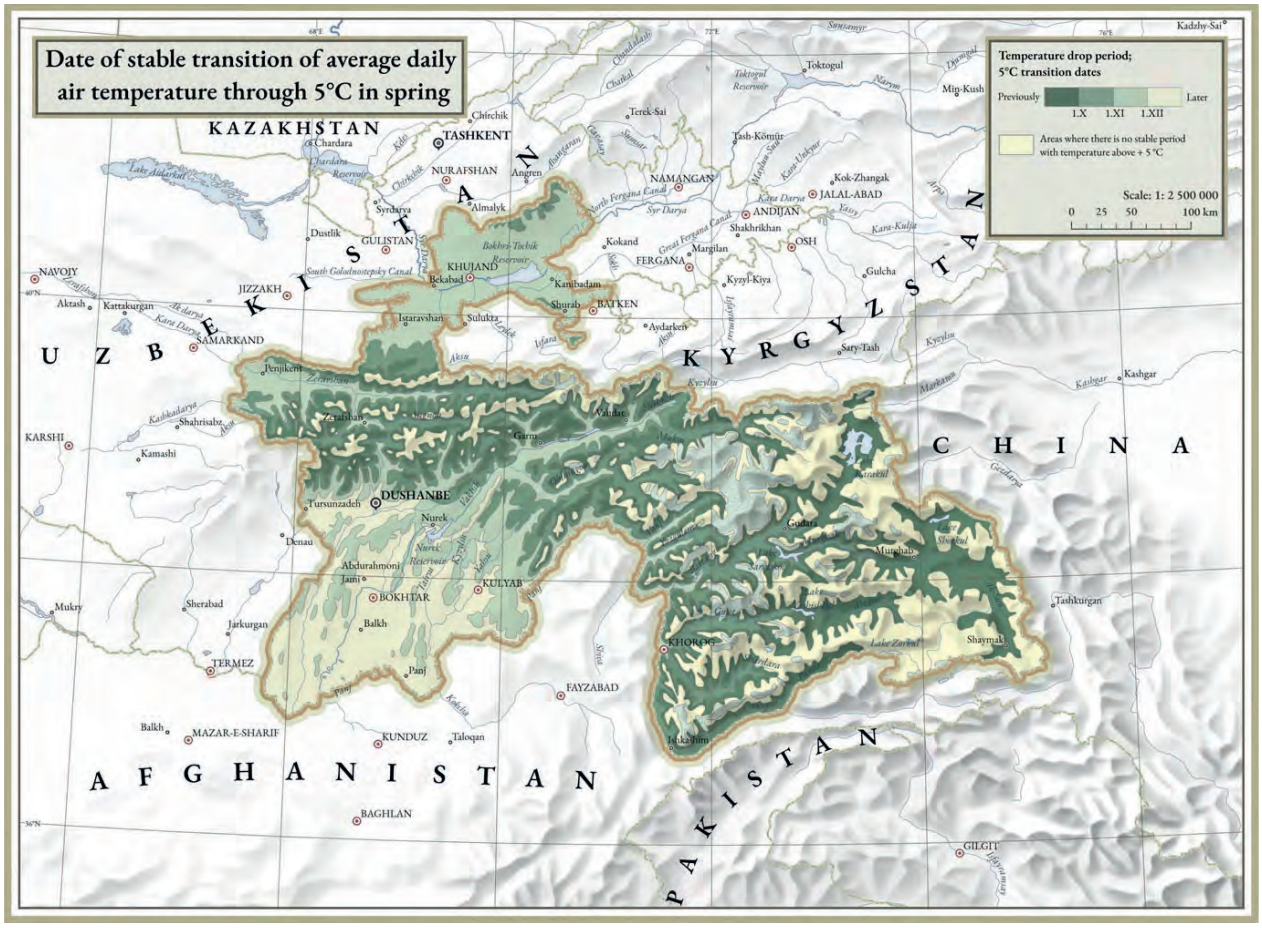

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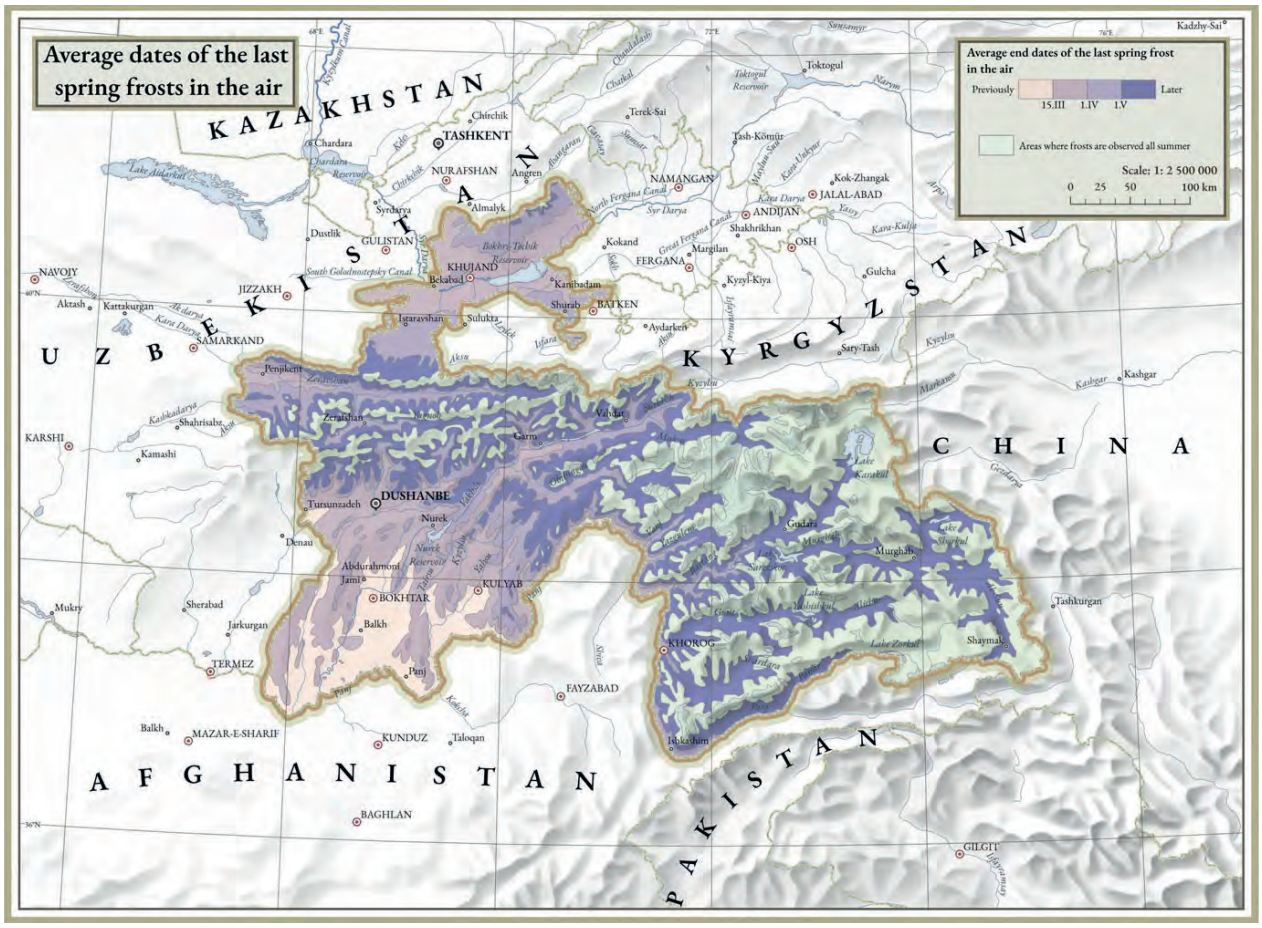

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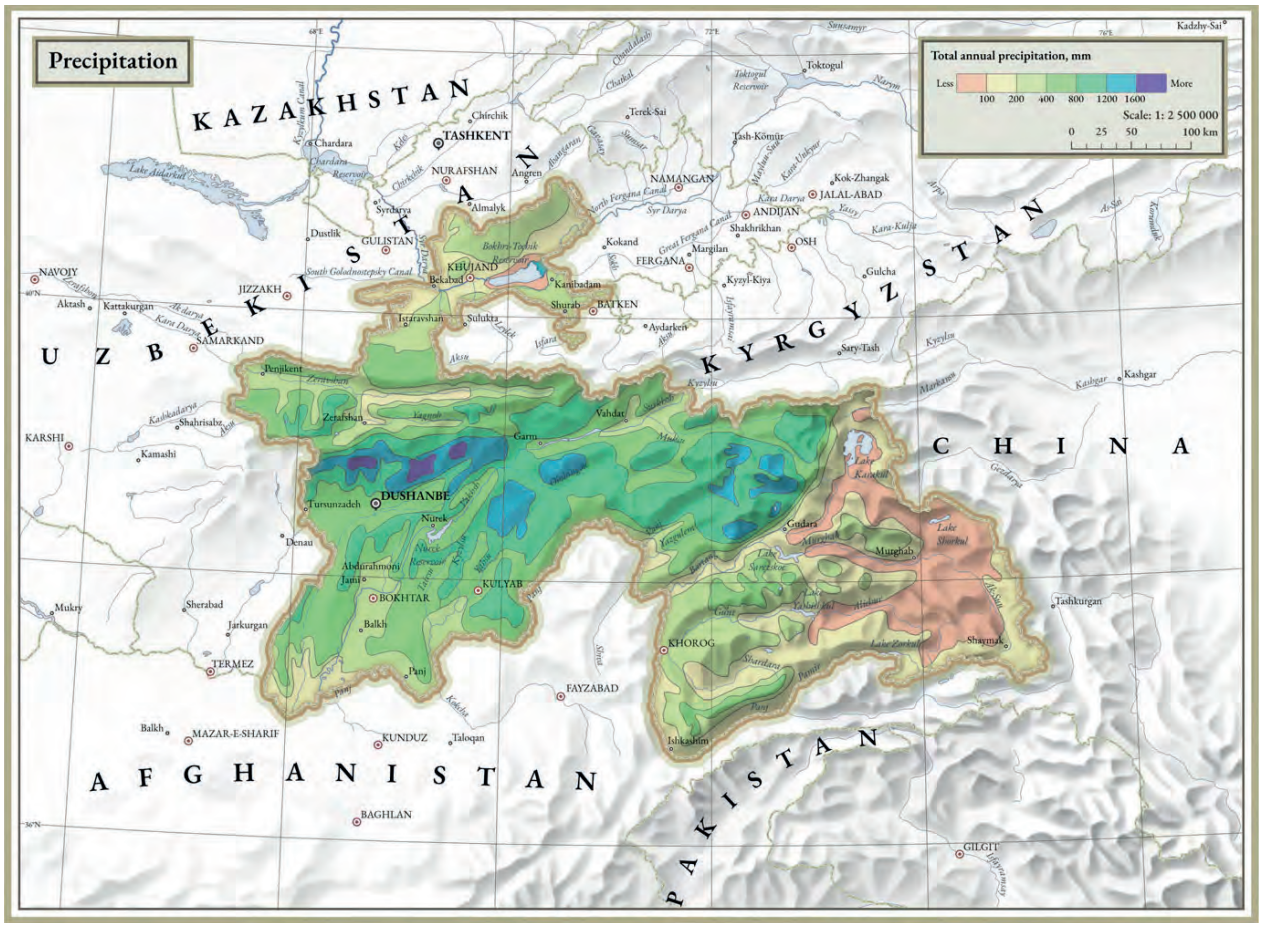

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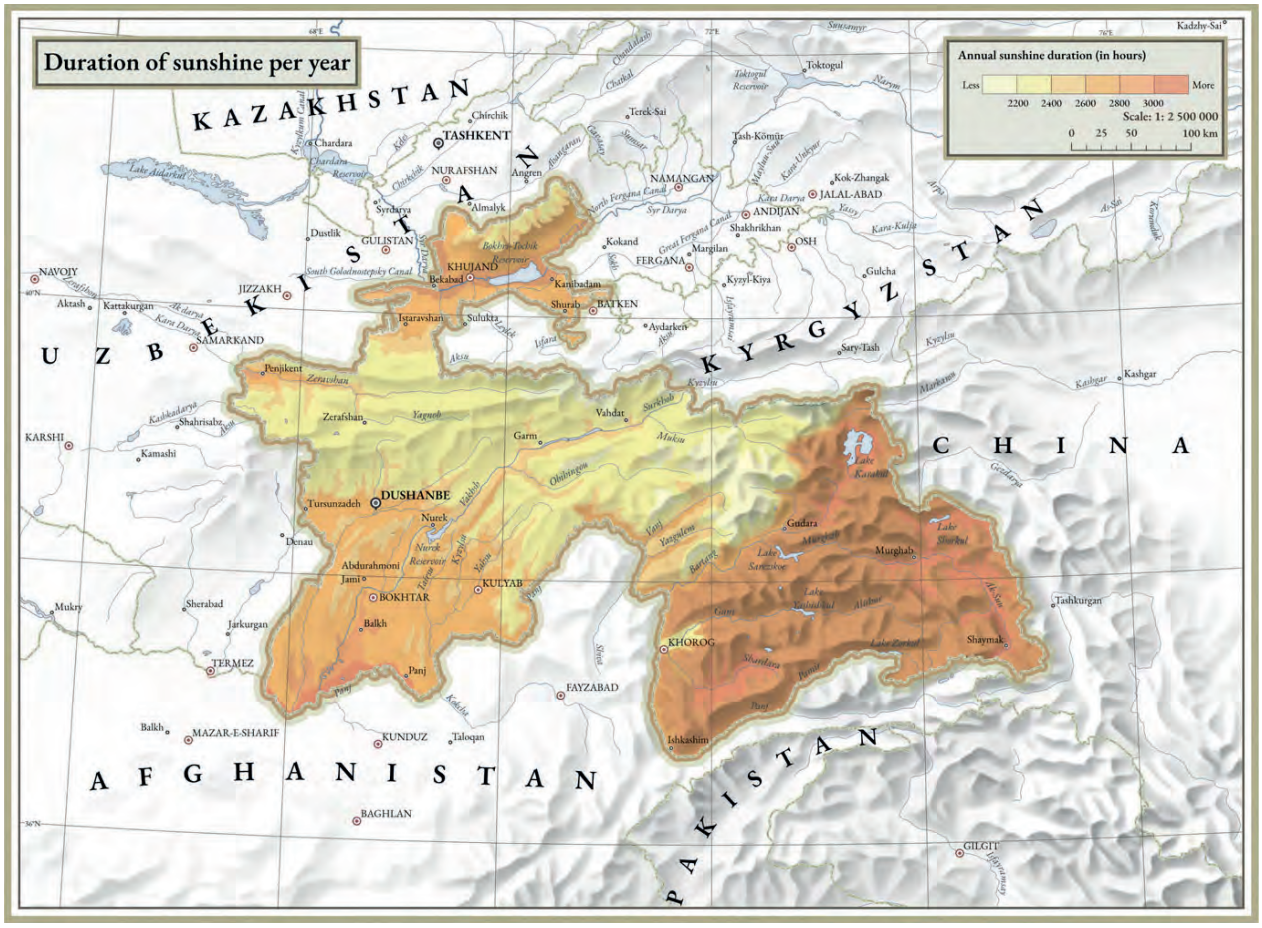

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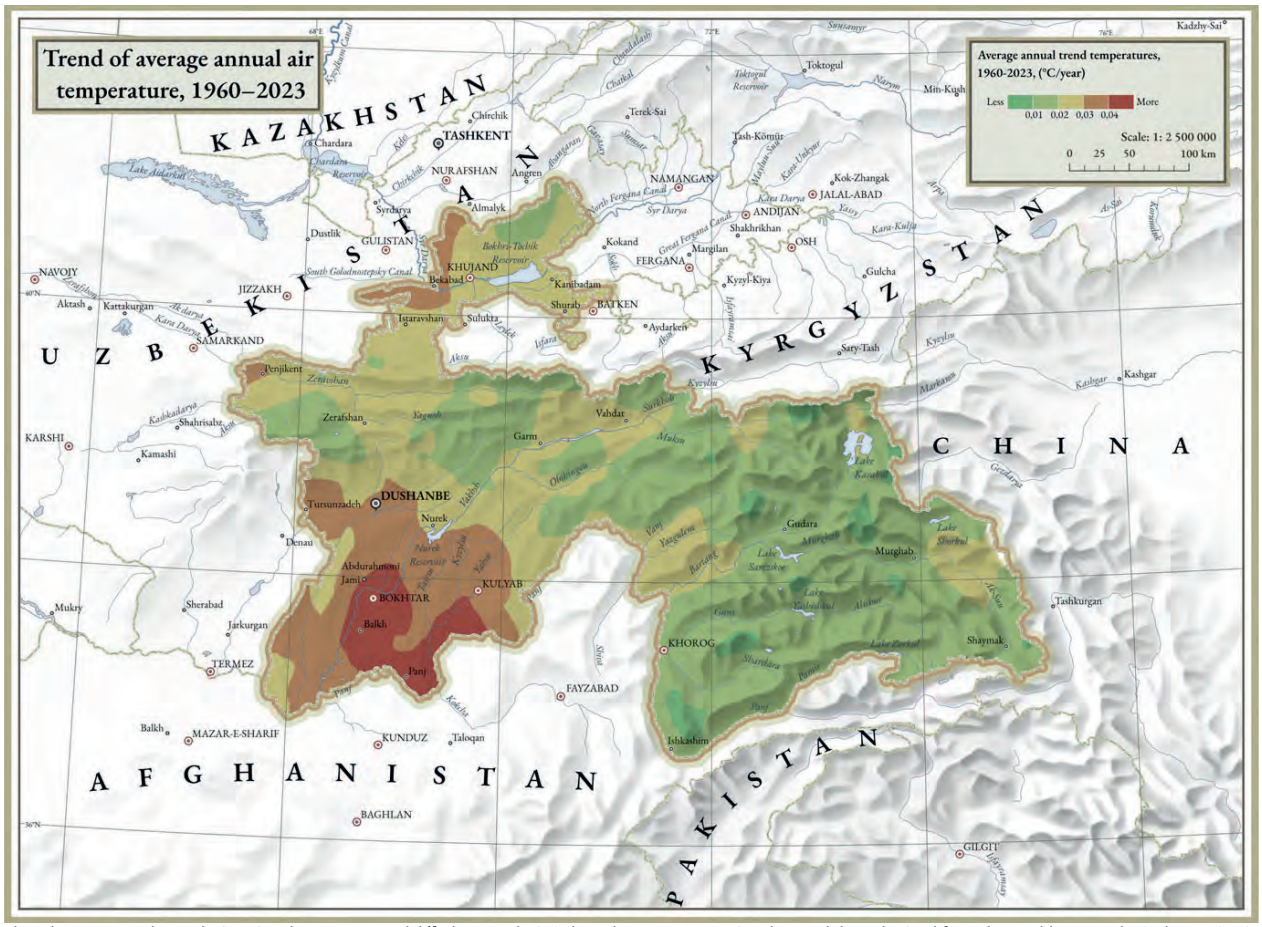

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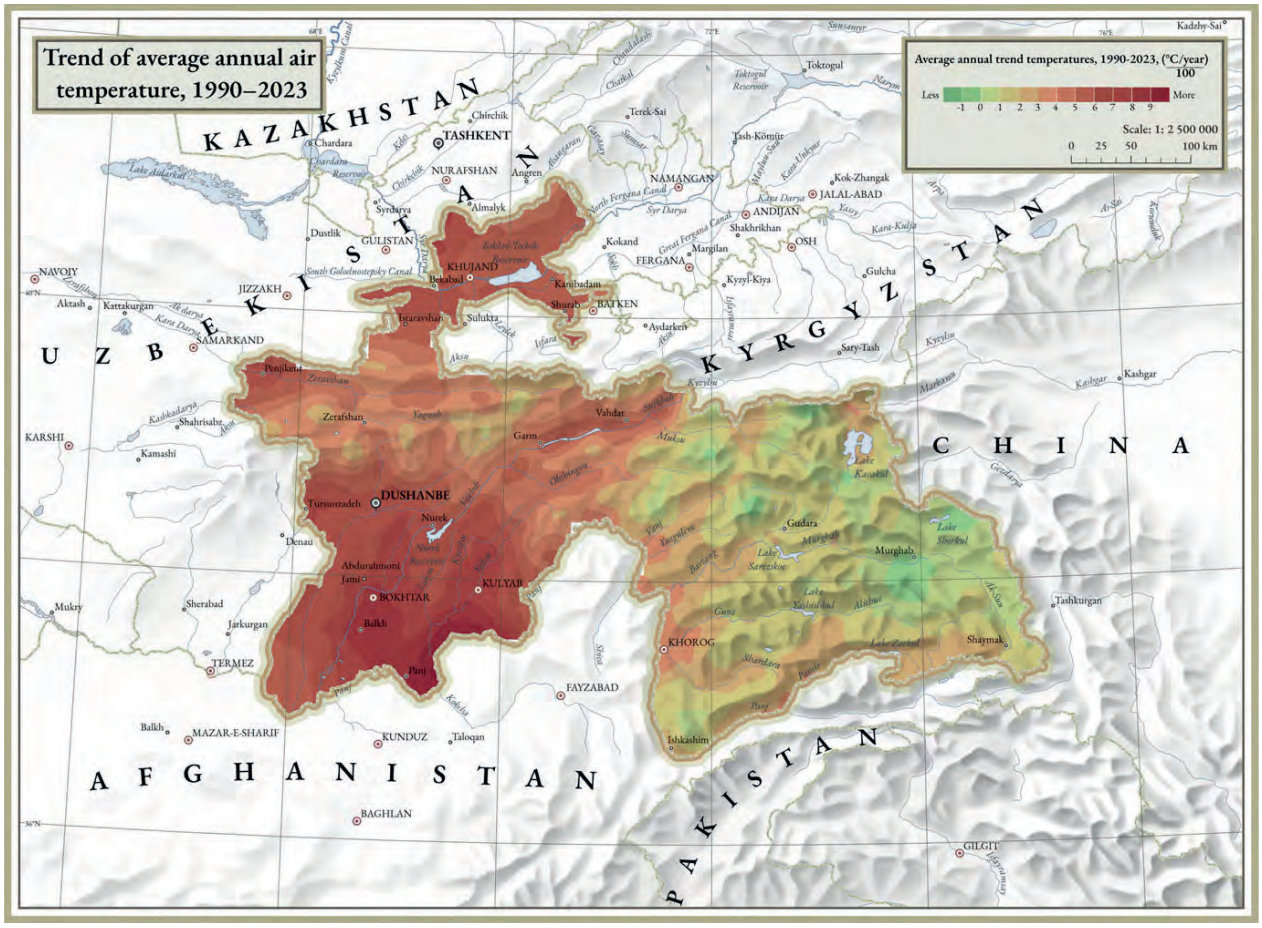



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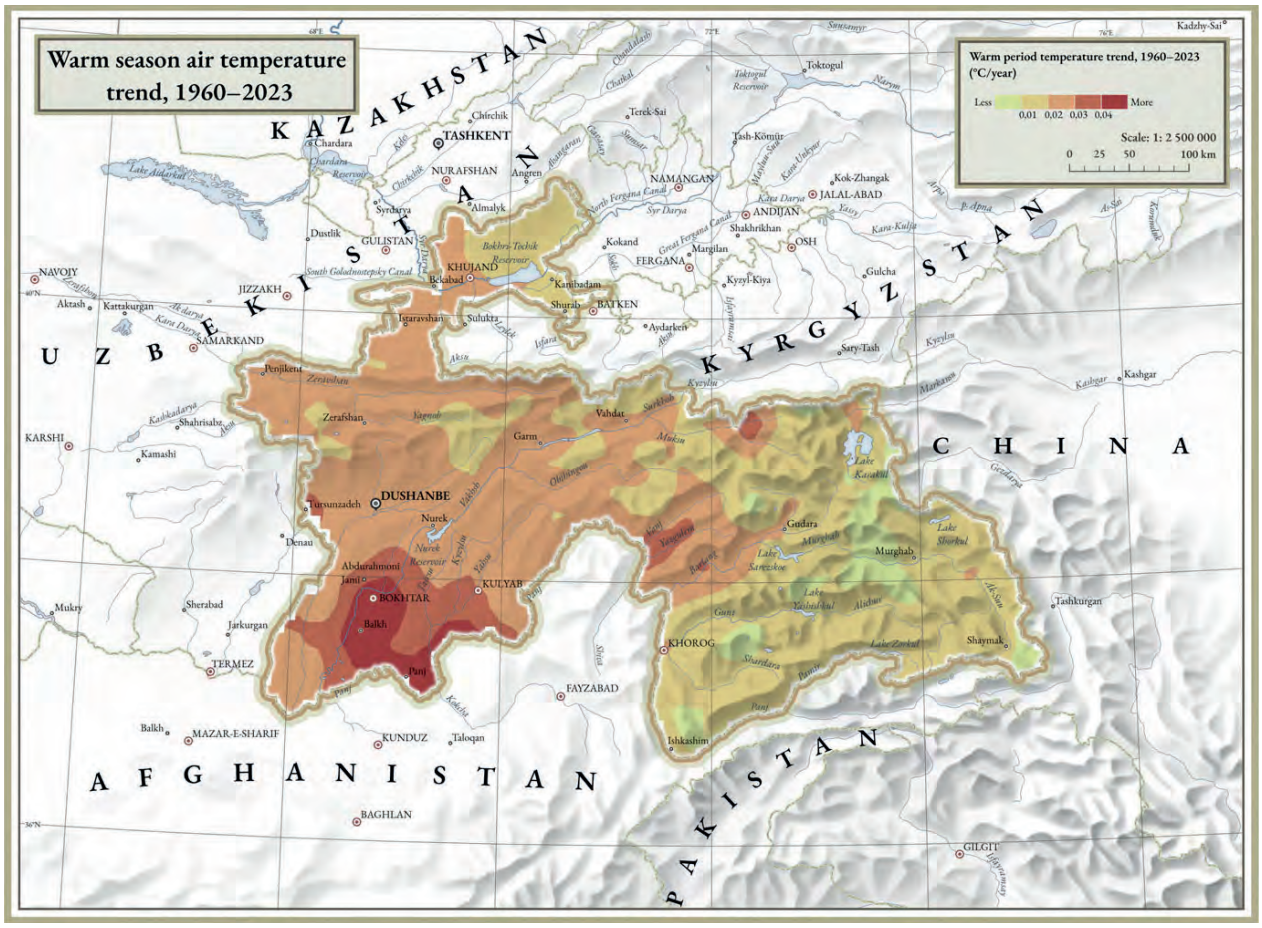



Based on the ERA5 Land reanalysis using the ECMWF model.[13] The reanalysis is based on remote sensing data and data obtained from the World Meteorological Organization (WMO) meteorological stations, only 10 of which are in Tajikistan.[14] The resolution of the ERA5 version used here is 11 km, temporal coverage is from 1950 to the present, the temporal resolution is one day. The trends were determined by the Sens method.

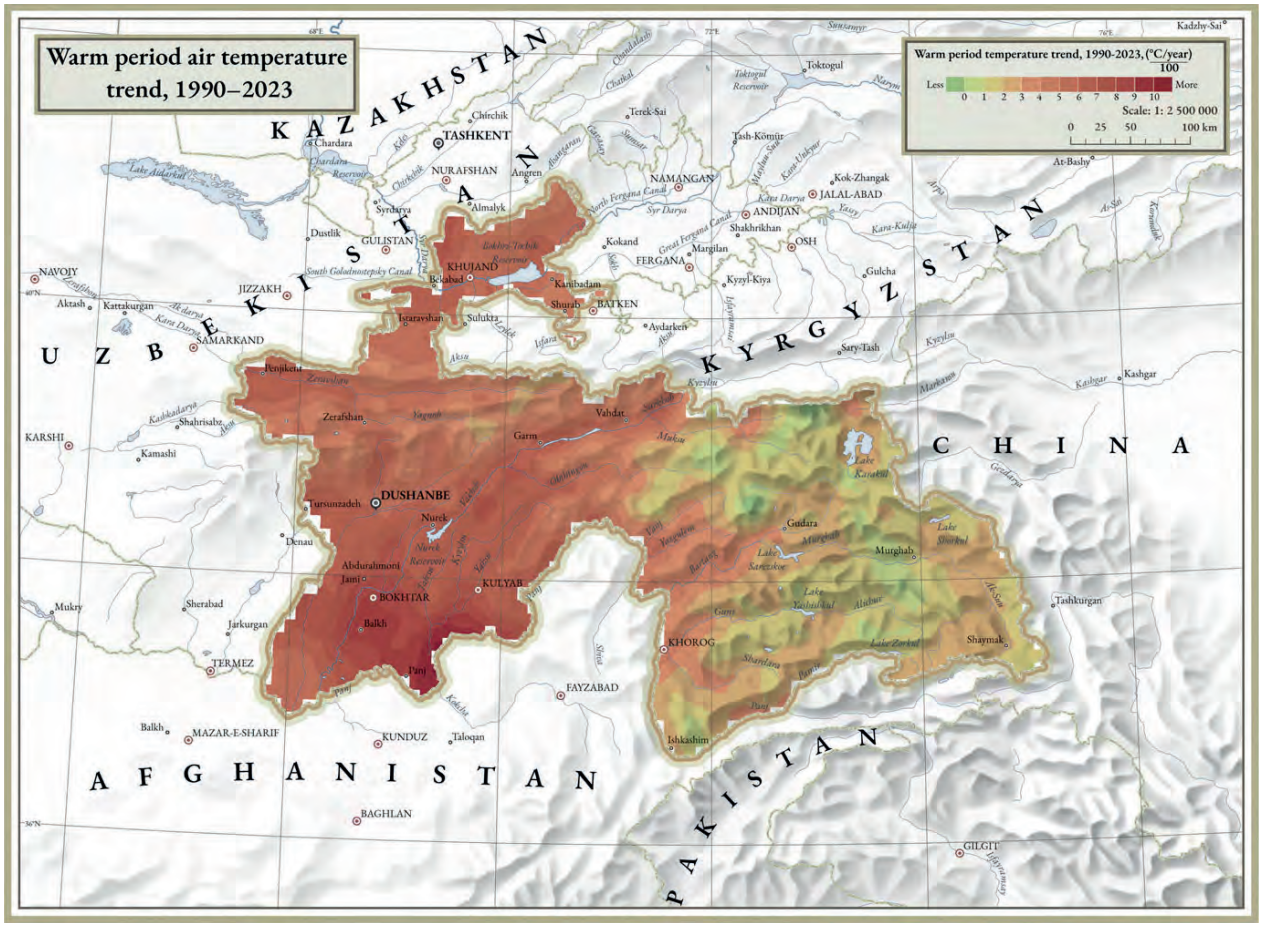
13 https://www.ecmwf.int/en/elibrary/80895-ifs-documentation-cy45r1-part-iv-physical-processes
14 Tajikistan | World Weather Information Service



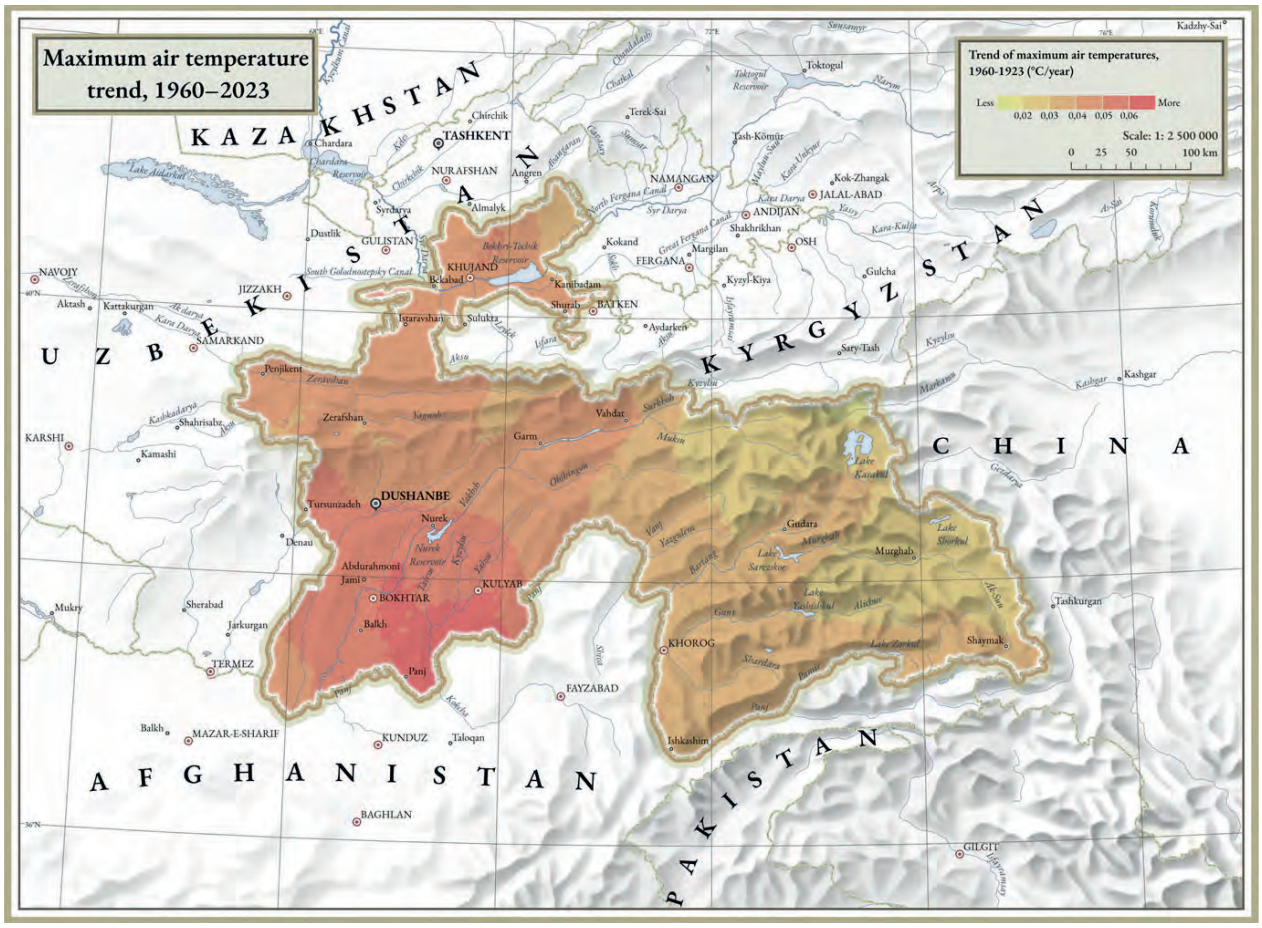

Based on the ERA5 Land reanalysis using the ECMWF model (see note to the above map, 'Trend of mean annual air temperature, 1960–2023').




Based on the ERA5 Land reanalysis using the ECMWF model (see note to the above map, 'Trend of mean annual air temperature, 1960–2023'). The average temperature from April to October for each considered year was taken into account in the calculation of the warm period temperature trend.



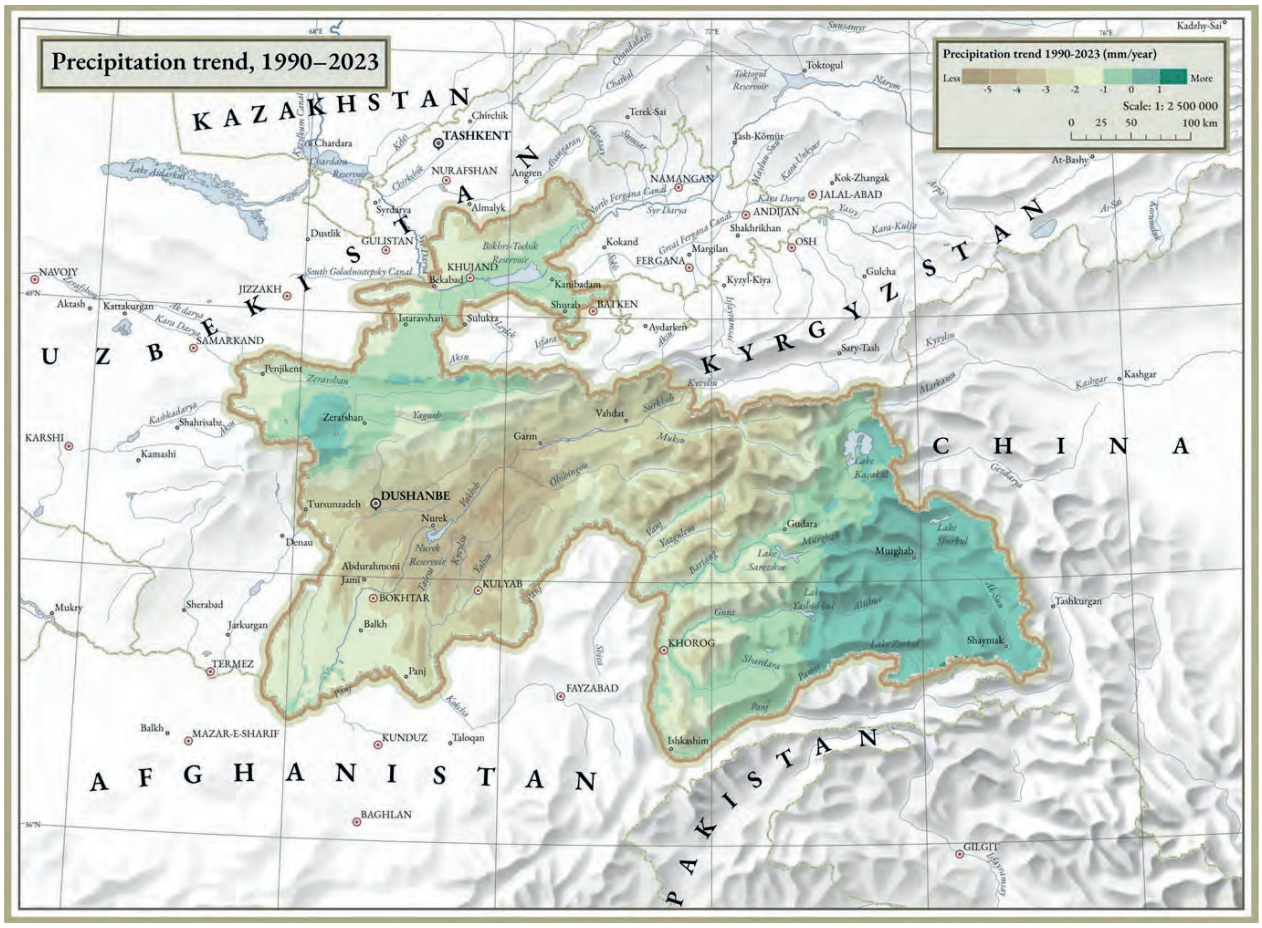

Based on the ERA5 Land reanalysis using the ECMWF model (see note to the above map, 'Trend of mean annual air temperature, 1960–2023').



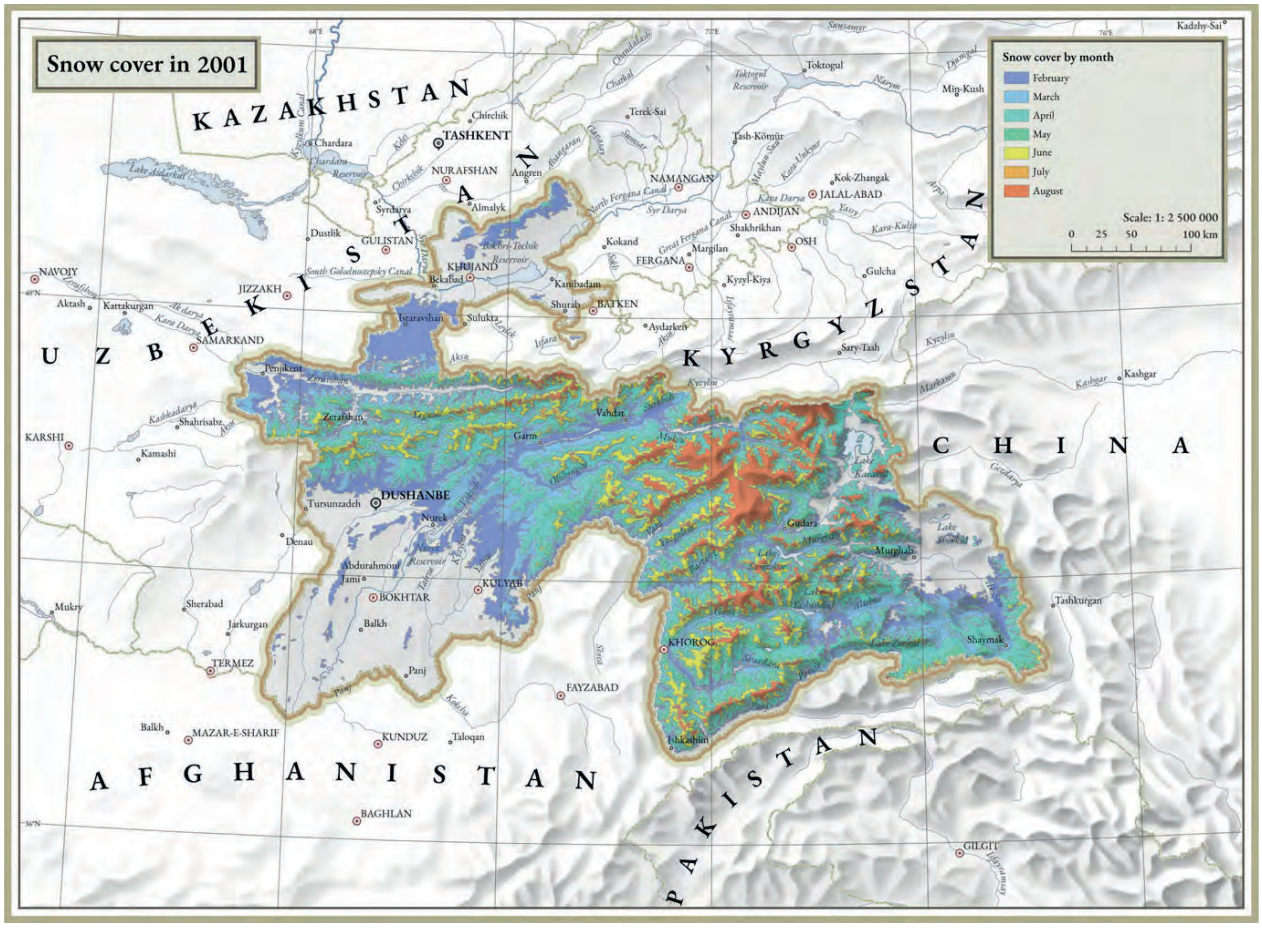

Based on TerraClimate obtained by a reanalysis of WorldClim data, CRU Ts4.0 and JRA55. TerraClimate shows a high degree of compliance with a number of observations at weather stations from various networks, including SNOTEL and RAWS. Spatial resolution is 4 km, temporal coverage is from 1958 to the present, the temporary resolution is 1 month.



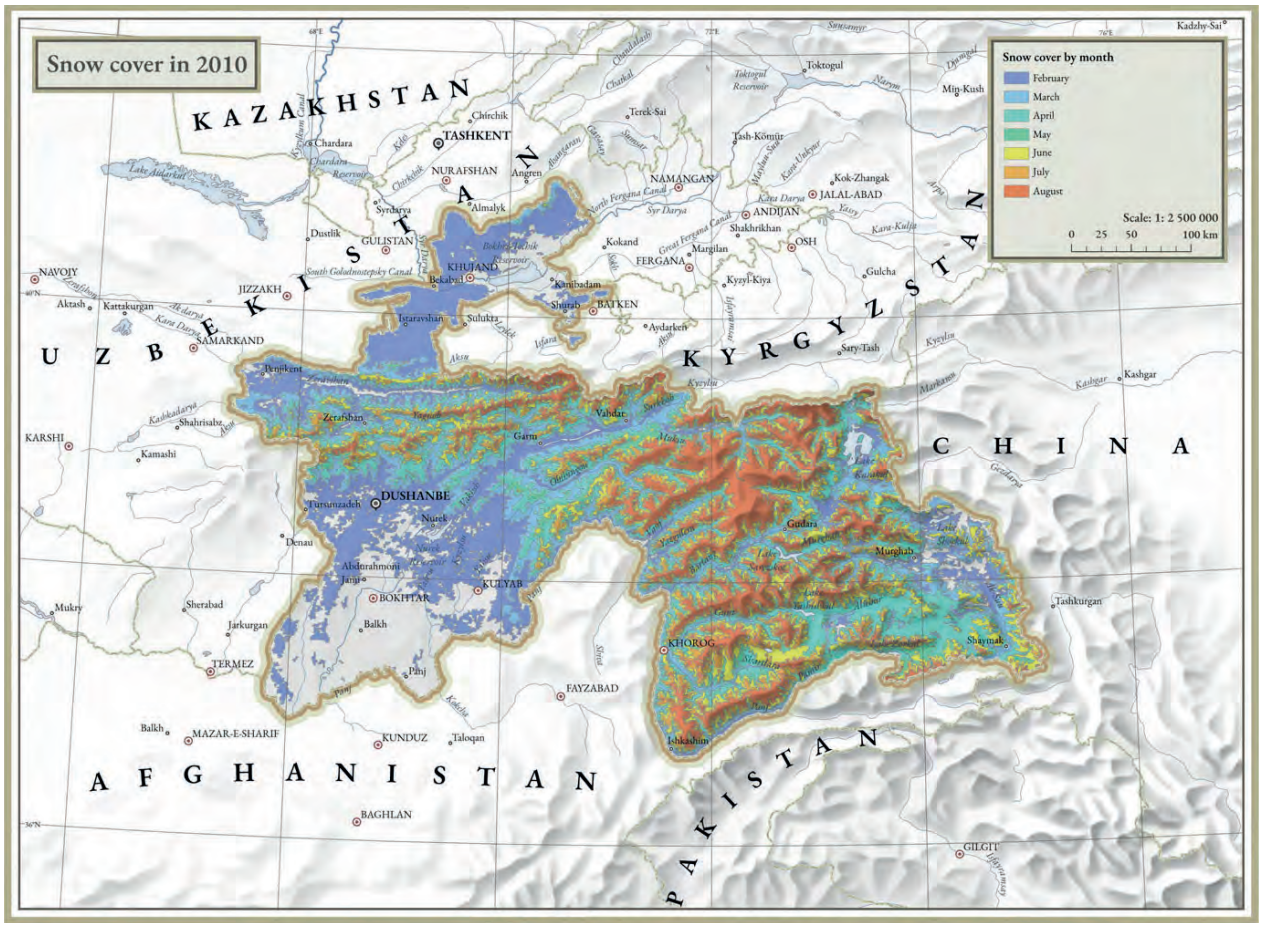

Based on TerraClimate (see note to the above map, 'Trend of maximum air temperature, 1960–2023').



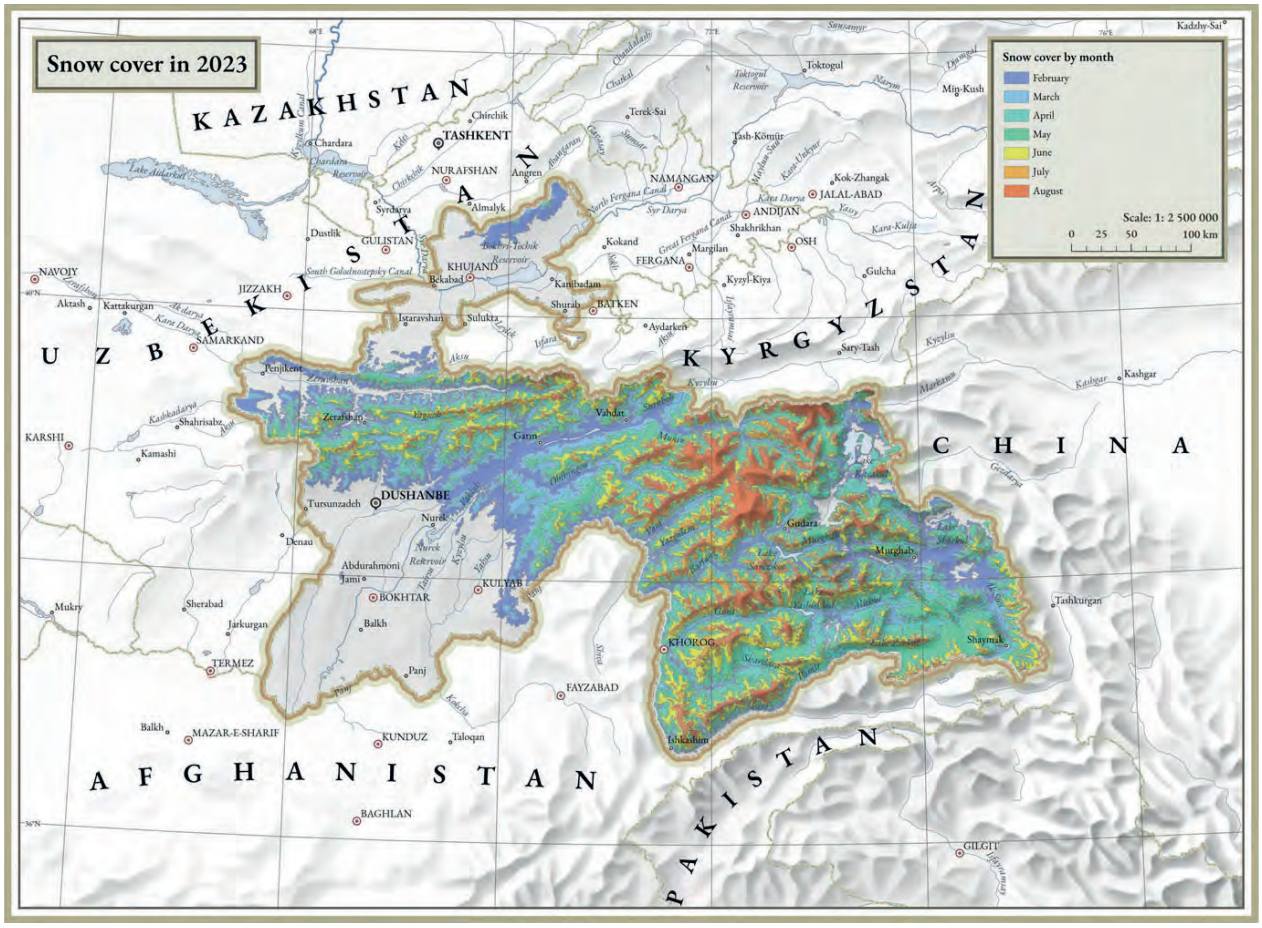

Based on TerraClimate (see note to the above map, 'Trend of maximum air temperature, 1960–2023').



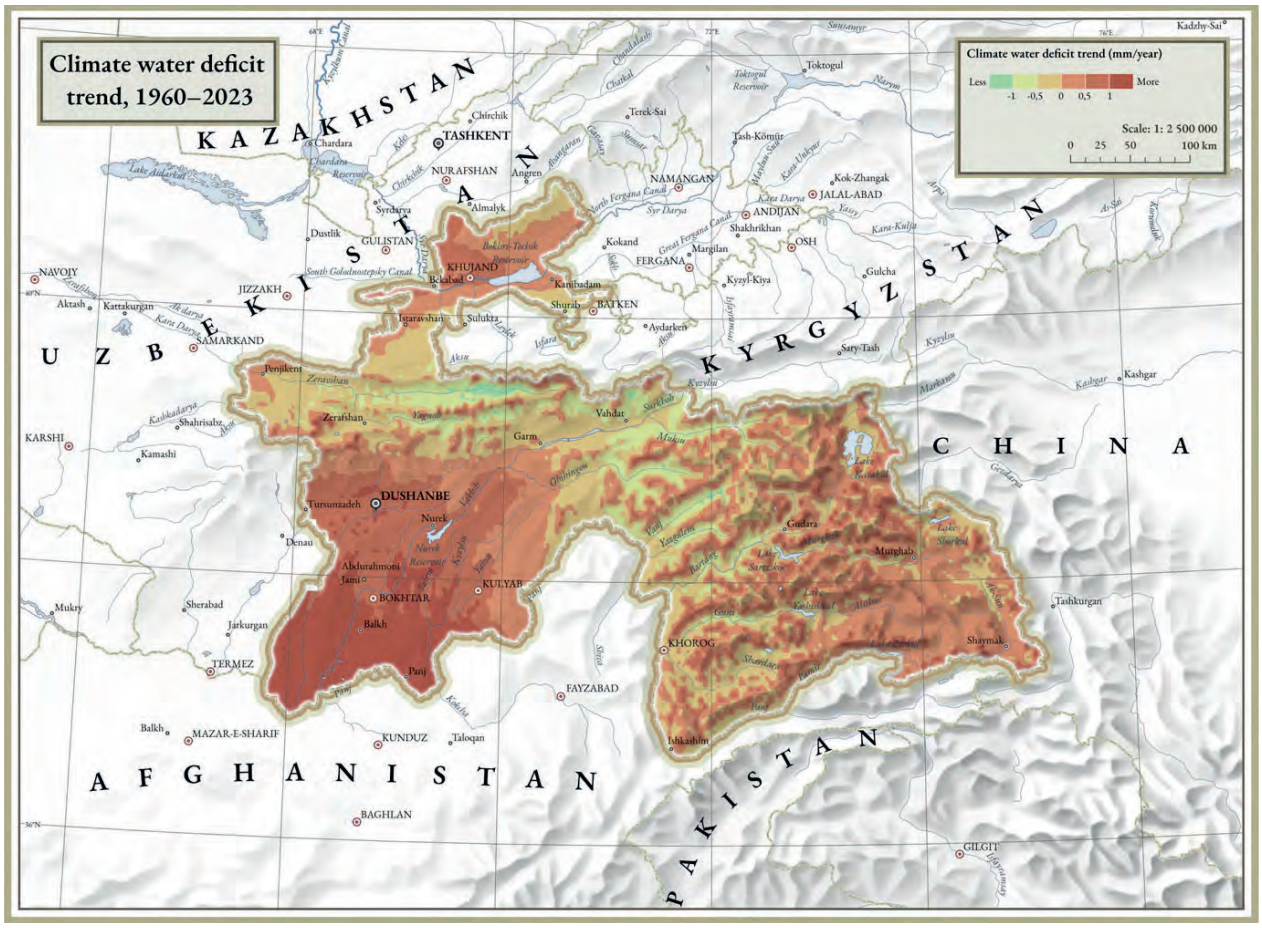

Results obtained by processing a multi-temporal series of MODIS satellite images.



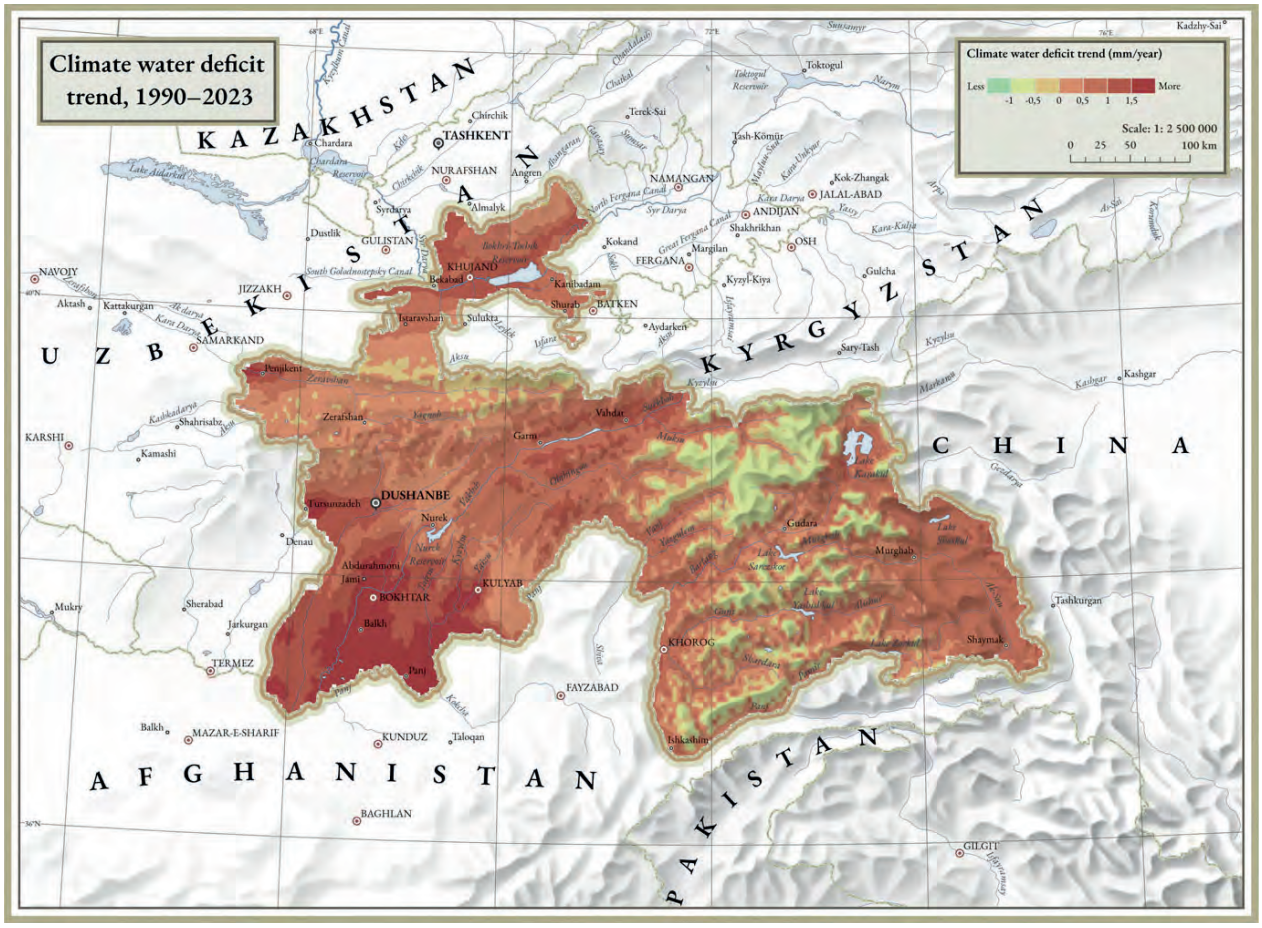

Results obtained by processing a multi-temporal series of MODIS satellite images.



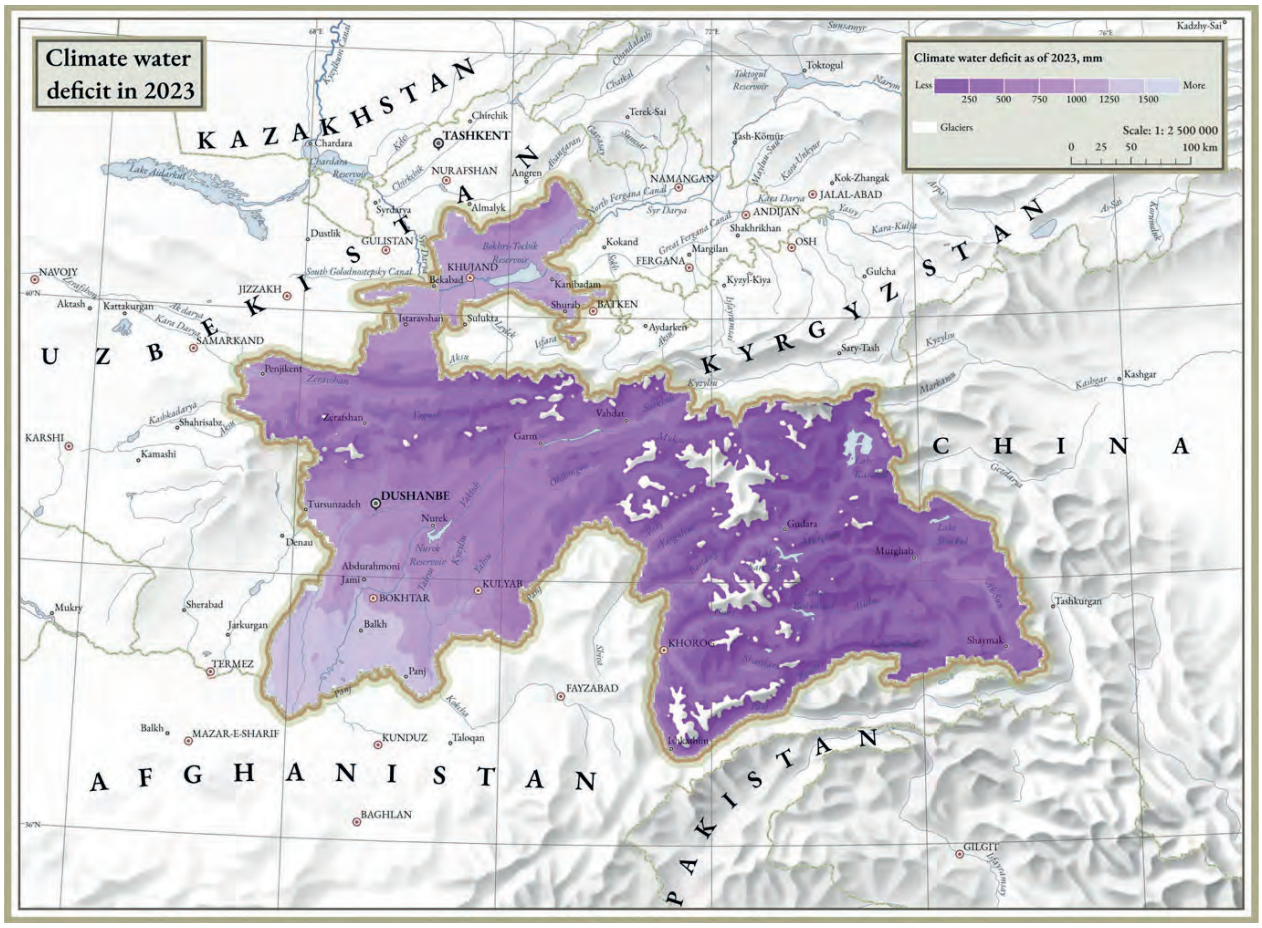

Results obtained by processing a multi-temporal series of MODIS satellite images.



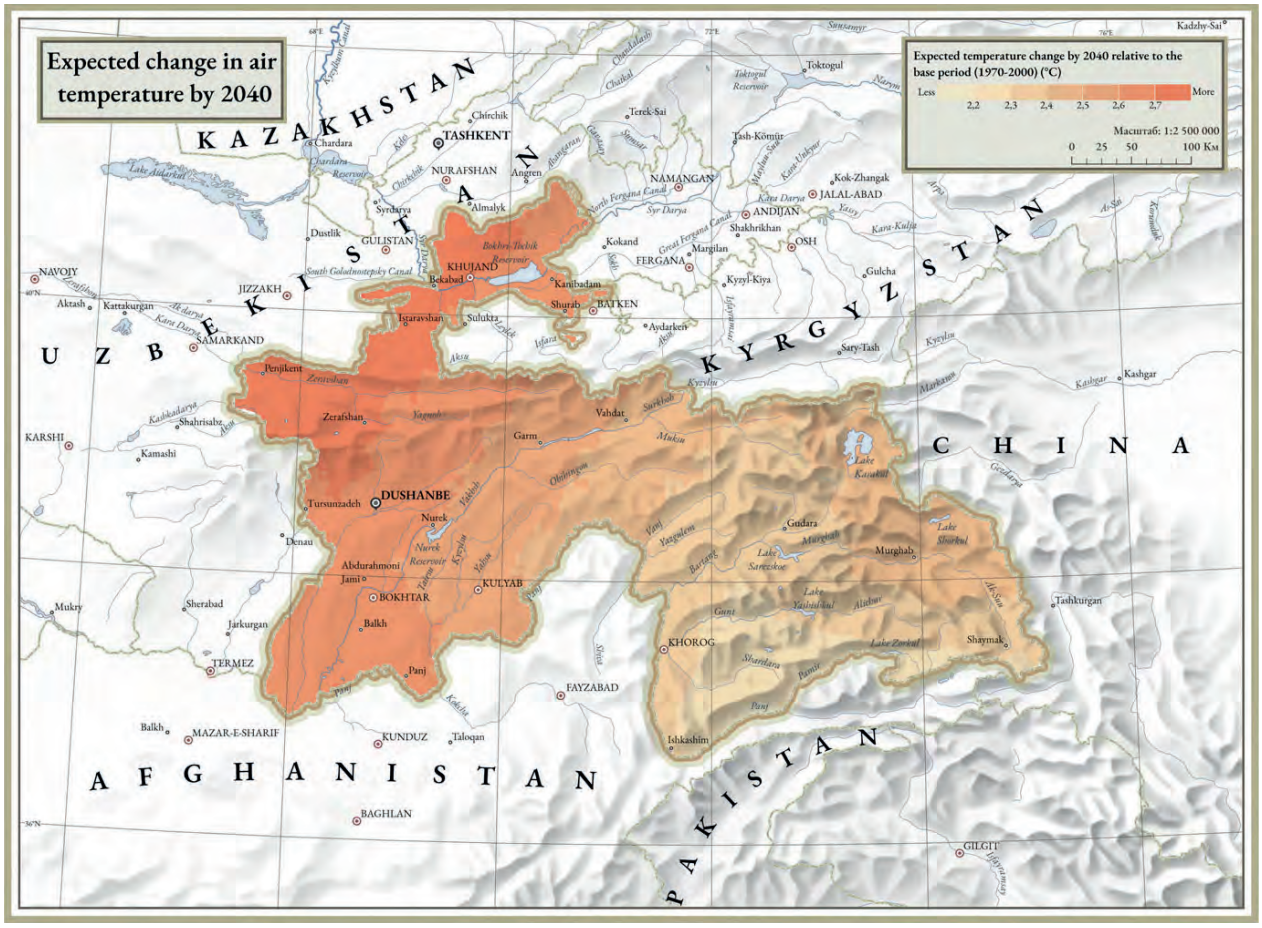

Climate water scarcity is the difference between how much precipitation falls in an area and how much water can evaporate from soil and vegetation surfaces in that area under given climatic conditions (taking into account the average daily temperature, wind speed and underlying surface). Based on Terraclimate (see note to the above map, 'Trend of maximal temperature, 1960–2023').




Based on Terraclimate (see note to the above map, ‘Climate water deficit trend, 1960–2023’).

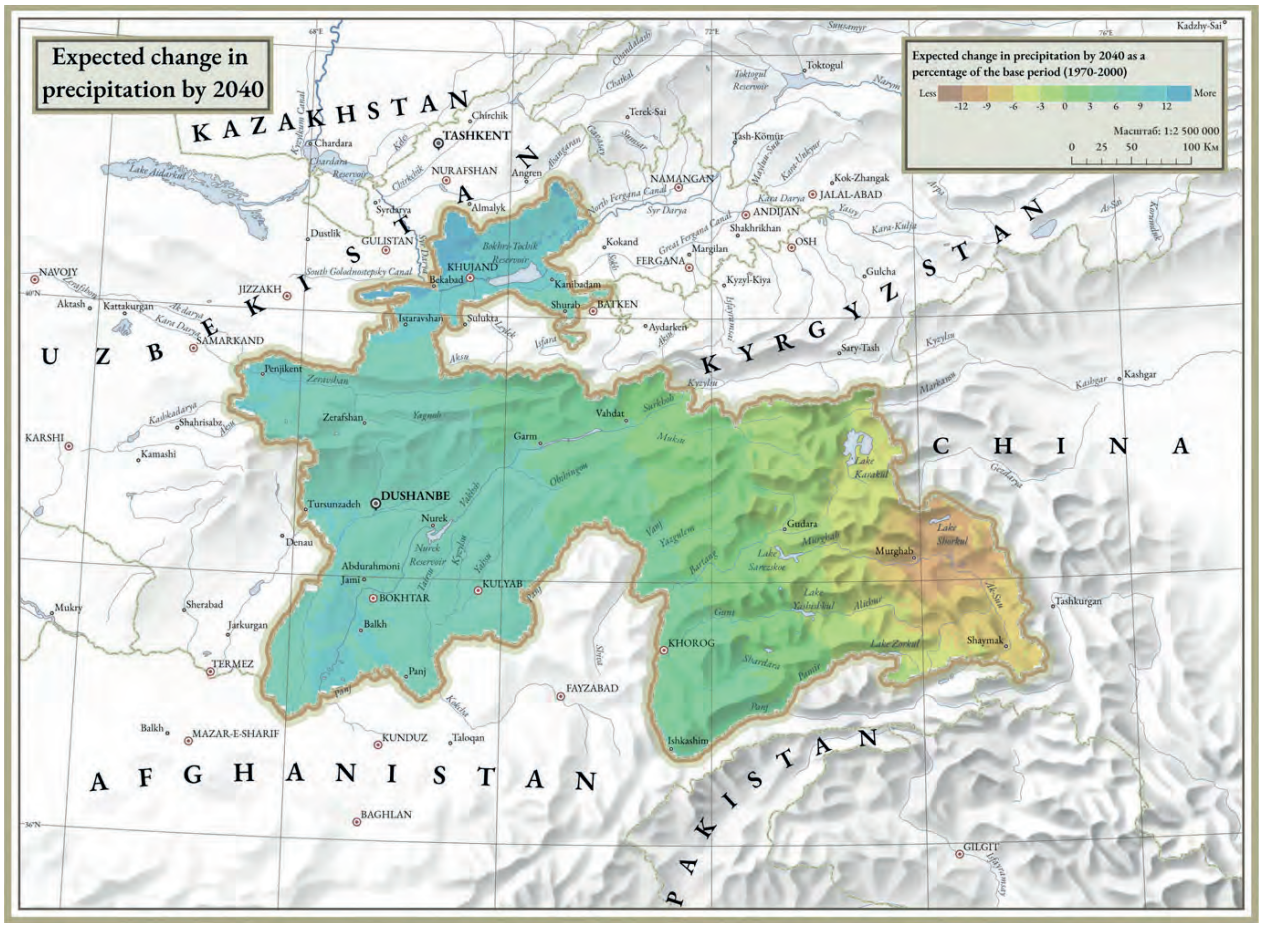



Based on Terraclimate (see note to the above map, ‘Climate water deficit trend, 1960–2023’).




Based on the results of the HadGEM3-GC31-LL model[15] in the implementation of the SSP126 scenario. Spatial resolution is 100 km, temporal coverage is from 2000 to 2100.

15 https://wcrp-cmip.org/cmip6/




Based on the results of the HadGEM3-GC31-LL model (see note to the above map, 'Expected change in air temperature by 2040').

**2.2. General characteristics**

Tajikistan is simultaneously the least urbanized and, with the region's highest population growth rates, the fastest growing country in Central Asia in terms of population[16]. According to the 2023 census, the population of the republic increased by 28 per cent from 2010 to 2020, going from 7.56 million to 9.66 million people[17]. The average annual population growth rate in this period was 2.53 per cent, although this is lower than in the late Soviet period when this figure was 3.37 per cent per year before falling to 2 per cent with the crisis years in the 1990s. The rapid population growth over the past 10 years is reflected in a 32 per cent increase in the number of households in both urbanized and rural areas. The highest annual population growth rates (2.95 per cent) were noted in cities and so called regions of republican subordination (RRS), including Dushanbe. The lowest population growth rates are for the Gorno-Badakhshan Autonomous (GBAO), where the population grew by less than 1 per cent per year during this period. The forecast for the country's total population in 2029 is 11.03 million people, indicating some slowdown in population growth[18]. According to the UN demographic sector's forecasts, Tajikistan's population could grow to 25 million by 2100, which equates to an average growth rate of approximately 1.8 per cent per year[19].



*Costume of a young woman (Darvaz)*

The population structure of Tajikistan is characterized by a predominantly rural population (73.7 per cent), almost universal literacy (99.79 per cent), a young average age (25.9 years), a high proportion of children under 17 (more than 40 per cent), a significant percentage (21 per cent) of households headed by women due to the war of the 1990s and current labour migration as well as a small percentage of disabled people (2.2 per cent) and elderly people (8 per cent). Tajikistan's society traditionally consists of large families as some 82 per cent of households have an average of 10 members, typically consisting of three adult women, three adult men and four children. Tajikistan is also characterized by low internal migration as more than 75 per cent of residents live in the place of their birth[20]. At the same time, emigration, mainly to Russia, is currently estimated at 25–30% of the economically active population, or about 0.9 million people (while employment in the agricultural sector of Tajikistan at about 0.5 million people)[21]. Almost half of Tajik households have close relatives who are labour migrants and provide significant financial support to their large families. However, a category of 'abandoned wives' has also emerged from this migration process, forcing such women to take responsibility for managing their households, including growing crops and, to a lesser extent, raising livestock. This increases the role of women in the country's economy and decision-making at the local level, which is also recognized by men. About 40 per cent or more of decisions on which crops to sow, the sowing calendar plan and the sale of the resultant produce are made by women independently, which provided the basis for the emergence of the perception that there was a 'feminization of agriculture' in a comprehensive gender survey of 2016[22].

The distribution of Tajikistan's population by regions and cities is also uneven, with most inhabitants concentrated in the Khatlon (35.9 per cent) and Sughd (29.1 per cent) regions as well as in the capital, Dushanbe (9.3 per cent). The smallest share of the population is in the GBAO (2.5 per cent) *(see map 'Share of built-up area to river basin area')*.



*Costume of a young man (Northern Tajikistan)*

Tajikistan's average population density has increased from 42.8 persons per km² in 2000 to 64.5 persons per km² in 2019, however, at the local level, this figure is highly dependent on the geographical features of the mountainous terrain. The most densely populated areas of the country are in the northern and southwestern lowlands, while the most sparsely populated areas are in the mountainous regions. By way of example, the population density in the valleys of northern Tajikistan is 385 persons per km² in places, creating an acute shortage of land resources, while the population density of the GBAO is only 3.4 persons per km² [23]. The GBAO, which constitutes the largest

16 Yu et al. (2021) Spatiotemporal changes in water, land use, and ecosystem services in Central Asia considering climate changes and human activities // Journal of Arid Land. Vol. 13. https://doi.org/10.1007/s40333-021-0084-3.
17 Population and Housing Census - Agency on statistics under the President of the Republic of Tajikistan.
18 Tajikistan - total population 2019-2029| Statista.
19 UN DESA (2019) World Population Prospects - Population Division - United Nations. Retrieved from: https://population.un.org/wpp/Graphs/Probabilistic/POP/TO T/762 .
20 Woman's time use in rural Tajikistan (2020) Asian Development Bank. P. 78.
21 Rocheva A., Varshaver E. (2018) Gender Dimension of Migration from Central Asia to the Russian Federation. Asia-Pacific Population Journal 32 (2): 87–135. doi:10.18356/e617261d-en.
22 National Gender Profile of Agricultural and Rural Livelihoods-Tajikistan (2016). FAO. Ankara. *NGP_Tajikistan_06_14.indd.
23 Olimova S., Olimov M (2012) Environmental Degradation, Migration, Internal Displacement, and Rural Vulnerabilities in Tajikistan. International Organization for Migration. Dushanbe. 48 p.

region of eastern Tajikistan, is largely uninhabited. Khorog, the largest city in the region, has a modest 28,900 residents, while the whole region's population is approximately only 205,000.



*Costume of a young woman (on the left – Southern Tajikistan, Kulyab, on the right – Kukhistan, Karategin)*

The settlement system of Tajikistan is characterized by low rates of urbanization. The share of the urban population in Tajikistan is about 27 per cent, which is not only the lowest rate among Central Asia countries but one of the lowest such national figures in the world. Cities in Tajikistan are small in number and unevenly distributed. The largest city in the republic is Dushanbe, with a population of 948,200 (2020), while other large cities include Khujand (196,400), Bokhtar (124,500) and Kulob (216,800).

The majority of Tajikistan's population lives in rural areas, where they are engaged in agriculture, especially in growing cotton, various grains, vegetables and fruits as well as livestock breeding. Rural settlements in Tajikistan have various forms and types depending on the local natural conditions, ethnic composition, historical development and economic specialization. Among such settlements, one can distinguish villages, auls, kishlaks, jamoats and others.



*A woman in a national costume*

Tajikistan has undergone a significant transformation of its settlement system in the post-Soviet period as, overall, there has been a significant increase in the number and area of settlements in the country *(see Tables 3 and 4)*. A comparison of modern satellite images and cartographic materials from the late Soviet period shows that since 1970 the total built-up area has increased by 89 per cent: going from 1,656 to 3,133 km2. Some 86 per cent of this increases is attributable to the expansion of large settlements *(see map 'Dynamics of built-up area by basins')*. New settlements increased the total built-up area by the remaining 14 per cent as the abandonment of small (on average about 0.1 km²) individual settlements marked on the maps of the 1970s – 361 of which were identified - had a total area of only 35 km² *(see map 'Disappeared settlements')*. However, this loss has been more than offset by the emergence of numerous small separate settlements that have appeared with a total area of 295 km² *(see Table 4)*.



*, Bride's costume (Western Pamir, Ishkashim)*

These dynamics generally indicate a trend toward population concentration: Large settlements are expanding and, in areas with high population density, larger conglomerate settlements are formed by merging several smaller ones. The largest expansion of settlements since the 1970s has been observed in the Khatlon region – increasing in number by 701 and covering an extra 556 km² *(see Fig. 4)*. In the Sughd region and the RRS (including Dushanbe), the expansion of old settlements was also characterized by high rates, with 556 such settlements covering an extra 529 km² *(see Fig. 4)*. However, the Sughd region leads in the number of settlements that have appeared as 1,312 new settlements now show on maps that were not there in the 1970s. While all of the above-mentioned regions are oases, with irrigated agriculture dominating the economy, the identified trends in the dynamics of settlements are also characteristic of the GBAO, albeit less pronounced and despite the very specific geographic conditions created by the Pamirs. The Pamirs are experiencing an increase in settlements, despite the settlement abandonment rate (15 per cent) being higher than the national average (10 per cent). The average area of settlements in the Pamirs that have disappeared since the 1970s did not exceed 0.1 km², i.e. they were isolated and very small households. In return , about 200 new settlements with an even smaller average area have appeared. The growth of the GBAO's built-up areas by 76 per cent is attributable to the expansion of existing settlements, which again corresponds to trends in the settlement system of other regions of the country *(see Fig. 4)*. This is a process that is occurring despite the GBAO's low population growth rate of less than 1 per cent per year.



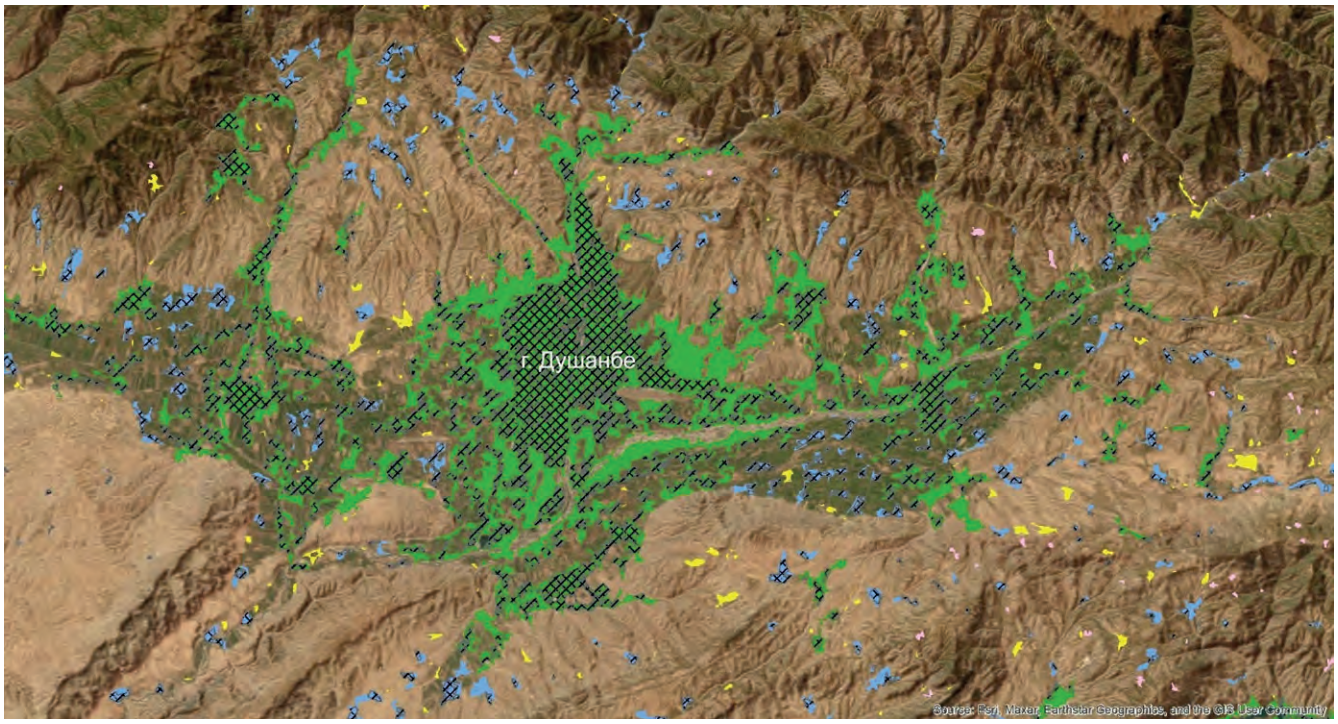

*Sughd region, Syr Darya river valley*



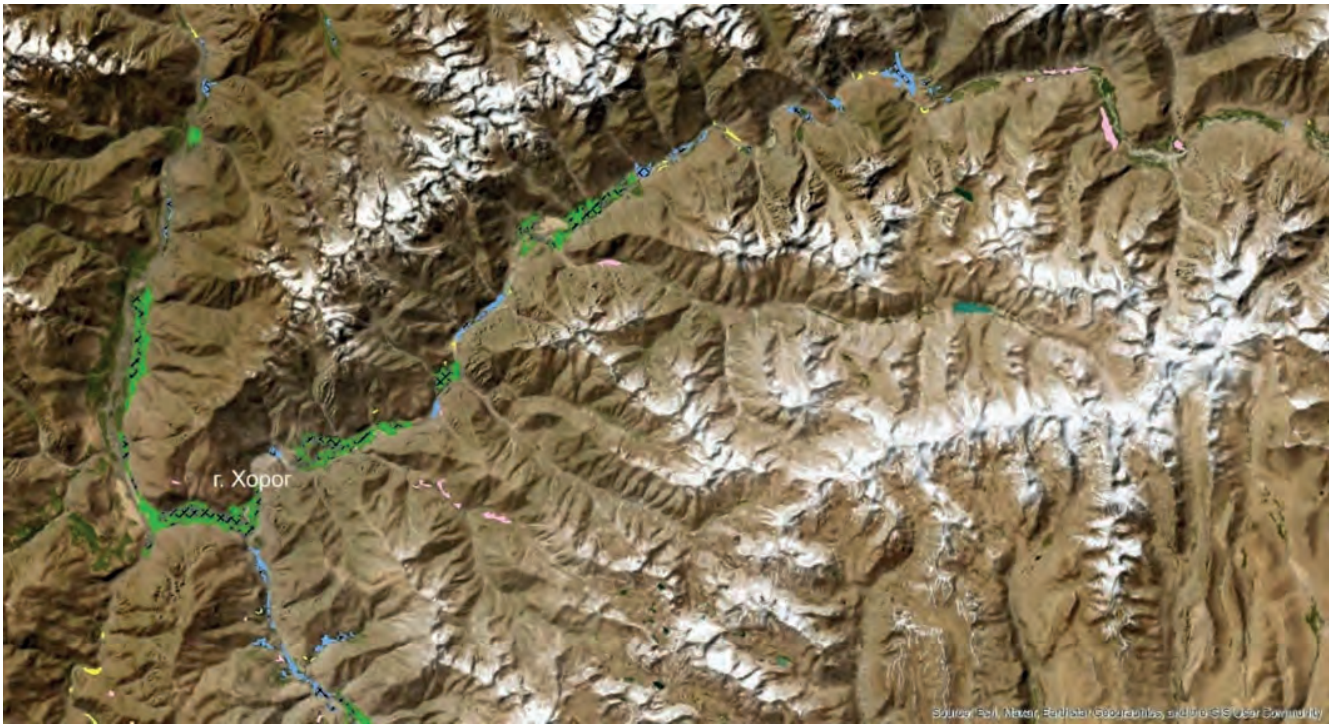

*Sughd region, Zeravshan river valley*




*Khatlon region, the Vakhsh and Pyanj river valleys*




*The Gissar valley, in the vicinity of Dushanbe*




*The GBAO, Gunt valley*

*Fig. 4. Dynamics of settlements in the regions of Tajikistan from 1970 to 2023.*

Boundaries of settlements in the 1970s

The area of the settlement did not change between 1970 and 2020

The area of the settlement increased in between 1970 and 2020

Settlements that appeared between 1970 and 2020

Settlements that disappeared in 1970–2020

*See note to the above map, 'Dynamic of built-up areas, 1970–2023'.*



*Khorog city, Gunt River and Pamir*

*Table 3. Change in the number of settlements in the regions of the Republic of Tajikistan from the 1970s to 2023.*

| Region | Number of settlements in 1970 | Number of new settlements | Number of abandoned settlements | Share of new settlements, per cent | Share of abandoned settlements, per cent |
|---|---|---|---|---|---|
| RRS | 1214 | 421 | 90 | 35 | 7 |
| GBAO | 372 | 200 | 54 | 54 | 15 |
| Khatlon | 1259 | 1113 | 170 | 88 | 14 |
| Sughd | 739 | 1312 | 47 | 178 | 6 |
| National total | 3584 | 3046 | 361 | 85 | 10 |

*Table 4. Changes in built-up areas in the regions of the Republic of Tajikistan from the 1970s to 2023.*

| Region | Area in the 1970s, (km²) | Area in 2023, (km²) | Increase in built-up areas, (per cent) | Stable, (km²) | Emerged, (km²) | Abandoned, (km²) | Expanded, (km²) |
|---|---|---|---|---|---|---|---|
| RRS | 479 | 773 | 61 | 210 | 34 | 7 | 529 |
| GBAO | 81 | 112 | 38 | 57 | 13 | 5 | 42 |
| Khatlon | 576 | 1217 | 111 | 384 | 132 | 19 | 701 |
| Sughd region | 520 | 1031 | 98 | 358 | 116 | 4 | 556 |
| National total | 1656 | 3133 | 89 | 1009 | 295 | 35 | 1828 |

**Infrastructure**

The quality of its infrastructure is key to the sustainable development of the country due to its mountainous terrain and sparse system of settlements. Tajikistan's transport sector consists of three subsectors: road, rail and air. Road transport plays the dominant role in freight and passenger transportation within the country, accounting for more than 90 per cent of the total and, as such, makes the most significant contribution to the national economy. In 2019, the share of the transport and communications sector in GDP was 8.9 per cent.

The transport infrastructure of Tajikistan is insufficiently developed and of poor quality, as typified by the road network *(see map 'Road density')*. The total length of roads in the country is about 30,000 km, of which only 14,339 km are public roads that allow for the movement of vehicles, goods and people. Most of the public roads are the responsibility of local authorities (62 per cent) and are low quality and in poor condition. The republic's highways that provide international connections (23 per cent) and national roads (15 per cent) also need repair and modernization. Unsurprisingly, the limited amount of rail and air transport infrastructure has limited capacity and accessibility. In Tajikistan, the total length of railways, none of which are electrified, is 987 km. The share of freight and passenger transportation by rail is very small, a situation exacerbated by the current state of the national railway network. According to the Statistics Agency, in 2019, rail transport accounted for only 7 per cent of total freight movement and 0.1 per cent of passenger traffic. According to the World Bank's Logistics Performance Index[24], Tajikistan's transport infrastructure ranks 147th out of 167 countries (and is the worst in Central Asia), contributing to the country's low level of competitiveness and integration into global trade.

Most of the roads were built before 1991. There are only two main highways: One runs north-south, connecting the cities of Khujand and Dushanbe, and the other runs east-west, from Dushanbe to Khorog in the GBAO before turning northeast through the mountains to Murghab to give access to either Osh (Kyrgyz Republic) or to Kashgar (China) via the Kulma border crossing. Between 1992 and 1997, there was a sharp deterioration in the condition of these highways, especially the one which links Dushanbe and Khorog. The condition of this highway has resulted in the cessation of public transportation along its length. The rural population of the GBAO suffers most from limited physical access to markets, health facilities and government services, all of which threaten the population's food security and limit income-earning opportunities. In some remote areas of the Eastern Pamirs, local residents do not have any access to markets during the winter period (from October to May) due to heavy snowfalls, avalanches and rockfalls, a situation that exists in other regions during the cold season, albeit with arguably less severity. For example, the more than 52,000 residents of Penjikent, an ancient city in the western part of the Zarafshan Valley, do not have access to large markets during the winter due to frequent avalanches, despite the being located on an arterial public road ostensibly linking Dushanbe to Samarkand[25].

The International Monetary Fund rated Tajikistan's roads as among the slowest in the world in 2022[26]. In this regard, climatic factors are partly to blame as natural disasters along the road network impact an average of 500 km each year, disrupting the flow of traffic. In the summer, if the temperature exceeds 26°C, the movement of heavy goods vehicles is prohibited from 10:00 to 20:00 to avoid deformation of the road surface, which causes excessive traffic in the early morning and night hours[27]. However, despite these environmental challenges, the primary underlying contributor to most of the above issues is the poor quality of the roads.

Despite the foregoing, Tajikistan has made significant improvements to existing highways over the past seven years, thanks to major road contracts being awarded to Chinese, Turkish and Iranian companies backed by loans from their respective countries and various international development banks. These contracts include, but are not limited to, works along:

- The Khujand-Dushanbe highway, a key artery between the republic's two largest cities that forms part of the north-south M-34 route to Tashkent;
- The reconstruction of the Kurgan-Tyube-Nizhniy Pyanj highway, financed by Japan;
- The Dushanbe-Tursunzoda road, partially upgraded into a four-lane highway;
- The new Dushanbe-Kulyab highway, with two long tunnels through a high mountain pass to reduce travel time;
- The reconstruction of the Murghab-Kulma road on the Chinese border, carried out by a Chinese company.

24 World Bank (2018). The Logistics Performance Index and Its Indicators. content.

25 Assessment of Economic Impacts from Disasters Along Key Corridors (2021) Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/545481624287902413.

26 IMF (2022)Where are the World's Fastest Roads? https://www.imf.org/en/News/~/link.aspx?_id=A908C7853AC14C0F89CBA07F82427479&_z=z

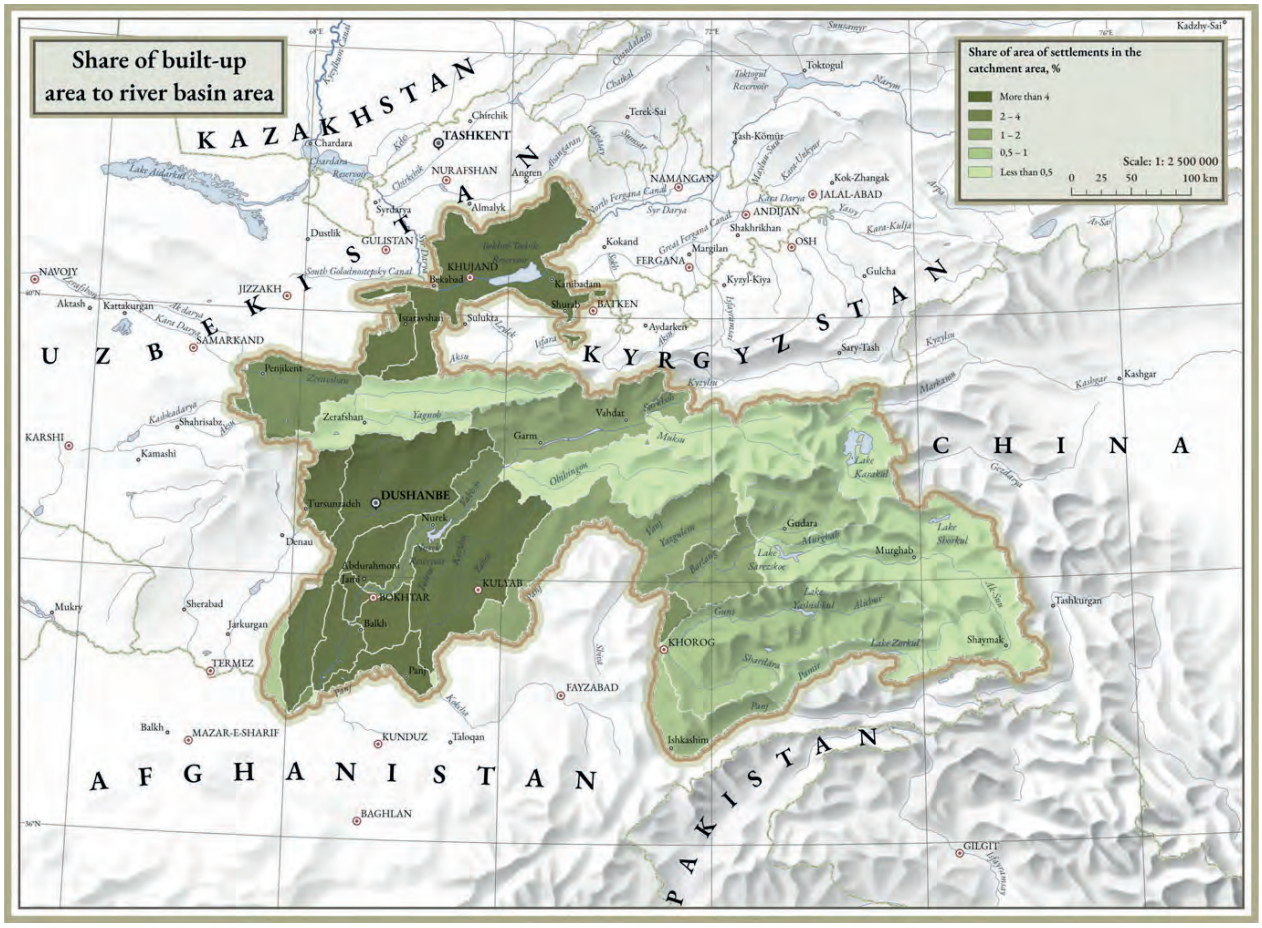
27 Climate Change Profile: Tajikistan (2020) Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Dushanbe. 18 p. Climate Change Profile Tajikistan.



*Panoramic view of Khujand, the second largest city in Tajikistan*



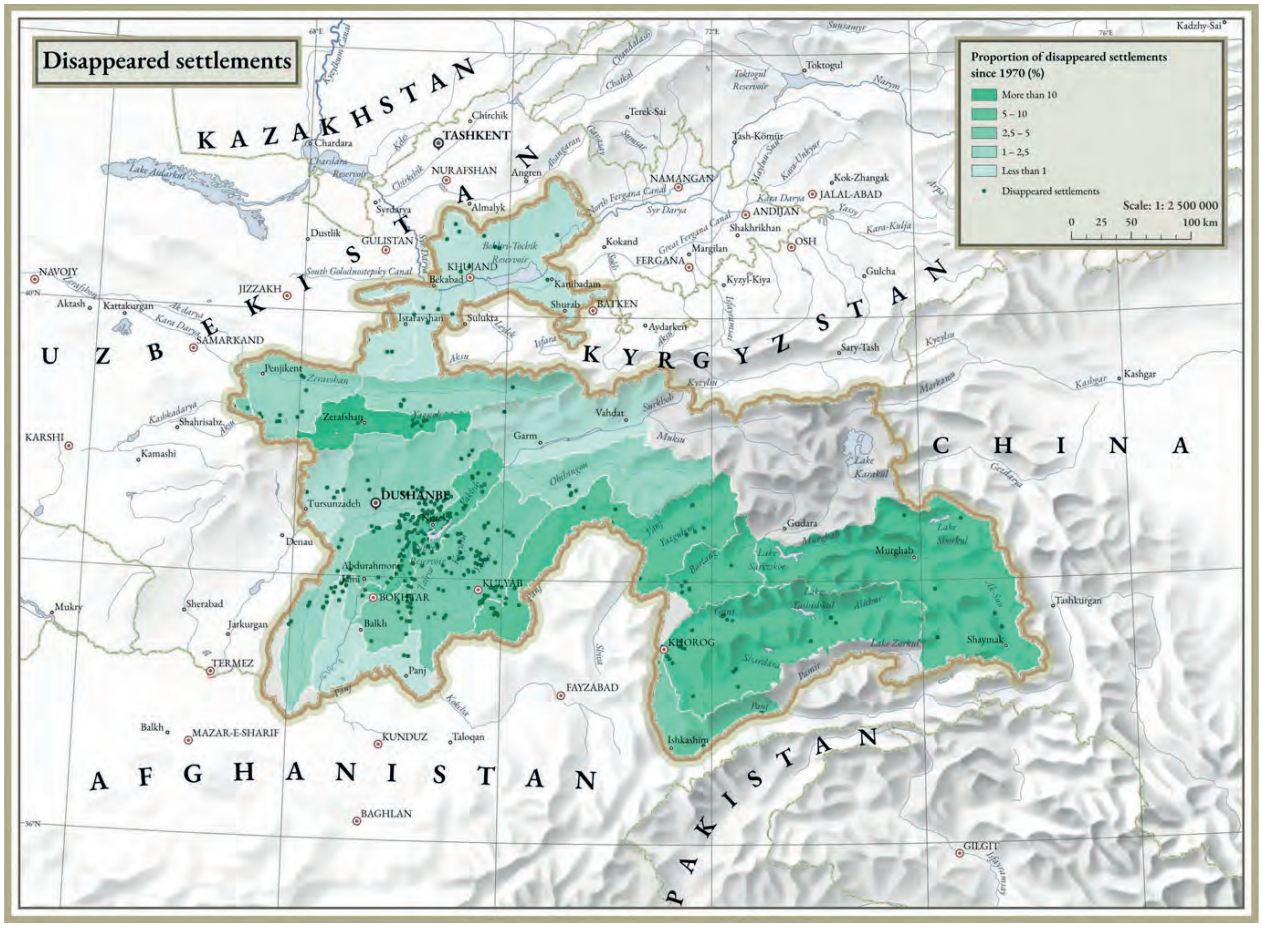
*View of Karakul Lake*




According to the DLR World Settlement Footprint obtained by classifying Sentinel 1 radar imagery with Sentinel 2 and Landsat optical imagery.[28] Spatial resolution 10 m, temporal coverage is 1985 to 2020, depending on the version, catchment boundaries have a sixth level of detail according to HydroSHED data.

28 Marconcini et al. (2020) World Settlement Footprint (WSF) 2015. Dataset. https://doi.org/10.6084/m9.figshare.10048412.v1

Current built-up areas according to the DLR World Settlement Footprint. The built-up areas of 1970 appear as per the maps of the General Staff of the USSR. The dynamics of development is determined by the method of GIS analysis. Watershed boundaries have a sixth level of detail according to HydroSHED data.




See note to the above map, ‘Dynamic of built-up areas, 1970–2023’.




Based on OSM.[29]

29 https://www.openstreetmap.org/



# Water Resources

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### 3.1. Key aspects

- The rivers of Tajikistan contribute 55.4 per cent of the average annual inflow to the Aral Sea basin, with water consumption being limited to 13.4 per cent of this flow.
- The main sources and regulators of water resources in Tajikistan are glaciers, which have a very large water reserve, although there is a general trend of their volume being reduced due to climate change.
- The distribution of runoff throughout the country is very uneven, which is countered by a system of complex and unique hydraulic structures dating from the Soviet era.
- Public access to centralized water supplies and sewerage systems is extremely low, especially in rural areas, where the majority of the population lives.

### 3.2. General characteristics

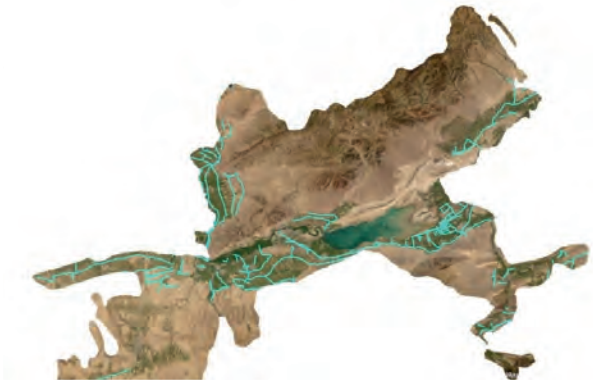
Many arid regions around the globe are characterized by an extremely sparse hydrographic networks, in Central Asia's case, this network equates to approximately two metres per km². In the face of severely inadequate rainfall, the region's transboundary rivers, which originate in high mountains covered by glaciers, play a vital role in agricultural activities that are entirely dependent on irrigation.

One of the most serious environmental problems in Central Asia is the situation with the Aral Sea, which currently contains less than 15 per cent of its maximum recorded volume of water. Sea levels have dropped significantly and the exposed bottom leads to sandstorms that carry salt and sand over long distances. These changes have affected not only the local climate and ecological situation, but also the state of soils, water bodies and glaciers in more remote regions.

While estimates of runoff into and water consumption by Aral Sea basin countries may differ in national and international reports, Tajikistan is clearly the key territory where the water regime of the whole of Central Asia is formed *(see Table 5)*[30]. This is especially indicative regarding the Amu Darya basin, where Tajikistan contributes more than 80 per cent of surface runoff to the Aral Sea, while Uzbekistan's and Kyrgyzstan's share is about 6 and 2.4 per cent, respectively. In total, this is 88.4 per cent of the surface runoff, with the remainder coming from Turkmenistan and Afghanistan.

The average flow of the Amu Darya has been calculated as 78.5 km³ per year, although some experts estimate it at

30 See Pulatov Ya.E., Mukhabbatov H.M. (2021) Water resources of the Aral Sea basin, water allocation and ways to solve water deficit. Central Asian Journal of Geographical Research. 1-2. (in Russian), Pp.70-83.



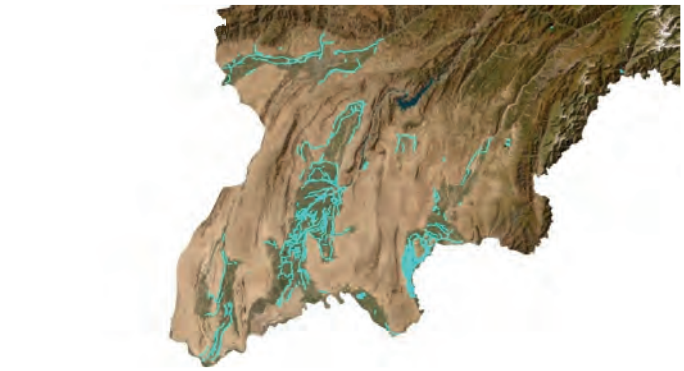
*The Syr Darya river valley (Kairakkum reservoir)*



*The Zeravshan river valley*



*The Gissar valley*



*The Vakhsh and Panj river valleys*

*Fig. 5. Irrigation network in the main oases of Tajikistan*
*See note to the above map, 'Density of irrigation canals'.*

70 km³ per year[31]. According to Soviet quotas from 1987, which the basin's countries agreed to maintain after 1991, the maximum amount of water drawn from the Amu Darya basin by Tajikistan is capped at 15.4 per cent of the total flow, or 9.5 km³; by Uzbekistan – 48.2 per cent, or 29.6 km3; by Turkmenistan – 35.8 per cent, or 22 km3 and by Kyrgyzstan – 0.6 per cent, or 0.4 km³ *(see Table 6)*. In 1987, a quota of 2.1 km³ was also agreed upon for Afghanistan; thus, the total volume of water consumption should have been capped at 63.6 km³ and, even accepting the lower estimates of the Amu Darya's flow, this allowed a so-called 'environmental flow' into the Aral Sea basin of a minimum 6.4 km³ of water annually. In the late 1980s, the Soviet government required a gradual increase in the 'environmental flow' from 8.7 km³ by 1990 to 20 km³ by 2005, however, these targets were never realized and the reduction of water in the Aral Sea continued at the same rate[32].

Water consumption quotas in the countries of the basin were determined based on the availability of land suitable for irrigation and the principle of equal water supply to irrigated lands. The area of the Aral Sea basin is 1.5 million km², however, only 100,000 km², or 6.5 per cent, is arable land. Uzbekistan has the largest share of that arable land – 51 per cent (52,100 km²), followed by Turkmenistan – 18.5 per cent (19,000 km²) and Tajikistan – 8.6 per cent (8,700 km²). All the irrigated arable land of these countries is located within the boundaries of the Aral Sea basin. The Kyrgyz Republic has the smallest area of arable land in the basin – 2.3 per cent (2,300 km²), although most of that (60 per cent) is located outside the boundaries of the Aral Sea basin[33].

This established order could be undermined in the near future by the growth of irrigated areas in Turkmenistan against the backdrop of declining water efficiency there[34] and the construction of the Kosh-Tepa Canal in Afghanistan. The latter is of greatest concern to the Aral Sea basin countries as the Kosh-Tepa mega-project, which was conceived in the 1970s but, due to political instability over the past 50 years, was not previously implemented, began construction in 2022 after the Taliban returned to power. Afghanistan, which accounts for about 8 per cent of the Amu Darya's flow, currently has a disproportionately low water withdrawal quota. In 1965, water withdrawal in Afghanistan stood at 3.85 km³, however, in 1987, under political pressure from the Soviet Union, the current quota of 2.1 km³ per year was agreed upon[35]. Due to be completed by 2028, the 285-km long canal will provide water to irrigate up to 550,000 hectares (ha) in the northern regions of Afghanistan, providing the country with the prospect of being self-sufficient in grain. This increase is almost equal to the entire irrigated area in Tajikistan, which is served by the national irrigation system (i.e. not taking into account local irrigation networks). Afghanistan will increase the volume of water it consumes from 2.1 km³ to between 10 and 13 km³, with this water being drawn from the flow of the Amu Darya below the mouth of the Vakhsh River (where the canal originates). The Amu Darya's annual flow here is 54.5 km³ and Afghan consumption will inevitably create threats to the sustainable water supply for agricultural lands in Turkmenistan and Uzbekistan[36].

Tajikistan is a key participant in water resources management in Central Asia, despite accounting for only 11 per cent of the region's total area. This is due to the fact that more

31 Faizee M., Schmeier S. (2023) Charting Complex Currents: The Qush Tepa Canal and Central Asia's Water. New Security Beat. Charting Complex Currents: The Qush Tepa Canal and Central Asia's Water | New Security Beat

32 Klemm W., Shobair S.S. (2010) Impact of Irrigation in Northern Afghanistan on Water Use in the Amu Darya Basin. FAO Rome. Microsoft Word - Draft_FAO_Paper_08OCT2010_-WK final.docx.

33 UNECE (2004). Strengthening cooperation for rational and efficient use of water and energy resources in Central Asia. effuse_en.pdf (unece.org)

34 Stanchin I., Lerman Z. (2007) Water In Turkmenistan, Discussion Papers 7142, Hebrew University of Jerusalem, Department of Agricultural Economics and Management.

35 Faizee, Schmeier, 2023.

36 Ibid.

than 55.4 per cent of all water resources in the region originate from Tajik territory. Within Tajikistan, these resources exist as annual renewable river flows of 64 km³, glaciers that contain 845 km³, lakes holding 46 km³ and groundwater amounting to 18.7 km³, much of which is eventually distributed by various means throughout the region.

The average annual runoff formed in Tajikistan and flowing into the Amu Darya river basin is 62.9 km³, with a further 1.1 km³ flowing into the upper basin of the Syr Darya River via small tributaries in the north of the country *(see map 'Annual flow by river basins')*. The area of the formation of surface runoff in Tajikistan covers almost 90 per cent of its territory. There are 947 rivers and temporary but recurring streams in Tajikistan with a total length of more than 28,500 km, mainly feeding into the basins of the Amu Darya and Syr Darya rivers. The largest of these tributaries are the Vakhsh, Pyanj (these rivers form the Amu Darya at their confluence on the Afghan-Tajik border), Kafirnigan and Zeravshan rivers, the basins of which occupy more than 75 per cent of Tajikistan's territory.

The runoff formation area in mountainous regions with a developed river network is represented by the 'high-mountain Central Asian type of water regime', which is characterized by the predominance of annual precipitation over evaporation, increased surface and river runoff and the presence of underground water deposits. In contrast, the 'steppe foothill Central Asian type of water regime', typical for the valleys of the Zeravshan, Syr Darya and the lower reaches of the Kafirnigan rivers, is distinguished by an acute moisture deficit during the growing season and low surface runoff. The water regime of the Eastern Pamirs is unique due to the extremely low evaporation on the elevated plateaus *(see map 'Water balance')*.

The usage of water taken from rivers is dominated by irrigated agriculture (84 per cent) with smaller shares consumed for domestic and drinking and agricultural (except for irrigation) water supply (8.5 per cent), industry (4.5 per cent) and fisheries (3 per cent). More than 37 per cent of the withdrawn water is returned to the receiving basins in the form of discharge and drainage water. During the period of political instability, from 1990 to 1994, water consumption in Tajikistan sharply decreased from 13.7 km³ to 11.87 km³, of which more than 92 per cent was used for irrigation. Currently, the water consumption in Tajikistan amounts to some 14 km³ per year, which is equal to 20 per cent of the national flow and 11 per cent of the total flow into the Aral Sea basin.

Tajikistan's main irrigation areas are located in the middle and lower parts of its large river valleys *(see maps 'Irrigated areas by basins' and 'Density of irrigation canals')*. The prevalence of complex mountain-valley relief significantly complicates and limits the development of irrigation infrastructure *(see Fig. 5)*. The prevalence of land that is arable but difficult to access for gravity irrigation determined the form of the current water system, which often consists of complex and unique hydraulic structures. Overall, some 44 per cent of the region's irrigated areas are supplied with water that is pumped to an elevated flat surface 100–200 m high from where it is distributed by gravity between the fields below. This arrangement is present in the largest share of land in Central Asian countries where water is supplied by pumps[37]. Tajikistan's agricultural sector is, therefore, also the largest consumer of electricity in the country – accounting for more than 20 per cent of consumption in the summer months. Electricity is subsidized by the Government of Tajikistan, and energy prices in Tajikistan are among the lowest in the world[38].

Tajikistan already has significant hydropower capacity, estimated at 527 billion kWh per year, which represents more than 95 per cent of its electricity production. Despite this, approximately 54 per cent of Central Asia's remaining potential hydropower resources are located in Tajikistan, which ranks 8th in the world in terms of hydropower potential. The majority of sites having hydropower potential are concentrated in the Pyanj, Vakhsh, Kafirnigan and Zeravshan river basins *(see map 'Main hydraulic facilities')*. The main problem in realizing this potential is the lack of electricity generation in the winter months due to low river flows, a problem that requires reservoirs to regulate flows throughout the year.

Unsurprisingly, Tajikistan already has a number of reservoirs, for example, there are seven in the Amu Darya basin and three in the Syr Darya basin that hold a total of 26 km3 of water. The largest reservoirs are Nurek, with a capacity of

37 World Bank (2017) The Costs of Irrigation Inefficiency in Tajikistan. http://documents.worldbank.org/curated/en/116581486551262816/pdf/ACS21200-WP P129682-PUBLIC-TheCostsofIrrigationInefficiencyinTajikistan.pdf.

38 World Bank (2013) Winter Energy Crisis: Electricity Supply and Demand Alternatives. Retrieved September 21, 2016, from http://documents.worldbank.org/curated/en/500811468116363418/pdf/796160PUB0RE PL00Box377374B00PUBLIC0.pdf .

*Table 5. Formation of surface runoff into the Aral Sea basin*

| Country | Amu Darya | | Syr Darya | | Total | |
|---|---|---|---|---|---|---|
| | km³ | per cent | km³ | per cent | km³ | per cent |
| Uzbekistan | 4.70 | 5.99 | 4.14 | 11.15 | 8.84 | 7.65 |
| Tajikistan | 62.90 | 80.17 | 1.10 | 2.96 | 64.00 | 55.36 |
| Kyrgyzstan | 1.90 | 2.42 | 27.40 | 73.77 | 29.30 | 25.35 |
| Turkmenistan (with Iran) | 2.78 | 3.54 | - | - | 2.78 | 2.40 |
| Kazakhstan | - | - | 4.50 | 12.12 | 4.50 | 3.89 |
| Afghanistan | 6.18 | 7.88 | - | - | 6.18 | 5.35 |
| Total | 78.46 | 100 | 37.14 | 100 | 115.60 | 100 |

*Table 6. Agreed limits on water withdrawals from river flows between the countries of Central Asia (excluding return water)*

| Country | Amu Darya | | Syr Darya | | Total | |
|---|---|---|---|---|---|---|
| | km³ | per cent | km³ | per cent | km³ | per cent |
| Uzbekistan | 29.60 | 48.20 | 10.48 | 46.19 | 40.08 | 47.6 |
| Tajikistan | 9.50 | 15.40 | 1.81 | 7.98 | 11.31 | 13.4 |
| Kyrgyzstan | 0.40 | 0.60 | 0.39 | 1.72 | 0.79 | 0.9 |
| Turkmenistan (with Iran) | 22.00 | 35.80 | - | - | 22 | 26.1 |
| Kazakhstan | - | - | 10.01 | 44.12 | 10.01 | 11.9 |
| Total | 61.50 | 100 | 22.69 | 100 | 84.19 | 100 |



*The spillway of the Nurek dam, August 2018*

10.5 km3 on the Vakhsh River and Kairakkum, on the Syr Darya River, with a capacity of 4.16 km³. The useful water supply in these two reservoirs allows the regulation of 22.8 per cent of Tajikistan's water runoff and 17.5 per cent of its transboundary water runoff. The reservoir bottoms are subject to siltation due to the large solid runoff coming from the country's mountain rivers. The intensity of siltation in small reservoirs is about 2 per cent of their initial volume, and in larger ones, about 1 per cent per year. It is estimated that the mass of silt accumulated in the Kairakkum Reservoir since 1950 may exceed 750 million tons, which is equivalent to a volume of 500 million cubic meters, or approximately one-third of the reservoir's "dead level," i.e., the level below which the reservoir cannot function normally. Further siltation of the reservoir could make it impossible to seasonally regulate water for irrigation, and in such a case, it would serve only as a transportation or power generating facility on the Syr Darya River[39].

All the rivers in Tajikistan are fed by a mix of melting snow and glaciers, with 80 per cent of precipitation in the mountainous regions of the country falling as snow. Throughout the vast expanse of the Pamirs, precipitation falls almost exclusively as snow *(see map 'Proportion of solid precipitation in annual amounts')*. Snowmelt on mountain slopes can provide 70-90 per cent of the annual runoff (*see map 'Maximum snow reserves'*). A decrease in the thickness of the snow cover and the dynamics of the snow line have not yet become manifest in Tajikistan. Indeed, the total reserve of snow (sensitive to temperature increases) and ice cover (less sensitive to temperature increases) and its spatial distribution has not undergone significant change in recent decades *(see map 'Snow and ice reserves')*[40].

Mountain glaciers are important regulators of river runoff in Tajikistan. Their melting ensures a smoother course of the hydrograph in the second half of summer, when the snow cover has already melted. Unlike the snow cover, the melting of which also replenishes groundwater reserves, glaciers in the valleys directly supply rivers with meltwater[41]. The contribution of valley glaciers to river runoff in an average year is estimated at 30 per cent, and in dry years it reaches 50 per cent. From June to September, the average contribution of runoff from glaciers in the Pamirs and the Gissar-Alai mountains into the Pyanj river basin is estimated by some researchers at 41 per cent (7.7 km³) of the total runoff it receives, for the Vakhsh river basin, this figure is 44 per cent (5.7 km³) and for the Zeravshan river basin, 43 per cent (1.5 km³). In dry years these figures rise to 55 to 72 per cent, 40 to 74 per cent and 44 to 61 per cent, respectively[42].

The total area of glaciers in Central Asia is 17,000 km², of which more than 65 per cent are in the Republic of Tajikistan, as its 14,509 glaciers cover an area of 11,146 km², which is almost 8 per cent of the country's territory. The Pamir-Alai mountain system is one of the world's largest centres of modern glaciation, the scale of which is comparable to the ancient Quaternary glaciations *(see map 'Glaciers')*. The Tupchak (200,000 years ago) and Lyakhsh (100,000 years ago) glaciations exceeded the modern-day Pamir glaciers in area by factors of 3.5 and 2.9, respectively, and the snow line was located 500 m or more lower than now[43]. During the Tupchak glaciation, the Gissar-Alai mountains were less glaciated than in the modern era *(see map 'Tupchak glaciation epoch')*. However, in the Lyakhsh epoch, almost all the mountain valleys facing south were filled with glaciers *(see map 'Lyakhsh glaciation epoch')*. In contrast, today in the western part of the Gissar Ridge there are only small glaciers that fill the karsts or are hanging. Further to the east, with increasing altitude, valley glaciers appear. Even further east, at the junction of the highest ranges – Academy of Sciences, Darvaz, Peter I, Vanch, Yazgulyamsky - there is a glaciation "knot" formed by the largest glaciers, including the Vanjakh (formerly Fedchenko) Glacier *(see map 'Glaciers')*.

The total amount of water in Tajikistan's modern-day glaciers (845 km³) is 13 times greater than the annual flow of all rivers in Tajikistan and seven times greater than the average annual flow of all rivers into the Aral Sea basin. The Vanjakh Glacier contains water reserve of 93.6 km3 in an area of 651.7 km² *(see Table 7)*. However, it is the numerous small glaciers, with an area of about 1 km², that contain up to 85 per cent of the republic's glacial ice volume, and these are highly susceptible to the impact of rising air temperatures.

Over the past decade, due to global warming, the area of glaciers in Tajikistan has significantly decreased. In the past few decades, 1,000 out of 14,000 glaciers have completely disappeared. According to the Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan, if the current rate of glacier degradation continues, many small glaciers in the country will completely cease to exist in the next 30 to 40 years[44]. In the late 1950s, when systematic observations of glaciers in the republic began, there were 4,287 glaciers with a total area of 2,183.5 km² in the river basins of the Gissar-

39 Abdushukurov et al. (2016) State of the Kairakum reservoir. Bulletin of the Tajik National University, Series of Natural Sciences, 1/1(192), Pp. 218-223. (in Russian)
40 Mirzokhonova, 2021.
41 Pohl et al. (2014) The hydrological cycle in the high Pamir Mountains: how temperature and seasonal precipitation distribution influence stream flow in the Gunt catchment, Tajikistan. Earth Surf. Dynam. Discuss.2, Pp. 1155–1215.
42 Water in Central Asia: Prospects in the Context of Global Change (2014) Regional Research Network 'Water in Central Asia' -CAWa. Tashkent. 160 P. cawa-2014.pdf. (in Russian)
43 Glaciers of Tajikistan (2003) Main Directorate for Hydrometeorology and Environmental Monitoring of the Ministry of Nature Protection of the Republic of Tajikistan. Dushanbe. 35 P. (in Russian)
44 GWP Central Asia and Caucasus (2014) National consultations on the Post-2015 Development Agenda in Tajikistan. https://www.gwp.org/ru-RU (in Russian)

Alai mountains. Between 1957 and 1980, 19 per cent of these glaciers had static boundaries, 4 per cent advanced and the rest retreated. The total area of glaciers has decreased by 15.8 per cent. In the Pamirs, over the same period, the area of glaciation decreased by 10 per cent, with 17 per cent of glaciers being static, 12 per cent advancing and 71 per cent retreating (mostly in the western and southern parts)[45].

However, the relationship between global warming and glacier melting is not always linear. According to data[46], the average annual rate of glacier degradation in the Zeravshan Glacier basin from 1980 to 2017 was almost half that of the period from 1957 to 1980 (0.24% and 0.42%, respectively). A detailed study of the Vanjakh Glacier showed that its dynamics varied in different periods: Between 2016 and 2023, increased melting of the glacier was observed (0.41 m per year), however, in the period between 1980 and 2010, the melting rate was much slower and was sometimes replaced by ice accumulation. In a wider geographical area, the dynamics of glaciers in the mountain systems of Central Asia show an ambiguous situation[47], and, according to some experts, the retreat of the then Fedchenko Glacier in the 1950 to 1980 period cannot be associated only with rising temperatures[48]. In support of this notion, radar remote sensing revealed the 'Pamir-Karakoram anomaly' in the 2000 to 2014 period, when the glaciers of the Western Pamir and Karakoram accumulated ice on their surface (0.1–0.14 m per year), while the glaciers of the western, eastern and central Himalayas significantly reduced the thickness of their ice cover (up to 0.4 m per year)[49].

The present rate of glacial melting in Tajikistan has already caused some increase in river runoff, however, this trend may reverse in the foreseeable future. Climate models show a reduction in the glaciated area in Tajikistan in the medium term[50]. For example, the Zeravshan river basin may see an estimated reduction in glacial runoff of 50 per cent, with an increase in the height of the firn line by an average of 260–330 m. The projected increase in average annual temperature of 2°C in the Pamirs by 2050 could cause a significant reduction in glacier volume in the Pyanj river basin of up to 75.5 per cent, while in the Vakhsh river basin this figure is estimated to be 53 per cent. Such a reduction could have a significant impact on freshwater supplies in all three basins. By 2050, river runoff into the Amu Darya river basin is likely to decrease by 30 per cent compared to the average runoff over the past 10 years *(see Box 1)*. This will exacerbate tensions over water resources both within and across the country's borders.

There are about 1,300 lakes in Tajikistan with a total area of 705 km² *(see map 'Volume of lakes')* that contain more than 46.3 km³ of water, including 20 km³ of fresh water. Some 73 per cent of these water bodies are located in the Pamir-Alay Mountains at altitudes between 3,500 and 5,000 m above sea level *(see Section 3.3 of map 'Water bodies in 1990' and map 'Water bodies in 2021')*. The largest of these lakes, such as Karakul, Yashilkul, Sarez Lake and Iskanderkul, some of which were formed as a result of landslides and earthquakes, are known to play an important role in the water balance of the region. However, most of the mountain lakes are difficult to access and, therefore, have not been sufficiently studied, making them important bodies for further research and potential sites for recreational activity.

Groundwater resources in Tajikistan are estimated at 18.7 km³ per year, of which 25.6 per cent are in the Sughd region, 21.8 per cent in the Khatlon region, 21.4 per cent in the GBAO and 31.2 per cent in the regions of republican subordination. While groundwater reserves are found in intermountain basins *(see map 'Underground water resources')*, it is mainly confined to the Quaternary alluvium of the Syr Darya, Kafirnigan, Vakhsh, Kyzylsu and Yakhsu river valleys, with Syr Darya and Zeravshan river valleys' groundwater being of a transboundary nature. The contribution of groundwater to the flows of large rivers varies from 20 per cent for the Amu Darya to 60 per cent for the Syr Darya (on average, about 40 per cent)[51]. For mountain rivers, the share of runoff coming from underground sources is insignificant and only 2.5km³ of underground water is used annually for economic purposes, namely to irrigate fields, supplement the water supplies of settlements and for use in industry[52].

Tajikistan still has great untapped recreational potential when it comes to the utilization of its water resources. Tajikistan is famous for its 200 mineral springs as well as its 18 mud and salt lakes *(see map 'Mineral waters')*.

45 Shetinnikov A.S. (1993) Changes in the extent of glaciation in the Pamir-Alai region during 1957–1980. Materials of glaciological studies. Moscow. 76. Pp. 77–83. (in Russian)
46 Karandaev S.V., Karandaeva L.M. (2021) Assessment of modern glaciation of the Zeravshan basin. Central Asian Journal of Geographical Research. 3-4. Pp. 75-86. (in Russian)
47 Water..,.2014.
48 Brun et al. (2025) Multi-temporal elevation changes of Fedchenko Glacier, Tajikistan, from 1928 to 2021. Journal of Glaciology 71, e45. Pp. 1–22. https://doi.org/10.1017/jog.2024.101.
49 Gardelle et al. (2013) Region-wide glacier mass balances over the Pamir-Karakoram-Himalaya during 1999–2011, The Cryosphere, 7. Pp. 1263–1286. https://doi.org/10.5194/tc-7-1263-2013.
50 Fourth..,, 2022.
51 Pohl et al., 2014.
52 Facts and figures about water in Tajikistan – DUSHANBE WATER PROCESS.

*Table 7.The largest glaciers of Tajikistan*

| Glaciers | Area, km² | Ice volume, km³ |
|---|---|---|
| Vanjakh (formerly Fedchenko) | 651.7 | 93.6 |
| Paridor (formerly Grum-Grzhimailo) | 143 | 19.84 |
| Garmo | 114.6 | - |
| Mirsaid Mirshakar (former Vitkovsky) | 50.2 | 6.882 |
| USSR Academy of Sciences) | 48.0 | 5.242 |
| Nalivkin | 45.2 | 8.588 |
| Bivachni | 37.0 | 8.05 |

*Таблица 8. Sources of water inflow into the main reservoirs of Central Asia and the forecast of its reduction due to climate change*[53]

| Reservoir | Contribution of inflow sources (per cent) | | | | Average runoff (m³ /s) | Forecast of maximum changes (per cent) | |
|---|---|---|---|---|---|---|---|
| | Glaciers | Snow | Rains | Ground water | | 2021–30 | 2041–50 |
| Nurek | 59.3 | 22.4 | 6.5 | 11.8 | 527 | -18.8 | -49.1 |
| Toktogul | 11.7 | 42.2 | 27.6 | 18.5 | 520 | -9.1 | -18.8 |
| Andijan | 14.8 | 43.4 | 22.3 | 19.6 | 110 | -8.9 | -25.2 |
| Charvak | 22.0 | 40.7 | 21.1 | 16.2 | 109 | -26.4 | -34 |

53 Ibid.

These resources are sites for future recreational development in Tajikistan that could generate more jobs and wealth than if the water is reserved just for the agricultural sector.

*Box 1. Changes in the area of reservoirs in Central Asia as an indicator of climate change*

Reservoirs in the upper reaches of rivers are hydrologically very different from those located in the lower reaches. Downstream of reservoirs, the hydrological characteristics of rivers differ significantly from the more natural ones upstream, as the lower reaches are entirely dependent on water discharge from the reservoirs. Above the reservoirs, anthropogenic impact on water flow is minimal, so the upstream area can be considered a natural system without human intervention, and changes in its hydrological regime can serve as an indicator of environmental changes throughout the entire catchment[54].

A reduction in the flow into reservoirs may indicate a change in the climate in the catchment area made manifest by events such as a decrease in precipitation, a shift of the snow cover to a greater height and/or a retreat of glaciers. Excluding the base runoff, the values of each factor cannot be directly measured and are subject to modelling based on some assumptions.

The Nurek (Tajikistan, Amu Darya basin) and Toktogul (Kyrgyzstan, Syr Darya basin) reservoirs in the upper reaches of their basins have very large catchment areas with maximum observed peak inflows of up to 2200 and 1800 m³/s, respectively. The Andijan (Kyrgyzstan, Syr Darya basin) and Charvak reservoirs (Uzbekistan, Syr Darya basin), also located in their basins' upper reaches, have smaller drainage basins and peak inflows of 700 to 800 m³/s. The observed reduction in the flood zone of the Andijan reservoir may indicate the ongoing impacts of climate change in the Syr Darya basin *(see Fig.6)*. In the case of the Syr Darya, the contribution of glaciers to its inflow is only 10.7 per cent while the contribution of snowmelt is estimated at 35.2 per cent, which is significant as snow cover reacts very quickly to warming *(see Table 8)*. For the Amu Darya, the contribution of glaciers to inflow is 38 per cent and the contribution of snowmelt is 26.9 per cent.

Overall flow changes for all reservoirs are likely to be negative over the next 30 years as, in general, glaciers in highland Asia are showing a trend toward negative mass balance. At present, the Toktogul and Nurek reservoirs are both showing a slight decrease in their volume, however, their future promises to be different to other reservoirs due to the very different contribution of glaciers to their inflows *(see Table 8)*. By 2050, the Nurek reservoir will experience a much greater reduction in water inflow than the Toktogul reservoir, even if all the glaciers in the basin of the latter disappear. A comparison with the Charvak and Andijan reservoirs yields similar results, albeit where the former is expected to be more sensitive to climate change in the medium term due to the higher contribution of glacier melting.

54 Immerzeel et al. (2012) Climate Change Impacts on the Upstream Water Resources of the Amu and Syr Darya River Basins. ADB Report Future Water. 103 P.

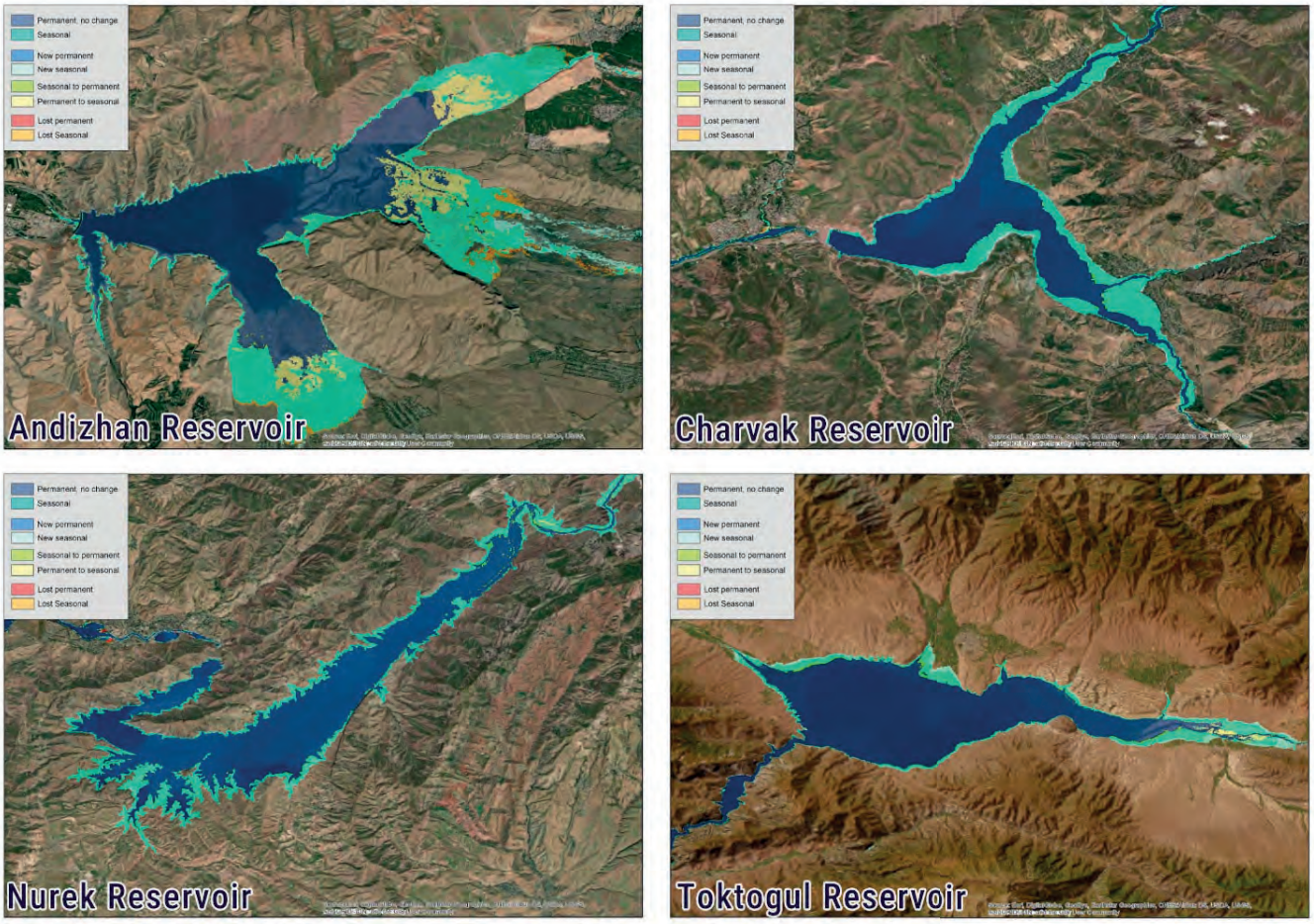
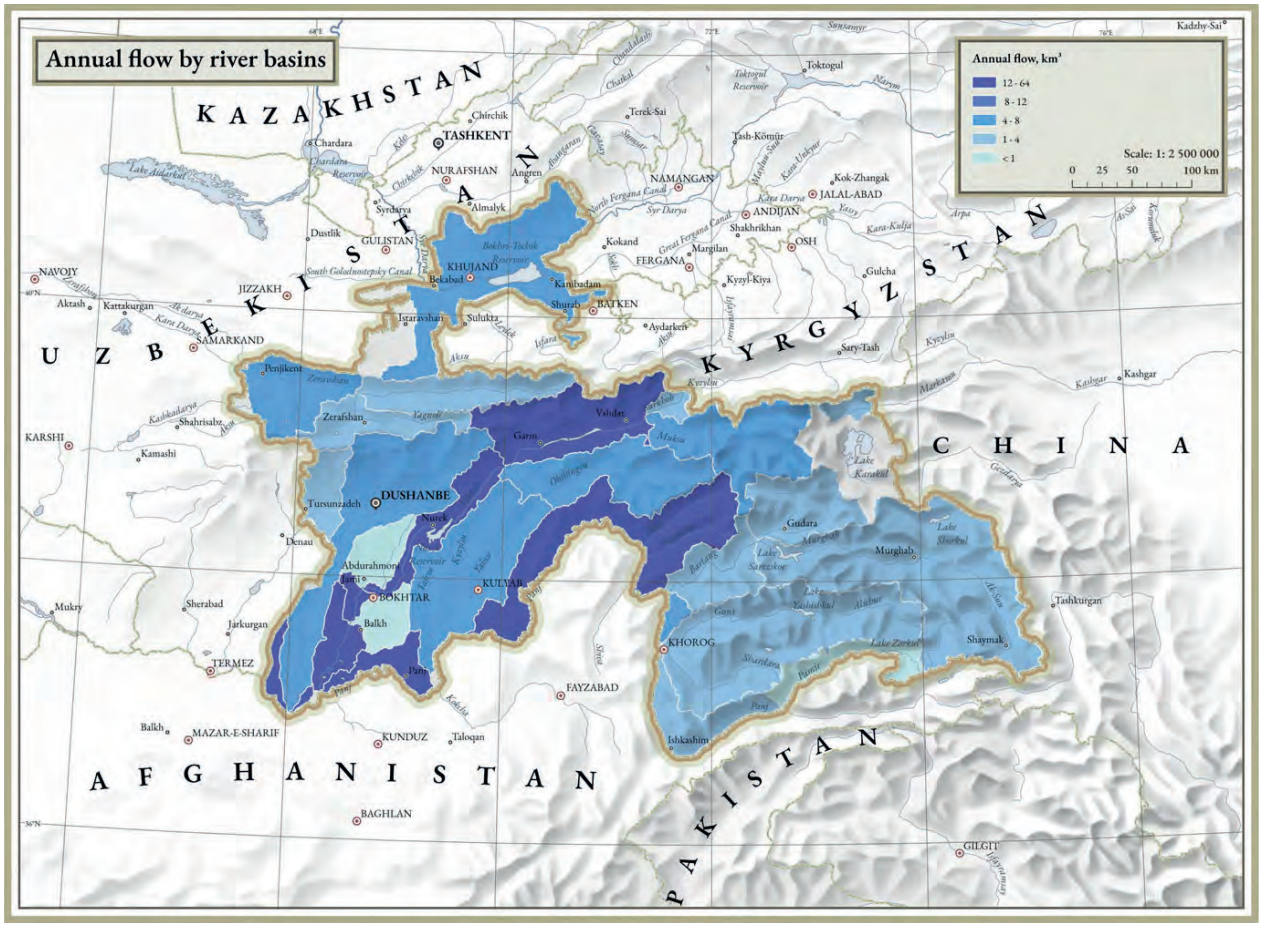


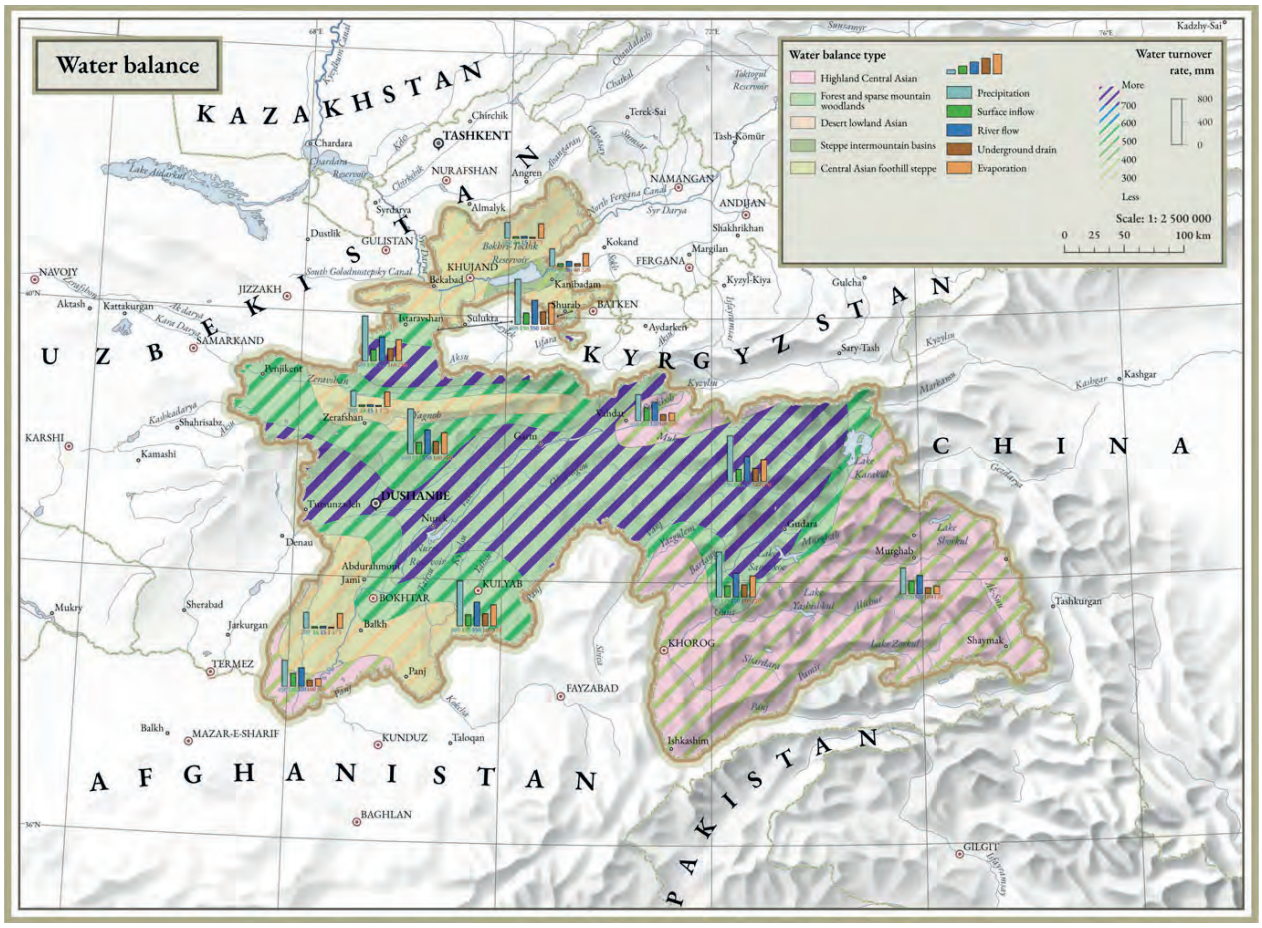

*Fig. 6. Dynamics of flood zones in large reservoirs in the target countries[55]*

55 According to the Freshwater Ecosystems Explorer (see note to the above map, 'Areas of aquatic ecosystems').

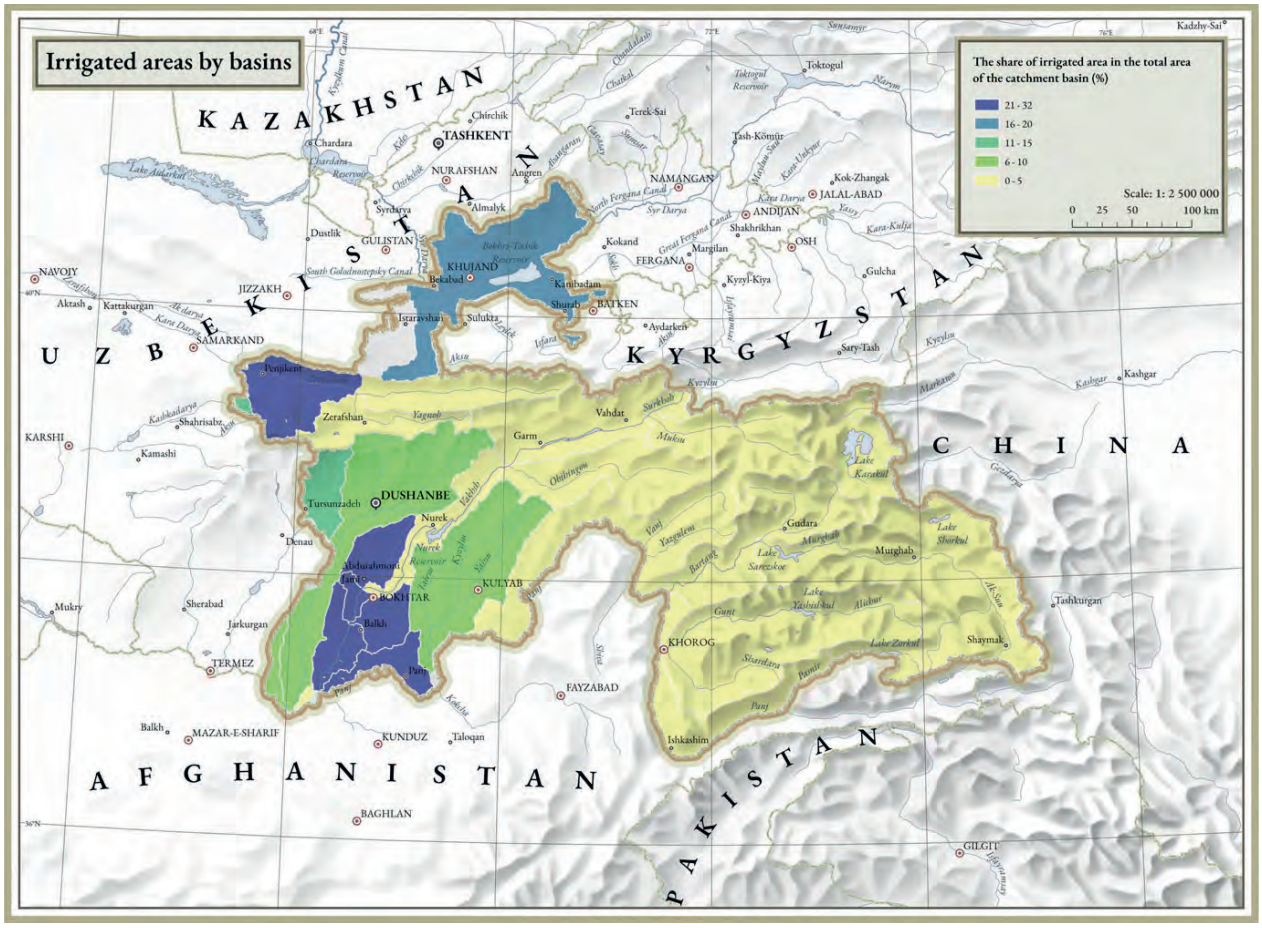



Based on HydroSHED calculations using the WaterGAP 2.2 model[56] and taking into account climatic variables, underlying surface features, water use patterns as well as the presence of natural and artificial reservoirs.

56 http://www.watergap.de/

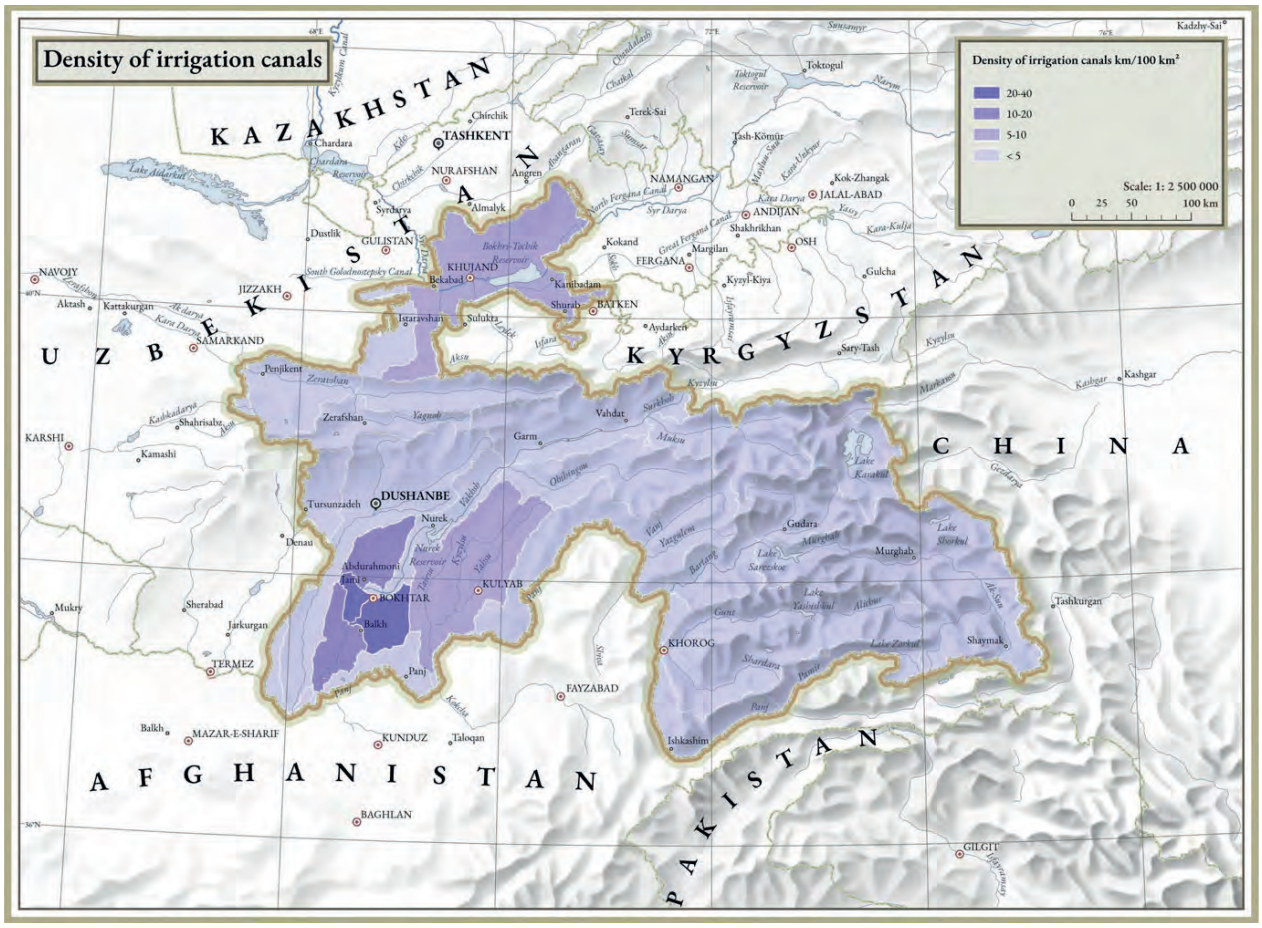



Map of the types of water balance of the USSR: [Maps]: for higher educational institutions (1985) Ed. by I.S. Osadchuk. GUGK. Moscow 1985.



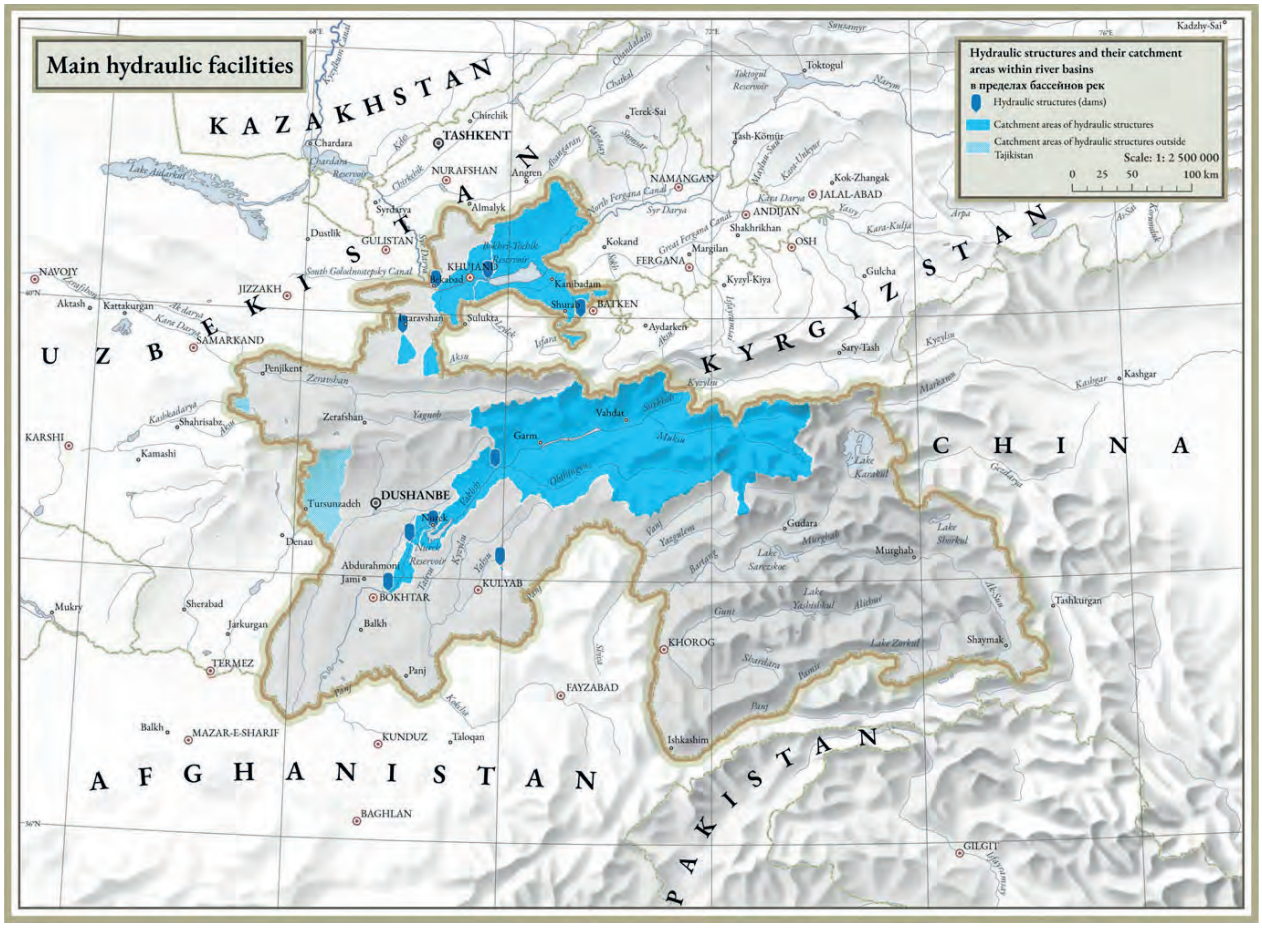

According to modelling by the FAO's Global Map of Irrigated Areas,[57] taking into account remote sensing data, landcover classifications and statistics on irrigated areas available to the FAO in the context of States and their regions. Spatial resolution of the source is five arc minutes.

57 AQUASTAT - FAO's Global Information System on Water and Agriculture. fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/

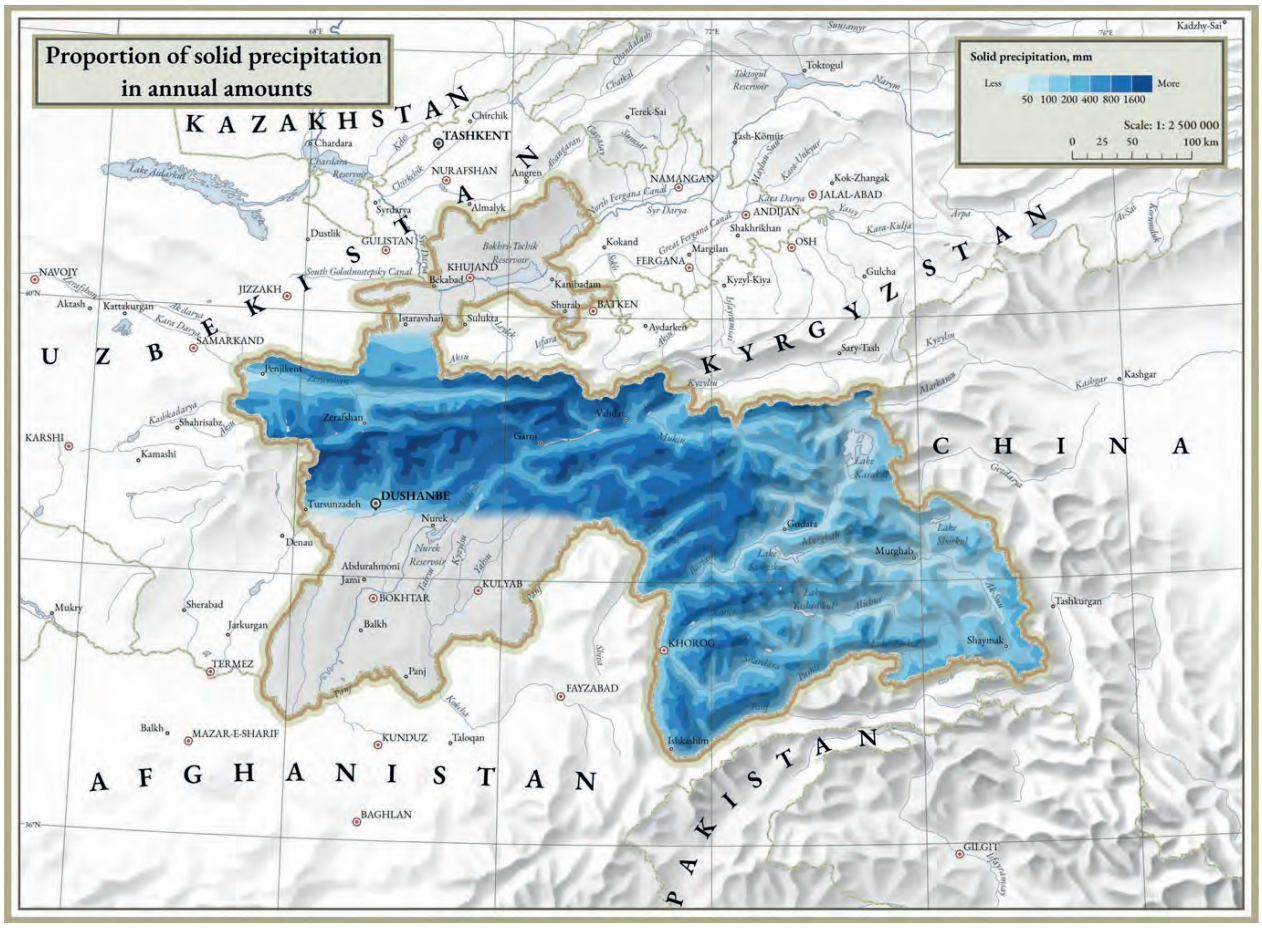



Based on OSM, [58] supplemented by visual interpretation.

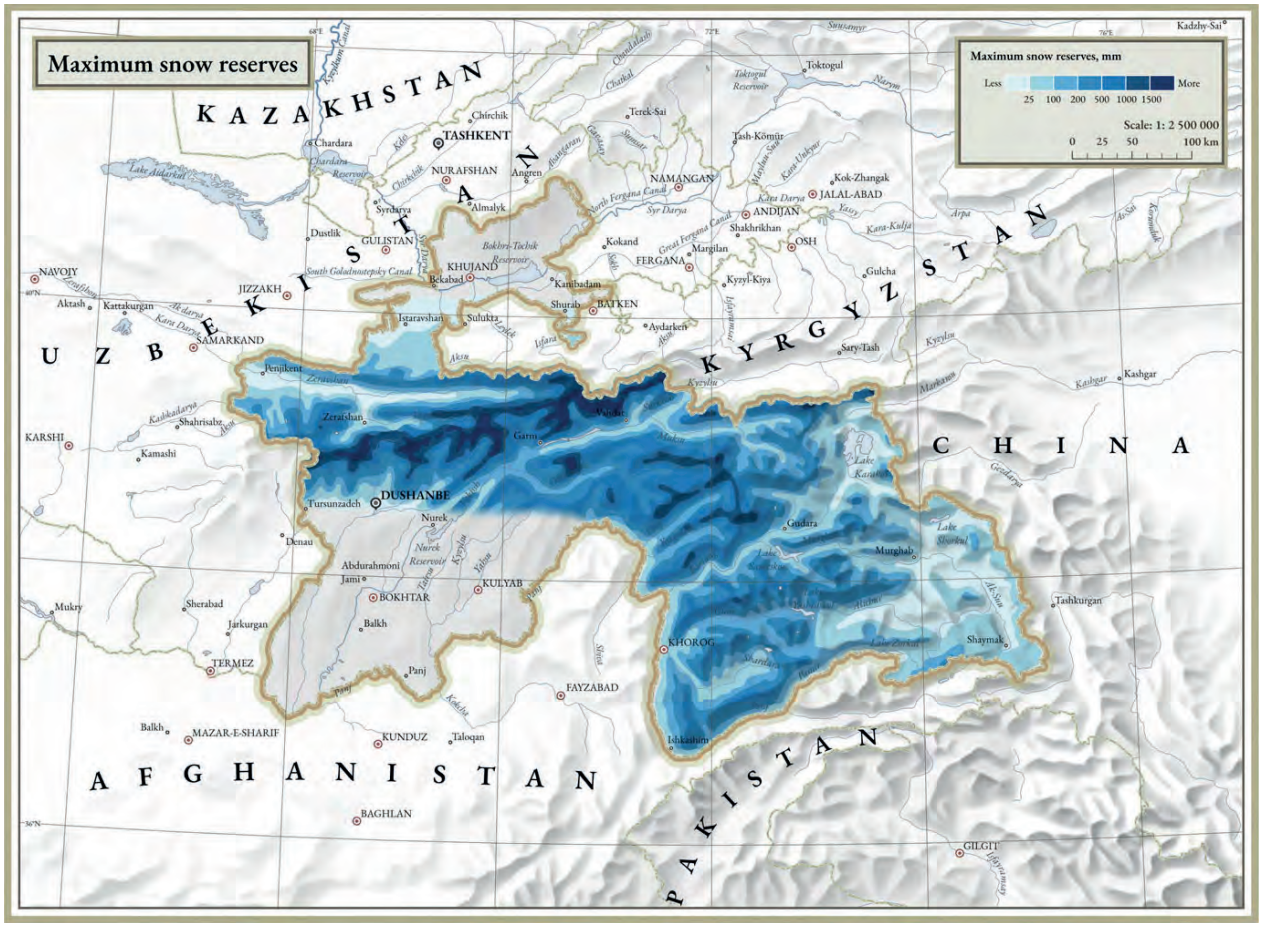
58 OSM. OpenStreetMap. https://www.openstreetmap.org/#map=3/69.62/-74.90



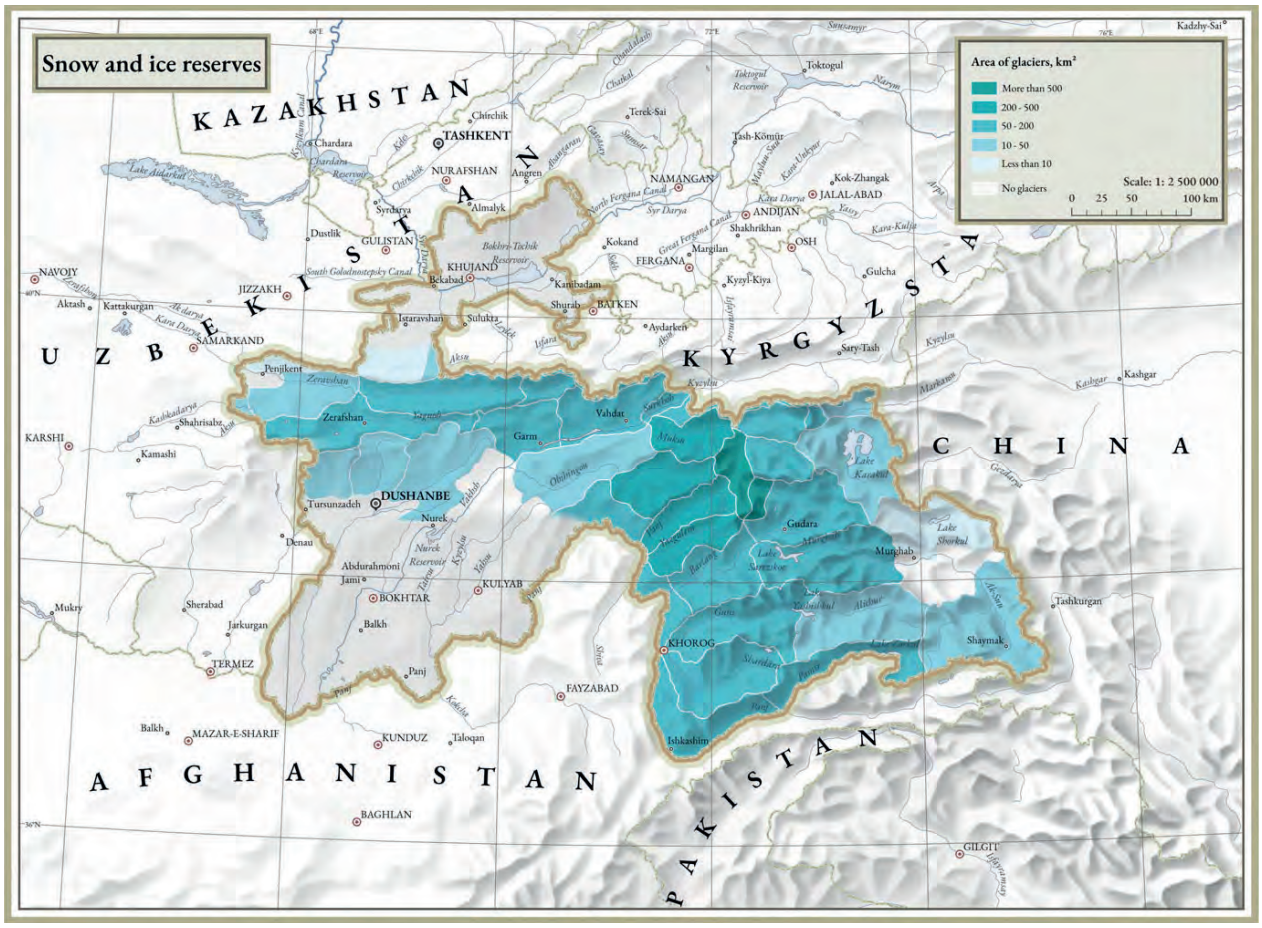

Based on the Global Dam Watch database global dataset, comprising more than 38,000 dams. This image was developed by digitizing visible dams using Google Earth satellite imagery.



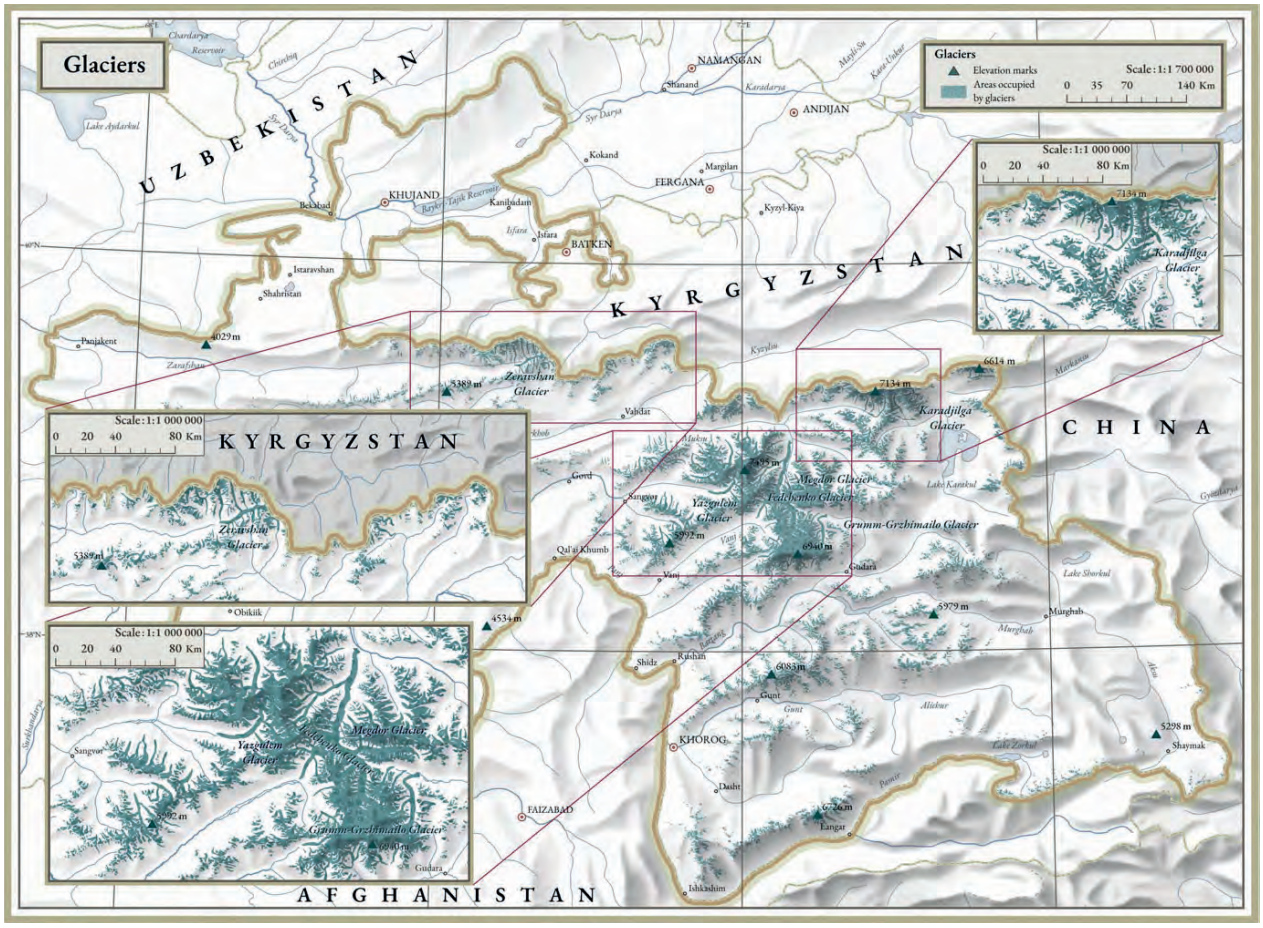

Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)




Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)



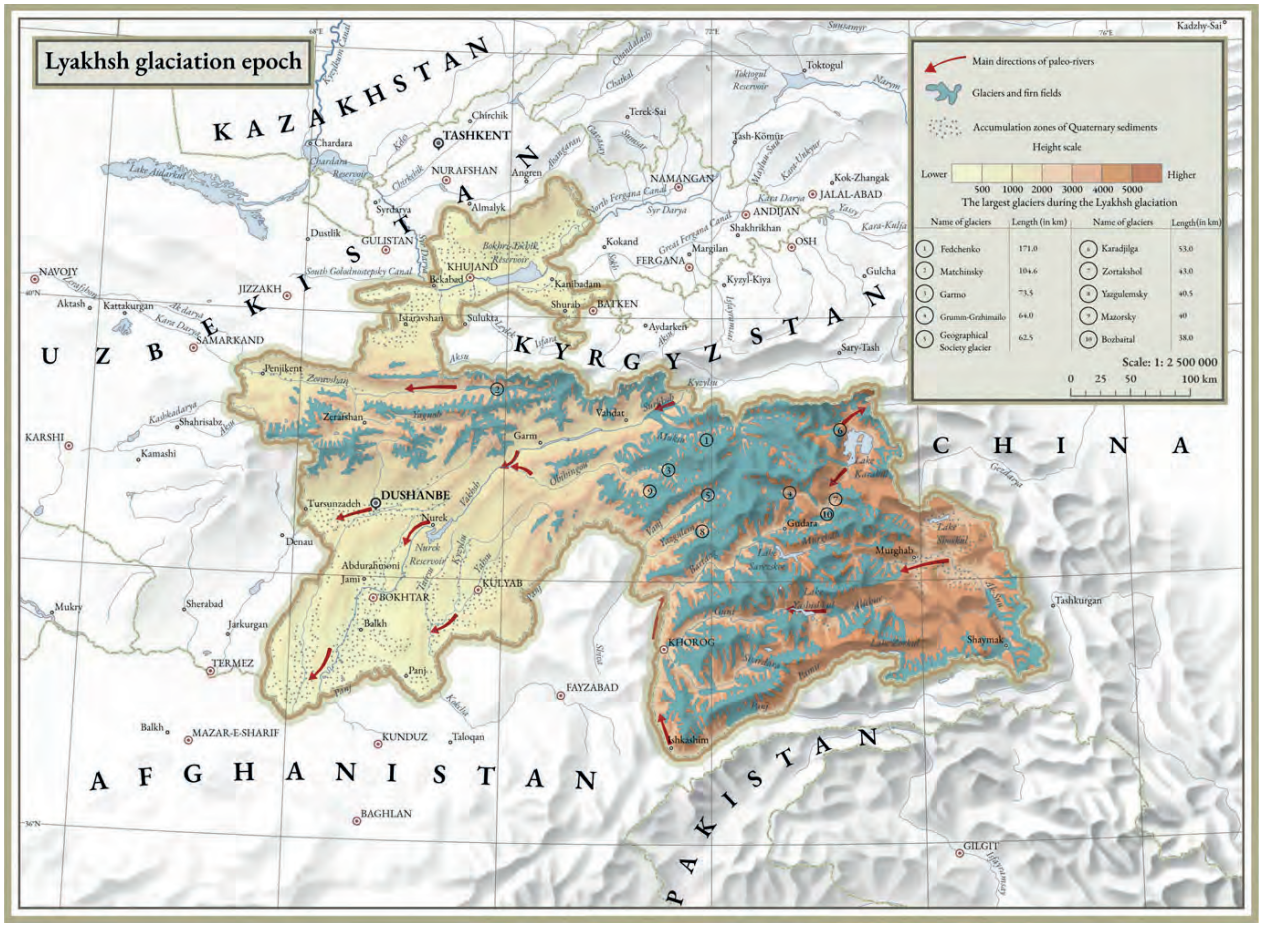

Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)



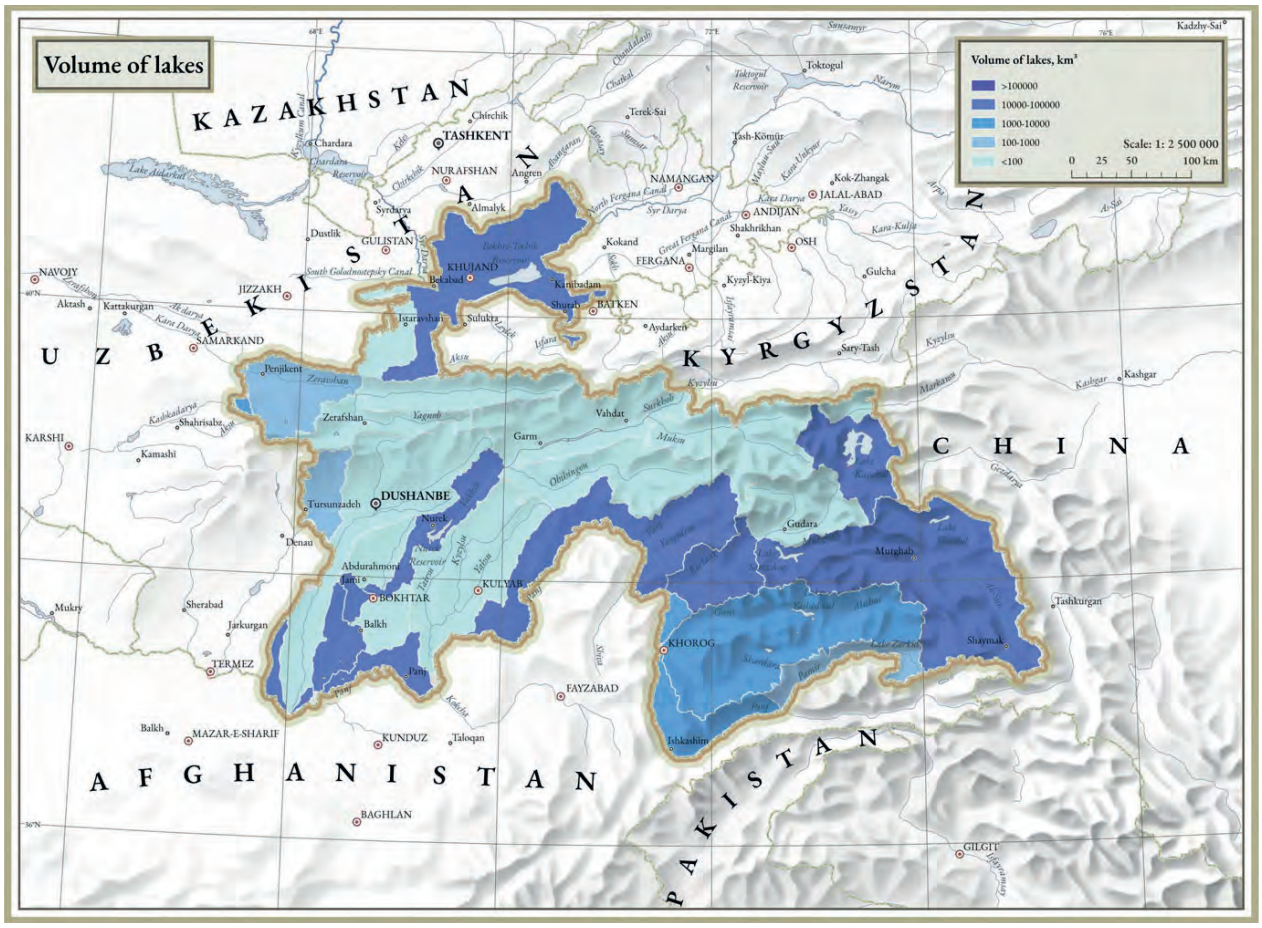

Based on data from the Global Land Ice Measurements from Space (GLIMS) - Geospatial Glacier Database (https://www.glims.org/glacierdata)




Atlas of the Tajik Soviet Socialist Republic/Scientific editorial board: academician I.K. Narzikulov (chairman) and Prof. K.V. Stanyukovich (senior editor). - Dushanbe; Moscow: GUGK, 1968. 200 p. (in Russian)

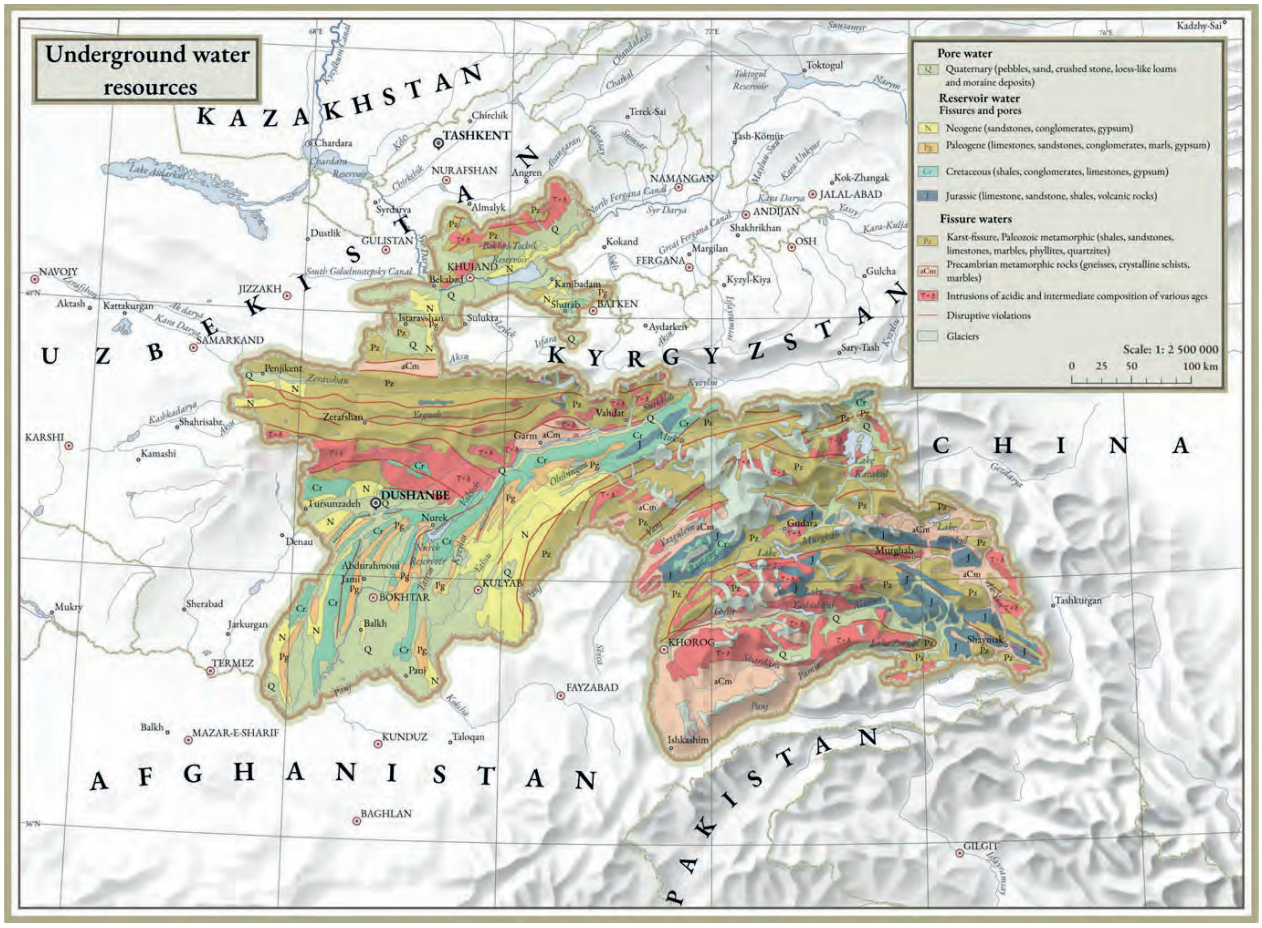



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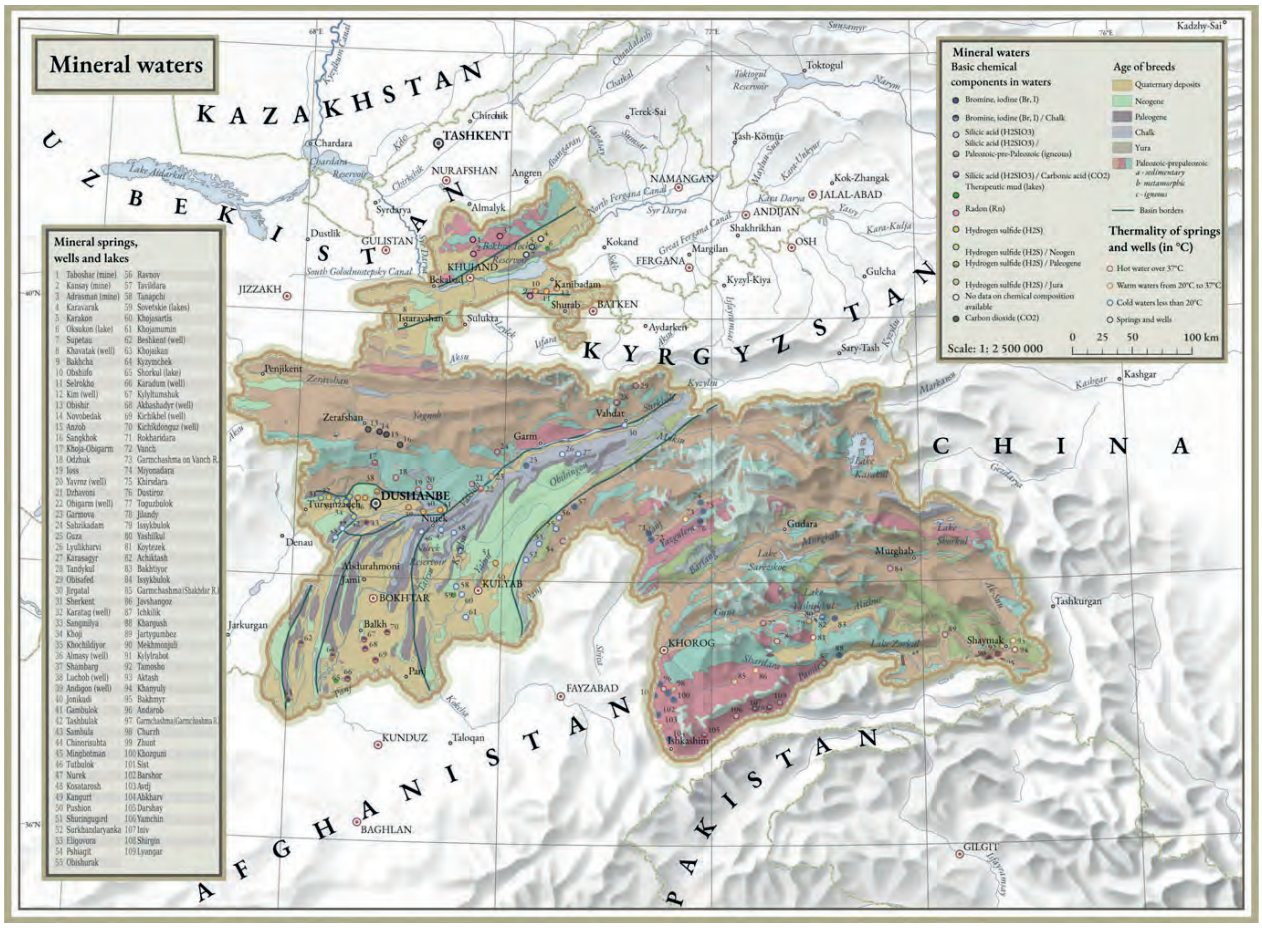



Based on HydroSHED data and a geostatistical model[59] taking into account the size of the lakes, the features of the terrain within a radius of 100 m and the available bathymetric data. The volume of reservoirs is based on GRanD data collected from national sources and remote sensing materials.

59 https://www.nature.com/articles/ncomms13603




Atlas of the Tajik Soviet Socialist Republic/Scientific editorial board: academician I.K. Narzikulov (chairman) and Prof. K.V. Stanyukovich (responsible editor). - Dushanbe; Moscow: GUGK, 1968. 200 p. (in Russian)




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### 3.3. Progress towards the SDGs

The Republic of Tajikistan is home to the headwaters of the Amu Darya, one of the two main rivers of Central Asia. In this regard, transboundary cooperation and IWRM are an important component of sustainable development not only for the republic but for all of Central Asia.

The global legal framework for IWRM is based on the UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992). The Convention provides a framework for the joint management of shared water resources and for addressing environmental problems related to transboundary waters. Among the five Central Asian countries, the Convention was only ratified by the three States downstream of the Syr Darya and Amu Darya rivers, namely Uzbekistan (in September 2007), Kazakhstan (in January 2000) and Turkmenistan (in August 2012)[60]. However, all the countries of the region understand the importance of international cooperation in the management of their transboundary water resources, as evidenced by a number of agreements they have collectively signed. Among these international agreements, the most important one is the 'Agreement on Cooperation in the Field of Management, Use and Protection of Water Resources in Interstate Sources' (1992) which established not only equal rights for all countries of the region to use its water resources but also their equal responsibility for the protection and rational exploitation of these resources (Article 1). In particular, this agreement provides for the need to carry out agreed ecological releases of water in each specific year, based on the hydrological and climatic features of the year (Article 5). One practical outcome of the agreement was the establishment of the Interstate Commission for Water Coordination (ICWC). The 1992 agreement is also enshrined in other important regional multilateral environmental agreements, such as the 1993 Aral Sea Basin Programme, the 1994 Nukus Declaration on the Management of the Aral Sea Basin and the revised mandate of the 1999 International Fund for Saving the Aral Sea.

As a co-founder of the International Fund for Saving the Aral Sea, Tajikistan is represented by its experts in two of the fund's commissions–ICWC and the Interstate Commission for Sustainable Development (ICSD), which provide platforms for discussing urgent transboundary water issues in the region.

There are also examples of bilateral agreements within the region on joint water resource management. Tajikistan and the Kyrgyz Republic (which is located upstream) confirmed the Soviet-era agreements on the division of water resources of the Isfara River in the Fergana Valley. In 2010, Tajikistan and Afghanistan signed an intergovernmental agreement on cooperation in the use of transboundary water resources, the basis of which is the establishment of a system for monitoring and exchanging operational and research information on the

60 Pulatov, Mukhabbatov, 2021.



*Bibi Fatima Hot Springs in Yamchun village of the Vakhan corridor on the border between the Pamir Highway region in Tajikistan and the Afghan province of Badakhshan*

state of water resources and water use in the Panj and Amu Darya river basins[61]. Furthermore, issues of transboundary water management are promptly resolved between Tajikistan and Uzbekistan in annual joint commissions.

The internal water policy of the Republic of Tajikistan is currently being adapted to meet the aims of sustainable development and SDGs.

• SDG 6.5 calls for the implementation of IWRM at all levels, including areas of transboundary cooperation by 2030. Tajikistan, as a member of the World Water Council, is trying to implement the concept of IWRM, the transition to which has been declared as the official strategy of the republic regarding its water resources. An important element of this strategy is the institutional implementation of IWRM at both the national and regional (local) levels. In this context, in 2000, the country's parliament adopted a new Water Code which aligned with the concept of IWRM (in its Chapter 23).

In 2015, the Government of Tajikistan approved the Water Sector Reform Programme for 2016–2025, an undertaking designed to improve the legal framework and institutional mechanisms used to develop infrastructure and create the relevant tools for implementing IWRM, including databases, information systems, research and capacity building. Within the framework of the programme, four river basins were identified: the Syr Darya (with the Zeravshan sub-basin); Kafirnigan, Vakhsh and Panj.

In 2020, a new Water Code was adopted, which sets out the principles of basin management in more detail. There are already five basins or 'basin zones' (in the terminology of the Water Code) in Tajikistan: Syr Darya; Zeravshan; Panj; Vakhsh and Kafirnigan. The Water Code also prescribes the establishment of River Basin Councils (RBCs) in each basin zone as multilateral bodies to support the activities of River Basin Organizations (RBOs). These new institutions should make water management more holistic, more responsive to emerging challenges and more reflective of the interests of different population groups and economic sectors.

The republic's successful implementation of water management reform requires improving the quality and quantity of data available on water resource use. This remains an issue as currently, for example, the actual amount of water consumed is not known for all water consumers and there are no reliable statistics on water losses from irrigation networks[62]. The second important aspect to successful implementation concerns the status of the RBC. In the Water Code, the status of the RBC is designated as a consultative and advisory body under the RBO, which are structural divisions of the relevant ministries. The created basin zones cover areas of tens of thousands of square kilometres and consist of several dozen administrative units. This complicates the management of such vast territories by the relevant RBO and limits the opportunities for active participation of public councils in decision-making. This is the case when 'size matters'. Further improvement of the RBC concept is seen in the creation of basin councils from representatives of local communities in small basins, including transboundary ones. Pilot projects of this kind are already being implemented in the Isfana and Isfara river basins, with the latter being a transboundary basin between Tajikistan and Kyrgyzstan[63].

Another important aspect is equal gender representation in IWRM. Although women are the main consumers and managers of water in households, they are underrepresented in basin councils and water user associations (WUAs). It is recommended to introduce gender quotas and conduct capacity-building activities for women in water resources management[64].

According to the country's self-assessment, Tajikistan scored 46 points out of a possible 100 for SDG 6.5.1 (2021), which corresponds to a «medium-low» status for its IWRM implementation. This result means that the country will not be able to meet the deadline to achieve the global goal unless progress is significantly accelerated. This score is an average of four items: enabling environment (policies, laws, plans and strategies – 49 points); institutions and participation (cross-sectoral coordination, private sector and participation of other stakeholders and gender goals – 43 points); management instruments (programmes for monitoring the availability of water resources, their rational use and pollution – 48 points); and financing (investments, including infrastructure, recurrent costs and revenue generation – 42 points)[65].

• SDG 6.b: Support and strengthen the participation of citizens' governments in improving water and sanitation management.

In the 1990s, during the water sector reform based on IWRM principles and with the support of the World Bank, Asian Development Bank and other international organizations, 40 WUAs were established in Tajikistan. These early WUAs, however, did not always spatially correspond to hydrological boundaries. In 2006, the Law on Water User Associations was adopted, which laid the foundation for the establishment, operation and management of WUAs as non-profit organizations providing irrigation system operation and maintenance services at the local level.

By 2019, there were 416 registered WUAs in the country, managing 379,430 ha of irrigated agricultural land, including 187,800 ha in pumped water supply zones. A common drawback of this system was that many WUAs were incorporated within administrative rather than hydrological boundaries. In 2020, the Government of Tajikistan adopted a new law on water user associations, formally establishing these public organizations as part of the republic's irrigation management efforts. As part of the reform, WUA boundaries were revised to more accurately align them with basin boundaries, an undertaking that required a reduction in the number of WUAs. Currently, there are 242 registered WUAs in the country (2025) responsible for supplying 499,500 ha of agricultural irrigated land, some 67 per cent of the total irrigated area, with irrigation water[66].

There are still certain problems in the activities of WUAs, such as shortages of experienced management specialists and equipment, low levels of financial collections to fund adequate water supply services and maintenance of irrigation networks and so forth[67]. The overall effectiveness of the current WUA system is not yet obvious, however, it can be tentatively assessed as rather positively *(see Box 2)*.

• SDG 6.4 says that by 2030, States should "significantly increase water efficiency in all sectors of the economy and ensure sustainable water supply and abstraction to address water scarcity". The target to meet this goal is dictated by two indicators: 6.4.1 (Water consumption per unit of GDP, m³/US $ 1000) and 6.4.2 (Water stress level: fresh water abstraction in relation to available freshwater resources).

In the 2021 UN SDG Country Profile[68], water use efficiency

61 Agreement between the Government of the Republic of Tajikistan and the Government of the Islamic Republic of Afghanistan on cooperation in the development and management of water resources of the Panj and Amu Darya rivers. bi-215068.pdf. (in Russian)
62 UNECE (2017) Third Environmental Performance Review of Tajikistan. Dushanbe.
63 Yakubov M. (2020) Small Basin Councils: linking water governance, water diplomacy and water sector reforms in Central Asia. Smart Waters Policy Papers Series. CAREC. 12 P. *9e030a6b4771491a3174803bc05eb89d.pdf.
64 Rajabov et al. (2021) Tajikistan - Country Gender Assessment (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/874641637562869105/
65 National Report on Implementation of Strategic Documents of the Country in the context of the Sustainable Development Goals (2018) Dushanbe. Report_V1_[ENG]_018.cdr (medt.tj).
66 Nazifov Sh.G., Ministry of Land Reclamation and Water Resources of the Republic of Tajikistan. Personal communication.
67 Ibid.
68 SDG Country Profiles.

(WUE) is estimated at US $1.10 per m³, which is two times lower than in Uzbekistan and seven times lower than in Kazakhstan. However, national reports have shown a pronounced positive trend since 2000, when this indicator stood at only US $0.20 per m³. The agricultural sector, being the largest water user in the country, is of primary importance for this indicator due to the high levels of water losses in irrigation. Tajikistan's irrigation system is both outdated and technically complex, requiring constant monitoring, repairs and maintenance of infrastructure that was built between the 1960s and 1980s. The World Bank estimates the efficiency of irrigation in the region at about 30 per cent, which was determined by the average use of 15,000 m3 water per irrigated hectare[69]. At the same time, local experts believe that the irrigation system is not operational if its efficiency is below 40 per cent[70]. Making an accurate assessment of the system is currently not possible as there is not enough information on the volumes of water consumed as, for example, in dehkan farms, there are no water meters at all. The installation of such meters could lead to significant savings in water consumption, as was shown by the country's experience of installing electricity meters[71]. Of the 5,192 water supply points (in former collective and State farms), only 1,972 were equipped with water meters (data for 2006)[72].

Despite the overall surplus of water resources in Tajikistan, their distribution across the country is very uneven and depends heavily on the amount of precipitation and the vagaries of river flows throughout the year. Therefore, in some irrigation areas, particularly those with a large share of diverted surface runoff, a tense situation with water resources may arise. A low (10 to 20 per cent) level of water stress is typical for the Vakhsh river valley due to abundant precipitation and the widespread glaciers in the northwestern Pamirs. The entirety of the Eastern Pamirs, which receives extremely little precipitation, is characterized by an average level of water stress (20 to 40 per cent) even with very low water consumption. The northern (Syr Darya valley) and western regions of the country (the middle and upper reaches of the Zeravshan River) have a high level of stress (40 to 80 per cent) and the lands of the central regions irrigated by the Great Gissar Canal have a very high level of stress (more than 80 per cent) *(see map 'Water stress')*. In dry years, the latter areas in particular may experience a sharp shortage of water for agricultural and domestic needs.

Water stress is reflected in the fact that in some years , many hundreds of dehkan farms do not sow their lands due to a physical lack of water, although, in general national statistics, the share of lands with water deficit may seem extremely insignificant. In 2023, there were 4,865.8 ha of land in Tajikistan that were not sown due to a lack of water, which was less than 1 per cent of the total irrigated area in the country[73]. However, if one considers that the average irrigated area of one farm equals 7.5 ha, then this area was equivalent to 650 dehkan farms. The Sughd region suffered the most in 2023, with 2,969 ha of irrigated land (equivalent to 400 farms) not cultivated due to a lack of water for irrigation and only a quarter of this was due to technical failures of pumps.

• SDG 6.1 deals with universal and equitable access to safe and affordable drinking water.

Targets 6.1 and 6.2 are of high relevance for Tajikistan as the current situation does not allow the country to fully utilize its water resources and provide its citizens and economic stakeholders in its subregions with sufficient quantities of environmentally safe fresh water.

In its progress reports on achieving the SDGs, Tajikistan uses an expanded definition of the concept of 'ecologically safe water', classifying almost all types of water supply as such sources, with the exception of open water bodies. However, even the centralized water supply in Tajikistan can only be classified as a source of safe water conditionally as, according to the WHO, of the 764 water pipes it tested in Tajikistan, 463 (61 per cent) did not meet sanitary requirements[74]. Moreover, other types of water supply – standpipes and wells with varying degrees of protection from agricultural and/or domestic waste cannot be 'by default' classified as safe sources. This underpins the need for cautious assessment regarding the republic's own published data on the state of the water supply in the country.

National reports show improvements in the provision of "safe" water: from 48.6% in 2010 to 59.2% in 2017, including the urban and rural populations with access to safe water, which are 94.1% and 45.2%, respectively. The rest of the population uses water from open sources (rivers, lakes, irrigation canals, etc.). The lowest level of access to 'safe' drinking water (25.4 per cent) was recorded in the Abdurahmoni Jomi district (former Kurgan-Tyube district) of the Khatlon region and where more than half (50.3 per cent) of the district's residents use water from open, i.e. epidemiologically dangerous, sources[75].

The UN SDG country profile[76] gives a relatively low figure for access to safe drinking water for 2022, indicating that only 55.3 per cent of the total population had access to safe drinking water free from contamination. Having noted this, the report also acknowledged there has been rapid progress since 2000, when the share was only 36 per cent. In contrast, an official Tajikistani report gives higher estimates for 2022, claiming 74 per cent of the total population and 56 per cent of the rural population had access to safe water[77]. This latter report rates Tajikistan's overall level of providing access to safe water as "acceptable".

The differences in these estimates depend on which water supply sources are considered to guarantee good water quality. If only tap water is considered as such a source, then the estimates are relatively low and align with the UN's estimate of up to 55.3 per cent for the entire population[78]. However, there are also large differences between access for urban and rural populations – about 86 per cent and 26 per cent, respectively. If public wells and taps are considered relatively safe sources, then the estimates are high, up to 74 per cent. However, despite these specifics, national statistics provide data that show a significant part of the population is forced to draw water from open sources, namely some 20 per cent, with this figure being 28 per cent for purely rural populations *(see map 'Share of the population using open water sources for domestic purposes')*. Such sources are recognized by national experts as not meeting sanitary requirements as they readily lead to the spread of infectious diseases transmitted through contaminated water.

Men and women depend on water resources in their daily lives to varying degrees, however, this is particularly salient in rural areas. A distinctive feature of Tajikistan is the almost equal representation of women (about 200,000 individuals) and men in agriculture, with very little female employment in forestry (200) and fishing (40). Despite their high employment in agricultural production, women are also involved in

69 World Bank, 2017.
70 Nazifov Sh.G., Ministry of Land Reclamation and Water Resources of the Republic of Tajikistan. Personal communication.
71 Shenhav et al. (2018) The Role of Water User Associations in Improving the Water for Energy Nexus. Technical Report. Dushanbe. 53 P.
72 Water sector development strategy in Tajikistan (2006) Dushanbe. Microsoft Word - Strategy.doc (cawater-info.net).
73 Tajikistan Loses Arable Land: Water Scarcity and Management Failures - CABAR.asia
74 WHO (2015) Better noncommunicable disease outcomes: challenges and opportunities for health systems: Tajikistan country assessment. WHO Regional Office for Europe. Copenhagen. Better non-communicable disease outcomes: challenges and opportunities for health systems: Tajikistan (who.int).
75 Ibid.
76 SDG Country Profiles.
77 Tajikistan General Water Security Assessment (2022) World Bank. 62 P. World Bank Document.
78 Tajikistan. Demographic and health survey, 2017 (2018) Statistical Agency under the President of the Republic of Tajikistan. Dushanbe. 429 p.

housekeeping, which takes about seven hours of their day compared to the average four hours for men[79]. Household activities, such as cooking and cleaning, entail significant water consumption and require access to clean water. According to a gender survey, while almost 55 per cent of the water required for housekeeping is purchased as bottled drinking water and 6.3 per cent comes from public wells or standpipes, almost 40 per cent is drawn from irrigation canals. Water from all these sources is delivered to family homes by women or their children. Furthermore, collecting wood for heating and cooking also takes a significant amount of time, even with the almost complete electrification of rural settlements throughout the country. This everyday employment of women in multiple key roles well illustrates the concept of 'time poverty'[80].

• SDG 6.2 requires access to adequate and equitable sanitation and hygiene services for all.

In relation to SDG 6.2, there is also a problem with Tajikistan's official broad interpretation of the concept of 'sustainable sanitation systems'. The country profile provided for UN SDG 6.3 presents data shows that 99 per cent of the country's population has access to adequate sanitation and hygiene services, while the overall proportion of the population with basic handwashing facilities on premises increased from 72.4 per cent in 2006 to 73.0 per cent (and 68 per cent in rural areas) in 2022. National statistics use the term "improved toilet facilities", which include any non-shared toilets of the following types: flush toilets emptying into sewer systems, septic tanks and pit latrines; ventilated improved latrines; pit latrines with slabs and composting toilets[81]. The use of such a definition gives deliberately inflated estimates of the degree of implementation of SDG 6.2. Most toilets in rural

79 National Gender..., 2016.
80 Woman's time ..., 2020.
81 Tajikistan. Demographic.., 2018.



*The spillway of the Nurek dam, August 2018*

areas (84.5 per cent) are unheated, located in the courtyards of households, schools and other public buildings and do not meet modern sanitary and hygienic requirements. The lack of safe and comfortable sanitary facilities incurs health problems as, for example, urinary tract infections can readily develop. Furthermore, such toilets are dangerous for children to use and all the issues surrounding their use are especially aggravated at night and in winter.

Most of the country's existing sewerage facilities were built before the 1980s and have not been properly maintained since the collapse of the Soviet Union. The actual capacity of the country's sewerage systems is 87.08 million m³/year, down significantly from the 158.92 million m³ capacity it had in 1990. The efficiency of the sewerage systems never exceeds 40 per cent and is accessible for only 15 per cent of the country's population. In urban areas, 44 per cent of the population has access to sustainable sewerage systems, while in rural areas this figure is 3 per cent[82]. These data provide grounds for the lower estimate given in this atlas of the availability of safe sewerage systems for the population of Tajikistan's districts than is provided in official statistics *(see map 'Population access to canalization systems')*. In support of this position, the World Bank provides similarly low statistics. The level of connection to sewerage systems in the country covers 16.5 per cent of the population, which highlights the need for radical improvement in this area. Rural areas face severe sanitation problems: less than 1 per cent of the population is connected to sewerage systems, and only 0.1 per cent of wastewater is treated[83]. Interestingly, in terms of gender, at the national level, women in urban and rural areas have a slight advantage in access to safe (piped) water and sanitation services[84].

The foregoing differences in data between national and international sources highlight the importance of harmonizing reporting methodologies to ensure the accuracy and comparability of indicators at the international level. This will allow more effective monitoring of progress towards achieving the SDGs and the development of targeted strategies to further improve the water supply situation in the Republic of Tajikistan, an argument that is especially pertinent for SDGs 6.1 and 6.2.

• SDG 6.3: Reduce pollution, eliminate discharges and minimize releases of hazardous chemicals and materials.

Tajikistan faces challenges in monitoring and collecting data on water quality and has not provided information on SDG 6.3 to the UN statistical services[85]. National environmental collections provide data on emissions of pollutants into the atmosphere but not on discharges or treatment of industrial and municipal wastewater into water bodies.

Industrial activities, as well as the use of fertilizers and pesticides in agriculture, can lead to water pollution that affects the water quality of both surface and groundwater sources in many areas. In some such areas, inadequate sanitation and sewerage systems can lead to the contamination of water supplies with human and animal waste, further increasing the risk of waterborne diseases.

The discharge of wastewater and drainage water in Tajikistan amounted to 4.6 km³ in 1990, decreased to 3.6 km³ in 2000 and returned to the previous level in 2004 (4.7 km³). The discharge of industrial wastewater decreased from 138.6 million m³ in 1990 to 108.2 million m³ in 2004, while the discharge of untreated sewage in 2004 was 2.86 million m³, 59 per cent less than in 1990.

Over the past 20 years, no maintenance or upgrading of sewer networks and related structures has been carried out, which has resulted in the reduced efficiency of the wastewater treatment system. This wastewater, in turn, is discharged into various water sources without treatment, thereby creating threats to human life and health. The share of non-standard samples for bacteriological indicators is 10.6 per cent, for chemical indicators – 32.2 per cent[86]. The main reasons for poor water quality throughout the republic are frequent accidents in water supply systems and structures as well as equipment failure and irregular power supply.

Protecting water quality from contamination from wastewater requires significant infrastructure and financial investment, and while there are 20 water treatment facilities in Tajikistan, only two of them (in Dushanbe and Khujand) function properly. Despite the adoption of the 'Programme for the Restoration of Hydrometeorological Stations and (31) Hydrological Posts for the Period 2007–2016', the available information does not allow conclusions to be drawn on the dynamics of Tajikistan's water quality[87].

• SDG 6.6 seeks to protect and restore aquatic ecosystems such as wetlands, rivers, aquifers and lakes, including those found in mountains and forests, by the target date of 2030.

Indicator 6.6.1 (gradual change in the size of aquatic ecosystems) is directly related to the implementation of the Ramsar Convention, which was ratified by the Republic of Tajikistan in 2001. Tajikistan joined the Central Asian Regional Ramsar Initiative on Wetlands (RRI-CA) in 2021. This project was established in 2015 to strengthen cooperation and coordination of efforts of the region's five countries to effectively implement the Ramsar Convention Strategic Plan for the period between 2016 and 2024 at the national and regional levels. There are 21 Ramsar sites in the Central Asian Region with a total area of 4.7 million ha, in Tajikistan, five sites, with a modest area of 94,600 ha, have been nominated so far, despite the abundance of water bodies[88].

This list of five Ramsar sites includes Lake Karakul, Lake Zorkul, the Rangkul and Shukul lake systems, the Tigrovaya Balka Nature Reserve and the Kairakkum Reservoir on the Syr Darya River. These sites have also been nominated as Important Bird and Biodiversity Area (IBAs) that are important for the protection of global biodiversity. The Ramsar sites of Tajikistan, with the exception of the Kairakkum Reservoir, are also included in the list of UNESCO World Heritage Sites. After being nominated for the Ramsar system in 2001, the sites' supervision was transferred from the Forestry Agency to the State Committee for Environmental Protection to strengthen their protective regime. This transfer of authority has proven useful as, for example, one achievement in enhancing the protection of these sites include data now being gathered on the conservation and restoration of wetland ecosystems in the Kairakkum Reservoir on the Syr Darya River, although they appeared because of excessive siltation of the reservoir[89].

Among the other Ramsar sites, Lake Karakul stands out due to its impressive size (26 km³) and hypersalinity, caused by extremely low precipitation (about 20 mm annually) and the lack of surface-water drainage *(see map 'Area of aquatic ecosystems by basins')*. Although this lake is poorly studied, water loss occurs mainly through evaporation and the shores of the lake are bordered by salt beaches, suggesting that in the recent past it occupied only a slightly larger area. According to a widely held theory, the relief of the lake bed is a crater 52 km in diameter, formed as a result of a meteorite impact about 25 million years ago. Lake Karakul has been included

82 UNECE, 2017.
83 Tajikistan General.., 2022.
84 TaStat. (2010) Women and Men in the Republic of Tajikistan. Dushanbe.
85 SDG Country Profiles.
86 WHO, 2015.
87 UNECE, 2017.
88 Ramsar Regional Initiative for Central Asia (RRI-CA) (review of project activities, 2016–2020) (2020) Central Asia, Regional Report 2020_fin.pdf. (in Russian)
89 National report on the implementation of the Ramsar convention on wetlands (2021) Microsoft Word - National Report_cop14_e (ENG).

in the UNESCO list of World Heritage Sites since 2013 due to the recognition of the Tajik National Park (TNP), within whose boundaries the lake is located. The intermountain valley containing the freshwater Lake Rangkul and the brackish Lake Shorkul, connected by a stream, is also part of the TNP. These lakes freeze completely in winter and contain no fish. Another Ramsar site is Lake Zorkul, located at an altitude of over 4,000 m in the southern part of the Pamirs in the border zone of Tajikistan and Afghanistan and outside the boundaries of the TNP. This lake and its surrounds have been part of a PA system since 1972 as a nature refuge established to protect bar-headed geese. In 2000, however, the PA was significantly expanded and its conservation status was upgraded to International Union for Conservation of Nature (IUCN) Category I (corresponding to 'nature reserve'). The lake is currently on the waiting list for inclusion in the World Heritage List[90].

All these water bodies in the harsh conditions of the high-mountain desert and uninhabited areas are stable formations that do not demonstrate any specific dynamics *(see maps 'Water areas in 1990', 'Water areas in 2021' and 'Change in the area of permanently flooded aquatic ecosystems')*. A study of the dynamics of high-mountain lakes in the Gunt river basin shows their insignificant multidirectional dynamics[91]. According to the country profile for the UN SDGs, the area of water bodies (lakes, rivers, reservoirs) in Tajikistan from 2001 to 2005 and from 2011 to 2015 decreased in some areas and increased in others, with a total slight decrease from 1,558 to 1,540 km² (1.2 per cent)[92].

A more problematic Ramsar site is the Tigrovaya Balka Nature Reserve, which occupies a vast area of 50,000 ha in the lower reaches of the Vakhsh River and the Tajik bank of the Pyanj River. Since its establishment in 1938, the reserve's primary function has been the protection of the floodplain tugai forests that once served as the habitat of the Turan tiger (considered extinct since the 1950s). These tugai forests require the maintenance of a natural hydrological regime, i.e. large spring floods and significant sediment loads. This regime was disrupted with the construction of 8 dams, but mainly the Nurek Dam in the 1960s, which "cut off" all spring peaks in the flow of the Vakhsh River *(see map 'Main hydraulic facilities')*. The increase in water consumption for irrigation has also led to a reduction in the periodically flooded areas of tugai forests, which is already evident in the lower reaches of the Vakhsh and Pyanj rivers *(see map 'Change in the area of seasonally flooded aquatic ecosystems')*. The situation in this nature reserve will become even more uncertain in ecological terms with the upcoming completion of the Rogun hydroelectric power station, a structure that was designed during the Soviet period.

*Box 2: The establishment of WUAs in Khatlon Province has led to some positive results*

Since 2011, Khatlon province has become a testing ground for the new WUA system with technical and financial support from USAID. This region is one of the poorest regions of Tajikistan but, at the same time, has a very extensive and difficult to manage irrigation network built during the Soviet era. The main goal of the USAID project is to increase agricultural productivity by implementing two principles of WUAs: first, their integration into hydrological boundaries to optimize the water distribution system among farms and second, increase the independence of WUAs in decision-making.

90 Diment A., Mallon D. (2012) First biodiversity survey of Zorkul reserve, Pamir Mountains, Tajikistan. Fauna & Flora International. Oryx, 46(1). Pp. 13–17. doi:10.1017/S0030605311002146.
91 Navruzshoev et al. (2022) Dynamics of the surface area of mountain lakes in the Gunt river basin. Central Asian Journal of Water Resources Research. 8(2), Pp. 85-101. (in Russian)
92 SDG Country Profiles.



*Local garden irrigation system*



*Panorama of the deep valley of the Zeravshan River and the Zarafshan range (left) and the Gissar range (right) near the mountain settlement of Aini.*

In total, 60 WUAs were established in Khatlon province during the project's implementation[93].

To examine the impact of the new WUA model on irrigation service quality, crop choice and cotton yields, USAID compared the performance of WUA-affiliated farms (the 'target group') and non-WUA-affiliated farms (the 'control group') located in Khatlon province over a three-year period from 2014 to 2016[94]. To provide consistency and comparability, the distribution of farms selected in both groups was required to occupy similar positions in the irrigation network (head, middle and tail sections of canals).

In 2014, about 17 per cent of farms in the target group perceived their water supply as 'timely'; in 2016, this figure had risen to 21 per cent. The same increase of 4 percentage points was observed for farms in the control group, rising from 13 per cent to 17 per cent. In 2014, about 25 per cent of farms in the target group perceived water distribution, in terms of amount, as 'fair'; in 2016, this figure had risen from 14 per cent to 39 per cent. In 2014, 24 per cent of farms in the control group perceived water distribution as 'fair', however, in 2016, this figure had risen only 8 per cent, to 32 per cent. The difference in perception between the two groups was 6 percentage points, which became statistically significant at the 5 per cent level.

Remote sensing data from 2010 to 2017 show that the proportion of wheat in the target group's arable land was significantly higher than in the other areas. In 2010, 9 per cent of the target group's arable land was under wheat, versus 5 per cent of the control group's arable land. By 2017, 21 per cent of the target group's arable land was under wheat, while the area under wheat in the control group's arable land had increased to only 12 per cent.

Despite the short observation period and sometimes statistically insignificant differences between the two groups, the study authors believe the results support the effectiveness of the newly established WUAs in ensuring a more equitable distribution of water and expanding the area under wheat, an important crop for the country's food security.

### 3.4. Responses

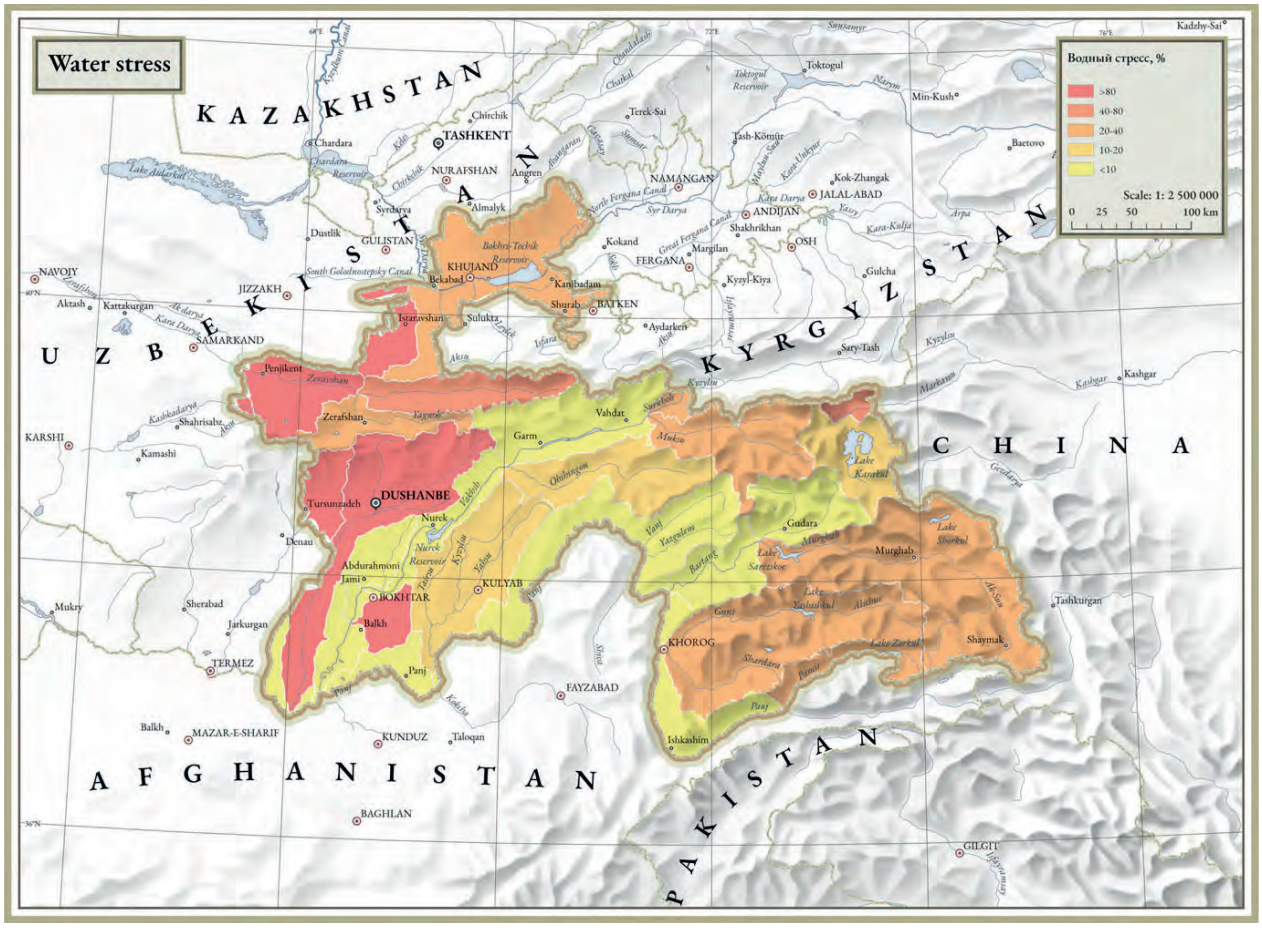
- Priority attention is given to issues of access of the population to safe water supply and safe sanitation systems, especially vulnerable groups such as women and children.
- Dissemination of experience in organizing public basin councils within the boundaries of small river basins.
- Further development of the WUA system in agriculture to ensure fair distribution of water and greater diversification of crops.
- Take into account gender aspects in water use policies, encouraging greater female leadership in water resources management

93 Balasubramanya et al. (2016) Water User Associations for improved agricultural productivity in Tajikistan: opportunities and challenges. 2nd World Irrigation Forum, 6 to 8 November 2016, Chiang Mai, Thailand.

94 Horbulyk T, Balasubramanya S.J. (2018) Impact of Water Users Associations on Water and Land Productivity, Equity and Food Security in Tajikistan. Final Report: Volume I. Colombo, Sri Lanka: International Water Management Institute (IWMI) 131 P.

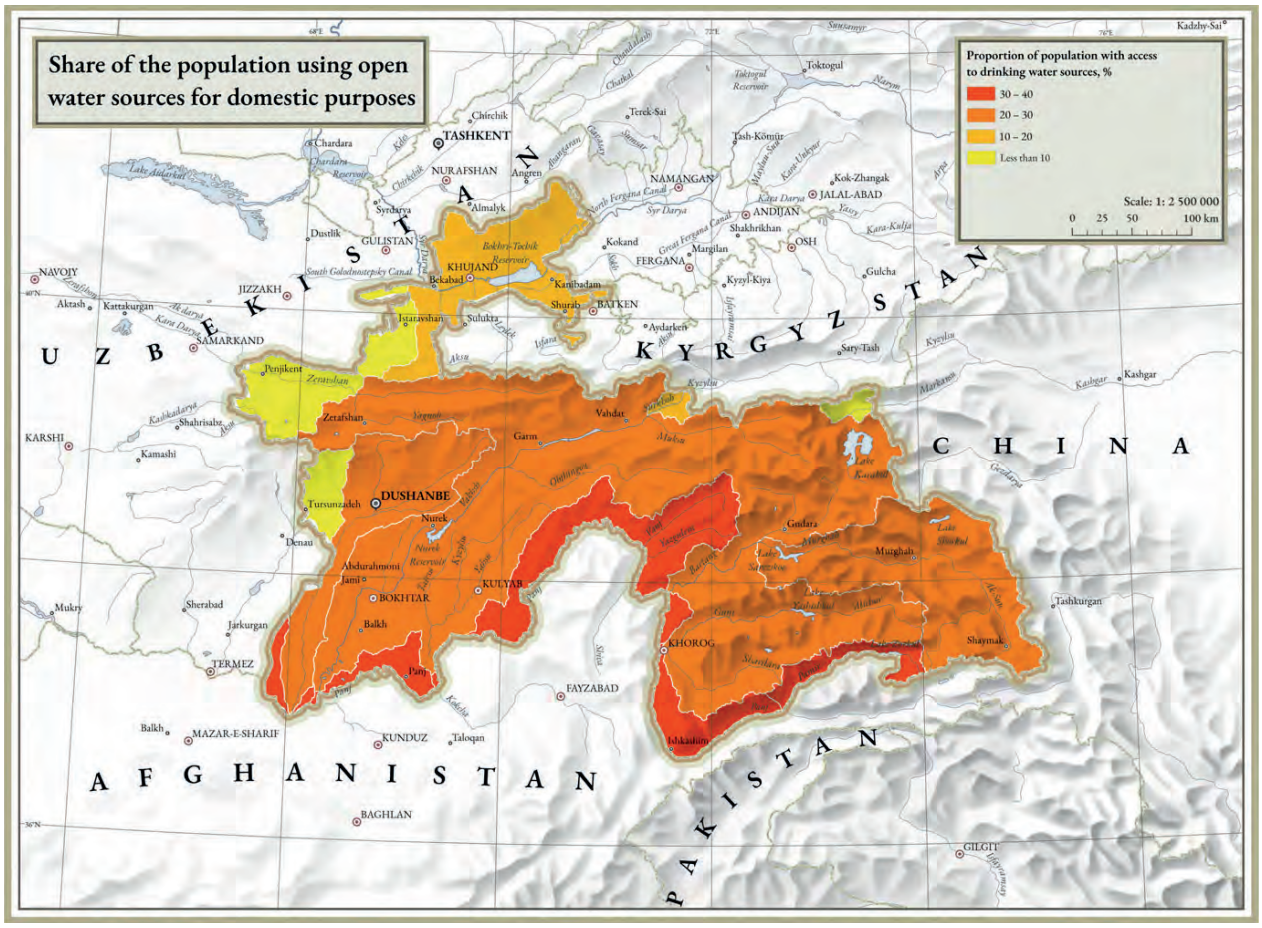


*Vanjakh Glacier in the Pamir Mountains in Tajikistan*



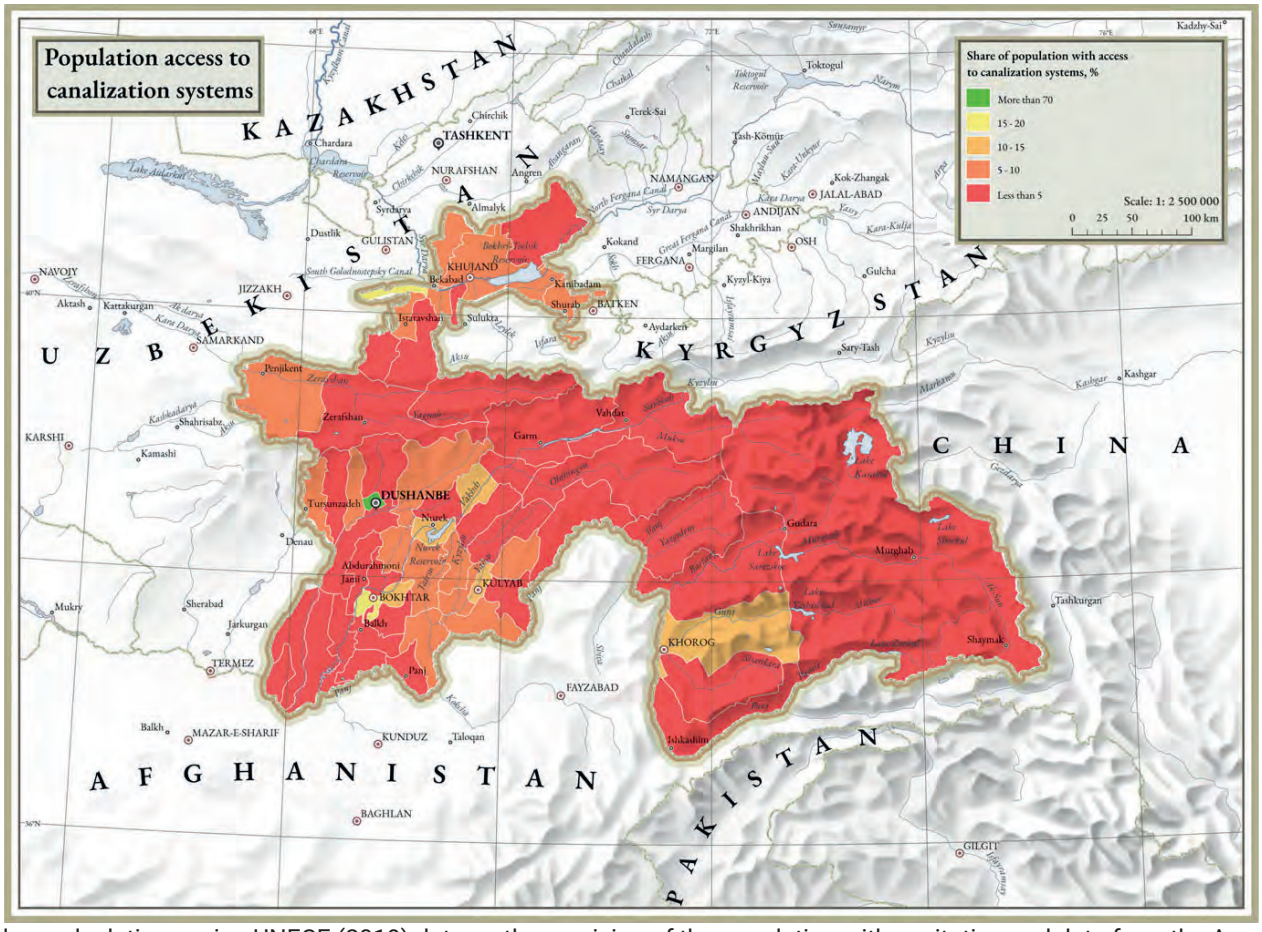

According to Aqueduct[95] calculations based on FAO Aquastat water consumption data, ERA5 climate data (see note to the above map, 'Trend annual air temperature, 1960–2023') and runoff modelling results using the WaterGAP model (see note to the above map, 'Volume of annual runoff').

95 https://www.wri.org/research/aqueduct-40-updated-decision-relevant-global-water-risk-indicators



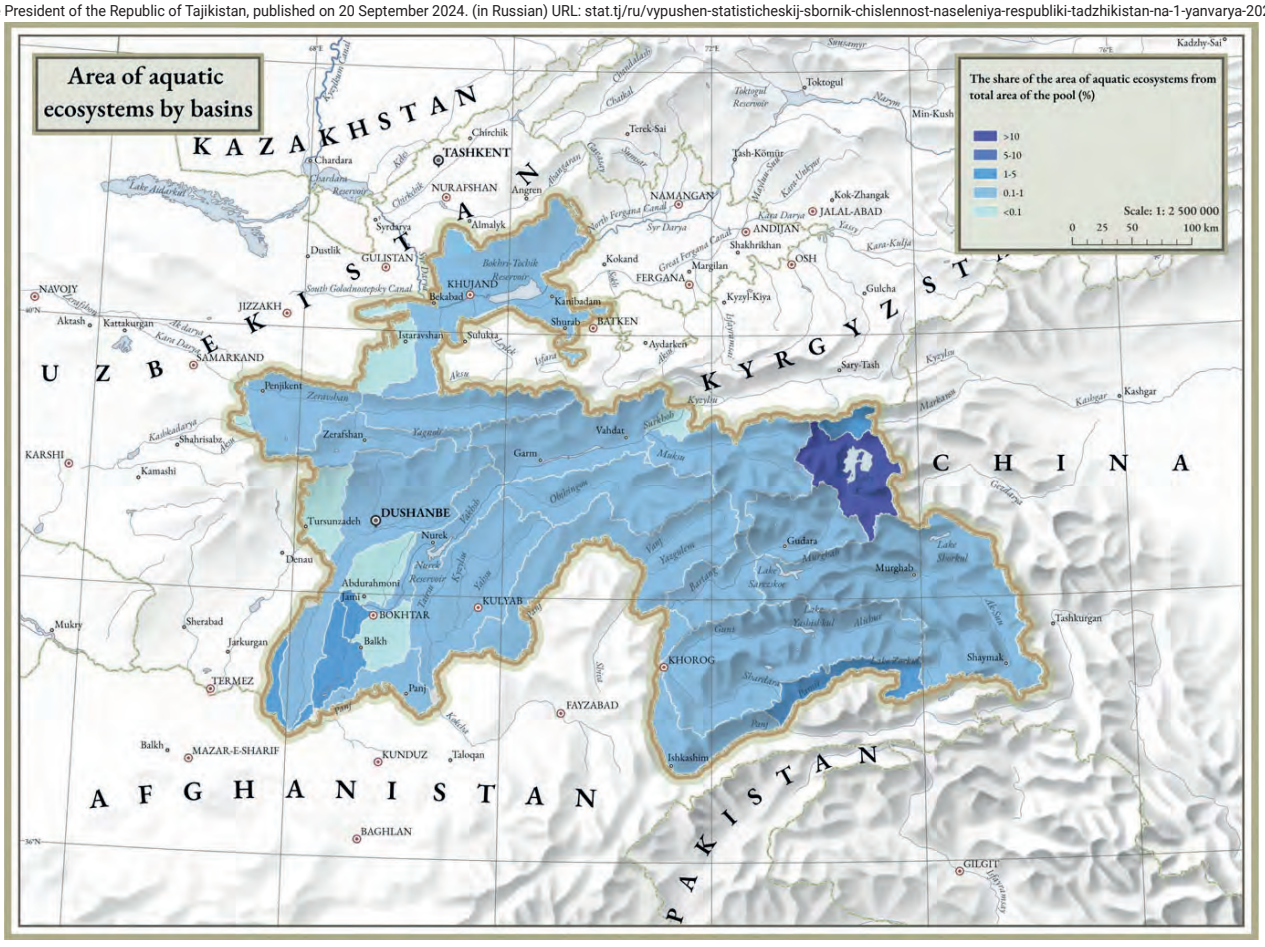

According to Aqueduct[96] calculations based on FAO Aquastat water consumption data.

96 https://www.wri.org/research/aqueduct-40-updated-decision-relevant-global-water-risk-indicators



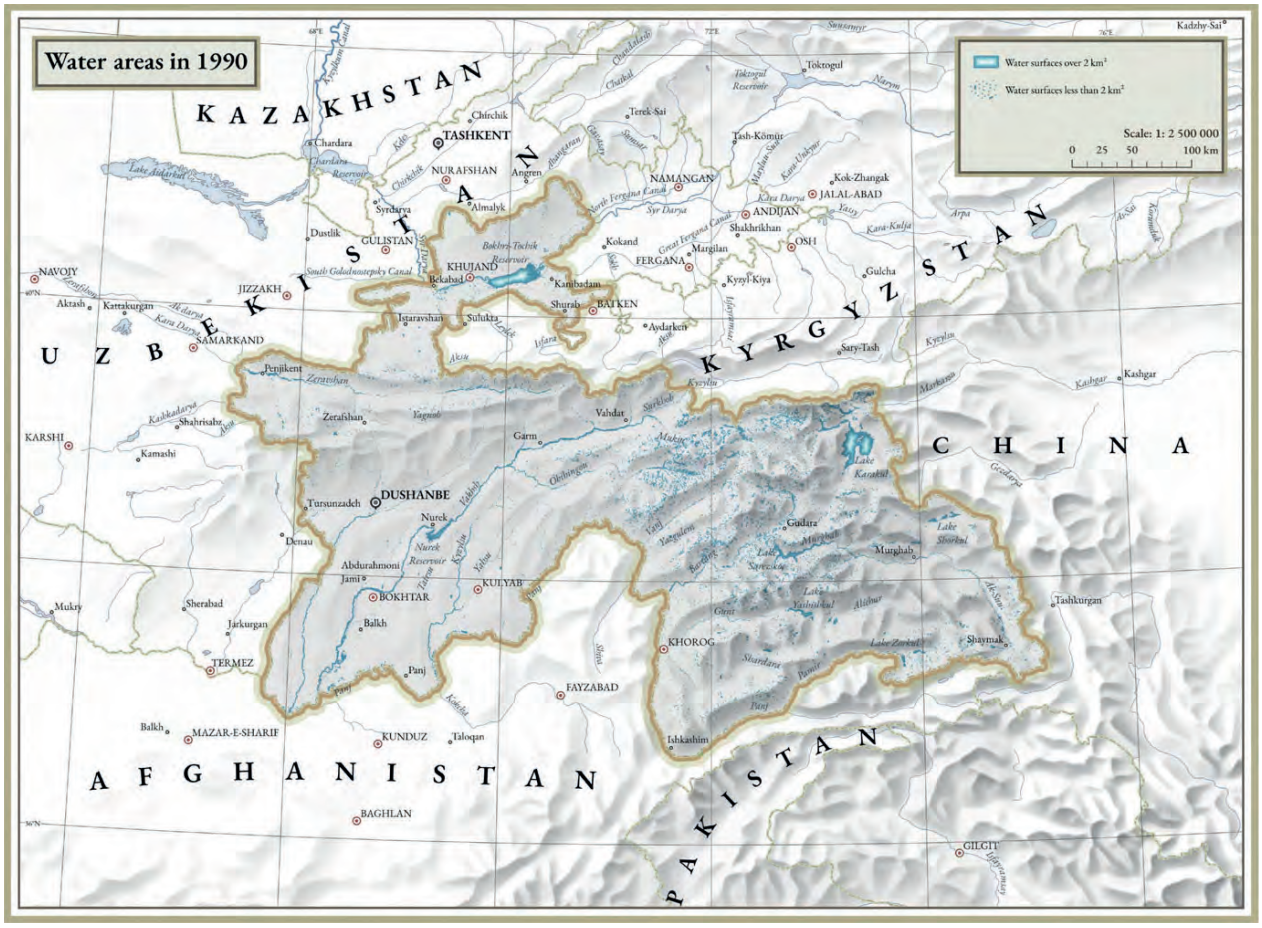

Based on calculations using UNECE (2019) data on the provision of the population with sanitation and data from the Agency on Statistics under the President of the Republic of Tajikistan on the population.[97]

97 Agency on Statistics under the President of the Republic of Tajikistan. 2024. 'Population of the Republic of Tajikistan as of January 1, 2024'. In the official publication on the website of the Agency on Statistics under the President of the Republic of Tajikistan, published on 20 September 2024. (in Russian) URL: stat.tj/ru/vypushen-statisticheskij-sbornik-chislennost-naseleniya-respubliki-tadzhikistan-na-1-yanvarya-2024-goda/

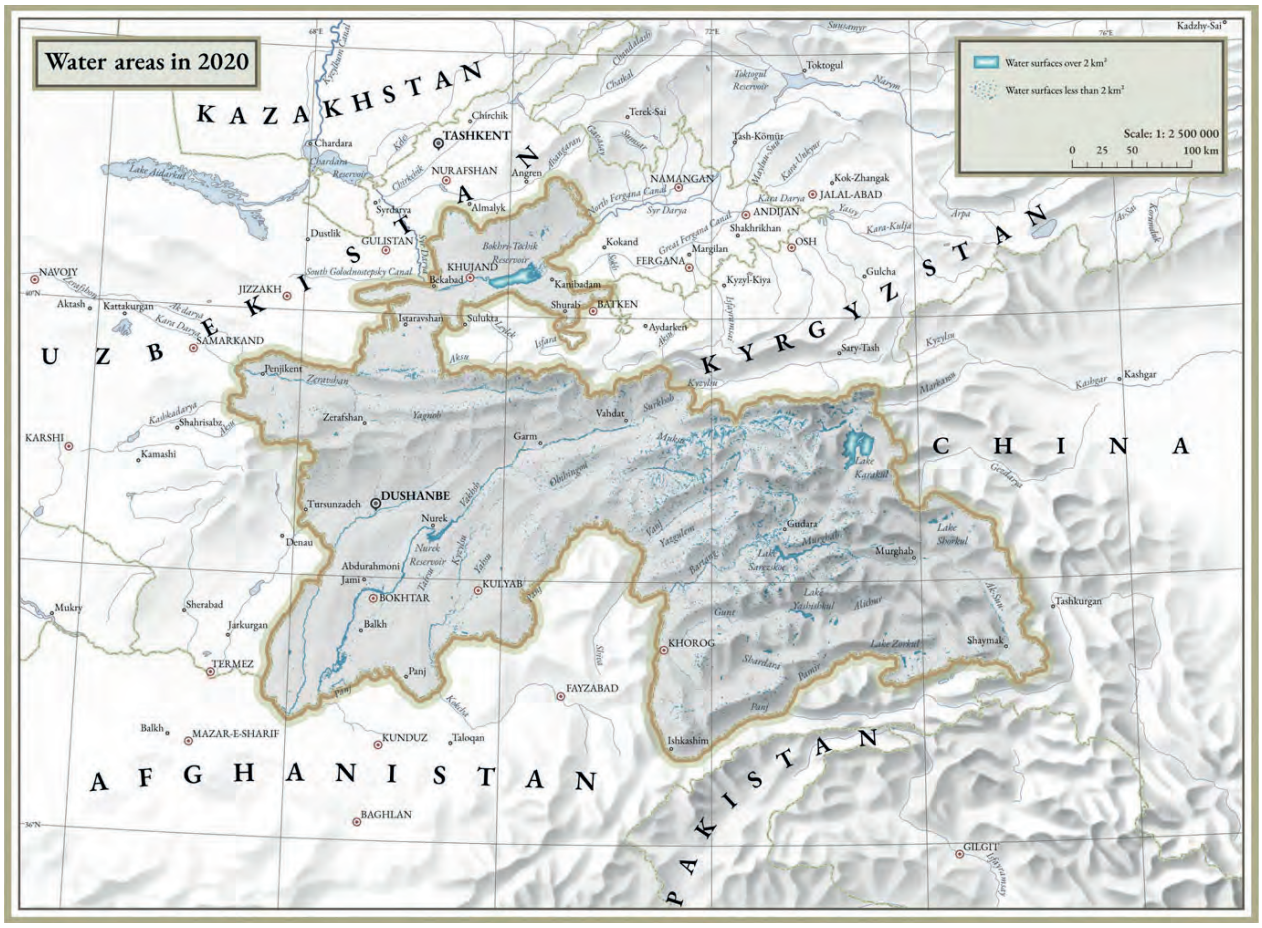



According to Freshwater Ecosystems Explorer,[98] obtained by the automatic classification of Sentinel, Landsat MODIS satellite images.

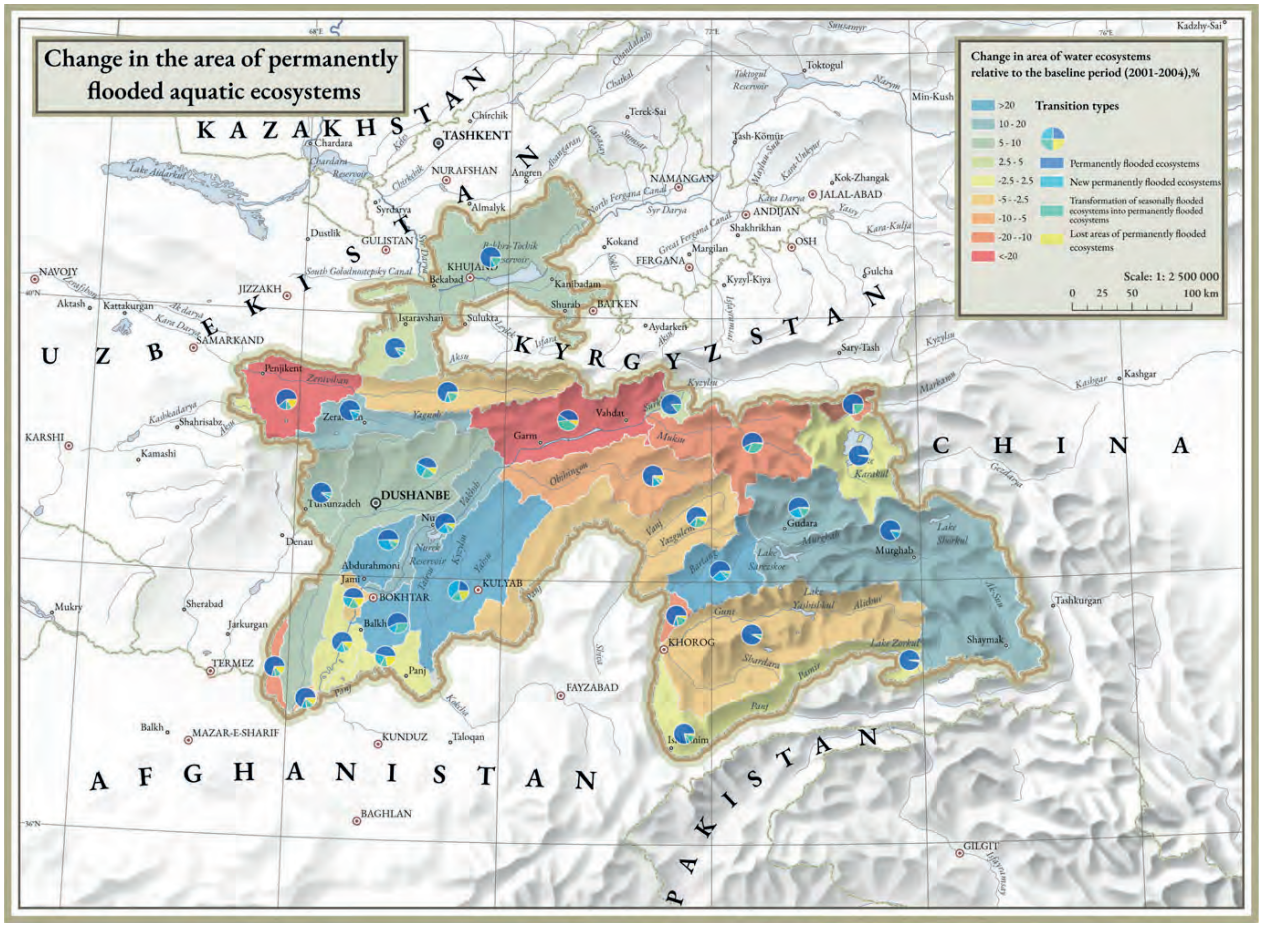
98 https://map.sdg661.app/



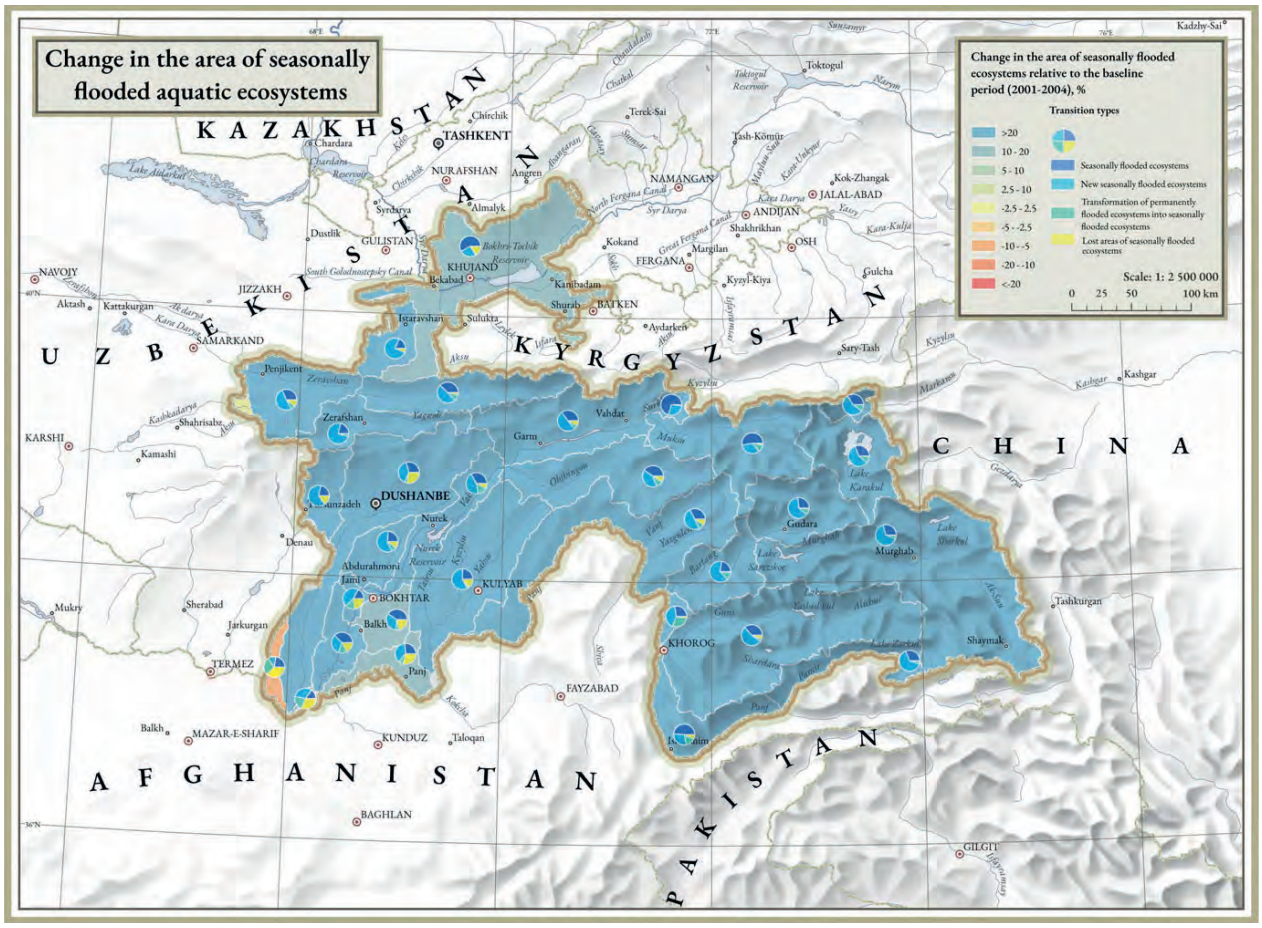

Results of Landsat satellite data processing.




Results of Landsat satellite data processing.




According to the Freshwater Ecosystems Explorer (see note to the above map, 'Area of aquatic ecosystems by basins').




According to the Freshwater Ecosystems Explorer (see note to the above map, 'Area of aquatic ecosystems by basins').

# Land Resources



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**4.1. Key aspects**

- Some 72 per cent of Tajikistan's population lives in rural areas where their livelihoods directly depend on the productivity of their farms.
- Agricultural production is heavily reliant on irrigation as irrigated agriculture produces up to 90 per cent of all agricultural products.
- The decline in cotton yields is caused by poor soil conditions and unreliable water supplies. The latter is largely due to the dilapidated state of irrigation systems, including pumping stations, that have lost up to 65 per cent of their capacity and/or efficiency.
- The number of cattle in households has almost doubled since the 1990s, a factor which is associated with the widespread (up to 85 per cent) degradation of pastures.

**4.2. General characteristics**

The agricultural sector plays a very large role in the economy of Tajikistan, accounting for 23 per cent of the country's GDP. Most of the republic's population (72 per cent) lives in rural areas and is economically completely dependent on the products they produce on their plots. Furthermore, the share of the population employed in agriculture are very high compared to, for example, Kazakhstan while Tajikistan's poverty level remains stubbornly high as GDP per capita is only US $1,160 (2023). The key resource for agriculture and livestock farming - soils - is most heavily influenced by the mountainous relief of Tajikistan *(see map 'Soil types')*. In brief, there are several altitude zones with specific soil formation features: plain, low-mountain, mid-mountain, high-mountain and nival.

The plain belt exists at altitudes from 300 to 500 m above sea level and occupies about 10 per cent of Tajikistan's territory, primarily in the north of the republic, in the western part of the Fergana valley and, to a lesser extent, is less developed in the southwest around the lower reaches of the Kafirnigan, Vakhsh and Panj rivers. This belt is dominated by sierozem soils, which are formed under the influence of a dry and hot climate, ephemeral and wormwood-cereal vegetation, as well as intensive evaporation and solonetzic conditions. Sierozem soils have a poorly developed humus horizon and a high content of carbonates and salts. They are of low fertility but with irrigation and fertilization they can produce good yields of cotton and cereals. In river floodplains and in areas experiencing spring moisture, there are salt marshes as well as meadow and meadow-marsh soils developing on boulder-pebble and sand-pebble deposits.

The low-mountain belt includes foothill plains and adyr hills located at altitudes from 450 to 500 m through to 700 to 800 m above sea level. This belt occupies about 15 per cent of Tajikistan's territory and represents a transition zone from the desert to the mountain steppes. Dark sierozem soils have developed in this belt, which differ from light sierozem soils by having a darker colour, deeper humus horizon and lower content of both carbonates and salts. Dark sierozem soils are more fertile than light sierozem soils and are suitable for non-irrigated farming. Grain crops (wheat, barley) are grown on them and Karakul sheep breeding is continuing to develop in dark sierozem soil areas. In the parts of the Pamirs that exist in this altitudinal zone, there are also desert, low-humus carbonate soils, as well as meadow-marsh permafrost soils on the terraces of the rivers of the Eastern Pamirs, which have a hummocky surface and a thin profile.

The mid-mountain belt prevails at altitudes ranging from 700 to 800 m through to 1,500 to 2,000 m above sea level. It occupies about 25 per cent of Tajikistan's territory and differs from the low-mountain belt in its less hot climate during the dry season, relatively wet spring, and richer vegetation. Mountain brown soils have developed in this belt under the influence of wheatgrass-forb steppe and shrub vegetation which creates conditions for the accumulation of organic matter. These soils are brown or dark brown in colour, have a medium or high humus content and a low or medium content of carbonates and salts. They are of medium or high fertility and are suitable for non-irrigated agriculture and forestry. Grain crops are grown on them as well as tree and shrub species, such as wild almond, hawthorn, pistachio, juniper, and in the valleys – maple, walnut and willow.

The high-mountain (alpine) belt occupies mountain slopes starting at altitudes of 1500 to 2000 m and extend up to Tajikistan's highest points at 3000 to 3500 m above sea level. The belt occupies about 20 per cent of the republic's territory and as the terrain stretches eastward, it climbs higher and higher, although terrain at such altitude is completely absent in the Eastern Pamirs. High-mountain meadow-steppe, steppe, desert-steppe and desert soils have developed in this belt, formed under the influence of a cold and snowy climate, the presence of cushion and teresken vegetation as well as strong weathering and erosion. The typical composition of the land cover in this belt is 7.5 per cent under glaciers and snowfields, 24.0 per cent meadow steppe and 67.6 per cent weakly sodded surfaces with dwarf shrubs *(see map 'Bare grounds')*[99]. High-mountain soils have different colours depending on the type of vegetation – from light grey to dark brown – have low or medium humus content and high or medium carbonate and salt content. They are of low or medium fertility and suitable for summer grazing.

Agricultural lands in Tajikistan occupy about 4.6 million ha and are mainly mountain pastures that exist within meadow-steppe ecosystems *(see map 'Land cover in 2021')*. Arable land suitable for crop production makes up about 23 per cent of the total agricultural land area. Of these, 741,200 ha, or 74 per cent, are irrigated lands. Most of the irrigated lands – 550,000 ha – are supplied with water from large rivers through irrigation systems managed by the Agency for Land Reclamation and Irrigation. The remaining irrigated areas are managed by local authorities, dehkan farms and WUAs, which use temporary watercourses, streams and groundwater for this purpose[100].

Tajikistan has the lowest amount of arable land per capita in the Aral Sea basin – only 0.08 ha, of which 0.06 ha is irrigated arable land (2016). Given the republic's previously discussed rapid population growth, this figure is gradually declining and the physical shortage of suitable land, material and financial resources hinders the development of new arable land.

According to official annual statistics, unemployment among working-age citizens is consistently around 24 to 30 per cent. Over the past ten years, the number of citizens employed in industry has decreased by almost 62 per cent while the number of workers in agriculture has, in contrast, increased by 28.6 per cent. At the same time, the volume of agricultural production has decreased by 35 per cent due to decreased labour productivity. While an important source of income for those engaged in agriculture is the produce obtained from their personal subsidiary plots, agriculture remains the sector of the economy with the lowest wages and poverty contributes to large-scale labour migration, exacerbating the current shortage of skilled labour[101].

In Tajikistan, cotton and wheat are the two main cash crops, grown on almost 66 per cent of the cultivated area (30 per cent cotton, 36 per cent wheat). Tajikistan was the third largest cotton producer in the former USSR, growing one million tons per year, and cotton is still the country's second most important export product after aluminum[102]. Cotton is produced on about 146,500 ha of land in three regions: Khatlon, Sughd and the Districts of Republican Subordination around Dushanbe, with the Zeravshan valley being too cool for cotton cultivation. Of these three regions, Khatlon (southwest Tajikistan) has the largest share land under cotton with 119,500 ha, or 82 per cent of the total area sown with this crop in the country. Approximately 90 per cent of the region's residents are employed in agriculture, especially cotton growing, and the vast majority of households (98.8 per cent) use only family members for labour.

The monoculture of cotton in Central Asia during the Soviet period depleted the soil and led to serious plant diseases and the spread of pests that negatively affect cotton yields to this day, which explains the overall reduction of cotton crops throughout the region by a third in *(see Box 3)*. Some 30 years agon in Tajikistan, large areas were under cotton – 298,000 ha, by 2015 this area had reduced to 158,900 ha, a 45 per cent decrease despite the fact that the loss of arable land has not exceeded 20 per cent. The most valuable fine-fibre varieties of cotton, which Tajikistan produced up to 25 per cent[103] of in the Soviet Union, have practically disappeared from cotton crop harvests[104].

In 2020, Tajikistan produced about 350,000 tons of cotton, of which only 7,000 tons are consumed domestically[105]. However, cotton production had already fallen by 32 to 33 per by the early 1990s due to a reduction in planted areas and a decline in yields with the latter explained by a lack of water and poor soil conditions. Yields fell from 2.77 t/ha in 1990 to 1.98 t/ha in 2004, then rose slightly to current 2.2 t/ha. Currently, combined product losses from

99 Pohl et al., 2014.
100 Irrigation and Drainage – TajNCID.
101 Umarov H. (2019) Livestock sector in Tajikistan: Problems of sustainable and balanced development. IAMO. 46 P. Сектор животноводства в Таджикистане: Проблемы устойчивого и сбалансированного развития. (in Russian)
102 Lerman Z., Sedik D. (2008) The Economic effects of land reform in Tajikistan. Report prepared for the European Commission under the EC/FAO Food Security Programme. 65 P. Microsoft Word - Economic effects of land reform in Tajikistan.doc.
103 Djanibekov et al. (2020) Cotton Sector Reforms in Central Asia. IAMO Annual. Pp. 48-54. Cotton sector reforms in Central Asia (iamo.de).
104 Umarov, 2019.
105 Lerman, Sedik, 2008.



*Agricultural land*

all stages of cotton production (growing, harvesting, transportation, storage and processing) range from 30 to 40 per cent. Reaching the cotton production volumes enjoyed before the 1990s crisis is impossible without modernizing the country's agriculture system.

Tajikistan has to import about 65 per cent of its food, including about one million tons[106] of wheat, mainly from Kazakhstan, as Tajikistan's annual wheat demand is more than two million tons. Interestingly, Tajikistan's 2004 wheat harvest was 891,600 tons, in 2018 it was 1.16 million tons and 1.754 million tons in 2023.

The peculiarity of Tajikistan's irrigation system is that 38 per cent of the 758,000 ha of irrigated land, almost 289,000 ha, rely on pumps to lift water from low-lying areas. The share of land irrigated by such a technically complex method is the highest in Central Asia. These irrigation pumps require an uninterrupted power supply to ensure their proper functioning. This makes remaining competitive with products grown using lift-and-pump irrigation difficult for farmers, especially if they pay the full price for electricity. However, abandoning pumping stations, as proposed by a number of international institutions, could cause secondary desertification of lands located on upland terraces and exacerbate population migration issues. As such, the consequences of closing pumping stations would cost more than financing their maintenance[107].

The efficiency of irrigation systems in the republic currently varies within a range of 0.25 to 0.40, i.e. 60 to 75 per cent of the water taken from the source is lost[108]. As such, preference is now given to furrow irrigation as it is less expensive, although the irrigation rate varies from 12,000 to 17,000 m³/ha. Gravity irrigation systems in the country are, on the whole, more than 50 per cent worn out, for pumping stations, this figure is 65 per cent. Funding remains an issue as the collected water fee is only 60 per cent of the established tariff, with only one third of that 60 per cent paid in cash, the rest is covered in the form of agricultural and other products. At the current tariff (US $2 per 1,000 m³) and the average irrigation rate (14,600 m³/ha), the potential water supply fee is US $28.60 per ha. The introduction of innovative technologies (rain/drip, underground feeder systems) on all 741,200 ha of irrigated land would cost several billion US dollars, which, given the abundance of water in Tajikistan and the economic situation of farmers, is currently not viable. A preferred and more attainable option would be the introduction of new technologies on individual land holdings with stony soils where irrigation-water requirements exceed 20,000 m³/ha[109].

Pastures in Tajikistan occupy 2,77 million ha, or 76.7 per cent, of agricultural land *(see map «Forage lands»)*. In economic terms, livestock farming in Tajikistan is experiencing an even deeper crisis than cotton growing[110]. A slight increase in meat and milk production compared to 1991 has been achieved solely by the constant increase in the number of animals in households. As of 1 July 2017, it was estimated there were 2,3 million head of cattle in Tajikistan, with 93 per cent of these in households and 6.1 per cent in farms. This estimate is almost 1.7 times higher than the number of cattle in 1992 (1,4 million). Of the estimated 5,58 million sheep and goats in the republic in 2017, 96.2 per cent were being kept in households and only 3.2 per cent in farms[111]. By 2024, the number of cattle had increased from the 2017 figure by 344,000 to 2,7 million while small cattle (sheep and goats) increased by 1,1 million to now exceed 6,7 million in total[112]. To provide further context on the economic importance of livestock, approximately 25 per cent of urban families (outside of Dushanbe) also keep cattle[113].

This rapid growth in livestock numbers is taking place in the context of a continuous narrowing of the forage base as the sowing of forage crops, which were mandatory in Soviet times, has decreased to a minimum. According to national statistics, pasture lands have also decreased by 15.6 per cent since 1991 - from 3.2 million to 2.78 million ha[114]. Among the reasons for the reduction of pasture lands, as highlighted by national experts, is the development of horticulture and viticulture in the foothills, low-mountain and mid-

106 Review of the Agri-Production Sector and Public Expenditures in Agriculture in Tajikistan. Europe and Central Asia Region (2021) The World Bank Group. Washington. 112 P. World Bank Document (in Russian)
107 Water sector.., 2006.
108 Guidelines for the development of integrated schemes for reducing water and electricity consumption in the design of new and modernization of existing pump irrigation systems in Tajikistan (2021) Dushanbe, publishing house of Khodji Hasan LLC. 34 P. (in Russian)
109 Ibid..
110 Umarov, 2019.
111 Ibid.
112 Number of cattle, sheep and goats in Tajikistan goes up.
113 National Gender..,2016.
114 Agriculture of the Republic of Tajikistan: Statistical Digest (2018) Dushanbe, Pp.18-21. (in Russian)



*Fahrobad Pass*



*View of the fields near the village of Vrang in the Vakhan valley*

mountain areas as well as the spontaneous ploughing of what were pasture land slopes for grain (mainly wheat)[115]. Pastures located in the immediate vicinity (within a radius of 2.5 km) of populated areas are also subject to excessive pressure. This is aggravated by the predominance of small livestock and the high cost of driving them to summer mountain pastures. Exceeding the load sustainably bearable by many pasture areas several fold, combined with unregulated grazing, has led to severe degradation of winter pasture lands while remote summer pastures may be underutilized.

Adding to the foregoing issues, the livestock sector makes a large and constantly growing contribution to anthropogenic greenhouse gas (GHG) emissions in the Republic of Tajikistan: some 6.7 million tons of the country's total emissions of 17.4 million tons. From 2004 to 2016, this contribution from the livestock sector increased from 25.6 per cent to 38.1 per cent due to the growth of livestock numbers and the resultant increase in animal waste produced[116].

*Box 3. Ranking of agricultural problems by Tajik farmers*

The GREAT project[117] presents the results of a survey of farmers who were clients of the Sorob consulting agency (Dushanbe). These farmers were asked to list the most important problems they faced and which, in their opinion, could be solved by a more effective agricultural advisory service *(see Table 9)*. The most frequently mentioned problem was pest control, probably a consequence of the cotton monoculture of the recent past. Lack of access to water is also cited as a significant problem, which needs to be addressed by improving irrigation efficiency. It is worth noting that salinity and soil erosion were concerns for only a small minority of farmers – 5 per cent and 1.9 per cent respectively. Low prices for their produce, the slow introduction of agricultural reforms and taxes were also of little concern to most respondents.

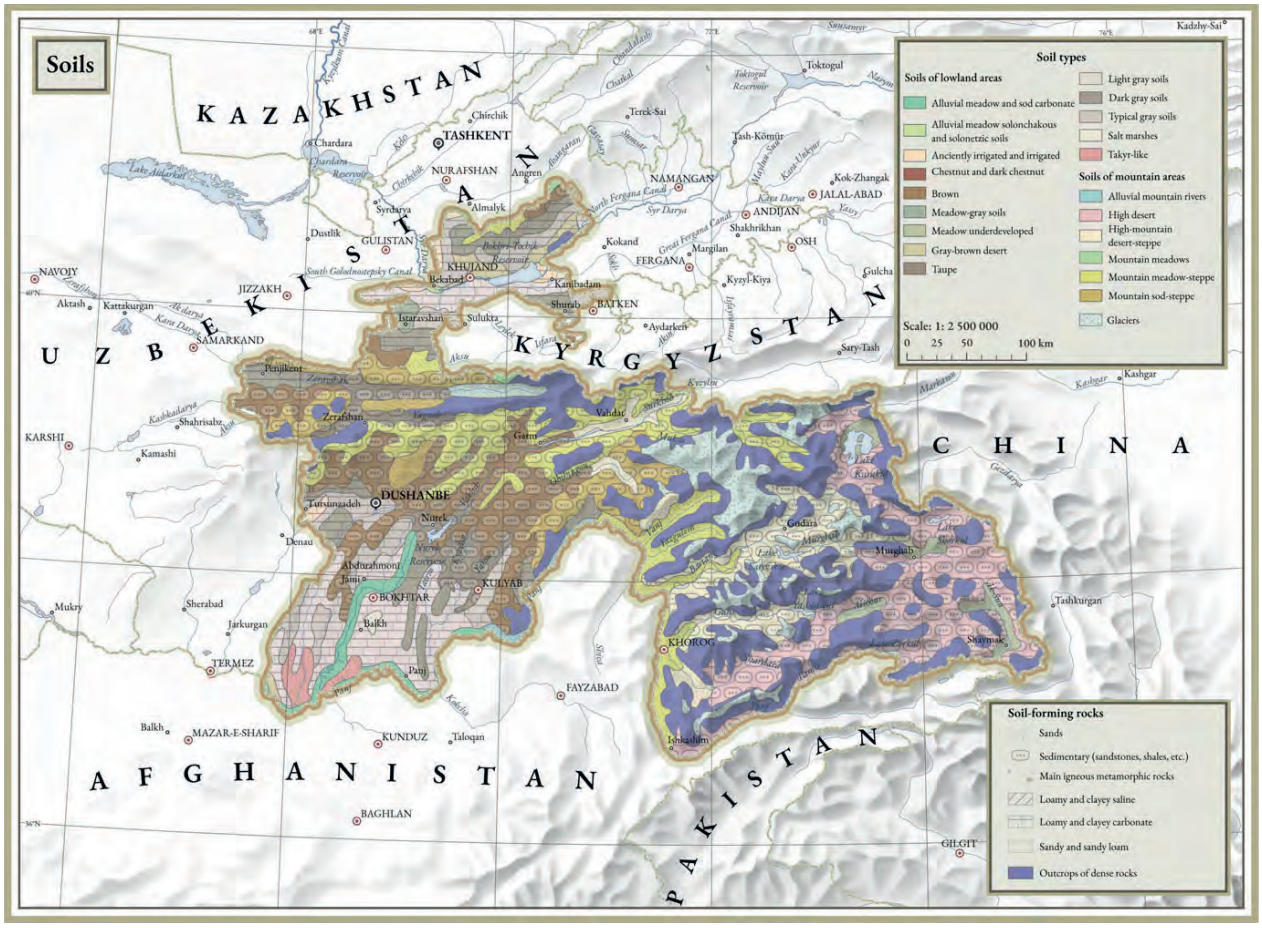
115 Umarov, 2019.

116 Projections of GHG emissions to 2030 in Tajikistan (2020) UNDP Tajikistan. Dushanbe. undp_tjk_Report_GHG_Projections_Tajikistan_2030.pdf.

117 Growth in Rural Economy and Agriculture in Tajikistan (GREAT) (2017) UK Department for International Development. April 2017. 380 P.

*Table 9.The most pressing issues in agriculture in the Sughd region*

| Problems | Number reporting | Percentage reporting |
|---|---|---|
| Pest attacks and pest control | 104 | 65.0 |
| Lack of access to water | 45 | 28.1 |
| Access to agrochemicals, particularly fertilizers | 39 | 24.4 |
| Access to machinery, particularly modern machinery | 37 | 23.1 |
| Access to quality seeds | 31 | 19.4 |
| Expensive inputs | 23 | 14.4 |
| Low yields/poor quality output | 22 | 13.8 |
| General lack of knowledge | 19 | 11.9 |
| Lack of capital and lack of access to finance | 18 | 11.3 |
| Soil salinity | 8 | 5.0 |
| Tree pruning | 6 | 3.8 |
| Soil erosion | 3 | 1.9 |
| Low product prices | 1 | 0.6 |
| Agrarian reforms process | 1 | 0.6 |
| Tax | 1 | 0.6 |
| TOTAL | 358 | 224 |

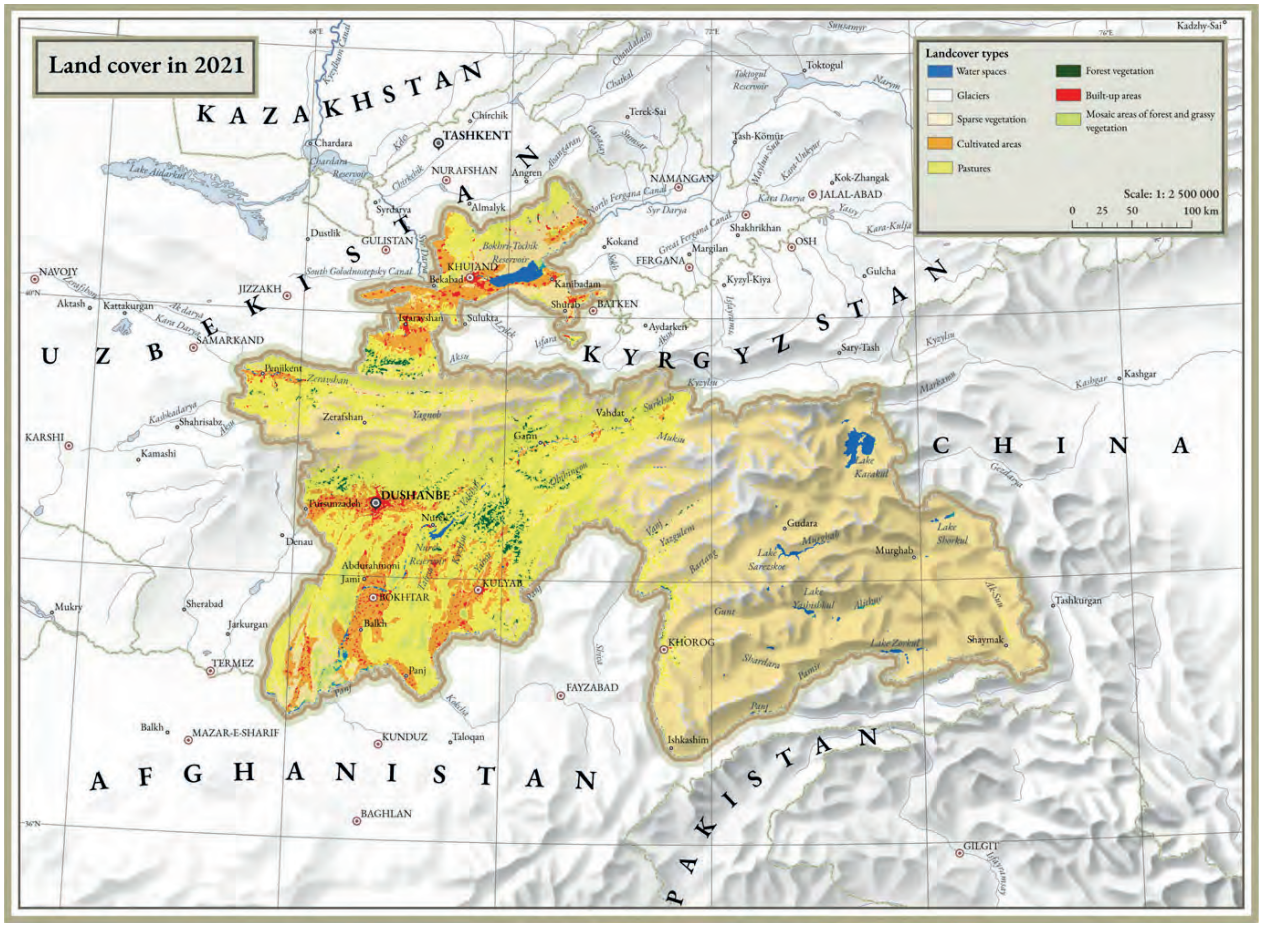



Geographical Atlas of Tajikistan - Dushanbe; National Agency for Space, Geodesy and Cartography, 2004. - 32 p. [Geographical Atlas of Tajikistan. - Dushanbe: Geographical Surveying, Geodesy and Cartography Agency, 2004. - 32 p.]

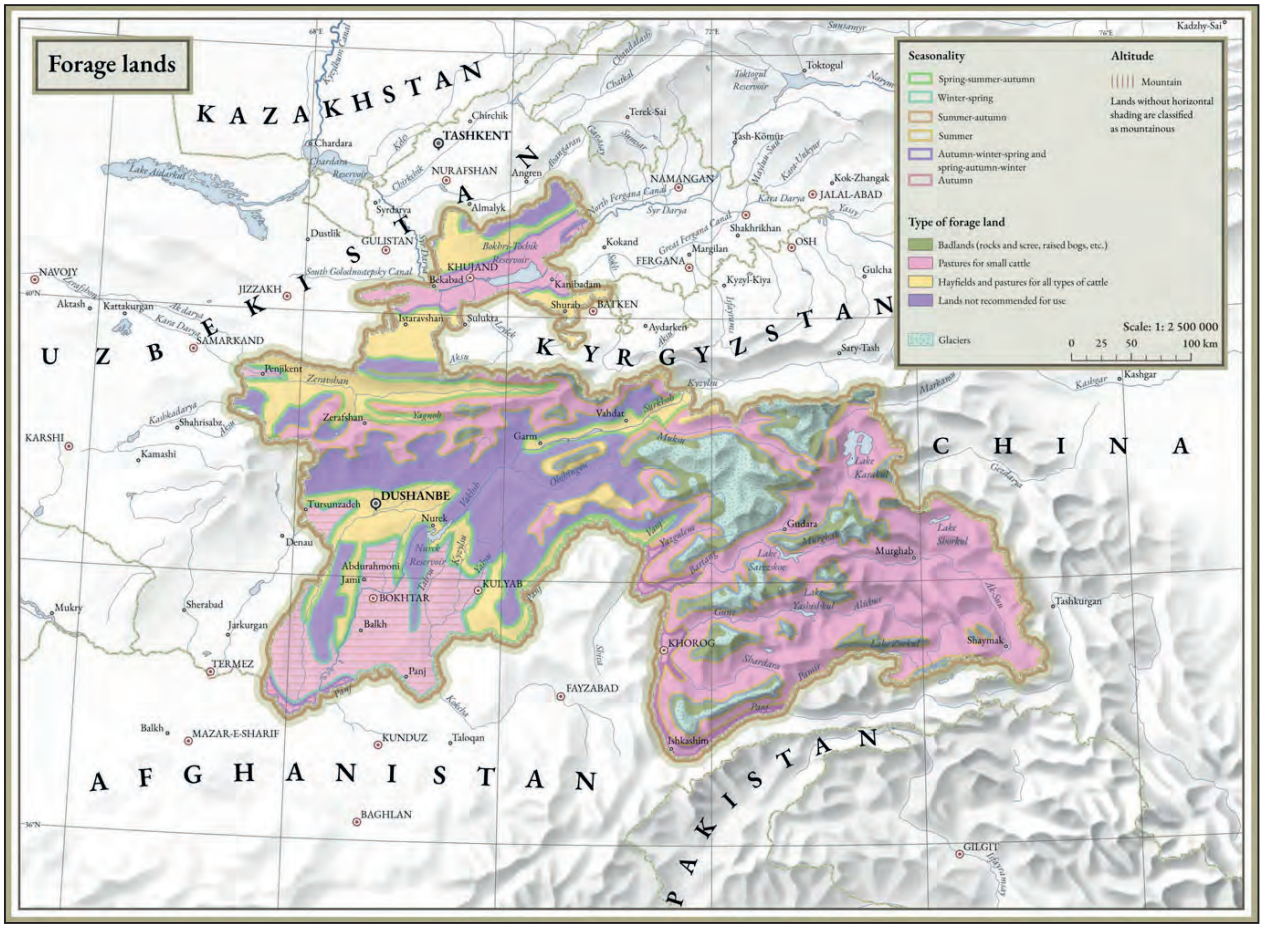



Based on Global 2010 Bare Ground data[118] obtained using Landsat 7 satellite images and regression tree models. Spatial resolution is 30 m, temporal coverage is 2010.

118 Hansen et al. (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change: Science. 342. 6160. Pp. 850-853.




According to ESA WorldCover 2021 data obtained from the results of the automatic classification of Sentinel 1 and 2 satellite images, spatial resolution is 10 m.




Natural forage lands of the Russian Federation and adjacent countries maps: For higher education institutions/Compiled and prepared for print by the Omsk Cartographic Faculty in 1994; scientific and method. manual of the Research Lab. of the Integrated Cartographic Faculty of Moscow State University; authors L. V. Shvergunova et al.; Senior editor T. V. Kotova. — Corrected in 2001 — Moscow: Roskartografiya, 2001. — 1 book (4 sheets): colour: 86x116 cm. (in Russian)

**4.3. Progress towards the SDGs**

Tajikistan recognizes the urgency of the problem of land degradation in its environmental policy. The republic officially acceded to the UNCCD on 12 August 1997, which was ratified by Decree of the President of Tajikistan No. 1140 on 8 December 1998. In 2001, the National Action Programme to Combat Desertification in Connection with Environmental Deterioration and Unsustainable Land Use was adopted. To implement the Convention, the Government adopted the Programme for Economic Transformation of the Agro-Industrial Complex and the Programme for Environmental Education of the Population for the Period up to 2010. Furthermore, laws on environmental protection and the land code oblige users of natural resources to ensure the conservation and rational use of land.

Tajikistan is an active participant in international projects on the rational use of land resources in Central Asia. In Central Asia, within the framework of the UNCCD, a permanent interregional group of parties to the convention was established to facilitate cooperation in the implementation of the goals and objectives of the UNCCD's Strategic Framework for 2018–2030. In 2018, another pilot project was launched in Central Asia entitled 'Regional relationships on dust and drought management'. It consists of a regional strategy for drought risk management and the mapping of vulnerable areas within Central Asia, combined with a strategy for preventing sandstorms. Back in 2003, Central Asian countries agreed on and adopted the 'Subregional action programme' in the context of the UNCCD that subsequently served as a platform to launch these countries' initiative on land management (CACILM). Another example of regional cooperation is the analytical project entitlted the Economics of Land Degradation in Central Asian countries (2014–2016), which is aimed at improving stakeholders' understanding of the economic value of productive lands based on market and ecosystem approaches. The project was implemented under the auspices of the UNCCD with the participation of the GIZ, the governments of the region and the Regional Environmental Centre for Central Asia.

The relevance of the issue of land degradation in Tajikistan is associated with the strong dependence of the population on the agricultural sector. The distribution of poverty in Tajikistan is uneven: according to the latest national statistics, based on a new, original approach, the proportion of the poor population in rural areas reaches 24%, compared to 8% in urban areas[119]. The level of poverty also varies significantly depending on the region in question, with the GBAO and Khatlon regions having the highest levels of rural poverty.

Sustainable Development Goal 15 aims to protect, restore and promote the sustainable use of terrestrial ecosystems, including the sustainable management of forests, combating desertification as well as halting existing and preventing further land degradation and biodiversity loss. The goal of achieving land degradation neutrality by 2030 is included in SDG15.3, the main indicator of which (15.3.1) is the share of degraded areas (irrigated and non-irrigated) compared to the total land area. This complex indicator, in accordance with international practice, includes three sub-indicators: land cover and land use change, land productivity/net primary productivity and carbon stocks in above-ground and soil horizons. In accordance with the 'one-out-all-out' principle, an area is defined as degraded if at least one of the sub-indicators shows a clear negative trend. However, the availability of relevant data for Tajikistan to judge trends in relation to these sub-indicators is clearly insufficient.

While the republic's land use has undergone significant transformation over time, the available data are insufficient to provide even a basic assessment of the direction of the dynamics of arable land, irrigated areas and pastures. The greatest changes in land cover and land use occurred in the 1990s, during the civil war that followed the collapse of the socialist collective and State farm system. At the time, the main problem that authorities and the population in the country's regions were addressing was ensuring food security and, as a result, the areas under grain (wheat, barley, corn) and legumes, oilseeds, potatoes, vegetables and melons increased. The areas under forage crops, including grain (oats) and root crops (sugar beet), were reduced to minimums while production of the main market crop, cotton, declined significantly during this period of political turbulence. This course of abandoning a market orientation in favour of subsistence farming proved to be inertial in the following decades[120].

As previously noted, women now make up a significant proportion of the agricultural labour force as a result of the significant labour migration of economically active men. The overlap of these two trends – the naturalization and 'feminization' of agriculture – has resulted in women's greater dependence on land resources[121].

119 Tajikistan. Poverty and Equity Assessment at Home (2025) The World Bank Group. Washington DC. 156 p. World Bank Document

120 Umarov, 2019.

121 Mukhamedova N, Wegerich K (2018) The feminization of agriculture in post-Soviet Tajikistan, Journal of Rural Studies, ISSN 0743-0167, Elsevier, Amsterdam [u.a.], Vol. 57. Pp. 128-139. http://www.sciencedirect.com/science/article/pii/S0743016717301766.



*An image from the ISS*

However, women still face systemic barriers to accessing land, agricultural credit, extension services and participation in WUAs. These constraints reduce their productivity and resilience to climate and economic shocks. Addressing these gender imbalances through targeted policy reforms, capacity building and inclusive governance mechanisms is critical to improving rural livelihoods, food security and sustainable land management[122]. As such, gender-sensitive land restoration programmes need to ensure women's access to restored land and participation in planning processes.

The Agency for Land Reclamation and Irrigation cites data that, as of 1 January 2018, showed 757,800 ha in Tajikistan were irrigated, of which 289,100 ha was irrigated by pumping stations that, according to other sources, slightly exceeds what was the country's total irrigated area in 1990 (710,000 ha)[123]. It is more likely that the totals of arable land and irrigated areas are stable or only slightly increasing due to demographic pressure *(see maps 'Land cover in 2000' and 'Land cover in 2010')*. The land cover map in 2021 shows there have been changes, however, this is based on higher spatial resolution data (10 m instead of 300 m for the period 2000–2010) and was processed using a different methodology *(see Section 4.2, map 'Land cover in 2021')*. As such, the visible changes are due to these underlying differences rather than land use dynamics.

In the context of the republic's rapid population growth in the 1990s (about 2.0 per cent annually), uncontrolled development of new lands took place. Since 1992, in the years of the economic crisis, the population has been intensively developing lands in foothill areas that were previously used as pastures[124]. In 1994–1997, steep slopes (up to 35 degrees) began to be ploughed for growing grain crops and modern field studies indicate that the practice of expanding the areas of subsidiary farms to produce vegetables and other food crops at the expense of pastures that are formally under State management persists[125]. Such unauthorized expansion of pastures and other cultivated lands was, in many cases, accompanied by the construction of rudimentary irrigation canals by rural communities (jamoats).

The exact scale and extent of physical land degradation in Tajikistan are unknown. Despite numerous reports of widespread land degradation, there are, for example, no statistics on agricultural lands abandoned due to soil exhaustion. Intensive land use inevitably causes severe erosion and humus loss that, in turn, leads to a drop in crop yields and increased desertification. It is officially recognized within the republic that 88.7 per cent of agricultural land, mainly pasture lands, suffer from high and medium levels of erosion. However, no government agency in Tajikistan regularly collects data on soil quality and/or the extent of land degradation[126].

As for arable land, the overall estimate of the extent of salinization varies in different reports, ranging from 8 per cent to 15 per cent of the total area (up to 741,200 ha). According to the hydromelioration expedition of the Agency for Land Reclamation and Irrigation under the Government of the Republic of Tajikistan, the total area of saline soils on irrigated lands amounted to over 62,200 ha or 8.3 per cent in 2022. Of these, only 3,222 ha, or 5 per cent, are classified as highly saline, with 12,454 ha (20 per cent) classed as moderately saline and 46,475 ha (75 per cent) as slightly saline, which is generally consistent with the very moderate estimates provided by the global database *(see map 'Soil Salinity')*. In the 1960s and 1970s, an advanced drainage and collector network (including vertical drainage wells) was built on irrigated lands, which ensured water discharge and prevented groundwater rise on terraces and alluvial fans of different levels. Despite the technical degradation of this network in the last 20 to 30 years, the extent of salinization remains largely unchanged due to the practice of annual washing of highly and moderately saline soils. On an area of 21,281 ha (2.9 per cent) in the republic there are irrigated lands with a critical depth of groundwater level (less than 1 m)[127]. Tajik farmers rate soil salinization as a moderate threat *(see Box 4)*.

The results of remote sensing show the prevalence of weakly expressed but positive trend toward salinization in all regions of the country except the high-mountain plateaus of the Pamirs, where no trend exists. In remote sensing studies, it is customary to use the NDVI and EVI vegetation indices as an indicator of land productivity, where a positive trend means an improvement in the condition of the land and a negative trend reveals its deterioration *(see maps 'Dynamics of Normalized Difference Vegetation Index' and 'Dynamics of Enhanced Vegetation Index')*. These and other vegetation indices give similar results in the case of Tajikistan *(see maps 'Dynamics of the Leaf Area Index' and 'Land Productivity Dynamics')*. Greening (an increase in green biomass) was observed in most land cover classes between 2000 and 2020, with greater pronounced effects in forest, shrubland and agricultural ecosystems *(see Table 10)*. High-mountain classes (mosses and lichens, unsodden surfaces, glaciers and snowfields) in the republic are generally characterized by the absence of any pronounced trends, however, where trends do exist, the positives prevail over the negatives. These trends are most likely temperature driven since it is not precipitation, which is limited in high-mountain areas, but low temperatures that are the main limiting factor for the development of vegetation in places like the Pamirs[128]. In the highest-mountain classes of land cover – glacial-nival landscapes (class 'glaciers and snowfields') – an increase in temperature is causing what was the permafrost to melt and is probably the cause of the noticeable positive trend, especially on moraines covered with cryophyte and subnival vegetation[129].

Similar results were obtained in a comprehensive study of vegetation dynamics for the period between 1984 and 2020, in the interfluve of the Pyanj and Gunt rivers within the Pamirs[130]. Using the Modified Soil Adjusted Vegetation Index, which is believed to be better suited for areas with sparse vegetation, it was determined that 62.3 per cent of the study area has no pronounced trend, 36.1 per cent (385.9 km²) was characterized by positive dynamics of green biomass and only 1.6 per cent showed a negative trend. This ratio of areas with different trends is observed for all land cover classes, slightly worse for mountain steppes (about 30 per cent with a positive trend) and noticeably better for cultivated lands and juniper forests, where 55 to 60 per cent showed a positive trend. Areas with a negative trend were mainly localized in the valley bottoms dominated by tugai forests. The results are discussed by authors of the study in the general context of climate change. However,

122 Ibid.
123 Land irrigation Agency for Land Reclamation and Irrigation under the Government of the Republic of Tajikistan.
124 Umarov, 2019.
125 Rahmonov et al. (2024) Environmental and land-use changes as a consequence of land reform in the Urej river catchment (Western Tajikistan). Resources. 13,59. https://doi.org/10.3390/resources13040059.
126 UNECE, 2017.
127 Khodjaev et al. (2024) Features of manifestation of salinization in Tajikistan. Reports of TASKhN. No. 2. Pp. 22-25 *Microsoft Word - Доклады ТАСХН № 2-2024 в_1.docx. (in Russian).
128 Vanselow et al. (2011) Time Series Analysis of Land Cover Change in Dry Mountains: Insights from the Tajik Pamirs. Remote Sens. 13. 3951. https://doi.org/10.3390/rs13193951.
129 Ibid.
130 Vanselow et al., 2021.

*Table 10.Evaluation of land cover classes using remote sensing methods (EVI)*

| Land cover classes[131] | Share of area of classes (per cent) | | | | |
|---|---|---|---|---|---|
| | No trend | Strong negative trend | Slight negative trend | Slight positive trend | Strong positive trend |
| Forests | 4.6 | 1.1 | 18.8 | 59.7 | 15.8 |
| Shrublands | 4.1 | 2.1 | 13.7 | 57.2 | 23.0 |
| Grasslands | 8.1 | 1.5 | 27.4 | 55.8 | 7.2 |
| Croplands | 4.9 | 3.3 | 22.8 | 46.0 | 23.1 |
| Swamps | 24.1 | 3.1 | 16.8 | 39.4 | 16.7 |
| Built-up areas | 22.4 | 6.4 | 18.7 | 34.4 | 18.1 |
| Mosses and lichens | 67.6 | 0.5 | 7.6 | 22.4 | 1.9 |
| Water bodies | 72.1 | 2.4 | 7.3 | 12.9 | 5.3 |
| Sparse vegetation/ bare soils | 79.4 | 0.4 | 5.8 | 12.5 | 2.0 |
| Glaciers and snowfields | 98.5 | 0.0 | 0.5 | 0.9 | 0.1 |

131 Zanaga, et al. (2022) ESA WorldCover 10 m 2021 v200.

it has been noted that these positive trends on cultivated lands were an unexpected result in light of numerous publications highlighting their degradation. An even more unexpected result was the predominance of positive trends in steppe and meadow ecosystems which serve as pasture lands, the grazing pressure on which has increased many times since the early 2000s.

The Pasture Development Programme in the Republic of Tajikistan for 2023 to 2027 recognizes the state of pasture lands as extremely unsatisfactory and threatening the country's food security. In addition to excessive livestock numbers in households and weak control thereof by local authorities, the reasons for this unsatisfactory state include infrastructure problems, such as the lack of roads, cattle bridges, water shortages and cattle pens. For more organized management of pasture lands, it is proposed to create pasture use regulation commissions and pasture user associations at the jamoat level[132].

The most problematic pastures in ecological terms are those in the winter and year-round categories. Winter pastures are located at altitudes between 500 and 1200 m and are used for 120 to 150 days a year, which leads to their high degradation and reduced productivity. According to estimates, the density of grazing cattle on these pastures exceeds the norm by 4.3 times. Year-round pastures surrounding populated areas or located within two to three days' travel from them are degraded by 85 to 90 per cent of their area, turning into fallow lands with depleted vegetation and extremely low yields, namely no more than 0.1 tons of dry edible mass per ha. The loads on these pastures are being exceeded by 10.5 times. Spring-autumn pastures (18.8 per cent of the country's pastures) are located along low mountain ranges and used for 100 to 130 days per year in the spring and autumn months and have a higher average yield of 0.4 to 0.7 tons of dry edible mass per ha. These pastures are grass communities combined with shrub and woody vegetation - for example, pistachio forests. The loads on them are 3.1 times higher than recommended. Summer pastures, which make up 52.7 per cent of the total pasture area and are located at altitudes of 2200 to 3500 m, are characterized by a high diversity and yield 0.7 to 1.3 tons of dry edible mass per ha. Summer pastures are considered underutilized, however, according to experts, these pastures appear to be deeply degraded[133]. The Pamir pastures, which are used only by locals due to their remoteness, are also under increased pressure due to the growth of livestock (cattle) numbers from 42,000 in the late 1980s, a figure which dropped to 19,000 during the crisis of the 1990s, before rebounding to now be more than 105,000[134].

Unfortunately, remote sensing results require ground verification, which is difficult to carry out in many parts of Tajikistan. According to EVI, a strong negative trend can be observed on 3.3 per cent of the area of cultivated land, which is consistent with official statistics showing the share of sown land with a poor melioration condition at 1 to 2 per cent (for example, the Sughd region)[135].

As for pastures, their 'greening' is not an indicator that their overall condition is trending positively. Degradation of pasture lands can also manifest as an increase in their biomass due to the gradual spread of plant species that are not edible for livestock. As such, degraded pastures are often populated by weeds, sub-shrub and shrub species which can have a longer growing season than fodder vegetation and their gradual expansion can be the reason for the prevalence of a positive trend in the dynamics of green biomass in all types of pastures, including the most degraded winter pastures. Field studies show that this form of degradation is typical for large pasture areas, as is the case, for example, in the mountain steppe and subalpine meadow steppe in the Western Tien Shan[136]. In the Pamirs, as a result of overgrazing, the spread of thorn-grass associations on degraded steppes was noted as far back as in Soviet times. Since then, the area of pastures under thorn-grass associations has increased significantly[137], while data from field observations indicate weedy groundsel (Senecio spp.) is spreading on grazed high-mountain pastures[138].

An important third component of land resource assessment is the dynamics of carbon content in the above-ground and soil horizons. However, changes in soil carbon content (SOC) occur very slowly, so an accurate series of observations requires several decades. According to Tajikistan's commitments to the UNFCCC, an increase in GHG inputs from soils will be prevented by the introduction of soil-protective agricultural practices. However, uncontrolled land use has resulted in the total carbon stock in intensively used soils significantly decreasing compared to natural soils. This process is particularly salient in valley and foothill soils under agricultural monocultures in the absence of crop rotation. Therefore, establishing an SOC monitoring system in Tajikistan is of great importance for assessing land use changes caused mainly by socio-economic factors.

The total carbon content of soils in Tajikistan (in the upper 30-cm soil layer and at a density of 1250 kg/m³) is estimated at 708.9 million tons, with the above-ground biomass having another 11.3 million tons and the below-ground biomass having 19.9 million tons[139]. The predominance of below-ground biomass over above-ground biomass is typical of arid territories. The average SOC content in soils of Tajikistan is only 49.5 t/ha, or in relative units, 1.3 per cent, which is significantly lower than the 2 per cent threshold SOC concentration often recommended for assessing the state of soils in terms of their productivity and potential for sequestration of atmospheric carbon *(see map 'Organic carbon in soils')*. By way of comparison, the average SOC content in soils of Tajikistan's mountainous neighbour, the Kyrgyz Republic, this figure is 1.9 per cent.

Low average carbon content in Tajik soils is due to natural factors as about 45 per cent of the country's area is in the Pamirs, where the average altitude is 4,200 m and the landscape is cold high-mountain desert with annual precipitation of no more than 130 mm and covered with snow almost all year round. In the soils of these periglacial and hyperarid landscapes, the content of organic carbon is the lowest value in the world, only 14 t/ha in a 50-cm layer, or 0.2 per cent[140]. Outside the Pamirs, Tajikistan's set of soils and their geographical confinement to high-altitude zones differ little from the neighbouring Kyrgyz Republic. The irrigated sierozem soils of the dry steppes on the plains, as well as rainfed lands in the foothills (adyrs) have an organic carbon content of no more than 0.45 per cent. More fertile brown forest, brown and dark-coloured soils of the republic's mid-mountains are distinguished by a relatively high SOC

132 On the Pasture Development Program in the Republic of Tajikistan for 2023–2027. taj221505.pdf.
133 Umarov, 2019.
134 Vanselow et al., 2011.
135 Gaforzoda et al. (2022) Socio-economic assessment, state of irrigated agriculture and operation of pumping stations in Sughd province and Zafarobod district of Tajikistan. CARES. Dushanbe. 130 P. Socio-economic-assessment-state-of-irrigated-agriculture-and-operation-of-pumping-stations-in-Sughd-province-and-Zafarobod-district-of-Tajikistan.pdf.
136 Zhumanova et al. (2018) Assessment of vegetation degradation in mountainous pastures of the Western Tien-Shan, Kyrgyzstan, using eMODIS NDVI. Ecological Indicators. Volume 95. Part 1. Pp. 527–543.
137 Umarov, 2019.
138 Vanselow et al., 2021.
139 Aichi Biodiversity Target 11 Country Dossier: TAJIKISTAN (2021) Aichi Biodiversity Target 11 Country Dossier: TAJIKISTAN (cbd.int).
140 Mętrak et al. (2024) Nutrient accumulation by biologically active soil cover in a dry, high-altitude glacier foreland in the NE Pamir (Tajikistan) in the context of ongoing climate changes, EGU General Assembly 2024, Vienna, Austria, 14 to 19 April 2024, EGU24-7292, https://doi.org/10.5194/egusphere-egu24-7292.

*Table 11. Maize yield and production cost indicators using conventional (CT) and conservation tillage (NT)*

| Farmer | Plot Size (ha) | Yield | | | Total Production Expenses | | | Gross Profit | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | MT/ha | | Difference (per cent) | USD | | Difference (per cent) | TJS/ha | | Difference (per cent) |
| | | CT | NT | | CT | NT | | CT | NT | |
| 1 | 2.5 | 7 | 12 | 71.4 | 11242 | 7783 | -30.8 | 2503 | 8567 | 242.2 |
| 2 | 1.5 | 20 | 27 | 35.0 | 3795 | 3564 | -6.1 | 17470 | 24624 | 41.0 |
| 3 | 0.9 | 13 | 14 | 7.7 | 5640 | 5544 | -1.7 | 6733 | 9240 | 37.2 |
| 4 | 3.0 | 25 | 25 | 0.0 | 6923 | 6402 | -7.5 | 22692 | 22867 | 0.8 |
| 5 | 0.1 | 11 | 12 | 9.1 | 518 | 443 | -14.3 | 6925 | 9967 | 43.9 |
| 6 | 0.2 | 12 | 13 | 8.3 | 577 | 587 | 1.8 | 9115 | 10063 | 10.4 |
| Mean | 1.4 | 14.7 | 17.2 | 17.0 | 4783 | 4054 | -15.2 | 11106 | 14221 | 28.0 |



*An image from the ISS*

content, although this is highly dependent on the level of erosion present. On uneroded soils, the carbon content can be as high as 2.02 to 2.61 per cent, on slightly eroded soils, 1.7 to 2.1 per cent and on moderately eroded soils, 1.4 to 1.7 per cent[141].

The contribution of agricultural soils (740,000 ha of irrigated and 320,000 ha of rainfed land) to the total GHG emissions in the country is estimated at five million tons, some 34 per cent of total emissions at an average of five tons per ha. Addressing the issue of SOC content in Tajikistan's arable lands is possible by changing farming techniques in favour of no-till ploughing, abandoning summer fallows, growing cover forage crops and using mulching. These innovations can significantly reduce the loss of soil carbon and even lead to an increase in its content, thereby ensuring a positive carbon balance in the soil-atmosphere system. According to estimates, such soil-conservation agriculture can lead to an increase in the carbon content in soils by 0.1 to 0.2 t/ha per year[142].

Pasture lands, which occupy 2.78 million ha are, in contrast, accumulators of organic carbon due to the influx of livestock waste and the significant presence of underground parts of plants. Models show that less than 2 t/ha of carbon enters the soils of Tajikistan's pastures annually in the Pamirs, up to 3 t/ha of carbon in the western regions and 3.5 t/ha in the Zeravshan Valley[143]. However, this does not exclude a decrease in pasture productivity due to overgrazing, meaning the accumulation of carbon in pastures can compensate for GHG emissions from arable lands.

Sustainable Development Goal 2.4 was proposed to "ensure resilient food production systems and implement sustainable agricultural practices that increase productivity and production, help maintain ecosystems, strengthen resilience to climate change, extreme weather events, drought, floods and other disasters, and progressively improve land and soil quality by 2030". Indicator 2.4.1 for Tajikistan is identical to the global ones, namely the "proportion of agricultural area under productive and sustainable agriculture". Two sub-indicators can also be used here: share of drip irrigation and share of organic agriculture.

To help meet its commitment to this SDG, the Government subsequently took a number of steps. The republic's 2008 Agrarian Policy Concept No. 658 aimed to restructure and expand the planning of agricultural activities. Agricultural zones were identified, each of which was assessed in terms of what was the most suitable land use (agriculture, horticulture, pastures)[144]. The Agricultural Sector Reform Programme for the period 2012 to 2020 envisaged the introduction of environmentally friendly technologies in agriculture and, finally, the Concept of Innovative Development of the Agro-Industrial Complex (2014) envisaged the greening of agriculture.

In Tajikistan, drip irrigation has not been developed due to its high cost, even when compared to pumping water with ageing infrastructure. Other sustainable agricultural practices, such as organic farming, are still limited to a few pilot projects, including in cotton farms, where they have returned good results in terms of crop yields and production costs *(see Box 4)*. However, these ecological approaches in agriculture have not yet become widely available to farmers due to the lack of technical (expert) and financial support from government agencies. However, according to the FAO, the cultivated area employing organic farming methods increased significantly from 0.2 to 1.8 per cent of arable land between 2020 and 2022[145].

*Box. 4. Conventional and Conservation Agriculture in the Sughd Region: clear evidence in favor of no-tilling.*

The GREAT project[146], undertaken by the UK Department for International Development in the period from 2013 to 2015, aimed to promote agricultural production and other rural economic activities, such as food processing and energy-efficient buildings. It was envisioned that these goals be pursued via the private sector, improved access to financial services and increased revenue from cross-border trade. Project advisors have collected data to compare the costs/benefits of conventional tillage (CT) and no-tilling (NT) via paired demonstration plots on the fields of six farmers. None of the farmers experienced a reduced harvest of maize, and for the one farmer who had no increase in yield, some extra profit was received due to the lower expenses of NT farming *(see Table 11)*.

**4.4. Responses**

- Rehabilitation of irrigation systems, including pumping stations.
- Further diversification of crops on irrigated lands with the introduction of crop rotations.
- Organization of a system to monitor SOC content.
- Organization of regular surveys to establish the degree of degradation of different categories of agricultural land, including pastures.

141 Raupova N.B., Abdullaev S.A. (2019) Composition and properties of humus in soils of vertical zonality of the Western Tien Shan and their washed-out differences // Scientific review. Biological sciences. No. 2. Pp. 63–68. (in Russian)

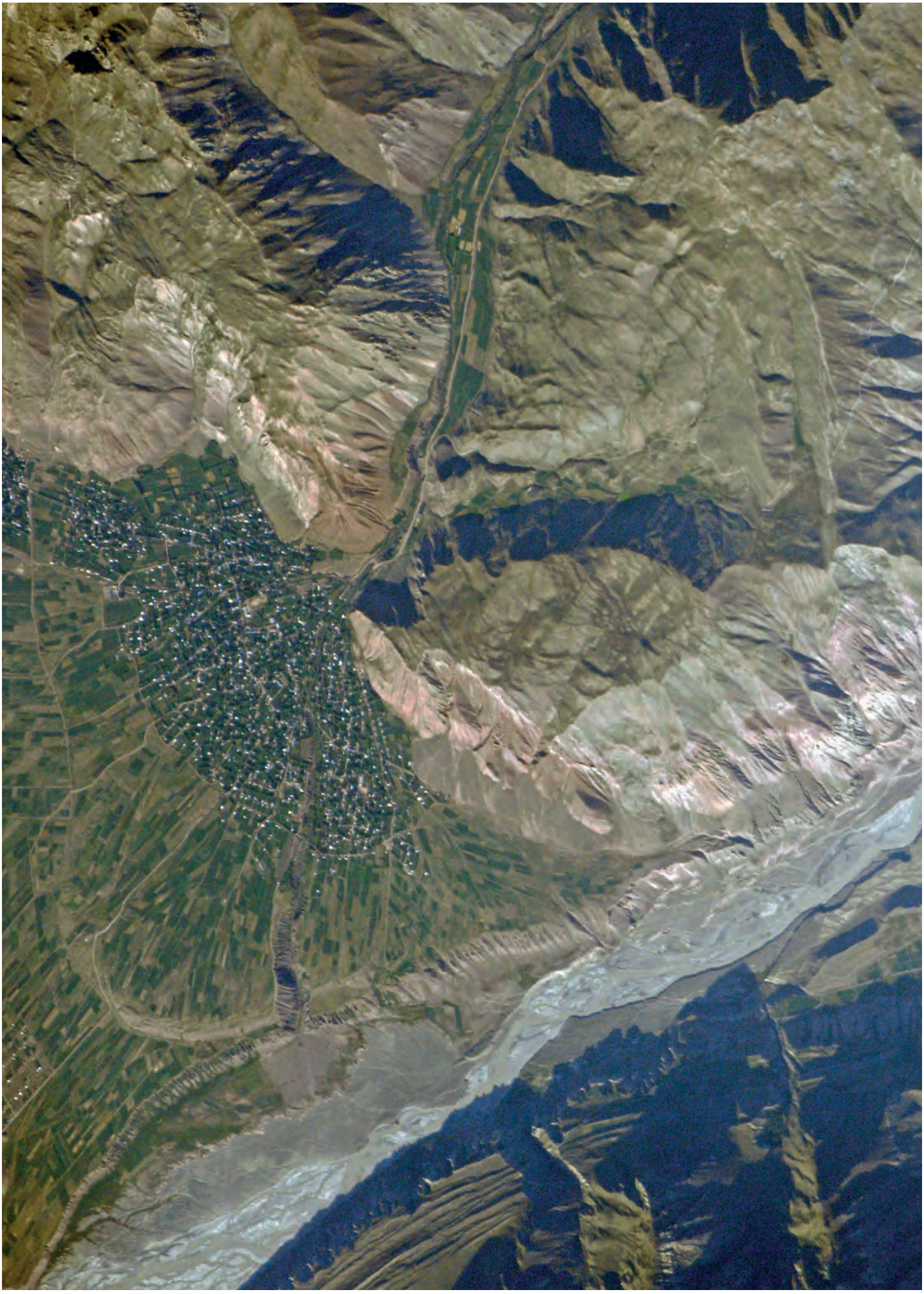
142 Lal R. (2004) Carbon sequestration in soils of central Asia. Land Degradation & Development. № 15. Pp. 563–572.

143 Loper et al.., 2021.

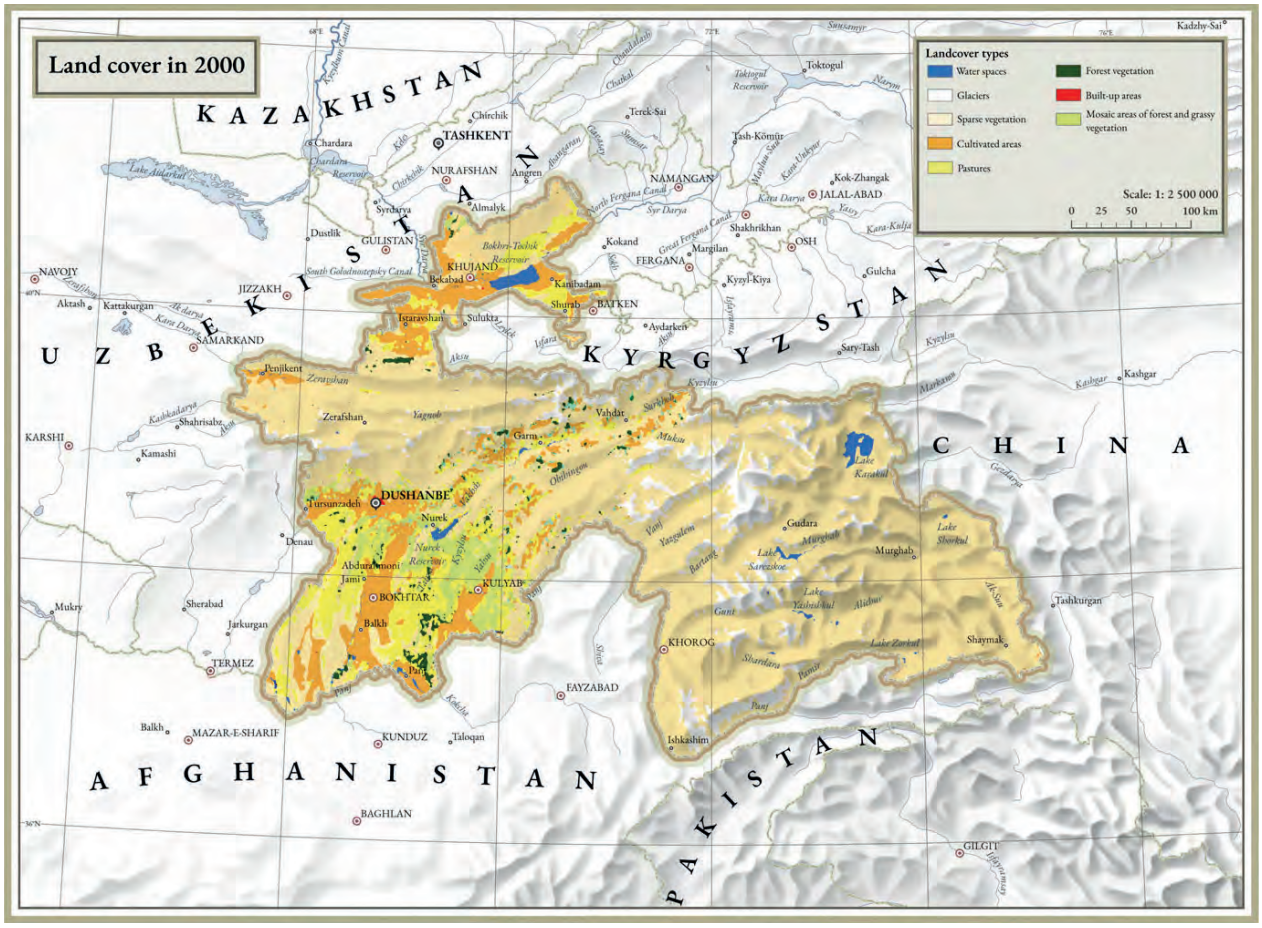
144 UNECE (2012) Second Environmental Performance Review of Tajikistan. Dushanbe. 209 P.

145 Tajikistan - Our World in Data.

146 Growth in Rural..., 2017.

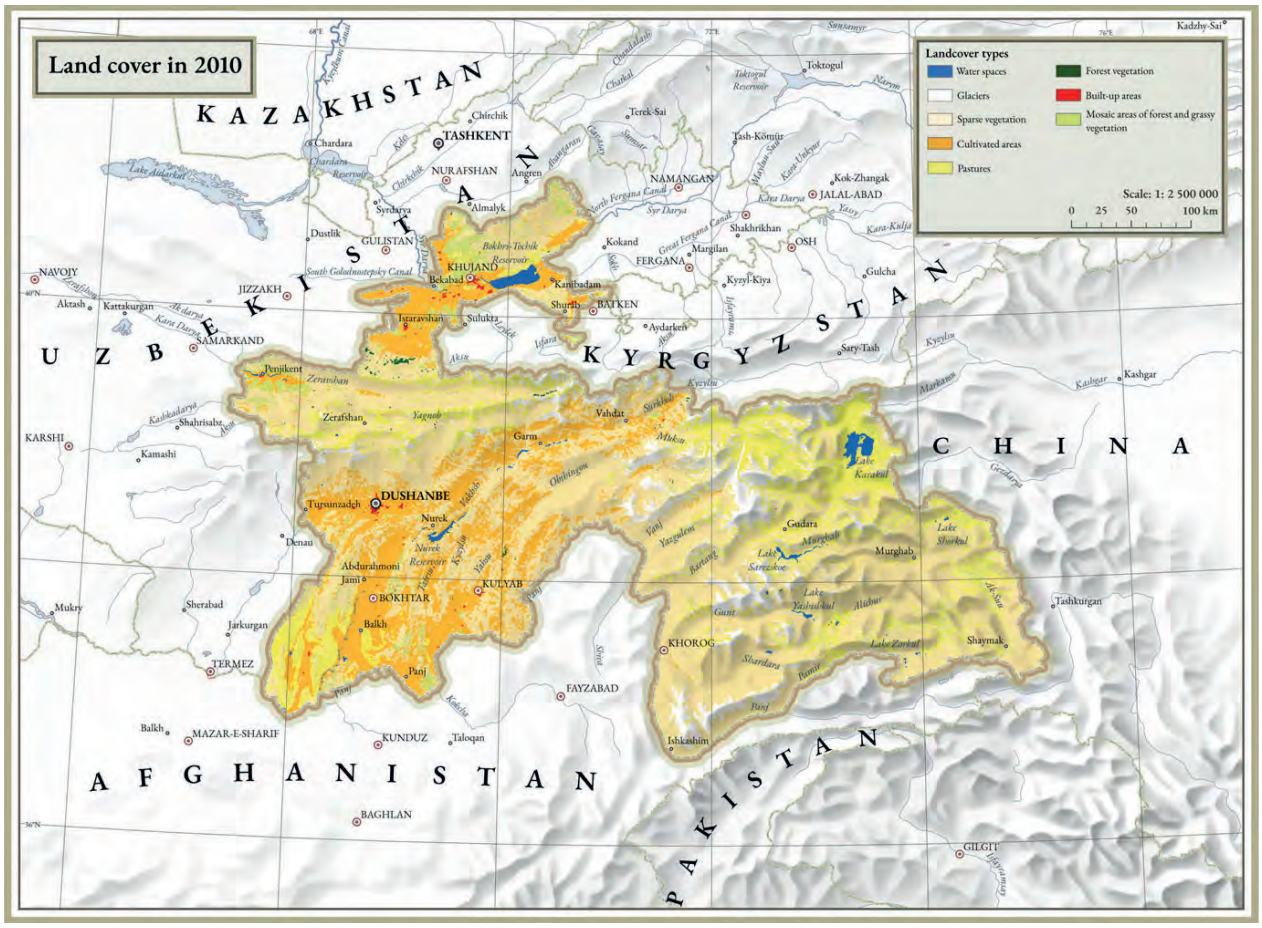


*An image from the ISS*




Based on ESA CCI (2000 to 2010) and ESA Worldcover (2021)[147] and Land Cover products. CCI Landcover was obtained by classifying ENVISAT and Proba-V satellite images. The spatial resolution is 300 m for the period from 2000 to 2010 and 10 m for 2021.

147 https://doi.org/10.5281/zenodo.5571936 per centC2 per centA0

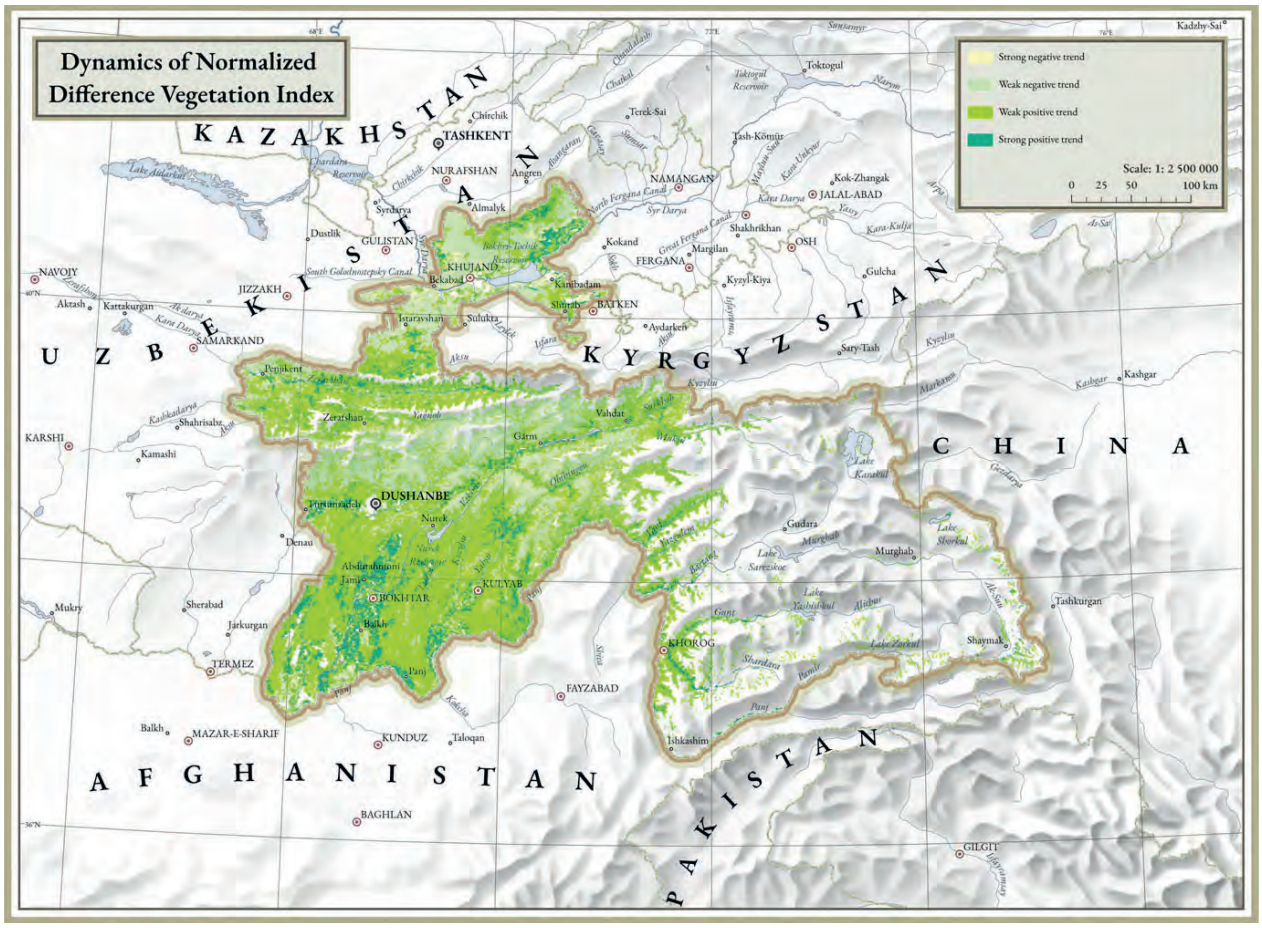



See note to the above map, 'Landcover 2000'.



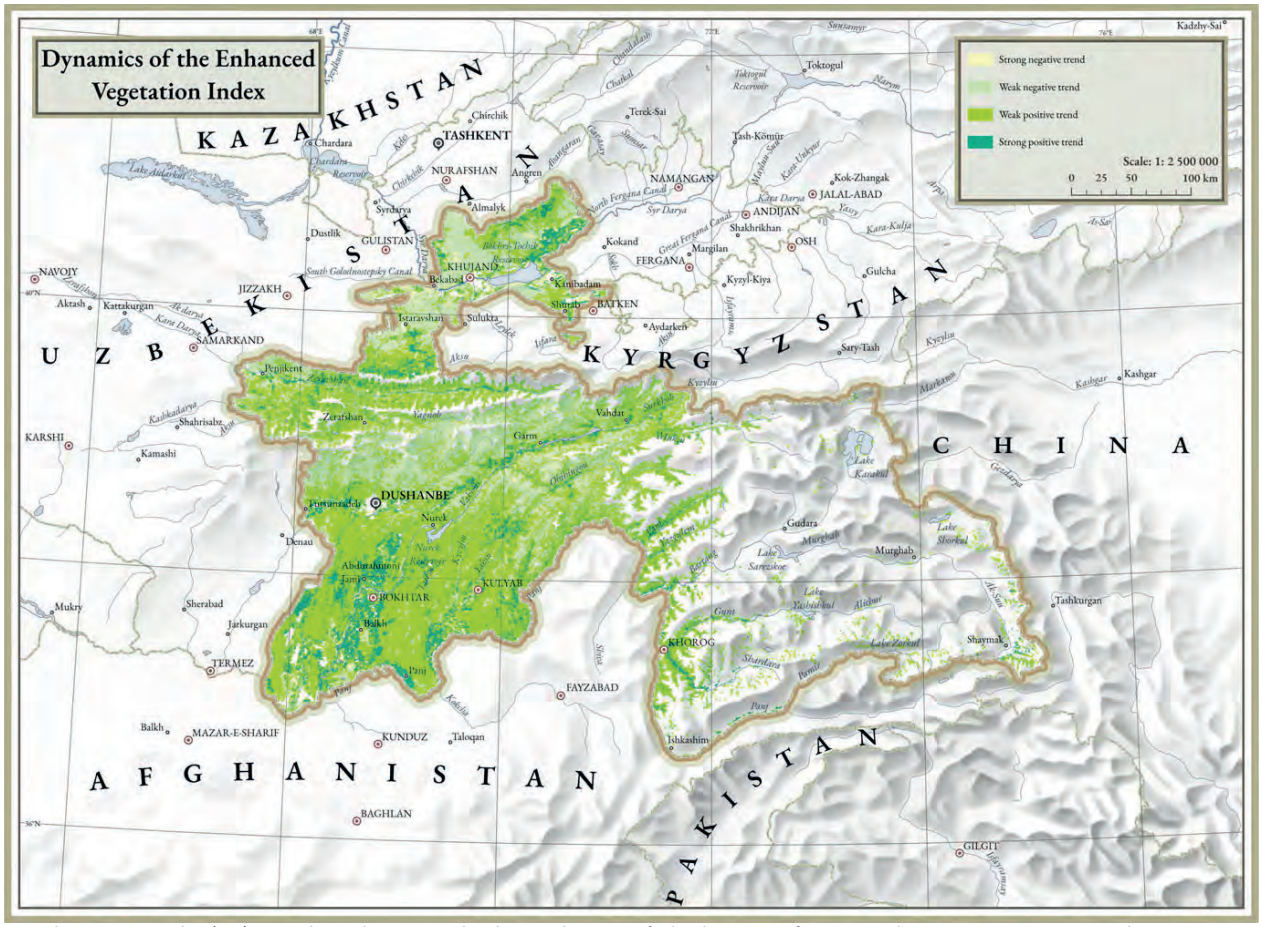

Based on the Global Soil Salinity Map[148], obtained using the 'Random Forest' algorithm that combines satellite data and field survey results which are then aggregated by the WoSIS database. Spatial resolution is 250 m, temporal coverage is 1986 to 2016. Published estimates show about 70 per cent accuracy. The degree of soil salinity is measured by its electrical conductivity (dS/m).

148 Ivushkin et al. (2019) Global mapping of soil salinity change. Remote sensing of environment, Vol. 231, 111260



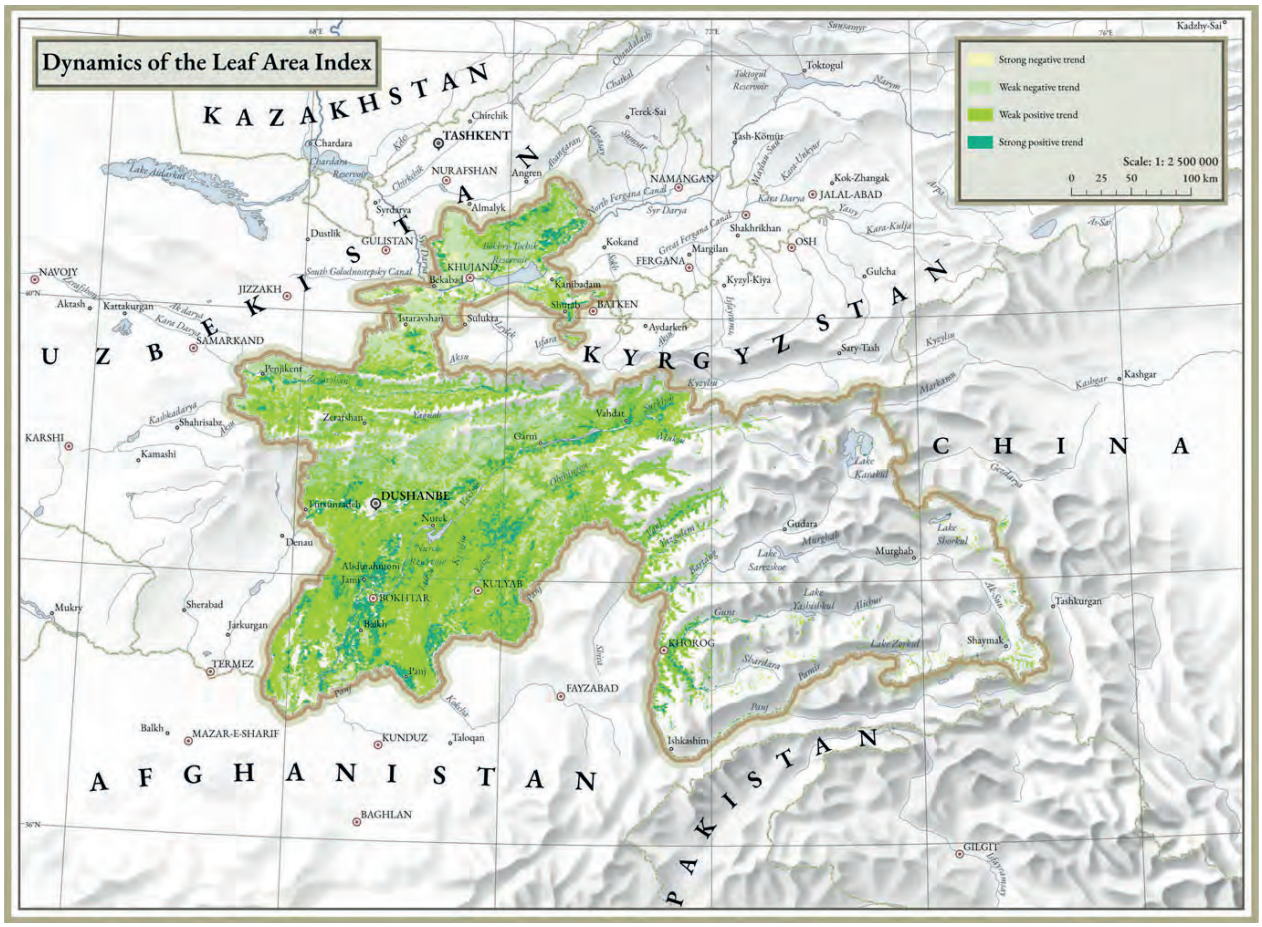

The change in the Normalized Difference Vegetation Index (NDVI) shows a trend in the amount of green biomass produced in a given location. According to the Global Land Productivity Dynamic Dataset[149], obtained by processing SPOT Vegetation and MODIS data, the dynamics of the NDVI index is given for the period from 1999 to 2013.

149 Cui Y., Li X. (2022) Global Land Productivity Dynamic Dataset Product. V1. Science Data Bank. https://doi.org/10.11922/sciencedb.j00076.00084.




The Enhanced Vegetation Index (EVI) is similar to the NDVI and is designed to quantify the dynamics of vegetation biomass over a given period. However, EVI corrects for some atmospheric conditions and canopy background noise and is more accurate in areas with dense vegetation. The above map was created according to the Global Land Productivity Dynamic Dataset[150] obtained by processing SPOT Vegetation and MODIS data. The dynamics of the NDVI index are given for the period from 1999 to 2013.

150 Cui ., Li, 2022.




Leaf Area Index (LAI) measures the projection of green leaf area per unit area of ground in a hardwood canopy, as well as half of the total surface area of needles per unit area of land in a softwood canopy[151]. The above map was created according to the Global Land Productivity Dynamic Dataset[152], obtained by processing SPOT Vegetation and MODIS data. The dynamics of the NDVI index are given for the period 1999–2013.

151 Copernicus Land Monitoring Service. land.copernicus.eu
152 Cui ., Li, 2022..




Land Productivity Dynamics (LPD) are estimated by integrating information on the dynamics of four biophysical indices: EVI, LAI, NDVI and NPP. These are then compared to the average indicators in this zone. The above map was created according to the Global Land Productivity Dynamic Dataset[153] and obtained by processing SPOT Vegetation and MODIS data. The dynamics of the NDVI index are given for the period from 1999 to 2013.[154]

153 Cui ., Li, 2022.

154 UN (2020) Map of the World [online] https://www. un.org/geospatial/, modified with Google Earth Engine Application developed for the region. https://projectgeffao. users.earthengine.app/view/reu-ldn-assessment




Based on the Global Soil Organic Carbon Map (GSOC v1.5.0) developed by the Global Soil Partnership (GSP).[155]

155 FAO and ITPS (2020) Global Soil Organic Carbon Map V1.5: Technical report. Rome, FAO. https://doi.org/10.4060/ca7597en.



# Forest Resources

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### 5.1. Key aspects

- Forest vegetation in official data most often represents open stands of trees which, according to international standards, can only be classified as forests conditionally.
- Despite the relatively small areas of forests (occupying less than 3 per cent of Tajikistan's area), they are distinguished by significant species and biocenotic diversity as well as performing important ecological functions, especially on mountain slopes.
- The actual state and dynamics of forests are unknown due to the lack of a monitoring system based on modern methods.
- More than 70 per cent of the country's population depends on wood as their main source of household fuel, which leads to illegal logging, including in PAs.

### 5.2. General characteristics

The national legislation of Tajikistan uses the term "forest lands" to mean all "lands covered and not covered by forests, but intended for their restoration, and intended for forestry needs". The second key term in the 2011 Forest Code reads, in part, as follows: "forest is…a complex of natural vegetation formed naturally and artificially in a certain territory based on a combination of trees and shrubs", a definition predicated on the territory in question having at least 10 per cent coverage by tree-forming plants, being an area of at least 0.5 ha and at least 10 m in width[156].

The total area of State 'forest lands' in Tajikistan is about 1.8 million ha (13 per cent of the country's territory), however, only 25 per cent of this area is occupied by 'forest', i.e. more or less closed tree stands *(see map 'Tree and bush vegetation')*. According to official data, the area of forests currently amounts to 421,200 ha (about 3 per cent of the country's area) in State ownership and about 50,000 ha in dehkan farms[157]. Of the total area of 'forest lands' under the jurisdiction of forestry authorities, 1.08 million ha, or about 60 per cent, including actual forests, are allocated for long-term use as pastures while the remaining 40 per cent, due to unfavourableconditions, is barely used for the development of the forest sector, such as the establishment of forest plantations[158].

In Soviet legislation dating back to the 1950s, all forests in the republic belonged to the first conservation category, meaning industrial logging was prohibited, however, the current Forest Code of 2011 is not so specific in this regard, for example, in Article 57 on final felling or clearcutting. The forests of Tajikistan are comprised mainly of stands of medium-low productivity (III and IV bonitet classes) with an average timber reserve of 35 m³/ha, which is a low indicator *(see map 'Forest above-ground biomass')*. The total timber reserve in these forests is officially estimated at approximately 5.3 million m3 (of which 3.5 million m³ is in juniper forests). In Soviet times, the import of wood products to the republic was established from other forest regions in the now former USSR, a practice that no longer exists. The demand for timber by the six million-strong rural population significantly exceeds the volume of permitted logging, which is less than 10,000 m³. This leads to illegal logging, the scale of which is difficult to estimate but is known to often occur in PAs.

There are not many true closed forests in Tajikistan. The mountain slopes at altitudes from 500–700 m to 3200–3700 m (depending on exposure) are covered with small groves that alternate with treeless areas or shrub thickets. Forests extend down into valleys only where there are rivers providing a constant source of moisture. In these sparse forest stands, the trees are too far apart for their crowns to close, resulting in a lush growth of shrubs and tall grass between them. In these sparse, arid forests, stands are often multi-stemmed, with dense, wide crowns and low trunks, little distinguishable from shrub thickets when viewed from a distance. As such, it is impossible to separate the stands from the shrub-herbaceous thickets by remote sensing methods due to

156 Forest Code of the Republic of Tajikistan dated 2 August 2011 No. 761. (in Russian)
157 Global forest resources assessment. Tajikistan (2020) FAO. Rome. 378 P.
158 FAO (2007) People, Forests and Trees in West and Central Asia: Outlook for 2020. FAO Forestry Paper 153. Rome, Italy. 23 P. FP2-148-versione x PDF-BASSA.indd.

the blurring of the transitions between them in terms of the density of green vegetation. Because of the widespread fragmentation of these forests and the severe sparseness of the stands, many botanists prefer to call these tree stands Pamir-Alai Park, groves, open or desert forests, savannas, or simply tree groups[159]. According to the Forest Landscape Integrity Index[160], all forests in Tajikistan are characterized by very weak connectivity, with the exception of the juniper forests on the northern slopes of the Turkestan Range *(see map 'Tree and shrub vegetation')*. For example, in neighboring Kyrgyzstan, which stretches across the Tien Shan mountain system, there is an order of magnitude higher degree of preservation of mountain forests[161].



*Juniperus polycarpos*

In most of Tajikistan, the lower forest line rises from 1200 to 1500 m, although in some places it may extend up to 2200 m. Only in the south of Tajikistan does the lower forest line descend to 500 to 700 m, albeit in the form of scattered stands of pistachio *(Pistacia vera)*. According to experts, this 500 to 700 m band is the natural lower limit of woody vegetation, although intensive grazing and logging have effectively raised this limit to 1200 m or higher in most of Tajikistan[162]. The upper forest boundaries, which are marked by open juniper communities and various birch species, exist at 3200 to 3400m, sometimes rising to 3700 m, while individual juniper trees can be seen in the Pamirs at altitudes of up to 4800 m.

Despite their relatively small area and sparseness, Tajikistan's forests are highly diverse *(see map 'Species composition of forests')* with the five most common types of forest ecosystems being: broad-leaved mesophilic forest, hard-leaved xerophilic light forest (shibliak), small-leaved mountain forest, juniper forest and tugai forest. Juniper *(archa)* forests predominate, occupying 36 per cent (150,000 ha) of the total forested area and are represented in two forms: tree-like and shrub-like. Turkestan *(Juniperus turkestanica)*, Semiglobosa *(J. semiglobosa)* and Seravshan *(J. seravshanica)* junipers form tall stands that can be considered forest ecosystems by international standards. The formation of Turkestan juniper is widespread in the mountains of Central Asia and throughout the highlands of Tajikistan at high altitudes. This species forms separate pure stands and is also found in mixed forests. At low altitudes, Turkestan juniper occurs as erect trees, sometimes reaching 15 m in height, however, at high altitudes, it takes a prostrate or creeping form and, according to formal criteria, these communities are not forests. Juniper ecosystems are distinguished by an extremely wide ecological niche as they are found in piedmont semi-deserts with grey soils, in steppe lowlands with rich chernozem soils, in midlands on mountain brown soils and in highlands of the subalpine belt with mountain meadow soils. Creeping forms of juniper are found everywhere in these zones, including on exposed rocky screes. Archa, or Central Asian juniper, is of great importance in preventing erosion in Tajikistan, protecting hillsides from landslides and washout. The main areas of juniper forests are found along the northern slopes of the Turkestan Range *(see map 'Species composition of forests')*.

In Tajikistan, broadleaf forests are represented by walnuts *(Juglans regia)*, Sievers apple *(Malus sieversii)*, Regel maple *(Acer Regelli)*, Turkestan maple *(A. Turkestanicus)* and Oriental plane *(Platanus orientalis)*. These forests are somewhat inferior to other types in terms of biodiversity, accounting for 45 species of dendroflora. However, such forests represent a very unique type of ecosystem and play an exceptional role in the life of the local population, since they also serve as a source of various wild plants. In the 2011 Forest Code, forests in nut-producing zones and those on fruit plantations are defined as a separate category of protected forests. The most common subtype of these forests is walnut stands. Walnut forests extend from the Gissar to the Alai ranges, covering the slopes of the Peter I, Vakhsh, Khazratishokh and Darvaz mountains at altitudes from 1,000 to 2,300 m. The walnut formation (with a total area of 9,000 ha) is widespread in the Hissar-Darvoz ranges and other mountainous regions of the country as well as on the humid northern slopes where it forms stands with a high degree of closure (0.7 to 1.0) and tall trunks (15 to 25 m). Apple tree stands are found throughout the Hissar-Darvaz range and, to a lesser extent, in the north of the GBAO. Maple forests in Tajikistan do not form large compact stands but alternate with shrubs in the upper altitude ranges while, finally, plane tree formations occupy a small area on the Hissar-Darvaz ridge along its rivers where they form dense stands of tall trees.



*Krascheninnikovia ceratoides*

Hard-leaved xerophilous light forests, or shiblyaks, are communities of deciduous trees and shrubs that occur as sparse stands. They are the richest in terms of species, numbering 89. Shiblyak stands are well adapted to surviving the long, dry summers and have a short period of winter dormancy. The canopy of shiblyak stands is formed by meadows of Bukharan almond *(Amygdalus bucharica)*, true pistachio *(Pistacia vera)*, large-flowered volgunets *(Calophaca grandiflora)*, Griffith's redbud *(Cercis griffithii)*, Caucasian hackberry *(Celtis caucasica)* and other tree species. Pistachio (growing over a total area of 78,000 ha) formations are widespread in the southwest of the country, growing on the slopes and in the foothills of the Babatag, Aktau, Karatau, Tereklitau and Vakhsh ridges. These sparse forests of true pistachio, in combination

159 Akhmadov K. (2008) Forest and forest products country profile: Tajikistan. New York and Geneva: UN, 2008. ECE/TIM/DP/46. 36 P.

160 Grantham et al. (2020) Anthropogenic modification of forests means only 40 per cent of remaining forests have high ecosystem integrity. Nat Commun 11, 5978. https://doi.org/10.1038/s41467-020-19493-3. 10 P.

161 United Nations Environment Programme (2025) Atlas of Environmental Change - Kyrgyz Republic. Geneva. https://wedocs.unep.org/20.500.11822/47208 (in Russian)

162 Zapryagaeva V. I. (1976) Forest resources of the Pamir-Alai. Science. Leningrad. 593 P. (in Russian)

with other above-mentioned tree species, represent xerophilic ecosystems characteristic of the republic's lowest semi-desert belt (extending from 700 to 900 m above sea level). Pistachio is an extremely unpretentious species and grows even on rocky outcrops while at higher altitudes (900 to 1100 m) in pistachio sparse forests, elements of steppe vegetation appear. The formation of Bukhara almond is widespread throughout the country, covering relatively large areas in the southwest. As a rule, this type of forest complex occupies low altitudes, although it can also be found quite high in the mountains, forming separate pure stands, often in combination with juniper, maple and pistachio. The grass cover in these communities is ephemeral or xerophytic.

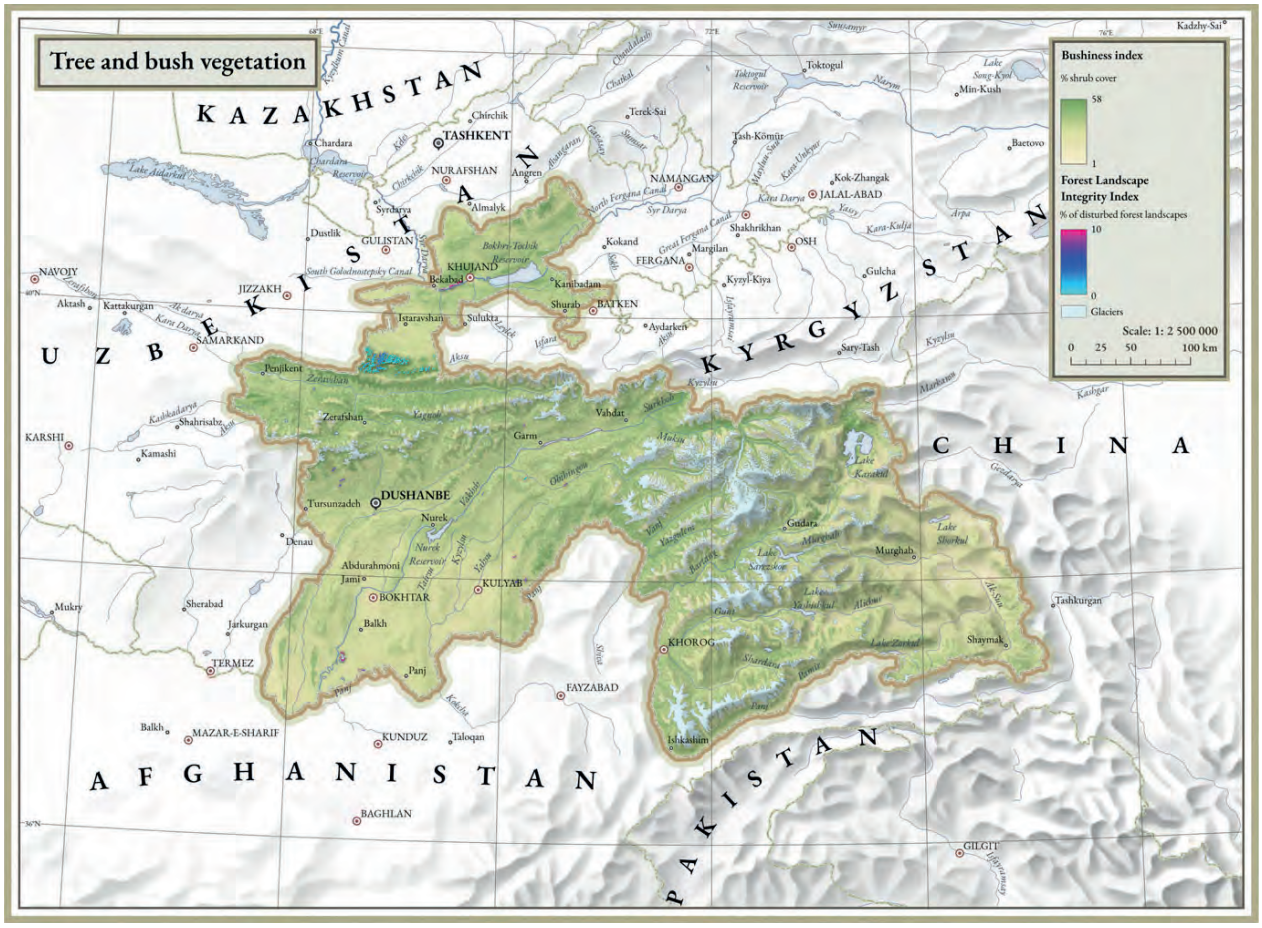
Small-leaved forests in Tajikistan are communities with a predominance of deciduous mesophytic (i.e. preferring moist habitats) trees. These forests are widespread along all the republic's mountain rivers and ridges from altitudes of 1500 m to the upper forest line (typically at altitudes of 3200 to 3400 m) and are also distinguished by great biodiversity. There are 57 plant species in such forests, 42 of which are trees. Depending on the altitude, small-leaved forests consist of species from the birch *(Betula)*, willow *(Populus)*, sea buckthorn *(Hippophae rhamnoides)* and olive *(Fraxinus)* families. These forests are often subject to the introduction of various shrubs and other forms of meadow vegetation. Birch groves are widespread among the alluvial forests of the middle mountains of Tajikistan where they are found in the form of pure stands or form mixed plantings together with tree species from other families. In total, 26 members of the Betula family are found in Tajikistan. Sea buckthorn formations are also widespread throughout Tajikistan in mountain river belts, starting to appear at 500 m above sea level and continuing to altitudes up to 3,700 m. In contrast, representatives of the Oleaceae family usually have the form of a low tree or shrub but occur exclusively in constantly wet areas – mainly in river valleys. Formations of Pamir poplar *(Populus pamirica)* also grows as valley forests but are confined to the gravel beds of all the western Pamir's rivers at an altitude of 2,000 to 3,000 m, where they form very dense stands (with crown density equal to 0.5–0.7) and include other tree species. Formations of Turkestan ash *(Fraxinus potamophila)* are usually only found in periodically flooded areas of valleys in the mid-mountain region while willow *(Salix)* grows in the valleys of mountain rivers – in particular, in the Western Pamirs at altitudes below 3000 m[163].

Tugai forests are a combination of dense undergrowth and shrubs with massive reed beds (phragmites) and oxbow lakes in river floodplains in the arid subtropical zone. At the beginning of the 19th century, Tajikistan had about one million ha of alluvial tugai forests, however, after the valleys were developed for cotton cultivation, the area of these forests decreased by 90 per cent, to about 120,000 ha. The largest tract of remaining tugai forest (24,000 ha) is located in the Tigrovaya Balka Nature Reserve in the lower reaches of the Vakhsh River. The main species present in tugai forests are: common reed *(Phragmites communis)*, wild sugar cane *(Saccharum spontaneum)*, Erianthus ravennae *(Erianthus ravennae)*, narrow-leaved cattail *(Typha angustifolia)*, Laxmann's cattail *(T. laxmannii)* as well as some representatives of the sedge *(Carex)*, butomus and cereal *(Calamagrostis)* families. On highly saline soils, salt- and sun-resistant species, such as the coastal salt marsh grass *(Aeluropus litoratis)* and naked licorice *(Glycyrrhiza glabra)*, are also found. Where the groundwater level is one to two metres below the surface, the tree layer is represented by species such as such as the variegated poplar *(Populus diversifolia)* and the narrow-leaved oleaster *(Elaragnus angustifolia)* along with several types of shrubs, notably the tamarisk *(Tamarix romosissima)*, the Russian wolfberry *(Lycium ruthenicum)* and the saltwort *(Halostachys belaneriana)*, among others.

163 Akhmadov, 2008.

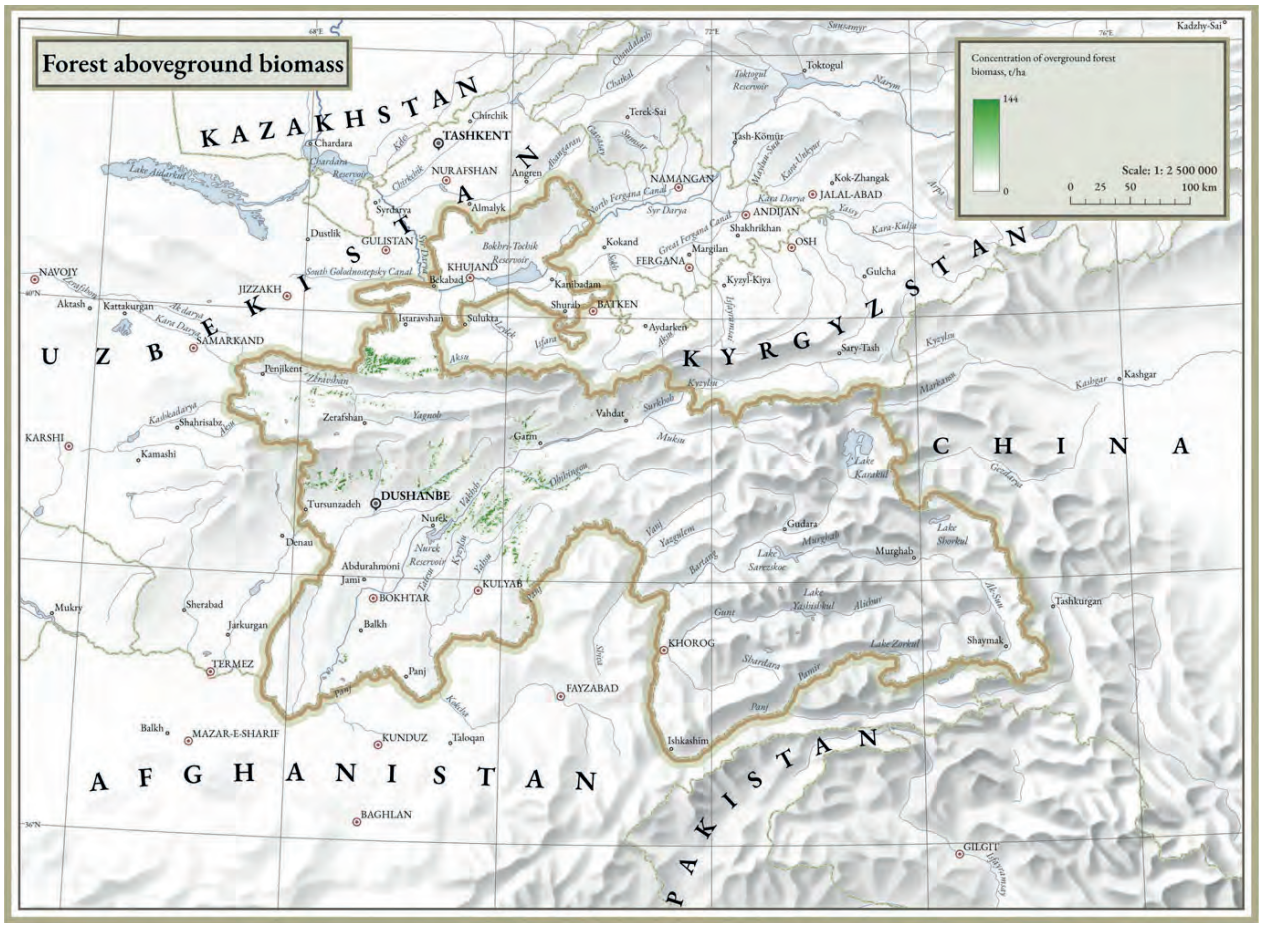


*Pistacia vera*



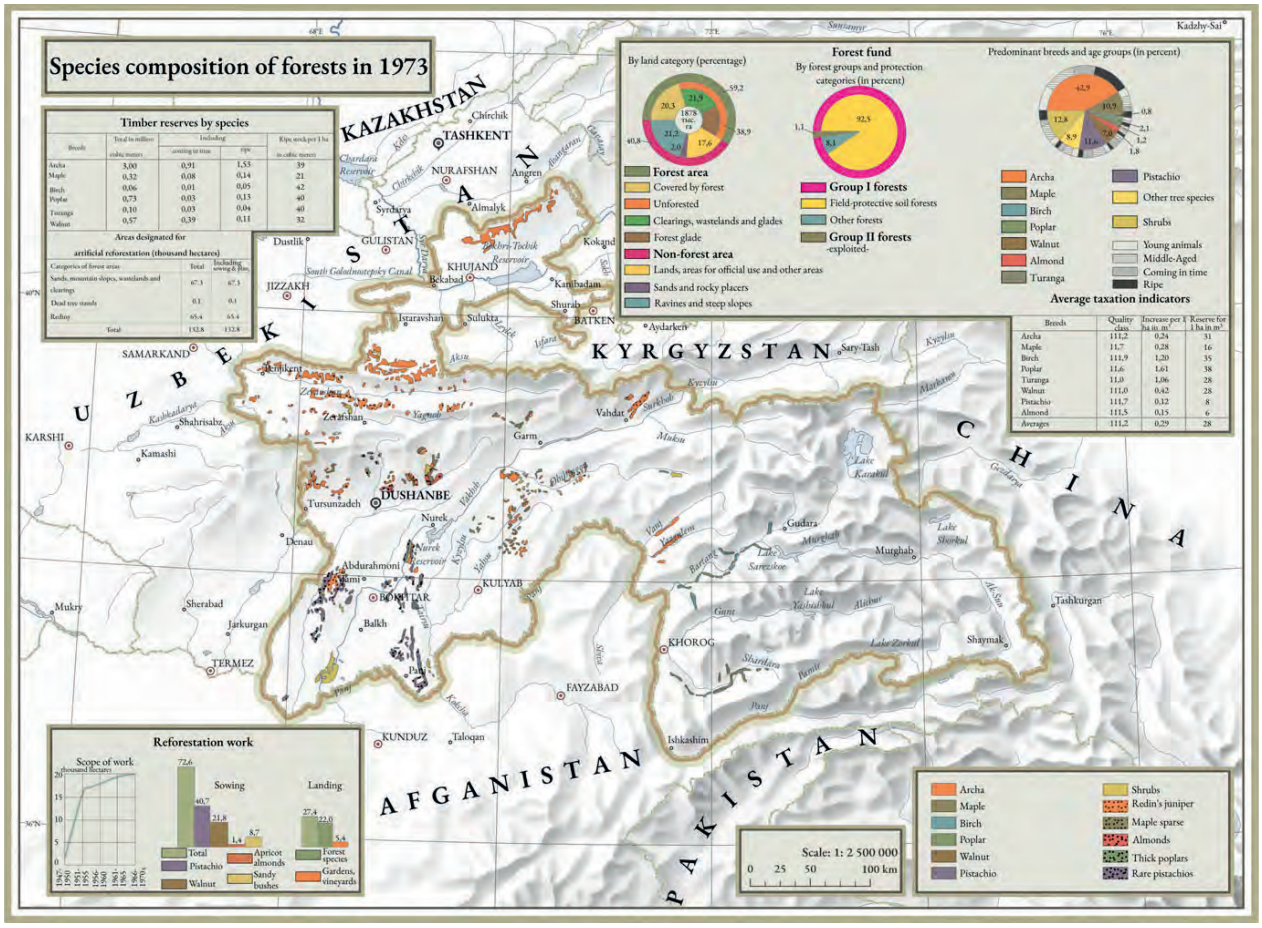

According to the Forest Landscape Integrity Index,[164] calculated using a combination of satellite data (such as global maps of forest cover and loss), observed and inferred human impacts as well as changes in forest connectivity. The index is calculated at a resolution of 300 m, temporal coverage is the year 2019.

164 Grantham et al. 2020.




According to ESA CCI Global Forest Aboveground biomass,[165] based on the results of an analysis of radar satellite data. Spatial resolution is 100 m, temporal coverage is 2010 to 2021.

165 https://climate.esa.int/en/projects/biomass/




Atlas of forests of the USSR. - Moscow: 1973. - 222 p. - (State Forestry Committee of the Council of Ministers of the USSR. All-Union State Design and Survey Institute. (in Russian)

### 5.3. Progress towards the SDGs

Tajikistan has a number of policy initiatives aimed at improving forest management based on approaches developed by the international community. A State programme adopted in 2009 for the period covering 2009 to 2019 contains measures to protect flora and fauna as well as to improve sustainable forest management, expand PAs, and improve the condition of existing ones. These measures were subsequently included in the current Forest Code, adopted in 2011.

Tajikistan also participates in the Central Asian Countries Initiative on Land Management, a programme aimed at addressing pressing forestry issues in Tajikistan, the Kyrgyz Republic and Turkmenistan that ran from 2006 to 2015 and received US $1.4 billion in funding. From 2013 to 2015, the ECE/FAO project Sustainable Forest Management for Green Economies in the Caucasus and Central Asia supported the development of a new forestry development strategy in Tajikistan. This project provided methodological support for the development of the private sector through local workshops based on an analysis of the problems and state of the sector. The ideology of forest management in Tajikistan is changing towards understanding the special social significance of forests, which inherently requires the direct involvement of local communities in forest management.

The Bonn Global Initiative (Bonn Challenge), adopted in 2015, called on all countries on the planet to restore forest landscapes on an area of 350 million ha by 2030. In 2018, as part of a regional initiative (the Astana Resolution), the countries of the Caucasus (Georgia, Armenia, Azerbaijan) and Central Asia made voluntary commitments to restore forests on an area of 3 million ha by 2030. Tajikistan set a national target for afforestation of 66,000 ha, including afforestation of 15,000 ha of degraded pastures and the reforestation of 30,000 ha of land that had been cleared of forests. As part of these commitments, Tajikistan is credited with 18,000 ha of forests that were planted in the country from 2011 to 2018. Tajikistan's goals appear quite ambitious as, going forward from here, they require creating forest plantations on an area of about 4,000 ha per year, which is slightly lower than the Soviet afforestation rate (4,500 ha per year)[166] but is twice as large as the scale of reforestation in the country from 2011 to 2018. One particular challenge here is that creating forests in mountains is an expensive undertaking, with one ha costing an average of US $2,000[167].

The possibilities for restoring and expanding current forest areas in Tajikistan are limited for several reasons, not the least of which are the harsh climatic conditions, as demonstrated by the model underlying the corresponding map *(see map 'Forest plantation potential')*. According to this model, the potential for reforestation does not exceed 3.8 to 4.0 per cent of the country's area (202,800 ha), with the most realistic estimate of current forest cover being expanded to no more than 2 per cent of the republic. According to some literary data, at the beginning of the last century (in the 1920s), forests could cover from 16 to 25 per cent of Tajikistan's area, i.e. from 2.2 to 3.6 million ha[168], this contrasts with the fact that modern-day forests occupy around 425,000 ha. This seemingly indicates there was a catastrophic amount of deforestation during the Soviet period, however, it also highlights that there was great potential for afforestation in Tajikistan. However, these historical estimates are now implausible. For comparison, in Kyrgyzstan, which has more favourable ecological conditions for forest growth, at the beginning of the last century, the forested area was approximately 1.2 million ha[169], while modern forests occupy 1.19 million ha[170]. Within the framework of the Bonn Initiative, the commitments of the Kyrgyz Republic to restore forests reach 323,200 ha, i.e. five times more than planned in Tajikistan, which reflects the differences in the natural conditions for forest growth in these countries.

166 FAO, 2007.

167 Novikova T.M. Yatimov O.R. (2011) Biodiversity of mountain ecosystems supporting the socio-economic well-being of local communities in south-eastern Tajikistan. Eds. A. Laletin, J. A. Parrotta, I. Domashov. Forest Biodiversity, Traditional Forest Related Knowledge and Sustainable Forest Management in Eastern Europe, Northern and Central Asia. IUFRO World Series Vol. 26. Pp. 45-51.

168 Pilkington et al. (2020) The first rapid forest inventory and resource use assessment of Dashtijum Nature Reserve, Tajikistan: a mixed methods approach. Oryx. 54. Pp. 1-8. 10.1017/S0030605319001170.

169 Forestry Development and Best Practices of Forest Management in Kyrgyzstan (2018) Asia-Pacific Network for Sustainable Forest Management and Rehabilitation. China Forestry Publishing House.

170 Second National Forest Inventory in Kyrgyzstan (2022) Report on the results of NFI#2. Forest Service under the Ministry of Agriculture of the Kyrgyz Republic.

In general, Tajikistan's forest policy is in line with SDG 15, which prioritizes the following tasks: «protect, restore and rationally use terrestrial ecosystems; sustainable forest management; combat desertification; halt and reverse land degradation; and halt biodiversity loss». To achieve these goals, two main progress indicators have been proposed.

• SDG 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems – in particular forests, wetlands, mountains and drylands – as well as their services, in line with commitments under international agreements.

Forest degradation is estimated to affect about 70 per cent of the republic's forest area, although this is difficult to confirm. The last forest inventory was conducted before 1991 and spatial information, as well as cartographic data, are either unavailable or outdated. Given that there is no systematic monitoring of forest ecosystems[171], to obtain adequate information on the state of Tajik forests requires the completion of a new forest inventory, which is possible as Tajikistan has the necessary tools to do so.

The official definition of a forest changed between the two Forest Codes of 1993 and 2011, however, this was not reflected in annually published reports on forest areas. The 1993 code obviously inherited the Soviet definition of a forest as "a community of trees of one or more species growing close to each other and forming more or less closed stands, the area of which is more than 0.1 hectares". The current 2011 code adopts different parameters to define a forest, namely an area with at least 10 per cent coverage by woody plants, an area of at least 0.5 ha and at least 10 m in width[172]. The use of the new definition, which was welcomed by international experts, would lead to a revision of forest statistics. However, no statistical revision has followed, and the latest official reports show virtually identical forest area figures from the 1990s to the 2010s: according to national estimates, forests occupy 421,200 hectares (3% of the country's territory). According to official statistics, the republic's forest areas increased from 380,000 ha in 1987 to 421,200 ha by 2016, up by almost 10 per cent, due to natural reforestation (accounting for 80 per cent of the increase ) and, to a lesser extent, due to the establishment of forest plantations[173].

An accurate assessment of the extent of forestation in the republic is difficult since large areas are occupied by open forests, which may or may not be classified as forests. For example, Tajikistan's open forest areas includes shrub communities, which occupy an area of 54,800 ha according to the definitions of Forest Code but are recorded as occupying 200,000 ha according to other official data[174]. If the latter estimate is correct, then forest areas should be about 220,000 ha, which aligns well with the close estimate of 215,000 ha made available in a 2001 USAID report, which is often cited as an alternative source for national forest statistics[175].

An example of the difficulties in establishing accurate forest statistics is seen in the situation in the Khatlon region. According to estimates by the Global Forest Watch, the area of forests (canopy density >10 per cent) is about 8,000 ha (only 1 per cent of the area of the region) while shrub communities occupy 316,000 ha. However, official statistics indicate there is 116,279 ha of forest area (14.5 per cent of the area of the region), primarily because these figures classify large areas (but not all) covered by shrubs as forests[176].

Experts, citing remote sensing data, believe that more realistic estimates of forest cover in the country should be several times lower than the official figures. A MODIS-based study shows that less than 1.3 per cent of the country's territory (186,000 ha) is currently covered by forests[177], while the lowest such estimate of the country's forest cover is 1.05 per cent (150,000 ha)[178]. These studies also do not confirm an increase in forest area in the country since the 1990s *(see map 'Change in forest density')*. The annual rate of deforestation may be as high as 2 per cent, which seems realistic in the context of the average global level of deforestation in developing countries[179]. Tajikistan is experiencing significant pressure on forests from local populations since the unsatisfied demand for fuelwood from individual households (10 to 15 m³ per year) is on the same order of magnitude as the wood stock in forests (30 m³ per ha)[180]. One of the most cited sources[181] suggests a total reduction in forest cover from 3 per cent to 1.75 per cent of the country's territory over the past 30 years, with annual losses of about 7,600 ha, or 2 per cent. Thus, the estimate of a reduction in forest area by 2 per cent per year seems to be the most probable rate, as does the estimate of the country's forest area not exceeding 200,000 ha.

The second of two main progress indicators for SDG 15 is SDG 15.2: By 2020, promote sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase forest restoration and afforestation globally. The corresponding indicator is 'Progress towards sustainable forest management', which can be measured by another set of specific indicators, such as the annual rate of changes in forest area and aboveground biomass stock of forests as well as the proportion of forest area within legally designated PAs.

Progress towards sustainable forestry as a key indicator of SDG 15.2 is again difficult to assess for Tajikistan based on forest area loss due to inconsistencies in published data. However, the main challenges facing Tajikistan's forestry sector are nevertheless clear and related to the high poverty rate against the backdrop of a general deficit of forest products in the country. Despite the almost complete coverage of all populated areas by electricity grids, only 20 per cent of urban dwellings have central heating, while in rural areas it is virtually non-existent (0.4 per cent)[182]. More than 90 per cent of the rural population uses solid fuel (wood, coal or dung) for heating and cooking, with almost 50 per cent of people using wood as their primary fuel in 2002. According to another estimate, 70 per cent of the country's population depends on wood as their primary fuel. During the Soviet era, imports of wood products totalled up to 400,000 m3, including 50,000 m³ of fuelwood[183]. Currently, the only legal domestic source of fuelwood is sanitary felling and logging operations, which provided only 9,200 m³ in 2009. In national statistics, the volume of fuelwood harvested by forestry enterprises averaged 6,000 to 7,000 m³ in the 2000s[184].

*Table 12. The share of the area of closed forests in Tajikistan's PAs according to remote sensing data*

| PA | Per cent of forest in total area of PA |
|---|---|
| Tigrovaya Balka | 9.9 |
| Ramit | 13.8 |
| Dashti-Dzhum | 2.1 |
| Zorkul' | 0.0 |
| Tajik national Park | 0.04 |
| Shirkentskij istoriko-prirodnyj park | 8.57 |
| Nacional'nyj park Sari-Hosor | 11.5 |
| Almasinskij | 30.0 |
| Zeravshanskij | 0.21 |
| Karatauskij | 0.03 |
| Kusavlisajskij | 30.4 |
| Muzkul'skij | 0.004 |
| Nurekskij | 10.8 |
| Sajvotinskij | 10.2 |
| Sangvorskij | 0.75 |

Legal timber extraction, therefore, accounts for less than 2 to 3 per cent of annual demand and less than 20 per cent of fuelwood demand. As such, the population now uses all types of forests, including mountain and tugai forests, as sources of fuelwood. The situation is particularly specific in the Eastern Pamirs where

171 UNECE, 2017.
172 Forest Code...,2011.
173 Global forest.., 2020.
174 On the Forestry Sector Development Program for 2022–2026. (2020) *taj224730.pdf. (in Russian)
175 USAID (2001) Biodiversity Assessment for Tajikistan. http://pdf.usaid.gov/pdf_docs/pnacn472.pdf.
176 Conservation and Sustainable Management of High-Value Arid Ecosystems in the Lower Amu Darya Basin. 10439_MFA_PIF.pdf.
177 Yin et al., 2017.
178 Rubinov, 2016.
179 UNECE, 2017.
180 Conservation and Sustainable Management of High-Value Arid Ecosystems in the Lower Amu Darya Basin. 10439_MFA_PIF.pdf. .
181 Kirchoff J. F., Fabian A. (2010) Forestry sector analysis of the Republic of Tajikistan. Eschborn, Germany: GTZ [Deutsche Gesellshaft für Technische Zusammenarbeit].
182 National Gender.., 2016.
183 UNECE (2015) Report from the regional workshops on the process for sustainable forest management strategy development for greener economy in Tajikistan. Dushanbe. 17 P.
184 FAO, 2010.

the main source of fuelwood is the teresken shrub *(Ceratoides papposa)*. Overharvesting of the shrub has led to the very noticeable disappearance of this type of vegetation in many areas of the Eastern Pamirs.

Forests are also widely used as a forage base for livestock, which hinders forests' capacity for regeneration. This pressure on forests has become particularly salient since 2000 due to the growth of livestock numbers and, as a result, in the Strategy for the Development of the Forestry Sector until 2030, the Government has set the goal of reducing the scale of grazing in forest areas by a third[185].

Establishing plantations of fast-growing trees to supply the population with building materials and fuel is one way to resolve this issue, or at least to somewhat alleviate it, however, priority should be given to the restoration and expansion of naturally occurring forests, as well as their use for income-generating activities. This is nominally supported by the Forestry Development Strategy for 2016 to 2030 and the Action Plan for 2016 to 2020 that envisaged reforestation on an area of 10,000 ha over 15 years, however, the 2011 Forest Code is also still in force and allows significant timber harvesting instead of classifying all forests as being in the old Soviet first conservation category (meaning industrial logging was prohibited) in accordance with the Soviet-style Forest Code of 1993.

Protected areas, which must maintain a strict protection regime for forest ecosystems, are of limited importance in Tajikistan since the average forest cover in them does not exceed 11 per cent *(see map 'Share of area of closed forests in PAs') (see also Table 12)*. These data show that the areas under closed forests are significantly lower than the official data on the forest cover of reserves and other protected natural areas. For example, the literature provides data that the area of tugai forests in the Tigrovaya Balka Nature Reserve is 24,000 ha, i.e. 50 per cent of the area of this PA, however, some sources specify that forests occupy no more than 33 per cent since 8,000 ha are occupied by shrubs[186]. According to remote sensing data, the area of closed forests in the reserve does not exceed 10 per cent, which is explained by the ribbon-like arrangement of floodplain forests, which are narrow frames of oxbow lakes or channels and do not form contiguous forest areas which can provide unique environment-forming ecological services.

However, the main problem with forest conservation in Tajikistan's PAs (and beyond) is that government agencies cannot effectively restrict forest use by local people. The main institutions in the forestry sector of Tajikistan that interact with local communities are forest enterprises that are responsible for forest protection but, at the same time, function as commercial organizations selling forest products to other State institutions (such as local schools) and directly to local residents. As a result, local communities are alienated from forest management issues since these forest enterprises with contradictory dual tasks stand between them and forest resources. An alternative approach for forest management could be to recognize forests in Tajikistan as part of socio-ecological systems[187], especially since about 70 per cent of the population live in or near forest areas. As such, there are practically no forests in the country that have not been improved or degraded as a result of human use[188], thus a more holistic approach to the protection of forest resources appears to be reliant on their joint management by a combination of State bodies and local communities, as has already been enshrined in the current Forest Code (Article 13). The Forestry Sector Development Programme for 2022 to 2026[189] calls this task of involving local populations in joint forest management a priority and mentions several pilot projects of this kind in the GBAO, the pistachio forests of the Farkhor and Dangara districts, the broad-leaved forests of the Khovaling forestry enterprise and in the juniper forest zones of the cities and districts of Penjikent. However, the results of such projects are too dependent on many local circumstances to draw clear conclusions about the prospects of this approach at the national level *(see Box 5)*.

Participatory forest management initiatives should include gender-sensitive approaches that ensure women's participation in forest user groups and benefit-sharing mechanisms is sufficiently representative. Such pilot projects should also be assessed in terms of their impact on both men and women's livelihoods and empowerment as the role of women in forest management is currently undervalued.

In line with SDG guidance 15.2.1, progress towards sustainable forest management can also be measured by the proportion of forest area under a long-term management plan and the area of forest under an independently verified forest management certification scheme.

The share of forest areas in Tajikistan for which there is a long-term forest management plan is currently only 5 per cent[190]. In official reports, the presence of such long-term plans appears to be consistent with SDG indicator 15.2.1, as they contain regulatory requirements for the use and protection of forest resources and emphasize the importance of social and cultural use of forests by local populations.

Recognized forest management certification schemes require the application of international standards that are generally higher than those set by existing national regulatory frameworks. Furthermore, compliance with these standards needs to be verified by independent accredited organizations. Increases in forest areas certified in this way is an important additional indicator of progress towards sustainable forest management (SFM). Forest certification data are reported annually to the FAO by the head offices of the respective forest certification schemes. These indicators include the area certified by each scheme, as well as areas certified by the two main schemes: the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). There is currently no forest certification being carried out in the Republic of Tajikistan. The UN SDG Indicators Database reported that "in 2023, the area of forests under independently verified forest management certification schemes was 0.0 hectares"[191].

SDG 15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, to enhance their capacity to provide benefits for sustainable development.

The main indicator in this context is the Mountain Green Cover Index (MGCI), which measures changes in a wide variety of landscape cover, including forests, shrub thickets, meadow communities, agricultural land, fruit plantations and others. A decrease in the MGCI indicates an increase in anthropogenic stress on mountain ecosystems, while an increase is associated with improved vegetation cover, possibly related to land restoration programmes, afforestation or reforestation. The indicator is based on the use of Collect Earth, numerous very high-resolution images from Google Earth and Bing Maps as well as Landsat 7 and 8 data from the Google Earth Engine. These sources are 99 per cent accurate at the global level but lower at the national level, especially for small countries. According to the republic's National Statistics Committee, a national version of the MGCI is under development. For reference, in the 2000 to 2021 period the UN SDG country profile indicates a slight decline in the index in Tajikistan: from 50.8 per cent to 49.9 per cent[192].

185 On the Forestry.., 2020.
186 Rakhmatilloev et al. (2024) Features of the use and protection of water resources in the Tigrovaya Balka Nature Reserve. Water resources, energy and ecology. Dushanbe. Pp. 114-120. wree-2-2024.pdf. (in Russian)
187 Rubinov, 2016.
188 Ibid.
189 On the Forestry.., 2020.
190 FAO (2010) Global Forest Resources Assessment Country Reports: Tajikistan. FAO, Rome, Italy. P. 378. i1757e.pdf.
191 SDG Country Profiles.
192 Ibid.



*Juniper bushes in the Fan Mountains*

*Box 5. Implementing joint forest management in the Pamirs*

In 2009, the GIZ and the State Forestry Institution (leskhoz) developed and tested a Joint Forest Management (JFM) project[193]. The JFM practice involved signing a detailed 20-year contract between the forestry enterprise and local residents who became forest users. The forestry enterprise determined the annual harvesting plan and the forest users were required to maintain the forest area in good sanitary condition and protect it from illegal logging, fires and other detrimental activities. Some 70 per cent of the profit from the sale of forest products was to go to the forest users and the remaining 30 per cent was retained as income for the forestry enterprise. The JFM covered about 2,000 ha of State-forest land in three districts of the GBAO, which is 20 per cent of the actual forest cover in the GBAO and included participation by about 350 households in 40 communities.

In-depth interviews conducted in three villages revealed very different outcomes in different communities regarding the implementation of the JFM. For example, most residents of community A refused to join the JFM, despite the complete deforestation of the part of the State forests used for winter grazing. In Soviet times, domestic herd size was limited to two cows and 10 smaller animals per household, currently, there is no limit on the size of a private herd. Another part of the forest was transferred to the control of 23 wealthier households that were allowed to grow crops on their forest plots in exchange for strict controls on illegal logging. Many of the poorer villagers in the community said they would be willing to participate in the JFM only if the income was equally distributed among all households.

Community B, located in the lower Ishkashim Valley, completely failed in its effort to implement the JFM. Eight tenants who left the agreement (in 2012) said that forest management there was impossible for several reasons, not the least of which was the local military base, whose soldiers regularly steal firewood at night as the base has no electricity or heating.

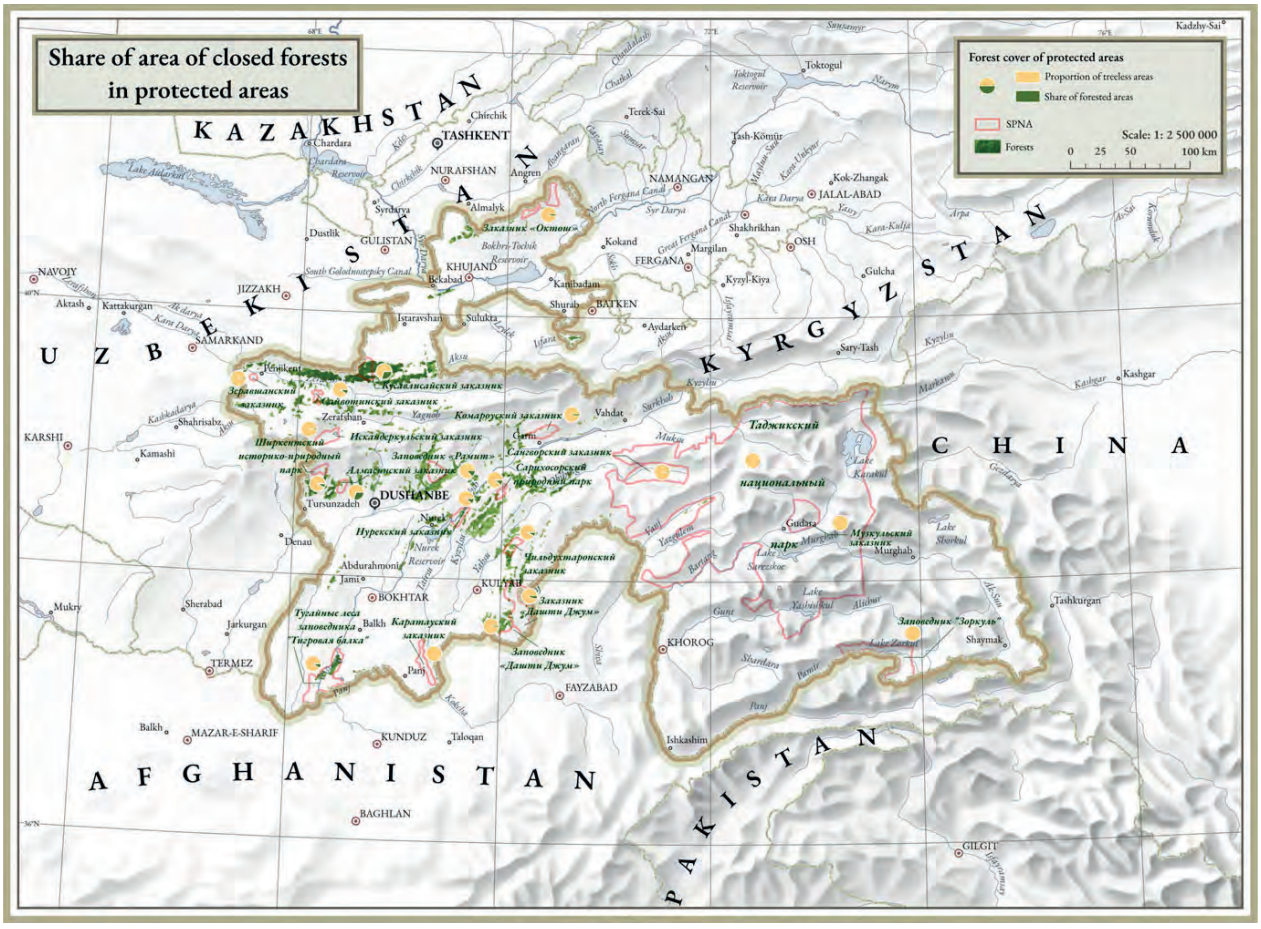
Of the three surveyed villages, only community C was meeting its annual logging targets. The village is located in the upper Ishkashim Valley and is inhabited by the Wakhi people, a small ethnic group that speaks its own language (Wakhi). Seven men in the village formed a forest management team whose efforts were likely helped by the fact that the community attaches great spiritual significance to two groves that have become sites for religious ceremonies.

Regarding the condition of the forests studied, the study shows that the oldest forests (pre-dating the Soviet era) are in better condition due to more favourable environmental conditions and the religious beliefs of the local population. Forests planted during the Soviet era (since the late 1950s) are often in poor condition.

193 Haider et al. (2019) Past management affects success of current joint forestry management institutions in Tajikistan. Environ Dev Sustain. 21. Pp. 2183 to 2224.

### 5.4. Responses

- Inventory and assessment of the condition and dynamics of forests according to international standards.
- Recognition of all forests as belonging to the first category when within a PA and the granting of a special status to forests managed by local communities within JFM frameworks.
- Certification of forests according to any of the internationally recognized schemes (FSC, PEFC).
- Creation of plantations of fast-growing trees to rapidly supply the population with building materials and fuel.




According to Hansen et al. (2023). Global Forest Change v1.10 (2000–2022). University of Maryland, Google, USGS, NASA.[194]

194 https://earthengine.google.com/datasets/catalog/UMD_hansen_global_forest_change_2022_v1_10



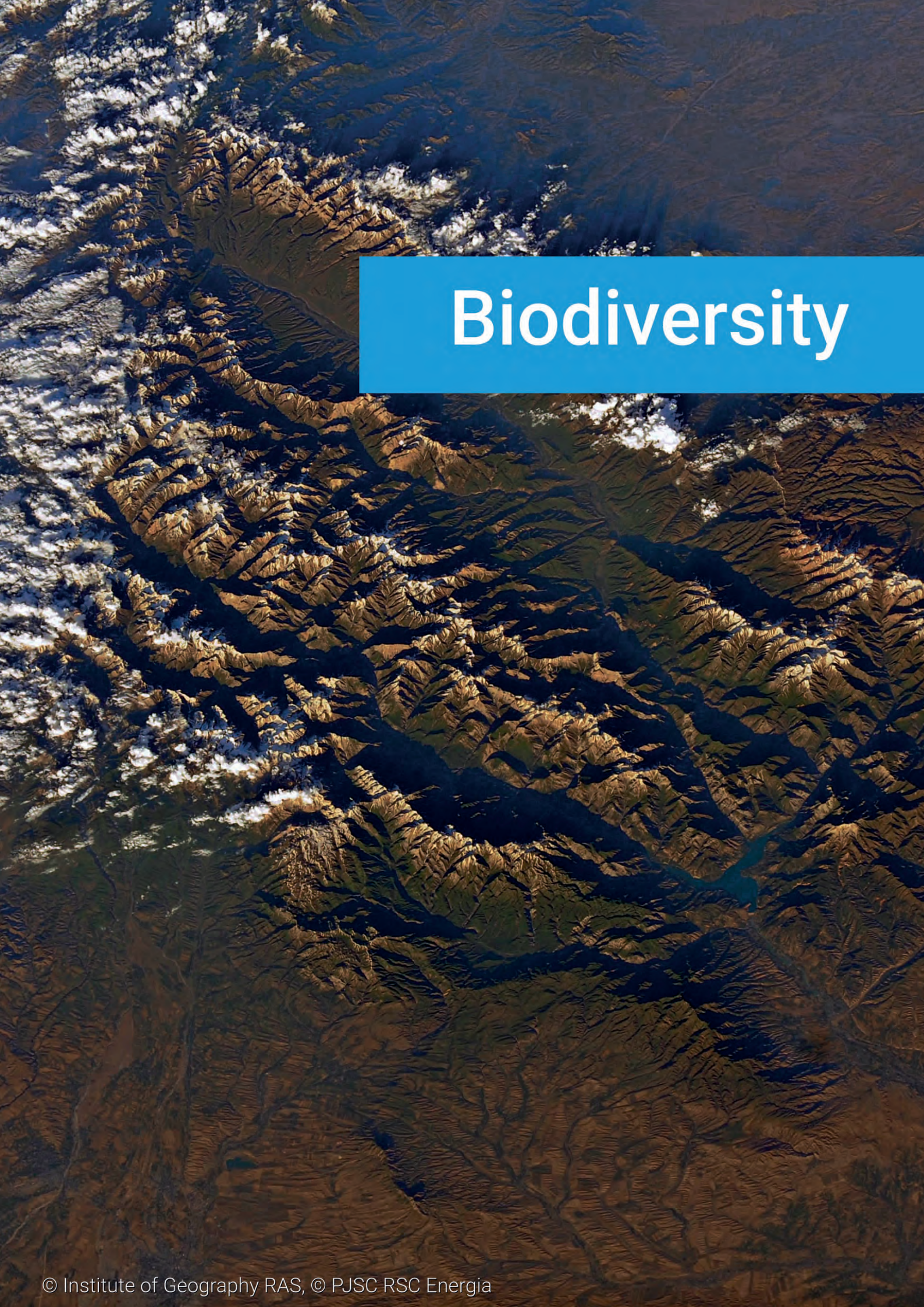

Based on an analysis of satellite data with a spatial resolution of 0.05° × 0.05° for the years 1982 to 2016 and with the allocation of three classes of landscape cover: cultivated land, residential areas and forest areas.[195]

195 Song et al. (2018) Global land change from 1982 to 2016. Nature 560, 639–643. https://doi.org/10.1038/s41586-018-0411-9




According to the Global Reforestation Map[196], obtained using satellite imagery with a spatial resolution of 250 m. Reforestation potential was determined by comparing maps of potential and current forest cover, taking into account data on population density, land use and urbanized areas and then distinguishing three categories of restoration: large-scale, mosaic and remote.

196 Griscom et al. (2017) Global Reforestation Potential Map. https://zenodo.org/record/883444



# Biodiversity

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**6.1. Key aspects**

- Despite its relatively small territory, Tajikistan has a wide range of habitats – from desert and steppe foothill landscapes to alpine meadows – with a correspondingly high diversity of flora and fauna.
- The IUCN Red List for Tajikistan includes only 12 species, which does not reflect the high endemism of the fauna and flora of the country.
- The country is the centre of origin of many domesticated crops and still has about 1,000 wild relatives of these plants.
- Tajikistan has the largest relative area of PAs in Central Asia, however, most of these have undefined boundaries and are practically unprotected from the economic activities of local populations.

**6.2. General characteristics**

The vegetation and landscape cover of Central Asia is characterized by diversity due to the arid climate, meaning any change in the hydrothermal regime will play a large role in the distribution of species, especially due to the role the complex terrain plays. The region has two main ecological and geobotanical provinces, Turan and Kazakhstan, with both have a predominance of heat-loving flora of the Paleogene and Neogene periods but which differ in climatic and hydrological conditions. The Turan province is close to the nature of the Iranian-Arabian region, with its characteristic subtropical features, while the Kazakhstan province is associated with a more temperate climatic zone.

The 'Mountains of Central Asia' form, according to the IUCN classification, one of the organization's 36 global 'biodiversity hotspots', having a total area of 860,000 km2 and stretching across parts of seven countries: south-eastern Kazakhstan; large parts of Kyrgyzstan and Tajikistan; eastern Uzbekistan; western China; north-eastern Afghanistan and south-eastern Turkmenistan[197]. Of these seven, only Tajikistan (with a total area of 141,100 km²) and the Kyrgyz Republic (199,900 km²) are almost entirely within the boundaries of this globally significant 'biodiversity hotspot'. The inclusion of the 'Mountains of Central Asia' in the IUCN list took place in 2011 during its revision because, according to the IUCN's formal criteria, a region should be recognized as a 'biodiversity hotspot' if there are more than 1500 endemic plants that have suffered a significant (more than 70 per cent) loss of their natural habitat. In addition to these 1,500-plus endemic plant species, the Central Asian 'biodiversity hotspot' is home to 17 endemic animal species, including seven mammals, one reptile, four amphibians and five freshwater fish[198]. Despite the complex high-mountain relief, anthropogenic impacts on the flora and fauna of the Pamirs and Tien Shan are recognized as significant. Of the approximately 6,700 species (excluding lower plants, protozoa and invertebrates) found in Central Asia, 68 species (1 per cent) are listed in the global IUCN Red List as being under threat of global extinction[199].

With 23,000 species of flora and fauna, including 1,900 species that are considered endemic and about 1,000 wild relatives of cultivated plants, Tajikistan has the highest density of species per unit area among the five Central Asian countries. Soviet geneticist Nikolai Vavilov identified Tajikistan as one of the world's centres of origin of cultivated plants, mainly cereals. Currently, more than 5,000 species of vascular plants have been catalogued, of which 850 (17 per cent) are endemic, i.e. they are found only in Tajikistan[200]. This represents 1.8 per cent of the world's plant diversity and 0.66 per cent of animal diversity - in a country that occupies less than 0.1 per cent of the world's land area.

In physical and geographical terms, the territory of Tajikistan is clearly divided into five regions or zones: the northern region, connected with the valley of the Syr Darya river; the Zeravshan

197 Mountains of Central Asia Biodiversity Hotspot. Ecosystem Profile (2017) Critical Ecosystem Partnership Fund. mountains-central-asia-ecosystem-profile-eng.pdf.

198 Mittermeier et al. (2011) Global biodiversity conservation: the critical role of hotspots. In Biodiversity Hotspots – Distribution and Protection of Conservation Priority Areas (eds. Zachos, F. E. & Habel, J. C.) Pp. 3–22.

199 The Mountains of Central Asia Hotspot: Ecosystem Profiles (2017) IUCN. Critical Ecosystem Partnership Fund. 202 P. https://d29l0tur8ol1gj.cloudfront.net/sites/default/files/mountains-central-asia-ecosystem-profile-eng.pdf

200 National Strategy and Action Plan for the Conservation and Rational Use of Biodiversity (2003) Dushanbe. 222 p. (in Russian)

river valley with two ranges framed by it, namely the Turkestan and Zeravshan ranges; the mountainous Darvaz region in the upper reaches of the Vakhsh and Panj rivers; the southwestern region, formed by the lower reaches of the Vakhsh, Panj and Kafirnigan rivers and, finally, the highland Pamirs *(see map 'Natural zones')*. Despite the relative simplicity of this zoning, it reflects well the natural structure of the territory of Tajikistan[201]. The Zeravshan and Darvaz regions differ, for example, in the distribution of juniper forests in the former and broad-leaved forests in the latter *(see map 'Vegetation')*. The Darvaz region has the mildest climate of the five zones: the average annual temperature is +11 °C while average annual precipitation is 500 to 1500 mm. The southwestern region, which is geologically distinct from other regions because of the predominance of loess rocks, is home to the main remaining tracts of nut-bearing forests, primarily pistachios *(see map 'Geological and engineering conditions' in Section 8)*. However, the most unique physical-geographical region is the Pamirs, with its monumental glacial-nival complex.



*Syrrhaptes paradoxus*

The complex and rich species diversity of Tajikistan is associated with pronounced vertical zonation in the distribution of plants and animals, the physical isolation of the mountain ranges, latitudinal transformation of climate from northeast to southwest, the presence of islands of relict flora and fauna and the penetration of species from surrounding regions (Europe, South and East Asia). The diversity of habitats is manifested in a wide range of ecosystem types, ranging from deserts in the south of Tajikistan, passing into steppes with forest fragments and sparse woodlands through to alpine meadows that stretch up to altitudes of over 3500 m where the dominant complexes are glaciers and the high-mountain rocky deserts of the Pamirs *(see map 'Landscapes')*. The state of these classes of landscape types can and has been assessed using remote sensing methods - in particular, using the EVI vegetation index *(see map 'Dynamics of the Enhanced Vegetation Index' in Section 5.3)*. In general, Tajikistan's high-mountain and mid-mountain complexes are characterized by the absence of significant trends in vegetation dynamics, while the natural complexes of low mountains, foothill plains and river floodplains have a weakly expressed positive trend in the growth of green biomass *(see Table 13)*.

According to the landscape classification used in Tajikistan, there are 12 classes of ecosystems, the last two of which represent agricultural lands and urbanized areas. There is also a class of weed-ruderal ecosystems, which are degraded lands where natural or cultural plant communities formed by ruderal and invasive species have taken hold on abandoned pastures or arable lands. The remaining classes of ecosystems are distinguished by a combination of altitude and plant characteristics, including two classes of forest complexes - mid-mountain coniferous forest and mesophilic forest ecosystems[202].

A class of piedmont aquatic and semi-aquatic (tugai) ecosystems also exists in the floodplains of large rivers, such as the Vakhsh and Pyanj, where tugai forests are widespread and have notable populations of swamp poplar (turanga), sea buckthorn, jida, willow, and large cereals. This separate class of ecosystems is characterized by increased biomass, comparable to the productivity of subtropical forests of South Asia. The biodiversity of these tugai ecosystems includes more than 600 species of meadow-marsh and sandy-desert plants and provides optimal conditions for waterfowl along with many species of migratory animals, provided that the tugai thickets are slightly disturbed. While significant parts of Tajikistan's tugai forests were fragmented as a result of the implementation of melioration projects in the Soviet period, recent decades have seen a weak 'greening' trend on 45 per cent of the area occupied by floodplain complexes *(see Table 13)*.

Foothill semi-desert and desert ecosystems in the republic occupy relatively small areas and are confined to the river terraces in the lower reaches of the Vakhsh, Pyanj, Kafirnigan and Syr Darya river valleys at altitudes of up to 500 m and where precipitation does not exceed 175 mm per year. The development of these types of complexes for irrigated agriculture has significantly reduced the habitat of desert plants and animals. The dominant species of desert plants are saltwort, sandy saxaul and calligonum, with wormwood being more typical of semi-desert habitats. The semi-desert belt covers foothill plains and adyr hills up to 800 m on the western slopes of the Kuramin Range and in the Vakhsh river valley. The belt serves as a transition zone to the mountain steppes, albeit where large tracts are used as winter pastures, which are now degraded or have been transformed into irrigated lands. Nevertheless, the vegetation index shows a rather positive trend in this belt, which may be associated with the spread of shrub weed vegetation over the degraded pastures *(see Table 13)*.

Tajikistan's lowland landscapes, common at altitudes from 700 to 2000 m, belong to the semi-savanna class. They are mountain steppes which are distinguished by a less hot climate and richer vegetation compared to semi-desert landscapes. At these altitudes, couch grass and mixed grass (primarily feather and fescue) steppes predominate, punctuated by the presence of thorny bushes and the ephemeral vegetation that actively grows during the spring rains. Endemism here is also quite high in these regions as there are several unique species of tulips and juno present.



*Panthera uncia*

The mid-mountain steppe is more diverse than the lowland landscape and is dominated by tall grasses, such as bulbous barley, common couch grass and common bearded grass. While the endemism of this type of ecosystem is also high, there is no discernible trend in changes to this class of ecosystem's green biomass *(see Table 13)*. Several types of steppes can be distinguished in the mid-mountain belt since the territory is both vast and diverse in its conditions. All of such steppes were formed by a succession of naturally occurring woody and shrubby vegetation taking hold due to the steppes' active use as pastures, although the shaping effects of natural factors should also not be excluded. At altitudes of up to 1500 m, the steppes are used as either year-round or winter pastures and the pressure on them is increasing due to deteriorating access for livestock to remote pastures due to population growth and changes in land management agreements. In terms of area, these mid-mountain steppe pastures make up only 10 per cent of the republic's total pasture area.

201 Ibid.
202 Fifth National Report on the Preservation of Biodiversity of the Republic of Tajikistan (2014) Dushanbe. 148 P.



*Ovis ammon*

Low-mountain and mid-mountain xerophytic sparse forests are widespread in a wide range of altitudes from 1,500 to 3,000 meters and occupy an area of up to 3,500 km2 in the Gissar-Alay Mountains and on the slopes of the Darvaz Range. This class of ecosystems forms a forest-steppe belt, outlining the lower boundary of the distribution of tree and shrub vegetation in mountainous areas. As a result of active grazing on seasonal pastures, logging and haymaking, the natural regeneration of nut-fruit forests has been disrupted and these have been replaced by xerophytic shrubs over vast areas (up to 80 per cent of the previously forested area). There are tracts of open forests of juniper, walnut, almond and pistachio but these are essentially shrub formations where rose, caragana, cotoneaster and spirea are the typical shrubs found mixed among the different types of junipers. There are many endemic flora species in this ecosystem class, including various species of almond and rowan, along with a rich and diverse array of fauna existing alongside the wild relatives of barley, vetch, almond, persimmon, jujube, pomegranate, grape and so forth.

Mid-mountain coniferous forest ecosystems make up almost 50 per cent of the total forest area of the country. They are widespread in the north of Tajikistan within the Kurama, Turkestan and Zeravshan ranges. Juniper forests and sparse forests are important for slope stabilization and the prevention of mudflows, landslides and other dangerous slope-related processes. Three species of juniper in Tajikistan are forest-forming: m. Zeravshan, m. Turkestan and m. semispherical, while juniper forests in grass cover can have a typical semi-desert, steppe and forb-meadow character. Most of the republic's juniper forests are used as summer pastures, which poses a serious threat to the successful restoration of these plant communities. Despite the large anthropogenic loads on these mid-mountain coniferous forest ecosystems, positive trends in biomass dynamics prevail in them over negative ones, however both trends are weakly expressed *(see Table 13)*. These ecosystems' altitudinal zone, ranging from 1000 to 2500 m, differs from other zones in that it is experiencing relatively favourable climate changes, particularly in terms of increased average annual precipitation (see Section 2.1.).

Mid-mountain and high-mountain subalpine meadows are confined to altitudes between 2300 and 3200 m. This class of ecosystems is found in all Tajik mountain ranges but in the form of relatively small areas of steppes dominated by cereals, especially fescue, feather grass and meadow bluegrass. Cenosis-forming plants, including black-flowered sedge, narrow-fruited sedge and cobresia, are also present. These plant communities have become vulnerable to overgrazing, resulting in the productivity of many meadows used as summer pastures declining from 0.20–0.25 to 0.10–0.12 t/ha, and the disappearance of many rare plant species. This type of degradation affects up to 30 per cent of the area of subalpine meadows, which is of particular concern as these meadows make up 54 per cent of Tajikistan's total pasture area.

Alpine meadows are generally located at altitudes of 2800 to 3600 m but can also be found as high as 5500 m. The flora in these meadows typically forms cryophyte communities where species diversity decreases as altitude increases. Geranium regelii and Nepeta pedunculosa are the dominant species in these communities and, despite their remoteness from populated areas, these meadows are also used as summer pastures.



*Cervus elaphus bactrianus*

High-mountain desert ecosystems occupy vast swathes of Tajik territory in the Eastern and Western Pamirs and are fragmentarily found in the Zeravshan river valley. They are used for summer grazing, tourism and hunting. The most valuable communities are wormwood-teresken and meadow-steppe, as they

*Table 13. Assessment of the state of the main landscape classes of Tajikistan using remote sensing methods*

| Landscape class | Share of area with EVI trend (per cent) 2000 to 2020 | | | | |
|---|---|---|---|---|---|
| | No trend | Strong negative trend | Weak negative trend | Weak positive trend | Strong positive trend |
| Valleys and plains | | | | | |
| Floodplains | 19.1 | 3.4 | 17.2 | 45.6 | 14.7 |
| Desert southern lowlands | 4.5 | 2.5 | 23.8 | 48.7 | 20.5 |
| Low mountain (700 to 1500 m) | | | | | |
| Low-grass savannoids | 5.5 | 0.5 | 18.0 | 65.7 | 10.3 |
| Mid-mountain (1500 to 3200 m) | | | | | |
| Полупустынные и пустынные (пояс горных полупустынь и степей) | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mountain steppes with arid sparse forests, forests and shrubs | 19.5 | 1.0 | 23.5 | 49.5 | 6.5 |
| High mountain (above 3200 m) | | | | | |
| Mountain subalpine meadows | 78.1 | 0.4 | 7.2 | 13.0 | 1.2 |
| High-mountain cold deserts | 95.8 | 0.0 | 0.4 | 3.2 | 0.6 |
| Mountain glaciers and rocks | 96.3 | 0.0 | 0.6 | 2.8 | 0.2 |

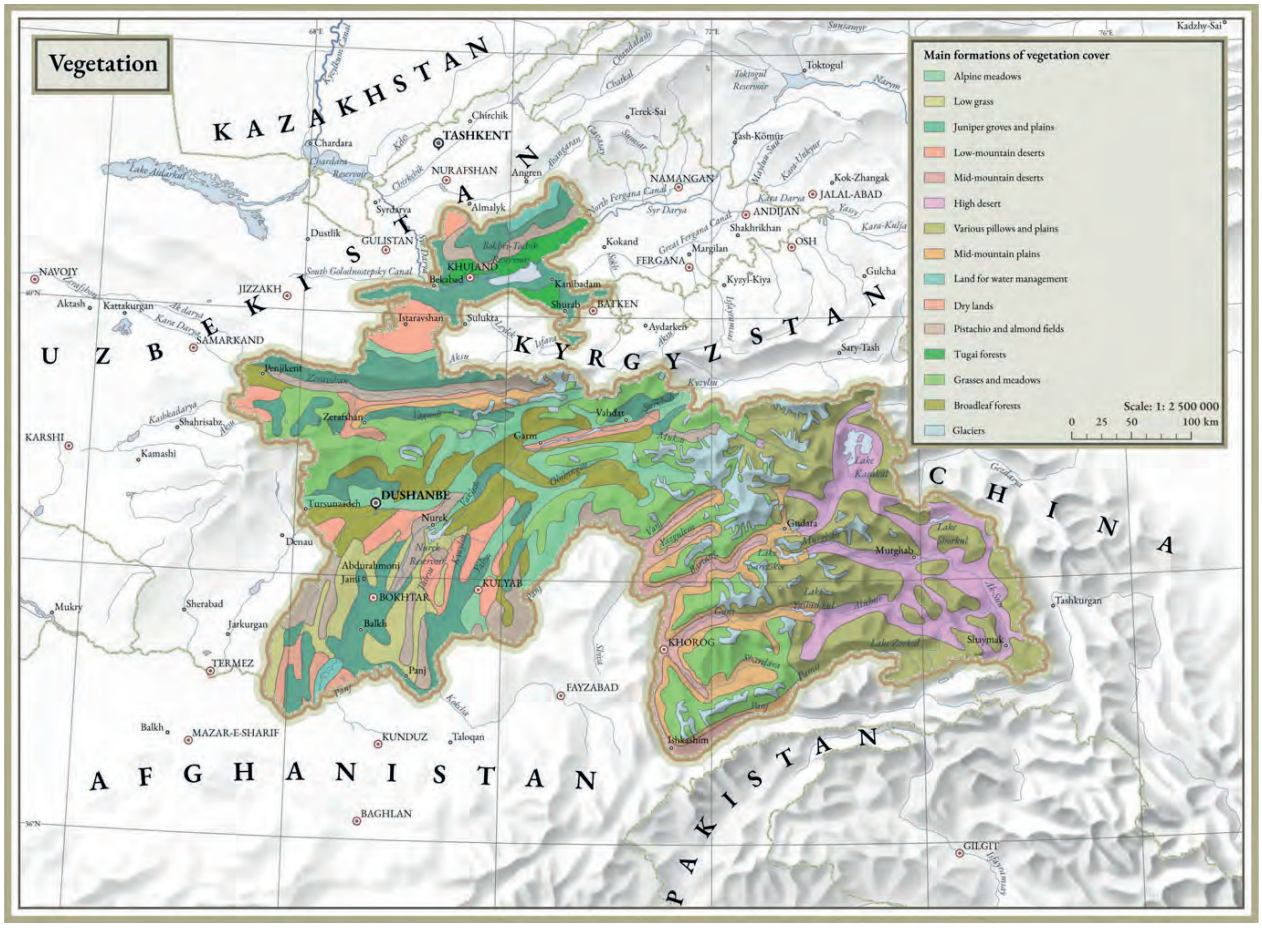
contain some endemic, rare and endangered plants - Badakhshan dandelion *(Taraxacum badach schanicum)*, Pamir desederia *(Desideria pamirica)*, etc.

In the periglacial rocky-glacial landscapes found within these ecosystems, 16 to 17 species of flowering plants grow, including common robin, Altai draba, black vetch, glacial saussuria. At the lower boundaries of these ecosystems, argali *(Ovis ammon),* snow leopard *(Panthera uncia)* and Siberian ibex *(Capra sibirica)* are found.

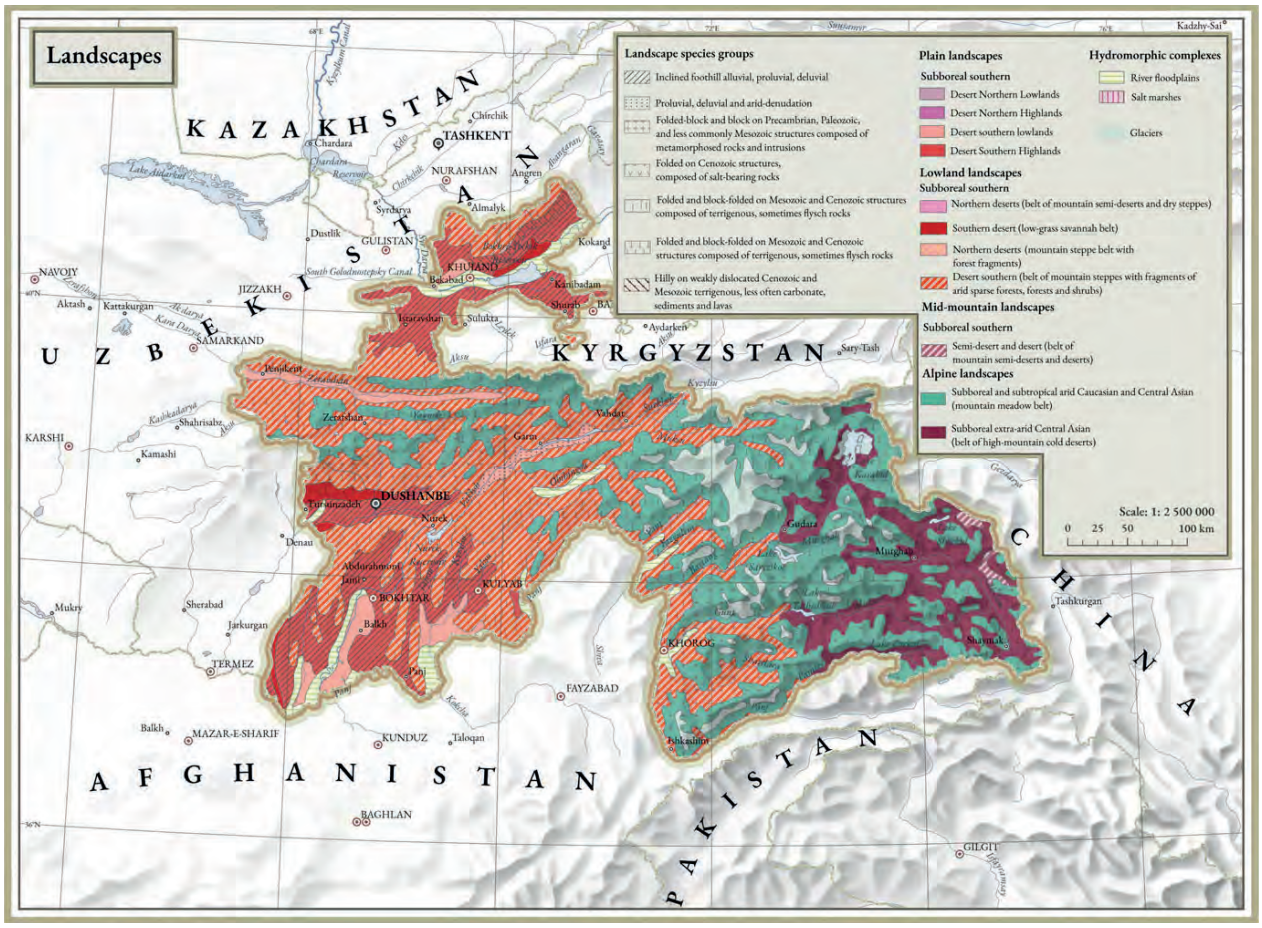
These high-mountain desert landscapes are characterized by the absence of any pronounced trends in vegetation productivity over the past 20 years, which can be explained by the relative stability of the highland climate in which minimal changes in most meteorological parameters have been observed over the past 20 years *(see Table 2 in Section 2.1)*.



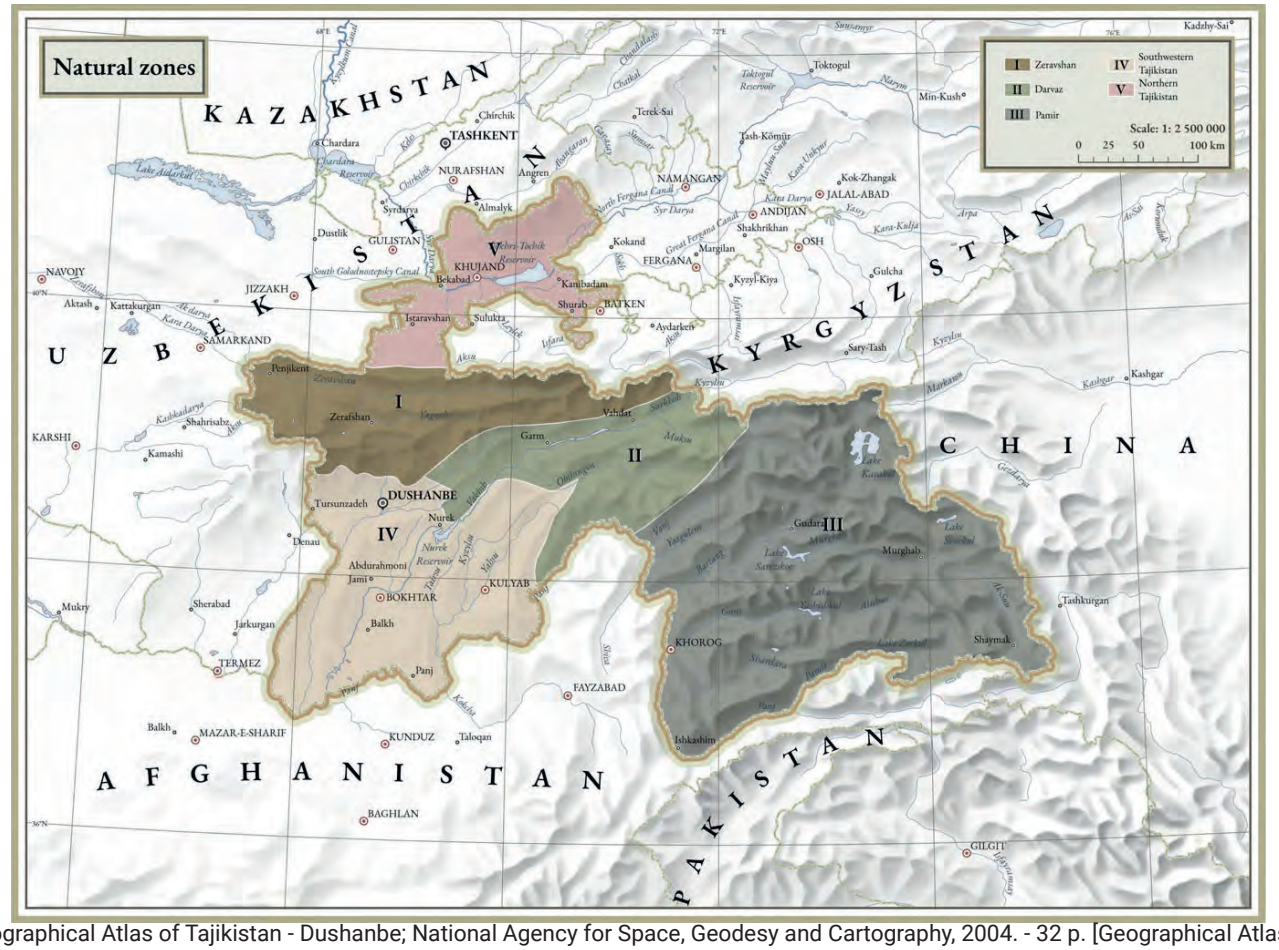
*A clearing in the mountains with ranunculus flowers and green grassy vegetation against the background of the rocky peaks of the Fan Mountains in Tajikistan*




Geographical Atlas of Tajikistan - Dushanbe; National Agency for Space, Geodesy and Cartography, 2004. - 32 p. [Geographical Atlas of Tajikistan. - Dushanbe: Geographical Surveying, Geodesy and Cartography Agency, 2004. - 32 p.]




Landscape map of the USSR: for higher educational institutions. Prepared for printing by Factory No. 10 in 1988; ed. by B. N. Kostyuk; Special. Contents. Developer. Sotr. Research Institute of Geography of Leningrad State University: A. G. Isachenko. Ed. by A. F. Voronin. Scale 1:4,000,000. (in Russian)




Geographical Atlas of Tajikistan - Dushanbe; National Agency for Space, Geodesy and Cartography, 2004. - 32 p. [Geographical Atlas of Tajikistan. - Dushanbe: Geographical Surveying, Geodesy and Cartography Agency, 2004. - 32 p.]

**6.3. Progress towards the SDGs**

The high priority given to biodiversity conservation in Tajikistan is reflected in the number of related laws and regulations the Government has passed as well as the number of relevant international agreements entered into in the post-Soviet period. Tajikistan ratified the Convention on Biological Diversity back in 1997 and committed to ensuring an satisfactory level of environmental protection on its territory. The Republic of Tajikistan is also a party to other global conventions related to biodiversity, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Ramsar Convention on Wetlands of International Importance. Furthermore, in 2003, the Government of Tajikistan adopted the National Strategy and Action Plan for the Conservation and Rational Use of Biodiversity of the Country, the main goal of which is to assess the state of biodiversity and then develop the necessary foundations for its conservation, restoration and rational use.

Simultaneously, a separate programme, the National Biodiversity Conservation Strategy of the Republic of Tajikistan, aims to achieve specific results on the strategic global objectives and Aichi goals for the medium term. The National Biodiversity and Biosafety Centre was established by Decree of the Government of the Republic of Tajikistan No. 392 on 1 September 2003. This centre's main objective is to coordinate the implementation of both the National Biodiversity Strategy and Action Plan as well as the UNCBD, along with other objectives in the field of ecology, nature conservation and sustainable development. In October 2018, Tajikistan ratified a technical cooperation agreement for the implementation of the Biodiversity and Ecosystem Services in Agricultural Landscapes project involving the Ministry of Agriculture of the Republic of Tajikistan and the GIZ.

Despite the seemingly positive step listed above, various international organizations have expressed some concern about inconsistencies within the relevant legal frameworks and contradictions in domestic legislation related to the protection of biodiversity[203]. For example, the 2013 Law on Fisheries and Protection of Fish Resources allows the harvesting of endangered species, an activity that was prohibited by the 2007 Fisheries Regulations. The latest law on hunting allows the hunting of endangered species, despite the prohibition to do so contained in the 2011 Law on Environmental Protection. Additionally, the transfer of PAs to the new Forestry Enterprises Association under the Government contradicts both the 2011 Law on Environmental Protection and the 2011 Law on Specially Protected Natural Areas. In the context of forests, current legislation does not prevent the use of forests for the collection of fuelwood or wild plants and most of the lands of the Forest Fund have been transferred to livestock farms via long-term leases[204]. A final area of concern to mention here is that women's traditional knowledge does not yet play a significant role in biodiversity conservation. Integrating this knowledge into conservation planning and ensuring women's participation in PA management is seen as a step that is highly likely to improve environmental outcomes.

Indicator 15.1.2: Proportion of important terrestrial and freshwater biodiversity areas covered by PAs, by ecosystem type, relevant to the country's environmental policy.

The main tool for protecting biodiversity has for many decades been the organization of specially protected natural areas (PAs), although along with these, there are also 'departmental' (forestry, agricultural, etc.) areas with specific protection regimes or environmental restrictions regarding the intensity of use or development of a given area *(see map 'Nature Protection')*. The system of SPNAs in Tajikistan has largely been inherited from the Soviet system where the highest level of PAs are reserves which should be managed purely for scientific research and environmental monitoring and have the strictest regime, corresponding to the IUCN category I protection regime. In recent years, there has been some transformation of the national system towards the inclusion of a larger number of multi-purpose areas, such as wildlife refuges and national parks. In post-Soviet Tajikistan, the area of PAs has increased by 60 per cent, which distinguishes the country from other Central Asian republics. The total area of PAs now covers 21.58 per cent of Tajikistan's territory, which significantly exceeds the Aichi

203 UNECE, 2017.

204 FAO, 2007.

target, however, while this is an impressive result it was achieved due to the creation of only one PA – the Tajik National Park, which occupies 18 per cent of the country's territory.

The network of nature reserves in Tajikistan includes four SPNAs: Tigrovaya Balka (49,700 ha), Ramit (16,200 ha), Dashtijum (19,700 ha) and Zorkul (87,700 ha) *(see map 'Protected natural areas of Tajikistan')*. The total area of these reserves is less than 1.2 per cent of the territory of the republic.

The Tigrovaya Balka Reserve was established in 1938 and is the oldest in Tajikistan. It covers the tugai forest-dominated floodplain of the lower reaches of the Vakhsh and Pyanj rivers. Of the reserve's 49,700 ha area, tugai forest occupy 24,000 ha, although 8,000 ha of this is covered in sparse stands of trees and shrubs, not forests[205]. In winter, many waterfowl and near-water game (white and black storks, cormorants, geese, swans, mallards and coots) stop at the floodplain lakes and swamps (with a total area of 11,000 ha). Of the ungulates present in this reserve, the most valuable species is the Bukhara deer (khangul). The state of the reserve's ecosystems is entirely dependent on the water release regime from the cascade of eight upstream dams and is, therefore, of great concern to ecologists[206]. As early as 1975, the idea was put forward that there is a need for artificial floods every 10 to 15 years to maintain a high level of groundwater and ensure a sufficient flow of alluvial sediment into Tigrovaya Balka. By way of specifics in this context, the annual flow of the Vakhsh River is about 20 km³, the volume of the Nurek Reservoir is 10.5 km³ and no more than 5 to 6 km³ of water flows into the lower reaches of the river. The imminent completion of the Rogun hydropower plant construction project (with the support of the World Bank) upstream of the Nurek Reservoir introduces even greater uncertainty into the water balance situation in the basin. Filling the Rogun Reservoir will require the further retention of 1.2 km³ per year for 15 or 16 years, which will intensify competition in the basin for water from irrigated agriculture. This makes the prospect of implementing ecological floods increasingly remote, at least for the foreseeable future.

The Ramit (or Romit) State Nature Reserve was created in

205 Rakhmatilloev et al., 2024.

206 Simonov E. (2025) The Survival of Tigrovaya Balka is Still in Question. World Heritage Watch Report. Pp. 183-186. (PDF) The Survival of Tigrovaya Balka is Still in Question. World Heritage Watch Report 2025



*Yak on Lake Karakul in the Pamirs*

*Table 14.Representation of ecoregions in the network of PAs of Tajikistan*

| Ecoregion | Per cent of the area of PAs in the ecoregion |
|---|---|
| Alai-West Tien Shan steppe | 7.0 |
| Gissar-Alai forest-steppe | 4.2 |
| Pamir alpine desert and tundra | 27.4 |
| Pamir shrub biome | 36.8 |
| Rocky-glacial landscapes of the Pamirs | 74.8 |
| Karakoram-Western Tibetan Plateau. alpine steppe | 0 |
| Pamir-Hindu Kush alpine meadows | 0 |
| Karabil and Badghiz semi-deserts | 11.7 |

*Table 15. Representation of landscape types in the network of PAs of Tajikistan*

| Landscape type | Per cent of the area of PAs in the landscape types |
|---|---|
| Mountain glaciers and rocks | 93.9 |
| Subboreal extra-arid Central Asian (belt of high-mountain cold deserts) | 49.7 |
| Subboreal subtropical arid Caucasian and Central Asian (mountain meadow belt) | 23.3 |
| Desert southern (belt of mountain steppes with fragments of arid sparse forests. forests and shrubs) | 4.7 |
| Desert southern (belt of low-grass savannoids) | 0.6 |
| Desert southern elevated | 0.003 |
| Desert southern lowland | 0.3 |
| River floodplains and deltas | 1.26 |

1959 and sits at an altitude of 1176 to 3195 m on the southern slopes of the Gissar Range in the upper reaches of the Kafirnigan River. While initially conceived to primarily protect and restore mountain coniferous and broad-leaved forests, one of the significant achievements of the reserve has been the artificial creation of a population of Bukhara deer. The reserve is located only 80 km from Dushanbe and is an active tourism and recreational activity hotspot, which apparently is the reason this reserve is mentioned in the first national communication to the Secretariat of the Convention on Biodiversity as a PA that has "almost completely lost its functions"[207].

The Dashtijum (Dashtijumsky) Reserve was established in 1983 on the southern slope of the Darvaz Range to protect typical mountain steppe complexes with their juniper and pistachio forests. It supports populations of markhor (Capra falconeri), snow leopard and Siberian ibex. A recent botanical survey and several sociological surveys revealed that 78 per cent of local residents use the reserve to collect wild fruits and nuts, 88 per cent use it to collect fuelwood and 85 per cent graze cattle within the PA. There were traces of logging on 92 per cent of the established botanical plots and 47 per cent of all trees surveyed despite local residents being well aware of the illegality of logging and grazing of cattle in the reserve[208]. Meanwhile, the Korzhinsky pear and Tajik pear, two of the five tree species listed in the IUCN Red List as being in a critical condition were discovered on the reserve's territory following the first inventory of the reserve's tree species being conducted since 1949.

In 2000, the Zorkul Nature Reserve was established in the GBAO on the border with Afghanistan. It is comprised of high-mountain ecosystems, including Lake Zorkul, which is the source of the Pamir River, and serves as a habitat for high-mountain nesting species such as the white-headed goose and the brown gull. The official decree establishing the reserve particularly emphasizes the strictness of its protection regime that, among other things, does not allow the presence of citizens within the reserve without special permission and prohibits any form of economic activity, including recreation and grazing[209]. The reserve is listed on the balance sheet of the Forestry Production Association of the Republic of Tajikistan, which environmentalists consider as creating a potential conflict of interests between the association's twin goals of securing forest resource products and nature protection.

There are a total of 13 nature refuges in the republic, eight of which have complex purposes, i.e. they protect various types of ecosystems, such as pistachio sparse forests and broad-leaved forests, which serve as habitats for rare species of animals. Another three refuges are intended to protect juniper forests and the final two are zoological refuges created to prevent the destruction of the last population of markhor and to protect the brown Tien Shan bear. The total area of these refuges is 3.5 per cent of the republic's territory.

There are three national parks in Tajikistan. The most important of these is the TNP, which started as the 5,000 km² Pamir Reserve in 1977. The creation of the TNP in 1992 greatly expanded this area and is now the largest PA in Central Asia, covering 26,116.74 km² and that, as previously noted, is 18 per cent of the total area of Tajikistan. The TNP is located within the GBAO and mainly covers mountain ranges, glaciers and other mountain landscapes. Forests here occupy insignificant areas (about 10,000 ha) and logging within the TNP is completely absent since the nearest settlements are located far from its boundaries. The size of this national park, while impressive, is nevertheless problematic. Its boundaries are not marked in many places and at more than 26,000 km², it is too large to be effectively managed. International environmental organizations adhere to the position that nature conservation areas should be of a size that guarantees their manageability, primarily in terms of biodiversity protection[210]. Nevertheless, in 2013, the TNP became the first natural UNESCO World Heritage Site in the republic, an occurrence that, according to local press reports, did nothing to address the very high levels of poaching and cattle grazing in the park[211].

The Sherkent Historical and Natural Park, in contrast, occupies a very small area of only 3,000 ha. It is located on the steep southern slopes of the Gissar Range, in the juniper forest zone, at a relatively high altitude (2500 m above sea level) and 100 km from Dushanbe. The park's boundaries are essentially orographic in nature and the original impetus for organizing the park in 1991 were unique finds in the Shirkent river valley: 400 dinosaur tracks belonging to four genera, one of which was named Shirkentazaurus, after the locality. The main anthropogenic impact on the park is associated with unregulated grazing of cattle, especially in the summer months when herders drive their cattle to summer high-mountain pastures[212].

207 First National Communication on the Conservation of Biological Diversity (2003) Dushanbe. 98 P. (in Russian)
208 Pilkington et al. , 2020.
209 tj-zorkul.pdf.
210 The Mountains...,2017.
211 Karimov K. (2019) Community-based trophy hunting of Ibex and Markhor in Tajikistan. CITES & Livelihoods Case Study. 7 P.
212 Michel S. (2024) Mapping transboundary conservation hotspots for Central Asian

The Sari-Khosor Nature Park, also a small park of 3,800 ha, was established in 2003. It is located on the slopes of the Vakhsh Range and extends from 1500 to 4000 m above sea level. The park was created to protect broadleaf forests, especially walnut forests, and has guaranteed recreational value with improved infrastructure. The park is located 200 km from the capital of Tajikistan, however, due to the lack of roads, it is difficult to access, and even the 40 km journey from the nearest settlement to the picturesque gorges of the park can take five to six hours by car. Indeed, originally there were several villages located within what would become the modern-day boundaries of the park, however, due to the inaccessibility of this area the inhabitants of these villages were resettled in Soviet times[213].

The optimality of Tajikistan's PA system can be assessed by its connectivity and representativeness in relation to the main types of natural complexes, key biodiversity areas (KBA and IBA) and the geography of the distribution of red-listed species. The connectivity of the PA system of Tajikistan is estimated at 0.47 (on a scale of 0 to 1, where 1 is the maximum), this indicator is relatively high compared to other Central Asian countries as[214], for example, the connectivity of the PA system in the Kyrgyz Republic is 0.35.

The degree of provision of the main types of natural complexes within the environmental protection regime can be assessed according to the Aichi goals, which require the extension of an environmental protection regime to at least 17 per cent of a country's area. The UNCBD secretariat dossier assesses the representativeness of the existing PAs in relation to the eight main types of 'ecoregions' of Tajikistan, which, according to WWF, are of particular importance for the protection of global biodiversity[215]. The average level of protection of the country's ecoregions is 22.8 per cent, which exceeds the Aichi indicator. However, the representation of ecoregions in Tajikistan's PA system is extremely uneven *(see map 'Ecoregions' and Table 14)*. The vast majority of PAs are comprised of the periglacial rocky-glacial landscapes of the Pamirs, since 74.8 per cent of the latter's area is within the boundaries of the TNP. The Pamir high-mountain tundra (in the national classification of ecosystems, they correspond to the class of high-mountain deserts) and the high-mountain shrub biome (on the border with northern Afghanistan) are another two ecoregions in which PAs cover significant areas. At the same time, two other ecoregions –

mammals initiative. UNEP/CMS/CAMI/Report Draft/Transboundary Conservation Hotspots. Almaty, Kazakhstan, 12–13 September 2024. 213 P. cms_arg-rs1_inf.2_transboundary-hotspots-study_e.pdf.

213 Dangerous Road to Sari Hosor - CABAR.asia.

214 Aichi.., 2021.

215 Ibid.



*Pamir birch*

the Pamir-Hindu Kush alpine meadows and the Karakoram alpine meadows – are not included in any PAs at all while the forest-steppe ecoregions of the Alai and Gissar ranges have only 4 to 7 per cent of their area with PAs.

In international practice, the main tool for protecting biodiversity is the identification and global monitoring (in IUCN terminology) of KBAs. The criterion for their allocation is the regular presence of species that are under threat of global extinction or narrowly endemic species that have a very small distribution area limited to a given habitat. In total, 20 KBAs have been identified in Tajikistan, most of which are large water bodies[216]. In the absence of detailed information on the geography and population status of species from the global list IUCN, these KBAs were identified by experts mainly based on information on the presence of red-listed species included in national lists. This means that the status of most KBAs still requires scientific verification in terms of their global significance.

According to UNECE[217], in 2022, the average share of PAs covering Tajikistan's KBAs was 18.8 per cent, which is not a high figure. According to the UNCBD secretariat dossier, only one KBA – the Lake Karakul basin, the largest endorheic lake in the Eastern Pamirs and the country – is adequately provided with a conservation regime since a PA (the TNP) occupies more than 98 per cent of its area *(see map 'Key Biodiversity Areas')*. Eight KBAs have between 35 and 57 per cent of their territories that fall within a PA, such as the vast wetland complex on the spit formed by the confluence of the Vakhsh and Pyanj rivers where the oldest PA, the Tigrovaya Balka Nature Reserve, covers 52.5 per cent of the KBA. However, PAs are practically absent in the remaining 11 KBAs which, as noted above, are mainly large bodies of water: lakes Rangkul, Shorkul, Bulunkul, Yashilkul, Drumkul and the Kairakkum reservoir. Most of these are also included in the list of Ramsar sites, although the presence of these sites on the Ramsar list does not mean that they are provided with a nature conservation regime since they are not included in the national system of PAs.

SDG 15.4: By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, to enhance their capacity to provide benefits for sustainable development.

Indicator 15.4.1 is designed as a share of PAs in mountainous regions. Tajikistan has 3 million ha of PAs, or 21.58 per cent of the country's territory, which is one of the highest rates in the world. Almost all these PAs are located in the mountains. The area of the TNP, which covers primarily the high-mountain rocky-glacial landscapes of the Pamirs, is 2.6 million ha. Therefore, from a formalistic point of view, SDG 15.4 has been achieved, however, most of these mountain PAs are so vast and have such undefined boundaries that they are not and cannot be effectively managed and maintained in terms of the protection they provide. In addition, not all types of the republic's high-mountain ecoregions are provided with a protection regime *(see Table 12)*. Currently, biodiversity monitoring in mountain ecosystems in Tajikistan is not carried out, making it impossible to systematically assess trends in the state of populations of individual animal and plant species in these hard-to-reach areas. There is only one voluntary project undertaken by an NGO, the Azbuka Prirody Tajikistana (Tajikistan Nature Foundation), operating with the support of the German government, and which recently published field observation data on large mammal populations in the GBAO and provided demographic estimates of ungulates as the main component of animal biodiversity in Tajikistan.

SDG 15.5: Urgent and significant action is needed to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect threatened species and prevent their extinction.

Indicator 15.5.1 uses IUCN Red List data to calculate an index that aggregates changes in extinction risk across species groups. This index ranges from 0 to 1, where 1 means that all species are classified as "not of concern" on the IUCN Red List, and 0 means that all species are classified as "extinct". The index for Tajikistan has a very high value of 0.99, which is the 4th best position among all countries in the world. For regional context, Uzbekistan is in 17th place (where the index is 0.97) and the Kyrgyz Republic is in 39th place (0.89)[218]. Tajikistan applies this indicator unchanged, i.e. based on the IUCN Red List rather than the national Red Book, as was done, for example, in Kyrgyzstan. This can be seen as a positive because the differences between the IUCN Red List data and the Red Book of Tajikistan are significant.

The first edition of the Red Book of Tajikistan (1988) included 226 plant species, 42 mammal species, 37 bird species, 21 reptile species and four fish species. The second edition of the national Red Book (2015)[219] listed 267 higher plant species (5 per cent of the 5,000 described species) and 222 animal species (1.7 per cent of the 13,000 described species), including 44 mammal species, 43 birds, 31 reptiles, 14 fish and nine mollusc species. While this initially appears particularly concerning, the list of species under threat of extinction has expanded significantly since the first edition of the national Red Book because of progress in the study of species diversity in the country rather than a deterioration in the environmental situation. This improved understanding prompted a revision of the risks for individual species, and not necessarily in the direction of a higher risk assessment. For example, in the first edition of the national Red Book, the Pamir argali was included as a "rare species, sharply declining in numbers" based on the first limited field data, which were extrapolated to the entire vast territory of the Pamirs (2.7 million ha) and are three times higher than modern, more realistic estimates. In the second edition of the Red Book, the status of this species was revised downwards in terms of risk and is assessed as "vulnerable"[220].



*Tulipa fosteriana is a species*

The second edition of the Red Book of Tajikistan already used the classification system of species according to the IUCN methodology. In this regime, the least threatened group includes species of minimal risk (LC) and species close to becoming threatened (NT). The group labelled as «globally threatened» includes three categories: vulnerable (VU), endangered (EN) and critically endangered (CR). Of the 44 mammals listed in the national Red Book, 17 species are recognized as vulnerable, 16 as endangered and nine as critically endangered. Of the 43 bird species listed in the Red Book, 16 are recognized as vulnerable, 23 as endangered and four as critically endangered.

This second edition of the Red Book of Tajikistan does not fully harmonize with the IUCN Red List as the latter lists 48 species as «globally threatened», including 12 plant, seven mammal, 15 bird, five reptile and five fish species. Of the seven mammal species on the IUCN list, five are recognized as "vulnerable" and only two (the markhor goat and snow leopard) are endangered (EN). Unlike the Red Book of Tajikistan, the IUCN list does not have any mammal species in the CR category. Of the 15 bird species, only one – the steppe lapwing *(Vanellus gregarius)* – is recognized by the IUCN as being in a critical condition (CR). This species, however, is not included in the national Red Book, apparently because the main population of the steppe lapwing is located in Kazakhstan (in the Ili river basin) and representatives of this species rarely fly into the territory of Tajikistan (only one observation was made in 2024)[221].

216 Aichi.., 2021.

217 Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas - Sustainable Development Goals - United Nations Economic Commission for Europe (unece.org).

218 Red List Index - Sustainable Development Goals - United Nations Economic Commission for Europe.

219 The Red Book of the Republic of Tajikistan: Rare and endangered species of animals and plants. Second edition (2015).Dushanbe: Donish. 535 P. (in Russian)

220 Muratov R. (2025) Who is behind the Pamir hunt? Кто стоит за памирской охотой? | Новости Таджикистана ASIA-Plus. (in Russian)

221 Sociable Lapwing - eBird.

Linking back to a concern raised when discussing PAs, the Amu Darya shovelnose sturgeon (*Pseudoscaphirhynchus kaufmanni)* is also on the international list of particularly endangered fish species. In the national Red Book, this species also has the status of CR. Of particular concern with this species is that it lives in the lower reaches of the Vakhsh and Panj rivers, which means it may be directly threatened by the Rogun hydroelectric power station project *(see map 'The Red Book of Tajikistan: Fish')*.

Of the higher plant species on the IUCN list, five are assessed as being in a critical condition: the Korzhinsky pear *(Pyrus korshinskyi)*, Tajikistan pear *(Pyrus tadshikistanica)*, Darvaz dogwood *(Swida darvasica)*, Darvaz hawthorn *(Crataegus darvasica)* and false-pinnate hawthorn *(Crataegus pseudoheterophylla)*[222]. In the 1988 edition of the Red Book of Tajikistan, only two such species – the Darvaz dogwood and the Darvaz hawthorn – were listed as endangered, in the second edition, which lists 26 species of higher plants in the EN category and 25 in the CR category, cites only one of the five species from the IUCN list – the Darvaz dogwood.

Such discrepancies regarding threatened species in Tajikistan between the national and international Red Lists are considered in this study[223] as a typical situation for the countries of Central Asia. Overestimations of the number and level of threats to species populations may be due to the limited distribution of these species in a given specific territory, while populations may be quite prosperous within the boundaries of a macroregion or in neighbouring countries. The second and more serious factor is the lack of reliable data at the national level regarding rates of population decline (criterion A in the IUCN methodology), which again requires wide spatial and temporal coverage for a well-founded overall assessment of the status of the species. However, some researchers working in the region believe that the responsibility for the discrepancies between national and international assessments lies more with the international expert community[224]. The fact that the IUCN Red List includes only 12 species (six CR, three EN and three VU) is certified by regionally-based researchers as "astonishing" given the fairly good study of the biota of Tajikistan (the link goes to the ten-volume catalog of the flora of the Tajik SSR, which was published from 1957 to 1991) and the high endemism of the fauna and flora of the country. It has been highlighted by such voices that in other global 'biodiversity hot spots', an order of magnitude greater number of threatened species (CR + EN + VU) have been identified, such a sin in Italy - 108, India - 398 and Indonesia - 481. Thus, the low assessment (0.99) of the level of threats to biodiversity in Tajikistan based on indicator 15.1.1 should be revised due to these discrepancies between national and international data on the state of species.

The series of maps presented here on the geography of Red Book-listed species (or at the family level if there are a large number of species) in the Republic of Tajikistan is based on data regarding their locations contained in the second edition of the national Red Book *(see maps 'The Red Book of the Republic of Tajikistan: Flowering plants', 'The Red Book of the Republic of Tajikistan: Lichens, 'The Red Book of the Republic of Tajikistan: Pteridophytes', 'The Red Book of the Republic of Tajikistan: Bryophytes', 'The Red Book of the Republic of Tajikistan: Algae', 'The Red Book of the Republic of Tajikistan: Mushrooms', 'The Red Book of the Republic of Tajikistan: Mammals', 'The Red Book of the Republic of Tajikistan: Birds', 'The Red Book of the Republic of Tajikistan: Reptiles», 'The Red Book of the Republic of Tajikistan: Fish', 'The Red Book of the Republic of Tajikistan: Molluscs' and 'The Red Book of the Republic of Tajikistan: Insects')*. This series of maps shows that most listed species should be protected ex situ as the role of PAs in protecting such species in the category of "globally threatened" is probably very limited due to these PAs being relatively small in size and insufficiently resourced to implement strict protection regimes. According to official data that supports this notion, only 10 to 15 per cent of the red-listed species are meaningfully protected in the national PA system[225]. According to the PA system representativeness index, which shows the representation of rare plant, vertebrate and invertebrate species in PAs, Tajikistan scored 29.5 out of a possible 100 points, the maximum awarded to regimes designed to protect species in need of such[226].

Several pioneering indices have been proposed for global ex situ biodiversity monitoring, however, while they appear comprehensive, they are based on models that still require verification at different spatial levels *(see maps 'Biodiversity Habitat Index', 'Bioclimatic Ecosystem Resilience' and 'Dynamic Habitat Indices')*. At this stage, the interpretation of these indices in relation to ongoing changes in landscape and species diversity due to natural (climatic)

222 IUCN Red List version 2020-1.

223 Milner-Gulland et al. (2006). Application of IUCN Red Listing Criteria at the Regional and National Levels: A Case Study from Central Asia. Biodiversity and Conservation. 15. Pp. 1873–1886. 10.1007/s10531-005-4304-5.

224 Nowak et al. (2020). Red List of vascular plants of Tajikistan – the core area of the Mountains of central Asia global biodiversity hotspot. Scientific Report. 10 P. https://doi.org/10.1038/s41598-020-63333-9.

225 Tajikistan – Country Profile. Main Details.

226 Protected Area Representatives and Connectedness Indices – GEO BON.



*Asafoetida flowers*



*Views from the trekking trail to the Gusgarf waterfall*

and anthropogenic factors in the Republic of Tajikistan may be difficult. On average, the country scores 47.40 on the HBI, where a score of 100 indicates that the country has not experienced habitat loss or degradation in the 2000 to 2020 period, and a score of 0 indicates complete habitat loss. The Bioclimatic Resilience Index of Ecosystems measures the ability of natural ecosystems to maintain species diversity in the face of climate change as a function of ecosystem area, connectivity and integrity. Encouragingly here, with a score of 62.1 and a 34th place ranking among countries in the world, Tajikistan seems to be demonstrating relative resilience to current climate change challenges[227]. Similarly, the Habitat Dynamics Index shows the extent of habitat loss for protected species due to land use change since 2001 and Tajikistan's score of 87.7 out of 100 indicates a stable situation in this regard as well. These index systems allow for accurate comparative assessments of different countries and, in terms of regional context, Tajikistan's scores are similar to those of Kyrgyzstan but significantly higher than those of Uzbekistan. However, one limitation is that there are no examples of the application of the indexes at subnational or local levels in Central Asian countries, making more nuanced assessments difficult.

SDG 15.7: Take urgent action to end poaching of and illegal trade in protected species of flora and fauna and address both the supply of and demand for illegal wildlife products.

There are two indicators to measure progress towards this SDG:

– 15.7.1.1: Proportion of wildlife species that are poached or trafficked in the total number of species in the relevant taxonomic groups (classes);

– 15.7.1.2: Number of permits issued for the export and import of animals and plants, their parts and derivatives covered by the CITES Convention.

The illegal extraction of rare species of animals and plants is an acute problem in Tajikistan, albeit one that can be addressed within the framework of domestic legislation and international agreements where, interestingly, the Republic only joined the CITES Convention in 2015. The Convention requires signatories to control the trade in species (and any parts thereof) listed in its three Appendices: I – species endangered by extinction, trade in which is strictly limited; II – species not endangered, but trade in which may threaten their survival; III – species protected by the country itself and which are objects of international trade.

Fauna in Tajikistan that fall into category I include the snow leopard, and the strictest export controls for this species are mandatory for all Central Asian countries (except Turkmenistan, which is not a party to CITES). Among Central Asian countries, the snow leopard is estimated to be most at risk in Tajikistan[228], with most snow leopard killings being 'acts of revenge' for the damage they cause to livestock herds (a leopard can kill an entire herd in one 'visit'). This does not, however, exclude the illegal trade in snow leopard skins that ensues from such killings. In both the Red Book of Tajikistan and the IUCN list, the snow leopard is listed as "vulnerable" (VU).

The Saker falcon *(Falco cherrug)* is listed in Appendices I and II in all countries in the region. In the Red Book of Tajikistan, the falcon is listed as a "threatened" species (NT) that is declining in numbers due to the illegal trapping of the birds and the removal of chicks from nests for falconry. The Saker falcon is the most frequently seized species in customs reports where, for example, in April 2019, a consignment of 27 live falcons was detected before being exported from Tajikistan to the UAE[229].

Tajikistan's list in Appendix II includes the golden eagle *(Aquila chrysaetos)*, which is widespread in the valleys of Tajikistan but is not numerous and is, therefore, listed in the VU category in the Red Data Book of Tajikistan. Also listed here is the Central Asian tortoise (Testudo horsfieldii), also classified as VU, the argali, whose status has been revised from CR to VU and the Bukhara urial (Ovis vignei), recognized as a critically endangered species (CR) in Tajikistan, but listed as VU on the IUCN Red List. Argali, urial, and other exotic species, such as markhor and ibex are all still commercially hunted. Tajikistan was the second third largest exporter of legal trophies (after the Russian Federation and Kyrgyzstan) between 2010 and 2019, exporting an average of 53 argali, 26 Siberian ibex, three markhor, and two urial trophies per year[230]. However, the actual level of trophy hunting and the biodiversity damage it causes in the country is unknown[231].

Appendix III's list of species protected by Tajikistan but

227 Environmental Performance Index - Bioclimatic Ecosystem Resilience (2024) Environmental Performance Index - Tajikistan

228 Nowell et al. (2016) An. Ounce of Prevention: Snow Leopard Crime. Revisited. TRAFFIC, Cambridge, UK. 72 p. An Ounce of Prevention: Snow Leopard Crime Revisited (PDF, 4 MB).

229 Tokubek uulu et al. (2024).Assessing Wildlife Trade in Central Asia. TRAFFIC. (in Russian)

230 Ibid.

231 Mallon, W. (2013) Trophy hunting of CITES-listed species in Central Asia. Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Geneva, Switzerland. 59 p. (in Russian)

that are objects of international trade cites the plant subspecies of Ferula *(Ferula czatkalensis)* and Ephedra *(Ephedra strobilacea, Ephedra persica, Ephedra intermedia)*, which are, unsurprisingly, also listed in the Red Book of Tajikistan. The most common violation in Tajikistan involving the illegal export of flora products concerned Ferula and, by way of example, from February to January 2023 alone, the customs services of Tajikistan seized seven shipments of Ferula resins weighing about three tons in total[232].

The fight against poaching by environmental protection officers in the republic is difficult due to the remoteness and sparse population of the many mountainous areas where poaching takes place. Given the difficulties a central authority has in protecting the country's valuable species in such remote areas, a new approach has been suggested that involves transferring responsibility for preserving these valuable living resources to local communities *(see Box 6)*.

SDG 15.8: By 2020, take action to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and take measures to prevent, control or eradicate priority species.

Attention to the problem of alien species and their inventory in the countries of Central Asia has appeared only in recent years, which creates uncertainty in estimates regarding the share of alien species in various systematic groups. In Tajikistan, the most studied groups in this context are vertebrates, agricultural pests, weeds and introduced plant species. One of the most dangerous species for juniper communities is the semi-parasitic dwarf semi-shrub *(Arceuthobium oxycedri*), spread by migrating birds. There is also a phenomenon of zonal invasion of species associated with the movement of livestock between winter and summer pastures. In this scenario, species from one altitude zone are transported to habitats that are not typical for them but are suitable enough for such species to gain a foothold and form stable communities of alien and often drought-resistant plants, typically cornflower *(Centaurea)*, wormwood *(Artemisia)*, mallow *(Malvaceae)*, gentian *(Gentiana)*, thermopsis *(Thermopsis)* and borage *(Boraginaceae)*, among others. These weeds are problematic as they successfully displace native species that are more valuable in terms of their forage properties, however, even more damaging are those invasive plants that are poisonous to domestic animals, such as goat grass *(Galega officinalis)*, trichodesma grey *(trichodesma icanum)*, heliotrope *(Heliotropium ellipticum)* and hemlock *(Conium maculatum)*.

The fauna of Tajikistan currently includes about 50 known alien species[233], of which about 30 species are invasive and, of this latter number, 20 are insects. Some of these insects are crop pests impacting potatoes *(the Colorado potato beetle, Leptinotarsa desemlineata)*, fruit trees *(Comstock mealybug, Pseudococcus comstocki and blood aphid, Eriosoma lanigerum)* and commercial crops *(Cotton whitefly, Bemisia tabaci)*. Furthermore, there is a significant range of alien species introduced by human action, including about 20 species of fish and several mammals. Among the latter is the nutria *(Myocastor coypus)*, a South American rodent which was brought and released into the Tigrovaya Balka Nature Reserve in the late 1940s and has now spread to the lower reaches of almost all rivers in the country. Another example is the North American muskrat *(Ondatra zibethica)*, which first appeared in the 1950s in the Fergana Valley but can now be found along most of the country's irrigation systems. A final example in this non-exhaustive list is the Norway rat *(Rattus norvegicus)*, this species is well-suited to life in and around human settlements and entered Tajikistan in the early 1980s as a result of the 'virgin lands campaign' in Kazakhstan in the 1960s.

The issue of alien species in the country is not yet adequately regulated by national legislation. There are, however, several very general provisions on this matter that can be found in the Law on the Use and Protection of Plant Life (Articles 25 and 26, 2004) and in the Law on Plant Quarantine (2001), both of which should be followed by organizations involved in the introduction and acclimatization of various plants. The Plant Quarantine Service of the Ministry of Agriculture of the Republic of Tajikistan exercises State control in the area of alien species and its activities are regulated by the Law on Veterinary Medicine (1996) (Article 3) and on Plant Quarantine (2001) (Article 8). Tajikistan is also a party to a number of international agreements in this area, with the Agreement on Cooperation between the Governments of the CIS States in the Field of Plant Quarantine and the Unified List of Quarantine Objects for the CIS States, both dated to 13 November 1992, being the most notable[234].

*Box 6. Wildlife conservation by local communities*

The Central Asian ibex *(Capra sibirica)* and markhor *(Capra falconeri)*, wild goats native to the Pamir Mountains, are prized primarily as trophies and are hunted in several Central Asian countries, including Tajikistan. Since 2008, these species have been managed and protected by local groups in so-

232 Ibid.

233 Third National Report on biodiversity conservation in Tajikistan (2006) Eds. N.Safarov and others. National Biodiversity and Biosafety Center. Dushanbe. 2006. 158 P.

234 Second National Report on Biodiversity Conservation in Tajikistan (2005) N. Safarov and others. National Biodiversity and Biosafety center. Dushanbe. 116 P.



*Marmota caudata*

called «conservancies»[235]. These groups were created by public NGOs or limited liability companies with the support of the Association of Nature Conservation Organizations of Tajikistan and the German government (through the GIZ), Panthera and others. Currently, eight 'conservancies' (similar to wildlife refuges) manage approximately 300,000 ha, with plans to expand this area by approximately 120,000 ha.

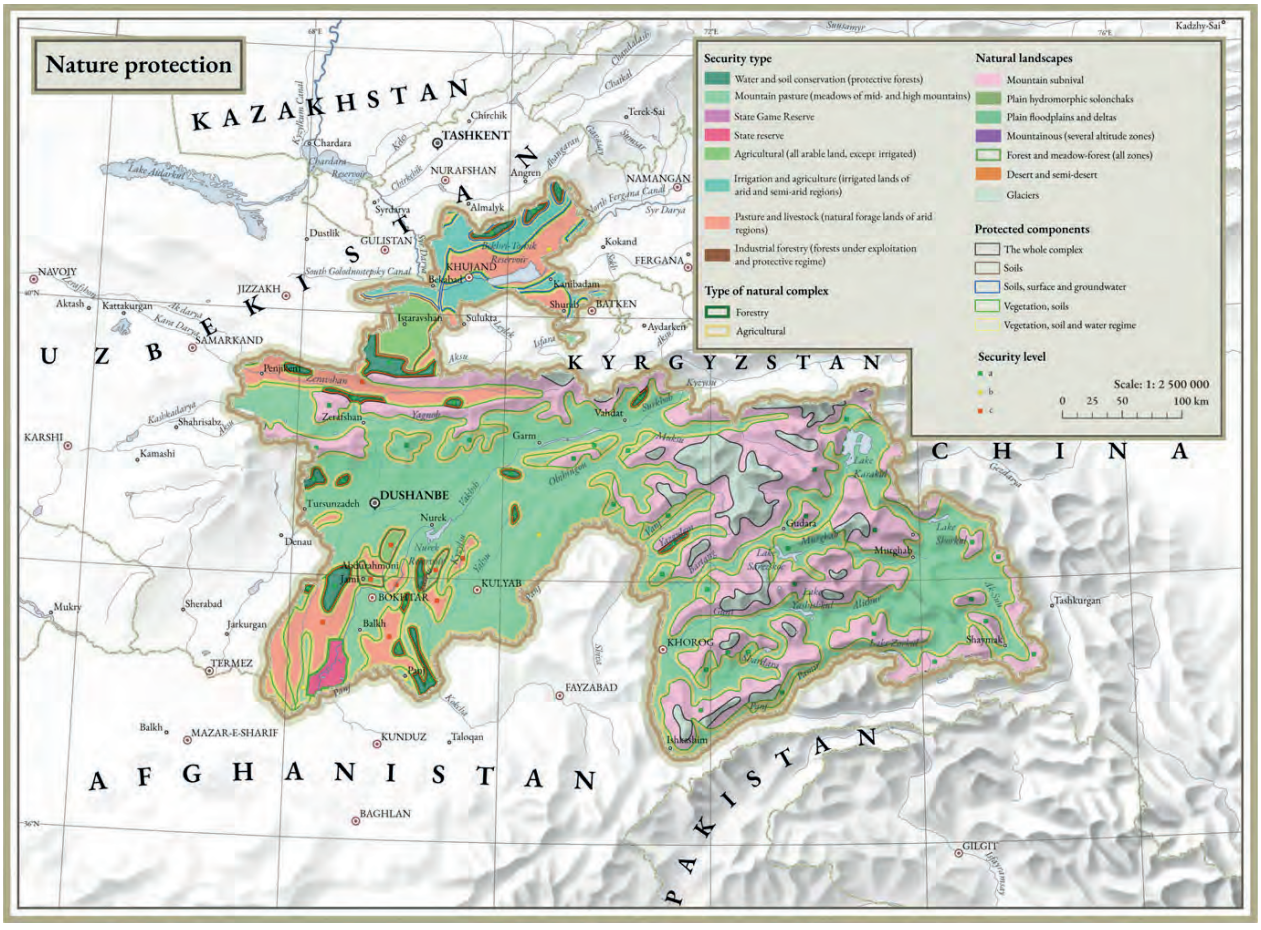
In accordance with the established State quotas, which constitute a maximum hunting limit of 1 to 2 per cent of the population of these species, the permitted harvest of Ibix in each conservation area is limited to 5 to 10 individuals per year (with the population in all conservation areas being approximately 2,500 individuals). Those interested in hunting pay approximately US $4,500 to US $12,000 per hunt, from which the 'conservancies' receive at least US $4,000. The quota for markhor harvesting is 2 to 4 trophies, which can bring the 'conservancies' a profit of US $5,000 per year. From an economic perspective, these 'conservancies' provide about 300 jobs in remote areas of Tajikistan for poor local communities where employment opportunities are scarce. An additional benefit 'conservancies' bring is gender-related: employment and empowerment of women in wildlife conservation is still increasing towards parity levels and the number of female 'conservancy' rangers is slowly growing.

Research suggests that these conservationists are responsible for 2,500 Central Asian ibex and 2,000 markhor, representing about 15 per cent of the current national population of the former and 80 to 90 per cent of the latter. The ibex population in Tajikistan is estimated at around 18,000 individuals, with over 50 per cent of the ibex's habitat essentially unprotected in either State-run PAs or private/community hunting areas. This is because, as previously noted, the size and remoteness of Tajikistan's PAs mean unchecked levels of poaching for meat and illegal grazing are leading to population declines and habitat fragmentation. For example, in the State-run TNP (covering about 30 per cent of the ibex's habitat), levels of poaching and illegal grazing are reported to be very high and resulting in significant damage. Meanwhile, in the Parcham Wildlife Sanctuary, located in Rushan district, south of TNP, the ibex population was 251 in 2009, while the latest census in December 2018 counted 524. In 1997, there were fewer than 350 markhor in Tajikistan. Although the Dashtijum nature reserve and Dashtijum refuge were established in the early 1970s to protect markhor, fuelwood harvesting, unregulated grazing and poaching remained common and continued to negatively impact markhor populations. With the establishment of the first local 'conservancies' in 2005 around the Dashtijum Nature Reserve and Sanctuary, the markhor population began to rapidly recover, with data from 2012 showing that there were over 1,000 individuals, of which approximately 80 per cent inhabited areas within the 'conservancies'.

### 6.4. Responses

- Organization of an effective biodiversity monitoring system that meets international standards.
- Harmonization of all domestic legislation related to biodiversity conservation issues.
- Establish clear demarcation limits of PA boundaries and strengthen their protection regimes.
- Expansion of programmes and assistance to local communities involved in protecting commercially hunted animal species.

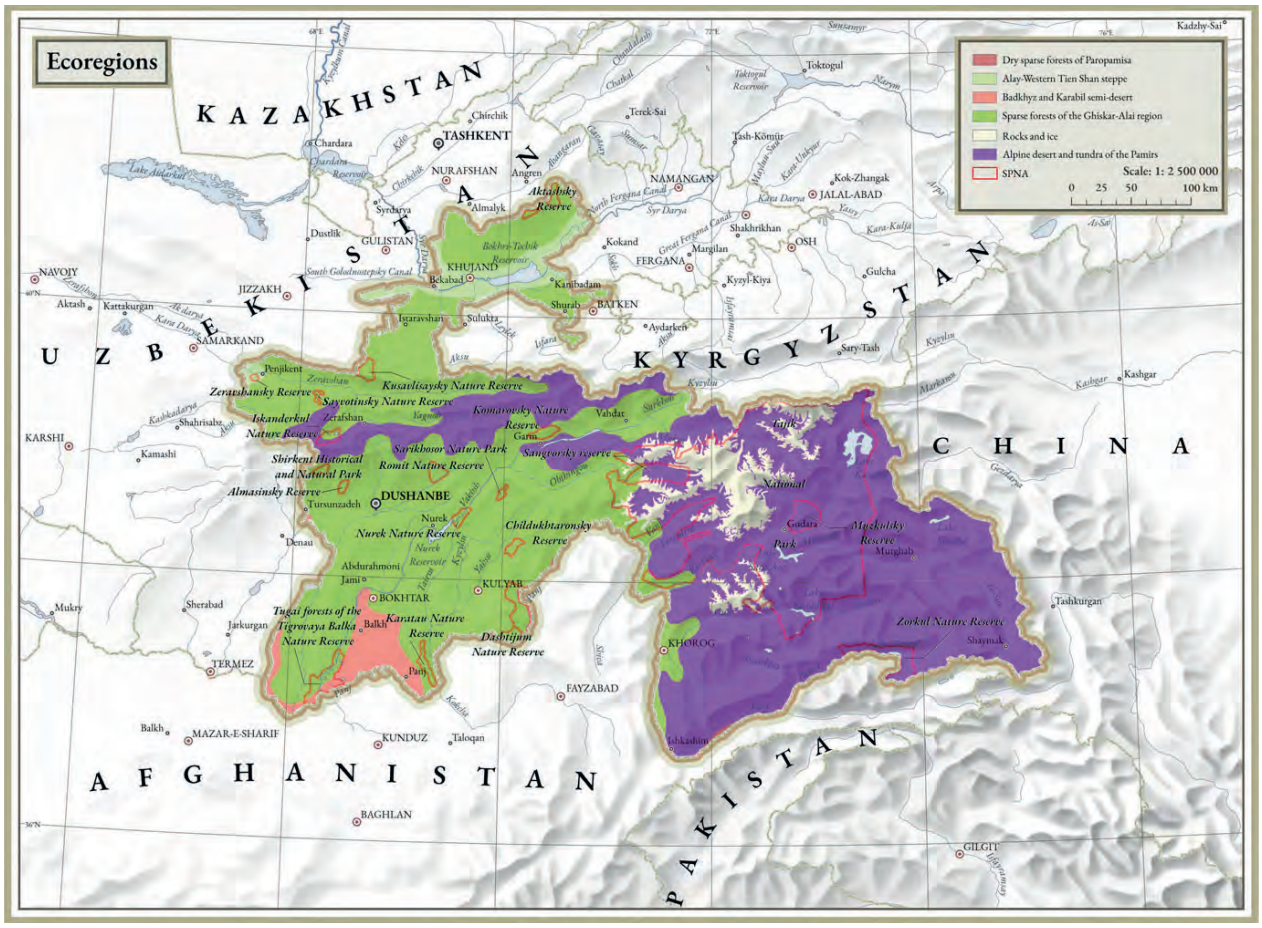
235 Karimov, 2019.




Map 'Nature Protection of the USSR'. Scale 1:4,000,000, GUGK, 1989. Methodical instructions on maps for higher educational institutions. Nature Protection of the USSR /Section written by S.E. Salnikov et al.]. - 1989. - 66 p.




World Database on Protected Areas



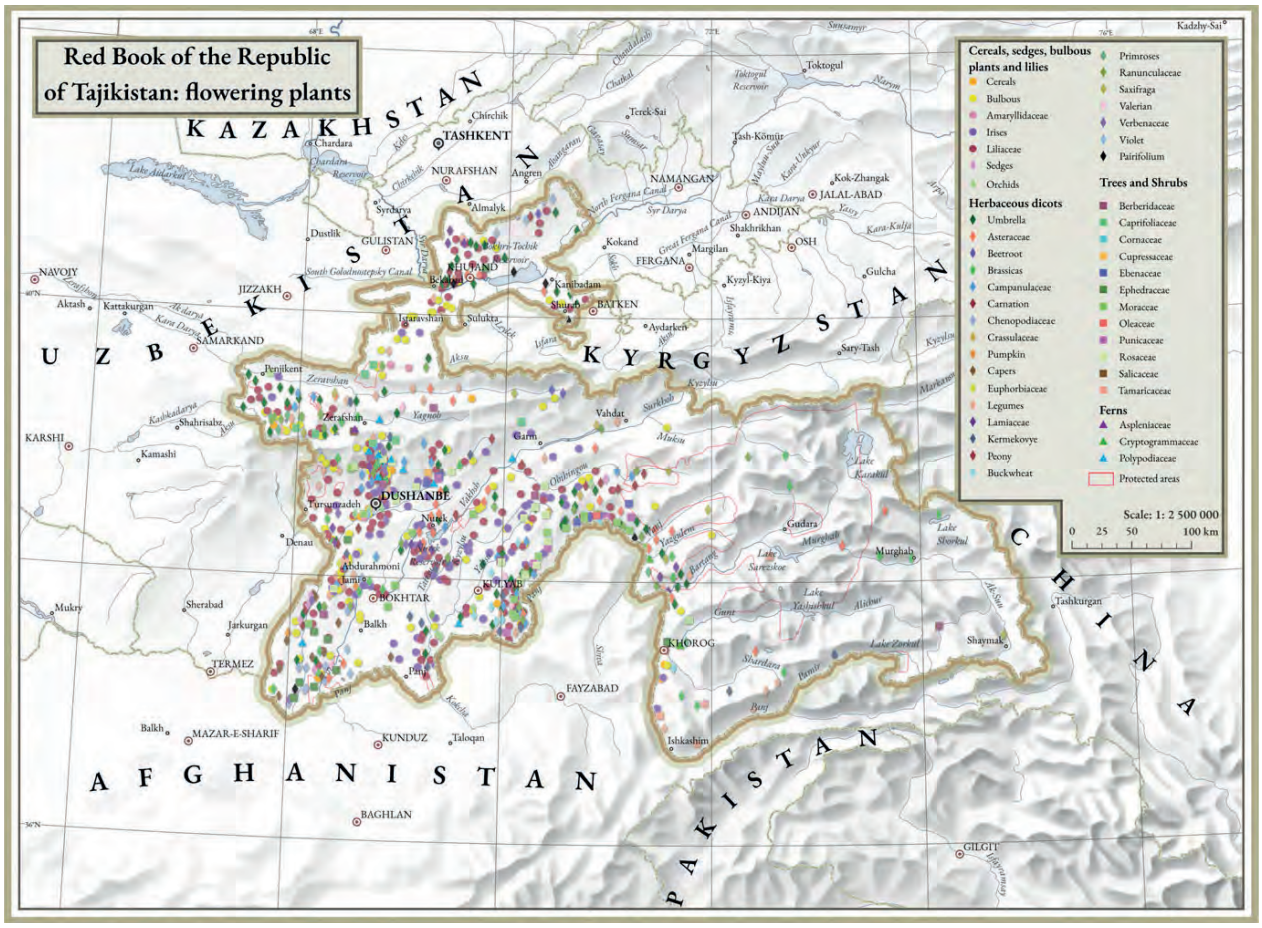

Ecoregions are relatively large areas of land that are important for the protection of global biodiversity as they are clearly distinguished from each other by their habitat and species complexes[236]

236 Terrestrial Ecoregions of the World | Publications | WWF




KBAs are land or water complexes with a large proportion of endemic species in different taxonomic groups (excluding micro-organisms) which determine their special value for the protection of biodiversity at a regional and/or global level.[237]

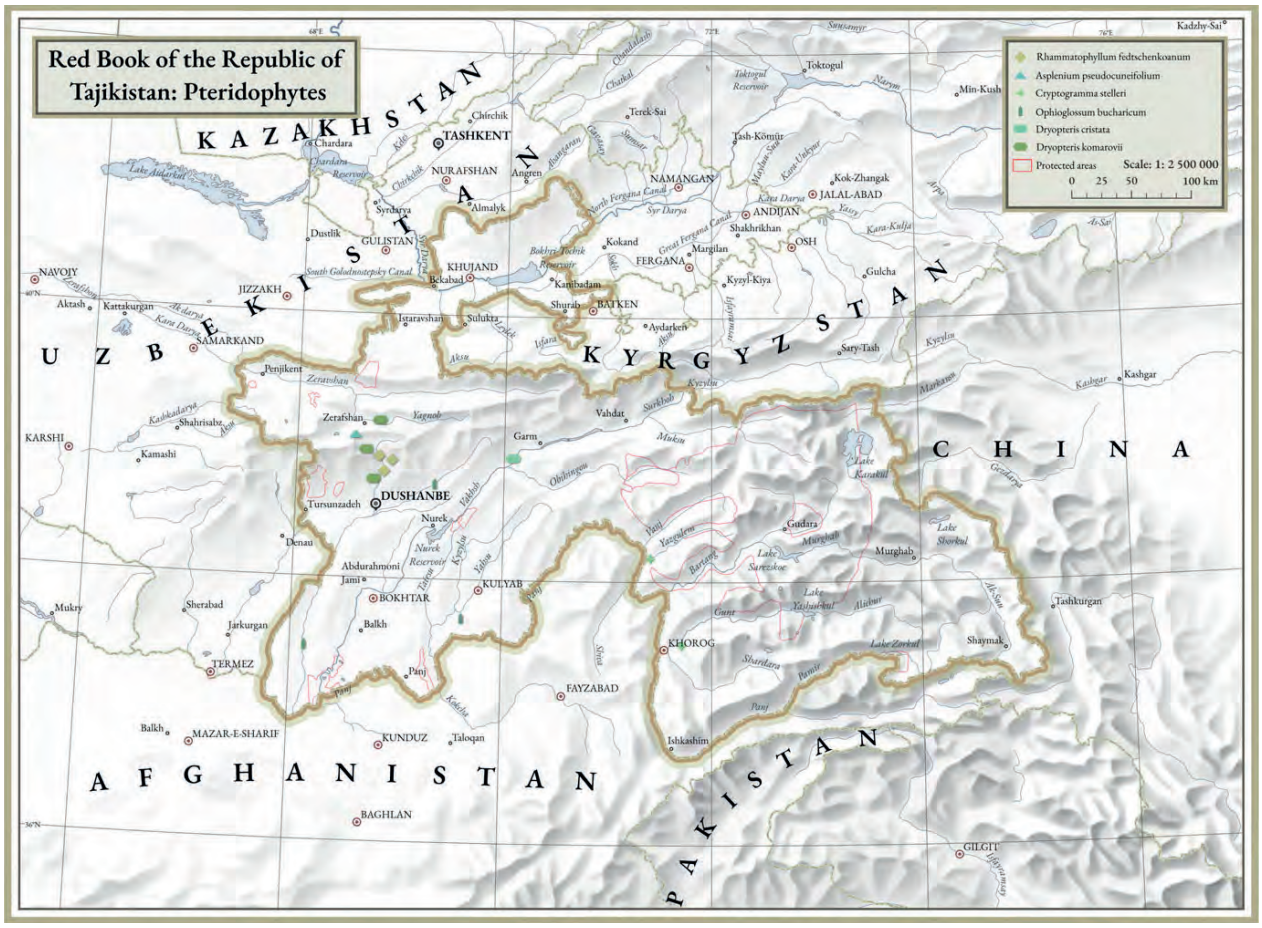
237 BirdLife International (2024) Important Bird and Biodiversity Area (IBA) digital boundaries: September 2024 version. BirdLife International, Cambridge, UK. http://datazone.birdlife.org/site/requestgis.




Based on materials from the Red Book of the Republic of Tajikistan/Academy of Sciences of the Republic of Tajikistan. — 2nd edition, with amendments and additions — Dushanbe, 2017. ISBN 978-99975-45-16-9.




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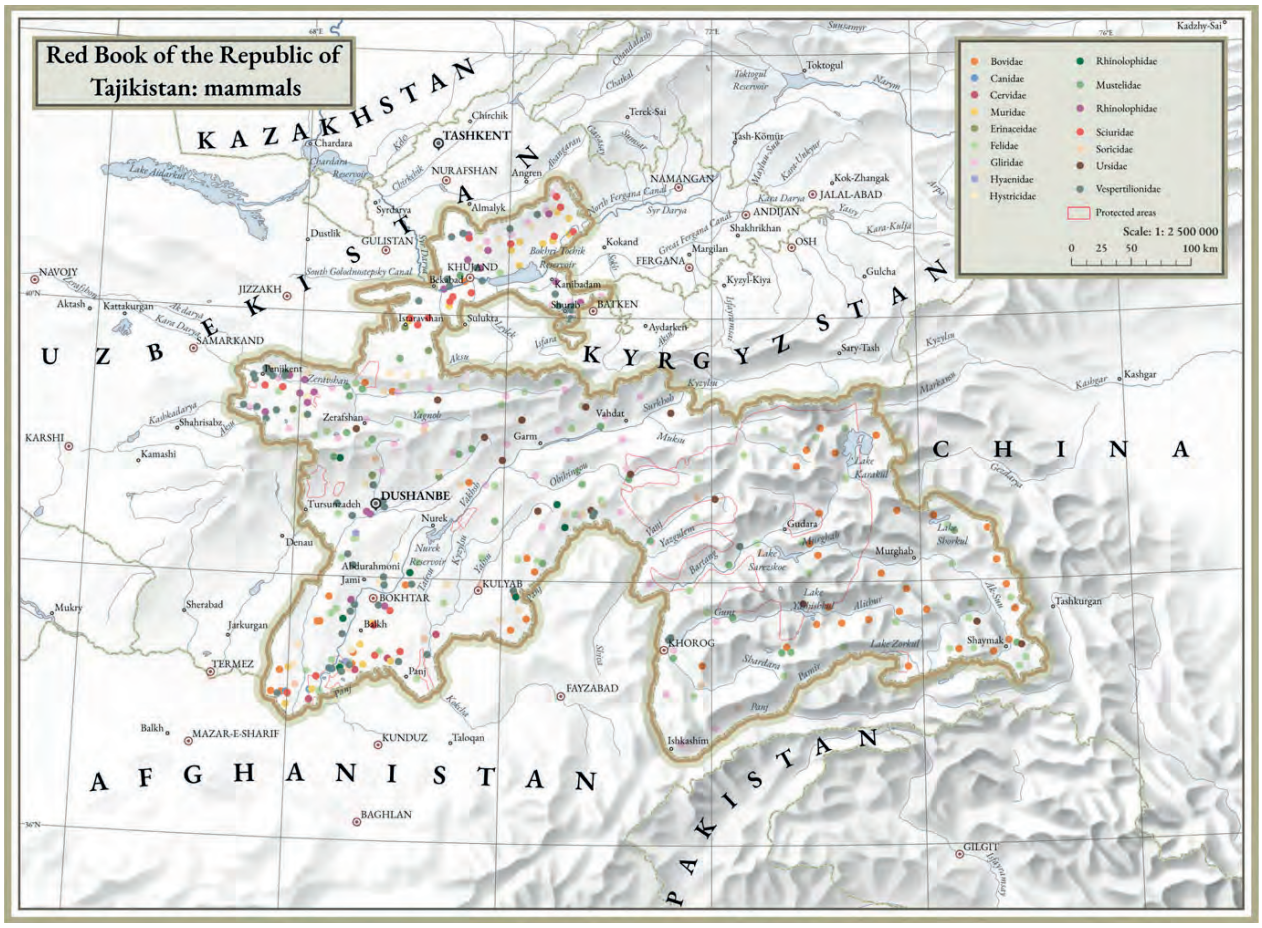

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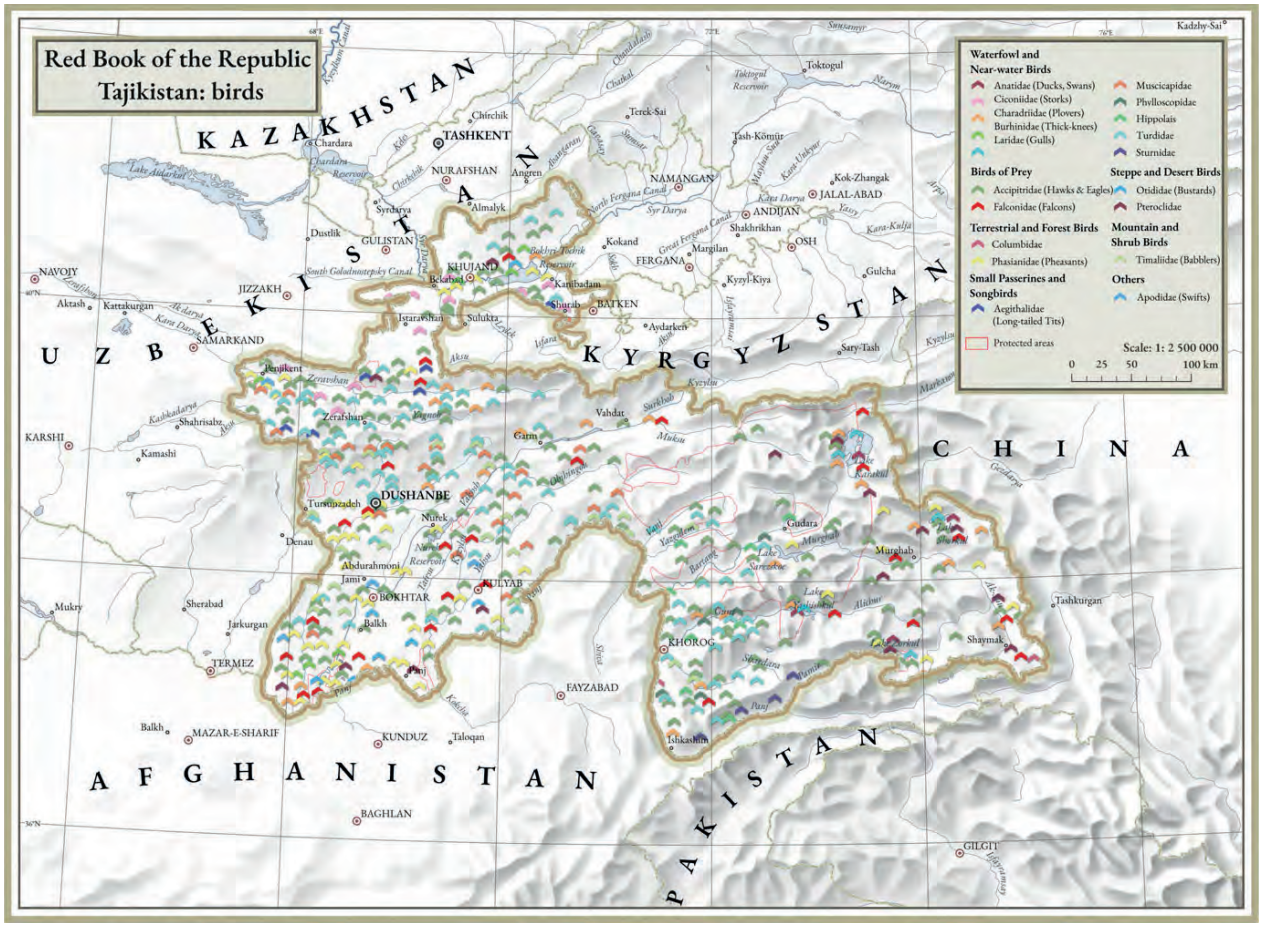

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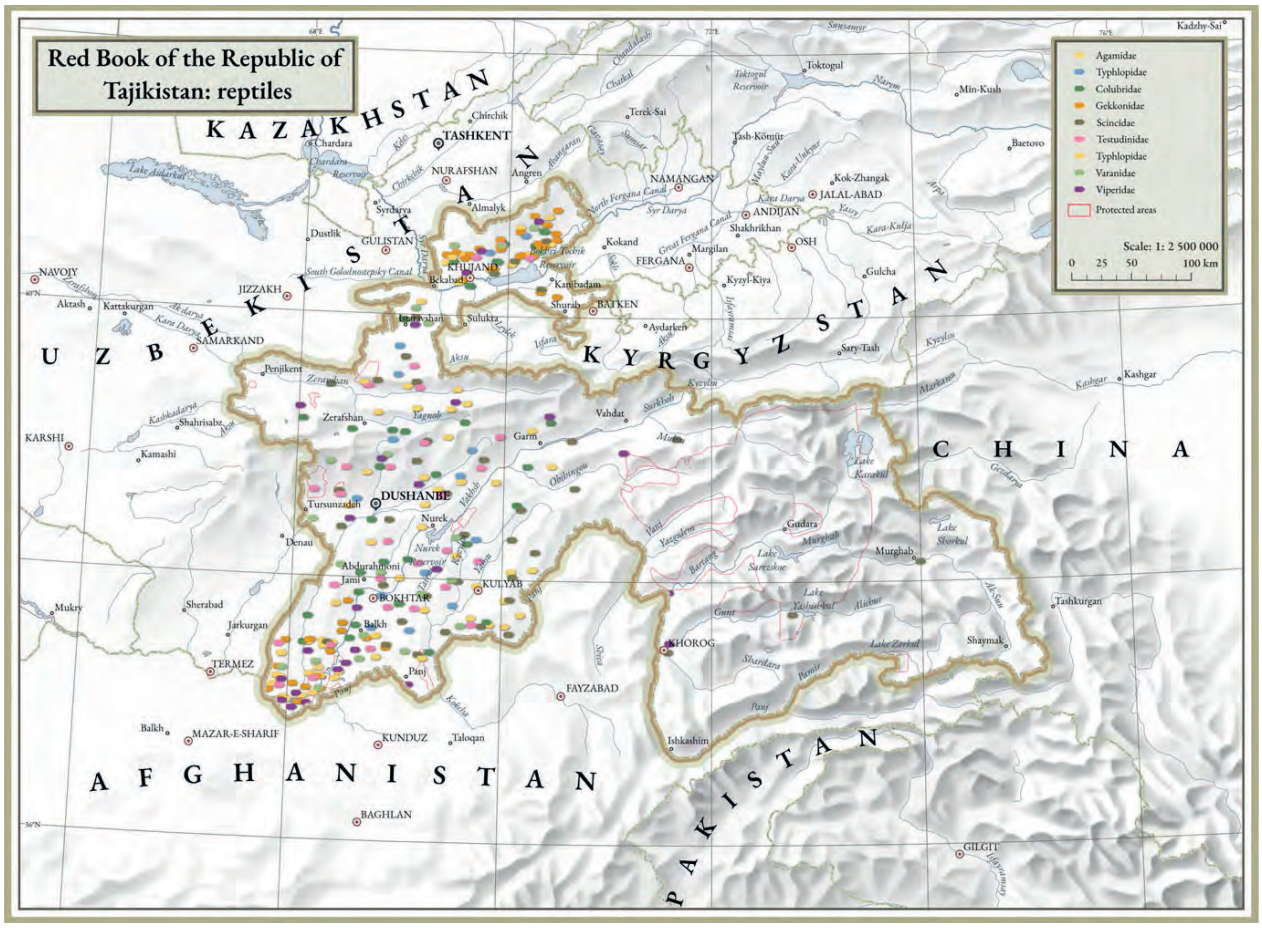

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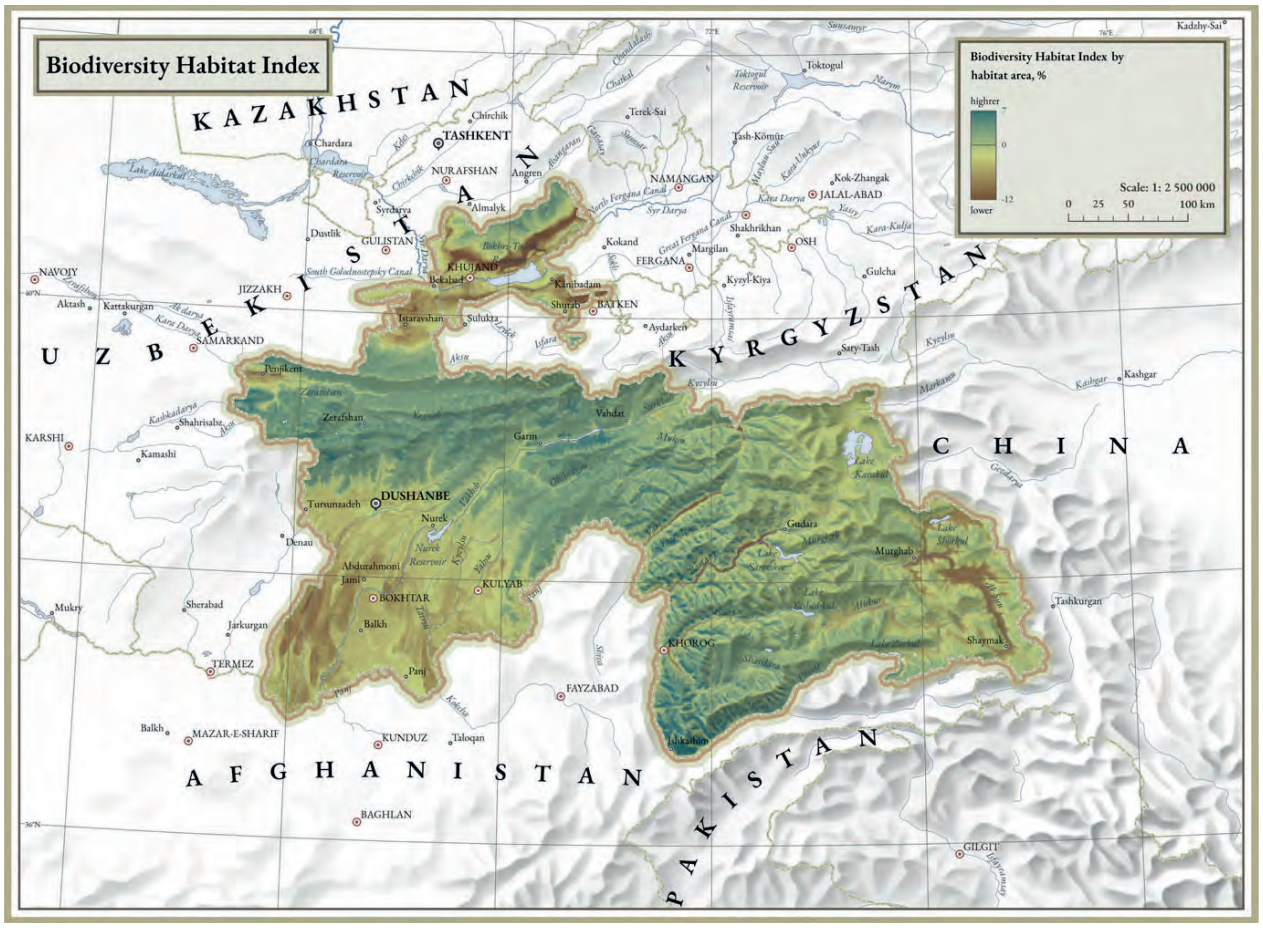

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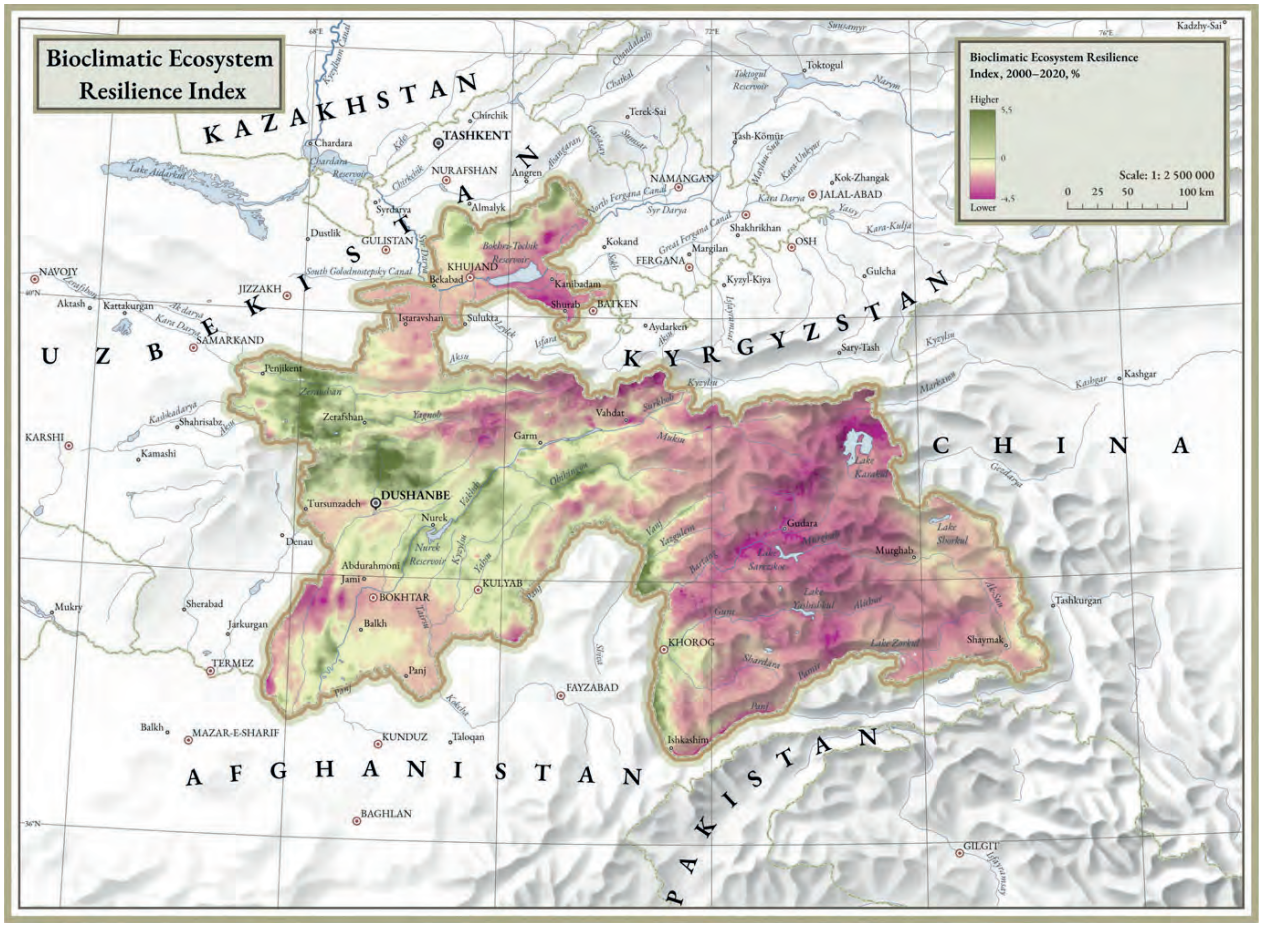



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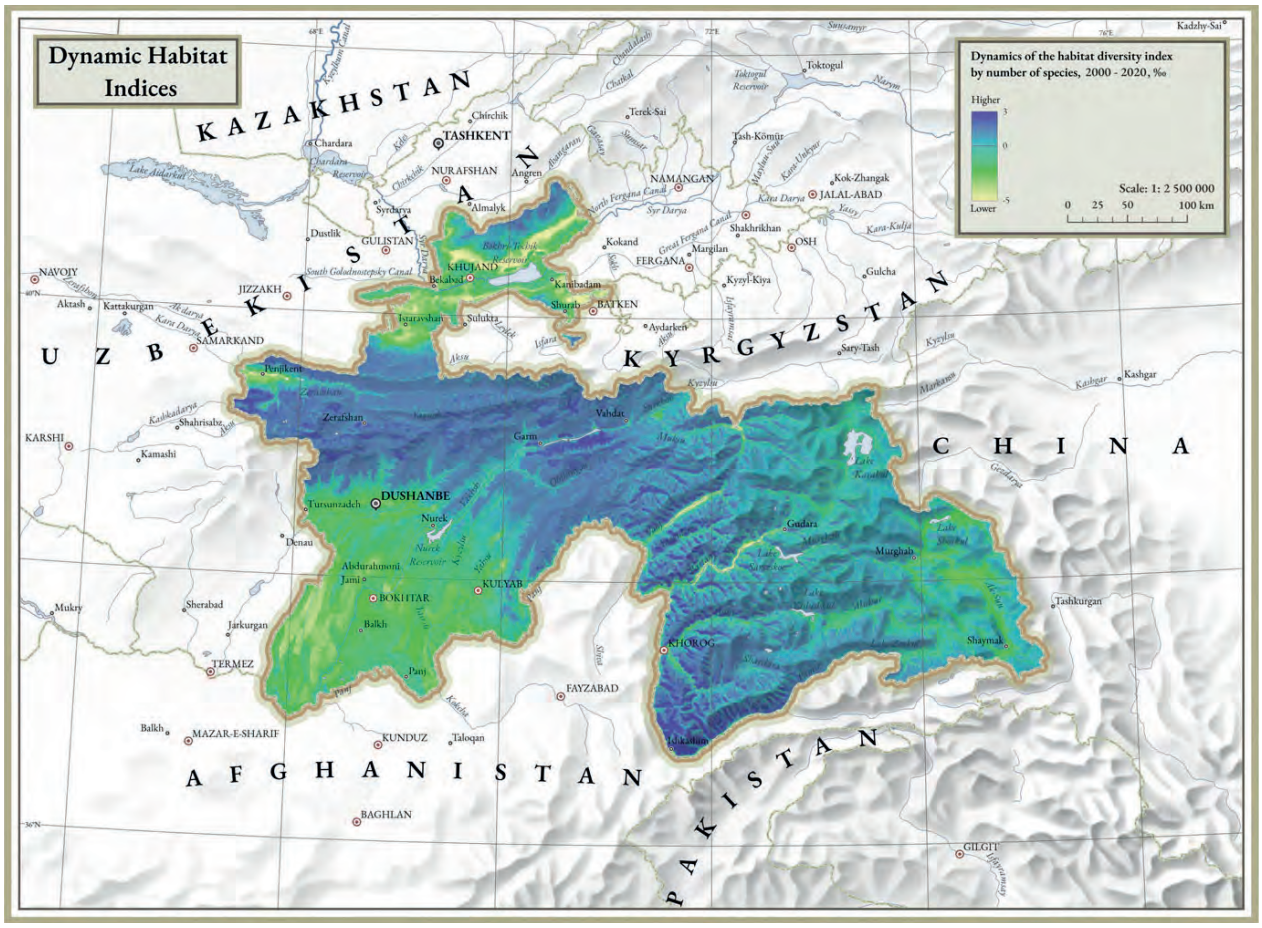

The Biodiversity Habitat Index (BHI v2) is a global product with a resolution of up to 30 arc seconds (approximately one km) and temporal coverage from 2000 to 2020 (in 5-year increments). The model assesses the level of species diversity that will be conserved within a given type of ecosystem (landscape) depending on its area, connectivity and integrity.[238]

238 Harwood et al. (2022).




The Bioclimatic Ecosystem Resilience Index is a global product with a resolution of up to 30 arc seconds (approximately one km) and temporal coverage from 2000 to 2020 (in five-year increments). The model is designed to assess the ability of natural ecosystems to conserve species diversity in the face of climate change, depending on their area, connectivity and integrity.[239]

239 Harwood et al. (2022).




Dynamic Habitat Indices (DHIs) integrate three indicators: annual biomass productivity to assess the energy potential of a habitat, minimum productivity in a year to assess the level of maximum stress, and seasonal variation in productivity to assess the stability of conditions in a given habitat.[240]

240 Radeloff et al. (2019) The Dynamic Habitat Indices (DHIs) from MODIS and global biodiversity. Remote Sensing of Environment. Volume: 222 204-214, https://doi.org/10.1016/j.rse.2018.12.009.



# Natural Disasters



### 7.1. Key aspects

- On average, 500 to 600 natural disasters are recorded in the republic each year, of which, 40 to 50 result in significant human and/or material losses.
- Climate change may lead to a greater frequency and intensity of natural disasters, the assessment of which requires more complete and reliable information, including on the state of glacial lakes.
- Given Tajikistan's mountainous terrain, the presence of numerous complex hydraulic structures and the absence of sufficient maintenance to ensure these structures' functionality significantly increases the country's vulnerability to natural disasters.

### 7.2. General characteristics

About 93 per cent of Tajikistan's territory is covered by mountains, the height of which ranges from several hundred to over 7,000 meters above sea level *(see map 'Hypsometric map')*. The predominance of this mountainous terrain creates complex relief and, coupled with its location within a high seismicity zone, this heightens the country's vulnerability to natural disasters *(see map 'Types of relief')*. On average, 500 to 600 natural disasters are recorded in the republic each year, of which, 40 to 50 result in significant human and/or material losses. In 2023, 557 natural disasters occurred in Tajikistan (in 2022, this figure was 697), of which, 48 caused material damage to the population and the country's economy totalling US $ 7.2 million. Of these 557 recorded disasters in 2023, 335 involved avalanches, 79 mudflows, 26 rockfalls, 22 landslides and were 17 floods[241].

The number of natural disasters, most of which each year are avalanches and mudflows, can vary significantly from year to year. Thus, in 2017, a record number of them was recorded, namely 879, of which, 89 caused significant material damage to the population and infrastructure. The following year, however, only 169 natural disasters were recorded with only 23 being distinguished by inflicting significant material losses. A comparison of these two contrasting years shows that the greatest differences in the frequency of manifestations of different types of natural disasters (causing significant material damage) concerned earthquakes, of which there were 11 in 2017 but none in 2018. In this context, seismic activity can be a significant trigger for the manifestation of many exodynamic processes, especially landslides and rockfalls. The unusually calm seismic situation in 2018 was also determined to be the single most significant factor in the differences concerning the geography of natural phenomena noted in that year's review by the national CES[242]. In 2017, the GBAO, located in the impact zone of earthquakes focused in Afghanistan, experienced the most natural disasters befalling Tajikistan's various regions (30 per cent of all events that led to material damage) and bore the largest share of their material damage (47 per cent). In the following year, the GBAO was the region with the smallest share of emergencies (9 per cent) and suffered the least amount of material damage (0.1 per cent).

The danger of many exodynamic processes, whether triggered by earthquakes or not, is largely associated with human settlement traditionally gravitating towards alluvial fans and temporary watercourses. Agricultural fields and costly transport infrastructure elements are frequently located in such places, which substantially contribute to large material losses when destructive slope processes are activated. Another factor adding to Tajikistan's vulnerability to natural disasters is the presence of complex hydraulic structures from the Soviet period, these require considerable expenditure to properly maintain and this is not being done, making these structures increasingly prone to damage. This creates a particularly vulnerable situation throughout Tajikistan's region when trying to sustain water supplies for hydropower as well as physically protect the population, infrastructure and arable land from floods, mudflows and swamping, all of which can carry serious consequences in terms of individuals' loss of life and livelihoods as well as impacts on the national economy. Of particular concern

241 Natural disasters kill 51 people in Tajikistan in 2023 - AKIpress News Agency.

242 Review of emergency situations and civil defense in the Republic of Tajikistan for 2018. Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan. Dushanbe. (in Russian)

here are structures such as: dams and reservoirs – especially large objects with complex uses (Nurek, Kairakkum, etc.); large pipelines and canals; aqueducts; pumping stations; irrigation and main canals on subsidence soils and slopes; damless water intakes; closed drains; main and group pipelines; water supply systems and so forth.

The traditionally high-profile role of seismic factors in Tajikistan's natural disasters distracts, to some degree, from the expected increase in the intensity of natural disasters associated with climate change, which is also an important factor in the occurrence of mudflows, avalanches, landslides and floods. By 2030, a significant increase in average annual temperatures is expected in most regions of Tajikistan. This forecast coincides with the trends observed in the country over the past 15 to 20 years. Climate change will lead to more frequent extreme weather events and their associated risks (for example, an increase in the scale of floods and longer droughts). Forecasts concerning increases in the intensity of natural disasters due to climate change are not very reliable, however, the general opinion of experts is that the probability of all types of such negative natural phenomena will increase without exception in the short term, the ratios of their frequency will likely be unchanged[243].

**Earthquakes.** The entire territory of Tajikistan is part of the Alpine-Himalayan seismic belt. The ongoing collision of the Indian and Eurasian plates has resulted in the formation of a high-mountain relief that is subject to active fault lines, deformation and the resultant frequent strong earthquakes[244]. The boundary between the two plates runs through the central part of the country from the south to the north-northeast *(see map 'Neotectonics zoning')*. According to the seismic zoning map, many areas of Tajikistan are located in zones that have the potential to experience earthquakes with a magnitude of seven («very strong») to nine («destructive») on the Richter scale, which can occur once every few decades *(see map 'Seismic zoning')*. Historical examples of very strong earthquakes in Tajikistan include those centred on Karatag in 1907, Sarez in 1911, Faizabad in 1943, Khait in 1949 and Gissar in 1989. Two more recent examples of strong earthquakes are the Kumsangir earthquake of 2006, which caused US $1.16 million in damage and in the GBAO earthquake of 2015, which resulted in about US $5 million worth of damage (0.06 per cent of GDP)[245].

The most famous historical example of this kind is the Usoi landslide, associated with the Pamir earthquake of 1911. The earthquake had a magnitude of 9.0 and triggered a large landslide that dammed the Murghab Valley, leading to the formation of Lake Sarez, which is now 55.8 km long, up to 500 m deep and has a volume of some 17 km³ of water. This makes it one of the largest water bodies in the Pamir Mountains, however, given that the reservoir wall was essentially created by a debris flow, the state of the lake is recognized as very unstable *(see Box 7)*. Experts' concerns are related to the likelihood of a breakthrough of the natural dam due to the enormous pressure of the water mass or as a result of a new earthquake, which could cause the collapse of a large volume of debris to fall into the reservoir, forming a destructive wave. In 1968, a large landslide caused waves 2 m high, but the dam held. According to experts, the victims of the scenario where the dam gives way would be the cities and towns on the downstream banks of the Bartang, Panj and Amu Darya rivers, home to about six million people.

Seismic activity with a magnitude of four to five is commonplace in Pamirs *(see map 'Seismic activity in the period 1990–2024')*. The modern period has been relatively calm in terms of seismicity, which is especially noticeable in the example of the GBAO. However, even the advent of relatively low-level seismic activity can be quite significant in Tajikistan due to the poor state of infrastructure and the low quality of housing stock. Earthquakes measuring four points are classed as 'noticeable', while those at five points on the MSK-64 scale are classed as 'emergencies', although if construction standards were to be met, the consequences of such earthquakes for most residents would manifest as swaying furniture and the appearance of cracks in plaster rather than the partial or total collapse of homes. According to the CES, earthquakes measuring four to five points are a common occurrence in the mountains of Tajikistan but even the most frequent earthquakes, measuring only two to three points, can pose a danger to local populations. Thus, on 30 March 2018, dozens of damaged houses were reported in the Baljuvon district of the Khatlon region alone, despite the seismological service of Tajikistan assessing the tremors responsible as 'minor'[246]. The settlements where such damage occurs typically consist of low-rise buildings built in a makeshift manner. These structures are unstable due to the use of locally produced weak building materials (e.g. adobe); the weak adhesion of mortar to bricks; shallow foundations; asymmetrical layouts; being built into niches; having additional buildings adjacent to the main house, along with an array of other similar contributive factors. Almost all the damaged buildings in the 2018 incident did not meet the standards for construction in high-seismic zones[247]. This is a relatively commonplace issue throughout Tajikistan as many settlements spontaneously arose during the civil war in the 1990s and are often located in dangerous areas.

**Avalanches** are the most frequent natural disasters in the republic as almost 75 per cent of the country's territory falls within the 30,000 to 40,000 avalanche-prone areas that have been identified *(see map 'Avalanche activity zones')*. Avalanche activity is controlled by macroclimatic processes; the most dangerous situation is when contrasting air masses collide, such as when warm and humid Mediterranean air mixes with cold, dry Arctic air. Avalanche danger in Tajikistan varies by season, with more than half of all avalanches occurring in March, while the safest months are May and November, with the latter typically accounting for only 1.5 to 2.5 per cent of annual avalanche activity. Furthermore, there are avalanches formed by freshly fallen wet snow and blizzard snow (snow drifts) that causes some differentiation of avalanche activity in mountainous areas *(see map 'Avalanche formation factors')*. With snow-based avalanches, the former are the most numerous, and the latter are the most voluminous. The largest avalanches by volume form at high altitudes where the growing instability of weather conditions, such as sudden temperature changes, is increasingly observed and provokes avalanches.

Most avalanches are reported on by the Ministry of Emergency Situations when they cause damage *(see map 'Density of avalanche cases')*. On average, up to 40 avalanches can be recorded per day, threatening the population and infrastructure. For example, from 15 January to 19 January 2023, up to 200 avalanches were recorded. On 15 February 2023, an avalanche occurred in Khorog, as a result of which 13 people died and 30 were injured. Heavy snowfalls in recent years have also caused significant damage to infrastructure – amounting to several hundred thousand dollars. In 2010 and 2017, avalanches completely blocked the strategic road linking Dushanbe with northern Tajikistan, causing significant economic disruption[248].

**Mudflows** are also a widespread phenomenon in Tajikistan (averaging 70 per year) but are the most dangerous type of natural disaster in terms of lives lost, accounting for an average of 35 deaths per year. About 85 per cent of the country's territory is subject to mudflows and 32 per cent is in zones at high risk of mudflows *(see map 'Mudflow hazard zones')*. Thus, mudflows can occur almost everywhere but the reports of the Ministry of Emergency Situations provide data only on mudflows that directly threaten populated areas, which may create the impression that mudflow activity is concentrated in the Gissar and Zeravshan valleys *(see map 'Density of mudflow cases')*. Catastrophic mudflows occurred in the Garm district (Yaldamich and Navdi villages) in 1969 and 1998, as well as in the vicinities of Penjikent (Shin jamoat), Tavildara (Langar) and Nurek (Navdeh). In 1998, across all of Tajikistan, more than 7,000 houses were destroyed and more than 130 people died as a result of mudflows[249]. An example of a recent catastrophic mudflow is that of one the occurred on the night of 11 May 2021 in the city of Kulyab, this event damaged 1,638 houses, with 35 being completely destroyed and another 96 partially destroyed, additionally, 736 household plots and 602 auxiliary buildings were also swallowed by the mud and stone mixture[250].

243 Assessment of Economic Impacts...,2021.
244 Gubin I.E. (1960) Patterns of seismic manifestations in the territory of Tajikistan, Academy of Sciences of the SSR. Moscow. Pp. 279–294. (in Russian)
245 Takeuchi et al. (2019) Country Note on Disaster Risk Financing: Republic of Tajikistan. Washington, DC: World Bank Group. (in Russian)
246 Новости | КЧС Таджикистана (kchs.tj).
247 National Gender..., 2016.
248 National Strategy for Adaptation to Climate Change of the Republic of Tajikistan for the Period up to 2030 (2019) Dushanbe. (in Russian)
249 Ibid.
250 Новости | КЧС Таджикистана (kchs.tj)

Mudflows are a direct consequence of heavy rainfall, which is often observed in the foothill and mountainous regions of Tajikistan at altitudes of up to 2000 m (at higher altitudes mudflows form mainly from glacial lake breakthroughs). An increase in the number of days with precipitation intensity of more than 30 mm per day can be observed in many places in the republic, for example, on the slopes of the Gissar Range. In general, the number of days with liquid precipitation has increased due to a decrease in the number of days with snowfall. According to climate scenarios, torrential rainfall will become more frequent in the northern part of the country, while in the lower parts of the Vakhsh and Pyanj river valleys, a decrease in precipitation and an increase in dryness are expected.

Another cause of mudflows may be the blocking of watercourses by landslides and glaciers, as well as the accumulation of loose material on slopes and in the beds of watercourses behind dams. Some of the mudflows resulting from such causes are truly destructive, moving at a speed of 60 to 80 km/h and causing significant damage to settlements. The danger of mudflows is heightened by the suddenness of their occurrence as a result of not only prolonged and heavy rains but also the intensive melting of snow or glaciers (so-called 'glacial mudflows'), breakthrough of reservoirs and as a result of earthquakes. Mudflows usually occur in several waves over several hours, with the steep leading edge at times reaching a height of 15 m or more with the accompanying rumble and roar of the fast-moving debris providing little to no warning. To eliminate or reduce mudflow activity, it is necessary to organize continuous monitoring in combination with the development and implementation of new automated means of early mudflow warning.

According to model forecasts, the snow line in Tajikistan will rise by an average of 200 to 300 meters by 2050. Mountain slopes previously covered with snow will be subject to erosion and melting permafrost in the highlands will make these slopes unstable, resulting in an increase in the frequency of landslides and mudflows.

**Landslides.** Tajikistan is recognized as a region with the highest risk of landslide processes not only in Central Asia but in the world[251]. One of the main reasons for this is the widespread occurrence of loess deposits, which are unstable under seismic activity and/or heavy rainfall *(see maps 'Engineering and geological conditions' and 'Forecast of subsidence of loess deposits')*. The thickness of loess deposits in Tajikistan can exceed 100 m, the maximum for this type of formation in Central Asia. These deposits are the oldest in the region and modern research shows that their creation is being accelerated by a process of increased deposition of aeolian dust stemming from dust storms in the deserts of Central Asia, an occurrence that has been happening to a greater or lesser extent for the last 800,000 years[252].

Landslides triggered by seismic events cause have proven much larger and more consequential than those triggered by non-seismic events. As an example, the still unstabilized site of the Baypaza landslide on the Vakhsh River, was triggered in 2007 by an earthquake epicentred in Afghanistan with a magnitude of 6.2. Furthermore, landslides in the area of loess deposits can have extremely destructive consequences, especially so if they are triggered by earthquakes. In July 1949, a magnitude 7.4 earthquake caused hundreds of landslides in the loess deposits in the Yasman Valley, these merged into a single massive loess flow covering a distance of up to 20 km with a surface slope of only 2°. As a result, 20 villages were buried with about 4,000 human casualties numbered, when including the villages destroyed in the neighbouring valleys, the number of victims exceeded 7,000 people. This landslide remains one of the most destructive in modern history[253].

To date, over 50,000 landslide areas have been catalogued in Tajikistan, 1,200 of which threaten residential areas, roads, irrigation facilities and other significant objects *(see map 'Landslide density')*. About 728,000 people (11 per cent of the population) live in such areas[254].

**Glacial lake outbursts.** Rising temperatures lead to the rapid melting and retreat of the marginal parts of glaciers and the appearance of new glacial lakes. These lakes can have a large water reserve and, if they burst, catastrophic flooding may result *(see map 'Density of outburst-hazardous lakes')*. Over the past 10 years, no cases of glacial lake outbursts have been recorded in the reports of the CES, however, in August 2008, a mudflow formed as a result of a glacial lake outburst in one of the upper tributaries of the Kofarendar River and swept down the river valley. This was a consequence of the accelerated melting of the glacier in the summer and resulted in the loss of some cattle grazing in the valley, washed away bridges and damaged both the highway and the head parts of irrigation networks[255].

Of particular danger in the context of glacial lake outbursts are so-called 'surging glaciers'. These are characterized by alternating long, relatively calm periods, when the glacier appears to be stationary, and short periods with sharp increases in the speed of ice mass movement down the valley (surge). Such glaciers can rapidly block river valleys, damming up watercourses and resulting in an accumulation of water which, when they break through, form a mud-rock-ice flow of great destructive force. The most common estimate for the number of this type of glacier in the Pamirs is 820 out of 13,495 glaciers (i.e. 6 per cent). The vast majority of glaciers likely to be classed as 'surging'– up to 80 per cent of them – have an area of 50 to 100 km². The risks of glaciers surging decrease if their area is outside this band, as such, the very large Vanjakh (formerly Fedchenko) glacier is not considered at risk of surging[256].

Scientific observations of glaciers make it possible to identify their inherent rhythm, which can be measured in cycles spanning several years for some glaciers or many decades for others *(see map 'Surging glaciers')*. The rhythm of these cycles is determined by the ratio of annual ice accumulation compared to the critical mass of the glacier, when the glacier begins to move down the valley. Having said that, climate change can affect these cycles, making them longer or shorter depending on a glacier's individual circumstances.

In this regard, the Medvezhy glacier has been studied the

251 Nadim et al. (2006). Global landslide and avalanche hotspots. Landslides. 3. Pp. 159–173.
252 Finaev, A. F. (2014). The model of dust aerosol accumulation in Tajikistan. Geography, Environment, Sustainability. 7(3). Pp. 97–107. https://doi.org/10.24057/2071-9388-2014-7-3-97-107.
253 Evans et al. (2009). Landslides triggered by the 1949 Khait earthquake, Tajikistan, and associated loss of life. Engineering Geology. 109. 3–4. Pp. 195-212.
254 Takeuchi et al.. 2019.
255 Pirmamadov et al. (2020) Risk and consequences of outbursts of high-mountain lakes in Tajikistan / collection Mudflows: disasters, risk, forecast, protection. Proceedings of the 6th International Conference (Dushanbe-Khorog, Tajikistan). Volume 1 // Ed. S.S. Chernomorets, K.S. Viskhadzhieva. Dushanbe: OOO Promotion. Pp. 1–24.
256 Goerlich et al. (2020) More dynamic than expected: an updated survey of surging glaciers in the Pamir, Earth Syst. Sci. Data. 12. Pp. 3161–3176, https://doi.org/10.5194/essd-12-3161-2020.



*Fann Mountains*

most. By Pamir standards, this is a relatively small glacier with a total area of about 25 km2 and a surging part (the 'tongue') occupying 5 km2. The glacier began to be studied by Russian scientists from the Institute of Geology and Geophysics of the Russian Academy of Sciences together with specialists from the Hydrometeorological Centre of Tajikistan and the Tajik National University (as well as a number of other organizations) after the glacier became abnormally active May 1963 and moved 1,750 m at a speed of about 50 m per day. This movement eventually blocked the Abdukagor river valley and resulted in the formation of a lake. Its breakthrough a month later led to the destruction of a site housing geologists and caused damage to a power plant. Stationary research made it possible to determine that the surge cycle of the Medvezhy Glacier was 10 to 15 years long, which allows predictions about its behaviour. However, with a 1°C increase in temperature over the last decade, the accumulation of the glacier's critical mass (about 275 million tons) has slowed down significantly and its advance down the valley in 2001 and 2011 did not exceed 400 and 800 m respectively and did not block the Abdukagor river valley[257]. Thus, while climate change can create circumstances that heighten the risks of some natural disasters, it can simultaneously reduce the risks of others.

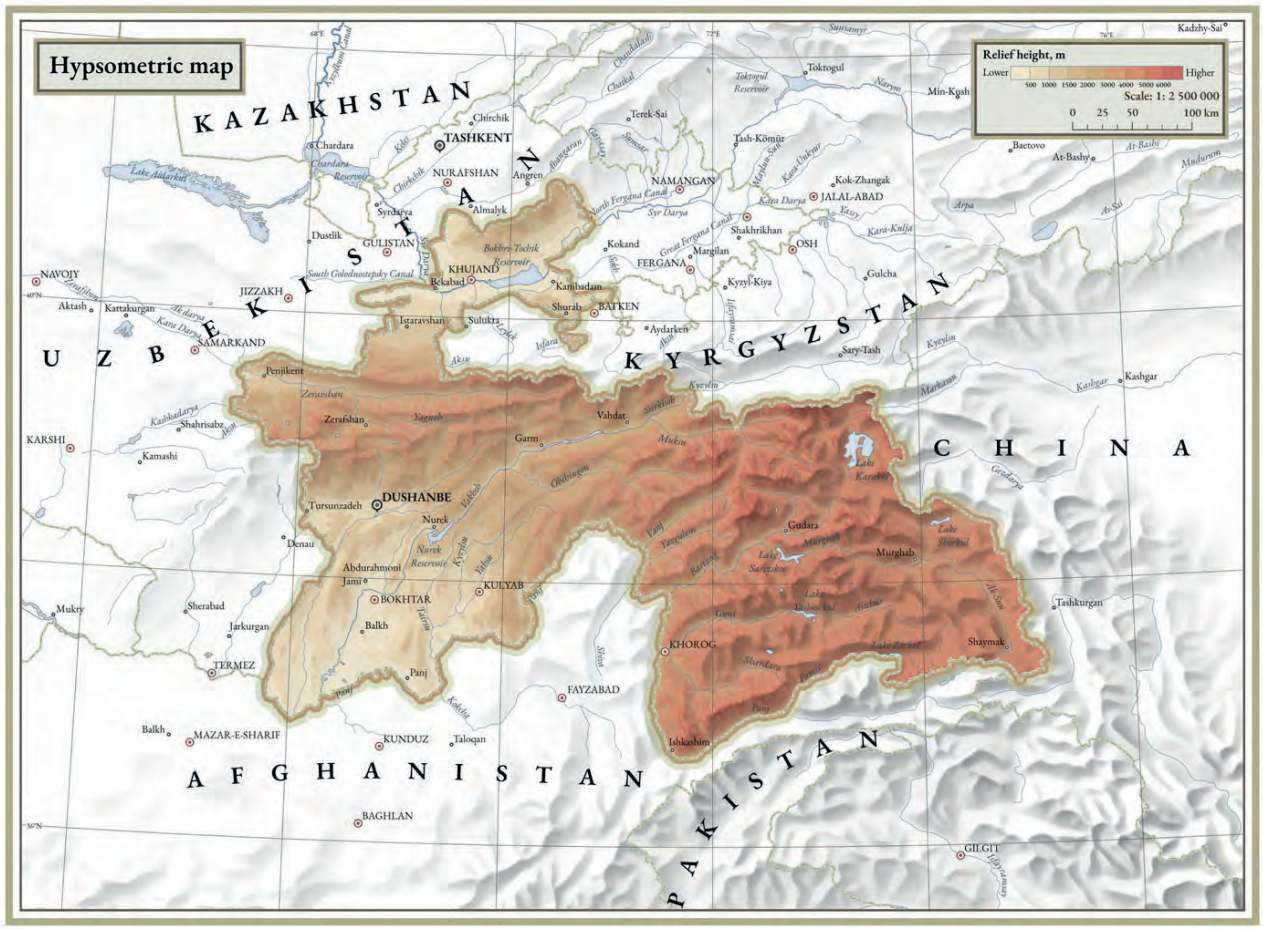
An important modern addition to the forecast models of surging glaciers is advent of continuous satellite monitoring, which allows the identification of the first signs of the onset of glacial surges and the formation of periglacial lakes. However, the lack of adequate hydrometeorological and glaciological information support creates difficulties for the country's integration into the Global Observing System, which would significantly improve the level of international cooperation for Tajikistan. This lack of data, as well as deficiencies in remote sensing capabilities and field observation tools, prevents accurate assessments of the stability of Tajikistan's glacial lakes and subregional glacial dynamics[258]. This shortcoming has been partially eliminated by the implementation of the Glacier Study and Conservation Programme for 2010–2030 No. 209, aimed at establishing a glaciology centre within the Hydrometeorological Service of Tajikistan to perform the special task of creating a catalogue of large, medium and small glaciers and then developing a system for their monitoring and remote sensing.

**Floods** in Tajikistan occur either in the spring after heavy rains or during period of rapid snow melting in the mountains due to warming. The global disaster database lists 143 major floods that have occurred in Tajikistan in the 30 years between 1988 and 2018 *(see map 'Flood density')*[259]. Given its predominantly mountainous terrain, flash floods in narrow valleys are particularly destructive in Tajikistan, a phenomenon added to by rises in river levels due to the accumulation of silt and rocks carried down from the mountains. The southeastern slopes of the Gissar Range, the northern slopes of the Turkestan Range and the southern slopes of the Kurama Range are areas of greatest flood activity, especially in the Yakhsu, Varzob, Vakhsh, Zeravshan and Obihingou river basins. Tajikistan's largest recorded flood occurred in June 2005, when a sudden warming period rapidly melted snow and caused the water level in the Pyanj River to rise significantly, damaging bank protection structures and 4,111 households in the Hamadoni district, forcing about 11,000 people to be evacuated to a temporary camp.

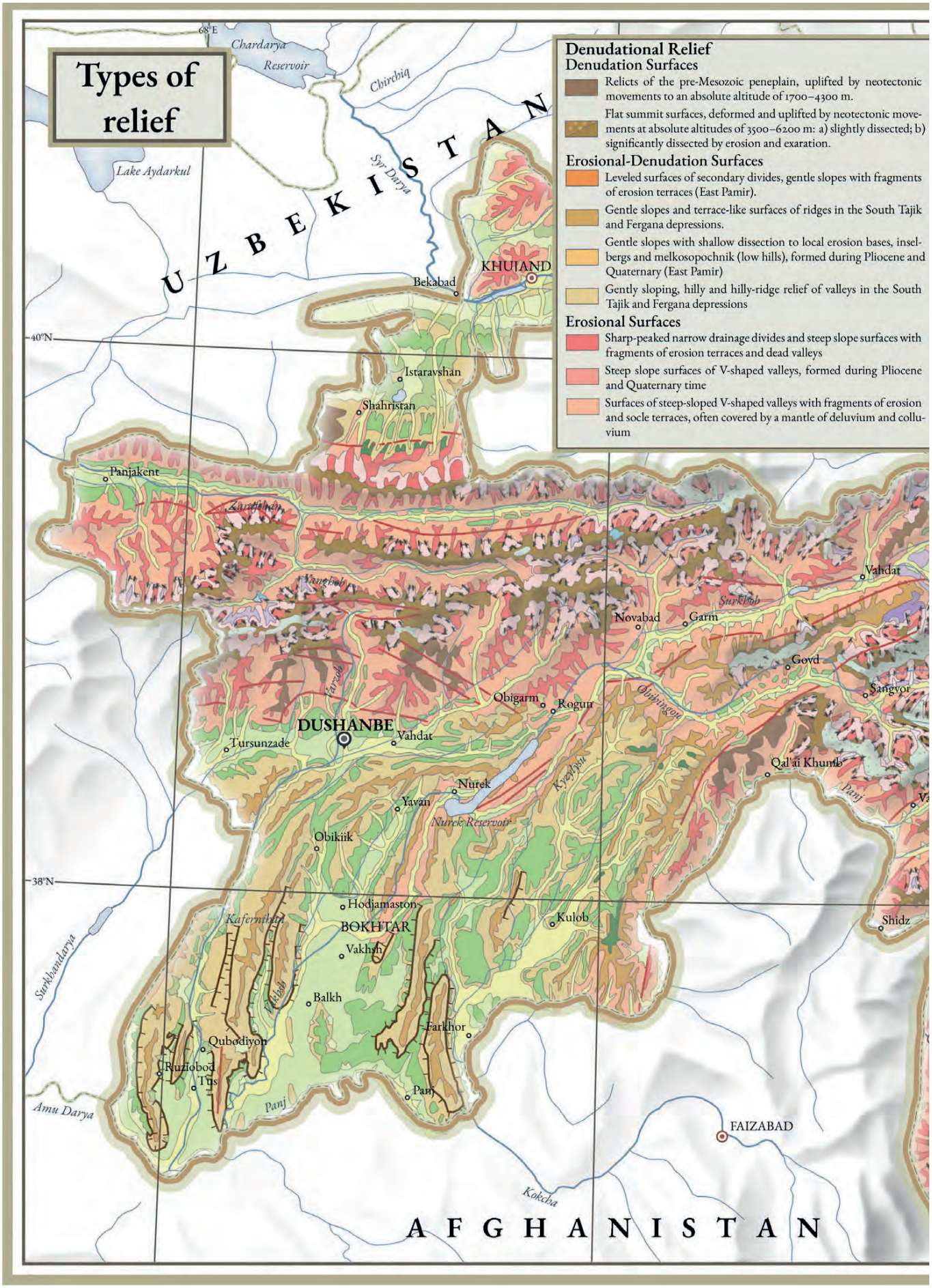
257 Osipova G.B. (2015) Fifty years of research by the Institute of Geography of the Russian Academy of Sciences on the Medvezhyi Glacier, Western Pamir. Ice and Snow. Pp.129-140 (in Russian)

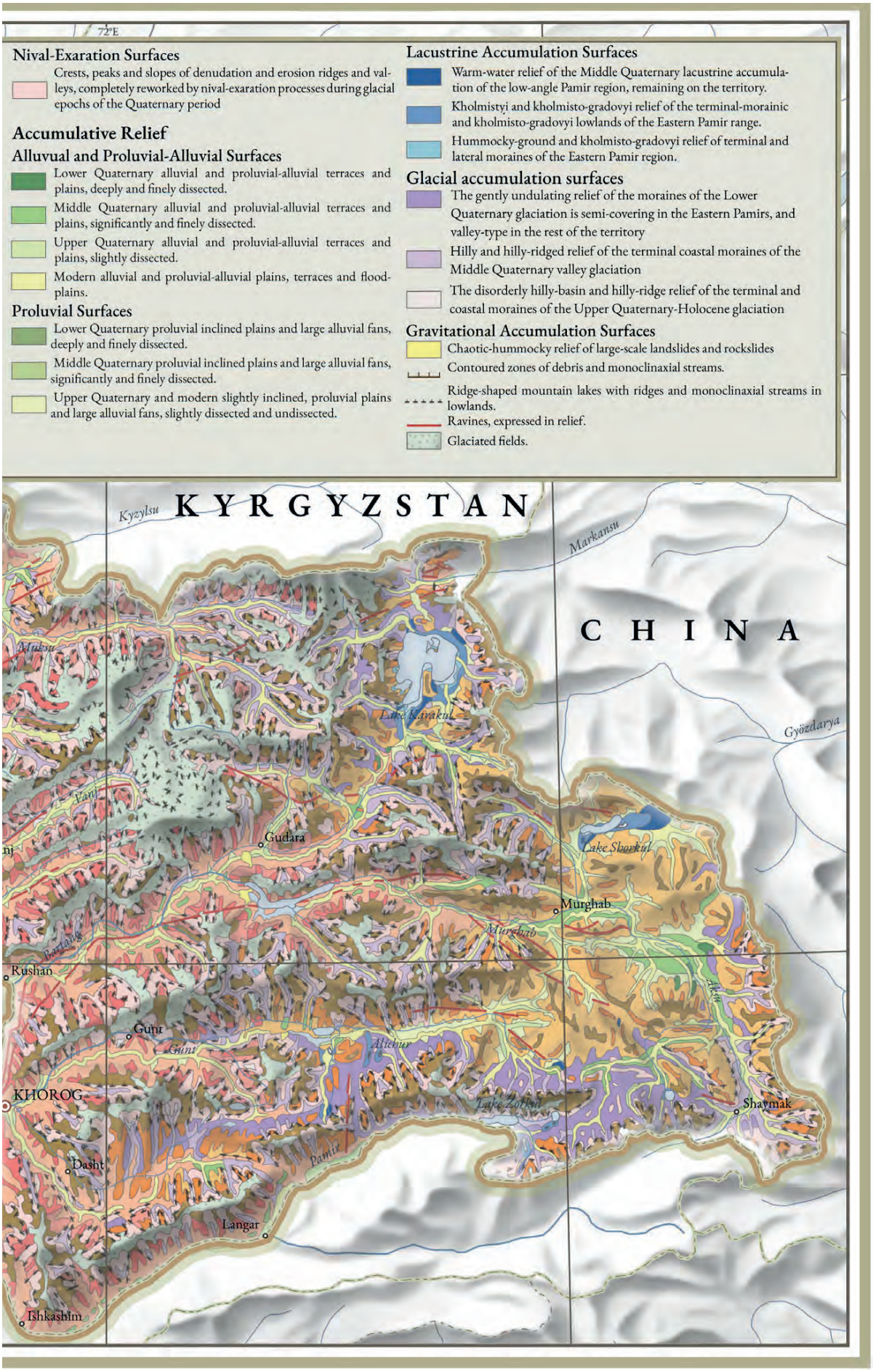
258 UNECE, 2012.

259 Rosvold E., Buhaug H. (2021) Geocoded Disasters (GDIS) Dataset. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/zz3b-8y61.

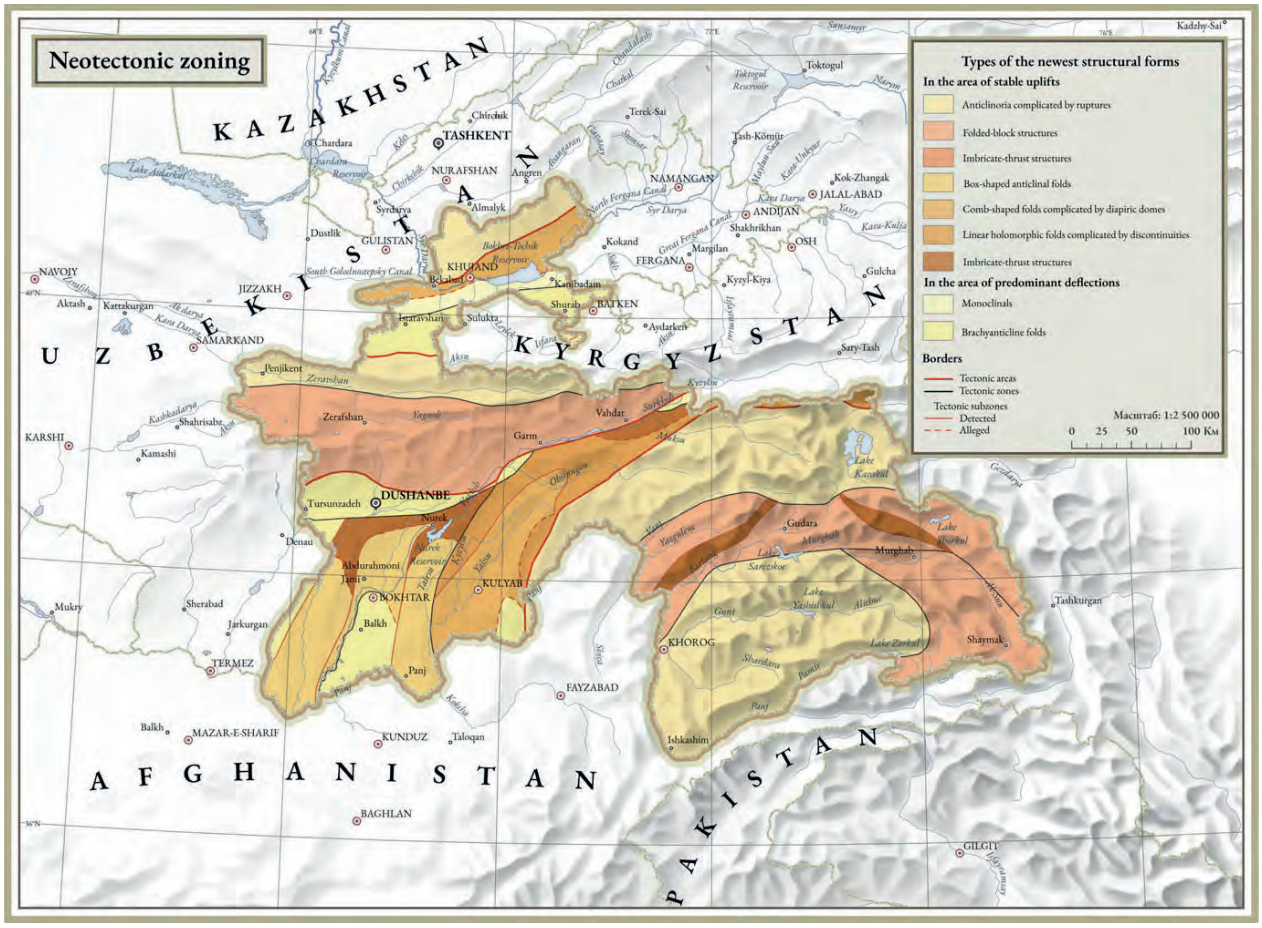



Shuttle Radar Topography Mission 1 Arc-Second Global data

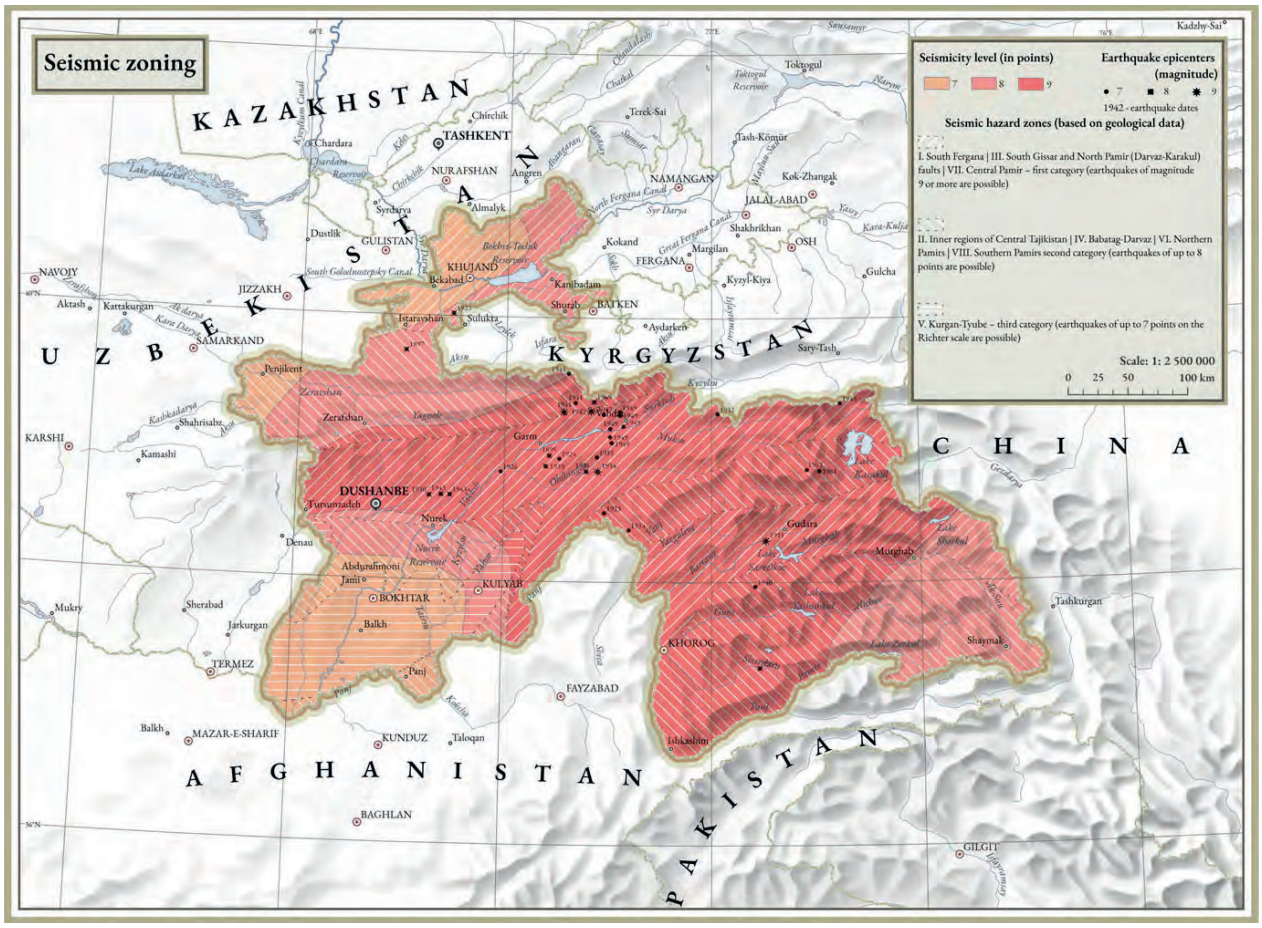

Types of relief
Denudational Relief
Denudation Surfaces
Relicts of the pre-Mesozoic peneplain, uplifted by neotectonic movements to an absolute altitude of 1700–4300 m.
Flat summit surfaces, deformed and uplifted by neotectonic movements at absolute altitudes of 3500–6200 m: a) slightly dissected; b) significantly dissected by erosion and exaration.
Erosional-Denudation Surfaces
Leveled surfaces of secondary divides, gentle slopes with fragments of erosion terraces (East Pamir).
Gentle slopes and terrace-like surfaces of ridges in the South Tajik and Fergana depressions.
Gentle slopes with shallow dissection to local erosion bases, inselbergs and melkosopochnik (low hills), formed during Pliocene and Quaternary (East Pamir)
Gently sloping, hilly and hilly-ridge relief of valleys in the South Tajik and Fergana depressions
Erosional Surfaces
Sharp-peaked narrow drainage divides and steep slope surfaces with fragments of erosion terraces and dead valleys
Steep slope surfaces of V-shaped valleys, formed during Pliocene and Quaternary time
Surfaces of steep-sloped V-shaped valleys with fragments of erosion and socle terraces, often covered by a mantle of deluvium and colluvium
68°E
Chardarya Reservoir
Chirchiq
Syr-Darya
Lake Aydarkul
UZBEKISTAN
KHUJAND
Bekabad
40°N
Istaravshan
Shahristan
Panjakent
Zarafshan
Vanch
Vahdat
Surkhob
Novabad
Garm
Govd
Sangvor
Obigarm
Rogun
Obihingou
DUSHANBE
Vahdat
Tursunzade
Qal'ai Khumb
Nurek
Yavan
Kyzylsu
Nurek Reservoir
Obikiik
Panj
38°N
Hodjamaston
Kafernihan
BOKHTAR
Kulob
Shidz
Vakhsh
Surkhandarya
Balkh
Farkhor
Qubodiyon
Ruziobod
Tus
Amu Darya
Panj
FAIZABAD
Kokcha
AFGHANISTAN



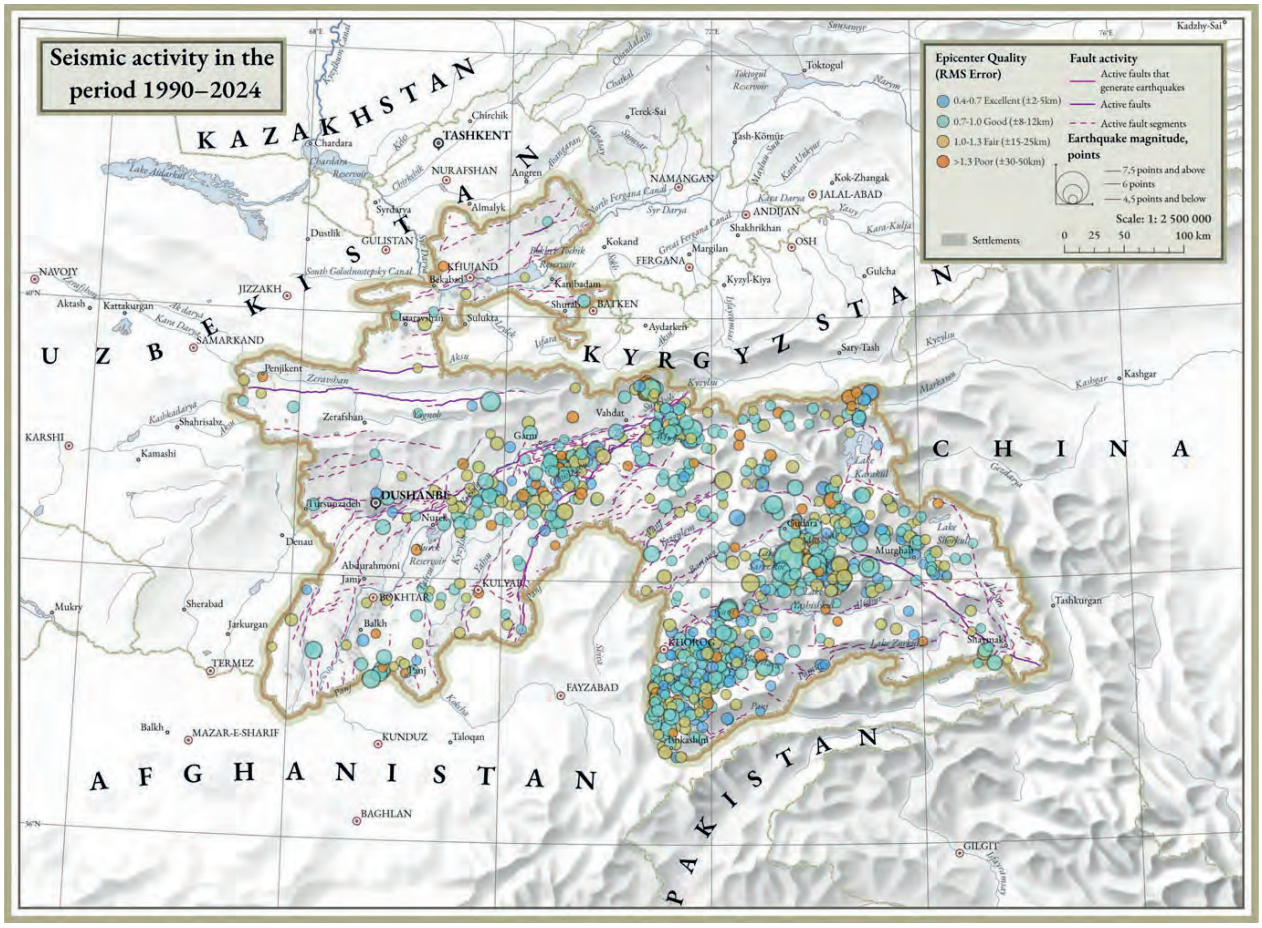

Natural resources of the Tajik Soviet Socialist Republic. I-IV. – Dushanbe-M.: Council of Ministers of the Tajik Soviet Socialist Republic; GUGK, 1983. (in Russian)



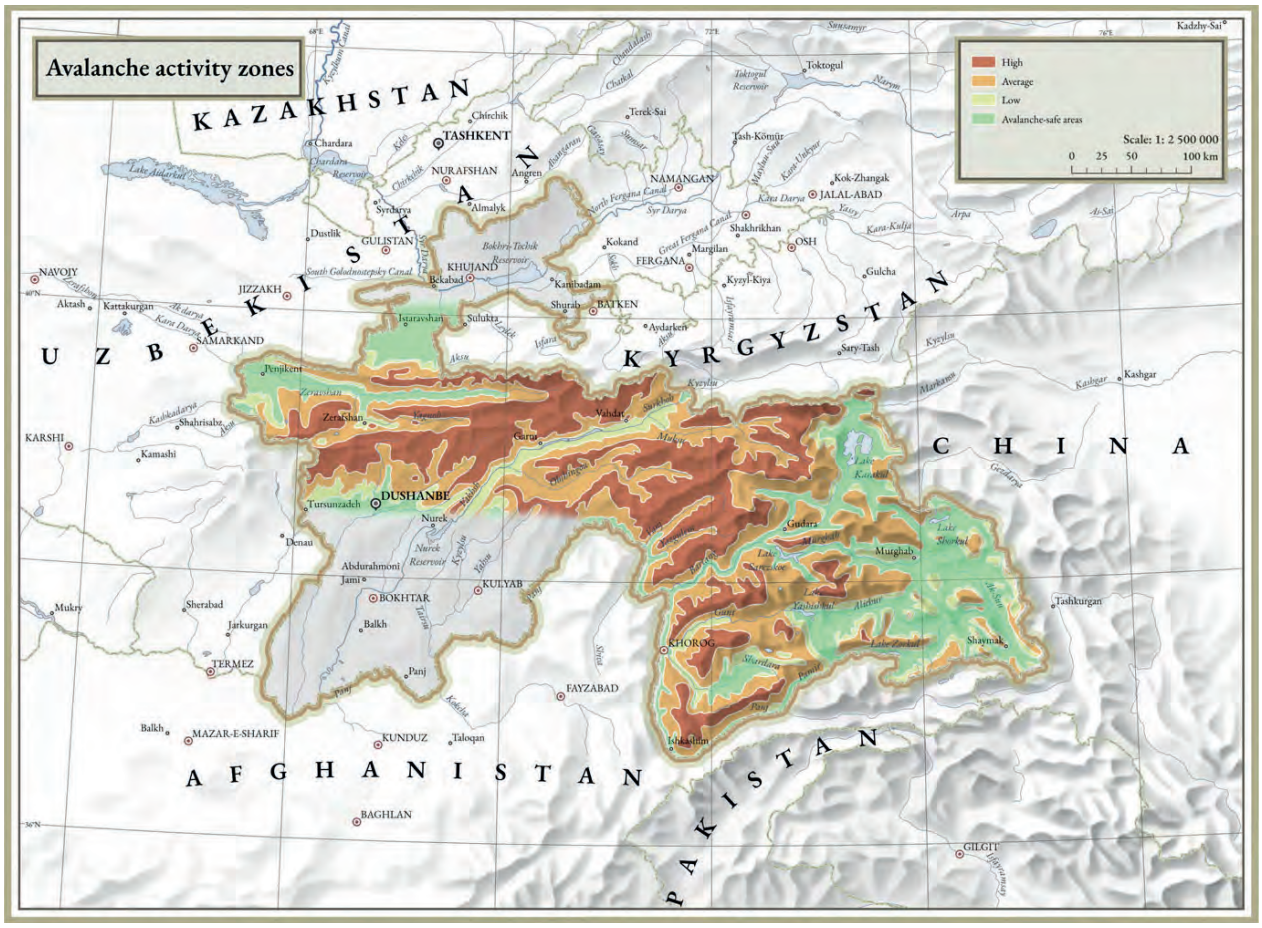

Atlas of the Tajik Soviet Socialist Republic/Scientific editorial board: academician I.K. Narzikulov (chairman) and Prof. K.V. Stanyukovich (senior editor). - Dushanbe; Moscow: GUGK, 1968. 200 p. (in Russian)



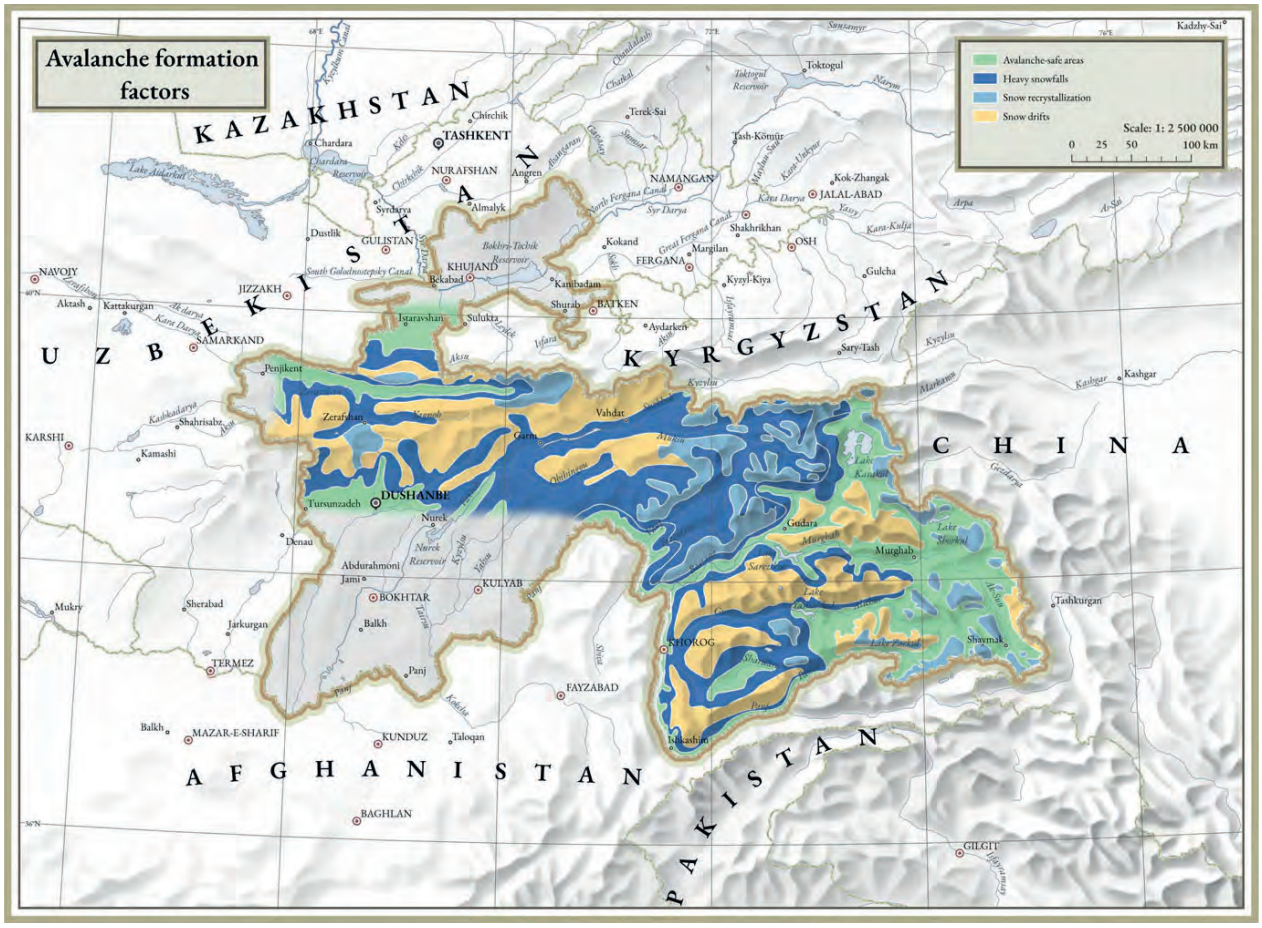

Atlas of the Tajik Soviet Socialist Republic/Scientific editorial board: academician I.K. Narzikulov (chairman) and Prof. K.V. Stanyukovich (chief editor). - Dushanbe; Moscow: GUGK, 1968. 200 p. (in Russian)



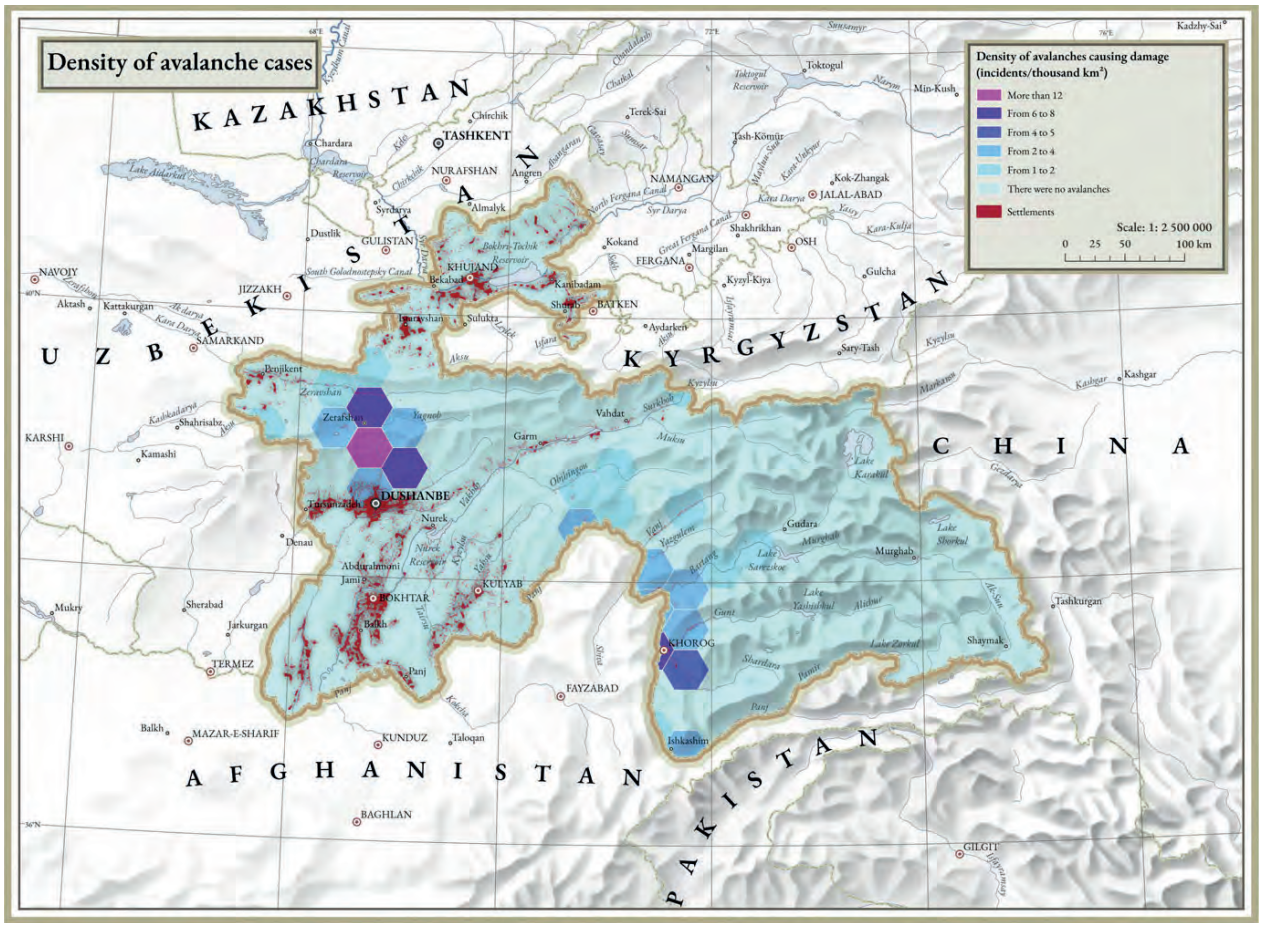

According to the US Geological Survey.




Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)

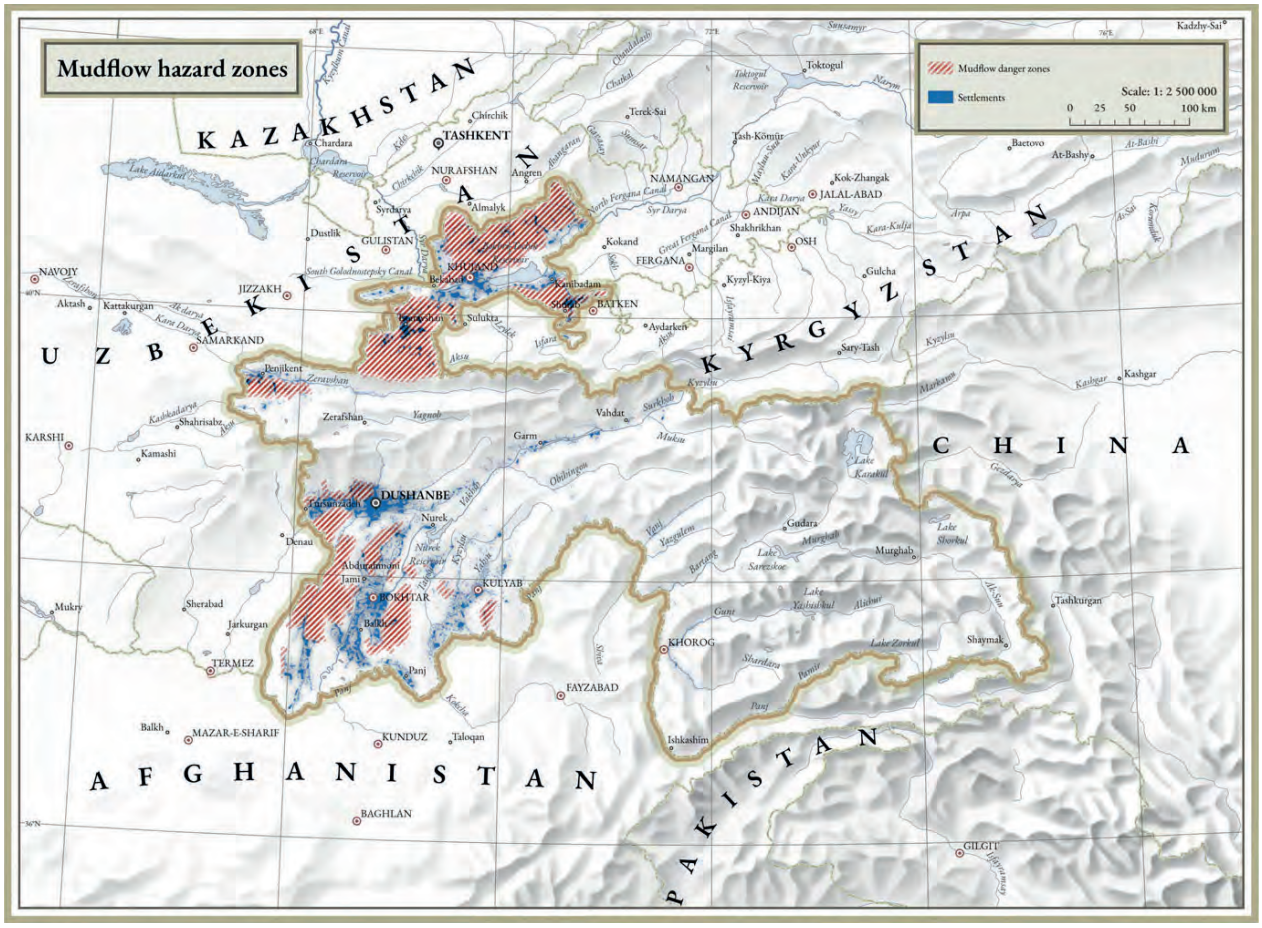



Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)



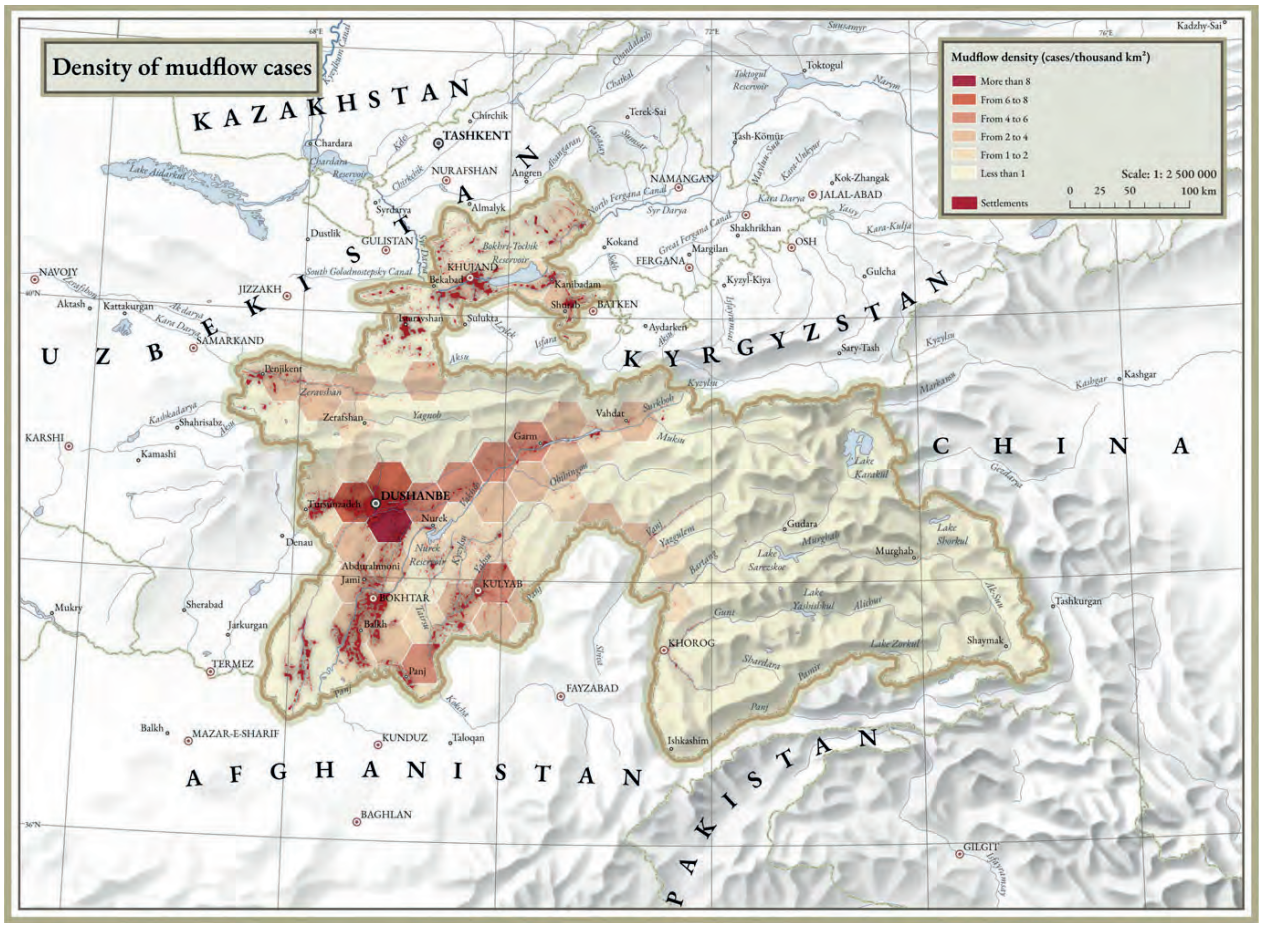

Data on incidents from the Emergency Situations Committee of Tajikistan[261]

261 КЧС Таджикистана




Data on incidents from the Emergency Situations Committee of Tajikistan[260]

260 КЧС Таджикистана




Data on incidents from the Emergency Situations Committee of Tajikistan[262]

262 КЧС Таджикистана

### 7.3. Progress towards the SDGs

The Republic of Tajikistan ratified the UNFCCC in 1998 and the first national policy document related to climate change adaptation and mitigation was the National Action Plan of the Republic of Tajikistan on Climate Change Mitigation, adopted in 2003. In 2007, the Government of Tajikistan adopted the Targeted Comprehensive Programme on the Use of Renewable Energy Sources for 2007 to 2015. This document provides for a number of measures to create a production base and infrastructure for the widespread use of renewable energy sources, including solar radiation, wind, biomass, small rivers and geothermal. Tajikistan signed the Paris Agreement on 22 April 2016, which was ratified by the country's parliament on 16 February 2017. In October 2015, the Government of the Republic of Tajikistan submitted its national commitments to reduce GHG emissions in accordance with the decision of the 19th session of the Conference of the Parties.

Tajikistan actively participated in the consultation process for the formulation of the Sendai Framework for Disaster Risk Reduction, which was adopted at the Third UN World Conference on Disaster Risk Reduction in March 2015. The Regional Platform for Disaster Risk Reduction, which unites the countries of Central Asia and the South Caucasus within the framework of the Hyogo Framework for Action, was also established at this conference. Tajikistan hosted the first meeting of the Regional Platform in July 2016, where strategic directions and priority actions at the national, local and regional levels to reduce the risks of natural and man-made disasters were presented. A further step taken by the Government was the Dushanbe Declaration, which emphasizes the relevance of developing national strategies for disaster risk management at the local level.

Currently, the republic's key documents related to the problem of disaster risk management are the National Strategy for Adaptation to Climate Change of the Republic of Tajikistan for the Period up to 2030, dated 2 October 2019, and the National Strategy of the Republic of Tajikistan for Disaster Risk Reduction for 2019 to 2034, dated 29 December 2018. Climate change adaptation objectives are also reflected in the nationalized SDG 13.1.

SDG 13.1: Enhance resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. Core indicator 13.1.2: Proportion of local authorities adopting and implementing local disaster risk reduction strategies.

The national strategy[263] is aimed at finding measures to reduce risks associated with climate change and to adapt both the population and key sectors of the economy (agriculture, energy, water resources and transport) to the rapidly changing climate. As specific measures for implementation, 33 projects have been proposed that have certain regional (at the provincial, district and local levels) and sectoral linkages. These projects are mainly related to issues of the adaptation of key economic sectors to climate change.

The problem of preventing and mitigating the consequences of emergency situations is defined in the National Strategy as one of seven cross-cutting themes (along with health care, education, gender inequality, etc.). At the grassroots level, adapting the population to climate change will entail developing educational programmes in schools and raising the awareness of local communities regarding various measures and technical capabilities at hand to prevent natural disasters. In practical terms, this means that central and regional authorities should organize preventive work in at-risk communities to clean riverbeds, drains, strengthen riverbanks and so forth.

An important aspect of the strategy is the introduction of the concept of 'environmental migrants'. These are people currently living in environmentally dangerous zones who are subject to planned resettlement to reduce the risk of them falling victim to natural disasters *(see Box 7)*. The basis for the resettlement of farms from dangerous zones is a real threat to the lives of people living in areas prone to landslides, rock falls, avalanches, mudflows, and other natural disasters. It is recognized that there are no comprehensive studies to assess and predict the relationship between aspects of migration and climate.

Another strategic document[264] provides data on natural disaster statistics and forecasts of their more intense and frequent occurrence due to climate change. The bulk of the economic damage Tajikistan suffers each year from natural disasters stems from mudflows. Predicted changes in climate and weather conditions will lead to more frequent mudflows and, paradoxically, droughts, as well as periods of abnormally hot weather and other adverse weather conditions (for example, heavy hail that can destroy crops). To successfully combat such climate changes, it is necessary to

263 National strategy...,2019.

264 National Strategy of the Republic of Tajikistan for Disaster Risk Reduction for 2019-2034 (2018) Dushanbe. portali-huquqi.tj/publicadliya/view_qonunhoview.php?showdetail=&asosi_id=21626.



*An image from the ISS*



*Consequences of the flood*

improve early warning systems and existing risk management methods (for example, with regard to mudflows and droughts). Additionally, developing new approaches to mitigate the severity of the consequences of adverse weather conditions and adapt to them, especially with regard to periods of abnormally hot weather and droughts. A geographical analysis of the occurrence of different types of natural disasters has identified 10 areas within the republic that have an abnormally high number of natural disasters and corresponding human loss. These areas fit into two geographical clusters: the Panj river basin, including the Roshtkala, Shugnan and Ishkashim districts; and the Surkhob river basin, including the Rasht, Nurobod, Tajikabad and Lakhsh districts.

Natural disaster prevention and response are the primary responsibilities of the Unified State System of the Republic of Tajikistan for the Prevention and Response to Emergencies. This agency is also supported by a number of other coordinating bodies, including the CoES at the national, regional, city, district, and jamoat levels, as well as other organizations. In this context, the CoES is the key structure responsible for disaster preparedness and response, as it has a training center and a dedicated structure for monitoring the most problematic areas, such as Lake Sarez.

SDG 11.5: By 2030, substantially reduce the number of deaths and affected people and substantially reduce direct economic losses as a proportion of global gross product caused by natural disasters, including water-related disasters, with a focus on protecting the poor and those in vulnerable situations.

In support of the above SDG, indicator 11.5.1 measures the number of people killed, missing and directly affected by natural disasters per 100,000 population. This indicator is fully consistent with one of the goals of the Sendai Framework for Disaster Risk Reduction 2015–2030 that Tajikistan voluntarily entered into.

As previously noted, the most dangerous type of natural disasters befalling the republic are mudflows, which occur, on average, 70 times per year and result in 35 fatalities. Another relatively common natural disaster is avalanches, which average 27 per year and result in six fatalities[265]. Both types of natural disasters tend to have a limited spatial distribution, however, they occur much more frequently than other dangerous exodynamic phenomena.

National statistics on casualties from natural disasters do not show clear trends due to the extreme variability of this indicator from year to year. The National Strategy[266] states that there are signs of a decrease in the number of natural disasters, but acknowledges that the available statistics from the CES for the period from 1997 to 2018 do not reflect long-term trends since, among other things, this 22-year period was seismically relatively calm.

In terms of human loss, casualty statistics show a weak correlation with the number of recorded emergencies. In 2017, only 31 fatalities were registered despite there being a record 879 registered natural disasters, in 2010, 61 fatalities were recorded in connection with 236 natural disasters. The same unclear picture can be observed for 2020 to 2023 *(see Table 16)*. The number of human casualties, like the natural phenomena themselves, are dependent upon numerous nuanced specifics and circumstances, making it even more difficult to see patterns than it is to manage risks[267]. Across all of Tajikistan, an average of 37 natural disasters and seven fatalities are registered in each region (oblast) annually. Given the extreme susceptibility of Tajikistan to natural processes, these mortality figures from natural disasters appear relatively low as, for example, they are only a fraction of the fatalities recorded in road accidents and accidents on water bodies, which total about 540 cases per year[268].

The main tool for preventing human casualties in natural disasters is now seen by the Government as the resettlement of residents as 'environmental migrants' from high-risk areas. To this end, the Geology Committee of the Republic of Tajikistan has identified 1,471 areas with a high risk of hazardous exodynamic processes, primarily floods, using remote sensing methods. There are 308 such zones in the GBAO, 293 in the Sughd region, 401 in the Khatlon region, 223 in the Rasht district, 236 in the Hisor district and even 10 in Dushanbe. Of the total number of such areas, 639 are considered extremely dangerous. Based on this data, the CES has drawn up a long-term plan to resettle people living in these areas to safer locations[269].

Between 2000 and 2005, a total of 50,000 people from 8,293 families were resettled from high risk areas[270]. Between 2005 and 2010, an additional 7,200 families were resettled. According to the CES, about 700 families currently require immediate resettlement from areas prone to natural disasters, mainly floods and waterlogging, and estimates of the number of potential environmental migrants suggest another 10,037 families will likely need to be resettled in the next few years. For example, in 18 districts of Tajikistan (four in Sughd, 11 in Khatlon and three in the RRS – Districts of Republican Subordination), there are 142 settlements that suffer from permanent flooding and 490 settlements that experience seasonal flooding. One concerning aspect here is that, while the resettlement programme has its merits, those being relocated rarely participate in decisions on the location of resettlement, which causes some resistance to these plans *(see Box 7)*[271].

*Table 16. Natural disasters in Tajikistan and their consequences from 2020 to 2023*[272].

| | 2020 | 2021 | 2022 | 2023 | Totals |
|---|---|---|---|---|---|
| Total number of natural disasters | 213 | 359 | 697 | 557 | 1826 |
| Number of victims | 8 | 42 | 8 | 51 | 109 |
| Economic damage, US $ (millions) | 5.40 | 12.59 | 5.20 | 7.01 | 30.20 |

265 National strategy...,2018.
266 Ibid.
267 Assessment of Economic Impacts...(2021).
268 Tajikistan - Our World in Data
269 Новости | КЧС Таджикистана (kchs.tj)
270 National strategy...,2019.
271 Olimova S., Olimov M. (2012) Environmental Degradation, Migration, Internal Displacement, and Rural Vulnerabilities in Tajikistan. International Organization for Migration. Dushanbe.
272 Safarov et al. (2025) Mapping the territories of the mountain-foothill zone of Tajikistan exposed to mudflows. J. Mt. Sci. 22. P. 16–30. https://doi.org/10.1007/s11629-024-9020-2 .

Indicator 11.5.2: Direct economic losses relative to global GDP, damage to critical infrastructure and disruption of basic services associated with natural disasters.

In line with SDG 11.5.2., the 2018 National Strategy sets the goal of reducing the financial value of damage caused by natural disasters by 2030 compared to the period from 2005 to 2015. Monitoring this indicator is difficult due to large fluctuations in the frequency of natural disasters and the amount of material damage incurred from year to year, especially given that these are two indicators that do not always correlate *(see Table 16)*. Different reports make conflicting claims about increases and decreases in the number of natural disasters[273], however, there is no doubt that the damage and losses that Tajikistan suffers will only increase with rising temperatures and precipitation.

In the years from 1997 to 2018, Tajikistan experienced about 4,194 natural disasters. The total economic losses from these events amounted to US $589 million, or an average of more than US$25 million per year. For example, the damage in 2004 was estimated at US $21 million due to a series of floods and mudflows that damaged agricultural land, and while this figure may not seem high from a global perspective, it nevertheless represented about 1 per cent of the country's GDP at the time. The largest financial losses - which average about US $15 million per year - are associated with mudflows, this is followed by drought (US $5.4 million) and then earthquakes (US $3.3 million)[274].

In 2015, floods and mudflows resulted in record material damage totalling US $100 million, or 1.2 per cent of the country's GDP[275]. While the CES provided lower estimates of material damage from natural disasters for the period from 2017 to 2022, about US $3.0 million per year, in 2023, a year distinguished by a large number of recorded natural disasters (557 events, 48 of which caused significant material losses), the damage amounted to US$7.1 million. Again, this highlights the vagaries associated with natural disasters in Tajikistan and their outcomes.

While the material damage may seem small in absolute terms[276], the real economic impact of even a small mudflow that destroys homes and infrastructure is catastrophic by local standards. For example, the cost of rebuilding a destroyed home can exceed US $50,000 and the impacted family must bear most of that financial burden, which often involves increasing debt levels and the prospect of very slow economic recovery, this slow down the pace of development not only in the many afflicted rural communities but for the country as a whole. As such, the Poverty Reduction Strategy[277] recognizes that natural disasters can be "a recurring obstacle to sustainable development and even jeopardize more than 15 years of poverty reduction efforts" in Tajikistan.

*Box 7. The 'voluntary immobility' of local populations living in a disaster-prone area in the GBAO[278]*

Most of the GBAO's approximately 216,000 people live in its western valleys, these valleys are characterized by rugged mountainous terrain and are prone to frequent avalanches, landslides, floods and mudslides. In the upper Bartang valley, the main threat is the potential for a natural dam to break through Lake Sarez, which is located in a zone of high seismic activity.

Lake Sarez is a natural phenomenon that is of particular concern to the government of Tajikistan and international organizations. The lake was formed by the blocking of the Murghab river valley by a 9.0 magnitude earthquake on 18 February 1911. The lake is located at an altitude of 3,263 m, has an area of 79.6 km², a length of 55.8 km, a maximum width of 3.3 km, and a depth of up to 500 m. A breakthrough of Lake Sarez would cause a disaster of national proportions,

273 Takeuchi et al.. 2019.
274 Fourth..., 2022.
275 Takeuchi et al.. 2019.
276 National strategy ...,2018.
277 Poverty Reduction Strategies for the Period 2010–2012 (2010) Dushanbe. (in Russian)
278 Blondin S. (2021) Staying despite disaster risks: Place attachment, voluntary immobility and adaptation in Tajikistan's Pamir Mountains. Geoforum 126. P.290–301.



*Cracks in the asphalt on the old Pamir highway*

potentially impacting an area of more than 55,000 km² with a population of six million people.

The main goal of the government's efforts to manage the risks associated with this lake is to find measures to reduce the risk and consequences of a possible lake outburst in the long term. One of these measures is the planned relocation of people from the risk zone.

Despite all the efforts of the CES, many residents show no intention of relocating and only temporarily leave their villages in the event of natural disasters. For example, in the village of Gudara, which was severely damaged by a 7.2 magnitude earthquake in December 2015, residents decided to stay on their traditional lands despite the government's offer to resettle them in a valley approximately 100 km away.

Ethnographic field surveys of settlements in risk zones were conducted non-consecutively over eight months between 2015 and 2019. Seventy people of different generations, both women and men, were interviewed, including 20 residents of the village of Gudara who were forced to leave their homes due to floods, landslides and a strong earthquake. The interview results showed that their place attachment is multidimensional and shaped by cultural, socio-economic, environmental and historical variables, making the relationship between place attachment and mobility complex. Many respondents had difficulty verbally expressing their love for their place of origin, which can be classed as a 'non-reflexive attachment'. Some of these respondents had never lived anywhere else and were reluctant to migrate simply because they were used to their village, it was the place they knew best. A common expression for these people was "homeland is sweet". However, the concept of 'homeland' (watan) can refer to their village, the entire valley (Bartang) or even the entire province inhabited by members of their religious community and speakers of the Pamir languages (including their various dialects). Religious practices in the Bartang valley are closely linked to place and identity. The valley's inhabitants, the Bartangi, pray at home or in shrines decorated with elements of the natural environment, such as ibex horns and, for them, the valley has significant spiritual power. The presence of multiple Pamir dialects plays a large role in their attachment to relatively small linguistically distinct places, which is why locals mostly identify themselves as Bartangi rather than Pamirs. This attachment to such a specific location is also reinforced by their strong sense of community.

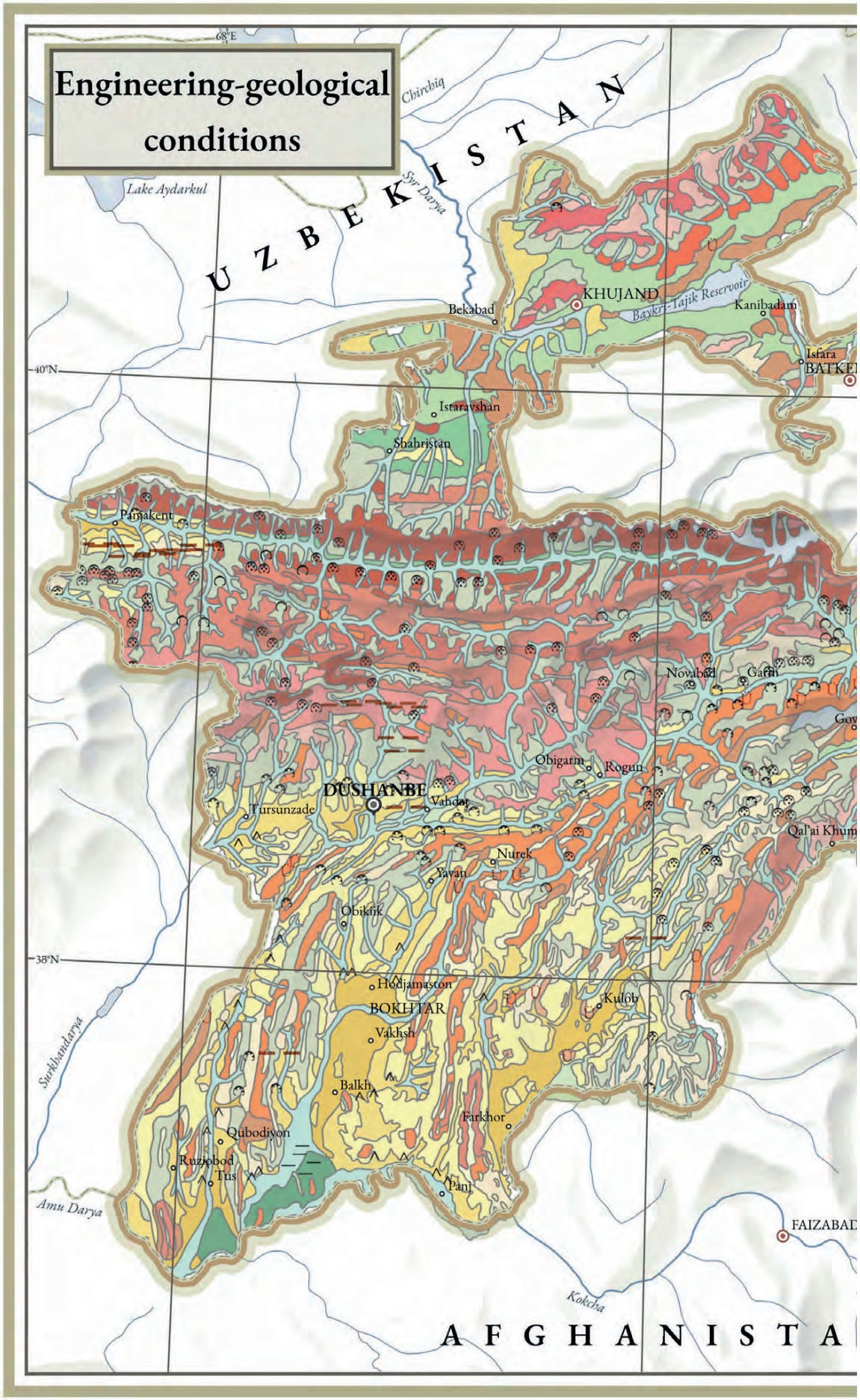
Historical memories of the massive forced resettlements to the irrigated lower reaches of various river valleys during the Soviet era, during which half of the settlers died, add special value to the valley and reinforce the idea that "Bartangi mountaineers are born to live exclusively in the mountains." Traumatic events, such as the forced resettlements that took place in 1953 in Bartangi villages such as Basid and Gudara, coupled with the civil war of 1992–1997, only seem to have served to strengthened the inhabitants' attachment to the valley. Finally, despite the high risks of natural disasters, the region is perceived by locals as especially clean and virgin (toza). The remoteness from cities, highways and any centres of production contribute to the high quality of local fruits, vegetables, dairy products and meat. This 'cleanliness' motivates residents not to use chemicals in agriculture, a matter of pride that the Bartangi always like to share with 'outsiders' when discussing their crops.

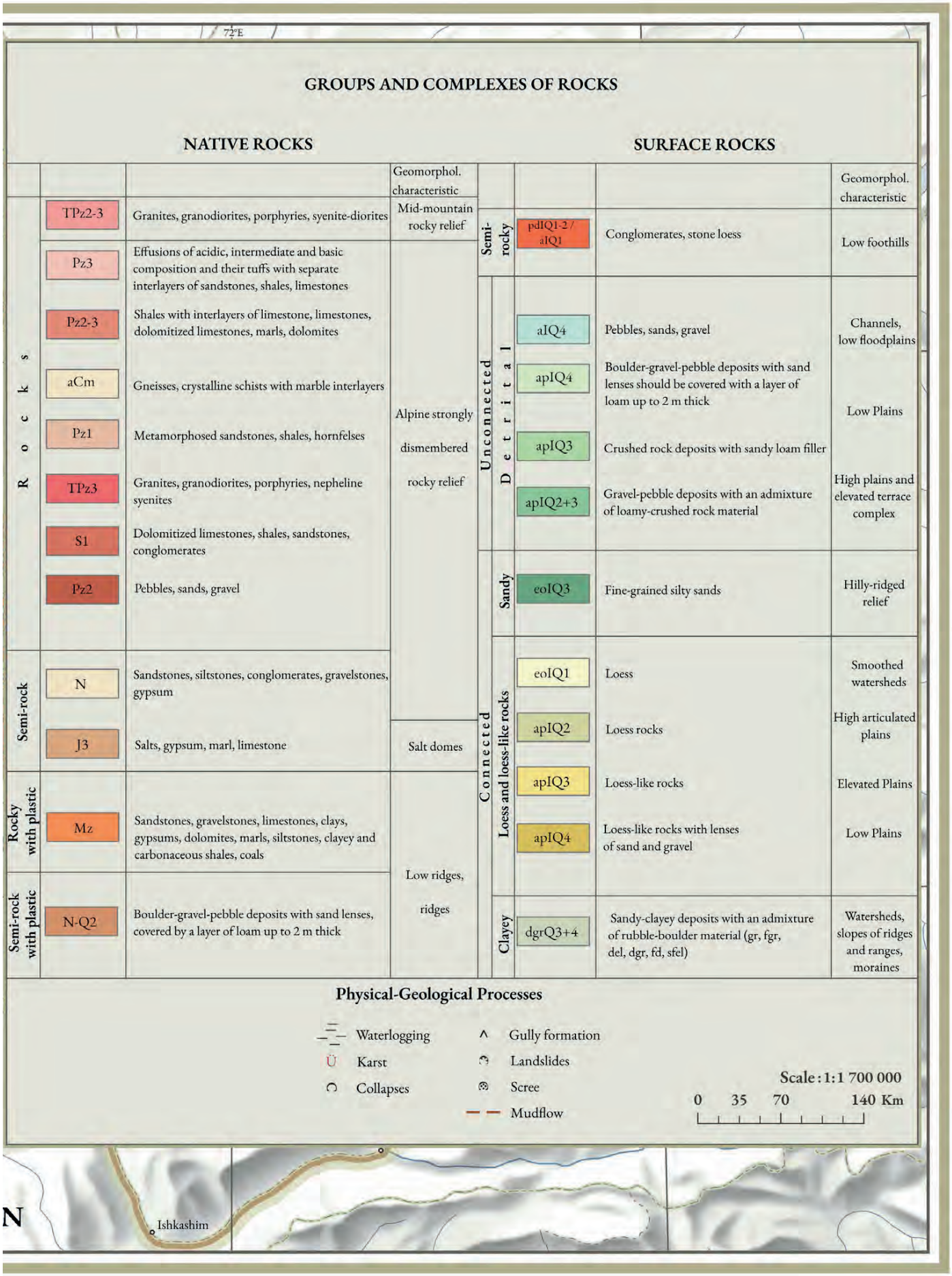
**7.5. Responses**

- Implementation of modern methods for forecasting floods and mudflows.
- Increased attention to the safety of dams and other hydraulic structures.
- Development of local disaster risk reduction strategies aimed at developing legal and political norms while simultaneously mainstreaming climate change issues at the local level.
- Development of a flexible system for the resettlement of villages from high-risk areas.

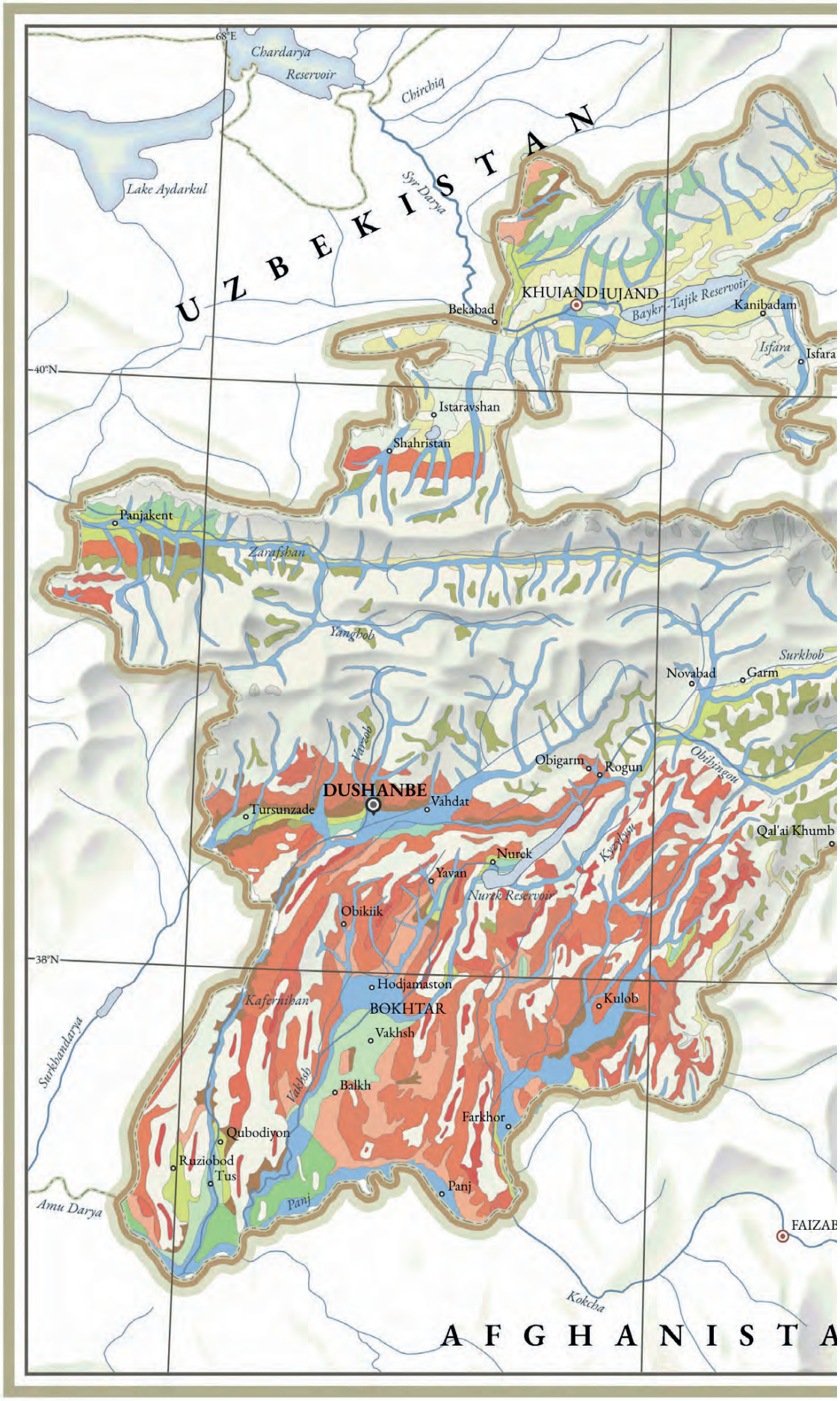


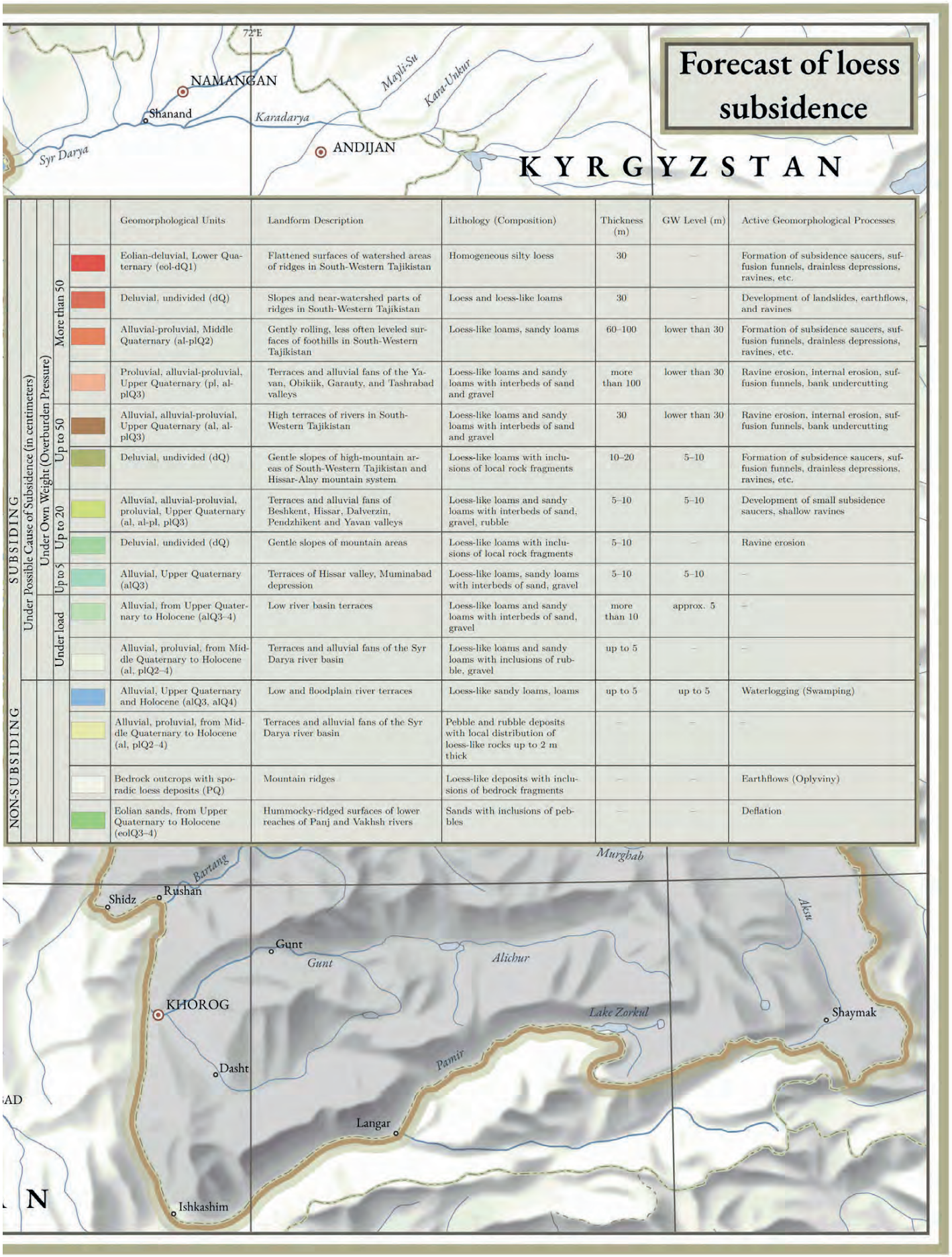
*A huge rock that fell from a mountain during a rockfall*


Engineering-geological conditions
68°E
Chirchiq
Lake Aydarkul
Syr Darya
UZBEKISTAN
KHUJAND
Bekabad
Kanibadam
Baykir-Tajik Reservoir
Isfara
BATKEN
40°N
Istaravshan
Shahristan
Panjakent
Novabad
Garmi
Obigarm
Rogun
DUSHANBE
Vahdat
Tursunzade
Qal'ai Khum
Nurek
Yavan
Obikik
38°N
Hodjamaston
BOKHTAR
Kulob
Vakhsh
Surkhandarya
Balkh
Farkhor
Qubodiyon
Ruzjobod
Tus
Panj
Amu Darya
FAIZABAD
Kokcha
AFGHANISTA



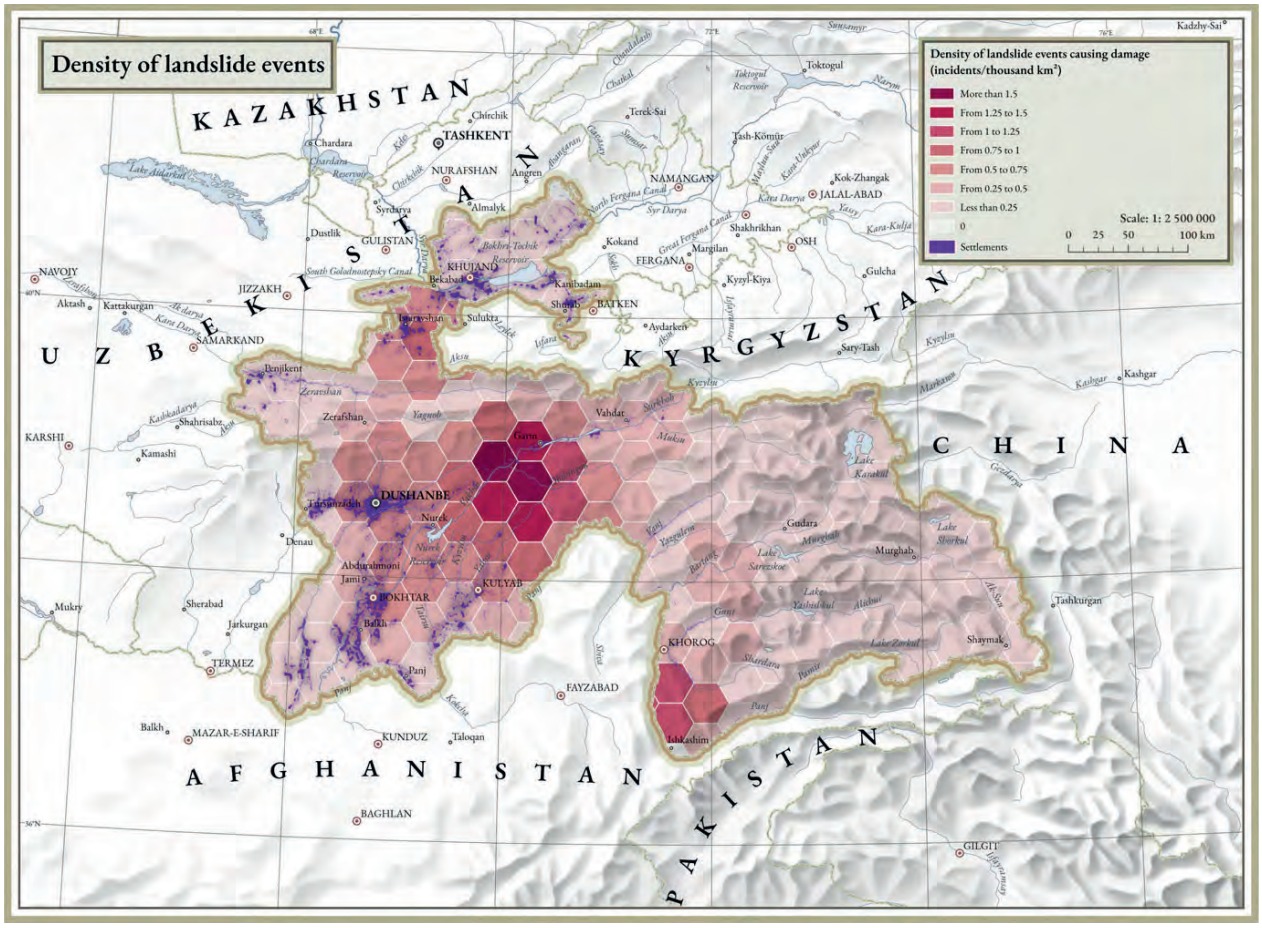

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68°E
Chardarya
Reservoir
Chirchiq
Lake Aydarkul
Syr Darya
UZBEKISTAN
KHUJAND
Bekabad
Baykr-Tajik Reservoir
Kanibadam
Isfara
Isfara
40°N
Istaravshan
Shahristan
Panjakent
Zarafshan
Yanghob
Surkhob
Novabad
Garm
Obigarm
Rogun
Obihingou
DUSHANBE
Vahdat
Tursunzade
Qal'ai Khumb
Nurek
Yavan
Kyzylsu
Nurek Reservoir
Obikiik
38°N
Hodjamaston
Kafernihan
BOKHTAR
Kulob
Vakhsh
Surkhandarya
Balkh
Vakhsh
Farkhor
Qubodiyon
Ruziobod
Tus
Panj
Amu Darya
Panj
FAIZAB
Kokcha
AFGHANISTA



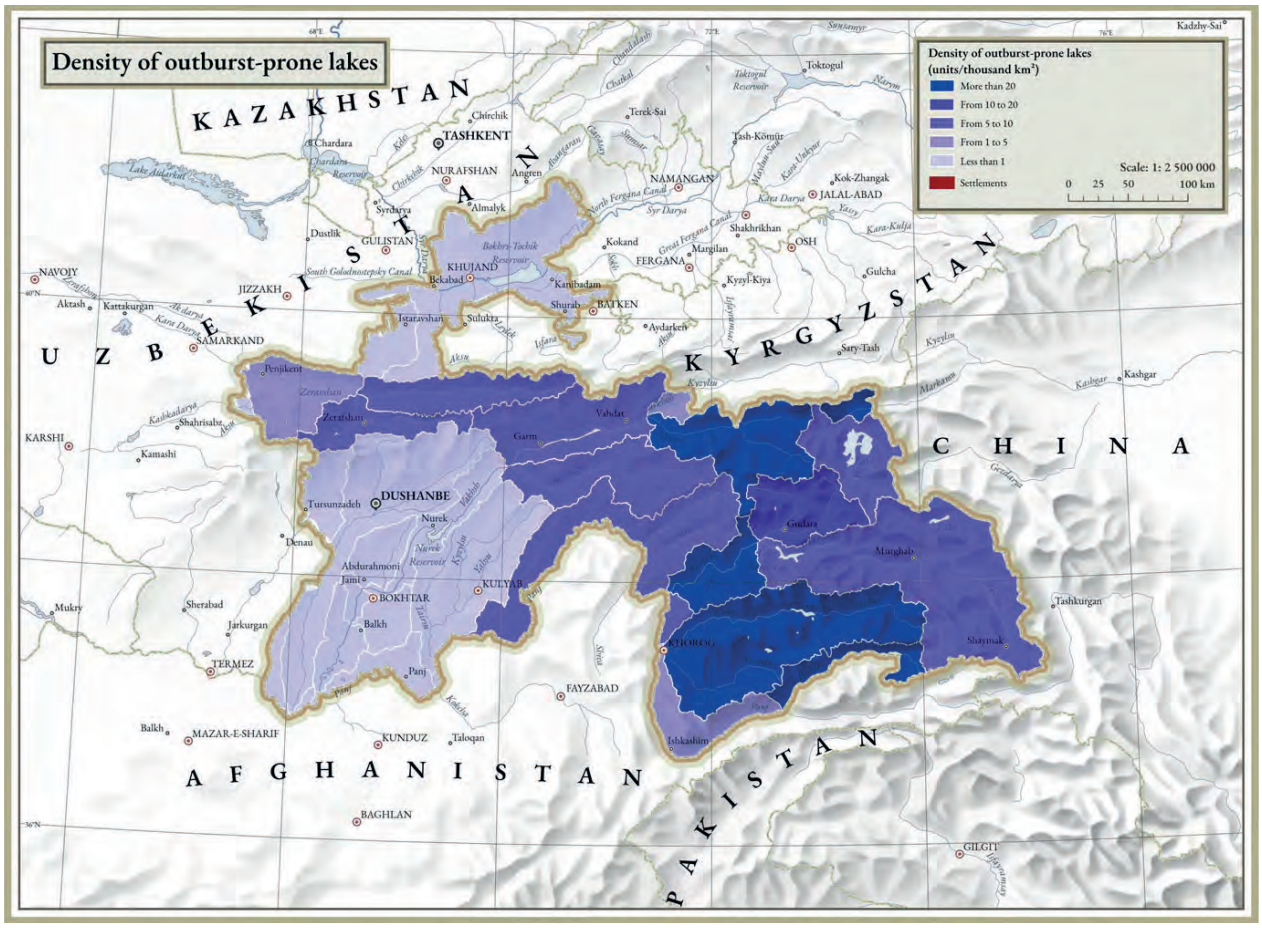

| | | Geomorphological Units | Landform Description | Lithology (Composition) | Thickness (m) | GW Level (m) | Active Geomorphological Processes |
|---|---|---|---|---|---|---|---|
| SUBSIDING — Under Possible Cause of Subsidence (in centimeters) — Under Own Weight (Overburden Pressure) — More than 50 | | Eolian-deluvial, Lower Quaternary (eol-dQ1) | Flattened surfaces of watershed areas of ridges in South-Western Tajikistan | Homogeneous silty loess | 30 | – | Formation of subsidence saucers, suffusion funnels, drainless depressions, ravines, etc. |
| | | Deluvial, undivided (dQ) | Slopes and near-watershed parts of ridges in South-Western Tajikistan | Loess and loess-like loams | 30 | – | Development of landslides, earthflows, and ravines |
| | | Alluvial-proluvial, Middle Quaternary (al-plQ2) | Gently rolling, less often leveled surfaces of foothills in South-Western Tajikistan | Loess-like loams, sandy loams | 60–100 | lower than 30 | Formation of subsidence saucers, suffusion funnels, drainless depressions, ravines, etc. |
| | | Proluvial, alluvial-proluvial, Upper Quaternary (pl, al-plQ3) | Terraces and alluvial fans of the Yavan, Obikiik, Garauty, and Tashrabad valleys | Loess-like loams and sandy loams with interbeds of sand and gravel | more than 100 | lower than 30 | Ravine erosion, internal erosion, suffusion funnels, bank undercutting |
| | Up to 50 | Alluvial, alluvial-proluvial, Upper Quaternary (al, al-plQ3) | High terraces of rivers in South-Western Tajikistan | Loess-like loams and sandy loams with interbeds of sand and gravel | 30 | lower than 30 | Ravine erosion, internal erosion, suffusion funnels, bank undercutting |
| | | Deluvial, undivided (dQ) | Gentle slopes of high-mountain areas of South-Western Tajikistan and Hissar-Alay mountain system | Loess-like loams with inclusions of local rock fragments | 10–20 | 5–10 | Formation of subsidence saucers, suffusion funnels, drainless depressions, ravines, etc. |
| | Up to 20 | Alluvial, alluvial-proluvial, proluvial, Upper Quaternary (al, al-pl, plQ3) | Terraces and alluvial fans of Beshkent, Hissar, Dalverzin, Pendzhikent and Yavan valleys | Loess-like loams and sandy loams with interbeds of sand, gravel, rubble | 5–10 | 5–10 | Development of small subsidence saucers, shallow ravines |
| | | Deluvial, undivided (dQ) | Gentle slopes of mountain areas | Loess-like loams with inclusions of local rock fragments | 5–10 | – | Ravine erosion |
| | Up to 5 | Alluvial, Upper Quaternary (alQ3) | Terraces of Hissar valley, Muminabad depression | Loess-like loams, sandy loams with interbeds of sand, gravel | 5–10 | 5–10 | – |
| | Under load | Alluvial, from Upper Quaternary to Holocene (alQ3–4) | Low river basin terraces | Loess-like loams and sandy loams with interbeds of sand, gravel | more than 10 | approx. 5 | – |
| | | Alluvial, proluvial, from Middle Quaternary to Holocene (al, plQ2–4) | Terraces and alluvial fans of the Syr Darya river basin | Loess-like loams and sandy loams with inclusions of rubble, gravel | up to 5 | – | – |
| NON-SUBSIDING | | Alluvial, Upper Quaternary and Holocene (alQ3, alQ4) | Low and floodplain river terraces | Loess-like sandy loams, loams | up to 5 | up to 5 | Waterlogging (Swamping) |
| | | Alluvial, proluvial, from Middle Quaternary to Holocene (al, plQ2–4) | Terraces and alluvial fans of the Syr Darya river basin | Pebble and rubble deposits with local distribution of loess-like rocks up to 2 m thick | – | – | – |
| | | Bedrock outcrops with sporadic loess deposits (PQ) | Mountain ridges | Loess-like deposits with inclusions of bedrock fragments | – | – | Earthflows (Oplyviny) |
| | | Eolian sands, from Upper Quaternary to Holocene (eolQ3–4) | Hummocky-ridged surfaces of lower reaches of Panj and Vakhsh rivers | Sands with inclusions of pebbles | – | – | Deflation |

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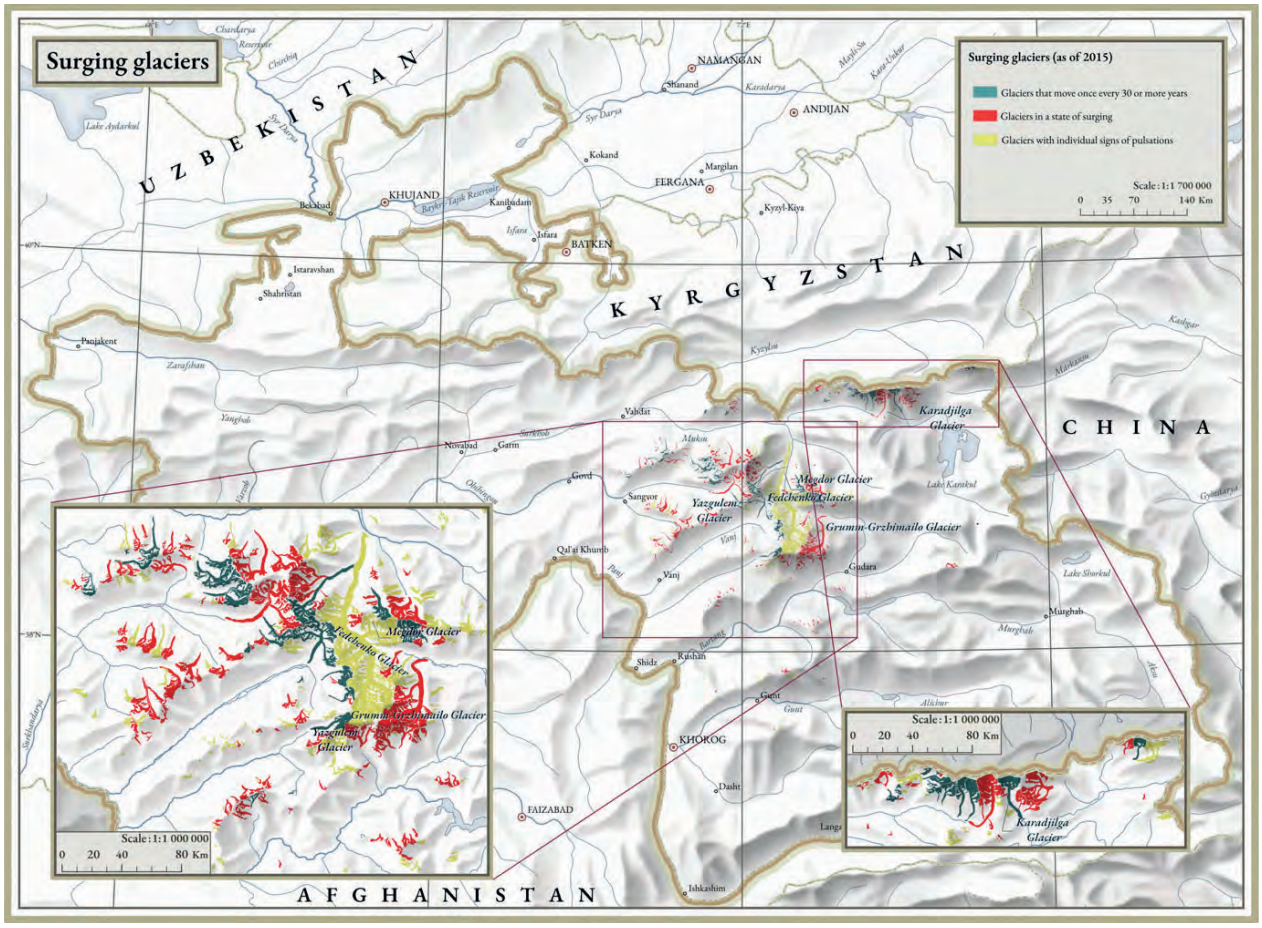



Data on incidents from the Emergency Situations Committee of Tajikistan[279]

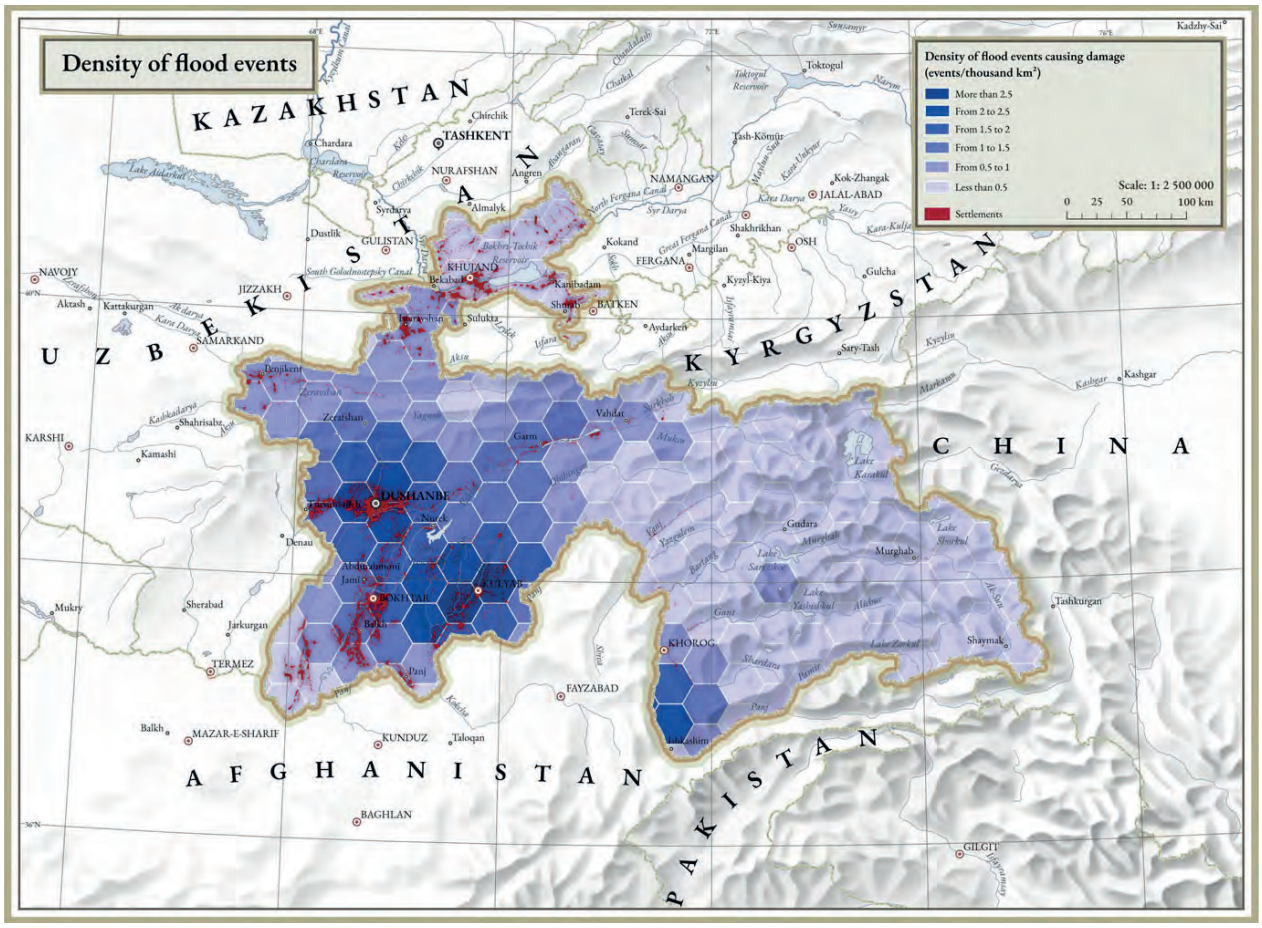
279 КЧС Таджикистана




Calculated from the relative share of the area of 197 periglacial lakes based on the interpretation of Sentinel-2 images.




Atlas of snow and ice resources of the world/Russian Academy of Sciences, Institute of Geography; [V.M. Kotlyakov et al., Editorial board: ed. academy V.M. Kotlyakov et al.]. - M.: Institute of Geography, 1997. 392 p. ISBN 5-89658-001-0 (in Russian)




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