Global Environmental Facility

Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan

United Nations Development Programme in Kazakhstan

Eighth National Communication and Fifth Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change

Astana, 2022

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8-е Национальное Сообщение и 5-й Двухгодичный Доклад Республики Казахстан Рамочной Конвенции ООН об Изменении Климата подготовлен группой национальных экспертов в рамках совместного проекта Министерства экологии, геологии и природных ресурсов Республики Казахстан и Программы развития ООН при финансовом содействии Глобального Экологического Фонда. В публикации содержится вся доступная информация о вопросах изменения климата в соответствии с международным доступным руководством. Для составления данного доклада использовалась информация из открытых источников, данные национальных и международных организаций, включая правительственные ведомства и агентства. В публикации представлены 9 разделов: Исполнительное резюме; Национальные условия, имеющие отношение к выбросам и абсорбции парниковых газов; Информация о кадастрах парниковых газов; Политика и меры; Прогнозы и общее воздействие политики и мер; Оценка уязвимости, воздействия изменения климата и меры по адаптации; Финансовые ресурсы и передача технологий; Исследования и систематическое наблюдение; Просвещение, подготовка кадров и информирование общественности. Кроме того, в доклад впервые включена гендерная статистическая информация, имеющая отношение к вопросам изменения климата согласно соответствующим решениям Рамочной конвенции ООН об изменении климата.

The 8th National Communication and the 5th Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change was prepared by a group of national experts under a joint project of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan and the United Nations Development Programme in Kazakhstan with the financial support of the Global Environment Facility. The publication contains all available information on climate change issues in accordance with internationally available guidance. Information from open sources, data from national and international organizations, including governmental departments and agencies were used for composing this report. The publication contains 9 sections: National conditions, Data on greenhouse gas emissions, Policies and measures of Kazakhstan regulating GHG emissions, Projections and general impacts of policies and measures on GHG emissions, Assessment of climate change impacts and measures on adaptation to climate change, Data on financial resources and technology transfer and Issues of climate change education and training. In addition, the report is enriched with gender-specific statistical information relevant to climate change.

Біріккен Ұлттар Ұйымының Климаттың өзгеруі туралы негіздемелік конвенциясы бойынша 8-ші ұлттық хабарламаны және 5-ші екі жылдық баяндаманы ҚР Экология геология және табиғи ресурстар министрлігінің бірлескен жобасы және Жаһандық экологиялық қордың қаржылай жәрдемдесуімен БҰҰ Даму бағдарламасы шеңберінде ұлттық сарапшылар тобы дайындады. Басылымда халықаралық қолжетімді нұсқаулыққа сәйкес климаттың өзгеруі туралы барлық қолжетімді ақпарат бар. Осы баяндаманы жасау үшін мемлекеттік ведомстволар мен агенттіктерді қоса алғанда, ашық көздерден алынған ақпарат, ұлттық және халықаралық ұйымдардың деректері пайдаланылды.

Басылымда 9 бөлім ұсынылған: Ұлттық шарттар, Парниктік газдар шығарындылары бойынша деректер, Қазақстанның парниктік газдар шығарындыларын реттеу жөніндегі саясаты мен шаралары, Саясат пен шаралардың ПГ шығарындыларына болжамдары мен жалпы әсері, Климаттың өзгеруінің әсерін бағалау мен климаттың өзгеруіне бейімделу шаралары, Қаржы ресурстары мен технологияларды беру деректері және Климаттың өзгеруі саласындағы білім беру және кадрларды даярлау мәселелері. Сонымен қатар, баяндама климаттың өзгеруі мәселесіне қатысты гендерлік статистикалық ақпаратпен байытылған.

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FOREWORD

Climate change is a serious threat for all humankind. We understand that we need to strive to reduce greenhouse gas emissions, and at the same time, we need to strengthen our capacity to adapt to the detrimental effects of climate change. Repeated studies in our country confirm that climate change impacts are uneven in different parts of the planet, and temperature increase is remarkably higher in Kazakhstan compared to other countries.

At the 2020 Climate Ambition Summit marking the fifth anniversary of the Paris Climate Agreement, Kassym-Zhomart Tokayev, the President of Kazakhstan, announced Kazakhstan's pledge to achieve carbon neutrality by 2060. “We have come a long way in terms of development in the last 30 years. But our economy relies on fossil fuels”. Therefore, Kazakhstan has no choice but to address two objectives in parallel: to transition the economy away from fossil fuels and to combat climate change at the same time, as Tokayev emphasized.

Yet achieving this goal is a complex task requiring major transformation of the economy and lifestyle of the population. The development of renewable energy sources, energy efficiency and energy conservation measures must be further supported.

In 2021, the new Environmental Code of the Republic of Kazakhstan came into force. This fundamental document was developed with input from the experience of the countries of the Organization for Economic Co-operation and Development (OECD) and the European Union. The main innovations were the ‘polluter pays’ principle, introduction of the best technologies and other improvements. It should be noted that the new Environmental Code includes a chapter on adaptation to climate change, which lays the foundation for the adaptation process in the country.

We will keep up the work on all priority areas to reduce greenhouse gas emissions, enhance our capacity to adapt to climate change, and allocate financial resources to greening the economy and the entire country.

Minister of Ecology,

Geology and Natural Resources

of the Republic of Kazakhstan **Serikkali BREKESHEV**

I. EXECUTIVE SUMMARY

1.1.NATIONAL CIRCUMSTANCES RELATED TO THE GREENHOUSE GASES EMISSION AND REMOVAL

The Republic of Kazakhstan is a unitary secular state with the presidential government system[1]. As of July 1, 2022, the following administrative territorial system has been in effect: 17 oblasts, three cities with a republican status, 186 administrative districts, 89 towns, 29 townships and 6293 rural settlements.

Power in the Republic of Kazakhstan is distributed among three independent branches. Legislative functions are assigned to the Parliament that consists of two chambers: the Senate (upper house) and the Mazhilis (lower house). Executive power is exercised by the Government, which manages the system of executive bodies. Judicial power is exercised by the judicial system comprising the Supreme Court, local (oblast, city, district) courts and specialized courts (military, juvenile, economic).

With regard to the regulation of greenhouse gas (GHG) emissions, the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan defines a regulatory framework for the development and approval of subsequent Nationally Determined Contributions under the Paris Agreement and implementation of the Emissions Trading System for greenhouse gas emissions including the Rules of State Regulation in the Field of Greenhouse Gas Emissions and Removals, which contain basic provisions on quota allocation, monitoring and reporting.

The total population of Kazakhstan amounted to 18,879.5 million people at the beginning of 2021. Of these, 9,719.1 thousand (51.48%) were women and 9,160.4 thousand (48.52%) were men. The urban population amounted to 11,151,376 people, while rural was 7,728,176 people.

The key indicators descriptive of the natural growth of the population have changed insignificantly from 2017 to 2020. The total fertility rate ranged from 2.75 to 3.13 (3.32 in 2021) births per thousand people of the population. The mortality rate increased from 7.15 to 8.6 deaths per thousand people.

The country's average population density was 6.8 people per square kilometer in 2020.

Life expectancy at birth in 2021 was 70.23 years, which is 1.58 years less than in 2017. The age composition of the population of the Republic of Kazakhstan in 2017 was as follows: 482 per 1000 people below employable age, 184 per 1000 people above employable age.

The gross domestic product (GDP) of the Republic of Kazakhstan has shown steady growth in 2017-2020.

From 2017 to 2020, the industrial output in current prices has grown by 4.4%. The average GDP growth in the industrial sector amounted to approximately 10% per year.

The gross output of agricultural products (services) has also been growing. The average growth in current prices amounted to KZT3,444.5 billion (by 45.8%) from 2017 to 2021.

The new wave of COVID-19 and associated restrictions led to an increase in the inflation rate by more than 6% per year during the reporting period[2].

The country's external turnover amounted to USD101.7 billion by the end of 2021 showing an increase by USD15.26 billion

Total workforce in 2021 made 9,256.8 thousand people (69.3% of the total population), employed population was 8,807.1 thousand people (95.1% of the workforce), of which 6,710.2

[1] Constitution of the Republic of Kazakhstan.
[2] Dynamics and plot of changes in the inflation rate in Kazakhstan from 2015 to 2022: https://bankchart.kz/spravochniki/indikatory_rynka/inflation_index

thousand people (76.2%) were payroll employees, while 2,096.9 thousand (23.8%) were self–employed. Unemployed population amounted to 449.6 thousand people (4.9%) in 2021.

The share of women in the workforce (2021) is 63.9%, while that of men is 75.4%. The employment rate of women is 94.6%, that of men is 95.6%.

Kazakhstan is located at the junction of two continents – Europe and Asia. The area of the Republic of Kazakhstan is 2,724,902 km^2. The length of the state border is 13,398 km [3].

The republic ranks ninth in the world in terms of land area. Kazakhstan is the largest landlocked country in the world. The terrain is predominantly flat – more than 90% of the entire territory. High mountains are located only in the south-east and east of the country. Flat tracts of land complicated by exposed and heavily destroyed ancient mountain structures occupy a significant part of the country.

Arid natural zones – desert, semi-desert, and dry steppe zone – cover most of the country's territory. Only its northern part's conditions are more favorable in terms of humidity: steppe and forest-steppe.

Agricultural lands continued to expand during the reporting period by more than 4% (or 4,512 thousand hectares), while the areas of specially protected natural territories grew by 8% (or 571 thousand hectares). At the same time, industrial, transport, communications, defense, and other non-agricultural lands significantly decreased by more than 23% (or 668.2 thousand hectares), while undistributed lands decreased by 3.5% (or 3395.2 thousand hectares)[4].

The climate of Kazakhstan, due to far distance from the ocean, is distinctly continental with prolonged hot summers and cold winters and sharp daily and annual fluctuations in air temperature. The maximum of the territory's average precipitation falls from April to July, while the minimum falls from August to September.

Kazakhstan's flat territories are distributed over four landscape zones – forest-steppe, steppe, semi-desert, and desert. Mountainous and foothill areas show distinct vertical climatic zoning.

The climate of Kazakhstan has significantly warmed. Comparison of long-term average ambient temperature values for two consecutive periods of 1961-1990 and 1991-2020 indicates that the country's average annual temperature has increased by 0.9 degrees Celsius. February and March warmed most significantly – by 2.0 and 1.7 degrees Celsius, respectively. July and December temperatures have changed little.

The territory's average annual precipitation has not changed much, still some months show an increase with a maximum in February (by 15.6%), while precipitation value in September and October decreased by 10.8% and 14.8%, respectively.

The goal of Kazakhstan's energy policy is to ensure adequate level and volume of electricity generating capacities for economic growth. First, this is achieved through upgrades to existing power plants. The investment attractiveness of electric power industry, including renewable energy development, is also improving.

The State Program for Industrial and Innovative Development of the Republic of Kazakhstan for 2015-2019 has been in effect since 2014[5]. This program continued with the State

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[3] Demarcation of the state border of the Republic of Kazakhstan: https://www.gov.kz/memleket/entities/kgk/press/article/details/2328?lang=ru

[4] Green economy indicators of the of the Republic of Kazakhstan. Land resources. Committee for Statistics of the Republic of Kazakhstan, 2011

[5] Approved by Decree of the President of the Republic of Kazakhstan No. 874 dated August 1, 2014

Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020-2025[6]. This policy document focuses on incentivizing competitiveness of the processing industry to increase labor productivity and the volume of exports of processed goods.

As of 2021[7], the country had 115 operational renewable energy facilities with a total capacity of 1897 MW including hydroelectric power plants (HPPs) with a total capacity of 255.08 MW, wind power plants (WPPs) – 601.3 MW, solar power plants (SPPs) – 1,032.6 MW, and a biogas plant – 7.82 MW.

The share of renewable energy generation in the total electricity output is 3.5%.

The apparent consumption of primary energy resources in Kazakhstan in 2020 fell by 2.7% to 89.5 million tons of oil equivalent following a particularly sharp drop in oil demand (by 12.3% to 15.8 million toe), as well as a decrease in coal consumption (by 0.9% to 49.8 million toe), while an increase was observed in natural gas consumption (by 0.2% to 21.3 million toe) and primary electricity consumption (by 7.5% to 2.6 million toe).

Net exports of primary energy resources from Kazakhstan, about 80% of which has recently been oil, decreased by 5.6% to 89.2 million tons in 2020 due to the shocks in world oil markets related to the COVID-19 pandemic.

Production and consumption of energy resources in Kazakhstan occurs mainly via combustion of mineral fuels, coal in particular. Plans to expand coal and oil extraction indicate that dependence on traditional energy sources will continue. Meanwhile, work is underway to upgrade coal-fired power plants, which will facilitate reduction of greenhouse gas and air pollutants emissions.

Kazakhstan is located in the center of the Eurasian continent, which determines the importance of the transport sector for the country. Motor roads and railways account for the major share of all land traffic. The mileage of public roads in 2020 increased by 0.37%, while the length of railway tracks grew by 0.13%[8]. In 2017-2019, passenger traffic increased moderately. Freight traffic turnover has grown too (by 3.5%). Meanwhile, there was a significant decrease in air freight traffic (by 53.74%) and an increase in rail freight traffic (by 3.96%). Civil aviation industry was one of the most affected by the spread of the pandemic in 2020.

In 2020, the number of registered passenger vehicles grew by 0.5%, cargo vehicles - by 8%[9].

Mining industry still occupied a major share in the total industrial production output from 2017 to 2020: 54% on average of the total industrial output. The share of processing industry in the structure of industrial production has increased.

Reducing energy intensity in industry, primarily in the processing industry is a priority of industrial and innovative development of Kazakhstan.

In 2019, total of 3,674 thousand tons of municipal waste were collected in Kazakhstan, which is 7.6% higher than in 2017. Up to 89% of municipal waste is neither sorted for recycling nor reused.

In the sector of solid waste and municipal wastewater management, the sources of greenhouse gas emissions are solid waste landfilling, wastewater discharge and treatment system.

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[6] Resolution of the Government of the Republic of Kazakhstan No. 1050 dated December 31, 2019.

[7] Kazakhstan Electricity and Power Market Operator Joint Stock Company

[8] The length of communication routes in Kazakhstan for 2019-2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

[9] Bus, passenger, freight transport. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

The total volume of emissions from this sector in 2020 amounted to 7,354.28 thousand tons in CO_2-eq.

The country's housing stock continued to grow and increased to 373.3 million square meters in 2020. Housing supply per capita in 2019 grew up to 21.9 square meters (21.6 square meters in 2018); this figure is to go up to 26 square meters by the end of 2025 as part of the implementation of 'Nurly Zher' program.[10]

Central heating is predominantly provided by coal-fired thermal power plants. Over a four-year period, the share of central heating increased slightly, from 35.9% to 36.6%.

The extent of household gasification increased from 30% in 2013 to 53.07% in 2020 to cover more than 9.5 million citizens. The number of domestic enterprises supplied with gas has doubled. Thus, Kazakhstan has been reducing ambient air pollution in cities and combining gas trunk lines into a single gas transportation system.

Greenhouse gas emissions in the construction (housing and utilities) sector are directly associated with electricity and heat consumption. From 2016 to 2020, emissions from household consumption increased by 1.66 times, emissions from public electricity and heat generation increased by 1.2 times.

In 2020, 27.7% of the population employed in the economy of Kazakhstan (139.4 thousand out of 503.8 thousand people) worked in agriculture, forestry, and fisheries of Kazakhstan[11]. Meanwhile, agricultural production (including forestry and fisheries) occupies only 5.4% of the GDP structure. This growth is mainly due to an increase in crop production by 7.8%[12]. The total cultivated area is 22.58 million hectares.[13] The gross output of crop production increased by 39%, animal husbandry grew by 31%, while agricultural services have shown a decrease of 8.7%.

Kazakhstan's agriculture is a source of methane and nitrous oxide emissions[14]. Methane emissions come from intestinal fermentation, and nitrous oxide comes from agricultural soils. These two sources account for a total of about 89%, or 33,122 thousand tons of CO2-eq of all greenhouse gases emitted by the sector. The amount of greenhouse gas emissions from the agricultural sector increased by about 10% from 2016 to 2020, mainly due to an increase in methane emissions.

According to the land balance, the total land area of the forest fund amounted to 22.4 million hectares, or 8.3% of the used land fund of the republic as of November 1, 2019. In 2019, the volume of reforestation increased. Thus, 63.9 thousand hectares of forest were actually planted while the planned planted area was 59.8 thousand hectares. In addition, a reduction of the forest fire areas was recorded in the State Forest Fund from 162.6 thousand hectares (2018) to 73.5 thousand hectares in 2019.

Sustainable forest development (constant increase in forest cover) is one of the principles of the forest legislation of the Republic of Kazakhstan[15]. One of the planned measures to reduce water shortage is expansion of the forest cover of the catchment areas of water bodies.

1.2. Information on greenhouse gas inventories

[10] Resolution of the Government of the Republic of Kazakhstan, the State program of housing and utilities development 'Nurly Zher' for 2020-2025.

[11] Employed population by type of economic activity and region, 2017–2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

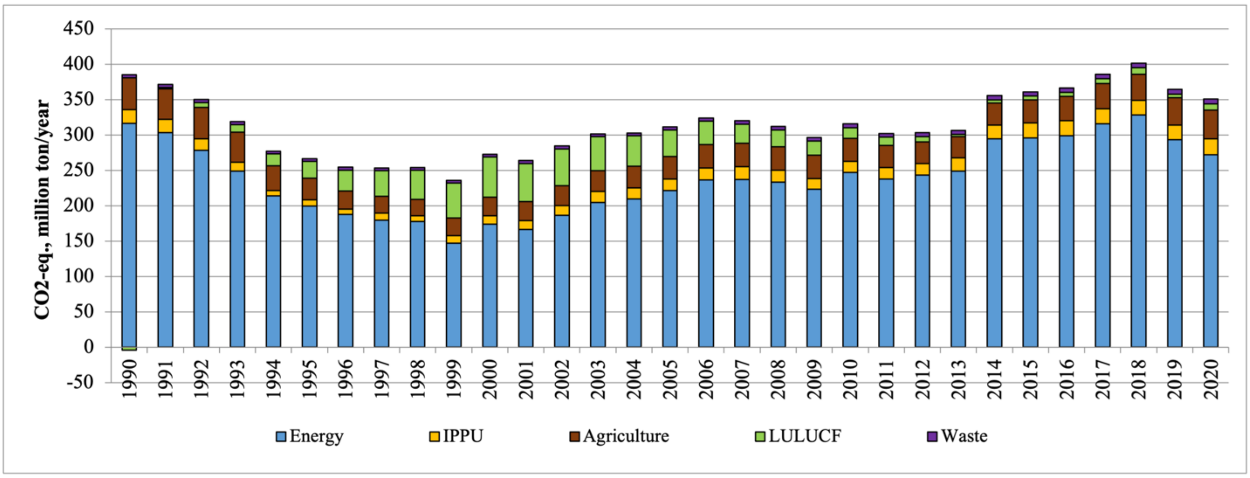
[12] GDP structure by method of production. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

[13] Updated cultivated area under key agricultural crops in 2020 in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

[14] Inventory of greenhouse gas emissions in Kazakhstan, 2019

[15] Code of the Republic of Kazakhstan No. 477 dated July 8, 2003, 'Forest Code of the Republic of Kazakhstan', Article 3.

Figure 1.1 Information on greenhouse gas inventories



As Figure 1.1 shows, total cumulative emissions from 1990 to 1999 have reduced almost two-fold due to economic downturn in Kazakhstan: to 186.72 million tons of CO_2-eq excluding LULUCF. This reduction was 52.6% of the level of 1990 excluding LULUCF.

Since 2000, revival of Kazakhstani economy has led to an increase in GHG emissions that reached the level of 392.755 million tons of CO2-eq without LULUCF and 401.662 million tons of CO2-eq with LULUCF by 2018, thereby exceeding the level of the base year 1990. However, a decrease in emissions in the energy sector was observed in 2019 and 2020 resulting in a decrease in total cumulative emissions.

Total GHG emissions for 2020 are below the 1990 base: by 11.08% excluding LULUCF and by 7.98% including LULUCF.

1.3.Policies and measures

1.3.1 Policies and measures in the fuel combustion sector

Low-carbon development of the economy entails a significant reduction in GHG emissions to the GDP, a transition in the energy sector from hydrocarbon fuel and energy resources combustion to renewable energy sources (solar energy, wind power, small-scale hydropower), a reduction of energy consumption and thereby a reduction of GHG emissions in manufacturing and housing-and-utilities (energy saving) Goals to reduce energy intensity of GDP are also reiterated in the Concept for development of fuel and energy complex of the Republic of Kazakhstan until 2030.

The Strategic Plan of the Ministry of Energy of the Republic of Kazakhstan for 2017-2021 was approved on December 28, 2016. This plan undertakes the mission to improve quality of the environment, to ensure transition of the Republic of Kazakhstan to low-carbon development and green economy to meet the needs of present and future generations.

The Strategic plan of the Ministry of Energy for 2020-2024 was approved by Order No. 421 of the Minister of Energy of the Republic of Kazakhstan on December 3, 2020. This document takes over all goals and objectives set out in previous strategic plans.

The key measures affecting the reduction of GHG emissions in the heat and electricity generation sector are boosting the share of natural gas generation, development of renewable energy sources, commissioning of nuclear capacities and development of generation based on coal-bed methane.

This measure has been implemented via the ‘Sary-Arka’ main gas pipeline construction completed in October 2019 and the conversion of Astana city heating plants to natural gas.

The goal to achieve the indicator of coal share in power generation was first officially announced in 2021. The target was proclaimed for international audience in the speech by A. Mamin, the Prime Minister of the Republic of Kazakhstan, at the UNFCCC Conference of the Parties on November 2, 2021, in Glasgow (UK). At the time of writing, this target has not been approved in any official strategic documents.

In early September 2021, K.-Zh. Tokayev, the President of the Republic of Kazakhstan, stated that “the time has come to consider this issue in substance, since Kazakhstan needs a nuclear power plant.” Later, in November 2021, he made another statement that he would still have to make an “unpopular” decision to build a nuclear power plant. On December 3, 2021, the documentary Qazaq: History of the Golden Man was released, where N. Nazarbayev, the first President of the Republic of Kazakhstan, said in an interview with Oliver Stone, the US director, that Kazakhstan will build a nuclear power plant. Thus, it would be true to say that the issue of the nuclear power plant construction will be resolved positively in the near future.

The Energy Efficiency Requirements for Transport (No. 389) were approved on March 31, 2015. They determine regulatory indicators for energy efficiency of transport The requirements apply to railway, road, maritime, inland waterway, air, and urban rail transport imported and produced after adoption of these requirements.

The Concept of development of the gas sector of the Republic of Kazakhstan till 2030 and General scheme of gasification of the Republic of Kazakhstan for 2015-2030 have been adopted and put into force as part of the efforts to expand gasification in Kazakhstan. In October 2019, the construction of the 'Sary-Arka' main gas pipeline aimed at gasification of Central Kazakhstan was completed.

After the prohibition of flaring, annual volumes of flared gas in Kazakhstan were reduced by more than 3.5 times, while gas production volumes continued to grow steadily. These indicators were achieved due to the systematic implementation of gas utilization programs, which existed under the former Law of the Republic of Kazakhstan 'On Oil' dated June 28, 1995.

1.3.2. Policies and measures in the industrial processes and product use sector (IPPU)

The Ministry of Ecology, Geology and Natural Resources (MEGNR RK) was established according to the Decree of the President of the Republic of Kazakhstan dated June 17, 2019. With the new authority in place, the Department of Climate Change under MEGNR RK regulates climate change issues.

The Industry sector, where unrelated to energy, is supervised by the Ministry of Industry and Infrastructure Development.

On September 1, 2020, the President of the Republic of Kazakhstan delivered an Address to the People of Kazakhstan instructing the Government of the Republic of Kazakhstan to develop a package of proposals for green growth in cooperation with the scientific community and private sector, which will allow for laying the foundation for deep decarbonization of the national economy in the medium term[16]. Kazakhstan intends to achieve carbon neutrality by 2060.

[16] The Address of the Head of State, Kassym-Zhomart Tokayev, to the people of Kazakhstan. September 1, 2020, Kazakhstan in a New Reality: Time for Action: https://www.akorda.kz/ru/addresses/addresses_of_president/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-1-sentyabrya-2020-g

In February 2021, Zhassyl Damu JSC completed the World Bank's PMR project 'Update Kazakhstan's NDC and provide a roadmap for NDC implementation for post-2020'[17].

The roadmap for the implementation of the updated NDC of RK for 2022-2025 has been developed with the involvement of all interested parties in the discussion process. It includes sectoral and institutional decarbonization measures. For each measure, estimates were prepared for GHG emission reduction potential and investment needs broken down by sources of financing, associated effects and risks related to measure implementation failure. Along with that, the document describes measures to eliminate barriers (risks), responsible government agencies and deadlines.

The NDC Implementation Project Office will ensure interagency coordination of the NDC roadmap implementation through the NPS Unified Project Management System, which is an information cross-platform 'KZ 2050' (Easy Project) launched in 2020 and robustly supporting the management of more than 5,000 current projects.

The PMR program assisted Kazakhstan in strengthening the Emissions Trading System (ETS) and carbon markets and allowed to verify the functionality of the country's carbon units register, provided comprehensive macroeconomic modeling necessary to assign allowances for the 4th National Allocation Plan (NAP) for 2021. Allowance values were proposed for the 5th and 6th National Plans for 2022-2030.

A new Environmental Code came into force on July 1, 2021. In the next 5 years, experts in manufacturing industries will conduct a comprehensive audit of major pollutant enterprises resulting in concrete proposals for introducing BAT and reducing emissions in the form of BAT reference books.

From 2025 to 2035, the plan is to introduce upgrades and new technologies that should reduce the emission of harmful substances into the atmosphere significantly. Natural resource users will be incentivized to install new available technologies through exemption from emission payments for 10 years. In case they refuse to implement BAT, the rate of emission payments will double every 3 years.

'Polluter pays' is one of the underlying principles of the new environmental legislation. The legislation focuses on the largest polluter enterprises rather than regulating all nature users.

On July 29, 2020, the Government of the Republic of Kazakhstan adopted Resolution No. 479 'On approval of the action plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to green economy for 2021-2030'. Specific measures to boost the innovative activity of enterprises include development of innovation clusters, promotion of technological entrepreneurship, technology transfer, upgrading the fleet of essential equipment (in particular, using domestic scientific developments) through the application of more efficient installations and equipment.

Measures aimed at digitalization of Kazakhstan's economy sectors under the state program 'Digital Kazakhstan'[18] facilitate energy efficiency improvement thereby reducing GHG emissions.

The National Allocation Plan for GHG emission quotas for 2021 has been put into effect since January 1, 2021. [19] For 2021-2025, the ETS shows the following quota allocation: in 2021, the quota should be 1.5% less than the 1990 level, and for each subsequent year, it should be 1.5%

[17] Technical report on the estimation of NDC achievement scenarios. Zhassyl Damu JSC, February 24, 2021
[18] The State program 'Digital Kazakhstan', 2018-2022:
https://digitalkz.kz/wp-content/uploads/2020/03/%D0%A6%D0%9A-%D1%80%D1%83%D1%81.pdf
[19]National allocation plan for 2021: https://adilet.zan.kz/rus/docs/P2100000006

less than the level of the previous year. From 2026 to 2030, the quota should annually become 1.5% lower than the level of the previous year.

1.3.3. Policies and measures in agriculture and LULUCF

In January 2021, Kazakhstan adopted the new Environmental Code[20]. The Environmental Code's key mechanism for emissions regulation comprises carbon quotas and establishment of a market mechanism for trading carbon quotas. The LULUCF sector is not subject to carbon quotas, according to both articles 289-291 of the Environmental Code and the national quota allocation plan[21].

However, article 298 of the Environmental Code introduces the concept of carbon offset. Carbon offset refers to projects aimed at GHG emissions reduction. A unit of carbon offset is equivalent to one ton of carbon dioxide. Further, carbon offsets can be sold on a commodity exchange between entities subject to quotas, as well as individuals and legal entities involved in the implementation of carbon offset (Article 299 of the Environmental Code).

According to the rules for carbon offset approval and offset units' provision[22], offset projects can be implemented in agriculture, landscaping of forest and steppe territories, and prevention of land degradation. GHG emissions in offset projects in agriculture and forestry are calculated following the methodology for calculating emissions and removals of greenhouse gases[23].

The new Environmental Code emphasizes land protection (Articles 228-238 of the Environmental Code). According to paragraph 3 of Article 228 of the Environmental Code, lands are subject to protection from soil degradation, depletion, damage, and deterioration (wind erosion, desertification, etc.). Article 238 of the Environmental Code also requires that individuals and legal entities shall preclude degradation and depletion of soils in their land use activities.

Article 264 prohibits any activities affecting vegetation resource territories in urban and rural settlements. Article 265 prohibits indiscriminate logging in green belts, as well as dumping of toxic waste and other substances adversely affecting the environment.

Protection and preservation of the national forest fund now provides for measures to adapt to climate change and reduce vulnerability to climate change in accordance with paragraph 10 of Article 62 of the Forest Code[24].

In his Address to the People of Kazakhstan dated September 1, 2020, President Tokayev instructed to ensure planting of two billion trees in the forest fund and 15 million trees in settlements during the five years from 2021 to 2025, as well as to develop an interactive map to monitor the progress of such works[25].

The country plans to systematically increase renewable energy penetration, including energy sources based on biofuel. Two bioelectric power plants with a total capacity of 5 MW were

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[20] Environmental Code of the Republic of Kazakhstan. Code of the Republic of Kazakhstan No. 400-VI SAM dated January 2, 2021

[21] On the approval of the National Allocation Plan for 2021. Resolution of the Government of the Republic of Kazakhstan No. 6, dated January 13, 2021.

[22] 'On the approval of the Rules for carbon offset approval and offset units' provision'. Order of the Acting Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 455 dated November 5, 2021. Registered with the Ministry of Justice of the Republic of Kazakhstan under No. 25074 on November 9, 2021.

[23] 'On the approval of Methods for calculating emissions and removals of greenhouse gases.' Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 371 dated September 13, 2021. Registered with the Ministry of Justice of the Republic of Kazakhstan under No. 24383 on September 16, 2021.

[24] Forest Code of the Republic of Kazakhstan. Code of the Republic of Kazakhstan No. 477 dated July 8, 2003.

[25] https://www.akorda.kz/ru/addresses/addresses_of_president/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-1-sentyabrya-2020-g

contracted in 2021 as part of the implementation of the policy to increase renewables penetration in the Republic of Kazakhstan[26].

In 2021, a system of forest resources allocation on the lands of the state forest fund for long-term forest use via auctions[27] and the Gosreestr platform (www.gosreestr.kz) were introduced. The land of the state forest fund can be available for long-term forest use to those individuals and companies that will offer the highest price for it. The Gosreestr platform can be used in the future for the allocation of lands of other categories for afforestation.

Penalties for land users causing deterioration of the fertility of agricultural soils have become more stringent. Thus, paragraph 5 of article 93 of the Land Code states[28]: ‘In cases where the use of a land plot or its part has led either to a significant deterioration of the fertility of agricultural land or to environmental damage, the owner of the land plot or the land user shall be obliged to eliminate the damage in accordance with the legislation of the Republic of Kazakhstan.’

According to the national project for the agro-industrial complex development of the Republic of Kazakhstan for 2021-2025[29], breeding cattle is to be subsidized in the Republic of Kazakhstan. In addition, it is planned to increase fertilizer subsidies by 1.4 times from KZT27 billion in 2021 to KZT41 billion in 2025.

Currently, the Government is considering a draft resolution 'On approval of nationally determined contributions of the Republic of Kazakhstan (NDC)'[30]. If this resolution is adopted, the Government of the Republic of Kazakhstan will encourage establishment of private industrial forest plantations and nurseries.

1.3.4 Policies and measures in waste management

According to article 33 of the Environmental Code, waste collection, sorting and (or) transportation is notification-based, therefore it is subject to state environmental control in accord with article 173. Articles 38 and 41 of the Environmental Code introduce waste accumulation limits and waste disposal limits for 1st and 2nd category enterprises.

In July 2021, an auction on waste-to-energy projects was held at the premises of Kazakhstan Electricity and Power Market Operator JSC (KOREM JSC). According to the auction results, six incinerators with a total capacity of 100 MW will be built.

Article 321 of the EC requires individuals and legal entities to conduct separate waste collection. Violation of environmental requirements for waste accumulation, collection, transportation, accounting, recovery, removal, and disposal shall be subject to a fine in the amount of forty monthly calculation indices (MCI)[31] for individuals, one hundred MCIs for officials, small businesses, or non-profit organizations, two hundred MCIs for medium-sized businesses, and five hundred MCIs for large businesses.

Article 350 of the EC introduces environmental requirements for landfills. In particular, there is a provision demanding to equip landfills with collecting and discharging systems for

[26] https://vie.korem.kz/eng/

[27] On amendments to Order No.18-02/896 of the Minister of Agriculture of the Republic of Kazakhstan dated October 7, 2015, ‘On approval of the Rules for holding tenders to allocate forest resources on the lands of the state forest fund for long-term forest use’.

Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 414 dated October 20, 2021. Registered with the Ministry of Justice of the Republic of Kazakhstan under No. 24839 on October 21, 2021.

[28] Land Code of the Republic of Kazakhstan. Code of the Republic of Kazakhstan No. 442 dated June 20, 2003.

[29] On the approval of the national project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021-2025. Resolution of the Government of the Republic of Kazakhstan No. 732 dated October 12, 2021.

[30] https://legalacts.egov.kz/npa/view?id=11811525

[31] https://online.zakon.kz/document/?doc_id=1026672#sub_id=0

leachate and landfill gas. A landfill operator must take measures to reduce methane emissions at the landfill by reducing the amount of biodegradable waste landfilling and installing landfill gas collection and disposal systems.

According to Article 351 of the EC, a ban on food waste landfilling has come into force since 2021in addition to the ban on plastic, paper, and glass landfilling.

1.4.Forecasts and overall impact of policies and measures

1.4.1. Forecasts and overall impact of policies and measures in the energy sector

Table 1.1 *Matrix of scenario assumptions*

General assumptions for all scenarios	**Scenario without measures**	**Scenario with current measures**	**Scenario with current and additional measures**
General assumptions for all scenarios			
Emissions trading system	X	X	X
GDP in 2022-2026 according to the Forecast of socio-economic development of the Republic of Kazakhstan (MNE RK), and further until 2030, grows by 4.0% per year, until 2035 – by 3.5% per year	V	V	V
Population growth in 2022-2026 according to the Forecast of socio-economic development of the Republic of Kazakhstan (MNE RK), and further until 2035, amounts to 0.8–0.9% per year	V	V	V
Oil production rises to peak (115 million tons) by 2035	V	V	V
The country's gasification is proceeding according to the forecast gas balance of the Republic of Kazakhstan as a minimum, and according to scenario assumptions as a maximum	V	V	V
2020 – 24,587 million m^3 (minimum)	V	V	V
2025 – 22,243 million m^3 (minimum)	V	V	V
2030 – 21,016 million m^3 (minimum)	V	V	V
Scenario assumptions			
The share of power generation from natural gas at the level of 20% and 25% in 2020 and 2030, respectively	X	V	V
The share of power generation from renewable energy sources at the level of 3%, 6%, 15% in 2020, 2025 and 2030	X	V	V
The share of coal-fired generation at the level of 40% by 2030	X	X	V
Commissioning of a 1.5 GW nuclear power plant (NPP) in 2030 and 2.0 GW by 2050	X	X	V
Carbon tax on sectors not covered by the emissions trading system	X	X	V

Additional measures are needed to achieve a reduction in GHG emissions from the energy sector to a level lower than minus 15% of the 1990 level (in the energy sector). Such measures include reducing the share of coal in power generation to 40% by 2030 (no more than 40% after 2030), commissioning a 1.5 GW nuclear power plant in 2030 and the introduction of carbon tax on GHG emissions from sectors not covered by quotas.

Current measures make it possible to stabilize emissions at a level slightly higher than the current level until 2030, afterwards there is a further increase in GHG emissions until 2035.

Power generation grows in all scenarios by about 20%, 30% and 50% in 2025, 2030 and 2035, respectively, compared to 2017. In the scenario with measures, these levels reach 122.11, 129.64 and 148.22 billion kWh. Coal-based power generation in scenarios with measures and with additional measures is lower compared to the scenario without measures.

In the scenario with additional measures, GHG emissions are reduced by half in 2030 and 2035 compared to other scenarios. This is due to the introduction of steel production capacity using hydrogen into the industry mix.

GHG emissions are increasing in all scenarios, which is associated with economic growth and demand for cargo and passenger transportation. Gas consumption growth in the scenario with measures leads to an increase in gas price compared to gasoline, which entails a transition from hybrid cars fueled by gas (using gasoline as an alternative) to vehicles fueled only by gasoline, which, in turn, increases GHG emissions.

Emissions related to the population (buildings) in the scenario with measures are higher than in the scenario without measures. This is due to the leakage of carbon from manufacturing industries in the form of a lower cost of coal for households. However, carbon tax introduction reduces GHG emissions from households by almost two times compared to the scenario without measures by 2035.

GHG emissions in agriculture are growing in all scenarios due to the assumption of industry growth as one of the most important parameters for the country's economy.

In scenarios with measures and with additional measures, GHG emissions after 2030 are higher than in the scenario without measures. This is due to the fact that in scenarios with measures and with additional measures, transition to electric transport occurs later as current measures lead to increased electricity cost.

The cumulative impact of the current measures is not sufficient to achieve the NDC target by 2030; they can only stabilize emissions at current levels until 2030, whereas further increase in GHG emissions occurs after 2030. In the scenario with additional measures, a reduction in GHG emissions is achieved, which contributes to NDC performance throughout the economy, and GHG emissions in the energy sector reach levels below minus 15% of the 1990 level.

1.4.2. Forecasts and overall impact of policies and measures in the industrial processes and product use sector

The MMC development will aim at domestic processing of raw materials and production of high value-added products that facilitate the development of adjacent industries, such as mechanical engineering, construction, and chemical industry as part of the roadmap for the development of the mining and metallurgy industry until 2025. Comprehensive measures will be taken in ferrous metallurgy to increase the feed of strategic raw materials to domestic enterprises, prioritize scrap supplies to the domestic market, and to boost output. The measures include an export ban on ferrous and non-ferrous scrap from the country by ground transportation for six months; quotas for the export of ferrous metal scrap and waste; licensing of collection, procurement, storage, processing and sale of scrap and waste of non-ferrous and ferrous metals. In non-ferrous metallurgy, it is planned to abolish import customs duties on titanium raw materials and export duties on aluminum alloys.

The chemical industry will continue to develop agrochemistry to produce products for export. Production of chemicals for industrial needs will remain basic and focused on the domestic market. There are plans to produce mineral and complex (NPK) fertilizers and plant protection products to ensure long-term growth in the agrochemical sector.

In Kazakhstan, industrial processes are sources of gas emissions such as CO_2 and CH_4, as well as the only source of emissions of PFCs, HFCs and SF_6.

This forecast also takes into account N_2O emissions from the production of weak nitric acid (46%). Fluoride gas emissions are generated during the production of aluminum (CF_4 and C_2F_6), use of refrigerants (HFCs, PFCs) and from insulation in high-voltage power engineering (SF_6). Metal industry has remained the major source of greenhouse gas emissions in industry both for the reporting year and previous years. According to the results of the 2020 GHG inventory, its contribution to the total GHG emissions from the IPPU sector in 2020 amounted to 54.0%, excluding ODS consumption.

The State Program of Industrial and Innovative Development for 2020-2025, unlike the previous ones (SPAIID 2010-2014, SPIID 2015-2019), does not focus on energy-efficient development of the processing industry, which may lead to an increase in GHG emissions, since the plan is to expand production capacities and boost output.

Total greenhouse gas emissions from the IPPU sector in 2020 amounted to 22,290.21 thousand tons of CO_2-eq. It is 6.8% more than the 2019 emissions and 15.5% higher than the GHG emissions across the entire IPPU sector in 1990.

Emissions under the scenario with measures (WCM) are increasing during the forecast period. With the adoption of additional measures from 2023, there is an opportunity for their reduction by 10% but emissions remain above the baseline across the horizon. Emissions exceed WCM by 5% under the scenario without measures.

1.4.3. Forecasts and overall impact of policies and measures in the land use, land-use change and forestry sector (LULUCF)

The driver of GHG emissions in the scenario without measures is the Cultivated Lands subsector, and the total emissions from LULUCF until 2035 remain almost at the same level as GHG emissions in 2020. The Cultivated Lands subsector show very large potential for reducing GHG emissions. In 2020, cultivated lands emitted about 32 million tons of CO_2-eq. Considering these figures, the reduction potential in the Cultivated Lands sector amounts to 30-35 million tons in CO_2 equivalent. Depleting humus and expansive area of arable land are the drivers of high GHG emissions from the Cultivated Lands sector.

The scenario with the measures stipulates plans for planting 2 billion trees as announced by the President of the Republic of Kazakhstan in the Address to the People of Kazakhstan on September 1, 2020. The scenario with measures also considers the state program of subsidizing agricultural fertilizers for cultivated lands.

Only the scenario with additional measures by 2035 reaches the level of removals of 1990.

1.4.4. Forecasts and overall impact of policies and measures in agriculture

In 2020, emissions amounted to about 40.72 million tons, which is still below the base level of 1990. However, the number of cattle is expected to grow by 2035, and emissions will exceed 1990 levels by more than 5.5 million tons of CO_2 in 2035. Emissions from the livestock sector account for about 2/3, while arable land and pastures account for 1/3 of total agricultural emissions. Rice cultivation will not have a noticeable impact on total emissions.

With the improvement of livestock breeds (breeding cattle), the same amount of meat, milk and other products can be obtained from fewer cattle, which in turn will lead to a reduction in methane emissions due to less fermentation. The A1 action can be performed by importing the breed and creating local breeding centers or by combining the first and second measures.

Manure-based biogas production is another efficient way of generating electricity and heat instead of consuming electricity produced by coal-fired power plants. One ton of manure in biogas production can save about 40 kg of CO2, while reducing the cost of heating and electricity for farmers.

1.4.5. Forecasts and overall impact of policies and measures in waste management

GHG emissions from industrial wastewater will almost double from 940.8 thousand tons of CO2-eq in 2021 to 1851.9 thousand tons of CO2-eq in 2035. By 2035, GHG emissions from municipal wastewater will increase from 2,185 thousand tons of CO2-eq in 2020 to slightly over 2,500 thousand tons of CO2–eq.

The scenario with measures implies such policies and measures as a ban on food waste, paper and plastic landfilling, separate waste collection, construction of incineration plants in 6 major cities of RK, payment for packaging and tires, as well as a vehicle recycling program.

In the scenario without measures, GHG emissions in 2035 will be almost twice as high as the 1990 level. In the scenario with measures, GHG emissions will reach 9 million tons in 2035, while in the scenario with additional measures, emissions will amount to about 8.5 million tons in CO2 equivalent.

1.5. Vulnerability assessment, climate change impact and adaptation measures

Kazakhstan ranks 40th among the countries participating in the assessment with the ND-GAIN index value of 58.7, vulnerability of 0.342, and readiness of 0.516.

In Kazakhstan, 2021 ranked the **5th** among the warmest years with an air temperature anomaly of 1.58 °C. Nine of the ten warmest years are in the XXI century. The absolute maximum temperature was observed in 2020, when the anomaly made 1.92 °C, thereby updating the record of 2013 with the anomaly of 1.89 °C.

Steady increase in average annual air temperature has been observed across all regions of Kazakhstan from 1976 to 2021. Linear trend coefficients range from 0.23 °C/10 years to 0.54 °C/10 years with a determination coefficient of 10-38%. All trends are significant at the 5% level.

On average, the winter season warming trend in Kazakhstan is 0.19 °C/10 years. The most intense warming was observed in all regions of Kazakhstan in the spring season. The temperature increase rate ranges from 0.43 °C/10 years to 0.87 °C/10 years at 18-36% of the variance explained by the trend. The average summer temperature in Kazakhstan steadily increased by 0.22 °C/10 years. The average autumn temperature in Kazakhstan increases by 0.22 °C/10 years.

Other characteristics change too, including the frequency and intensity of weather and climatic extremes, along with the average air temperature and precipitation.

Observed vegetation period tends to increase by 2-5 days/10 years across the country.

The frequency of high summer temperatures increases along with the average temperature growth. Considering hot and dry summers in the western and southern regions of Kazakhstan, this affects vegetation, humans, and animals. For example, the frequency of days with temperatures above 30 °C increases almost nationwide.

In most of the country's territory, the total number of heat-wave days during the warm period is growing significantly (a heat wave when the excess heat rate has a positive value for several subsequent days).

An increase in the number of individual heat waves during the warm period is observed almost throughout the entire territory of the republic.

The duration of the maximum heat wave in the warm period is increasing ubiquitously.

Air temperature increase across all seasons leads to an increase in the total duration of heat waves over the year (when, for at least six consecutive days, the daily maximum air temperature was above the 90th -percentile) countrywide.

Air temperature growth in most months of the warm season leads an increase in the *shortage of cold*, or the need to maintain favorable indoor temperature, in this case, a commonly accepted threshold is 23 °C.

In many regions of Kazakhstan, the daily minimum temperature value is increasing at a faster pace than the increase in the daily maximum in about half of the cases. During the warm season, this leads to an increase in the number of tropical nights (when the daily minimum temperature exceeds 20 °C).

Due to an increase in the minimum daily temperatures, in general, the number of frost days (when the daily minimum temperature drops below 0 °C) and strong frost days (when the daily minimum temperature drops below minus 2 °C) decreases over the year.

The number of days with very severe frosts (when the daily minimum air temperature is below minus 20 °C) goes down almost countrywide.

Widespread reduction in heat deficit during the cold season stems from the fact that there are fewer days with negative temperatures.

On average, annual precipitation in Kazakhstan decreased in the1960s and 1970s; during the recent 46-year period there have been no long-period trends, while only alternation of short periods with positive and negative anomalies in precipitation has been observed.

The observed increase in the frequency and duration of high-temperature periods during the warm season leads to negative consequences for both humans and animals, as well as transport infrastructure (for example, road pavement may deform), for urban conditions and recreation areas, for the energy sector, as there is a need for additional power generation to cool premises.

An increase in surface temperature shortens the period of negative temperatures, therefore, probability of liquid precipitation is higher. This, in turn, may affect snow accumulation during the cold season. In mountainous areas, both the area and the period of solid precipitation are reduced, which affects glacial systems.

An increase in surface temperature during the cold season alleviates the need for heat generation. Reduced number of frosty days, on the one hand, has a positive impact on public health, on the other hand, heat waves during the cold season may lead to icy conditions on the roads.

Longer vegetation season in those areas where it is combined with more intensive precipitation and reduced maximum duration of the period without precipitation (some northern and southeastern regions) improves conditions for crop production.

Future climate change impacts may be both negative and positive. Because the existing infrastructure has been generally created to fit the climatic conditions of the past decades, climate change mainly leads to negative, often very grave, consequences, especially in arid regions. First, this is due to higher the probability and intensity of heat waves and changes in the hydrological cycle. To avoid dangerous climate change impacts, measures must be taken along two directions: reduce impact on the climate system by reducing GHG emissions into the atmosphere and adapt to the changes already observed and expected. Estimates of probable short-term and long-term climate change are necessary for efficient adaptation with minimum damage and maximum advantage of climate change and its impact on economic sectors, population, and natural landscapes.

Surface air temperature is expected to further rise across all seasons. The average annual temperatures by the end of the XXI century will significantly increase along all the considered emission trajectories, while the country is projected to experience a more significant increase in temperature than the average rise globally and in most other Asian countries. According to the trajectory of the highest emissions, by the end of the century, the average annual temperature in Kazakhstan is projected to increase by more than 6 °C, which is about 3 °C higher than in the scenario with lower emissions, indicating a large difference in warming in Kazakhstan, which can be achieved by control over global emissions.

Increased temperature level, on the one hand, would spur the demand for power to cool premises during the warm season; on the other hand, it would alleviate the need for indoor heating, since the period when outdoor temperatures are below the threshold comfortable values will shorten, while the sum of negative temperatures during the cold period of the year will also decrease. In the energy sector, it is necessary to take such changes into account in seasonal peak loads.

Most climate models predict a slight increase in annual precipitation on the territory of Kazakhstan. By the middle of this century, this increase will average 7-8% in Kazakhstan depending on the scenario of GHG emissions; by the end of the century, it will be in the range of 11-14%. The change in annual precipitation amounts is uneven across the country's territory – from 10 to 20%.

The greatest increase in the average seasonal precipitation in Kazakhstan can be expected in winter – by 20-35% by the end of the century, by 13-16% in spring, and by about 7% in autumn. An unfavorable scenario is expected for summers – precipitation in Kazakhstan will decrease by 12% on average.

An increase in air temperature in all seasons of the year, including the cold period, leads to a reduction in the amount of precipitation falling in the form of snow. This, in turn, leads to a reduction in snow accumulation, which is an unfavorable factor for the regions of rain-fed agriculture including grain-growing areas of Northern Kazakhstan. This may also adversely affect irrigation agriculture developed mainly in the foothill areas of the south and southeast and obtaining water from rivers sourced from snow and ice.

Droughts affect two-thirds of Kazakhstan's territory and are a characteristic feature of the climate. Drought often affects grain production in non-irrigated agricultural areas in the north. To date, no strong signs of climate change impact on historical drought trends have been detected. However, under global climate warming scenarios of 1.5 °C, 2.0 °C and 3.0 °C, a significant increase in the duration and scale of drought in Central Asia is expected in the future at global warming levels[32].

Water resources

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[32] Seneviratne, S.I., X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, I. Iskandar, J. Kossin, S. Lewis, F. Otto, I. Pinto, M. Satoh, S.M. Vicente-Serrano, M. Wehner, and B. Zhou, 2021: Weather and Climate Extreme Events in a Changing Climate. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1513–1766, doi:10.1017/9781009157896.013.

The outputs of the climatic parameters and river flow forecasting for selected HEB areas revealed the following changes: an increase in air temperature is expected in all hydro-economic basins, and precipitation amounts would go up to varying degrees depending on the basin. Temperature increase affects the melting of glaciers, which leads to more intensive runoff in mountain rivers until the middle of the century with further decrease because of glaciers depletion by the end of the century. This trend in runoff changes is characteristic of the following HEBs: Aral-Syrdarya, Yertis, and Shu-Talas. However, the Balkash-Alakol HEB would show more intensive runoff by the end of the century, which can be possibly explained by protracted degradation of glaciers.

All HEBs in flat areas, in particular, Nura-Sarysu, Yesil, Zhaik-Caspian, and Tobol-Torgai tend to reduce water runoff by the end of the century, which is associated with an increase in air temperature, high evaporation, and a slight increase in precipitation.

Thus, according to modeling results under two scenarios – ssp 126 and ssp 370 – runoff is expected to reduce by the end of the century in all water basins, except for the Balkash-Alakol HEB, where the model shows an increase in water runoff until year 2100.

Moreover, according to forecast estimates, water consumption is expected to grow because of expansion of the area of irrigated agriculture from 1.8 million hectares to 3 million by 2030, while increased average annual temperature will boost water consumption per 1 hectare of land.

Considering the planned expansion of irrigated agricultural land in the country, possible shortage of water should be kept in mind, in particular, in flat-area rivers, and mountainous-area rivers by the end of the century. Therefore, the above outputs of climate parameters forecasting must be accounted for in expanding irrigated agriculture, along with river runoffs for each individual HEB.

1.5.4. Agriculture

Over the past three years, there has been an increase in arable land by 5%, which is 26.3 million hectares, hayfields – by 5% or 2.2 million hectares, pastures – by 7.4% or 75.6 million hectares. Fallow land decrease by 40%, or 1.8 million hectares, has been observed. In addition, 307 thousand hectares have been withdrawn from agricultural land over the past three years to expand the boundaries of settlements and industry facilities.

The current agricultural policy focuses on boosting domestic production to replace imports and promote exports.

It is mainly large agricultural enterprises that cultivate arable land. Small-scale agricultural enterprises (individual entrepreneurs, peasant farms and households) predominate in animal husbandry and vegetable growing[33].

Wheat production is one of the most important segments of agriculture that ensures the country's food security. Kazakhstan is also a leading wheat exporter (UNDP, 2019).

Agrotechnology and weather are the key factors crop production output. Other factors like technical, scientific, educational and information support contribute to the improvement of cultivation technology and taking maximum advantage of weather conditions (or reducing damage).

In 2020, water intake for agricultural needs amounted to 13.3 km^3, which is 1 km^3 more than in 2019. According to the estimates of the Ministry of Ecology, Geology and Natural

[33] Preliminary data for 2021. Statistical Yearbook of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics.

Resources of the Republic of Kazakhstan, projected shortage by 2030 will be 11.7 km^3 if the current trend of water consumption is maintained. Advanced application of water-saving technologies and transition to drought-resistant crops are key drivers of water consumption efficiency in the country.

The area of pasture lands in Kazakhstan amounted to 186.4 million hectares in 2017. Of these, 6.0 million hectares are used by foreign land users. The state uses 180.4 million hectares of pastures, of which 5.9 million hectares have been reclaimed, 105.2 million hectares have been watered. Hence, more than 111.1 million hectares of pastures are suitable for grazing. Of the 180.4 million hectares, 71.1 million hectares are currently being used including 4.0 million hectares of reclaimed and 43.3 million hectares of watered pastures.[34] More than 80% of the total livestock are concentrated in private farmsteads, and their owners let the cattle graze within a radius of 5-7 kilometers from their residence for economic considerations. This resulted in degradation of about 27 million hectares of pastures located predominantly near settlements. Natural hayfields are land plots used for haymaking in a regular manner. The area of hayfields is 4.9 million hectares, of which 43.9 thousand hectares have been reclaimed, and 727.5 thousand hectares are irrigated by inundation.

Highland pastures are more vulnerable to climate change. They are more likely to be affected by a significant decrease in the yield of pasture plants. For example, pasture yield of Assy area are expected to decrease by 20% by 2030, which is up to 80% of the current yield level.

Thus, the anticipated climate warming by 2030 will lead to a slight decrease in pasture yield in the lowlands and a more significant decrease in the mountainous areas of southern Kazakhstan.

The expected decrease in pasture productivity will naturally lead to a change in their livestock capacity and optimal grazing pressure. Based on the pasture yield expected by 2030, the livestock capacity (N) and the optimal grazing pressure (H_o) for summer grazing of sheep have been calculated (Table 6.12). Here, the average summer rate of forage consumption per flock (50% of young animals and 50% of adult animals) was taken equal to 1.6 kg/animal∗day.

1.5.5. Tourism

The State program for the development of the tourism industry of the Republic of Kazakhstan for 2019-2025 was approved by Decree No. 360 of the Government of the Republic of Kazakhstan dated May 31, 2019[35]. The program’s expected outcomes are as follows: improved availability and quality of tourist services and products, better quality of life of the population via the development of sites of tourist interest and mass involvement of labor forces in the tourism industry, disruptive growth of external and internal tourist flows, increased investment in the tourism industry based on the creation of favorable tourist environment and promotion of the touristic potential of Kazakhstan in domestic and international markets. The program's target tourism share in the total GDP of the Republic of Kazakhstan is at least 8% by 2025.

The Concept's section titled 'Creating favorable environment and improving quality of service' emphasizes promoting the availability and quality of tourist services and products through the development of tourist destinations and mass involvement of labor force in the industry,

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[34] Summary analytical report on the state and use of the lands of the Republic of Kazakhstan for 2017. Agency for Land Management of the Republic of Kazakhstan. Astana, 2018. 273 p.

[35] https://adilet.zan.kz/rus/docs/P1900000360

creating favorable tourist environment, wide publicity of Kazakhstan's tourist potential; it also considers issues of improving the quality of tourist services in detail.

In general, the tourism industry of Kazakhstan is likely to be affected by seasonal changes (changes in characteristics, timing, and duration of seasons), which may either harm or benefit tourism activities. These industries may suffer from off-season weather and extreme events (storms, blizzards, hail, etc.) that cause damage to infrastructure. The closer a tourism activity relates to the natural environment, the more vulnerable it is to climatic impacts.

Kazakhstan is a landlocked country; however, it has large natural and anthropogenic lakes, which are popular tourist destinations in both summer and winter. During the hot and dry summer, beach tourism is popular among local tourists and often attracts tourists from abroad.

Ski tourism develops exclusively around snowy mountain peaks and mountain resorts of Kazakhstan. The two main areas of ski tourism development are the Northern Tien Shan (Almaty) and the Altai Mountains. The Northern Tien Shan is planned to be developed with government support that includes large investments. The Altai Mountains region is developing mainly due to private investments.

Kazakhstan possesses a significant potential for the development of both medical and wellness tourism. There are 20 registered and operational resort areas in Kazakhstan, and more than 10 of them have proven and researched natural healing factors. Those are balneological, mud treatment, and climatic resorts. Resort areas with such natural healing factors as more than 500 sources of therapeutic mineral waters, 78 mud lakes, 50 climatic sites show good prospects for the development of recreational and health tourism in Kazakhstan.

The most popular type of tourism in terms of attracting foreign tourists to Kazakhstan are MICE and business tourism. Business meetings, conferences, and exhibitions, such as the successfully held international exhibition Astana EXPO-2017, attract thousands of foreign visitors from neighboring countries and overseas annually. This tourism sector is least affected by climate change.

Ecotourism in Kazakhstan is a small but developing sector. It is an important component of recreation for domestic and foreign tourists. In recent years, the number of ecotourism facilities has noticeably increased. Some small ecotourism enterprises show the share of foreign tourists of about 100%.

1.5.4. Assessment of climate change impact risks and economic benefits

Increase in temperature, change in precipitation and shift of arid zones to the north are expected to aggravate the risk of land degradation and erosion, which will lead to a drop in agricultural productivity in Kazakhstan. Drought poses a significant risk for the entire industry too, particularly for wheat production on rain-fed lands. Climate change will make national development, food security and the natural environment more vulnerable.

The problem of water shortage will be aggravated by a combination of scarce precipitation and extreme temperatures in the summer, which will accelerate desertification processes in the plains of Western, Northern and Central Kazakhstan. At the same time, temperature increase causes glacier melting; in the medium term, this will aggravate flooding risks in the southern and eastern regions therefore becoming a threat to water supply by the middle of the century. Since 1950, the mass of glaciers in Kazakhstan has decreased by 14-30% (USAID, 2017).

In the future, agricultural conditions can be expected to improve in some regions due to increased rainfall, while other areas will suffer from droughts.

According to UNDP (2020), economic losses of wheat yield are estimated at 33% (or KZT457 billion in 2019 prices) of the current potential by 2030 and 12% (KZT608 billion in 2019 prices) by 2050.

A similar outlook is predicted for a drop in pasture yield: livestock productivity will decrease by 10% (or KZT108 billion) by 2030, and up to 15% (or KZT170 billion) by 2050 against the current potential. The most severe climatic scenario may show a decrease from 10% to 20%. However, a positive impact of climate warming on the yield of sunflower seeds is expected, which will lead to an increase in production by 8% (almost two billion tenge) by 2030 and by about 4% (almost one billion tenge) by 2050 compared to the current gross output. In general, crop production is more vulnerable to risks than animal husbandry (World Bank, 2016).

Investments in adaptation provide co-benefits. Economic losses can be reduced both in agriculture and in adjacent supplying or consuming industries. Measures aimed primarily at supporting the domestic economy are even more beneficial. For example, construction activity creates jobs in Kazakhstan. Products like drip irrigation systems are mostly imported and reduce these benefits. However, in both cases, permanent jobs can be created in agriculture and related industries.

The fight against climate change requires a holistic approach including both GHG reduction and adaptation measures. In case of water scarcity, it is very important to combine adaptation measures such as expanding the area of irrigated land, collecting water, and building water-saving infrastructure. Adaptation measures that provide small benefits at small costs are also important, especially for small farmers who do not have rich financial resources.

1.5.5. Extreme hydro-meteorological events in Kazakhstan

The air temperature anomaly of 1.58 °C in Kazakhstan in 2021 ranked 5th among the warmest years observed in the country. Of the ten warmest years, nine are in the XXI century. The absolute maximum temperature was observed in 2020, when the anomaly made 1.92° C, thereby updating the record of 2013 with the anomaly of 1.89° C.

A growing trend of costs incurred in relation to disaster management is observed.

Extreme meteorological events characteristic of Kazakhstan's territory during the cold period are heavy snowfalls and blizzards accompanied by storm and even hurricane winds, severe prolonged frosts, icy-frost conditions, and late spring frosts. During the warm period one observes heavy downpours accompanied by thunderstorms, hail, and squall wind. In the summer, cases of extreme fire threat are recorded. In addition, Kazakhstan is characterized by severe droughts leading to a sharp decrease in crop yield.

Abnormally low air temperatures pose a significant threat to the communities' normal life and cause emergencies associated with accidents in heat and power systems, and utility networks.

In terms of the number of hazardous hydrological events, mountain river floods rank first in Kazakhstan – 47% of the total number of NHMP cases; lowland river floods – 26%; gorges – 13%; mudslides and extreme low water – 7% and 6%, respectively.

Higher water levels in most mountain rivers and frequency of floods are associated with climate change, increased air temperature, degradation of mountain glaciation and higher water output from glaciers. Warming pushes the upper limit of rainfall in the mountains further up, thereby expanding the area of rain floods.

Gorges on lowland rivers and associated flooding of depressed terrain areas are most often observed on rivers flowing from south to north (the Syrdarya, Yertis, Yesil, Tobol rivers). Climate change and rising air temperatures have caused earlier ice breakup in upper reaches with ice remaining downstream.

Mudslides are the most significant natural hazards in Kazakhstan in terms of incidence, frequency, and destructive impact.

Mountains and foothills of Kazakhstan, where mudflows mainly emerge and cause damage, occupy about 13% of the territory. Foothill terrains possess natural features making them most suitable for permanent residence, therefore the population density is higher here: more than 1/3 of the country's population live in foothills.

1.6. Financial resources and technology transfer

The expenses of enterprises for environmental protection in 2020 decreased to KZT384 billion compared to KZT420.4 billion in 2019. Of these, 54.8%, or KZT210.4 billion, were operating expenses, the remaining 45.2% were investments in capital assets.

Almost 60% of the enterprises' expenses for environmental protection were incurred in relation to ambient air protection and climate change problems (KZT88.5 billion), waste management (KZT73.2 billion) and wastewater treatment (KZT67 billion).

A significant amount of expenses was also incurred on environmental activities in the field of renewable energy sources amounting to KZT115.4 billion, which is 29.2% less than in the previous year.

Kazakhstan became a member of the Global Environment Facility (GEF) on March 30, 1998. Since them, the GEF allocated funds in the amount of USD118,646,610 for 36 national-level projects (the total amount of co-financing has been USD994,659,756), as well as funds in the amount of USD674,326,919 for 36 regional/global projects (the total amount of co-financing has been USD4,306,315,409)[36].

On October 15, 2020, the Adaptation Fund Board approved a project proposal for Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan to reduce the vulnerability of the Central Asian population to floods caused by glacial lake outbursts in a changing climate. The project is being developed jointly by the United Nations and UNESCO. Funding in the amount of USD6,500,000 was allocated for the project [37].

The Green Climate Fund is implementing two projects in Kazakhstan with a total cost of USD148,700,000 with co-financing in the amount of USD 408,300. [38].

The investment plan of CIF (Climate Investment Funds) in Kazakhstan is aimed at concessional financing in the amount of USD200 million of the efforts to upgrade district heating systems in target cities, which includes improving energy efficiency and incentivizing transformative investments in the latent potential of renewable energy sources.

Currently, three World Bank climate change programs are underway in Kazakhstan[39].

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[36] https://assembly.thegef.org/country/kazakhstan
[37] https://www.adaptation-fund.org/wp-content/uploads/2020/10/AFB-Decision-B.35.a-35.b.83_Approval_of_proposal_for_Central-Asia.pdf
[38] https://www.greenclimate.fund/countries/kazakhstan
[39] https://projects.worldbank.org/en/projects-operations/projects-list?countrycode_exact=KZ&os=0&status_exact=Active

According to the quarterly reviews of the Eurasian Development Bank based on information from 15 international development banks, in 2020, Kazakhstan received financing in the amount of USD 2.8 billion, of which USD 1.8 billion were sovereign loans, and another USD billion was financing in the private sector.[40]

The largest development banks that approved financing in Kazakhstan were the Asian Development Bank – ADB (USD1 billion) and the Asian Infrastructure Investment Bank – AIIB (USD750 million). ADB provided funding to counter the social, economic and health impacts caused by the COVID-19 pandemic. AIIB approved a loan to provide budget support to mitigate the negative effects of the COVID-19 pandemic.

In December 2017, the Government of Kazakhstan and the EBRD signed a new three-year agreement as a continuation of the Partnership Framework Agreement that will give a great impetus to joint activities between the EBRD and Kazakhstan in the municipal infrastructure sector, development of green economy and renewable energy, improving Kazakhstan's global competitiveness, preparing for privatization in the country and many other areas.

ADB's current activities in Kazakhstan are carried out within the framework of the Country Partnership Strategy for 2017-2021, which includes three components: economic diversification, inclusive development, and sustainable growth. Kazakhstan is an active participant in the Central Asian Regional Economic Cooperation (CAREC) Program with the largest portfolio among the participating countries amounting to USD9 billion, of which USD2 billion. were funded by the ADB.

ADB started co-financing operations in Kazakhstan in 1999. Since then, the amount of sovereign co-financing obligations of Kazakhstan has reached USD4.58 billion for six investment projects and USD7.15 million. for nine technical assistance projects. The amount of non-sovereign co-financing for Kazakhstan reached USD134.02 million for three investment projects.

As of now, AIIB has approved one non-sovereign project in Kazakhstan in the field of climate change (Energy sector). It is the ‘Zhanatas 100 MW Wind Power Plant’ project worth USD136.2 million, of which AIIB loan is about USD 46.7 million and the rest is to be funded by the sponsors and other financial institutions.[41]

In 2019, EDB financed a project for the 'Sary-Arka' gas pipeline construction in the amount of KZT102 billion.[42] In 2013-2019, it financed a project to build a 45 MW wind power plant at the Yerementau site worth KZT14.167 billion. Since 2010 to this day, USD385 million were allocated for the expansion and reconstruction of Ekibastuz GRES-2. Since 2015, USD 7.7 billion have been allocated to finance the improvement and construction of the gas distribution network in Aktobe oblast.

Kazakhstan provides assistance to developing countries implementing the Law of the Republic of Kazakhstan 'On Official Development Assistance' dated December 10, 2014, and in accordance with its invitee status at the OECD Development Assistance Committee (hereinafter – DAC).

The total amount of official development assistance (hereinafter – ODA) provided by Kazakhstan to foreign countries through bilateral and multilateral channels in 2019 amounted to USD34.21 million.[43]

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[40] https://kapital.kz/finance/98440/finansirovaniye-bankov-razvitiya-v-stranakh-tsa-vyroslo-za-god-v-poltora-raza.html
[41] https://www.aiib.org/en/projects/approved/2019/_download/kazakhstan/Kazakhstan-100-MW-Zhantas-Wind-Power-Project.pdf
[42] https://eabr.org/en/projects/eabr/
[43] https://stats.oecd.org/qwids/#?x=1&y=6&f=4:1,2:1,3:51,5:3,7:1&q=4:1+2:1+3:51+5:3+7:1+1:204+6:2012,2013,2014,2015,2016,2017,2018,2019

As of 2020, Kazakhstan's contribution under UNFCCC amounted to EUR45,530.[44]

Kazakhstan's contribution under Kyoto Protocol for 2020 amounted to EUR6,724.[45]

Kazakhstan's voluntary contributions to UNEP amounted [46] to USD100,000 in 2020 and 2021. Kazakhstan's voluntary contributions to the UN amounted to USD4,993,497 [47](2020) and USD5,148,755[48] (2021).

On December 8, 2021, a regional workshop on the Development Finance Assessment in the framework of the regional platform on Sustainable Development Goals (SDGs) in Central Asia was organized. On November 25, 2021, Kazakhstan hosted the International Environmental Forum 'Kazakhstan – Benelux.' In November 2021, a round table was held on ‘The current situation in Kazakhstan's power industry: challenges and solutions’. On November 18, 2021, the Ministry of Energy of the Republic of Kazakhstan hosted a discussion on the prospective power balance of Kazakhstan and sustainable energy development until 2035. On November 11, 2021, a meeting of the Coordination Council on Ecology and Low-carbon Development was held. On November 2, 2021, the annual meeting of the Executive Assembly of the World Energy Council (WEC) was held in an online format. On October 26, 2021, Uralsk hosted the IV international environmental forum ‘Uralsk Green Forum’. On October 13, 2021, President Kassym-Zhomart Tokayev took part in the international conference 'Ways to Achieve the Goals of the Paris Agreement and Kazakhstan’s Carbon Neutrality' arranged in Astana. In October 2021, Astana hosted the World Energy Week and the XIV Eurasian KazEnergy Forum attended by representatives of 90 countries. On October 26, 2021, Kazakhstan presented the experience of implementing solutions for the transformation of public and private sector finances to mitigate the adverse impact on nature on the global platform of Nature for Life Hub. KAZENERGY Association and Shell Kazakhstan hold annual Student Energy Challenge-JUNIOR in Kazakhstan. In August 2021, Kazakhstan hosted the International Forum on Decarbonization of the Extractive Industry and Carbon Tax (CBAM). In July 2021, successful auctions were held for the first time in Kazakhstan to select WtE projects with a total capacity of 100.8 MW on the trading platform of KOREM JSC. On July 8, 2021, the conference on NDC titled 'Long-term strategies as a means of promoting energy transition in Central Asian countries' was held online. On June 28, 2021, an online meeting was held between A. Wilkinson, Secretary General of the World Energy Council, and representatives of Kazakhstani National Committee at WEC. On June 3, 2021, the session 'Women in Ecology and Sustainable Initiatives' was held within the framework of the ECOJER International Congress ‘Shaping Sustainable Future’. On May 30, 2021, Astana hosted the round table ‘Green Economy – Paradigm of Innovative and Sustainable Development of Kazakhstan’. On April 27-28, 2021, a national workshop was held with the participation of representatives of the National Commission for Women, Family and Demographic Policy under the President of the Republic of Kazakhstan. At the 6th annual award ceremony of the international Climate Bonds Awards 2021, Kazakhstan Entrepreneurship Development Fund ‘Damu’ was recognized as one of the world's leading organizations in promoting ‘green finance’. On January 2, 2021, the President of Kazakhstan Kassym-Zhomart Tokayev signed the new Environmental Code of the Republic of Kazakhstan. In November 2020, UNDP, in cooperation with the Government of Kazakhstan, began developing

[44] https://unfccc.int/sites/default/files/resource/sbi2021_inf01.pdf
[45] https://unfccc.int/sites/default/files/resource/sbi2021_inf01.pdf
[46] https://www.unep.org/about-un-environment/funding-and-partnerships/check-your-contributions
[47] https://www.un.org/en/ga/contributions/honourroll_2020.shtml
[48] https://www.un.org/en/ga/contributions/honourroll.shtml

GIS tools to promote environmental protection and sustainable land use within the framework of the global project ‘Mapping Nature for People and the Planet’.

1.7. Education, personnel training, and awareness-raising campaigns

Adoption of the Concept of lifelong learning in July 2021 became a milestone in the development of the education system in general and the potential promotion of climate change knowledge through the non-formal education system in particular.[49] The purpose of this Concept is ‘to create a system of continuing education that provides coverage of the country's population with formal, non-formal and informal education to raise its competitiveness and basic competencies to the level of OECD countries.’

The new Environmental Code of the Republic of Kazakhstan (dated January 2, 2021) adopted new provisions regulating access to environmental information, and its full Chapter 4 is dedicated to this matter.[50]

Moreover, the new Environmental Code prescribes maintenance of PRTR (Pollutant Release and Transfer Register) – a structured electronic database on the state of pollutant emissions into the environment and levels of environmental pollution publicly available on the official internet resource, as Kazakhstan ratified the Protocol on Pollutant Release and Transfer Register (PRTR).

A special section 'Climate of Kazakhstan' is now available on the website of Kazhydromet RSE of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.[51]

In 2021, the network of preschool institutions consisted of 10,848 units including 7,304 kindergartens and 3,544 mini-centers. The network of private preschool organizations has grown by more than 13 times due to involvement of private business and placement of educational public procurement order: from 347 units in 2010 to 4,881 units in 2021.

In 2021, 7,549 schools training 3,594,972 students were functioning in the general secondary education system.[52]

The total number of students in educational institutions in the 2020-2021 academic year amounted to 4,583.10 thousand people, of which 49.5% were female and 50.5% were male. The share of students enrolled in general education schools was 76% of the total number of students, technical and vocational institution students – 10.4%, undergraduate students – 12.6%, graduate students – 0.8%, doctoral students – 0.2%, residency students – 0.1%.

Women predominantly enroll and graduate from degree schools, technical and vocational institutions majoring in social, humanitarian, and medical sciences, while men mainly major in technical and technological sciences.

In recent years, higher education has become significantly more accessible. Over the past four years, the number of grants allocated for bachelor's degree programs has increased by 1.7 times, master's degree programs – by 1.8, doctoral studies – by 3.7.

Kazakhstan fulfills its obligations to ensure fair access to universities for people with low socio-economic status. In 2021, the list of university admission quotas for categories of individuals

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[49] Resolution of the Government of the Republic of Kazakhstan No. 471 dated July 8, 2021 'On Approval of the Concept of Lifelong Learning (Continuing Education)': https://adilet.zan.kz/rus/docs/P2100000471
[50] Environmental Code of the Republic of Kazakhstan dated January 2, 2021, No. 400-VI ZRK: https://adilet.zan.kz/rus/docs/K2100000400
[51] https://www.kazhydromet.kz/ru/
[52] Ministry of Education and Science of the Republic of Kazakhstan: https://www.gov.kz/memleket/entities/edu/activities/158?lang=ru

from socially vulnerable population groups. In addition, a provision on state educational loan for degree students was included in the Law of the Republic of Kazakhstan 'On Education'.

Kazakhstani universities tend to be more and more represented in global university rankings. Since 2016, the number of universities listed in the QS World University Rankings has grown from 8 to 14. The country's three national universities have been recognized by the Times Higher Education rating publication.

In 2020, Kazakh universities implemented 152 dual-degree programs with 77 partner universities. Partner universities are based in the CIS, Europe, Asia, and the USA. The student population enrolled in such programs amounted to 1,120 people: bachelor's degree – 674, master's degree – 435, doctoral studies – 11.[53]

Plenty of climate information presented in a format appealing to public is posted on the website of the online eco-magazine 'LIVEN. Living Asia'.

Many useful pieces of information on climate change, mitigation and adaptation have been collected on the YouTube channel 'UNDP Kazakhstan Climate Learning Video Portal'.[54]

The presentation of the collective monograph 'Tomorrow was Too Late: Environmental Risks of Kazakhstan' was a noticeable public awareness event dedicated to environmental issues. On October 2-8, 2021, the student festival 'Climate Week' was held online timed to coincide with the 26th UN Conference on Climate Change (COP26). Also in October 2021, the student debate 'The Voice of Youth: Uniting the World to Fight Climate Change' was held.

As noted above, there is no specific 'Ecology' course in the secondary school program of the Republic of Kazakhstan. Environmental issues are recommended for integration in other school courses as a cross-cutting topic. It is also recommended to conduct environmental education during advisory hours. In 2020, the Republican Educational and Methodological Center for Extracurricular Education of the Ministry of Education and Science of the Republic of Kazakhstan developed a 'Program of advisory hours on environmental education for students of grades from 1 through 11.' Moreover, the 'Republican Educational and Methodological Center for Extracurricular Education' RSE offers several programs with environmental content. Kazakh-German University offers the educational program 'Energy and Environmental Engineering'. Several online training courses on climate change are available on the platform of the Central Asian Climate Information Platform (CACIP).[55] The Department of Climate Policy and Green Technologies of the Ministry held an online training course on 'Adaptation to climate change in the Republic of Kazakhstan' from August 28 to September 7, 2020. UNDP in Kazakhstan organized several trainings on access to financing and calculation of GHG emissions.

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[53] https://www.gov.kz/memleket/entities/edu/activities/272?lang=ru
[54] https://www.youtube.com/channel/UCWj-QJOO7QlI7NnlOHd33qw
[55] https://elearn.centralasiaclimateportal.org/courses

II.NATIONAL CIRCUMSTANCES RELATED TO THE GREENHOUSE GASES EMISSION AND REMOVAL

2.1.Political structure

The Republic of Kazakhstan is a unitary secular state with the presidential government system.[56]

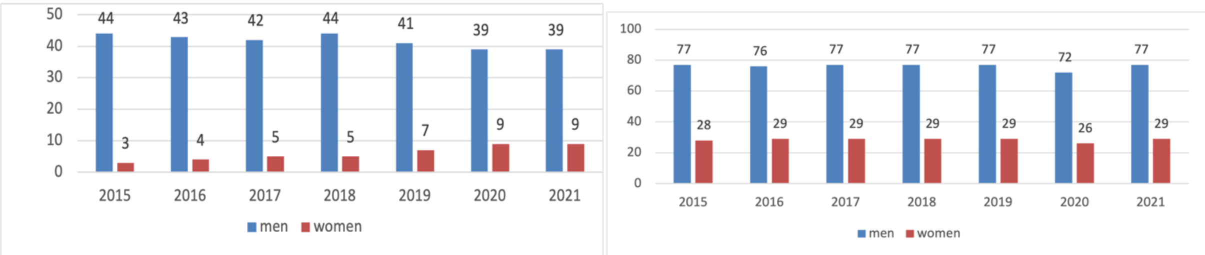
Until June 2018, two cities of republican status (Astana and Almaty) were registered in Kazakhstan. The President’s decree introduced changes to the administrative-territorial system: the city of Shymkent was classified as a city of republican status, the administrative center of South Kazakhstan oblast was moved from Shymkent to Turkestan, South Kazakhstan oblast was renamed into Turkestan oblast[57]. In accord with amendments to the administrative-territorial system of 2022, three new oblasts were established in the country: Abay, Zhetysu and Ulytau. The city of Semey became the center of Abay oblast, and Zhezkazgan was assigned the center of Ulytau oblast. Taldykorgan, which was the center of Almaty oblast, became the center of Zhetysu oblast, in turn, the city of Konaev is now the center of Almaty oblast.

As of July 1, 2022, the following administrative territorial system has been in effect: 17 oblasts, three cities with a republican status, 186 administrative districts, 89 towns, 29 townships and 6,293 rural settlements.

Power in the Republic of Kazakhstan is distributed among three independent branches. Legislative functions are assigned to the Parliament that consists of two chambers: the Senate (upper house) and the Mazhilis (lower house).

The share of female members in the Senate (2021) is 18.7%, male – 81.3%; in the Mazhilis: female members – 27.4%, male – 72.6%. Prevalence of male Parliament members has been observed over the entire period under review.

Figure 2.1. The number of male and female members in the Parliament
a) Senate b) Mazhilis

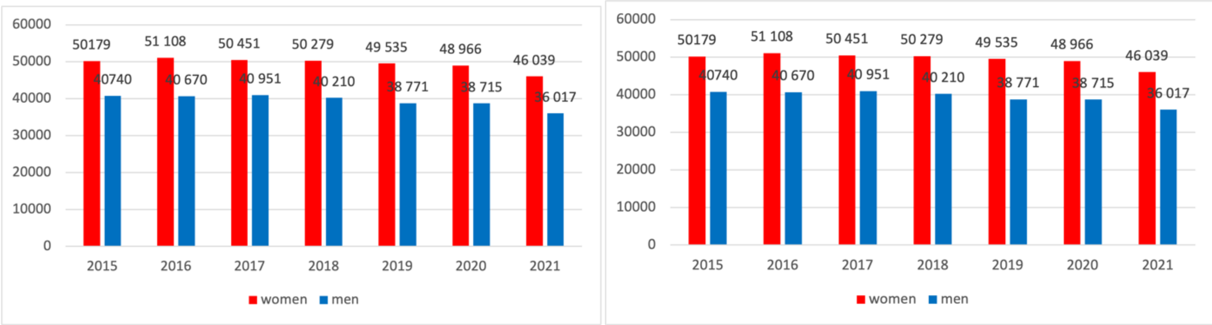


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Executive power is exercised by the Government, which manages the system of executive bodies. The shares of women and men among political civil servants in 2021 is 9.1% and 90.9%, respectively; the shares of women and men among administrative civil servants is 56.1% and 43.9%, respectively.

[56] Constitution of the Republic of Kazakhstan.
[57] Decree of the President of the Republic of Kazakhstan No. 702 dated June 19, 2018 'On some issues of the administrative-territorial structure of the Republic of Kazakhstan.'

Figure 2.2. Number of civil servants by gender



a) Political civil servants b) Administrative civil servants

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Judicial power is exercised by the judicial system comprising the Supreme Court, local (oblast, city, district) courts and specialized courts (military, juvenile, economic).

In June 2019, the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan (MEGNR) was established. It is the central executive body of the Republic of Kazakhstan exercising leadership in the development and implementation of state policy and coordination of management processes in the following areas: environment protection, development of green economy, waste management (with the exception of municipal, medical and radioactive waste), protection, control and supervision of sustainable use of natural resources, state geological exploration, rehabilitation of mineral resources, use and protection of water resources, water supply, sanitation, forestry, protection, reproduction and use of wildlife and specially protected natural areas.

The Ministry has the following Departments:

1) Committee for Environmental Regulation and Control of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan;
2) Committee for Geology of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan;
3) Committee for Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan;
4) Committee for Water Resources of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.[58]

With regard to the regulation of greenhouse gas (GHG) emissions, the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan defines a regulatory framework for the development and approval of subsequent Nationally Determined Contributions under the Paris Agreement and implementation of the Emissions Trading System for greenhouse gas emissions including the Rules of state regulation in the field of greenhouse gas emissions and removals, which contain basic provisions on quota allocation, monitoring and reporting. Additionally, there are Rules for carbon quota trading, Rules for offset mechanisms implementation, and others. Moreover, the new Environmental Code adopted in 2021 introduced a section on adaptation to climate change and approved the Rules for organizing and implementing the adaptation process.

[58] Regulations on the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.

The National Carbon Inventory is maintained in accord with Article 303 of the Environmental Code of the Republic of Kazakhstan and the Rules for maintaining the National Carbon Inventory approved by Order No. 190 of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated June 10, 2021.[59]

The National Carbon Inventory is a system of accounting for sources of GHG emissions, the volume of emissions produced by them, as well as the value of GHG emission reduction or removals increase within the limits established for installation operators.

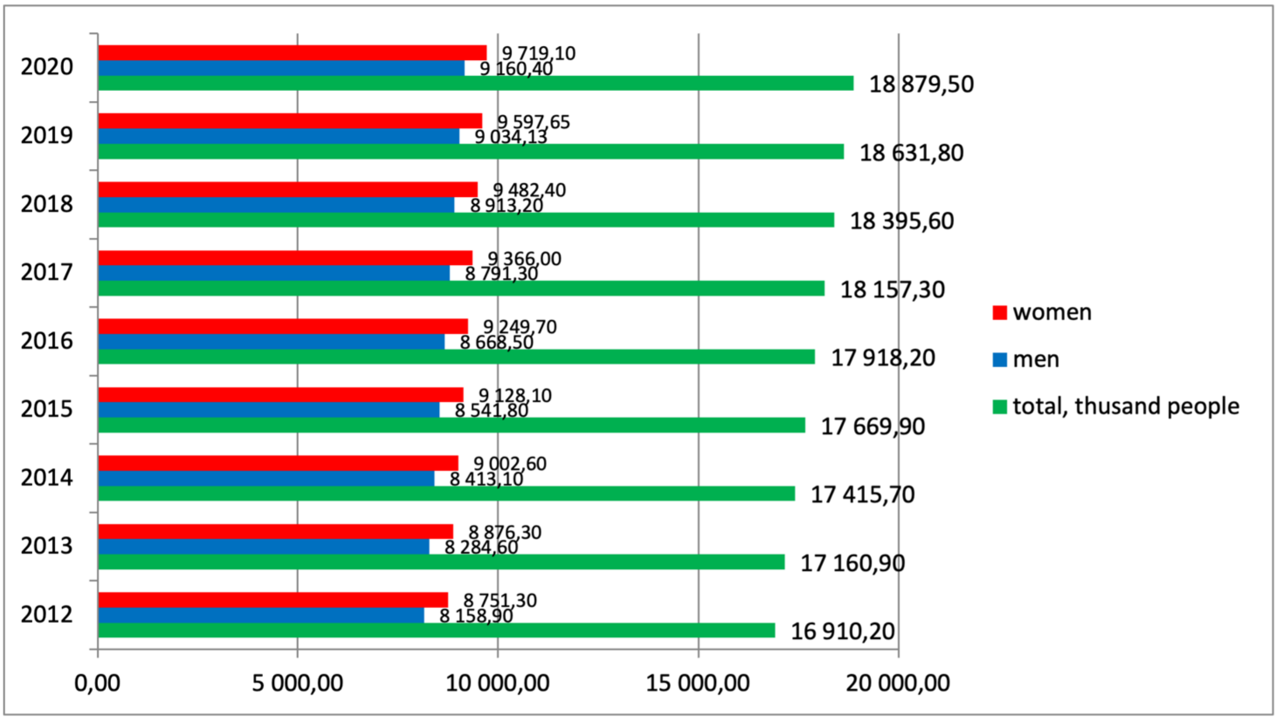
The National Carbon Inventory is maintained using an information system.

The structure of the central office of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan includes the Department of Climate Policy and Green Technologies responsible for the implementation of policies and measures in the field of climate change and green economy.

2.2.Population characteristics

The total population of Kazakhstan amounted to 18,879.5 million people at the beginning of 2021. Of these, 9,719.1 thousand (51.48%) were women and 9,160.4 thousand (48.52%) were men (Fig. 2.1). In 2013, the percentage of women and men was 51.75% and 48.25%, respectively.

Figure 2.3. The population of Kazakhstan and the ratio of men and women for 2013- early 2021.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

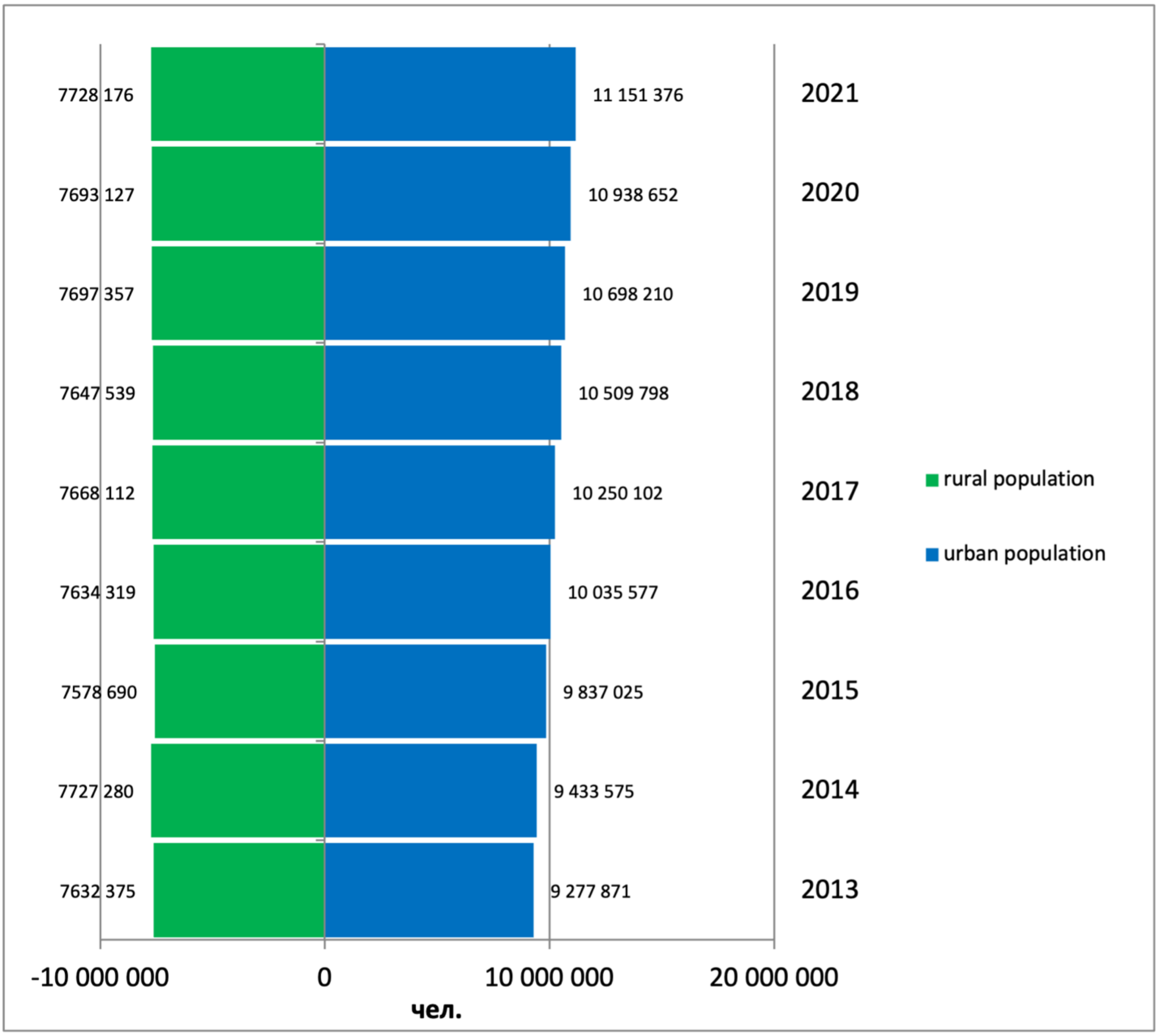
The growth was mainly due to the urban population, which has grown by more than 624 thousand people since 2017.

The urban population amounts to 11,151,376 people, while rural is 7,728,176 people, and the urban population is higher than the rural population (Fig. 2.4). A steady increase in the urban population is observed. While the ratio of the urban and rural population was 54.9% and 45.1%,

[59] On approval of the Rules for maintaining the National Carbon Inventory. Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 190 dated June 10, 2021. Registered with the Ministry of Justice of the Republic of Kazakhstan under No. 23110 on June 19, 2021.

respectively, in 2013, the same ratio in 2021 was 59.1% and 40.9%, i.e., the urban population grew by more than 4% during the reporting period.

Figure 2.4. The numbers of urban and rural population of Kazakhstan for 2013 - early 2021.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

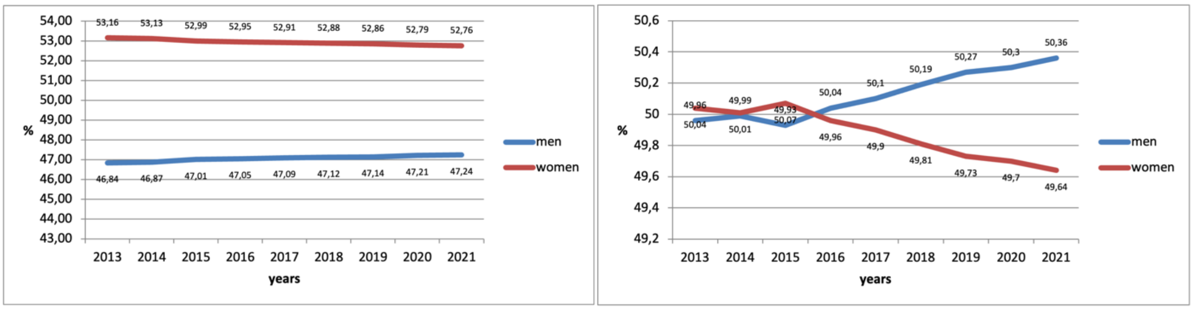
The urban population prevails over the rural population, there is a steady increase in the urban population. In 2013, the ratio of urban and rural population was 54.9 and 45.1%. In 2021, the same ratio was 59.1% and 40.9%, i.e., the urban population grew by more than 4% during the reporting period.

Meanwhile, the growth of the rural population was insignificant – it increased by a little more than 93 thousand people. The decrease in the share of the rural population is primarily due to the outflow of rural residents to cities.[60]

[60] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Demographic Yearbook of Kazakhstan, 2021

The number of women in the urban population slightly exceeds the number of urban men. In 2013, the excess was 6.3%, and in 2021 it decreased to 5.52%, i.e., the number gap between men and women tends to decrease (Fig. 2.5. a).

Figure 2.5. The ratio of the number of men and women of the urban and rural population.



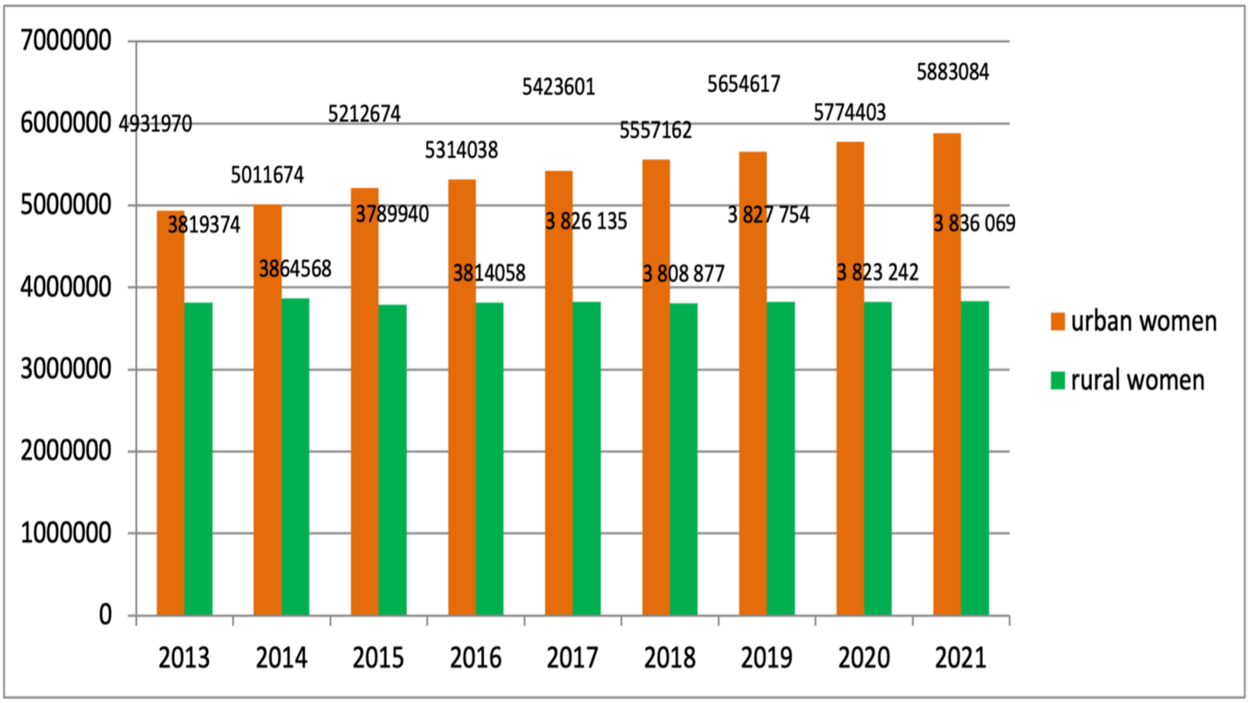
a) urban population b) rural population

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The number of rural men and women are close in value and the difference is less than 1% for the period under review. However, it should be noted that there has been a slight trend of growth in the number of men in rural areas in recent years.

In 2021, the share of urban women (60.5%) exceeds the share of rural women (39.5%) by 21.1% (of the total Years er of women). In 2013, the ratio of urban Years ural women was 56.4% and 43.6%, respectively, i.e., the period from 2013 to 2021 shows a growth trend in the female urban population and its value is 4%. At the same time, we see a decrease in the share of rural women. In 2013, the share of female rural population was 43.6%, then in 2021 it decreased to 39.5% (Fig. 2.6. below).

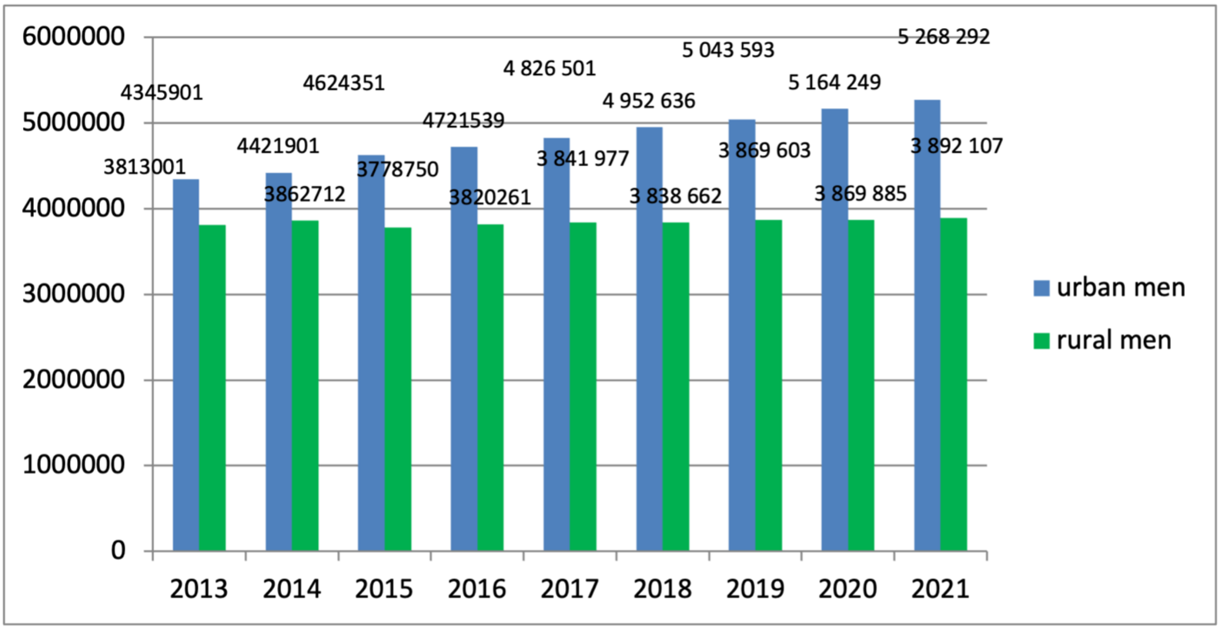
Figure 2.6. The ratio of women in urban and rural population for 2013-2021.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The ratio of urban and rural male population is 57.5% and 42.5%, respectively (2021). The number of men in the city is 15% higher than in the village (of the total number of men). In 2013, the share of men in the urban population was 53.3%, while their share in rural population was 46.7%. From 2013 to 2021, a positive trend has been observed in the growth of the male urban population (4.2%), as well as a decrease in the share of the male rural population. In 2013, the share of male rural population was 46.7%, then in 2021 it decreased to 42.5% (Fig. 2.7. below).

Figure 2.7. The ratio of men in urban and rural population for 2013-2021.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The key indicators descriptive of the natural growth of the population has changed insignificantly from 2017 to 2020. The total fertility rate ranged from 2.75 to 3.13 (3.32 in 2021) births per thousand people of the population. The mortality rate increased from 7.15 to 8.6 deaths per thousand people.

Infant mortality rates increased from 2017-2020 (from 3,109 to 3,286 people), as well as maternal mortality (from 14.8 per one hundred thousand births in 2017 to 36.5 in 2020). In 2021, the mortality rate was 24 units.

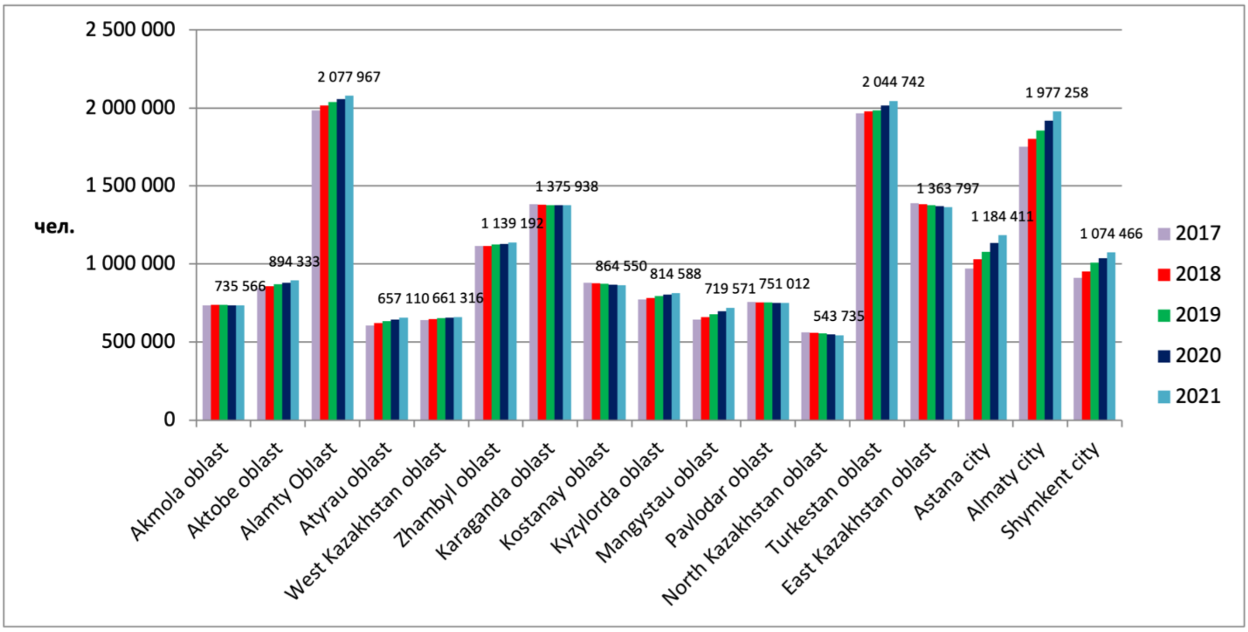
A negative balance of external migration of the population has been recorded from 2017 to 2020. We should note the upwards trend of this phenomenon: in 2017, the migration balance was minus 22,130 people, in 2018 – minus 29,121, in 2019 – minus 32,970, and in 2020 – minus 17,718.

The country's average population density was 6.8 people per square kilometer in 2020. The population is mainly concentrated in the southern part of the country – in South Kazakhstan and Almaty oblasts. The same areas are distinguished by the predominance of the share of rural population.

The most densely populated regions of the country are Almaty (2,077,967 people) and Turkestan (2,044,742 people) oblasts of Kazakhstan. These oblasts are a home to 38% of the country's population considering the population of the largest cities of these regions, such as Almaty (1,977,258 people) and Shymkent (1,074,466 people).

The least populated region of the country is North Kazakhstan region oblast with total population of 543,755 people.

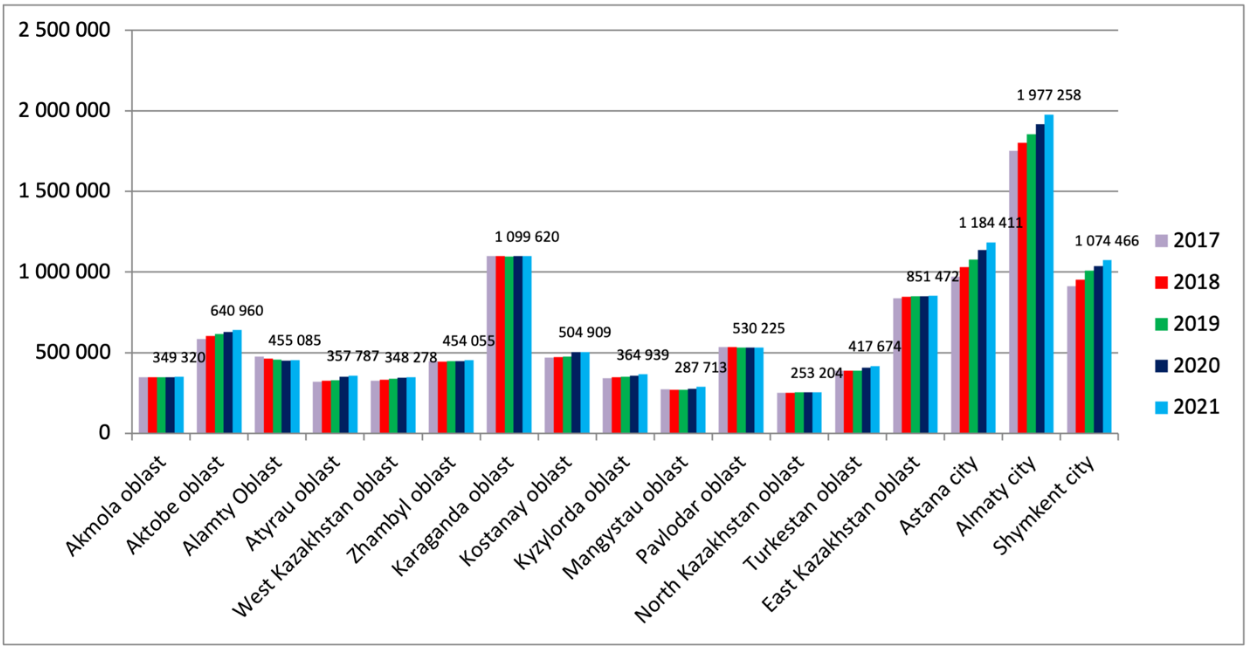
Figure 2.8. Population of Kazakhstan by regions.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The urban population is concentrated (Fig.2.9.) mainly in large cities of Kazakhstan (55.48% of the total urban population): Almaty (1,977,258 people), Astana – the capital of Kazakhstan (1,184,411 people), Shymkent (1,074,466 people), the cities of Karaganda oblast (1,099,620 people) and East Kazakhstan oblast (851,472 people).

Figure 2.9. Urban population of Kazakhstan by regions.

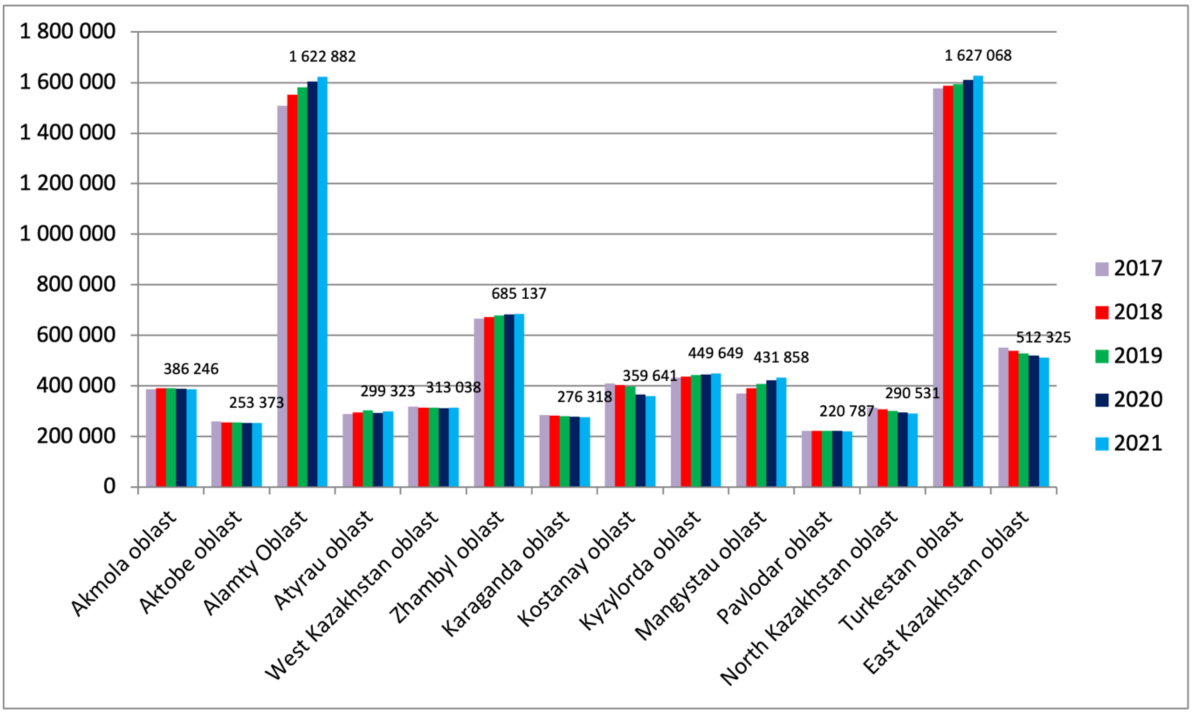


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The rural population is concentrated mainly in the south, south-east and east of the country (57.55% of the total rural population): in Turkestan (1,627,068 people), Almaty (1,622,822 people), Zhambyl (685,137 people) and East Kazakhstan (512,325 people) oblasts.

The regions with small rural population are Pavlodar (220,787 people), Aktobe (253,373 people), Karaganda (276,318 people), North Kazakhstan (290,531 people), Atyrau (299,323 people), and West Kazakhstan (313,038 people) oblasts.

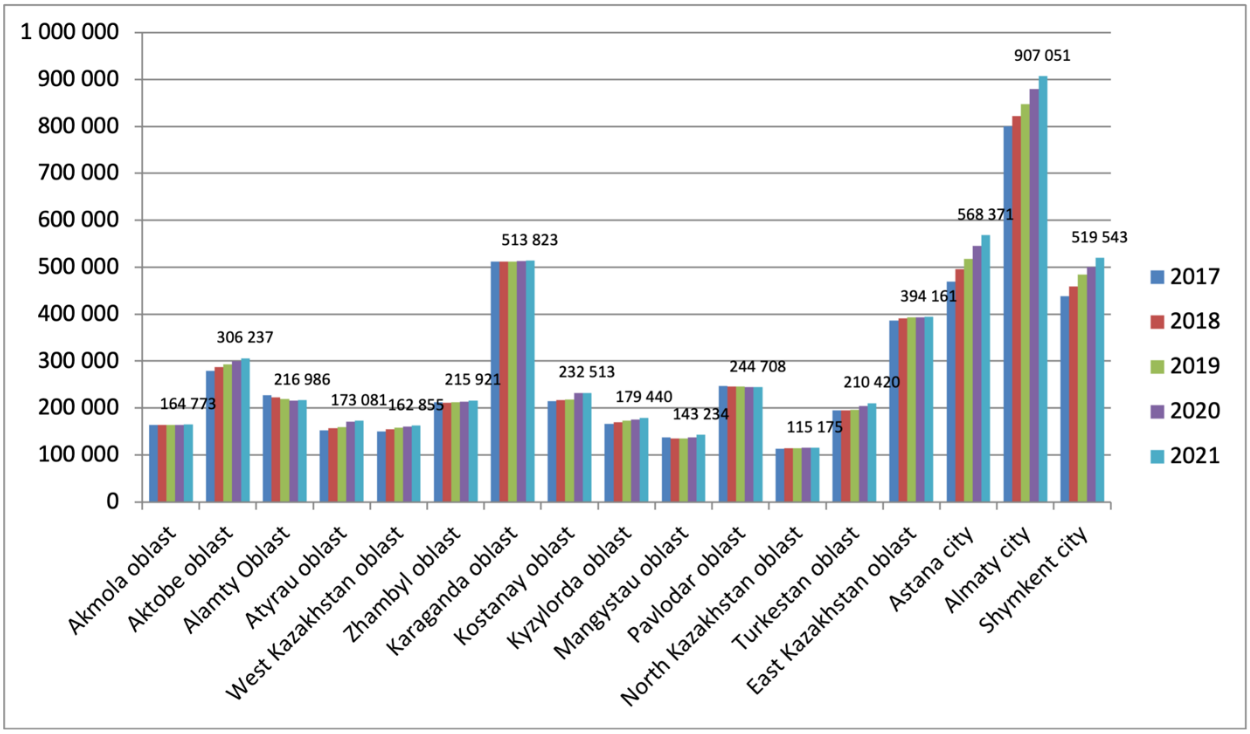
Figure 2.10. Rural population of Kazakhstan by regions.



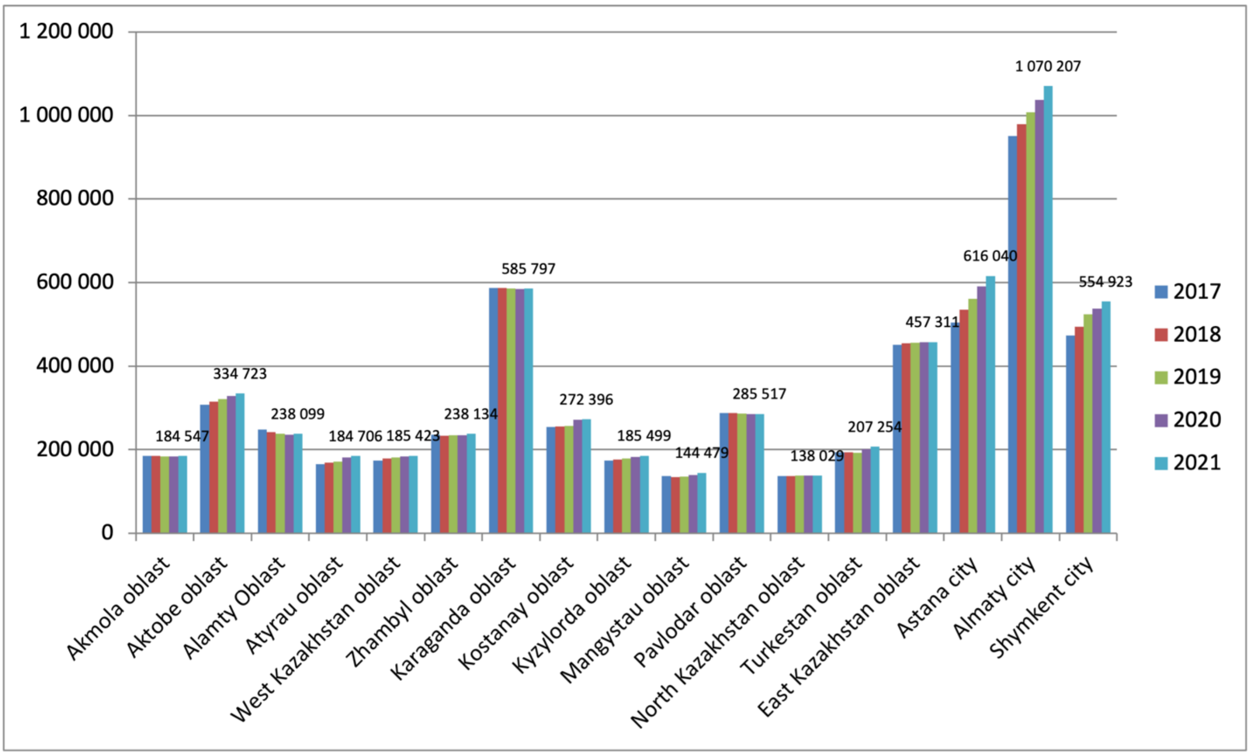
Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The shares of men and women in urban population are close in value, but the number of women is several percent higher. In large cities of Kazakhstan, the ratio of men and women in 2021 was as follows: Almaty – 54.13% women, 45.87% men, Astana – 52.01% women, 47.99% men, Shymkent – 51.65% women, 48.35% men, Karaganda oblast – 53.27% women, 46.73% men, East Kazakhstan oblast – 53.71% women, 46.29% men (Fig. 9). The closest values of the shares of men and women are observed in Kyzylorda and Mangystau oblasts, where the predominance of women is by 0.43% and 1.66%, respectively.

Figure 2.11 Urban population (men and women) of Kazakhstan by regions.



a) men

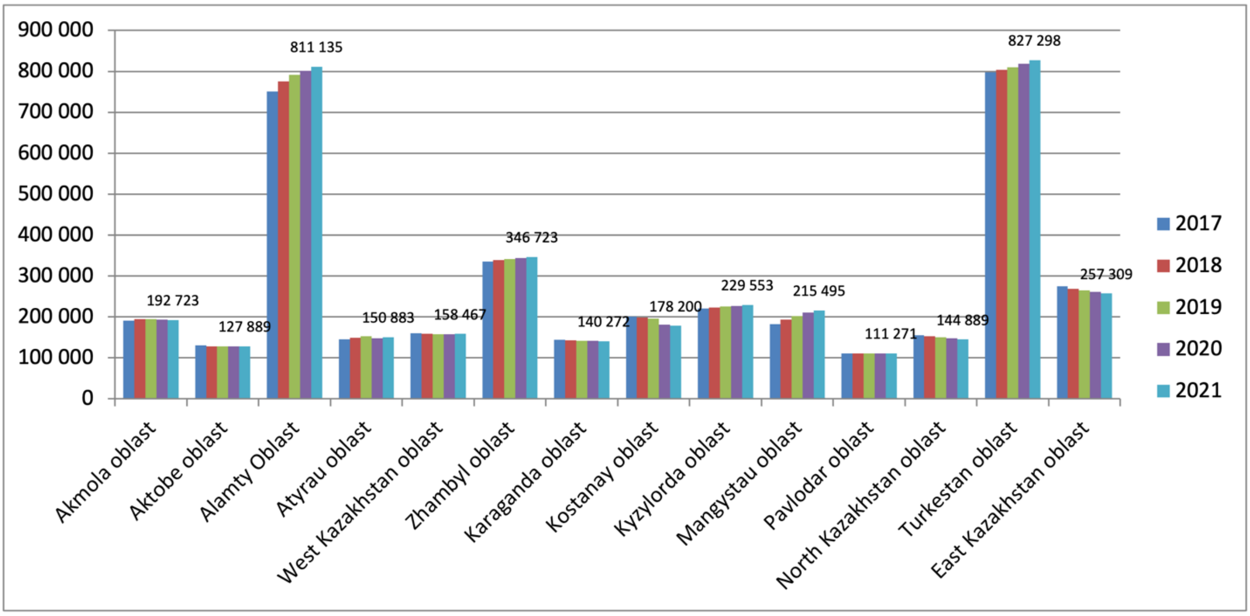


b) women

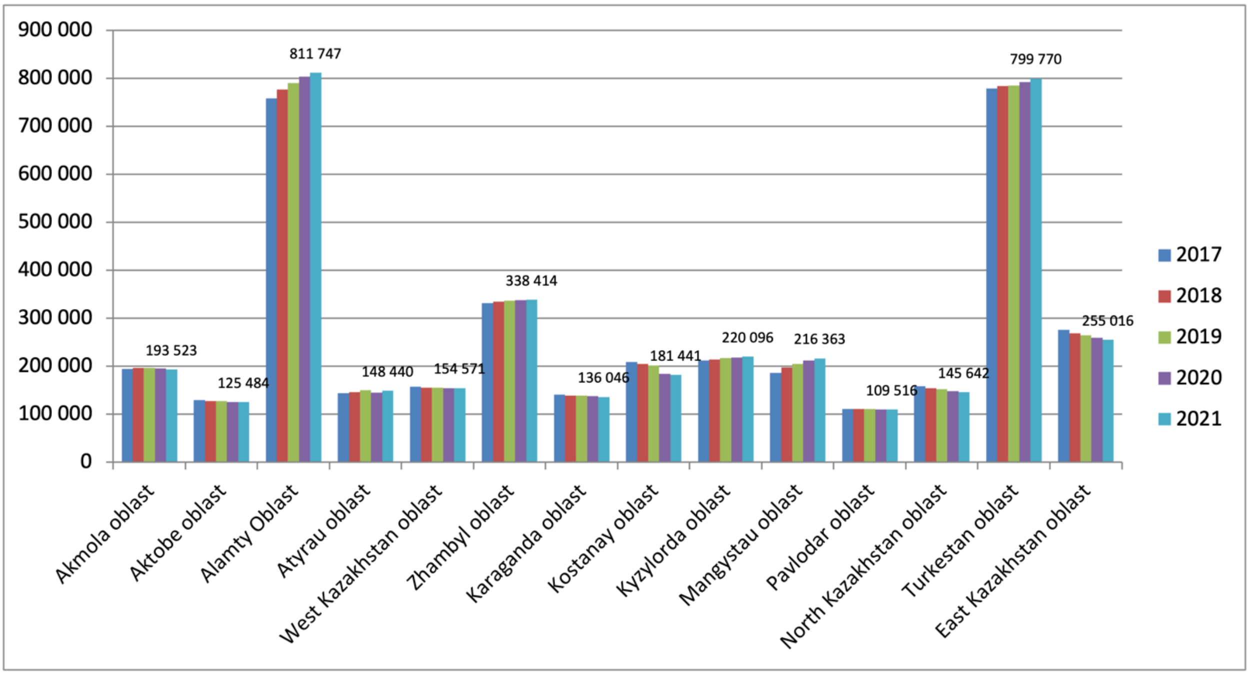
Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The values of men and women in rural population (Fig. 2.12) are almost equal. In 2020, the following concentrations are observed in highly populated territorial centers of Kazakhstan: Almaty oblast – 50.02% women, 49.98% men, Turkestan oblast – 49.15% women, 50.85% men, Zhambyl oblast – 49.39% women, 50.61% men, East Kazakhstan oblast – 50.22% women, and 49.78% men.

Figure 2.12 Rural population (men and women) of Kazakhstan by regions.



a) men



b) women

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.*

Life expectancy at birth in 2021 was 70.23 years, which is 1.58 years less than in 2017. Gender-disaggregated life expectancy values in 2021 are 66.33 years for men and 74.03 for women[61]. Urban population: women – 73.70 years, men – 65.71 years. Rural population: women – 74.64 years, men – 67.19 years.

The age composition of the population of the Republic of Kazakhstan in 2017 was as follows: 482 per 1000 people below employable age, 184 per 1000 people above employable age.

The population aging index (the number of individuals over 65 years of age per 100 children under 15 years of age) in the Republic of Kazakhstan amounted to 25.9 in 2017.

The highest aging index is typical for the north, east and center of the country (North Kazakhstan oblast – 55.8, Kostanay oblast – 53.2, East Kazakhstan oblast – 47.4, Pavlodar oblast – 44.2, Karaganda oblast – 41.4, Akmola oblast – 39.8). In the southern and western oblasts, on the contrary, this indicator is significantly lower than the national average (Mangystau – 11.9, Turkestan – 11.8, Kyzylorda – 15.4, Atyrau – 14.9, Zhambyl – 18.5).[62]

Given that the lowest aging index, and hence the population reproduction potential, is observed in the most populated territories of the country, we should expect continued population growth due to natural movement in the southern regions of Kazakhstan. According to forecasts, the country's population will amount to 24.5 million people by 2050. If the current trend continues, the population of the northern regions will decrease by 0.9 million people by 2050, while the number of residents of the southern regions will grow by 5.3 million people. At the same time, the settlement density of the southern regions will be four times higher than that of the northern regions.[63]

To eliminate the imbalance in the population distribution, the government adopted a program of voluntary resettlement from 'labor-surplus' regions (mainly southern regions) to 'labor-deficient' (northern) in late December 2016.[64]

The upwards trend of urban population growth may push the demand for power generation as urban population shows higher level of energy consumption. Considering that most of the energy in Kazakhstan is still produced by combustion of hydrocarbons such a trend in demographic changes may lead to an increase in greenhouse gas emissions.

2.3. Economic characteristics

The gross domestic product (GDP) of the Republic of Kazakhstan has shown steady growth in 2017-2020.

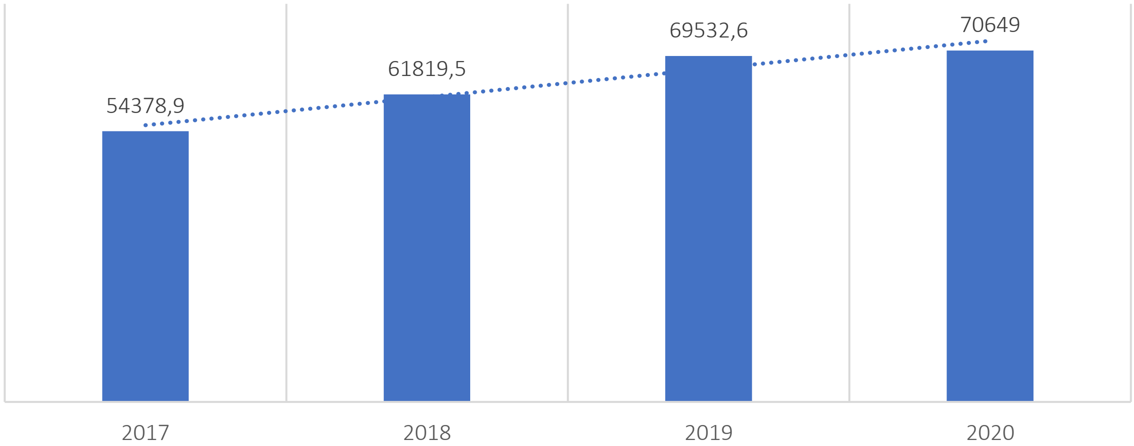
[61] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Demographic Yearbook of Kazakhstan, 2021

[62] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Population Aging Index in the Regions of the Republic of Kazakhstan.

[63] Resolution of the Government of the Republic of Kazakhstan No. 919 dated December 29, 2016, ‘On approval of the Program for productive employment development and mass entrepreneurship for 2017 – 2021’

[64] Within the framework of the Program for Productive Employment Development and Mass Entrepreneurship for 2017 – 2021.

Figure 2.13. *Gross domestic product, million KZT*



Source: *Kazakhstan in Numbers. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. Bureau of National Statistics, 2020*

During the reporting period, stable GDP growth of 11-13% has been recorded until 2020. The slowdown in GDP growth in 2020 was due to the global difficulties caused by the COVID-19 pandemic. This effect has been observed since late 2019 to the present causing long-term consequences for the economy of Kazakhstan.

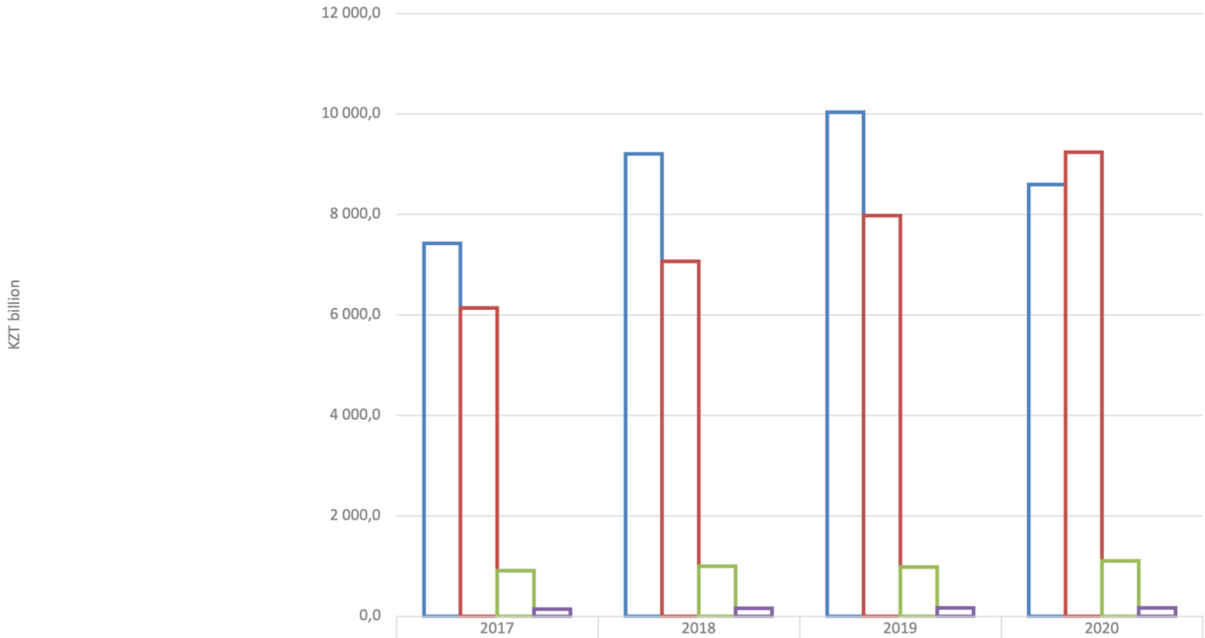
Table 2.1. *GDP by method of production in 2020.*

Types of economic activity	**Gross value added (GVA), million KZT**	**Share in GDP, %**
Agriculture, forestry, and fishing	3,808,889.1	5.4
Industry	19,098,171.4	27.1
Construction	4,285,102.3	6.1
Wholesale and retail trade and repair of motor vehicles and motorcycles	12,166,037.6	17.2
Transporting and storage	4,824,663.8	6.8
Accommodation and food service activities	722,736.0	1.0
Information and communication	1,670,561.0	2.4
Financial and insurance activities	2,376,245.1	3.4
Real estate activities	5,147,649.0	7.2
Professional, scientific, and technical activities	2,919,937.4	4.1
Administrative and support services activities	1,609,821.0	2.3
Public administration and defense; compulsory social security	1,342,993.7	1.9
Education	2,572,779.7	3.6
Human health and social work activities	1,804,796.2	2.6
Arts, entertainment, and recreation	639,680.6	0.9
Other services activities	1,788,578.2	2.5

Source: *GDP. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. Bureau of National Statistics, 2020*

From 2017 to 2020, the industrial output in current prices has grown by 4.4%. Significant growth was recorded in the processing industry (by 14.5%) and construction (by 9.8%). At the same time, significant decrease was recorded in the mining and quarrying sectors (by 11.4%), as well as in the supply of electricity, gas, steam, hot water, and conditioned air (by 6.25%). Short-term economic indicators in 2020 point to some improvement in domestic economic activity, both in the industrial and service sectors.

Figure 2.14. *Gross output in the industrial sector in current prices of the corresponding years, billion KZT*

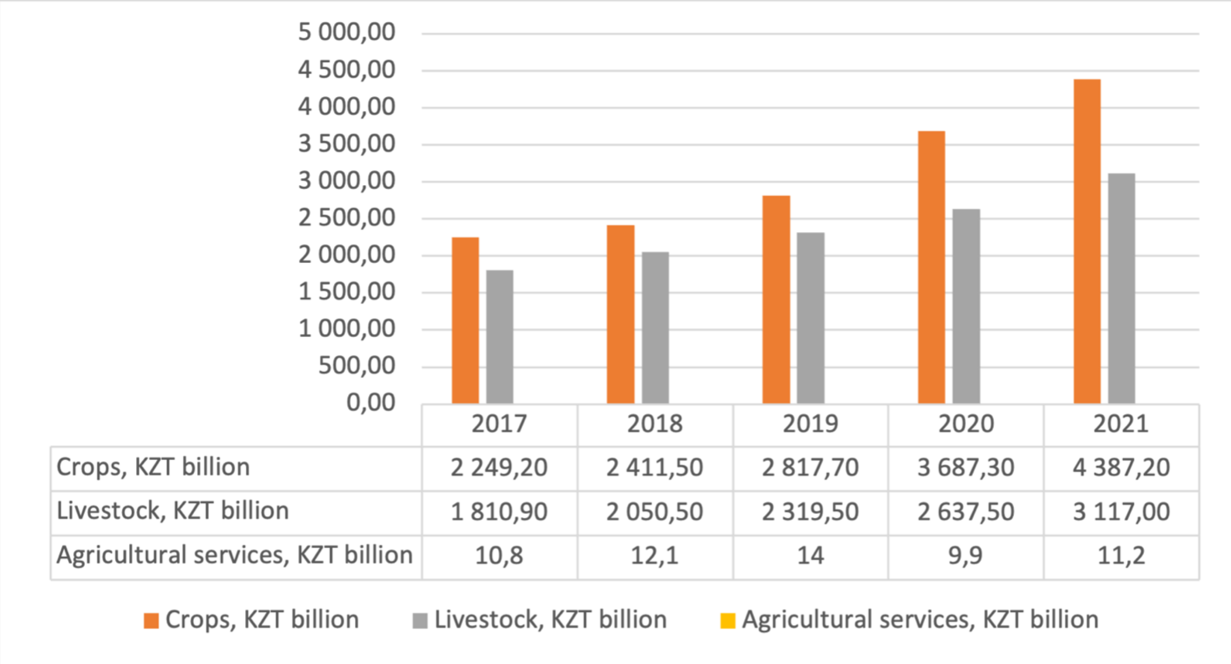


	2017	2018	2019	2020
Mining and quarrying	7 421,7	9 204,7	10 032,1	8 596,8
Processing industry	6 134,0	7 065,1	7 972,9	9 235,6
Power, gas, hot water, conditioned air supply	903,5	995,4	980,8	1 097,1
Water supply; waste collection, processing, removal, pollution response	141,7	156,1	168,7	168,6

Source: *Gross output in the industrial sector for 2017-2020. Bureau of National Statistics*

The volume of gross output in the industrial sector, although it shows growth in almost all sectors, but, as can be seen from Figure 2.14, economic growth is slowing down by 2020, except for the processing industry. The average GDP growth in the industrial sector amounted to approximately 10% per year.

Figure 2.15. *Gross output of agricultural products (services) in current prices of the corresponding years, billion KZT*



Source: *Gross output of agricultural products (services) for 2017-2021. Bureau of National Statistics.*

The gross output of agricultural products (services) has also been growing. The average growth in current prices amounted to KZT3,444.5 billion (by 45.8%) from 2017 to 2021. GDP growth in the agricultural industry was based on contributions from almost all sectors with stable average increase of 15.8% starting from 2018.

Based on global indicators, the decline in the retail trade and freight transport industries has gradually decreased.[65] The construction industry in the Republic of Kazakhstan shows stable growth, among others, due to policy measures that allow partial withdrawal of pension savings,[66] and the state program to support investments in residential real estate.

The new wave of COVID-19 and associated restrictions led to an increase in the inflation rate by more than 6% per year during the reporting period.[67] The course of the COVID-19 pandemic is likely to affect the balance and speed of recovery and have long-term consequences for the economy.

Table 2.2. *Foreign trade turnover of the Republic of Kazakhstan*

	2017	**2018**	**2019**	**2020**	**2021**
Exports, million USD	48,503.3	61,111.2	58,065.6	47,540.8	60,321.0
Imports, million USD	29,599.6	33,658.5	39,709.3	38,929.1	41,415.4
Foreign trade turnover, million USD	78,102.9	94,769.7	97,774.9	86,469.9	101,736.4
Growth rate against the previous period, %	125.70	121.34	103.17	88.44	117.66

Source: *External turnover of the Republic of Kazakhstan, 2017-2021 Bureau of National Statistics*

[65] Report on the economy of Kazakhstan, summer 2021: https://www.vsemirnyjbank.org/ru/country/kazakhstan/publication/economic-update-summer-2021
[66] On approval of the Rules for lump-sum pension payments withdrawal to improve housing conditions in accord with the legislation of the Republic of Kazakhstan.
[67] Dynamics and plot of changes in the inflation rate in Kazakhstan from 2015 to 2022: https://bankchart.kz/spravochniki/indikatory_rynka/inflation_index

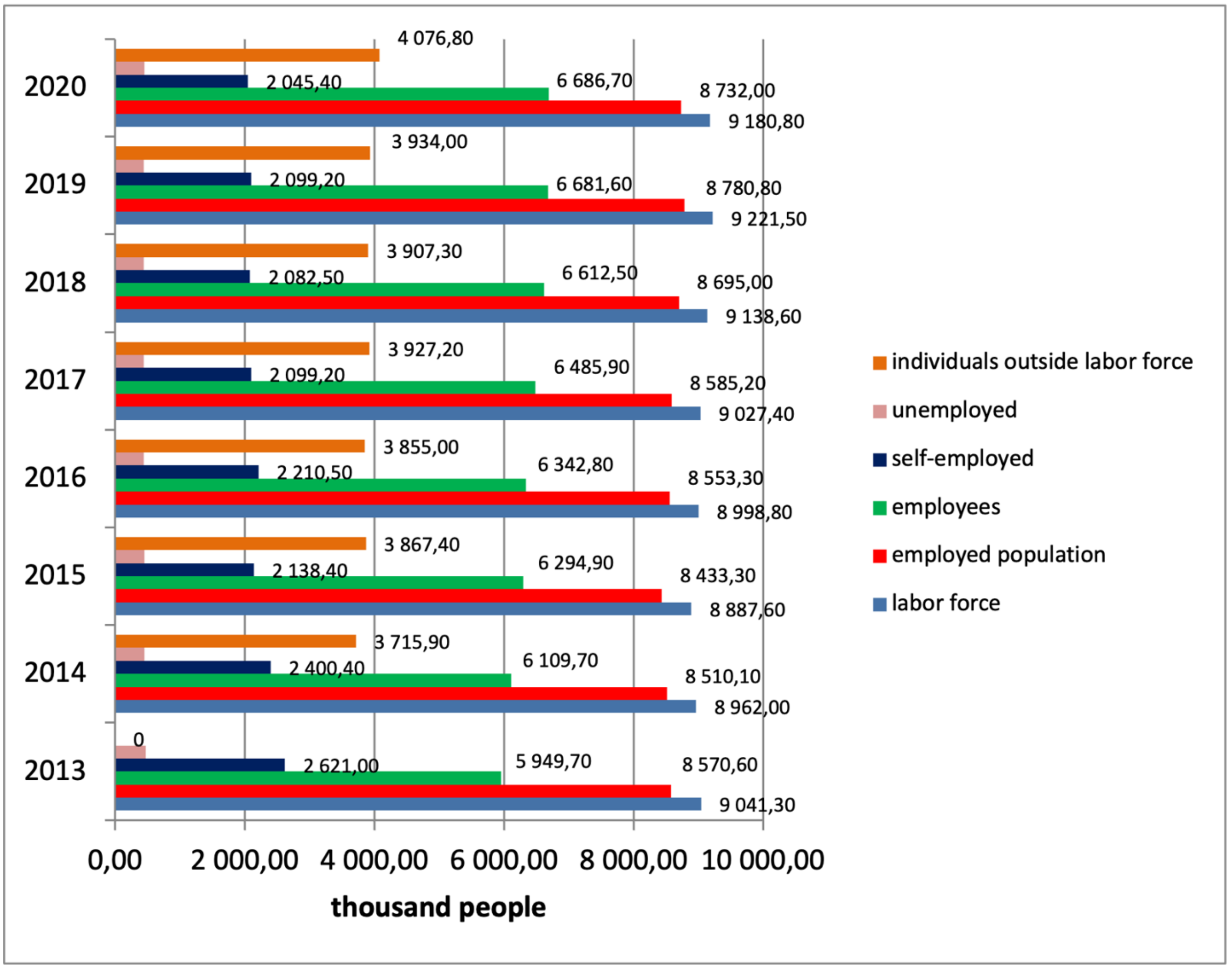
The country's external turnover amounted to USD101.7 billion by the end of 2021 showing an increase by USD15.26 billion. A decrease in the country's internal turnover in 2020 shows that a similar regression was observed in external turnover.

2.3.1 Labor market indicators

Total workforce in 2021 made 9,256.8 thousand people (69.3% of the total population), employed population was 8,807.1 thousand people (95.1% of the workforce), of which 6,710.2 thousand people (76.2%) were payroll employees, while 2,096.9 thousand (23.8%) were self-employed. Unemployed population amounted to 449.6 thousand people (4.9%) in 2021.

During the period from 2013 to 2021, the lowest level of employment was recorded in 2015.

Figure 2.16. *Labor market indicators*



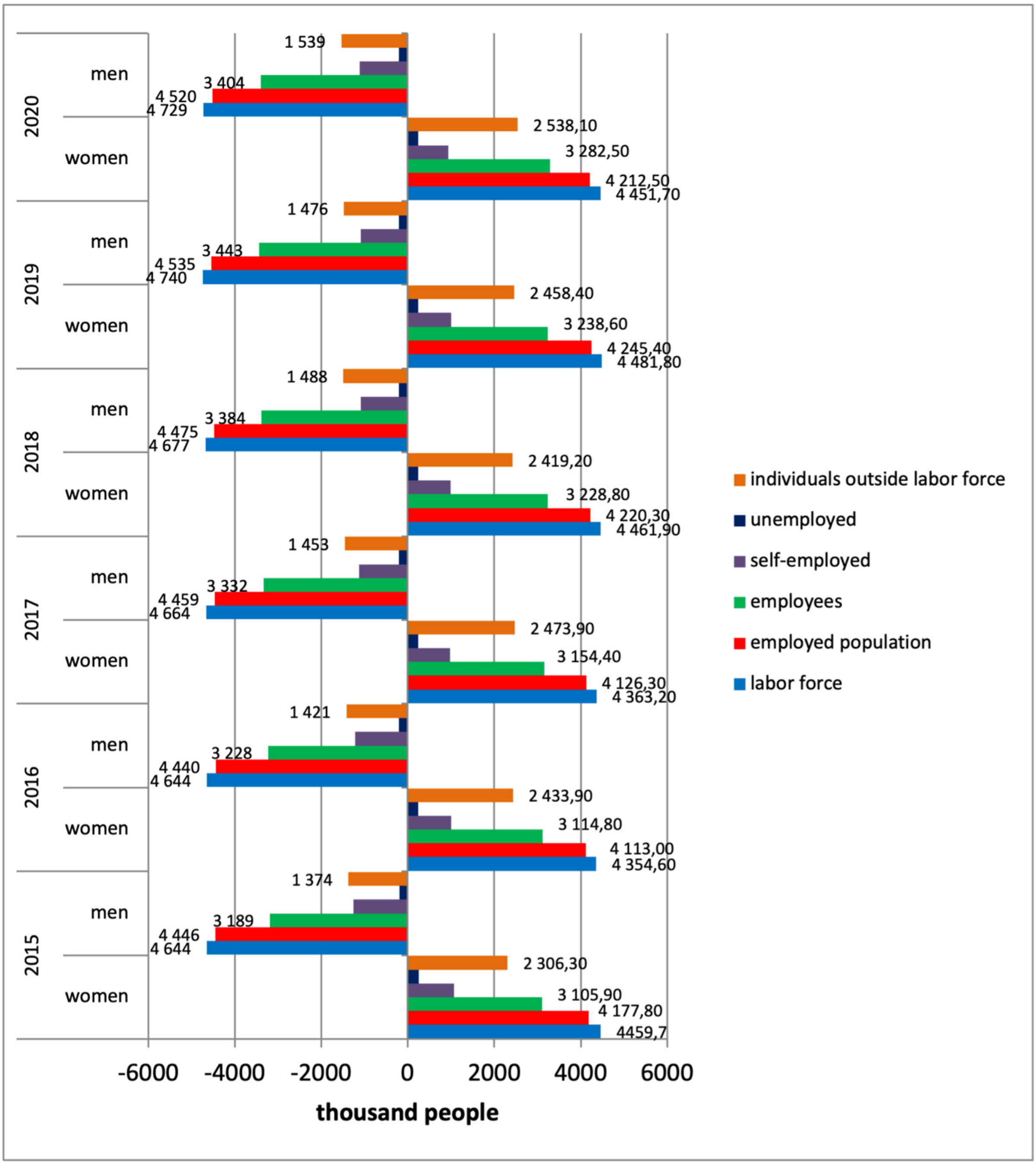
Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The share of women in the workforce (2021) is 63.9%, while that of men is 75.4%. The employment rate of women is 94.6%, that of men is 95.6%.

Employed population: women – 94.5%, men – 95.8%. Unemployed population: women – 5.5%, men – 4.2 %.

The rate of long-term unemployment of women is 2.6%, the same of men is 1.6%. The share of individuals not included in labor force in the population: women – 36.1%, men – 24.6%. Although the indicators of the labor force status of men and women are close in value, women's lower employment and higher unemployment is apparently persistent (Figure 2.17 below).

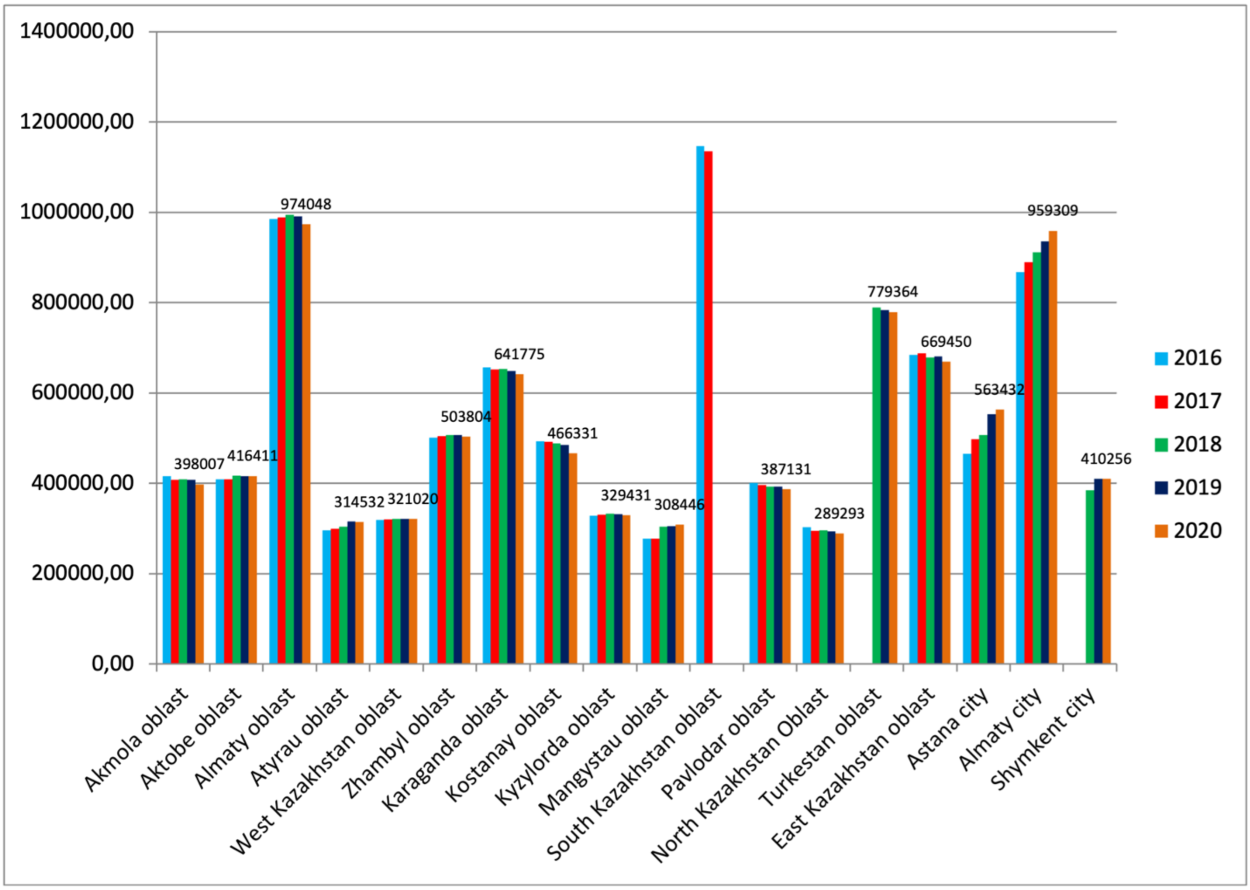
Figure 2.17 *Population distribution by labor force participation status and individuals not included in labor force from 2015 to 2020*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The highest level of employment is observed in Almaty oblast (974,048 people), Turkestan oblast (779,364 people), East Kazakhstan oblast (669,450 people), Karaganda oblast (641,775 people), Zhambyl oblast (503,804 people) and cities of republican status - Almaty (959,309 people), Astana (563,432 people) and Shymkent (410,256 people).

Figure 2.17. *Population employment level in Kazakhstan by regions for 2016-2020.*

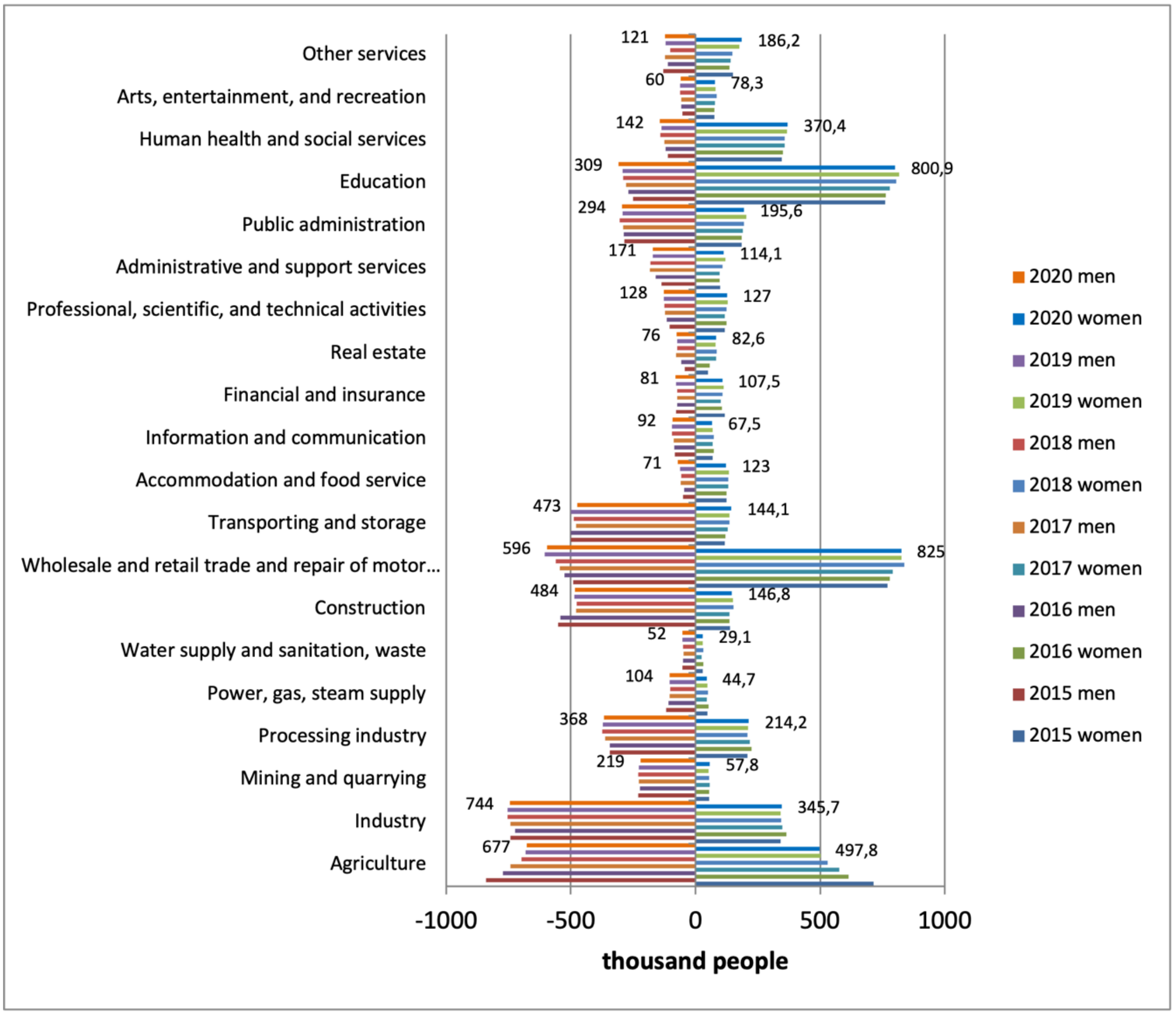


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Figure 2.18 below clearly shows the prevalence of men engaged in the following activities: industry (mining (79.1%) and manufacturing (63.2%)), energy (70%), water supply, sanitation systems and control over waste collection and distribution (64.3%), construction (76.7%), transport and storage (76.7%), information and communications (57.7%), agriculture, forestry and fishing (57.6%), public administration and defense, compulsory social security (60%), administrative and support services (60%).

Women apparently prevail in the following types of activities: healthcare and social services (72.3%), education (72.2%), accommodation and food services (63.5%), wholesale and retail trade, repair of motor vehicles and motorcycles (58%), arts, entertainment, and recreation (56.6%) (Fig. below). The percentage is given against the total number of people employed in the corresponding type of activity.

Figure 2.18. Distribution of employed population by gender and types of economic activity from 2015-2020.

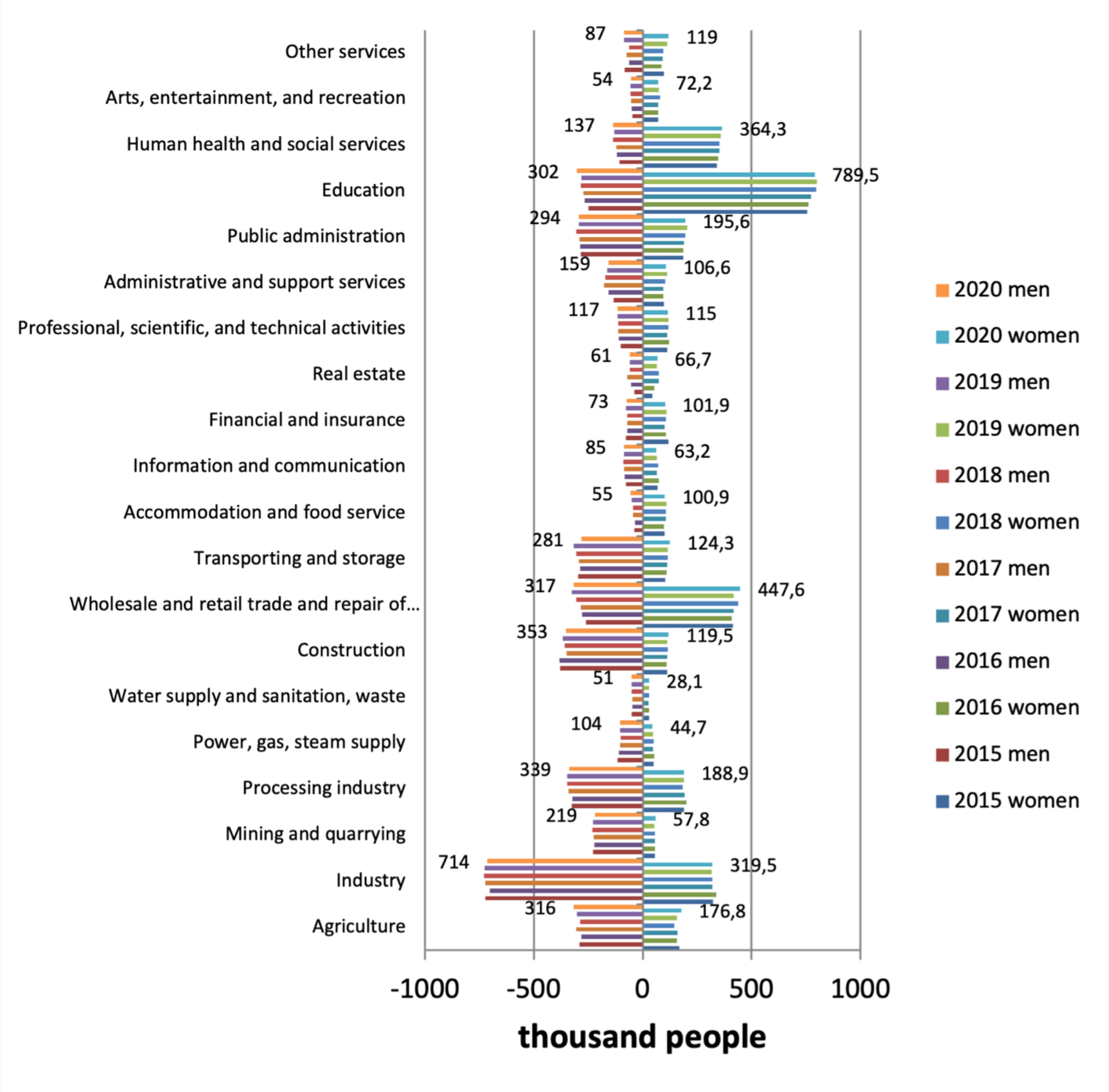


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Among employees, prevalence of men is noted in the following types of activities: industry (mining (79.1%) and manufacturing (64.2%)), energy (70%), water supply, sanitation systems and control over waste collection and distribution (64.6%), construction (74.7%), transport and storage (69.3%), information and communication (57.5%), agriculture, forestry, and fishing (64.1%), public administration and defense, compulsory social security (60%), administrative and support services (59.8%).

Women apparently prevail in the following types of activities: healthcare and social services (72.6%), education (72.3%), accommodation and food services (64.6%), wholesale and retail trade, repair of motor vehicles and motorcycles (58.5%), arts, entertainment, and recreation (57.1%).[68]

Figure 2.19 *Distribution of employees by gender and types of economic activity from 2015-2020*

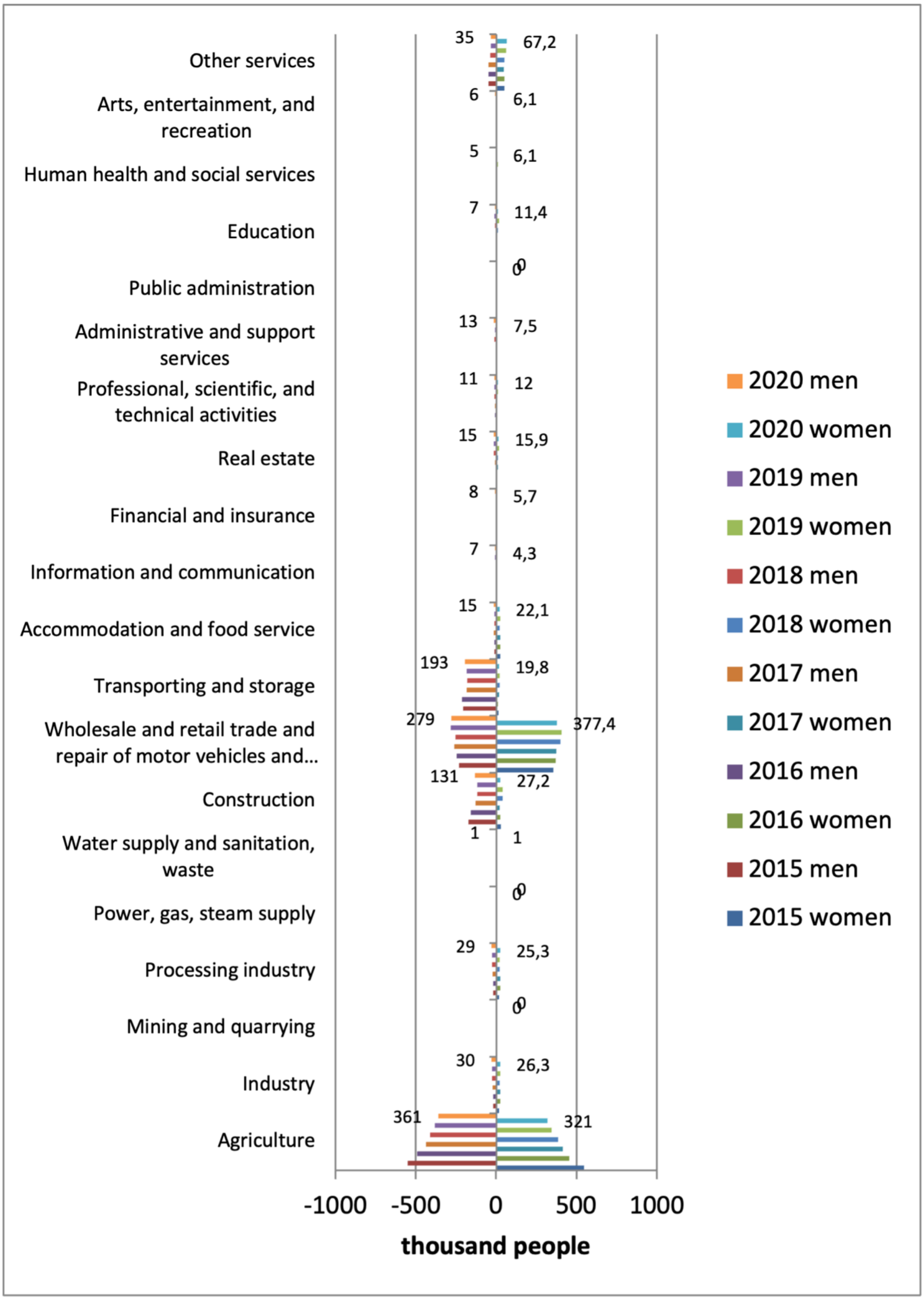


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The distribution of self-employed workers by gender and types of economic activity (Figure 2.20 below) is similar to the previous figure.

[68] Data for 2020

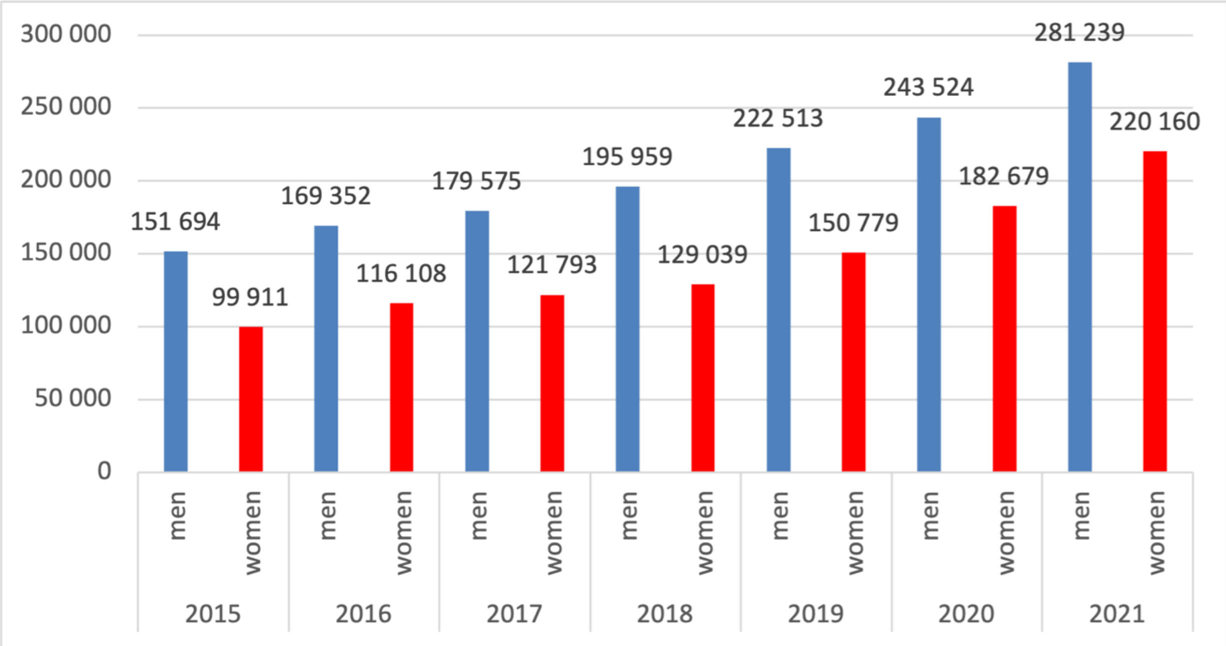
Figure 2.20. *Distribution of self-employed workers by gender and types of economic activity from 2015-2020.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Average monthly nominal salary of men is higher than that of women (**Fig. 2.21** below).

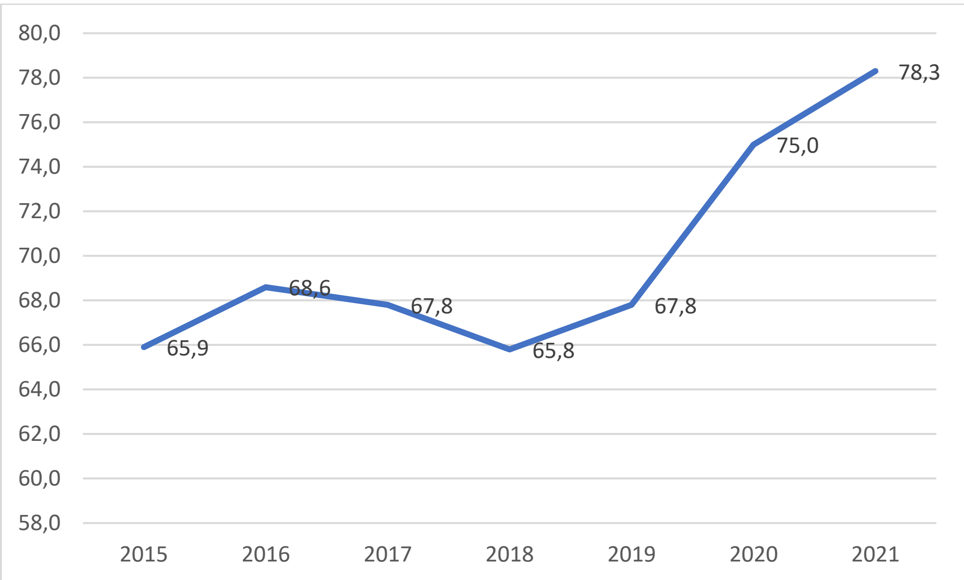
Figure 2.21. Average monthly nominal salary of employees from 2015-2021.



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The ratio of women's salary to men's salary in 2021 was 78.3%, i.e., the salary gap between men and women is 21.7% (Figure 2.22 below).

Figure 2.22. *Ratio of women's salary to men's salary from 2015-2021.*

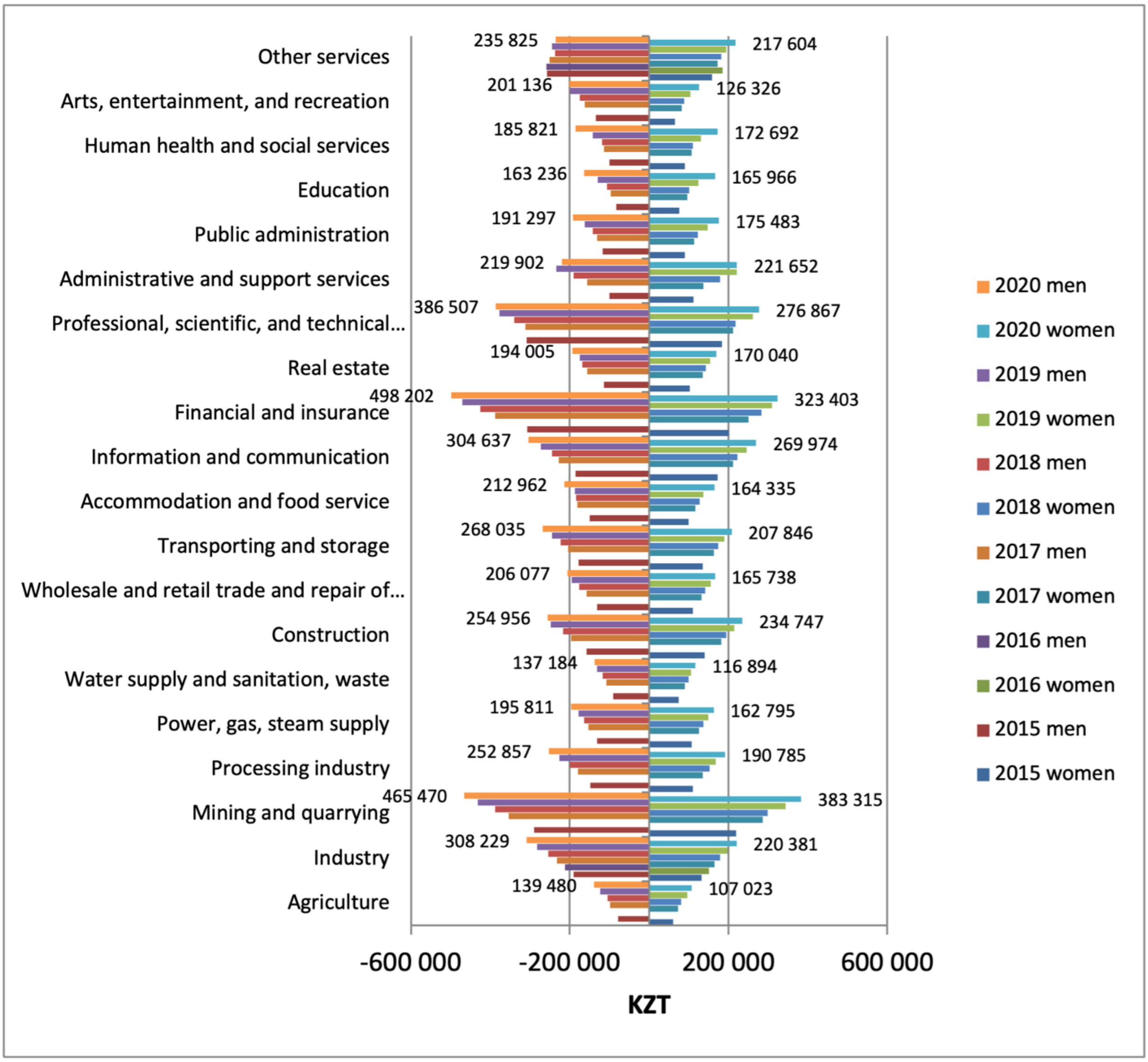


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The average monthly nominal salary of employees by type of economic activity is shown in the figure below. The lowest-paid activities are agriculture, forestry, and fishing; water supply; sanitation system, control over waste collection and distribution; health and social services; education; arts, entertainment, and recreation; accommodation and food services; wholesale and retail trade; repair of motor vehicles and motorcycles. The listed activities include the types of activities where the largest number of employed women is observed.

In 2020, the highest value of the ratio between women's and men's salaries is noted in the following activities: arts, entertainment, and recreation (62.8%), financial and insurance activities (64.9%), professional, scientific, and technical activities (71.6%), industry (71.5%), agriculture, forestry, and fishing (76.7%), accommodation and food services (77.2%), transport and storage (77.5%).

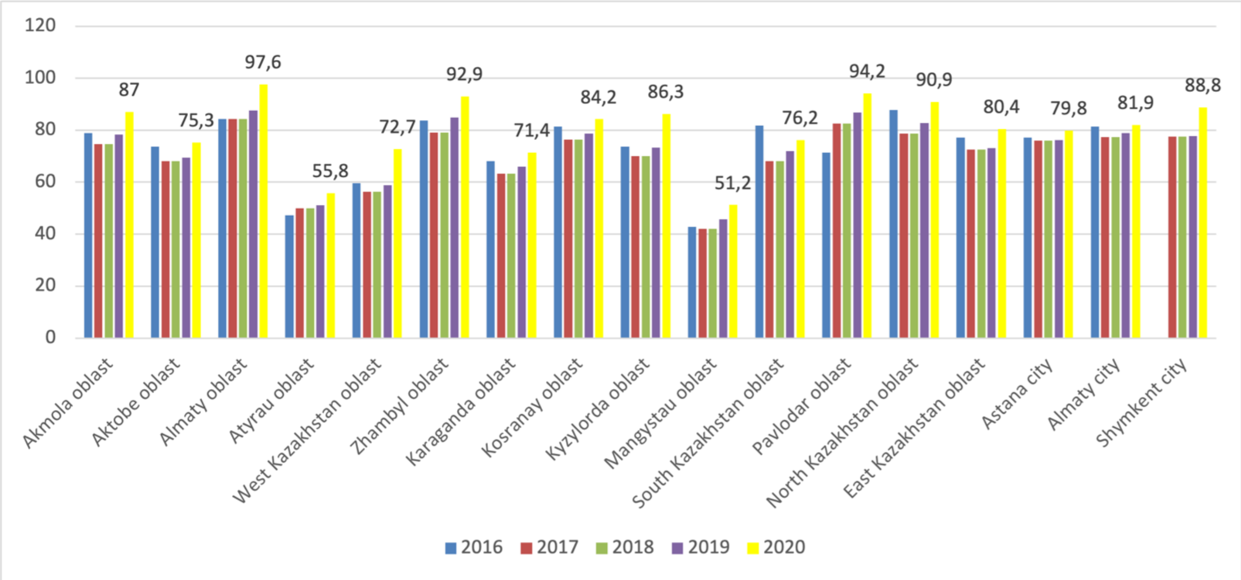
Figure 2.23. *Average monthly nominal salary of employees by type of economic activity.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The highest wage gap between men and women is observed in Mangystau (48.8%), Atyrau (44.2%), Karaganda (28.6%), West Kazakhstan (27.3%), Aktobe (24.7%), Pavlodar (23.8%), and East Kazakhstan (19.6%) oblasts.

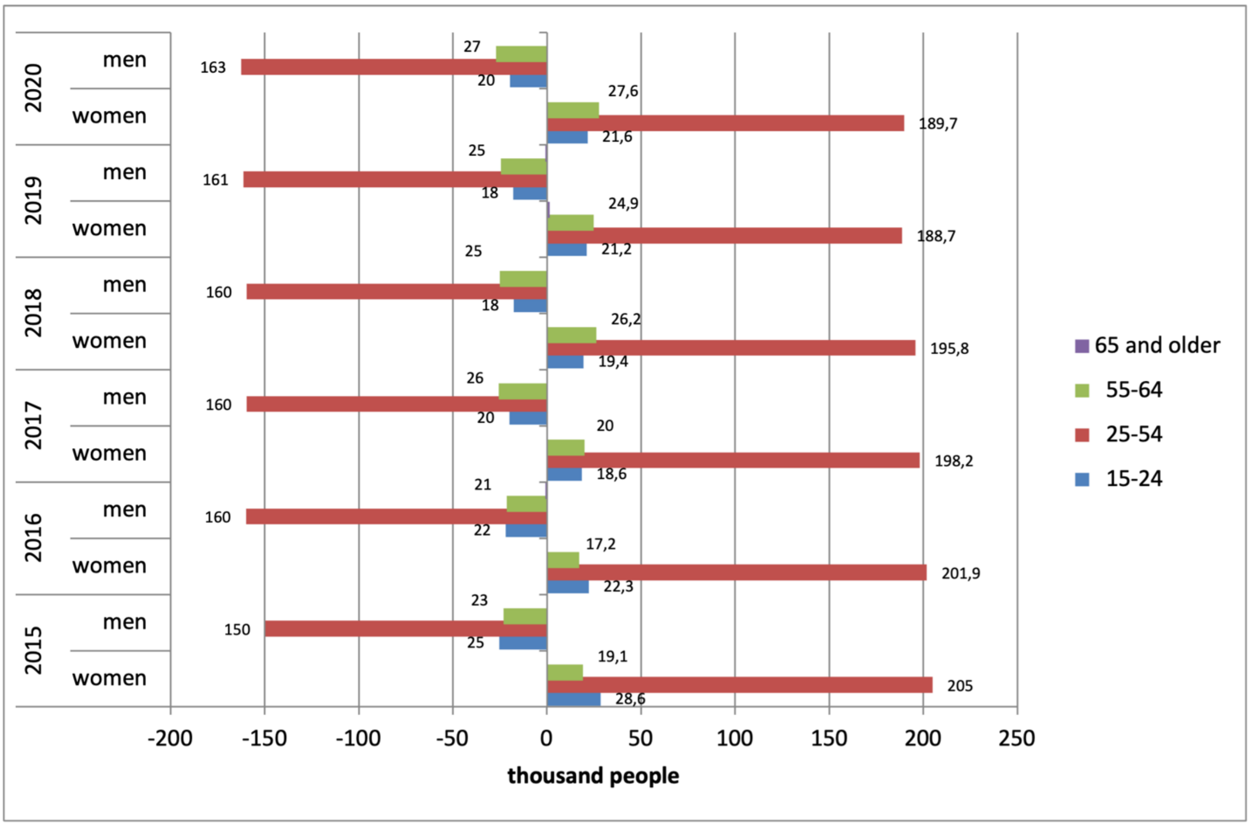
Figure 2.24 *Ratio of women's salary to men's salary from 2015-2020 by regions.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Unemployed population aged 15 years and older in 2020 amounted to 448.8 thousand people, of which 53.3% were women and 46.7% were men, i.e., the percentage of female unemployment is higher. We should also note the growth of male unemployment during the period under review. People aged from 25 to 54 years make up most of the unemployed population.

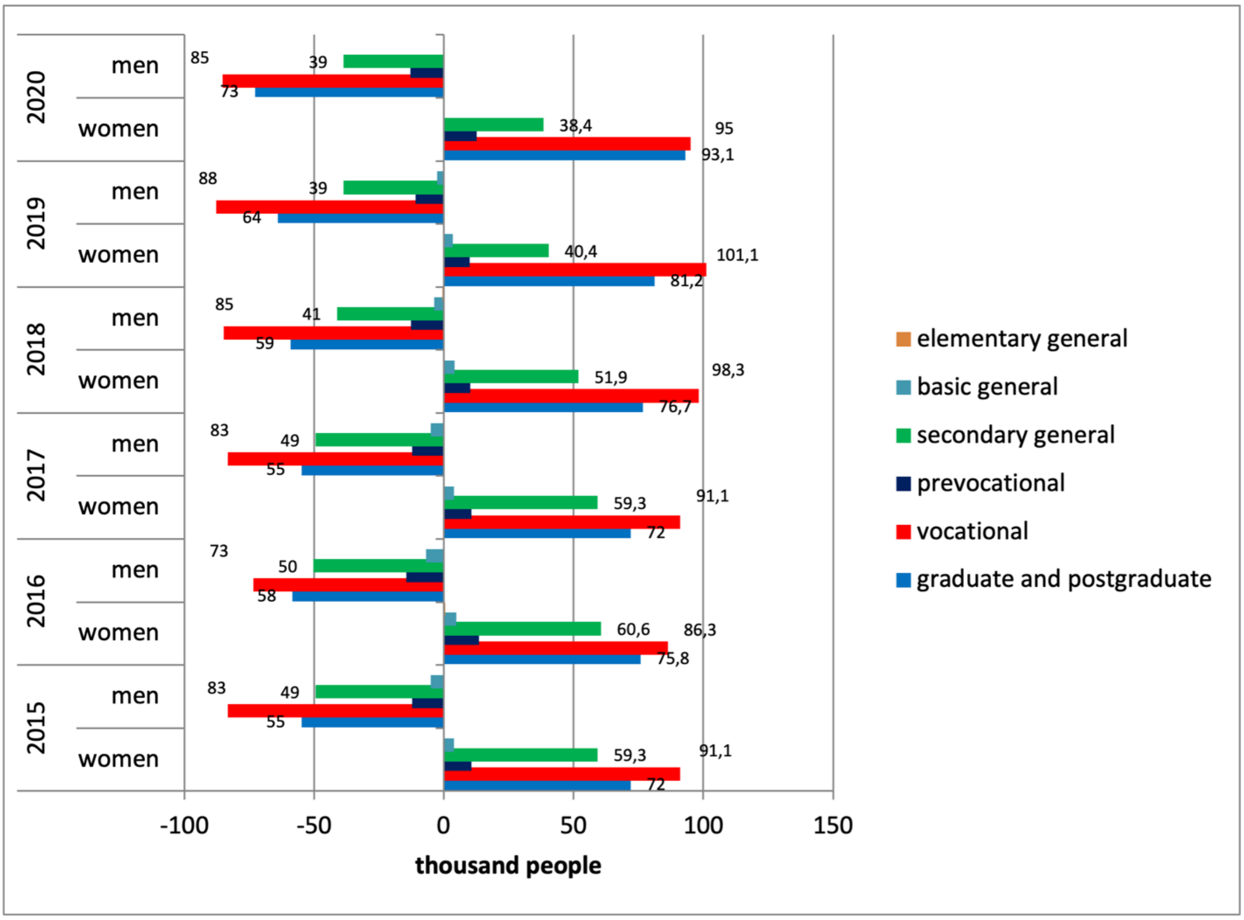
Figure 2.25. *Distribution of unemployed population by gender and age from 2015 to 2020.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The share of unemployed population with graduate and postgraduate education in 2020 is 37%, secondary vocational - 40.2%, primary vocational - 5.7%, general secondary - 17.1%. The share of unemployed women with graduate and postgraduate education (38.9%) is higher than that of men (34.7%).

Figure 2.26. *Distribution of unemployed population by gender and education from 2015 to 2020.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The largest contribution to the share **of the adult population owning land (owners and land users) is made by men. Thus, the share of women in 2020 is 1.57%, men – 8.22% (Table 5 below).**

The share of women who have been granted agricultural land in Kazakhstan totals **1.57%. But in some regions, this share is even lower. For example, in Kyzylorda oblast it is 0.09%, Aktobe – 0.15%, Mangystau, Pavlodar – 0.17% (Table 2.4).**

Table 2.3. *Share of the adult population owning land (owners and land users), in percent*

	2016	2017	2018	2019	2020
Entire population	6.46	6.67	6.39	6.61	4.88
by gender					
men	10.60	11.58	10.99	11.42	8.22
women	2.72	2.21	2.21	2.25	1.57

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Table 2.4. *Percentage of women granted agricultural land, in percent*

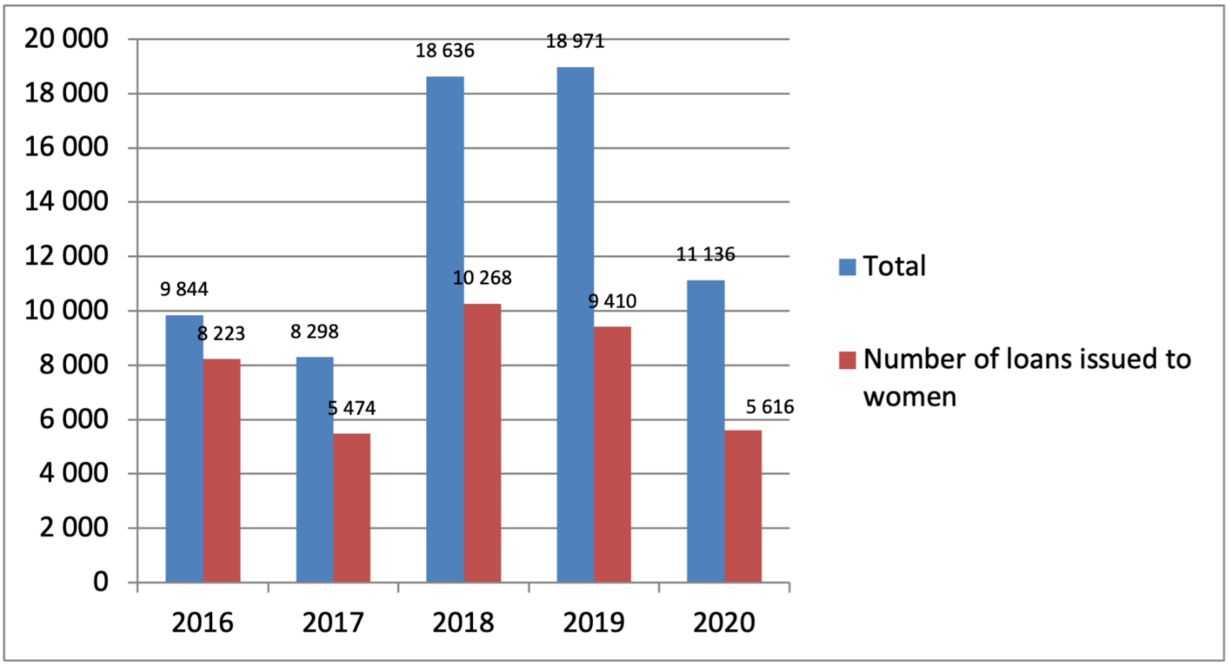
	2016	2017	2018	2019	2020

Republic of Kazakhstan	2.72	2.21	2.21	2.25	1.57
by region					
Akmola	4.92	3.75	3.21	3.17	1.74
Aktobe	0.15	0.15	0.15	0.15	0.15
Almaty	5.48	1.96	2.08	2.08	3.12
Atyrau	1.78	1.51	1.76	2.36	0.81
West Kazakhstan	6.17	6.18	6.19	6.20	6.22
Zhambyl	0.73	1.19	1.19	1.19	1.19
Karaganda	4.16	4.08	4.12	4.15	0.62
Kostanay	0.29	0.29	0.29	0.28	0.29
Kyzylorda	0.09	0.09	0.09	0.10	0.09
Mangystau	0.01	0.02	0.01	0.01	0.17
Turkestan	1.49	1.61	1.44	1.43	1.12
Pavlodar	0.05	0.16	0.23	0.24	0.17
North Kazakhstan	2.66	2.66	2.77	2.80	0.21
East Kazakhstan	4.88	4.88	4.93	4.98	3.71

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The number of loans granted to female entrepreneurs under conditional placement programs in 2020 amounted to 5,616 out of a total of 11,136, or 50.4% of total loans (Figure 2.27 below).

Figure 2.27. *The number of loans issued to female entrepreneurs under conditional placement programs from 2016-2020.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Time spent on unpaid work by the population of Kazakhstan (aged 15 years and older)

The burden of home care is considered to be mainly the responsibility of women. The statistics on the use of daily time show a clear trend of gender-based labor division in the family. Cooking, washing dishes, cleaning the house, as well as physical care of children and babysitting are mainly women's activities, since they spend more time on this on average than men. Women are usually responsible for washing, ironing, and making handmade products and textiles. Construction, repair, maintenance, and care of pets are primarily the responsibilities of men, which generally take less time.

The table below shows the time spent by the population on unpaid work.

Table 2.5. *Time spent on unpaid work by the population of Kazakhstan (aged 15 years and older) in 2018*

	Employed					Unemployed				
	Total	by type of locality		by gender		Total	by type of locality		by gender	
		urban	rural	men	women		urban	rural	men	women
Unpaid services for household and its members	2-16	2-07	2-29	1-09	3-36	3-12	3-10	3-16	1-24	4-05
Unpaid care services for household members	00-28	00-31	00-23	00-19	00-38	00-37	00-40	00-32	00-10	00-50

Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

2.4. Geographical characteristics

Kazakhstan is located at the junction of two continents – Europe and Asia. The area of the Republic of Kazakhstan is 2,724,902 km^2. The length of the state border is 13,398 km. [69]

The republic ranks ninth in the world in terms of land area. Kazakhstan is the largest landlocked country in the world. The terrain is predominantly – more than 90% of the entire territory - flat. High mountains are located only in the south-east and east of the country. Flat tracts of land complicated by exposed and heavily destroyed ancient mountain structures occupy a significant part of the country.

Arid natural zones – desert, semi-desert, and dry steppe zone – cover most of the country's territory. Only its northern part’s conditions are more favorable in terms of humidity: steppe and forest-steppe.

During the reporting period, the structure of land use in the Republic of Kazakhstan has undergone certain changes that maintain dynamics (Table 2.5 a, Figure 2.28). Agricultural lands continued to expand during the reporting period by more than 4% (or 4,512 thousand hectares), while the areas of specially protected natural territories grew by 8% (or 571 thousand hectares). At the same time, industrial, transport, communications, defense, and other non-agricultural lands

[69] Demarcation of the state border of the Republic of Kazakhstan: https://www.gov.kz/memleket/entities/kgk/press/article/details/2328?lang=ru

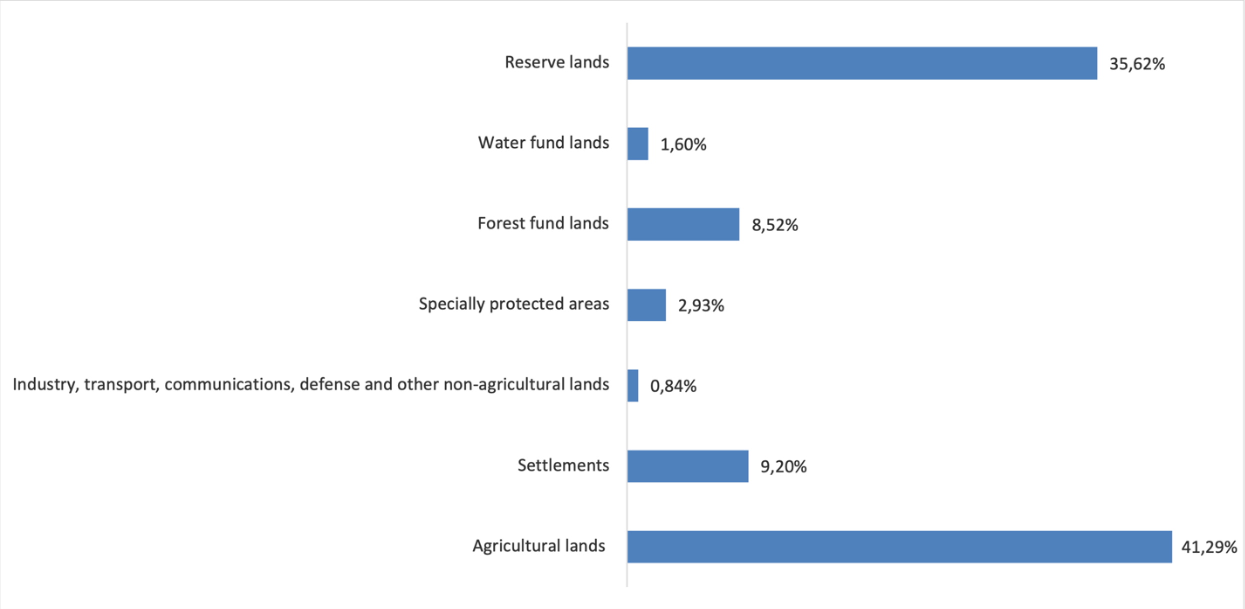
significantly decreased by more than 23% (or 668.2 thousand hectares), while undistributed lands decreased by 3.5% (or 3,395.2 thousand hectares)[70].

Table 2.5.a *Dynamics of changes in land resources, in thousands of hectares*

Land category in thousand hectares	2017	2018	2019	2020
Agricultural land	104,050.6	105,337.4	106,432.6	108,562.7
Settlement lands	23,805.6	24,053.2	24,077.2	24,192.2
Industrial, transport, communications, defense, and other non-agricultural lands	2,877.2	2,244.6	2,317.7	2,209.0
Lands of specially protected natural territories	7,134.3	7,284.3	7,696.7	7,705.7
Forest fund lands	22,880.8	22,737.6	22,398.2	22,398.3
Water fund lands	4,140.0	4,144.6	4,222.1	4,208.4
Reserve lands	97,037.3	96,706.5	95,716.1	93,642.1

Source: 'Green Economy Indicators of the Republic of Kazakhstan. Land Resources', Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan

Figure 2.28. *Structure of land resources of the Republic of Kazakhstan, 2020*



Source: *Green Economy Indicators. Land Resources. Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan, 2021*

In the context of land use and state of land resources, the possible driver of GHG emissions and inhibitors of GHG removals is gradual expansion of agricultural land by an average of 1% (or 1.1 million hectares) per year. The risk of land degradation may aggravate because of growing climate aridity and application of unsustainable practices in land use and agriculture.

2.5. Climate characteristics

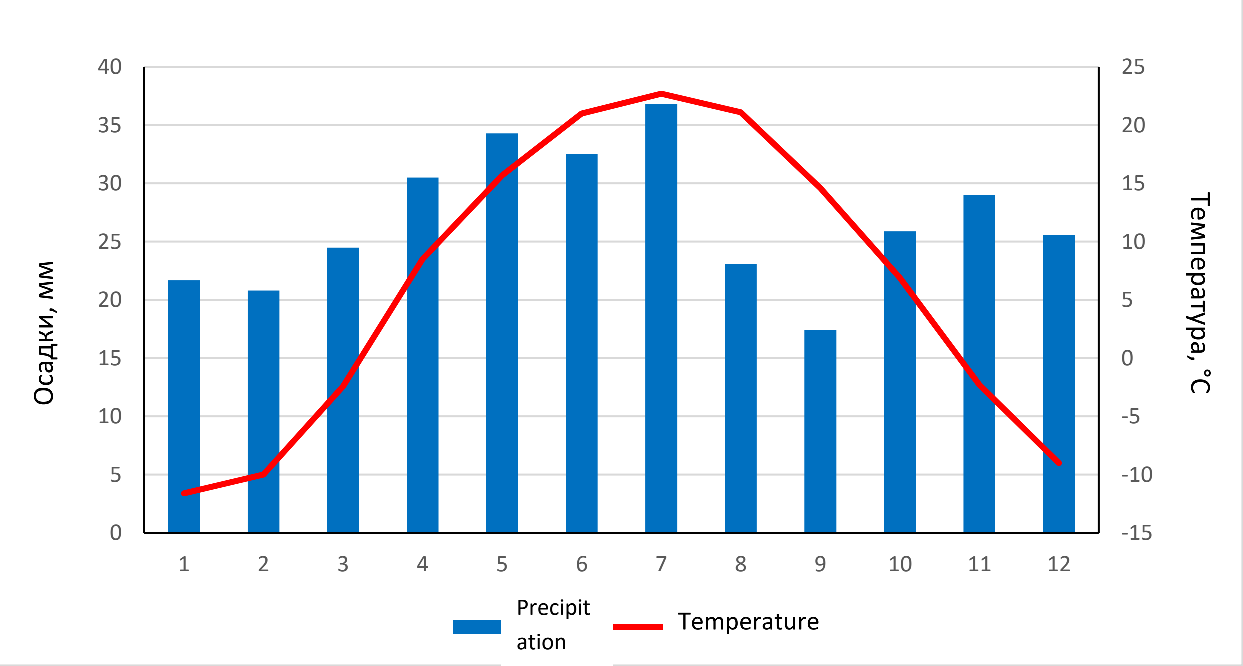
The vast territory of Kazakhstan is characterized by extraordinary diversity of landscape – from depressed plains to highlands. Flat terrain with low altitudes within 200-300 m above sea level is characteristic of the western, southwestern, northern, and central regions of Kazakhstan.

[70] Green economy indicators of the of the Republic of Kazakhstan. Land resources. Committee for Statistics of the Republic of Kazakhstan, 2011

Hummocks massifs have elevations up to 500-600 m. Foothill and mountainous areas occupy about 10% of the territory of Kazakhstan and are in the south, southeast and east.

The climate of Kazakhstan, due to far distance from the ocean, is distinctly continental with prolonged hot summers and cold winters and sharp daily and annual fluctuations in air temperature (Figure 2.29). The maximum of the territory's average precipitation falls from April to July, while the minimum falls from August to September.

Figure 2.29. *Average long-term values of monthly precipitation (mm) and average monthly precipitation (°C) obtained for the period of 1991-2020.*



Source: *Kazhydromet RSE*

Kazakhstan's flat territories are distributed over four landscape zones – forest-steppe, steppe, semi-desert, and desert. Mountainous and foothill areas show distinct vertical climatic zoning.

The forest-steppe zone occupies a small part of the territory of the country's north and includes relatively moist plains in the north of Kazakhstan. Annual precipitation varies from 350 to 450 mm, with about 80% of the annual amount falling during the warm period. The shortest season is spring lasting only 1.5 months; summer lasts 3 months; winter lasts from October through April.

The steppe zone occupies a vast territory in the north of the republic and has drier climate. Annual precipitation varies from about 250 to 350 mm. The maximum, which is 65-80% of the annual precipitation, also falls on the warm half of the year. Compared to the forest–steppe zone, the duration of the winter period here is shorter, and the summer period is longer. Spring is short, while autumn comes in early September and lasts less than two months.

The zone of *semi-deserts*, dry steppes with harsh winters and hot summers stretches through the central part of Kazakhstan. Annual precipitation varies from about 150-200 to 250 mm. In this zone, precipitation also prevails during the warm period, amounting to 55-70% of the annual amount, but to a lesser extent than in the steppe.

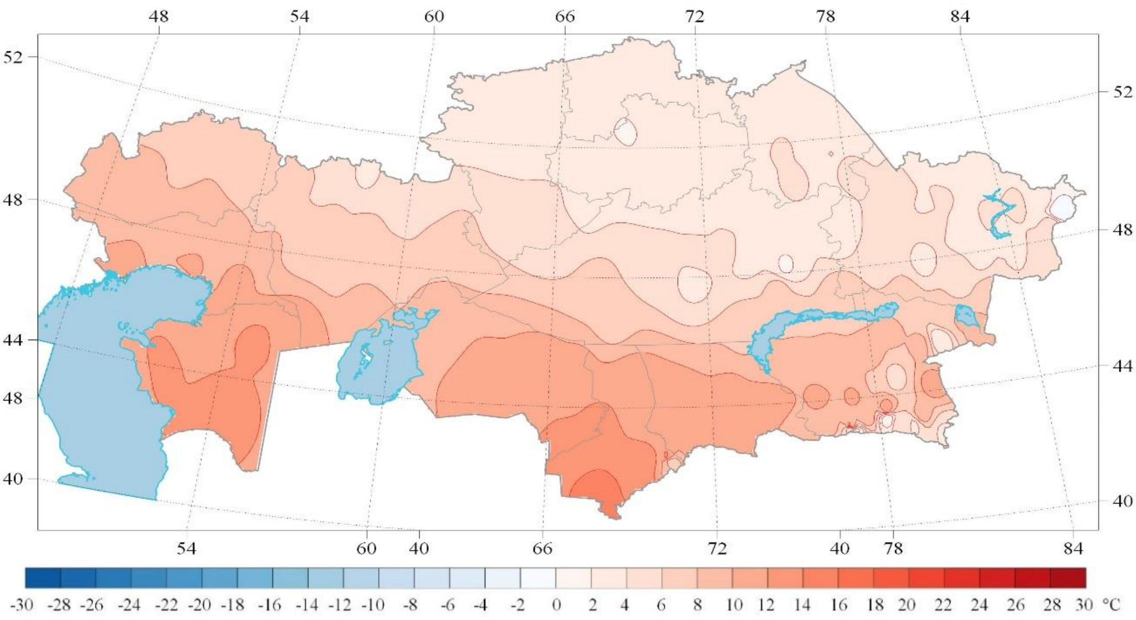
The desert zone occupies a large part of lowland Kazakhstan. In general, this zone's climate of is characterized by prolonged hot summers, cold winters for these latitudes, large annual and daily temperature amplitudes, high dryness of the air, and mostly clear sky. Annual precipitation is less than 200 mm per year, in some extreme southwestern and southern regions, it is even less than 100 mm. The amount of precipitation during the cold period is often higher that the warm period precipitation and may amount to 55% of the annual amount.

In *foothill and mountainous* areas, where vertical climatic zoning is clearly expressed, annual precipitation amounts to 500-1500 mm or more.

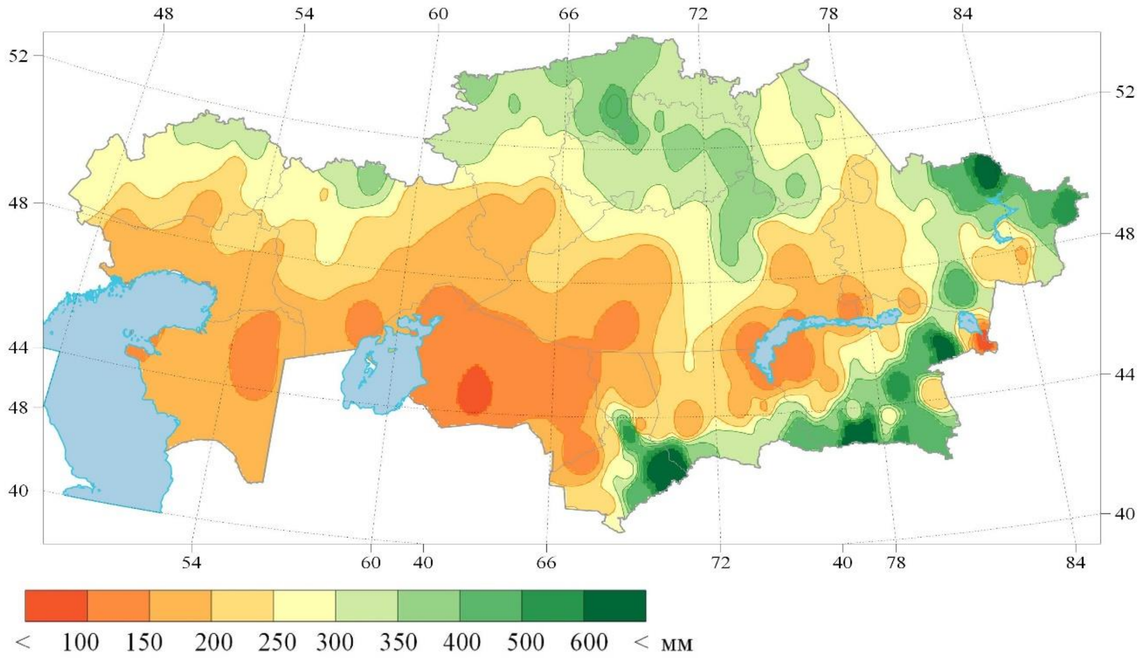
Air temperature distribution in lowland areas closely follows zonal distribution: average annual temperatures rise from 2-3 °C in the north to 13-15 °C in the south (Figure 2.6); the average temperature of January, the coldest month, ranges from minus 16-18 °C in the north to ± 0.5 °C in the south; the average temperature of July is from 18-20 °C in the north to 29-30 °C in the south. Winter in the north is long and cold. In some years, frosts went as low as minus 46-48 °C, and even lower (in Astana, the absolute minimum is minus 52 °C) in the northern regions of the country, however, thaws of up to 5 °C above zero are sometimes recorded in winter. Absolute maxima of air temperature in Kazakhstan's lowlands are rarely below + 40 °C, while in the southern regions they are rarely below + 45 °C. In some southern regions, absolute maximum temperatures reach + 49-50 ° C.

Figure 2.30. *Average annual air temperature (a, °C) and annual precipitation (b, mm) in Kazakhstan (1991-2020)*

a)



b)



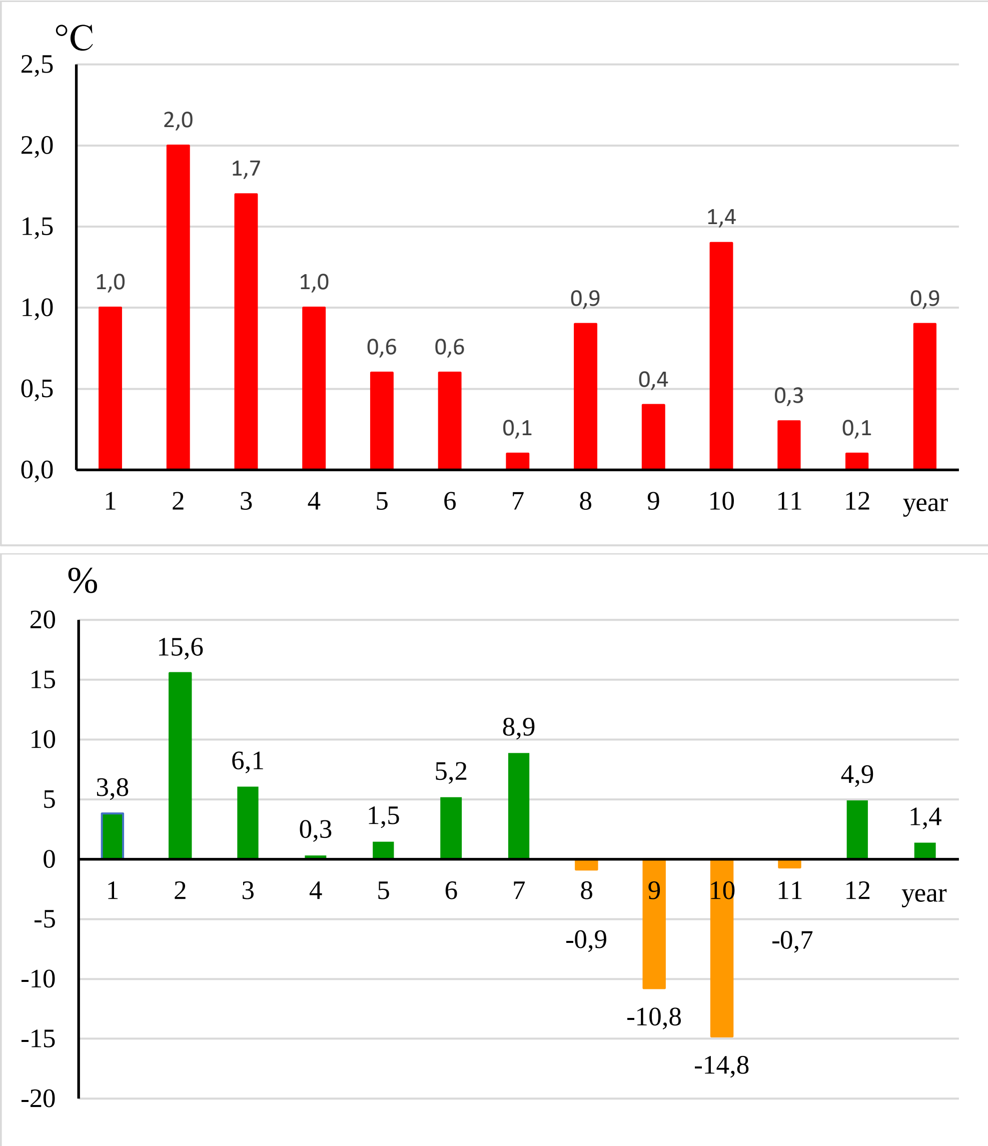
The climate of Kazakhstan has significantly warmed (Fig. 2.30a). Comparison of long-term average ambient temperature values for two consecutive periods of 1961-1990 and 1991-2020 indicates that the country's average annual temperature has increased by 0.9 °C. February and March warmed most significantly – by 2.0 and 1.7 °C, respectively. July and December temperatures have changed little.

The territory's average annual precipitation has not changed much (Fig. 2.30b), still some months show an increase with a maximum in February (by 15.6%), while precipitation value in September and October decreased by 10.8% and 14.8%, respectively.

Figure 2.31. *Changes in air temperature (a) and precipitation (b) averaged across the territory of Kazakhstan. Temperature changes are calculated as the difference between the average long-term values for the periods of 1991-2020 and 1961-1990 (in °C); precipitation changes – as the ratio of long-term average values (in %).*

a)

b)



Source: Kazhydromet RSE

Analysis of trends in extremes of surface air temperature and precipitation, based on the data of most meteorological stations (MS) for the period from 1961 to 2021, has shown the following:

- steady increase in the number of days with temperatures above 30-35 °C, particularly noticeable in the south, southwest and west of the republic;
- countrywide increase in the total duration of heat waves and reduction in the total duration of cold waves;
- countrywide steady increase in the duration of the vegetation season (with average daily temperature above 5 ° C) and the sum of positive temperatures for the vegetation season;

– in many regions, appreciable reduction is observed in the number of days with frosts and severe frosts when the daily minimum air temperature is below 0 °C and minus 20 °C, respectively.

Changes in the extremities of precipitation regime occurred only in some regions:

– in rare cases, the maximum duration of no-precipitation periods has decreased, it increased even less often;
– the same conclusion was made about the maximum duration of periods with precipitation;
– according to some MS, the frequency of extreme precipitation went up; according to others, it went down;
– in some locations the amount of precipitation during consecutive rainy days has changed, mainly towards reduction;
– in rare cases, the intensity of daily precipitation has changed, both towards increase and towards decrease.

2.6. Energy

The goal of Kazakhstan's energy policy is to ensure adequate level and volume of electricity generating capacities for economic growth. First, this is achieved through upgrades to existing power plants. The investment attractiveness of electric power industry, including renewable energy development, is also improving.

The State program for industrial and innovative development of the Republic of Kazakhstan for 2015-2019 has been in effect since 2014.[71] This program continued with the State program of industrial and innovative development of the Republic of Kazakhstan for 2020-2025.[72] This policy document focuses on incentivizing competitiveness of the processing industry to increase labor productivity and the volume of exports of processed goods. In 2013, Kazakhstan approved the concept for transition of the Republic of Kazakhstan to green economy and adopted an Action Plan for its implementation for 2013-2020.[73] The concept covered general approaches to the transition to green economy in the energy-saving and energy-efficiency sectors, as well as energy development in general.

Regarding the development of the power industry, the Concept provides for the following technical measures:

1) conduct energy audit and modernization of all existing coal-fired power plants that will be operated after 2020, with the installation of gas treatment stations to capture primarily emissions of dust, sulfur dioxide and nitrogen oxide to achieve modern standards for emissions of harmful substances;
2) construct new thermal power plants using the world's best technologies in terms of fuel efficiency and environmental parameters;
3) gradually replace existing old coal facilities with new modern coal plants, except for large cities where power generation will switch to gas;
4) start the development of renewable energy via construction of wind power plants (WPP) and solar power plants (SPP): achieving not less than 3% of solar and wind in

[71] Approved by Decree of the President of the Republic of Kazakhstan No. 874 dated August 1, 2014
[72] Resolution of the Government of the Republic of Kazakhstan No. 1050 dated December 31, 2019.
[73] Decree of the President of the Republic of Kazakhstan No. 577 dated May 30, 2013.

the total power generation by 2020, 10% by 2030; 50% of alternative and renewable energy sources (including wind, solar, hydro, and nuclear energy) in power generation by 2050;

5) diversify the energy sector by investing in nuclear power with simultaneous implementation of safety initiatives;

6) convert CHPPs to gas in all major cities through investments in the creation of gas infrastructure in the northern, eastern, and southern regions of the country;

7) convert existing CHPPs to gas, primarily in large cities (Almaty, Astana, Karaganda), and build new gas-fired stations until 2020 to improve the environment in these cities.

As of 2021,[74] the country had 115 operational renewable energy facilities with a total capacity of 1897 MW including hydroelectric power plants (HPPs) with a total capacity of 255.08 MW, wind power plants (WPPs) – 601.3 MW, solar power plants (SPPs) – 1,032.6 MW, and a biogas plant – 7.82 MW.

The share of renewable energy generation in the total electricity output is 3.5%. Measures to improve the efficiency of the entire power industry were included in the Program 'Plan of the Nation – 100 concrete steps'.[75] They include elimination of existing differences in electricity tariffs between regions (paragraph 50), consolidation of regional power grid companies to improve the reliability of energy supply, reduce the cost of power transmission in the regions and, accordingly, reduce the cost of electricity for consumers (paragraph 51), introduction of a new tariff policy aimed at stimulating investment in the power industry (paragraph 52).

Now, Kazakhstan has a system of cap power rates in place for power-generating organizations[76]. Starting in 2019,[77] a capacity market began operating along with the power market. With the introduction of the capacity market, the existing power tariff was divided into two parts:

1) power tariff: a variable part that will cover the costs of power generation;
2) capacity tariff: a permanent part that will ensure the return on investment in the construction of new capacities and renovation, modernization, reconstruction, expansion of existing capacities.

The law on support for the development of renewable energy sources (RES) was adopted in the Republic of Kazakhstan in 2009.[78]

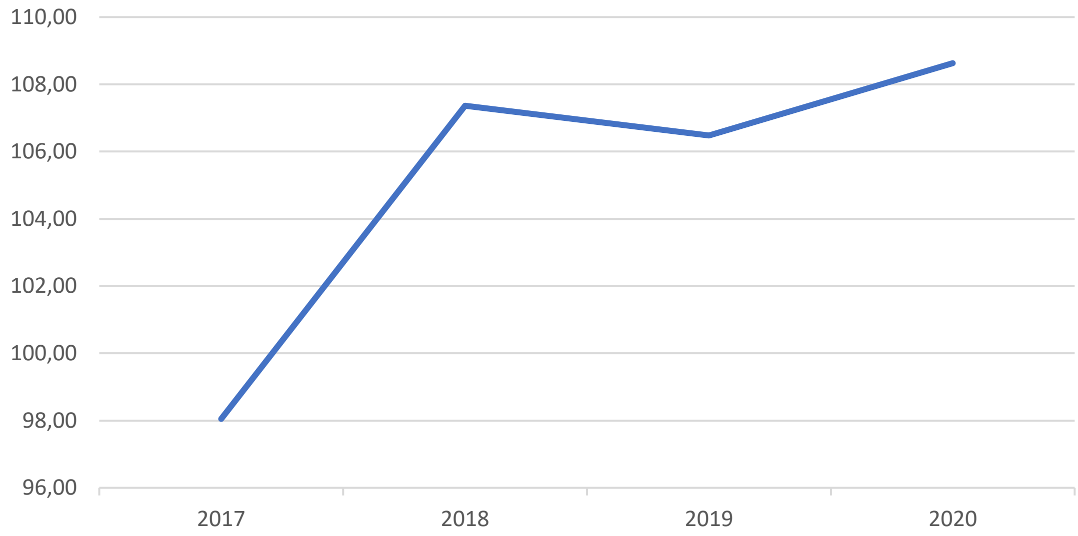
In 2014, by-laws were adopted to implement the measures required to support RES, namely, fixed tariffs were determined [79] and the rules for centralized purchase and sale of power generated by RES were approved. The rules define Financial Settlement Center (FSC) as a buyer for the power produced, guarantee the purchase of RES power at a fixed tariff for 15 years (however, fixed tariffs are subject to annual indexation aligned with inflation rate inflation), and determines FSC's responsibility for the financial settlement of power imbalances from RES. In addition, RES generators are exempt from paying for the power transmission services of power

[74] Kazakhstan Electricity and Power Market Operator Joint Stock Company
[75] The program of the President of RK dated May 20, 2015.
[76] Order of the Minister of Energy of the Republic of Kazakhstan No. 514 dated December 14, 2018. Registered with the Ministry of Justice of the Republic of Kazakhstan under No. 17956 on December 14, 2018.
[77] Order of the Minister of Energy of the Republic of Kazakhstan No. 465 dated July 3, 2015, 'On approval of cap power tariffs and cap capacity-readiness tariffs'.
[78] Law of the Republic of Kazakhstan No. 165-IV dated July 4, 2009, 'On support for the use of renewable energy sources'.
[79] Resolution of the Government of the Republic of Kazakhstan No. 645 of June 12, 2014.

transmission organizations, while power transmission and dispatch from RES generators is prioritized. Moreover, legal entities engaged in the design, construction and operation of RES facilities are provided with investment preferences in accordance with the legislation of the Republic of Kazakhstan on investments.[80]

Electricity generation in Kazakhstan in the period from 2017 to 2020 has shown overall positive dynamics. Thus, the total increase was about 10.5 billion kWh (or 10.8%) during the period under review. In 2019, power generation went down slightly by less than 1% compared to 2018. This had been due to a decrease in electricity consumption by industrial consumers, as well as a reduction in household consumption, however, the general growth trend resumed later.

Figure 2.32. *Total power generation output, billion kWh*



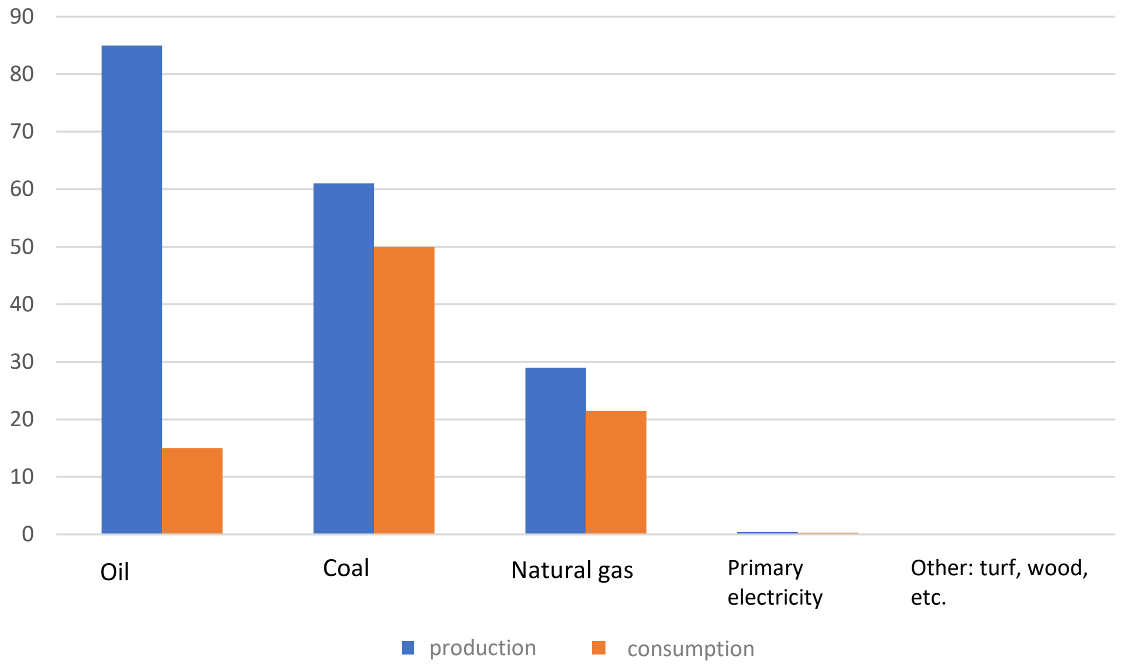
Source: 'Fuel and energy balance of the Republic of Kazakhstan. Statistical Digest.'

In 2021, 190 power plants of various forms of ownership produced electric energy in Kazakhstan. The total installed capacity of Kazakhstan's power plants amounted to 23,957.3 MW as of January 1, 2022, while the available capacity was 19,004.1 MW.[81]

Kazakhstan remains a net exporter of primary energy (mainly crude oil). However, net exports of primary energy from Kazakhstan decreased more sharply than its domestic consumption during the pandemic, as a result, the share of total primary energy output supplied to domestic markets increased from 49.3% in 2019 to 50.1% in 2020. In the future, the share of output consumed domestically is projected to average 52% (and reach 61% in 2050) during the forecast period.

[80] Resolution of the Government of the Republic of Kazakhstan No. 79 dated February 21, 2020.
[81] Kazakhstan's Power industry: Key Facts, KEGOC

Figure 2.33. *Balance of primary energy in Kazakhstan by fuel type in 2020, in million tons of oil equivalent*



Source: *IHS Markit, 2021.*

The apparent consumption of primary energy resources in Kazakhstan in 2020 fell by 2.7% to 89.5 million toe following a particularly sharp drop in oil demand (by 12.3% to 15.8 million toe), as well as a decrease in coal consumption (by 0.9% to 49.8 million toe), while an increase was observed in natural gas consumption (by 0.2% to 21.3 million toe) and primary electricity consumption (by 7.5% to 2.6 million toe).

Net exports of primary energy resources from Kazakhstan, about 80% of which has recently been oil, decreased by 5.6% to 89.2 million tons in 2020 due to the shocks in world oil markets related to the COVID-19 pandemic.

Coal continues to dominate domestic consumption showing a smooth shift to a more balanced structure with an increase in the use of gas, renewable energy and (possibly) nuclear energy to achieve Kazakhstan's decarbonization goals.

The share of RES-generated power increased by almost 3 times during the reporting period and reached 3,123.4 million kWh by 2020. The policy initiated in 2014 to implement essential support measures for RES, identify fixed tariffs, and other measures, were helpful in attracting investment as part of Kazakhstan's transition to green economy and significantly accelerate this sector of the economy. The dynamics of the RES share in the total power generation maintains stable growth.

Table 2.6. *Power generation output by RES, in million kWh*

Name	**2017**	**2018**	**2019**	**2020**
Total power generation in RK	102,383.6	106,797	106,029	108,085
Total RES in RK	1,109	1,335.1	1,927.7	3,123.4
Share of RES in RK, %	1.08	1.25	1.82	2.89

Source: *Analysis of Power and Coal Market of Kazakhstan for 2017 - 2020. Samruk Energo, 2017-2020*

The highest growth is observed in solar and wind power generation. The growth in other sectors is insignificant.

Table 2.7. *Distribution of power generation by RES type, in million kWh*

Name	**2017**	**2018**	**2019**	**2020**
Total RES in RK	1,109	1,335.1	1,927.7	3,123.4
SES	89.8	138.6	412.4	1,304.3
WPP	338.5	400.5	701.9	1,091.6
Small HPPs	680	794.7	807.3	722.6
Biogas plants	0.7	1.3	5.8	4.9

Source: Analysis of power and coal market of Kazakhstan for 2017 - 2020. Samruk Energo, 2017-2020

Kazakhstan's emissions trading system covers emissions of only carbon dioxide (CO_2) from major pollution sources, which account for about a half of all GHG emissions in the country. Zhassyl Damu JSC is the operator of the emissions trading system.[82]

The volume of transactions estimated to cover real emissions for 2013-2015 amounted to at least USD8.6 million, while from 2018-2020, the turnover decreased to USD5.6 million. From 2018 to 2020, a total of 52 transactions were made and quotas in the amount of over 7.35 million tons of CO_2[83] were traded in the country. The average price for 1 ton of CO_2 varies from KZT500 to 600 (USD1.2–1.3).

According to the Roadmap for the implementation of updated Nationally Determined Contributions, the price per metric ton of CO_2 may go up to USD17 by 2023 and over USD50 by 2026.

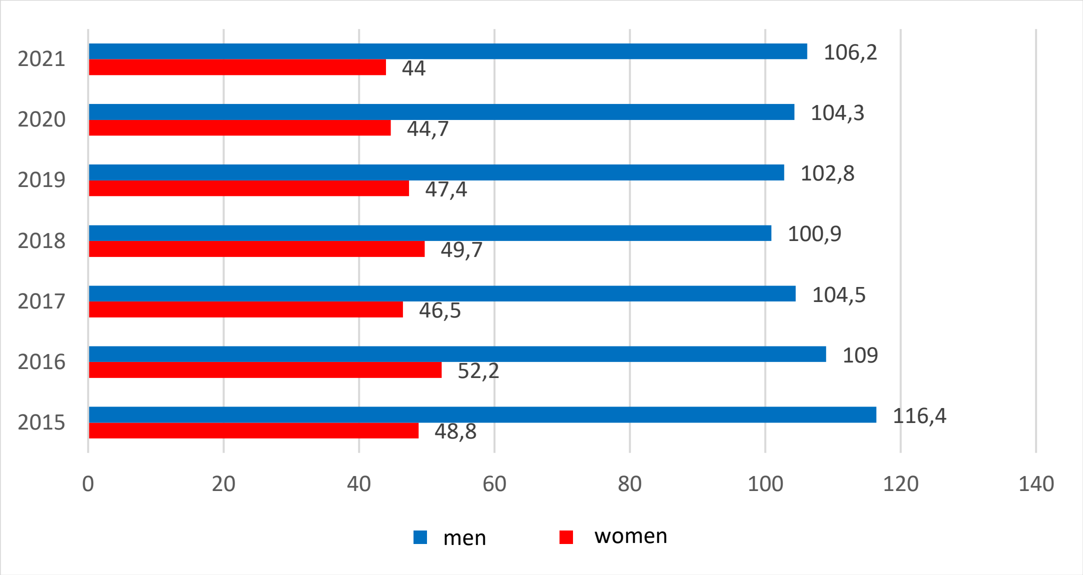
The forecast is based on Kazakhstan's current plans to partially transition from coal to gas in the power industry, improve energy efficiency and increase the RES penetration (15% by 2030). To achieve the NDC targets by 2030, the Republic of Kazakhstan will tighten carbon regulation.

Production and consumption of energy resources in Kazakhstan occurs mainly via combustion of mineral fuels, coal in particular. Plans to expand coal and oil extraction indicate that dependence on traditional energy sources will continue. Meanwhile, work is underway to upgrade coal-fired power plants, which will facilitate reduction of greenhouse gas and air pollutants emissions. By 2020, the use of renewable energy has reached almost 3% of the total power generated in the country. Kazakhstan considers nuclear energy as an alternative energy source too. A feasibility study for the construction of a nuclear power plant is currently under development. By 2050, half of the electricity produced in the country is planned to come from renewable and alternative energy sources. The carbon unit trading market and the updated NDC plan are expected to encourage GHG sources like major power plants to upgrade their facilities and invest in RES. Kazakhstan still considers reduction of the industry's energy intensity as one of the most important factors in improving energy efficiency and competitiveness of the economy, which may also lead to a reduction in GHG emissions.

The number of people employed in the sector amounts to 150.2 thousand (2021). Of these, 29.3% are women and 70.7% are men.

[82] Official web page of Zhassyl Damu JSC: https://recycle.kz/ru.
[83] KAZENERGY National Energy Report, 2021.

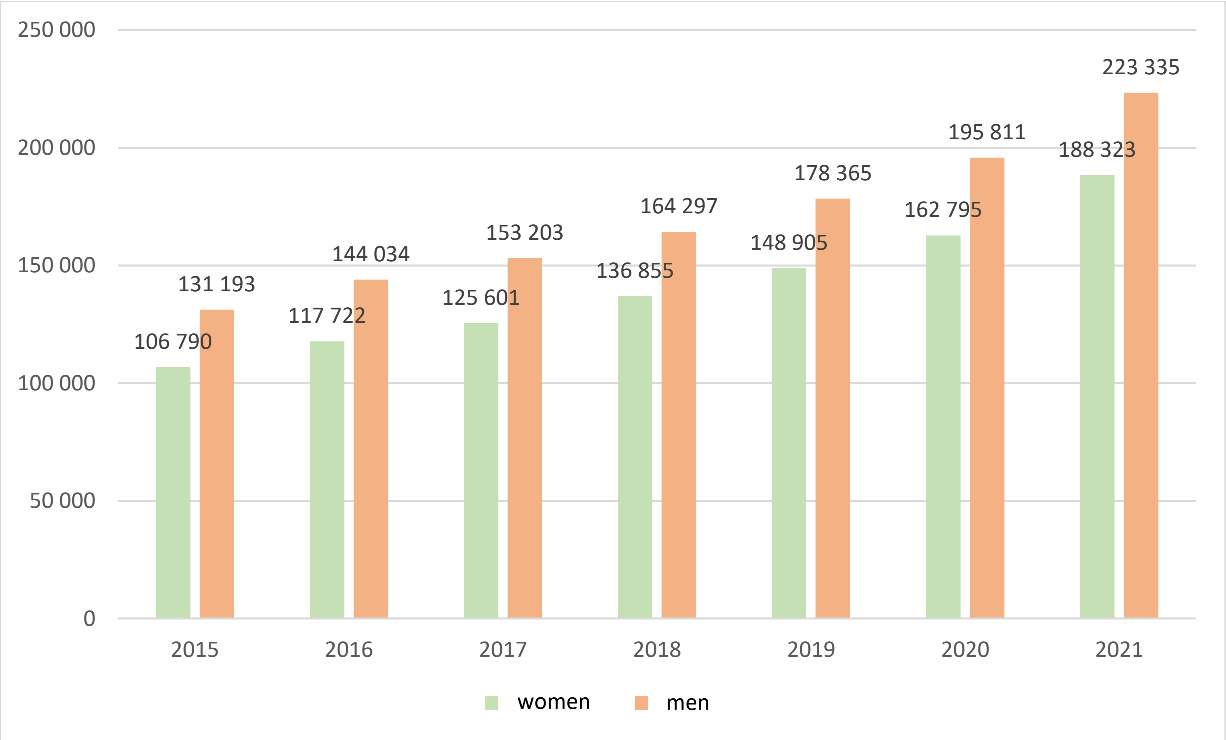
Figure 2.34. *Employed population in the sector of power, gas, steam, hot water, and air conditioning supply by gender.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

In 2021, the ratio of women's wages to men's wages was 84.3%, i.e., the wage gap between men and women was 15.7% (Figure 2.35 below).

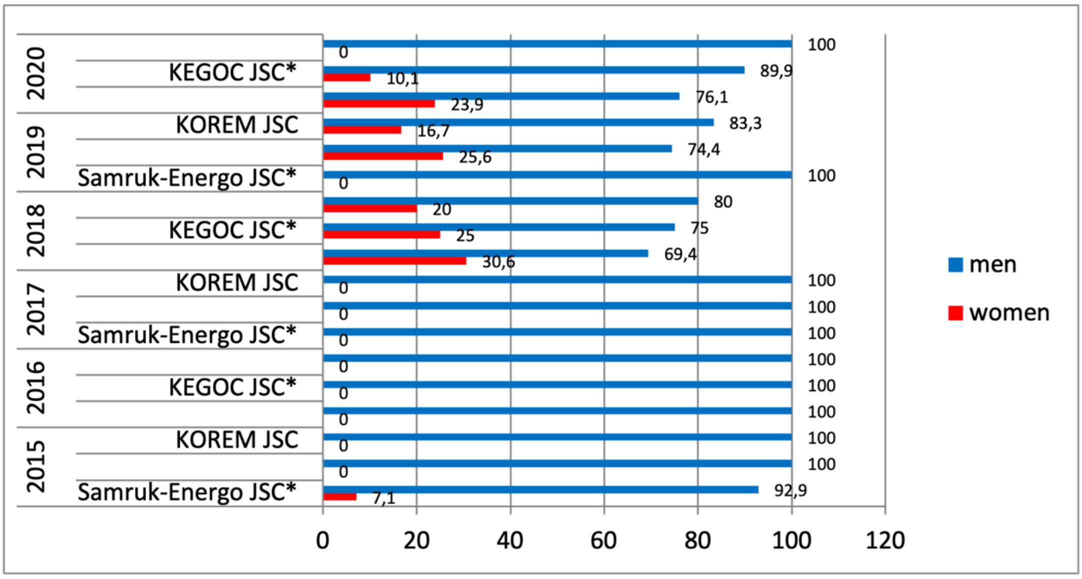
Figure 2.35. *Nominal wages of women and men*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Figure 2.36 below shows the percentage distribution by gender among the executives of national management holdings and KEGOC JSC, Samruk-Energo JSC and KOREM JSC from 2015 through 2020. The figure clearly shows the prevalence of men among the chief executives of national management holdings and national companies.

Figure 2.36. *Ratio of male and female executives of national management holdings and the companies KEGOC, Samruk-Energo and KOREM.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Effects of changes in energy sector on GHG emissions

Production and consumption of energy resources in Kazakhstan occurs mainly via combustion of mineral fuels, coal in particular. The goal of Kazakhstan's energy policy is to ensure adequate level and volume of electricity generating capacities for economic growth. First, this is achieved through upgrades to existing power plants.

Based on the estimates of GHG emissions from the energy sector[84] (Table 2.7), the emissions decreased from 2016 to 2020 (by 26,556.43 thousand tons of CO_2-eq, or 9.8%).

Table 2.7. *Greenhouse gas emissions in the energy sector, in thousand tons of CO2-eq.*

Year	2016	2017	2018	2019	2020
Fuel combustion (sectoral approach)	270,502.93	286,424.58	299,77.19	266,967.99	243,946.58

Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

In December 2020, President Tokayev announced the goal of achieving carbon neutrality by 2060 at the Climate Ambition Summit. To achieve this goal, Kazakhstan has developed a long-term Doctrine of Achieving Carbon Neutrality until 2060 – concrete steps to ensure sustainable post-crisis recovery, low-carbon economic development and transformation in the energy sector. The Doctrine stipulates a set of key measures to reduce emissions and decarbonize the economy, such as abandoning new coal-fired generation projects and phasing out coal combustion (2021-2025), implementing a program to plant 2 billion trees (2025), doubling the share of RES in power

[84] Inventory of greenhouse gas emissions in Kazakhstan, 2022

production (2030), 100% sorting of municipal solid waste household waste (2040), sustainable agriculture on 75% of arable land (2045), 100% electrification of personal passenger vehicles (2045), using green hydrogen and exiting coal completely starting from 2050.

2.7. Transport

Kazakhstan is located in the center of the Eurasian continent, which determines the importance of the transport sector for the country. Motor roads and railways account for the major share of all land traffic. The mileage of public roads in 2020 increased by 0.37%, while the length of railway tracks grew by 0.13%.[85]

Table 2.8. *Length of motor roads and railways*

Year	Motor roads, km	Railway tracks, km
2017	95,409.6	16,614.3
2018	96,245.7	16,634.8
2019	95,629.0	16,634.8
2020	95,767.8	16,636.7

The state program of infrastructure development of the Republic of Kazakhstan 'Nurly Zhol' for 2015-2019 ensured building, reconstruction, and repair of eight thousand kilometers of roads of international and national significance. The reconstruction of the international transit corridor 'Western Europe – Western China' has been completed. Sections of the republican road network Astana – Temirtau, Almaty – Kapshagai, Kokshetau – Petropavlovsk, Beineu –Aktau, Bypass of the Kordai Mountain Passage, Uralsk – Kamenka were reconstructed; a bridge crossing over the Yertis River was built in Pavlodar oblast.

In 2020, the Transport Committee of the MIID RK launched the implementation of the state program of infrastructure development ‘Nurly Zhol’ for 2020-2025 approved by the Government Decree of the Republic of Kazakhstan No. 1055 dated December 31, 2019. The Program was developed in compliance with the goals and priorities of the Strategic Development Plan of Kazakhstan until 2025 and is aimed at promoting further economic growth and improving the standard of living of Kazakhstani population through the development of efficient and competitive transport infrastructure, transit, and transport services, as well as improving the technological and institutional environment for the functioning of the transport and communication complex.[86]

Transportation services (passenger and cargo transportation)

In 2017-2019, passenger traffic increased moderately (Table 2.9). In 2020, total passenger traffic went down sharply by 60% due to the COVID-19 pandemic and quarantine measures, while the share of passenger traffic by rail, air and road transport decreased by 2, 1.7 and 2.64 times, respectively.[87]

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[85] The length of communication routes in Kazakhstan for 2019-2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.
[86] The state program of infrastructure development 'Nurly Zhol' for 2020-2025.
[87] The key indicators of transport development from 2017 to 2020 in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

Table 2.9. *Passenger traffic by all types of transport in Kazakhstan, million passenger-kilometers.*

Year	Railway	%	Automotive and urban electric	%	Inland water	%	Air	%	Total
2017	18,222.2	6.67	240,586.9	87.9	0.7	0.0003	1,4383.7	5.27	**273,193.4**
2018	18,562.2	6.59	24,7931.2	87.9	x	x	14,989.7	5.33	**281,484.1**
2019	17,721.0	6.0	260,909.1	88.1	0.7	0.0002	16,885.5	5.71	**295,516.6**
2020	9,163.0	8.43	91,022	83.6	0.5	0.0005	8,525.2	7.84	**108,711.0**

Source: Key transport performance indicators from 2017 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Freight traffic turnover has grown too (by 3.5%). Meanwhile, there was a significant decrease in air freight traffic (by 53.74%) and an increase in rail freight traffic (by 3.96%). Civil aviation industry was one of the most affected by the spread of the pandemic in 2020.

Table 2.10. *Cargo turnover by all types of transport in Kazakhstan, billion tons/km*

Year	Railway	%	Automotive	%	Inland water and marine	%	Air (million tons/km)	%	Pipeline	%	Total
2017	266.6	47.27	166.1	29.45	1.6	0.28	53.8	9.54	129.5	22.96	**564.0**
2018	283.3	46.48	185.2	30.39	0.04	0.01	57.6	9.45	x	x	**609.5**
2019	286.7	47.98	173.5	29.03	0.69	0.12	83.8	14.02	136.7	22.87	**597.6**
2020	299.2	51.23	160.0	27.40	0.02	0.00	55.1	0.01	124.2	21.27	**584.0**

Source: Key transport performance indicators from 2017 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Fleet of motor vehicles

In 2020, the number of registered passenger vehicles grew by 0.5%, cargo vehicles – by 8%[88]. A slight decrease in bus transport is caused by the wear and due disposal of the vehicles. Noticeable increase was recorded in the number of passenger cars in individual ownership – by 0.7% compared to 2017.

Table 2.11. *Fleet of motor cars in Kazakhstan*

Year	Passenger transport, thousand units.	%	Buses, thousand units.	%	Cargo transport, thousand units.	%	Total, thousand units.
2017	3,851.6	87.88	90.43	2.06	440.612	10.05	4,382.66
2018	3,848.0	88.62	89.291	2.06	404.848	9.32	4,342.16
2019	3,776.9	87.32	86.61	2.00	461.78	10.68	4,325.31
2020	3,870.3	87.30	83.58	1.89	479.64	10.82	4,433.52

Source: Key indicators of transport development from 2017 to 2020. Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan

Table 2.12. *Individually owned passenger vehicles of the population*

[88] Bus, passenger, freight transport. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

Year	Units per 100 people
2017	20.2
2018	19.9
2019	19.3
2020	19.5

Source: Key indicators of transport development from 2019 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Fuel consumption

In 2020, Kazakhstani fuel producers covered 100% of domestic demand for gasoline (including aviation), 87.6% of demand for gas oil (diesel fuel) and 95.3% of demand for kerosene.

Table 2.13. *Production and sale of products in kind, t*

Motor fuel (gasoline, including aviation)				
Year	**2017**	**2018**	**2019**	**2020**
Produced	3,072,700.0	3,969,200.0	4,539,900.0	4,496,200.0
Import	1,064,005.3	416,010.5	19,179.9	1,686.3
Consumed	4,136,705.3	4,385,210.5	4,559,079.9	4,497,886.3
Export	2,271.8	14,616.0	54,054.3	516,258.0
Sold in domestic market	4,134,433.5	4,370,594.5	4,505,025.6	3,981,628.3
Kerosene				
Year	**2017**	**2018**	**2019**	**2020**
Produced	500.0	388,300.0	632,100.0	440,500.0
Import	206,795.3	208,280.7	38,159.4	21,783.7
Consumed	207,295.3	596,580.7	670,259.4	462,283.7
Export	17,496.6	18,195.5	25,028.2	6,381.3
Sold in domestic market	189,798.7	578,385.2	645,231.3	455,902.5
Gas oil (diesel fuel)				
Year	**2017**	**2018**	**2019**	**2020**
Produced	4,408,900.0	4,671,700.0	5,036,800.0	4,678,500.0
Import	452,430.2	334,259.8	249,129.9	660,030.5
Consumed	4,861,330.2	5,005,959.8	5,285,929.9	5,338,530.5
Export	107,287.7	222,912.5	43,814.6	128,744.2
Sold in domestic market	4,754,042.4	4,783,047.3	5,242,115.3	5,209,786.3

Source: Resources and use of certain types of products (goods) and raw materials in the Republic of Kazakhstan from 2017 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

In 2020, domestic demand for light petroleum products decreased due to the imposed quarantine measures. Thus, to prevent product disruptions in the domestic market, the Ministry of Energy adjusted the oil refining plan for refineries from 17 to 15.5 million tons also reducing the output of diesel fuel and jet fuel, while increasing bitumen production to cover the demand from more intensive road construction. Moreover, the Ministry has taken the following measures to support the industry:[89]

– lifted the ban on the ground export of petroleum products from the Republic of

[89] 'Oil Production, Gasification and Investment Attraction — How Kazakhstan's Energy Industry Developed in the Context of the Pandemic': https://primeminister.kz/ru/news/neftedobycha-gazifikaciya-i-privlechenie-investiciy-kak-razvivalas-energeticheskaya-otrasl-kazahstana-v-usloviyah-pandemii-52034

Kazakhstan and the countries of the Customs Union. After the ban was lifted in July 2019, gasoline exports to Europe and Central Asia have resumed;

– exempted producers of excisable goods from payment of excise duties for gasoline and diesel fuel sold for export;

– introduced of a ban on the supply of gasoline, diesel, and aviation fuel to the country by rail, road, and pipeline transport (Order of the Minister of Energy of the Republic of Kazakhstan No. 431 dated December 8, 2020, ‘On certain issues of the supply of petroleum products to the Republic of Kazakhstan’);

– zeroed the rates of export customs duties on petroleum products including gasoline, diesel fuel and fuel oil.

During the period under review from 2017 to 2020, the output of motor fuel (gasoline, including aviation), kerosene and gas oil (diesel fuel) increased. The price dynamics of the most popular brands of fuel is presented in Table 2.14 (prices are indicated as of the end of the year). This behavior is primarily due to the government's efforts to phase out state regulation of fuel pricing, as well as due to the annual inflation of the national currency.

Table 2.14. *Price dynamics (as of the end of the year) for the most common brands of fuel, in KZT.*

Year	**AI-92**	**AI-95, 96**	**AI-98**	**summer**	**winter**
2017	159.64	177.36	188.66	158.79	211.87
2018	154.85	175.29	191.89	193.44	264.11
2019	146.67	169.96	187.64	193.00	274.59
2020	150.61	171.29	190.23	183.48	247.37

Source: Oil and petroleum product prices in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of RK

Pricing for fuel and lubricants in the domestic market is based on supply and demand, that is, the prices are regulated by the market and are not tied to world oil prices. According to the Ministry of Energy, the main pricing factors include the cost of oil in Kazakhstan (domestic prices), processing (oil refining service), taxes and excise taxes, costs of laboratory tests and additives, servicing of bank loans, spotting/picking of tanks, product transportation and other related costs.[90]

Effects of changes in transport on GHG emissions

GHG emissions in the transport sector (Table 2.15) are largely generated by emissions from road transport.[91] During the reporting period, their share has been 86-84%. The contribution of domestic aviation and rail transport has remained at a relatively low level: in 2019, it amounted to 4.58% and 5.56%, respectively.

[90] ‘Fuel Cost Increase: Pricing and Reasons for Growth’: https://strategy2050.kz/ru/news/povyshenie-stoimosti-gsm-tsenoobrazovanie-i-prichiny-rosta /

[91] Status report of the annual inventory of Kazakhstan, UNFCCC Secretariat, April 16, 2021 (hereinafter referred to as 'Inventory of Greenhouse Gas emissions in Kazakhstan, 2019': https://unfccc.int/documents/273502)

Table 2.15. *Greenhouse gas emissions in the transport sector, thousand tons of CO2-eq*

Year	Road transport	%	Domestic aviation	%	Railway	%	Domestic navigation	%	Other	%	Total
2016	19,110.74	85.9	929.31	4.18	1,246.53	5.60	14.44	0.06	956.28	4.30	**22,257.30**
2017	20,221.64	85.6	985.97	4.17	1,502.74	6.36	8.75	0.04	903.67	3.83	**23,622.76**
2018	21,324.35	84.0	1,074.04	4.23	1,443.17	5.68	9.77	0.04	1,535.23	6.05	**25,386.57**
2019	21,803.15	84.4	1,182.51	4.58	1,437.16	5.56	6.91	0.03	1,412.78	5.47	**25,842.51**
2020	15,704.23	86.5	11.19	0.61	1,001.41	5.51	3.02	0.02	1,344.28	7.40	**18,164.13**

Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

Greenhouse gas emissions from road transport have increased (by 12.3%) in 2019 compared to 2016 during the period from 2016 to 2020. During the period under review, there has been an increase in GHG emissions from rail transport (by 15.3%). This may be due to the depreciation of the fleet of shunting locomotives.

Greenhouse gas emissions in domestic aviation increased by 27% in 2020 compared to 2016, which may be due to an increase in cargo and passenger traffic by air.

2.8. Industry

Mining industry still dominates in the total industrial production output from 2017 to 2020 (Table 2.15): 54% on average of the total industrial output. The share of manufacturing industry has increased in the structure of industrial production (Figure 2.8): from 38.4% in 2019 to 48.7% in 2020.[92]

In 2020, a decrease was recorded in the following industries: mining and quarrying (by 3.7%), water supply, waste collection, treatment and disposal, activities to eliminate industrial pollution (by 2.6%), supply of electricity, gas, steam, hot water, and air conditioning (by 0.3%). At the same time, there is an increase in the processing industry (by 3.9%). Oil and natural gas production went down by 7.2% and 2.3%, respectively, in the mining sector in 2020.[93]

Table 2.16. *Industrial production output in Kazakhstan, billion KZT.*

Year	**2017**	**2018**	**2019**	**2020**
Industry (total)	22,790.2	27,218.1	29,380.3	27,028.5
Mining and quarrying	11,568.8	14,877.1	15,978.1	11,785.6
Processing industry	9,400.8	10,403.9	11,573.3	13,232.7
Power, gas, steam, and air conditioning supply	1,582.3	1,693.3	1,561.4	1,740.7
Water supply; sanitation, control over waste collection and distribution	238.3	243.8	267.6	269.5

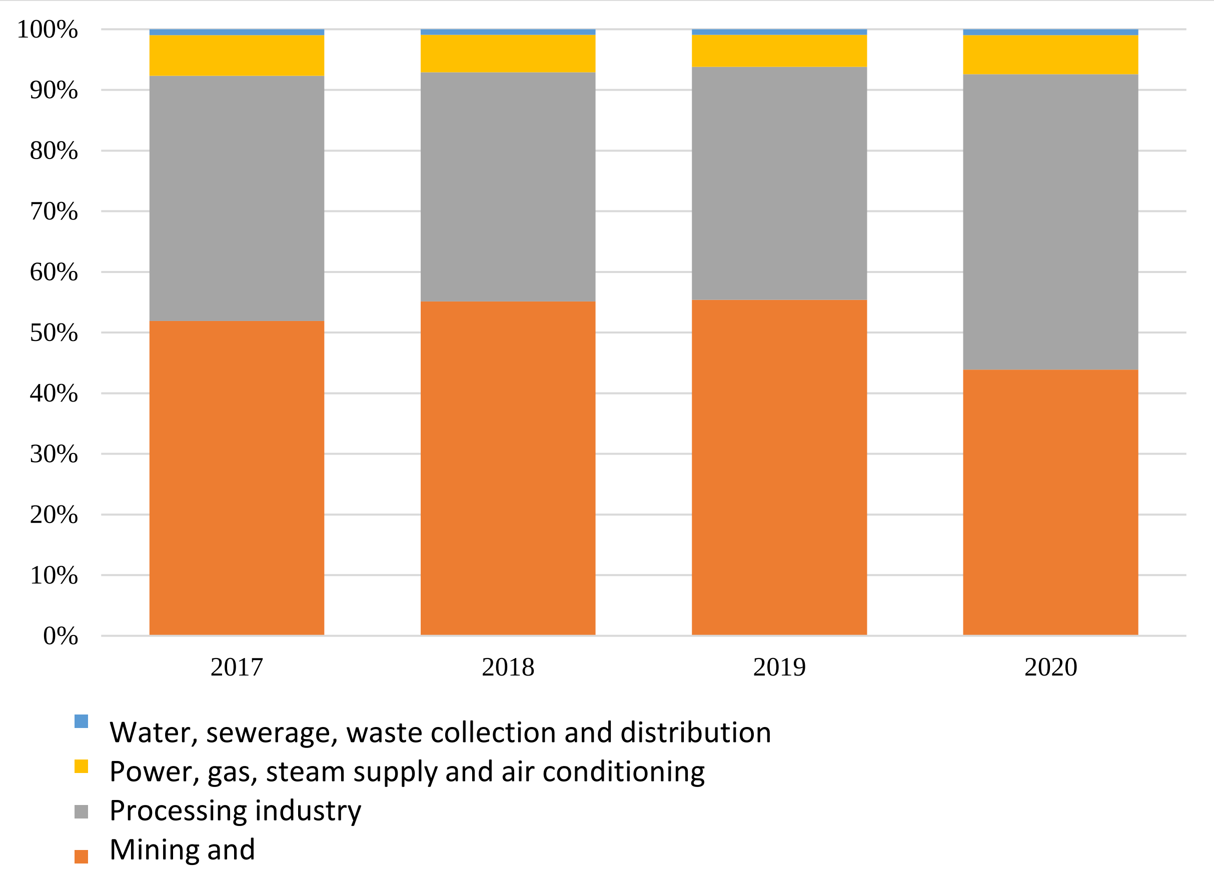
Source: Volume of industrial activity by type of economic activity from 2017 to 2020. Bureau of National Statistics

[92] Industrial output by type of economic activity in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.
[93] Production output (goods, services) in current prices by type of economic activity. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

The processing industry is strengthening its position by boosting output of food (1.3 times in 2017 compared to 2020), beverages (1.4 times), tobacco products (1.99 times), light industry (1.3 times), paper (1.45 times), coke and refined petroleum products (by 1.17 times), chemical industry products (by 1.4 times), plastic and rubber products (by 1.37 times), other non-metallic mineral products (by 1.49 times), mechanical engineering (by 1.98 times) and metallurgy (by 1.38 times).

Figure 2.37 *Structure of industrial sector, in percent*



Source: Key industry performance indicators from 2017 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Effects of changes in industry, trade, and production processes on GHG emissions

Reducing energy intensity in industry and, in particular, in the processing industry is a priority of industrial and innovative development of Kazakhstan.

Based on the estimates of GHG emissions from the industrial sector [94](Table 2.16), the emissions decreased from 2016 to 2020 (by 10,629.29 thousand tons of CO_2-eq, or 29%). However, the output of industrial production (Table 2.15) increased by 22% over the same period.

The reduction in GHG emissions in the 'Other' sector is due to the fact that 21 renewable energy facilities with capacity of 504.55 MW have been commissioned since early 2019.[95]

[94] Inventory of greenhouse gas emissions in Kazakhstan, 2019
[95] In 2019, 21 large RES facilities were commissioned in Kazakhstan: https://www.gov.kz/memleket/entities/energo/press/news/details/38575?lang=ru

Table 2.17. *Greenhouse gas emissions in the industry sector, thousand tons of CO2-eq*

Year	2016	2017	2018	2019	2020
Ferrous metallurgy	19,363.30	19,774.92	19,492.78	9,820.52	9,809.92
Non-ferrous metallurgy	7,677.29	7,550.60	7,565.92	7,682.07	7,744.31
Chemical	443.57	518.31	588.82	359.37	517.30
Paper	45.26	56.59	53.01	40.57	42.88
Food	734.03	719.02	737.21	824.20	720.98
Non-metallic minerals	2,971.53	3,420.86	3,293.18	3,242.45	3,282.66
Other	3,687.02	3,534.39	2,884.53	2,655.81	2,842.77
Total (industry)	34,921.99	35,574.69	34,615.44	24,624.98	24,960.81

Source: *Calculated based on the national inventory. Inventory of greenhouse gas emissions in Kazakhstan, 2022.*

2.9. Waste

Waste and wastewater management

In 2019, total of 3,674 thousand tons of municipal waste were collected in Kazakhstan, which is 7.6% higher than in 2017. Municipal waste includes waste from households, production, parks, streets, markets, construction sites and other sources.

Up to 89% of municipal waste is neither sorted for recycling nor reused. The rest is sent for sorting and further recycling and/or disposal.

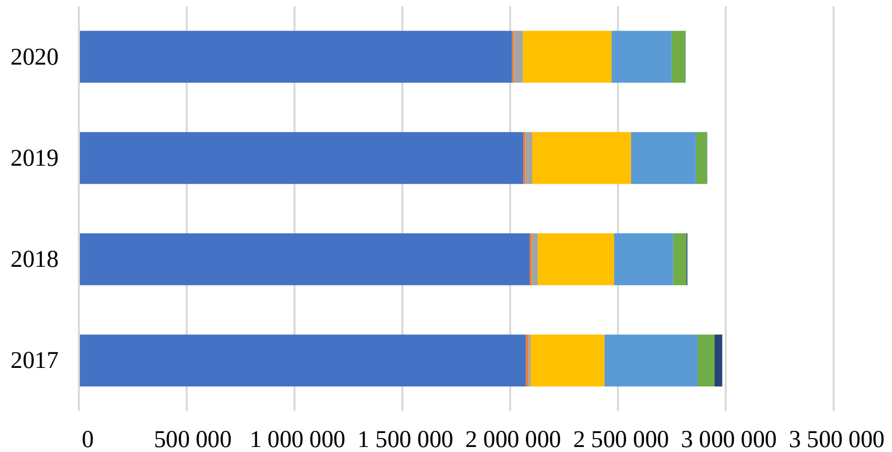
Table 2.18. *Intensity of waste generation and recycling rate*

		Units	2017	2018	2019
	Municipal waste				
1	Generation of municipal waste	tsd tons	3,415.0	3,692.0	3,674.0
2	Index of municipal waste generation	% 2010 = 100	90.2	97.6	97.1
3	Recycling and disposal of municipal waste	tsd tons	442.7	427.1	418.3
4	Share of recycling and disposal of municipal waste	%	13.0	11.6	11.4
5	Generation of municipal waste per capita	kg	189	202	198
6	Population of the country	people	18,037.775	18,276.452	18,513.673

Source: Green Economy Indicators of RK. Intensity of waste generation and recycling rate. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

During the period under review, the amount of waste per capita increased by 4.5%.

Figure 2.38 *Amount of waste collected, tons*



	2017	2018	2019	2020
Household waste	2 073 411	2 091 006	2 060 542	2 009 342
Park waste	10 476	10 170	10 048	8 595
Construction waste	10 470	28 273	32 507	41 473
Industry waste (equal to household)	342 786	352 685	457 992	411 450
Street litter	432 784	274 716	300 969	278 850
Market waste	77 760	60 062	50 867	61 324
Other waste	36 287	4 560	889	1 206

Source: 'On the collection, removal, sorting and depositing of municipal waste from 2017 to 2018'. 'On the management of municipal waste in the Republic of Kazakhstan for 2019 and 2020'. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Generation of municipal waste (Figure 2.38) has been apparently lowering from 2017 to 2020 in household waste (3% less) and street litter (35.6% less). Construction waste generation went up (by 74.8%).

Legal framework and objectives on MSW and municipal wastewater management

The fundamental document regulating legal issues of waste and wastewater management in Kazakhstan is the Environmental Code.96 The national environmental policy on waste management is based on the following special principles:

1) hierarchy;
2) proximity to the source;
3) waste generator responsibility;
4) extended producer (importer) responsibility.

This document regulates the complete waste cycle (general requirements, classification, certification, etc.), and establishes requirements for storage/deposition sites and landfills. In terms of wastewater regulation, this document determines the requirements for wastewater discharge and treatment.

According to Article 351 of the Environmental Code of the Republic of Kazakhstan, it is prohibited to accept the following waste for landfilling:

– any waste in liquid form (liquid waste);
– hazardous waste that is explosive, corrosive, oxidizable, highly flammable or

[96] Environmental Code of the Republic of Kazakhstan No. 400-VI ZRK dated January 2, 2021.

flammable in landfill conditions;

– waste reacting with water;
– medical waste;
– biological waste determined in accordance with the veterinary medicine legislation of the Republic of Kazakhstan;
– used tires as one piece and in fragments, except for the cases when they are used as a stabilizing material for reclamation;
– waste with persistent organic pollutants content;
– pesticides;
– waste that does not meet the acceptance criteria;
– waste of plastic material, plastic and polyethylene, polyethylene terephthalate packaging;
– recyclable paper, cardboard, and paper waste;
– mercury-containing lamps and appliances;
– glass containers;
– glass cullet;
– scrap of non-ferrous and ferrous metals;
– lithium, lead-acid batteries;
– electronic and electrical equipment;
– decommissioned vehicles;
– construction waste;
– food waste.

Space monitoring of waste disposal sites has been arranged in cooperation with NC Kazakhstan Garysh Sapary JSC. Interagency action plan has been developed together with interested public bodies to take systematic measures to eliminate and prevent fly dumping, conduct space monitoring of waste disposal sites and 'Taza Kazakhstan' (Clean Kazakhstan) raids, distribute memos and booklets to the population to develop environmental culture, and launch a hotline under MEGNR RK.[97]

MSW and municipal wastewater disposal

Modernization program for municipal solid waste (MSW) system was initiated in 2016. The main objectives of this initiative are as follows: to prevent the entry of electronic and electrical waste, including batteries, into landfills; to reduce volumes of MSW disposal; to improve the environmental situation; to provide recycled materials to producers of goods.

The key innovation was the introduction of the principle of extended producer responsibility (EPR). Within the framework of this program, the strategy of phased regulated inclusion of waste from the list of ‘not acceptable for landfills’ was chosen with the subsequent referral of the controlled waste types for further disposal/processing by a single operator. The first stage, which is currently being implemented, involves full processing/recycling for vehicles and their components (tires, tire casing, batteries, engine oil, etc.).[98]

In 2016, ERP was extended to include motor vehicles and automotive components (tires, batteries, oils, and special liquids). Since January 2017, ERP has been extended to include paper,

[97] Information on waste reduction, processing, and recycling: https://egov.kz/cms/ru/articles/ecology/waste_reduction_recycling_and_reuse
[98] The official website of the ERP system operator: www.recycle.kz

cardboard, metal, glass, plastic and combined packaging, packaged goods, electrical and electronic equipment (EEE) without charging a recycling fee.

On December 23, 2019, an order came into force providing for the extension of the ERP scope to agricultural machinery (tractors and combines).

On December 26, 2019, changes were made to the Methodology of fee calculation for organizing waste collection, transportation, processing, neutralization, use and (or) disposal to introduce the calculation of fees for packaging and products in packaging. These changes have been put into effect since January 17, 2020.

In 2021, the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan adopted an order providing for amendments to the Methodology of Fee Calculation, according to which fixed fee rates are introduced for cable and wire products. These changes came into force in 2021.[99]

Table 2.19. *Amount of waste delivered for sorting, disposal, and deposition*

Year	Number of enterprises, engaged in waste sorting. disposal and deposition	Total waste received, t	Of the total waste received, t				
			sorted	sent for recycling	disposed	accepted for deposition	waste from self-collecting enterprises
2017	207	3,224,821	182,345	5,258	442,727	2,596,558	431,001
2018	203	3,423,861	622,156	164,130	427,060	2,374,645	845,162
2019	214	3,860,881	1,041,094	142,401	248,142	667,091	760,211
2020	225	3,752,516	1,114,797	616,492	130,253	405,010	896,248

Source: On collection, removal, sorting and depositing of municipal waste from 2017 to 2018, On the management of municipal waste in the Republic of Kazakhstan for 2019 and 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

The measures taken have significantly contributed to reducing the volume of waste burial: the amount of buried waste decreased 6.4 times in 2020 compared to 2017. Improved legal network boosts the processing capacities and the number of organizations engaged in sorting, recycling, and disposal of waste.

Table 2.20. *Main indicators of sewerage treatment facilities performance, in thousand m3*

Year	Total wastewater throughput	Wastewater treated by full-scale biological treatment	Treated to standard quality	Insufficiently treated
2017	655,894.4	533,282.0	470,527.8	45,782.5
2018	668,642.0	532,920.9	472,599.7	43,549.6
2019	685,668.1	495,526.0	484,508.0	12,081.5
2020	682,889.2	501,153.9	449,055.5	11,801.7

Source: On the operation of water supply and sewerage facilities in the Republic of Kazakhstan for 2017-2018, On the operation of water supply and sanitation systems in the Republic of Kazakhstan for 2001-2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

The total volume of wastewater processed by treatment facilities increased by approximately 4% in 2017-2020. It should be noted that the share of insufficiently treated wastewater in 2020 decreased by 3.8 times compared to 2017.

[99] The official website of the ERP system operator: www.recycle.kz

Effects of changes in MSW and municipal wastewater management on GHG emissions

In the sector of solid waste and municipal wastewater management, the sources of greenhouse gas emissions are solid waste landfilling, wastewater discharge and treatment system. The total volume of emissions from this sector in 2020 amounted to 7,354.28 thousand tons in CO_2-eq, which is 16.9% higher than in 2016.

Table 2.21. *Greenhouse gas emissions in the MSW and municipal wastewater management sector, in thousand tons of CO2 equivalent*

Name	2016	2017	2018	2019	2020
Total	6,110.36	6,271.51	6,444.82	6,689.41	7,354.28
MSW burial	3,501.25	3,567.25	3,650.75	3,743.25	3,835.50
Waste incineration	7.87	7.27	7.50	7.31	30.92
Wastewater treatment and discharge	2,601.55	2,696.99	2,786.56	2,938.61	3,487.86

Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

Greenhouse gas emissions from MSW and wastewater increased by 4-6% (Measures to increase the share of MSW disposal, section 5.4. Waste Management Sector).

2.10. Housing stock and urban structure

Energy efficiency standards in construction

The law on energy conservation and improvement of energy-efficiency adopted in 2012[100] outlined a range of requirements for ensuring energy efficiency of buildings and structures. The requirements to be fulfilled by the developer include:

- indicators characterizing the specific value of the consumption of energy resources in a building or structure;
- requirements for architectural, space-planning, technological, structural, and engineering solutions;
- requirements for the engineering systems and technological equipment used;
- requirements for technologies and materials included in the design documentation and used in construction (reconstruction, renovation), which allow to exclude unsustainable (unreasonable) consumption of energy resources.

Projects for the construction of facilities that consume energy and water resources should include the use of energy-saving materials, installation of metering devices and automated systems for regulating heat consumption. The projects of multi-apartment residential buildings should also provide for the mandatory use of energy-saving materials, installation of communal metering devices for heat and water, individual metering devices for electricity, cold and hot water, control devices in heating systems, and automated heat control systems. The law precludes commissioning of new facilities that consume energy and water resources unless they are equipped with metering devices and automated systems for regulating heat consumption.

In 2015, the requirements for energy conservation and energy efficiency improvement applied to design (design and estimate) documentation of buildings, structures and facilities were approved.[101] According to these requirements, the design (design and estimate) documentation for

[100] Law of RK No. 541-IV dated January 13, 2012, ‘On Energy Conservation and Improvement of Energy-Efficiency’ (with amendments and supplements as of June 29, 2020).
[101] Order of the Minister for Investment and Development of the Republic of Kazakhstan No. 406 dated March 31, 2015, ‘On approval of requirements for energy conservation and energy-efficiency improvement for design (design and estimate) documentation of buildings, structures and facilities’.

the construction, renovation or reconstruction of buildings, structures, or facilities with energy consumption equivalent to 500 or more tons of conventional fuel per calendar year should contain a section on energy conservation and energy-efficiency improvement. This section should include: the general energy specification of the planned building, structure, or facility; energy performance certificate; energy efficiency class; information about design solutions aimed at energy conservation and energy-efficiency improvement; information about the compliance of design solutions with the requirements of building codes, as well as their technical and economic indicators in terms of energy consumption.

When awarding or revising the energy efficiency class of a building, structure or facility, the following classes are assigned: for new and reconstructed buildings – from A++ (very high) to C- (normal), for existing ones – D (reduced) and E (low).[102]

In addition, the owner of an existing building, structure or facility, when intending to determine its energy efficiency class, applies to an energy audit organization to conduct an energy audit in accordance with Order of the Minister for Investment and Development of the Republic of Kazakhstan No. 400 dated March 31, 2015, ‘On approval of the Rules for energy audit’. Based on the energy audit results, an opinion is issued stating the energy efficiency class of the buildings, structures, or facilities.

According to the Law of the Republic of Kazakhstan ‘On energy conservation and energy-efficiency improvement’ and Order of the Minister for Investment and Development of the Republic of Kazakhstan No. 264 dated December 12, 2014, ‘On approval of the evaluation mechanism for the activities of local executive bodies on energy conservation and energy-efficiency improvement,’ the Ministry has been annually evaluating the activities of local executive bodies (hereinafter referred to as LEB) on the matters of energy conservation and energy-efficiency improvement.

According to paragraph 4 of the Mechanism, the LEBs of oblasts, cities of republican status and the capital shall annually, no later than January 30 of the year following the reporting year, submit to the authorized body (the Committee for Industrial Development of the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan) a report on activities on energy conservation and energy efficiency recorded on electronic media. This report includes the following items:

- performance on the target indicators of a comprehensive plan;
- monitoring of compliance with energy consumption standards of SE;
- conducted energy audits of SE;
- completed thermal modernization of SE;
- installed energy metering devices;
- automated systems;
- park and street lighting upgrades;
- disposal of mercury-containing lamps.

Reports on LEB's activities related to energy conservation and energy-efficiency improvement for 2019 were timely received from the akimats of five regions: Akmola, Kostanay, Aktobe, Karaganda oblasts and the city of Shymkent.

[102] Order of the Minister for Investment and Development of RK No. 399 dated March 31, 2015, ‘On approval of the Rules for assignment and revision of energy efficiency classes for buildings, structures, and facilities’ (as amended on December 28, 2017)

Akimats of North Kazakhstan, Pavlodar, East Kazakhstan, Kyzylorda, Mangystau, Zhambyl, West Kazakhstan, Turkestan oblasts and Astana city sent reports beyond deadlines. Akimats of Atyrau oblast and Almaty city did not provide the above information.

The Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan conducted an appropriate analysis based on the submitted LEB reports. The analysis has indicated the high score earned by the akimat of Pavlodar oblast (35 points out of 40). Almaty oblast akimat has scored medium (32 points out of 40), as well as the cities of Astana and Shymkent (25 points out of 40). The rest of the regions have scored low (less than 24 points).[103]

Housing stock

The country's housing stock continued to grow and increased to 373.3 million square meters in 2020. Housing supply per capita in 2019 grew up to 21.9 square meters (21.6 square meters in 2018); this figure is to go up to 26 square meters by the end of 2025 as part of the implementation of 'Nurly Zher' program.104

Table 2.22. *Housing stock statistics, total area; taken at the end of the year, in million square meters*

	2016	2017	2018	2019	2020
Total housing stock including:	342.6	347.4	356.4	364.3	373.3
Private	334.5	334.5	334.5	334.5	334.5
Public	8.1	8.1	8.1	8.1	8.1
Total urban housing stock including:	216.1	216.1	216.1	216.1	216.1
Private	209.4	209.4	209.4	209.4	209.4
Public	6.7	6.7	6.7	6.7	6.7
Total rural housing stock including:	125.1	125.1	125.1	125.1	125.1
Private	126.8	126.8	126.8	126.8	126.8
Public	1.4	1.4	1.4	1.4	1.4

Source: Statistical Yearbook, 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Now, the state continues actions to promote the real estate market in Kazakhstan. The industry's growth driver is the state program 'Nurly Zher' (since 2018) designed to improve access to housing for the population and incentivize housing construction by private developers.

In 2014, the Regional Development Program until 2020 was approved.[105] The purpose of this program is to enable the development of the regions' socio-economic potential via rational territorial organization of the country, incentives for the concentration of population and capital at the centers of economic growth.

Table 2.23. *Total area of commissioned residential buildings, thousand square meters*

	2017	2018	2019	2020
Total area of commissioned residential buildings	11,168	12,521	13,126	15,332

Source: Total area of commissioned residential buildings. Bureau of National Statistics of the Agency for Strategic

[103] Evaluation of LEB performance on energy conservation and energy-efficiency improvement for 2019: https://www.gov.kz/memleket/entities/comprom/documents/details/55513 ?lang=ru

[104] Resolution of the Government of the Republic of Kazakhstan, the State program of Housing and Utilities Development 'Nurly Zher' for 2020-2025.

[105] Resolution of the Government of the Republic of Kazakhstan No. 728 dated June 28, 2014, 'On approval of the Regional Development Program until 2020.'

We should note positive dynamics in almost all areas of housing stock utilities (water supply, sewerage, central heating, electrification, etc.) except for gas supply (Table 2.24).

Table 2.24. *Improvement of housing stock amenities, %*

Year	2017	2018	2019	2020
Water supply	98.4	98.3	98.2	98.2
Sewerage	65.4	69.7	70.4	71.4
Central heating	40.6	41.1	41.5	42.1
Gas	87.7	87.7	87.3	87.0
Central hot water supply	35.9	36.1	36.2	36.6

Source: Statistical Yearbook, 2020 Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Central heating is predominantly provided by coal-fired thermal power plants. Over a four-year period, the share of central heating increased slightly, from 35.9% to 36.6%.

The Action Plan for the Implementation of the Concept for the Transition of the Republic of Kazakhstan to Green Economy for 2013-2020 stipulates conversion of existing coal-fired power plants and thermal power plants in the cities of Astana and Almaty and other cities with population of more than 300 thousand people.[106] On November 4, 2014, the Government approved the General Scheme of Gasification of the Republic of Kazakhstan for 2015-2030.[107] This policy document defines economically sound strategic directions for ensuring reliable gas supply to consumers in the country.

According to the General Scheme, gasification of domestic consumers of the country is carried out at the expense of public funds and investment programs of the group of companies of the National Operator for gas and gas supply of the Republic of Kazakhstan KazTransGas JSC.

The extent of household gasification increased from 30% in 2013 to 53.07% in 2020 to cover more than 9.5 million citizens. The number of domestic enterprises supplied with gas has doubled: from 23,725 to 51,285.[108] Thus, Kazakhstan has been reducing ambient air pollution in cities and combining gas trunk lines into a single gas transportation system.

In 2019, the first stage of the project was the construction of the ‘Sary-Arka’ main gas pipeline. The gas pipeline will connect the cities of Kyzylorda and Astana. Thanks to this project, 171 settlements in Karaganda and Akmola oblasts will have access to natural gas.

The first stage of the ‘Sary-Arka’ gas pipeline starting from the Kyzylorda region made it possible to provide the capital, the central and part of the northern regions of the country with an environmentally friendly fuel, which is one of the historically significant events for the republic since independence. Thus, as of January 1, 2021, the extent of gas supply for the country's population reached 53.07%, or 9.8 million people who have access to natural gas.[109]

[106] Resolution of the Government of the Republic of Kazakhstan No. 750 dated July 31, 2013, ‘On approval of the action plan for the implementation of the concept for the transition of the republic of Kazakhstan to green economy for 2013-2020’.
[107] Resolution of the Government of the Republic of Kazakhstan No. 1171 dated November 4, 2014, 'On the general scheme of gasification of the republic of Kazakhstan for 2015-2030’.
[108] Annual report of KazTransGas JSC for 2020: https://kase.kz/files/emitters/KZTG/kztgp_2020_rus.pdf
[109]Data of the Ministry of Energy of the Republic of Kazakhstan: https://www.gov.kz/memleket/entities/energo/press/article/details/47386?lang=ru

Effects of changes in construction on GHG emissions

Greenhouse gas emissions in the construction (housing and utilities) sector are directly associated with electricity and heat consumption (Table 2.24). For the period from 2016 to 2020, emissions from household consumption increased by 1.66 times (or by 13,076.91 thousand tons of CO_2-eq), emissions from public electricity and heat generation increased by 1.2 times (or by 16,503.17 thousand tons of CO_2 - eq).[110]

Table 2.25. *Greenhouse gas emissions in the housing and utilities sector, thousand tons of CO_2-eq*

Year	Public generation of electricity and heat	Housing sector
2016	93,368.79	19,849.80
2017	102,296.86	23,198.51
2018	109,111.27	24,422.23
2019	109,871.96	32,926.71
2020	110,429.08	25,031.10

Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

Greenhouse gas emissions (and hence fuel consumption) have increased in the residential sector, which may be due to the growth of the urban individual housing neighborhoods that burn coal and gas for household needs.

2.11. Agriculture

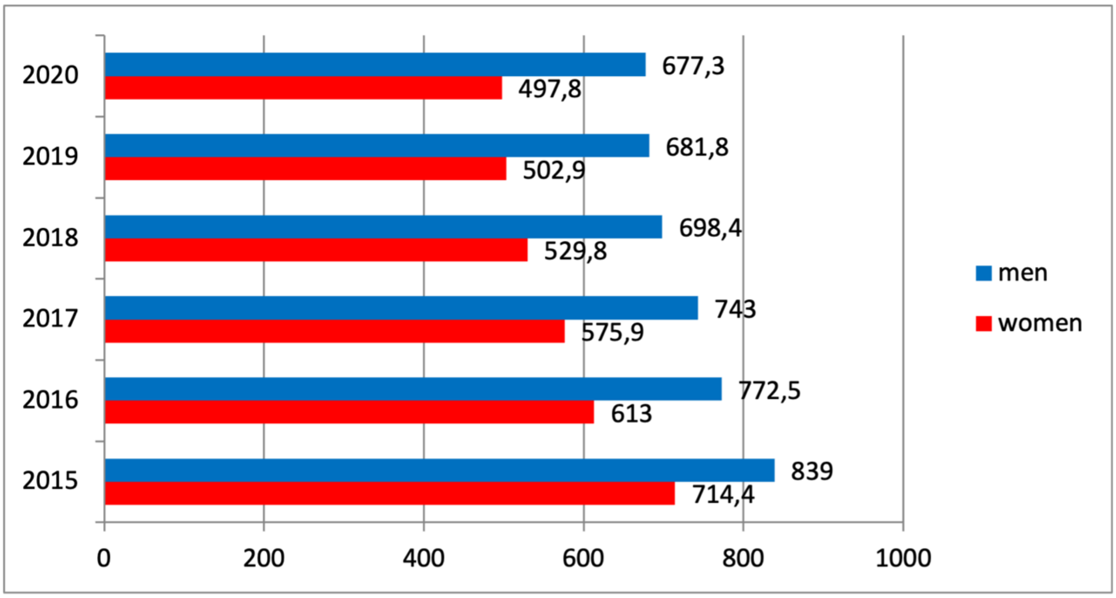
In 2020, 27.7% of the population employed in the economy of Kazakhstan (139.4 thousand out of 503.8 thousand people) worked in agriculture, forestry, and fisheries of Kazakhstan.[111] Meanwhile, agricultural production (including forestry and fisheries) occupies only 5.4% of the GDP structure. This growth is mainly due to an increase in crop production by 7.8%.[112]

The numbers of men and women employed in agriculture, forestry and fisheries are close in value.

We should note the steady trend for greater employment of men than women. Men employment has been increasing since 2015. If in 2015 the ratio of women to men was 46-54%, then the ratio went 42.4-57.6%, respectively, in 2019-2020 (Fig.2.39 below).

[110] Inventory of greenhouse gas emissions in Kazakhstan, 2019
[111] Employed population by type of economic activity and region, 2017–2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.
[112] GDP structure by method of production. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

Figure 2.39. *Ratio of men and women employed in agriculture, forestry, and fisheries.*

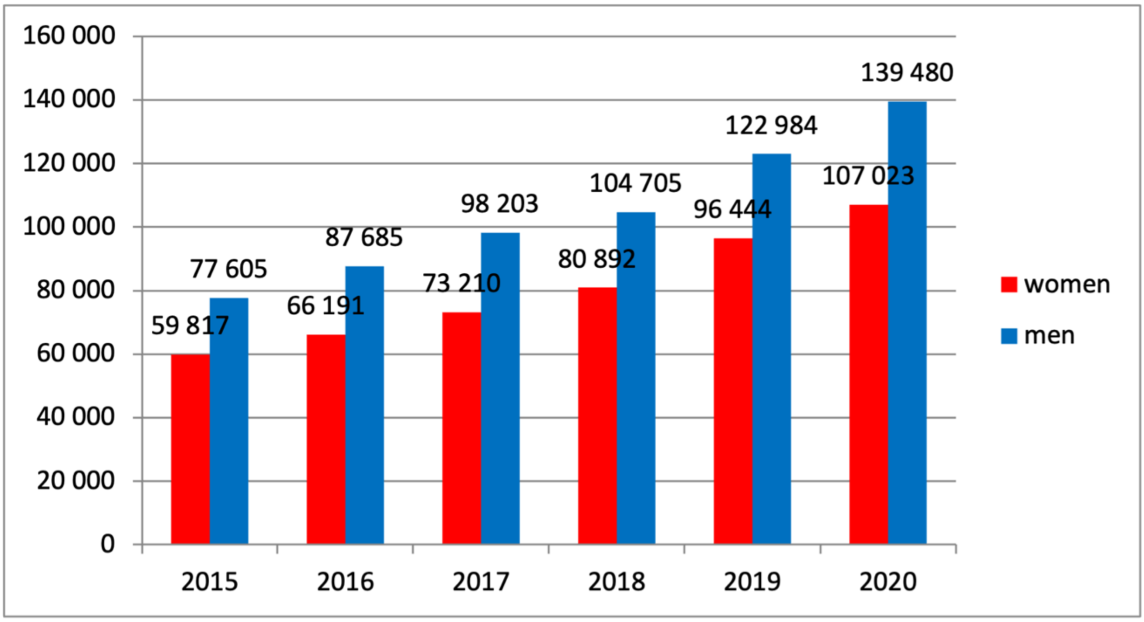


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The average monthly nominal wages of women in agriculture, forestry and fisheries are lower than that of men. The ratio of women's wages to men's wages in 2020 was 76.7% and the gap made 23.3%.

It should also be noted that the average monthly nominal salary in the agricultural sector is lower than in other sectors of the economy.

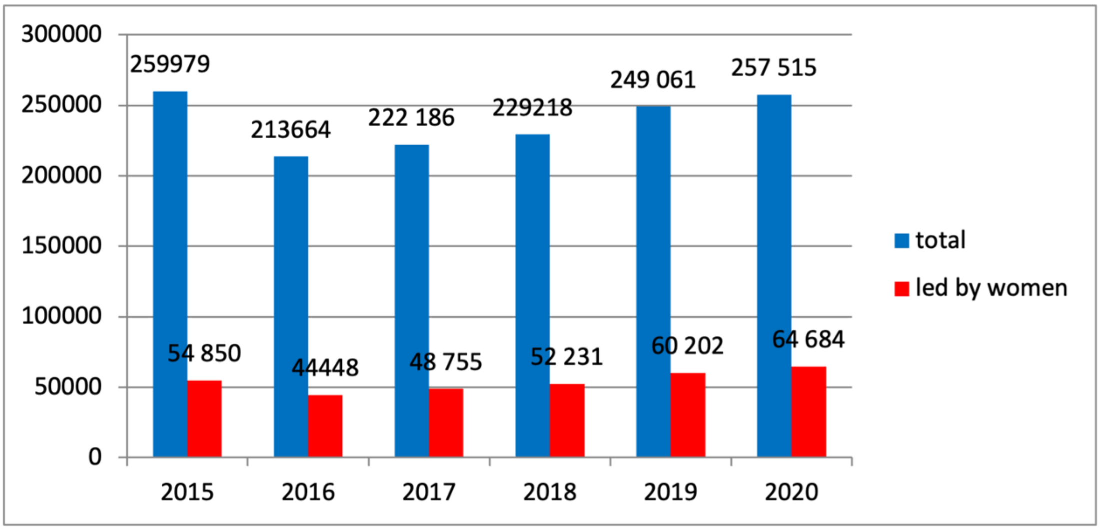
Figure 2.40 *Average monthly nominal wages in the agricultural sector*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The number of active SMEs in agriculture, forestry and fisheries managed by women is lower than that of men. In 2015-2020, the average ratio of the number of enterprises headed by men and women is 77.3% and 22.7%, respectively (Figure 2.41 below).

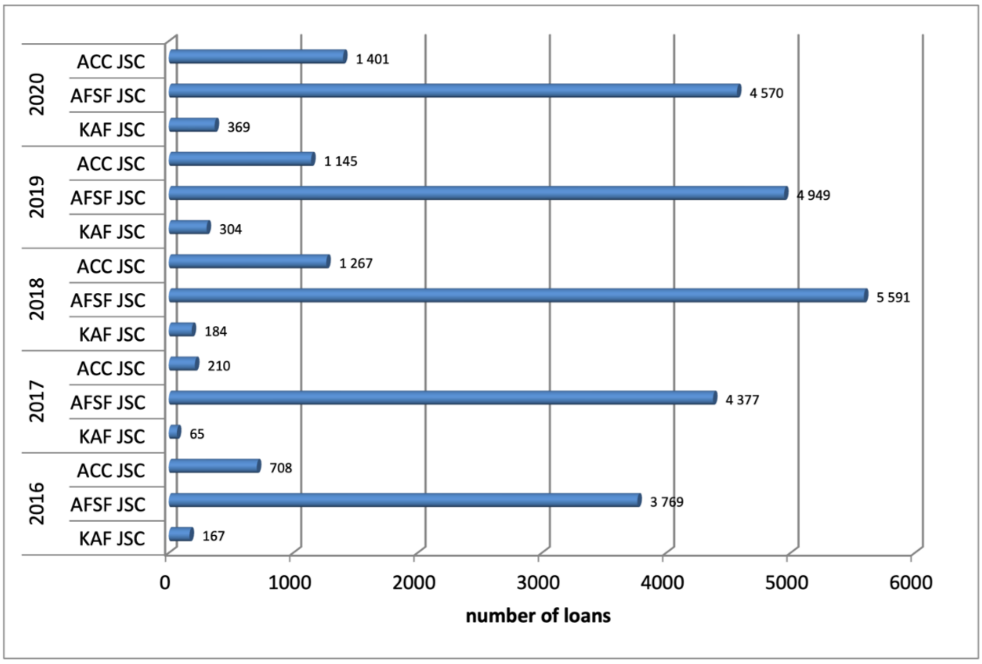
Figure 2.41 *Active of SMEs in agriculture, forestry, and fisheries*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The number of loans issued to women in the framework of support by subsidiaries of the National Management Holdings KazAgro and Baiterek – KazAgroFinance JSC, Fund for Financial Support of Agriculture JSC and Agrarian Credit Corporation JSC – amounted to 6 340 in in 2020 (Fig. 52). The largest number of loans were issued in 2018, while a downward trend has been observed in the number of loans issued in recent two years.

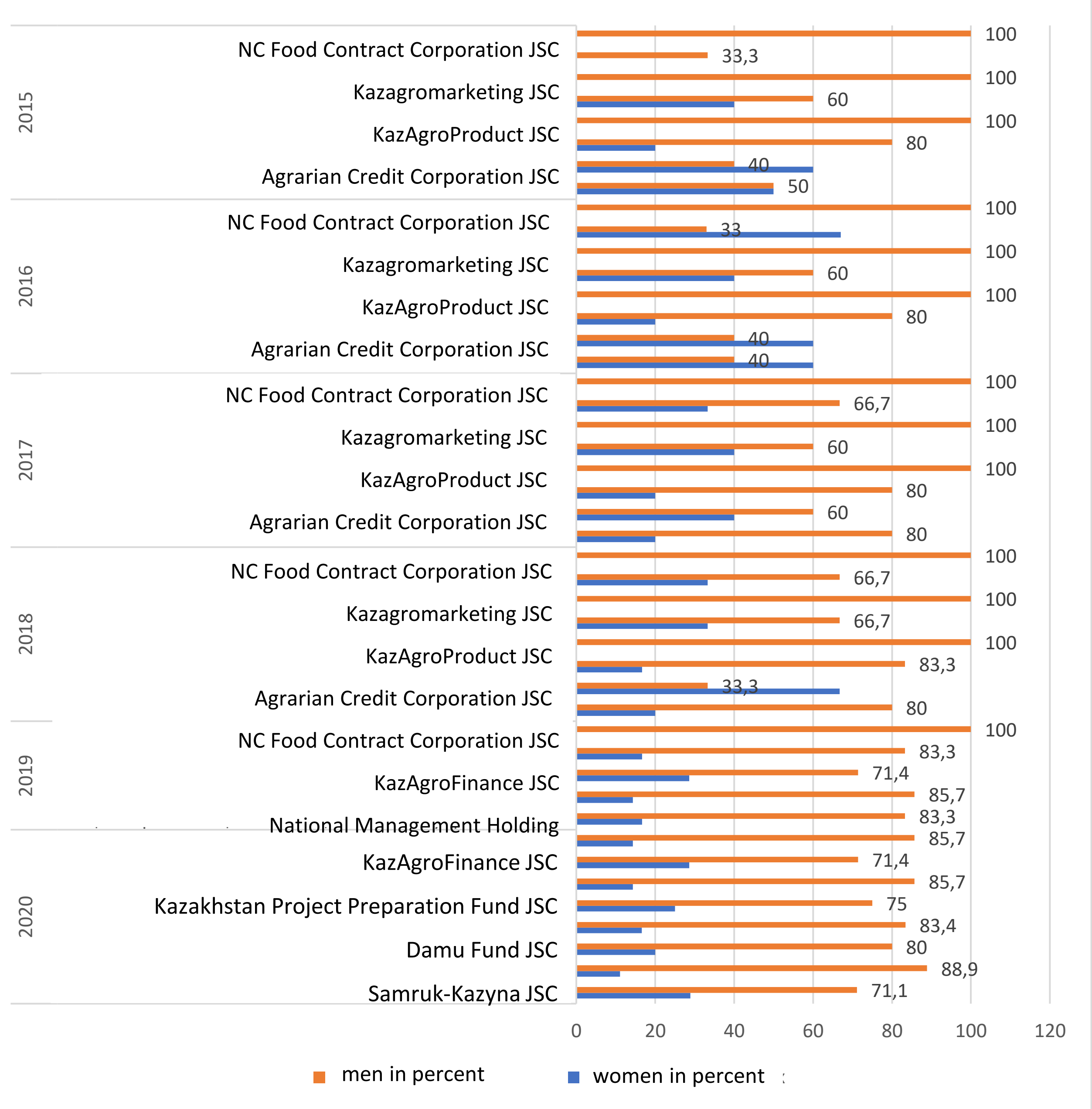
Figure 2.42. *Loans issued to women in the framework of support by subsidiaries of the National Management Holdings KazAgro and Baiterek in 2016-2020.*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

Analysis of the gender distribution among the executives of national management holdings and national companies in the agricultural sector demonstrates prevalence of men among managers. There are no female executives at NC Food Contract Corporation JSC and Kazagromarketing JSC. In Kazagrofinance JSC, the number of women decreased to 28.6%, while in Agrarian Credit Corporation JSC it went down to 14.3%.

Figure 2.43. *Ratio of male and female executives of national management holdings and national companies of National Management Holdings KazAgro and Baiterek.*

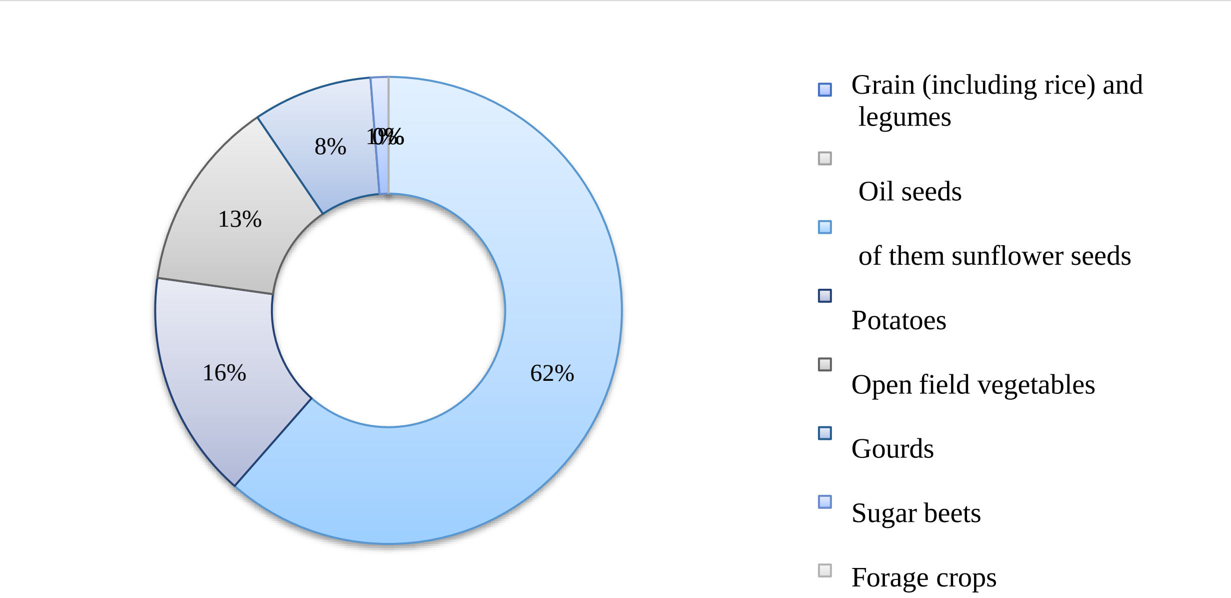


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests*

The total area of cultivated areas (Figure 2.44) is 22.58 million hectares.[113]

Investments in capital assets in agriculture increased by 13.4% in 2020 and amounted to KZT565.4 billion, food production investments went up by 19.1% and amounted to KZT109 billion. This growth in the industry was achieved mainly due to the well-coordinated work of farmers and the timely governmental adoption of the Work Algorithm for conducting sowing operations with the account of the COVID-19 pandemic situation, which included ensuring unhindered movement of agricultural producers, delivery of fuel, spare parts, seeds, fertilizers, and plant protection products. As a result, the sowing campaign was carried with high quality and within optimal agricultural timeframe.[114]

Figure 2.44 *Updated cultivated area under key agricultural crops for 2020, thousand hectares*



Source: Updated cultivated area under key agricultural crops for 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

In 2017, the State Program for the Development of Productive Employment and Mass Entrepreneurship for 2017-2021 'Enbek' was adopted, within the framework of which agricultural lending is performed via Fund for Financial Support of Agriculture JSC.

In 2020, lending to agriculture increased by more than 1.5 times and amounted to KZT138 billion compared to 2019. While banks boosted agriculture financing in 2020, the KazAgro Holding Group slightly reduced the amounts of lending to agricultural producers by 0.7%, from KZT449 billion to KZT446 billion. Thus, in 2020, the volume of lending through KazAgro subsidiaries amounted to KZT446 billion, which was 0.7% less than in 2019 (KZT449 billion in 2019, KZT385 billion in 2018, KZT246 billion in 2017), or 3.2 times more than the volume of lending from second-tier banks. It should be noted here that crop production occupies the largest share in the lending structure of KazAgro Holding Group – 52%, animal husbandry is 34%, processing – 8% and others - 6%. The share of the Fund for Financial Support of Agriculture in the total volume of financing of the agro-industrial complex from KazAgro Holding in 2020

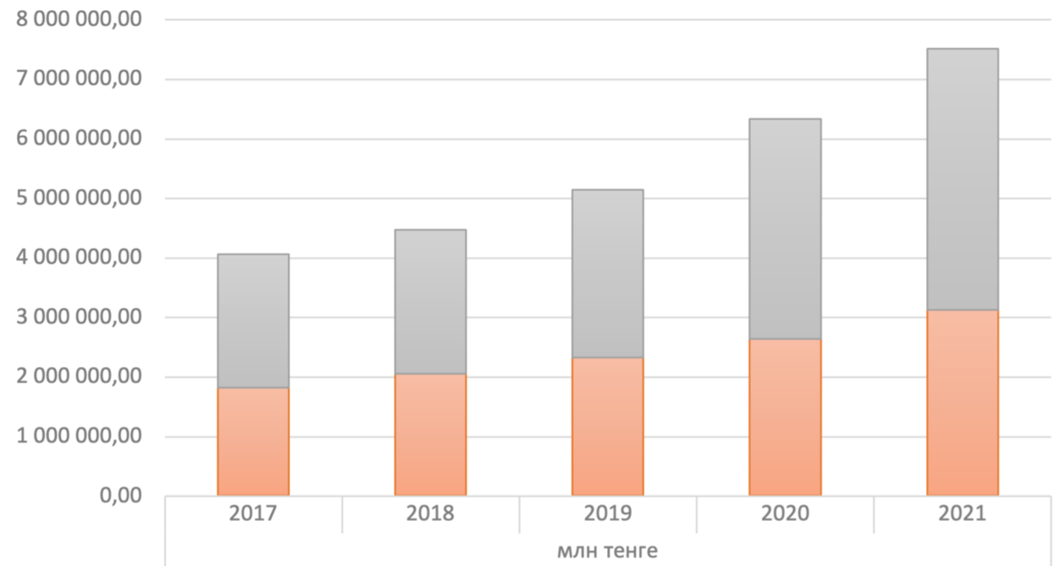
[113] Updated cultivated area under key agricultural crops in 2020 in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

[114] Report of S. K. Omarov, Minister of Agriculture at the Government Meeting 'On the results of socio-economic development of the Republic of Kazakhstan for January-December 2020':
https://www.gov.kz/memleket/entities/moa/press/article/details/34455 ?directionId=168&lang=ru

amounted to 14.1% (KZT63.1 billion out of total KZT446.0 billion), which is slightly lower than 2019 – by 1.2% (in 2019, the volume of financing from the Fund was KZT68.5 billion out of total KZT448.6 billion, or 15.3%).

By the end of 2020, 391 guarantees were issued within the framework of the Enbek Program for a total amount of KZT1.2 billion. In addition, the Fund has addressed the issue of guaranteeing loans for agro-industrial complex by second-tier banks in 2020. By the end of 2020, one guarantee in the amount of KZT0.65 billion was issued under the new mechanism.[115]

Figure 2.45 *Gross product (services) output in agriculture, million KZT*



	2017	2018	2019	2020	2021
Crops gross output	2 249 166,90	2 411 486,70	2 817 660,60	3 687 310,30	4 387 236,50
Livestock gross output	1 810 914,10	2 050 455,80	2 319 496,70	2 637 460,70	3 116 973,50
Agricultural services	10 835,80	12 145,60	14 005,70	9 897,90	11 223,40

Source: Gross output of agricultural products (services) in 2017-2020, Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

The sector shows positive dynamics (Figure 2.45). The gross output of crop production increased by 39%, animal husbandry grew by 31%, while agricultural services have shown a decrease of 8.7%.

[115] Annual report of the Fund for Financial Support of Agriculture for 2020, https://fagri.kz/upload/iblock/6f4/6f4cb63a499b754d5fc5ff64f0d50aae.pdf

Table 2.26. *Dynamics of number of livestock /poultry and area of cultivated lands in Kazakhstan*

	2017	2018	2019	2020
Thousand animals				
Cattle	6,745.4	7,137.9	7,437.6	7,848.5
Pigs	819	802.7	822.2	819.9
Sheep	16,018.8	16,399.8	16,858.2	17,736.3
Goats	2,281.8	2,278.6	2,233.7	2,305.6
Horses	2,395	2,623.7	2,825.9	3,118.3
Poultry	40,102.1	44,452.9	45,197.1	43,160
Thousand hectares				
Grains (including rice) and legume crops	15,405.4	15,150.0	15,396.6	15,878.4
Oil crops	2,478.9	2,834.2	2,861.1	2,905.1
Potatoes	183.4	193.0	193	194.4
Open field vegetables	142.9	152.3	159.1	163.6
Gourds	93.8	96.1	102.1	101.9
Sugar beets	17.4	17.4	15.2	15.2
Forage crops	3,382.3	3,323.2	3,277.2	3,197.5

Source: The key indicators of livestock development from 2017 to 2020; Updated cultivated under key crops in 2017-2020 in the Republic of Kazakhstan. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

Cattle, sheep, and poultry breeding mostly represent livestock breeding. In plant growing, grain and legume crops, as well as forage crops and oil-bearing crops occupy the biggest share of cultivated lands (Table 2.26).[116]

Compared to 2017, in 2020, the number of livestock increased across all types including cattle – by 14%, sheep – by 9.7%, horses – by 23%, and poultry – by 7%. Population of pigs and goats increased slightly– by 0.1% and 0.8%, respectively.

The area occupied by forage crops decreased significantly by 21.6% over the same period, while the acreage of grains and legumes decreased by 3%.

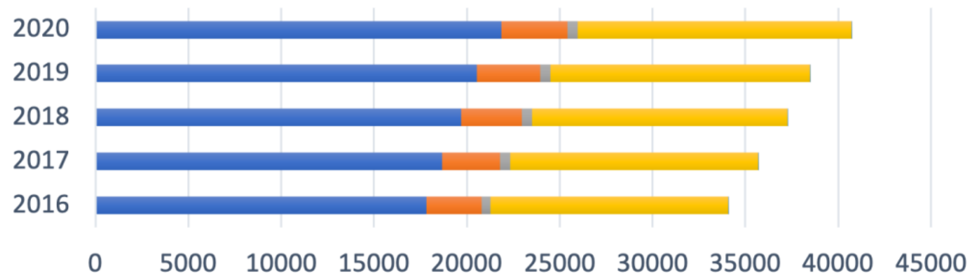
In 2015, Kazakhstan adopted the law 'On production of organic products,'[117] in 2016 – the Rules for production and distribution of organic products.[118] The Law identifies four principles in organic farming: 1) assistance in developing healthy nutrition; 2) limitation of finite natural resources use; 3) ensuring environmental safety and preservation of ecosystems; 4) preservation and recovery of soil fertility. The rules have also introduced the concepts of organic farming and organic livestock breeding.

Effects of changes in agriculture on GHG emissions

Kazakhstan's agriculture is a source of methane and nitrous oxide emissions.[119] Methane emissions come from intestinal fermentation, and nitrous oxide comes from agricultural soils (Figure 2.12). These two sources account for a total of about 89%, or 33,122 thousand tons of CO_2-eq of all greenhouse gases emitted by the sector.

[116] Statistics of agriculture, forestry, hunting and fishing, the key indicators of livestock development in the Republic of Kazakhstan from 2017 to 2020. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.
[117] Law 'On production of organic products in RK' No. 423-V SAM dated November 27, 2015.
[118] 'On approval of the Rules for production and distribution of organic products' No. 230 dated May 23, 2016.
[119] Inventory of greenhouse gas emissions in Kazakhstan, 2019

Figure 2.47 *Greenhouse gas emissions from agriculture, thousand tons of CO2-eq*



	2016	2017	2018	2019	2020
Internal fermentation	17808	18652,5	19683,25	20546,25	21853,5
Manure management	2986,42	3122,41	3292,39	3418,36	3573,86
Rice growing	495	548,75	532,75	546	537
Cultivated land	12784,2	13368,28	13773,56	13985,14	14756,96
Calurea application	0,59	1,97	2,54	3,11	3,67

Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

The amount of greenhouse gas emissions from the agricultural sector increased by about 10% from 2016 to 2020 (or 3,733 tons of CO2-eq), mainly due to an increase in methane emissions. At the same time, gross output in animal husbandry increased by 31% (Figure 2.11). Thus, methane emissions will increase with the further planned increase in livestock production.120 Measures aimed at the transition to the production of organic products are currently localized.

Impact of climate change on agriculture

Adverse changes in natural and climatic conditions and instability of weather conditions are designated as threats to the development of the agro-industrial complex of Kazakhstan.[121]

In January 2020, the Law 'On compulsory insurance in crop production' ceased to be in effect, with further transition from the compulsory form of insurance to voluntary insurance of risks in crop and livestock production.

The new insurance system also provides for specific measures of state support for agricultural entities. For example, the Ministry of Agriculture introduced subsidies for the purchase of insurance policies instead of the mechanism of subsidizing insurance payments. This will reduce farmers' expenses and make the processes of insurance and receiving insurance payments transparent.[122]

The Strategic plan of the Ministry of Agriculture of RK for 2017-2021[123] and the State program for AIC RK Development provide for several measures that contribute to adaptation to climate change:

- production of organic agricultural products;
- application of phosphorus fertilizers and biostimulants to accelerate crop ripening;

[120]State program of AIC RK development for 2017-2021.
[121] State program of AIC RK development for 2017-2021.
[122]The Ministry of Agriculture has radically changed the insurance system for farmers: https://www.gov.kz/memleket/entities/moa/press/news/details/38875?lang=ru
[123] Approved by Order No. 541 of the Deputy Prime Minister of RK, the Minister of Agriculture of RK, dated December 30, 2016.

- subsidizing the purchase of herbicides by agricultural producers by reducing their cost to prevent weeds spreading due to heavy rainfall in May and June;
- cultivation of at least 2-3 varieties with different maturation periods per farm to mitigate the risk of adverse effects of weather and climatic conditions;
- introduction of water-saving technologies and promotion of water conservation using tariffs;
- state support of compulsory insurance in crop production against adverse natural events;
- providing a 50% guarantee of insurance payments to insurance companies that have fulfilled their obligations under insurance claims to agricultural producers;
- increase in forest cover of catchment areas;
- implementation of environmental flow augmentations.

According to the Report on the Implementation of the Strategic Plan of the Ministry of Agriculture of the Republic of Kazakhstan for 2017-2021, provision of state support for compulsory insurance in crop production continued in 2019. Thus, 4622 contracts were concluded by insurance companies and mutual insurance companies, under which 5.9 million hectares of agricultural crops were insured. In 2019, 105 applications were submitted for partial reimbursement of insurance payments from insurance companies and mutual insurance companies. The amount of partial reimbursement for the insurance payments amounted to KZT83.2 million. To accelerate crops ripening, 75.3 thousand tons of phosphorus fertilizers were applied. To boost the yield and quality of agricultural crops, 14.1 million liters of herbicides were used to control weeds in 2019. LEBs allocated KZT27.4 billion from their budgets.

One of the drivers of sustainable harvests is farms' compliance with the recommended set of varieties by maturity group. Akmola, Kostanay and North Kazakhstan oblasts are most exposed to these risks when growing spring wheat. According to the oblast departments of agriculture, the share of early-ripe and medium-early wheat varieties in the republic was 40.4%, mid-season-ripening – 41%, medium-late – 13.9%. In general, the ratio of wheat varieties of different maturity groups in the regions is maintained (according to scientifically based standards, the percentage of medium-late varieties should not exceed 20-30%).[124]

2.12. Forestry

The land composition of the forest fund includes land plots covered with forest, as well as those uncovered with forest but allocated for the needs of forestry. According to the land balance, the total land area of the forest fund amounted to 22.4 million hectares, or 8.3% of the used land fund of the republic as of November 1, 2019.

The major areas of the forest fund lands are located in Kyzylorda (6,510.3 thousand hectares), Zhambyl (4,429.0 thousand hectares), Almaty (3,695.8 thousand hectares), Turkestan (3,010.3 thousand hectares) and East Kazakhstan (2,153.9 thousand hectares) oblasts, while the areas of forest and tree and shrub plantations included in the forest fund are in Kyzylorda (5,143.6 thousand hectares), Almaty (2,133.8 thousand hectares), Zhambyl (2,239.2 thousand hectares) and East Kazakhstan (1,449.7 thousand hectares) oblasts.

The forest fund lands of North Kazakhstan (88.6%) and Pavlodar (86.4%) oblasts are the richest in forest cover, while Turkestan oblast (16.7%) is the poorest. The forest cover of the forest

[124]Report on the implementation of the Strategic plan of the Ministry of Agriculture of the Republic of Kazakhstan for 2017-2021 in 2019, approved by Order No. 541 of the Minister of Agriculture of the Republic of Kazakhstan dated December 30, 2016.

fund in Kyzylorda oblast is listed as quite expansive in the accounting data (79.0%), however, it is characterized by extreme sparsity of saxaul forests.[125]

According to the [126] Committee for Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, reafforestation increased in 2019. Thus, 63.9 thousand hectares of forest were actually planted while the planned planted area was 59.8 thousand hectares. At the end of the year, reforestation measures have been accomplished in full.

In addition, a decrease in the area of forest fires was recorded in the State Forest Fund from 162.6 thousand hectares (2018) to 73.5 thousand hectares in 2019. Despite the positive indicators, major fires occurred in forest institutions of Zhambyl and Kostanay oblasts, which indicates poor preparedness of state institutions for the fire season. There are several areas in the country's forestry that require special attention. These are prevention and control of forest fires, forest pests, and control over the assignment of forest protection measures.

Table 2.27. *Key forestry indicators in Kazakhstan*

Name	2017	2018	2019	2020
Forest fund area, mln ha	29.8	30.1	29.1	30.0
Forested areas, mln ha	12.9	12.9	12.9	13.1
Total standing timber, mln m^3	421.9	435.74	441.94	456.81
Forested area, m^2 per capita	7,152	7,058	7,076	7,070
Forest cover, % of the total country area	4.7	4.7	4.8	4.9

Source: State accounting of the forest fund and distribution of the forest fund by categories of the state forest fund and land.

In July 2021, Landscape Recovery Project was launched in Kazakhstan.[127] The Project addresses the issues of forestry development, works with farmers and local communities on reclaiming degraded lands through afforestation.

The Project activities are as follows:

– mapping of the state forest fund lands on the dry bottom of the Aral Sea in Kyzylorda oblast on an area of 300 thousand hectares;
– design and survey work for afforestation on the state forest fund lands on the dry bottom of the Aral Sea in Kyzylorda oblast on an area of 50 thousand hectares;
– inventory of unaccounted forests (including satellite imagery and forest management) in Kyzylorda and Turkestan oblasts on an area of 100 thousand hectares;
– establishment of a forest nursery at the Kazalinsky forestry institution of Kyzylorda oblast with an area of 33 hectares and annual productivity of 4 million saxaul seedlings;
– creation of a green zone around the city of Kyzylorda on an area of 3 thousand hectares;

[125]Summary analytical report on the state and use of the lands of the Republic of Kazakhstan for 2019. Ministry of Agriculture of the Republic of Kazakhstan: http://cawater-info.net/bk/land_law/files/kz-land2019.pdf

[126]Results of the extended session on the results of activities for 2019. Committee for Forestry and Wildlife of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan: https://www.gov.kz/memleket/entities/forest/press/news/details/227812 ?lang=ru

[127] Landscape Recovery Project of the Republic of Kazakhstan. Fundamentals of Socio-Environmental Management (SEM): https://www.gov.kz/uploads/2020/11/24/d9f354a2f119c093c3a664d9e8f6e700_original.2422576.pdf , https://www.gov.kz/memleket/entities/forest/press/news/details/227812?lang=ru

– establishment of a genetic bank of forest seeds at the premises of Republican Forest Selection and Seed Center RSE in Shchuchinsk;

– acquisition of forestry machinery and equipment for the Koskuduk forest institution of Zhambyl oblast and Kazalinsky forest institution of Kyzylorda oblast.

The implementation of this project expected to contribute to expanding the country's forest cover, improving the material and technical facilities of the forest institutions in Kyzylorda and Zhambyl oblasts.

Effects of changes in forestry on GHG emissions

In Kazakhstan, total estimated emissions, and removals in the forestry sector from natural pastures, forests, tree and shrub vegetation, arable land, wetlands, and perennial plantations in 2016-2020 have increased by approximately 5.2 times (or by 7,752.39 thousand tons of CO_2 equivalent). This may be due to the expansion of arable land and extensive application of mineral, mainly nitrogen, and organic fertilizers on these lands.

Table 2.28. *Greenhouse gas emissions/removals in forestry, in thousand tons of CO2-eq.*
Source: Inventory of greenhouse gas emissions in Kazakhstan, 2022

Name	2016	2017	2018	2019	2020
Total	5,874.23	6,409.21	8,907.00	5,051.91	8,375.47
Forest lands	-4,412.53	-3,389.83	-2,865.86	-6,461.03	-10,056.93
Arable land	31,735.00	30,411.33	30,560.10	28,372.66	31,905.13
Pastures	-18,810.00	-17,941.00	-15,775.66	-13,768.33	-10,120.00
Wetlands	0.18	14.89	0.00	0.00	0.00
Settlements	-2,645.50	-2,859.27	-3,202.83	-3,245.27	-3,540.90

Impact of climate change on forestry

Sustainable forest development (constant increase in forest cover) is one of the principles of the forest legislation of the Republic of Kazakhstan.[128] One of the planned measures to reduce water shortage is expansion of the forest cover of the catchment areas of water bodies.

The country's state forest fund is monitored via space monitoring on an ongoing basis. The relevant data of the fund exposed to fires is provided by the Committee for Forestry and Wildlife of MEGNR RK. This provides a reliable picture of burned-out areas to take the necessary measures to fight fires. In addition, to prevent and fight forest and steppe fires in the border territories, an agreement with the Government of the Russian Federation is in effect. In the event of forest, steppe fires or danger of fire propagation, the parties promptly inform the competent authorities via the points of contact to take the necessary measures to suppress fires.[129]

In 2015, Fire safety Rules in Forests were approved. According to the, to ensure protection of settlements located in forests from fires, local executive bodies (forest owners) shall develop and implement measures that exclude the possibility of fire propagation to buildings and structures

[128] Code of the Republic of Kazakhstan No. 477 dated July 8, 2003, 'Forest Code of the Republic of Kazakhstan,' Article 3.
[129] 'Analysis of the forestry and wildlife industry, 'Consortium of Agricultural Associations, 2019':
https://atameken.kz/files/orc/ОРК%20Лесное%20хозяйство%20и%20животный%20мир%20-%20Анализ%20отрасли.pdf

during forest fires (arrangement of fire trails at least four meters wide, removal of dry vegetation in summer).[130]

[130]Order of the Minister of Agriculture of the Republic of Kazakhstan No. 18-02/942 ‘On approval of Fire safety rules in forests’ dated October 23, 2015.

III. INFORMATION ON GREENHOUSE GAS INVENTORIES

A. Summary tables

According to the UNFCCC reporting guidelines, summary information on national greenhouse gas inventory is provided for the period, starting with the base year 1990 to the latest inventory year, 2020. Information on national greenhouse gas inventory is provided in full compliance with the national inventory submitted. Information on the inventory is provided in summary table 3.1 in CTF format (Common Tabular Format).

Table 3.1. *Dynamics of total national GHG emissions in 1990-2020 by sectors of the economy in the Republic of Kazakhstan, thousand tons of CO_2 equivalent.*

Years	Energy activities	IPPU	Agriculture	LULUCF	Waste	Total emissions without LULUCF	Total emissions with LULUCF
1990	316,918.54	19,292.85	44,742.14	-3,908.21	4,649.47	385,603.00	381,694.78
1991	303,780.40	18,365.54	43,567.03	1,536.04	4,599.22	370,312.19	371,848.23
1992	278,326.30	16,725.07	44,293.65	7,016.43	4,277.43	343,622.44	350,638.87
1993	248,816.73	12,504.28	42,629.11	11,142.77	3,997.43	307,947.55	319,090.32
1994	214,083.38	7,737.62	34,855.17	17,027.60	3,837.22	260,513.39	277,541.00
1995	199,752.59	8,688.02	30,939.96	23,344.86	3,827.99	243,208.56	266,553.42
1996	187,528.83	7,641.44	25,957.47	29,506.61	3,841.49	224,969.22	254,475.83
1997	179,968.43	9,924.30	23,338.70	36,207.00	3,869.78	217,101.21	253,308.22
1998	177,732.76	8,456.00	23,066.57	41,131.18	3,825.82	213,081.15	254,212.33
1999	146,898.01	10,900.97	25,038.72	49,143.23	3,882.34	186,720.04	235,863.27
2000	173,758.55	12,326.59	26,161.46	56,572.05	3,942.34	216,188.94	272,760.98
2001	166,500.99	12,683.21	26,846.39	53,750.75	4,060.86	210,091.45	263,842.20
2002	186,503.64	13,772.22	28,052.04	52,268.75	4,117.34	232,445.25	284,714.00
2003	204,892.67	15,386.31	29,484.08	47,827.13	4,160.80	253,923.85	301,750.98
2004	209,669.67	15,828.08	30,699.29	42,729.92	4,283.78	260,480.82	303,210.74
2005	221,553.05	161,72.63	31,848.52	37,441.05	4,398.76	273,972.96	311,414.01
2006	236,517.51	17,199.85	33,114.46	33,017.93	4,614.95	291,446.79	324,464.71
2007	237,141.93	18,045.02	33,389.73	26,874.11	4,772.64	293,349.32	320,223.43
2008	233,446.62	17,153.99	33,086.27	23,599.55	4,856.92	288,543.80	312,143.35
2009	223,349.85	15,159.26	33,109.70	20,201.24	5,100.69	276,719.50	296,920.73
2010	247,136.57	15,761.39	32,660.21	14,940.42	5,268.83	300,827.00	315,767.42
2011	237,699.39	16,483.28	31,298.08	11,680.64	5,300.17	290,780.93	302,461.57
2012	243,451.65	16,302.76	30,495.02	7,730.12	5,434.23	295,683.66	303,413.78
2013	248,873.14	18,797.85	30,435.29	3,205.43	5,565.01	303,671.29	306,876.71
2014	294,694.87	19,345.23	31,677.62	4,320.75	5,758.70	351,476.42	355,797.17
2015	296,297.47	20,838.66	32,849.52	5,336.40	5,847.21	355,832.87	361,169.27
2016	299,118.24	21,607.40	34,074.21	5,874.08	6,110.36	360,910.22	366,784.30
2017	315,973.53	21,496.94	35,693.91	6,409.21	6,271.51	379,435.89	385,845.10
2018	328,674.13	20,351.31	37,284.49	8,907.01	6,444.82	392,754.75	401,661.76
2019	293,568.55	20,871.44	38,498.86	5,051.91	6,689.41	359,628.25	364,680.17
2020	272,499.31	22,290.21	40,724.99	8,375.48	7,354.28	342,868.79	351,244.26
Difference in 2020 to 1990, in %	–14.02	15.54	–8.98	314.30	58.17	–11.08	–7.98

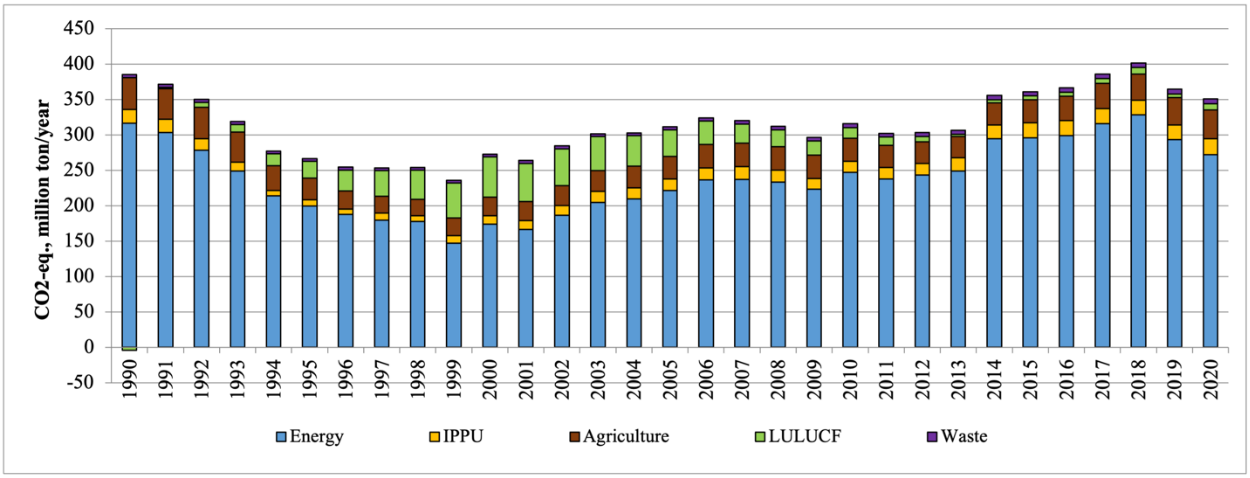
Difference in 2020 to 2019, in %	–7.18	6.80	5.78	65.79	9.94	–4.66	–3.68

B. Narrative summary

According to the UNFCCC guidelines, a summary of the inventory, summary tables and diagrams of all GHGs listed in the summary tables are provided. Additionally, a description of the factors underlying greenhouse gas emission trends is provided.

In the base year 1990, cumulative GHG emissions in Kazakhstan, without LULUCF, amounted to 385.603 million tons of CO2-eq. With the LULUCF sector, GHG emissions in 1990 amounted to 381.695 million tons of CO2-eq. (table 3.1 above).

Figure 3.1. *Cumulative greenhouse gas emissions in Kazakhstan*



As can be seen from Table 3.1 and Figure 3., total cumulative emissions from 1990 to 1999 have reduced almost two-fold due to economic downturn in Kazakhstan: to 186,72 million tons of CO_2-eq excluding LULUCF. This reduction was 52.6% of the level of 1990 excluding LULUCF.

Since 2000, revival of Kazakhstani economy has led to an increase in GHG emissions that reached the level of 392.755 million tons of CO_2-eq without LULUCF and 401.662 million tons of CO_2-eq with LULUCF by 2018, thereby exceeding the level of the base year 1990. However, a decrease in emissions in the energy sector was observed in 2019 and 2020 resulting in a decrease in total cumulative emissions.

According to the inventory data, a decrease against the baseline level occurred in the energy sector (-14.02%) and the agriculture sector (-8.98%). The following sectors have shown increase: IPPU (by 15.54%), LULUCF (by 314.3%) and waste (58.17%).

Total GHG emissions for 2020 are below the 1990 base: by 11.08% excluding LULUCF and by 7.98% including LULUCF.

C. National inventory development procedure

According to the guidelines for the submission of national systems in accordance with Article 5, paragraph 1, of the Kyoto Protocol, for Kazakhstan as a Party included in Annex I for the purposes of the Kyoto Protocol, this section presents the results of how Kazakhstan fulfills the general and specific functions of the national system item by item.

a) the name and contact information of the national authority and its designated representative who has overall responsibility for the national inventory of the Party

The Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan (MEGNR) has been responsible for the national inventory of greenhouse gases in the Republic of Kazakhstan since 2019. National Coordinator of the UNFCCC – Suleymenova Zulfiya Bulatovna, Vice-Minister of MEGNR, office phone of the reception: +7 7172 74 00 69, email address: z.suleimenova@ecogeo.gov.kz. The report is developed under the leadership of the Department of Climate Policy and Green Technologies of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.

Contact information:

Department of Climate Policy and Green Technologies of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan: Astana, Mangilik El Street, 8, House of Ministries, entrance 14. Phone: +7 (7172) 74 02 28, Director of the Department of Climate Policy and Green Technologies: Kopbaeva Ainur Irgaliyevna, e-mail: a.kopbaeva@ecogeo.gov.kz

Ainur Kopbaeva has also been appointed National Coordinator for Climate and Gender.

b) the roles and responsibilities of national institutions and organizations in the implementation of the inventory development process, as well as the organizational, legal, and procedural measures taken to prepare the inventory

The national GHG inventory in Kazakhstan is conducted based on the relevant provisions of Articles 4 and 12 of the UNFCCC and decisions of the COP. Institutional, legal, and procedural mechanisms for preparing greenhouse gas inventories are also regulated by the internal regulatory documents of the Republic of Kazakhstan. National reports on the greenhouse gas inventory are the information basis for the development of climate change policies implemented by the Government of Kazakhstan.

After the ratification of the Kyoto Protocol in 2009, Kazakhstan began to submit annual reports on the national inventory of greenhouse gas emissions to the UNFCCC Secretariat in the form of national inventory reports (NIR) and the electronic table (Common reporting format – CRF). All submitted NIRs and CRF tables can be found on the website of the UNFCCC Secretariat.

Preparation of annual national GHG emission inventories in Kazakhstan has been conducted annually since 2009 under agreements with the Ministry of Environmental Protection of the Republic of Kazakhstan in 2009-2013, with the Ministry of Environment and Water Resources of the Republic of Kazakhstan in 2014, with the Ministry of Energy of the Republic of Kazakhstan in 2015-2019, and since 2020 – with the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, which currently performs the functions of the authorized body for coordinating the implementation of policies and measures in the field of climate change in the Republic of Kazakhstan. The same specialized organization Zhassyl Damu JSC works on the national GHG inventory, which ensures continuity in its preparation.

Public bodies provide the information necessary to prepare the inventory at the request of the authorized body in the field of environmental protection (Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan), as well as verify and approve the draft National Inventory Report.

The national system for assessment of greenhouse gas emissions and removals was developed in accordance with paragraph 4 of Article 158-1 of the Environmental Code of the Republic of Kazakhstan dated January 9, 2007. After the adoption of the new Environmental Code of the Republic of Kazakhstan dated January 2, 2021, the basis of the national system for assessing greenhouse gas emissions and removals is paragraph 5 of Article 302 of the Code.

It includes institutional, legal, and procedural mechanisms for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. To this end, Kazakhstan adopted regulatory documents that were relevant depending on the current version of the Environmental Code of the Republic of Kazakhstan. The National GHG Inventory for 2020 was organized in accordance with Order No. 214 of the Minister of Energy of the Republic of Kazakhstan dated March 18, 2015, Rules for monitoring the completeness, transparency and reliability of the state inventory of greenhouse gas emissions and removals. However, these Rules have now been replaced by a new document, Order No. 46 of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated February 22, 2022, Rules for monitoring the completeness, transparency, and reliability of the national inventory of greenhouse gas emissions and removals. It is important to note that the new version of the Rules is aimed at eliminating barriers and systemic errors identified by Expert Review Teams in previous years while evaluating national reports on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol (hereinafter – the National Inventory Report).

The Rules outline the following concepts:

1) the key source category is one of the prioritized categories in the national inventory as its assessment has significant impact on the overall inventory of direct greenhouse gas emissions from the perspective of the absolute level of emissions, emission trends, or both;
2) the operator of the carbon units trading system is a subordinate organization for regulating greenhouse gas emissions under the authorized body in the field of environmental protection (hereinafter referred to as the Operator) providing technical and expert support for state regulation and international cooperation in the field of greenhouse gas emissions and removals;
3) recalculation is a procedure for re-evaluation of anthropogenic greenhouse gas emissions from sources and their absorption by sinks indicated in previously submitted inventories due to changes in methodologies, changes in the methods of obtaining and using emission factors and activity data, or the inclusion of new categories of sources and sinks;
4) the national system of inventory of greenhouse gas emissions and removals is a set of organizational measures for the collection, processing, storage, and analysis of data necessary to determine the actual volumes of greenhouse gas emissions and removals in the Republic of Kazakhstan for the corresponding period;
5) quality control – a system of routine technical work on quality measurement and control of the inventory of sources of emissions and removals of greenhouse gases in the course of its development and compilation;
6) quality assurance – a planned system of review procedures carried out by employees who are not directly involved in the process of developing and compiling inventories to verify the fulfillment of tasks in the field of data quality, to ensure maximum accuracy of the inventory in terms of estimating emissions and removals considering the current level of scientific knowledge and available data, and to support the effectiveness of the quality control program.

The Order specifies the functions of the authorized body in the field of environmental protection (hereinafter referred to as the authorized body), according to which the procedure for monitoring the completeness, transparency and reliability of the state inventory consists of three stages:

1) convening an interagency Working Group;
2) presenting input data based on the results of the functioning of the state inventory;
3) development and verification of the National Inventory Report and the Common Reporting Format Table (hereinafter referred to as the CRFT) based on the results of the annual operations of the state inventory in accordance with subparagraph a) of paragraph 1 of Article 4 of Decree No. 2260 of the President of the Republic of Kazakhstan dated May 4, 1995, 'On Ratification of the United Nations Framework Convention on Climate Change' (hereinafter referred to as the UNFCCC).

c) description of the process for collecting activity data, emission factors and method

At the first stage of monitoring the completeness, transparency and reliability of the national inventory, the authorized body convenes a Working Group. The working group is established under the chairmanship of a representative of the authorized body and consists of representatives of the authorized body, the Operator (Zhassyl Damu JSC), public bodies and organizations responsible for performing all functions in accordance with subparagraph a) of paragraph 10 of Decision 19/CMP.1. To ensure the control of completeness, transparency and reliability of the national inventory, the Operator develops a quality control and quality assurance plan (hereinafter referred to as the Plan) in accordance with subparagraph (d) of paragraph 12 of Decision 19/CMP.1.

The first meeting of the Working Group is held annually no later than April 30. The dates of subsequent meetings of the Working Group are determined based on the results of the first meeting. According to the new Rules, the first meeting was held on April 22, 2022. To ensure the control of completeness, transparency and reliability of the national inventory, the Operator (Zhassyl Damu JSC) develops a quality control and quality assurance plan (hereinafter referred to as the Plan) in accordance with subparagraph (d) of paragraph 12 of Decision 19/CMP.1.

The Plan contains the following activities:

1) schedule of work preparation from the beginning of development to its submission to the UNFCCC Secretariat;
2) description of verification procedures;
3) a list of assigned persons for quality control procedures and deadlines for their implementation by sector.

The Plan also contains the following procedures for national inventory quality control:

1) appointment of persons assigned to the verification;
2) establishment of a work schedule and deadlines for verification;
3) input data validation;
4) cross-control of calculations between experts in individual sectors.

The second stage of monitoring the completeness, transparency and reliability of the state inventory is carried out by submitting initial data on the results of the national inventory operations at the second meeting of the Working Group no later than July 1. At the second meeting, the Working Group distributes the presentation of the input data among the relevant representatives of the Working Group and confirms the list of representatives providing data for the inventory of greenhouse gases at the request of the authorized body before August 1 of the year following the reporting period, except for representatives of the authorized body in the field of state statistics.

The authorized body sends requests for the provision of input data for the development of the National Report to the authorized body in the field of state statistics, as well as to relevant organizations not included in the Working Group. Representatives of the Working Group and the organizations to which the requests were sent must provide the requested input data by August 1 or within 20 working days from the date of receipt of the relevant request.

The third stage of monitoring the completeness, transparency and reliability of the national inventory consists in the development and verification of the National Report and CRFT based on the results of the annual operations of the national inventory. The Operator (Zhassyl Damu JSC) develops the National Inventory Report and CRFT based on the results of the annual operations of the national inventory by collecting, analyzing, and processing data received from government agencies and enterprises whose activities generate greenhouse gas emissions and removals.

The authorized body sends the draft National Inventory Report by February 15 next year for consideration to national validation and verification bodies, independent experts, specialized scientific institutions that did not directly participate in the preparation of the national inventory. These organizations submit their comments and suggestions within ten working days. The operator finalizes the results of the national inventory considering the comments and suggestions of Organizations' representatives until March 10 of each year. In turn, in case of disagreement with the comments and suggestions of Organization representatives, the Operator provides them with reasoned justifications for not taking into account the relevant comments and suggestions within ten working days.

Considering the above procedures, the Working Group reviews and approves the annual National Inventory Report by April 10 of each year. The authorized body annually, by April 15, ensures the submission of the results of the annual national inventory for the evaluation procedure in accordance with paragraph 2 of Decision of the Conference of the Parties 3/CP.1 of April 7, 1995 Preparation and submission of national communications from the Parties included in Annex I to the Convention.

The 2006 IPCC methodology set out in the IPCC Guidelines for National GHG Inventories is used to compile the inventory. Calculations are partially performed at methodological level 1. Levels 2 and 3 are mainly used for key source categories. Detailed information about the levels used is provided in the sectoral sections of the NDC. In some categories, the methodology contained in the new methodological guidelines prepared by the IPCC (2019 Update to the 2006 IPCC Guidelines on National GHG Inventories) approved on May 12, 2019, by IPCC decision IPCC-XLIX-9 was used.

d) Description of key source identification and data archiving process

The analysis of key categories was carried out in accord with the requirements of the 2006 IPCC Guidelines and corresponds to level 1 methodology. The tables include categories in the total amount of 95% of the emission/removals under one of the following parameters:

- contribution to cumulative emissions/removals excluding LULUCF for 1990 and 2020;
- contribution to cumulative emissions/removals including LULUCF for 1990 and 2020.;
- contribution to the trend of cumulative emissions/removals for 1990-2020 excluding LULUCF;

– contribution to the trend of cumulative emissions/removals for 1990-2020 including LULUCF.

The key categories are ranked by the absolute value of the contribution to the amount or trend of emissions/removals in the national GHG inventory using CO_2 equivalent emissions calculated by the values of the global warming potential for each gas.

The analysis of key categories is based on the level of detail of the categories presented in Chapter 8 of 2006 IPCC Guidelines and carried out using CRF Reporter.

Table 3.2. *Key source categories according to the 2022 NIR of the Republic of Kazakhstan*

Years	By level without LULUCF	By level with LULUCF	Trend estimate without LULUCF	Trend estimate with LULUCF
1990	24	26	-	-
2020	23	26	25	29

The results of the analysis of key categories are used in the preparation of the next annual inventory to reduce the uncertainty of estimates and optimize resource allocation, so that the improvement of methodologies, collection and validation of input data, quality evaluation and control for key categories are carried out as a priority.

Archiving covers the storage of all the input information and results of calculations of GHG emissions and removals, from the procedure for input data collection and storage to accounting and recording of administrative and structural information for the preparation of GHG inventories.

The data for the annual inventory is stored in both soft and hard copies. A dedicated data storage room has been allocated with shelves for storing inventory reports of enterprises that have been collected since 2010 as part of the internal Emissions Trading System. There are also printed methodological materials, statistical yearbooks, correspondence with suppliers of input information for calculations and reporting materials for recent years.

Data and results of calculations of GHG emissions by sectors are stored in a dedicated database in the file storage system in printed and electronic form. The archive and the server room are isolated rooms on the fifth floor, which only the system administrator has access to. Protection from natural disasters, fires and floods is provided by service personnel. Fire safety is observed. The archive is equipped with a fire extinguisher. A person responsible for fire safety has been appointed.

Security is ensured by password-protected access to the server. The password is issued by the server administrator on behalf of the Director of the Greenhouse Gas Inventory Department of Zhassyl Damu JSC.

According to paragraph 16 of Decision 19/CMP.1, when preparing a National Inventory Report, the following conditions shall apply:

1) archiving of information used in the preparation of the National Inventory Report: activity data used to calculate greenhouse gas emissions and removals, internal documentation on quality control and quality assurance procedures, data on key and non-key categories of emission sources, as well as planned improvements to the National Inventory Report;

2) access to archived information for the representatives of the authorized body, Operator employees, international experts during the annual review of the National Inventory Report initiated by the UNFCCC Secretariat.

3) development of responses of the Operator's employees to the questions of the inspectors during the international review, and implementation of recommendations based on the review results in the National Inventory Report.

Access to archived information is provided by the national experts of Zhassyl Damu JSC at the request of the authorized body or during the GHG inventory review by the team of international experts.

e) Description of recalculation procedures

Recalculations arise as a result of correcting errors, obtaining new input data, improving the methodology and emission factors and, eventually, are the result of constant work to improve the national inventory. Recalculations are made on an ongoing basis and are reflected in the relevant chapters of the National Inventory Report and CRFT.

f) Description of the quality assurance and quality control plan, its implementation, as well as information on internal and external evaluation and analysis processes and their results

The GHG inventory uses the main elements of procedures that meet the requirements of IPCC Good Practice Guidelines, 2000. The QA/QC system adopted in Kazakhstan has several stages of coordination and control by the agencies involved in the national GHG inventory system functioning.

According to the results of the last NIR review for 1990-2017 conducted by the ERT under the leadership of the UNFCCC Secretariat in September 2019, Kazakhstan was recognized as a Party non-compliant with obligations under the Kyoto Protocol. In accord with the ERT comments, a new draft regulatory document governing the process of preparation and submission of Kazakhstan's NIR was developed.

Moreover, the Department of Climate Policy and Green Technologies of MEGNR RK has prepared a Plan for the withdrawal of the Republic of Kazakhstan from the non-compliance with the Kyoto Protocol. The first report on the progress of the implementation of the plan to cease the non-compliance was submitted by Kazakhstan and sent to the Compliance Committee of the UNFCCC Secretariat in January 2021. Over the past year, two Progress Reports on the implementation of the compliance plan have been sent to the Kyoto Protocol Compliance Committee of the UNFCCC Secretariat. The second Report was submitted on January 29, 2022.

There are neither financial sanctions under the Kyoto Protocol for Kazakhstan, nor consequences associated with the loss of credits (although there is a loss of access to the carbon market).

IV. POLICIES AND MEASURES

4.1. Policies and measures in the energy sector

A. Political decision-making in the energy sector

This section provides information on Kazakhstan's actions to prevent climate change including policies and measures it has implemented or plans to implement since the last national communication (2017) or biennial report (2019) to achieve the target of reducing emissions across the economy.

The country's decision-making process on climate policy is described in the previous Seventh National Communication and the Fourth Biennial Report.[131]

This chapter outlines the amendments in policies and measures leading to the reduction of greenhouse gas emissions in the fuel combustion and fugitive emissions sector in the Republic of Kazakhstan.

Cross-sectoral policies and measures

Adoption of policies and measures impacting the reduction of GHG emissions was a key and essential action to mitigate climate change.

Environmental Code

Adoption of Environmental Code No. 212 dated January 9, 2007, became the first step of shaping the national legislation on greenhouse gas regulation.[132] In 2021, the Environmental Code (EC) was adopted in a new edition.[133] In this edition, the of 'the polluter pays and remedies' principle was introduced, a chapter on adaptation to climate change was included, and much more.

The purpose of the Environmental Code is to define the legal framework, objectives, and principles, as well as mechanisms for the implementation of the nationwide environmental policy in the Republic of Kazakhstan. That is, the Environmental Code does not contain any specific measures to reduce GHG emissions, but it defines a policy to reduce GHG emissions in the form of establishing the foundations of the market mechanism of ETS and introducing a 1.5% annual reduction in the carbon budget until 2030.

Market mechanisms of GHG emissions reduction and removals

Market mechanisms for reducing GHG emissions and removals are described in Chapter 20 'State regulation in the field of greenhouse gas emissions and removals' of the new Environmental Code (Chapter 9-1 in the previous version of the Environmental Code). Market mechanisms include the carbon unit trading system. This system has been operating in the Republic of Kazakhstan since 2013. Initially, the system was based on the historical approach of quota allocation. Now, the system is based on the benchmarking approach, which involves the use of specific emission factors. The earlier stages of the carbon unit trading system are described in the Fourth Biennial Report.[134]

It is currently impossible to assess the quantitative impact of the carbon unit trading system since the system had worked inefficiently in the previous period and was suspended in February 2016 in terms of trading quotas for GHG emissions until 2018 due to certain distortions in the

[131] https://unfccc.int/documents/28937
[132] http://adilet.zan.kz/rus/docs/K070000212_
[133] https://adilet.zan.kz/rus/docs/K2100000400
[134] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

system. After the trade was resumed, the accumulated data was insufficient to assess the impact on reducing GHG emissions.

NDC and Paris Agreement

On December 12, 2015, Paris Agreement was adopted at the 21st session of the UNFCCC Conference of the Parties held in Paris from November 30 to December 13, 2015. After signing the agreement on August 2, 2016, Kazakhstan ratified it on December 6, 2016. On September 28, 2015, Kazakhstan announced its INDC -Intended Nationally Determined Contribution - indicating that the nation intends to achieve the 15% unconditional reduction in GHG emissions against the 1990 levels by 2030 and the 25% conditional reduction in GHG emissions against the 1990 levels by 2030 subject to international support.

During 2020-2021, work has been underway in the Republic of Kazakhstan to update the NDC for submission to the UNFCCC. In February 2021, Zhassyl Damu JSC, in partnership with the international consulting company Ernst & Young, completed the World Bank's PMR project ‘Update Kazakhstan’s NDC and Provide a Roadmap for NDC Implementation for post-2020’.[135]

At the time of writing, these documents had not been approved and had not been submitted to the UNFCCC, therefore, no NDC Roadmap activities were used to assess the effect.

Low-Carbon Development Concept (LCDC)

In 2020-2021, the Concept of Low-Carbon Development of the Republic of Kazakhstan was prepared within the framework of the project of the German Society for International Cooperation (GIZ) ‘Supporting Green Economy in Kazakhstan and Central Asia for a low carbon economic development’ funded by the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) within the framework of the German Climate Initiative (IKI).[136] This document was developed in compliance with the decisions of the parties to the Paris Agreement. To implement the Paris Agreement, all parties are preparing low-carbon development strategies (LCDS), which provide a long-term horizon for NDC and describe a vision for future national development.

In December 2020, President Tokayev announced that Kazakhstan would become climate-neutral by 2060 at the Climate Ambition Summit. Based on this statement, two scenarios have been developed within the framework of LCDC until 2060: a business-as-usual scenario and a carbon neutrality scenario, which contains the necessary measures to achieve the stated ambition. At the moment, the LCDC has not yet been approved and its revision is underway, therefore, the LCDC activities have not been used to assess the effect.

B. Policies and measures and their impact in the energy sector

Policies and measures in the fuel combustion sector

Reduction of the GDP carbon intensity is a key principle of green transition under Kazakhstan's concept of transition to green economy. Since the fuel combustion sector is responsible for the bulk of GHG emissions in Kazakhstan, policies and measures in the fuel combustion sector directly impact the reduction of energy intensity and the carbon intensity of GDP.

[135] http://zhasyldamu.kz/ru/glavnaya/8-novosti/615-ob-38.html

[136] https://www.international-climate-initiative.com/en/details/project/support-of-green-economy-in-kazakhstan-and-central-asia-for-a-lowcarbon-economic-development-18_I_240-2938

Even though LCDC has not yet been adopted at the time of writing, policies and measures in the fuel combustion sector are among the most essential to the ambition of achieving carbon neutrality.

The subsections below describe the main objectives and strategic documents related to the fuel combustion sector. They are given without the quantitative assessment of the impact on the reduction of GHG emissions, as these documents lay the foundations for the development of measures to achieve the relevant goals and objectives.

Reduction of Kazakhstan's GDP energy intensity

Low-carbon development of the economy entails a significant reduction in GHG emissions to the GDP, a transition in the energy sector from hydrocarbon fuel and energy resources combustion to renewable energy sources (solar energy, wind power, small-scale hydropower), a reduction of energy consumption and thereby a reduction of GHG emissions in manufacturing and housing-and-utilities (energy saving) Goals to reduce energy intensity of GDP are also reiterated in the Concept for development of fuel and energy complex of the Republic of Kazakhstan until 2030.

Table 4.1. *Reduction of GDP energy intensity of Kazakhstan against 2008*

Year / Targets	Concept for transition of the Republic of Kazakhstan to Green Economy
2015	–10% against the 2008 level
2020	–25% against the 2008 level
2030	–30% against the 2008 level
2050	–50% against the 2008 level

Energy conservation and energy-efficiency improvement

The Law 'On Energy Conservation and Energy-Efficiency Improvement' (No. 541) was adopted on January 13, 2012[137]. For additional information, please see the Fourth Biennial Report[138].

Concept for development of fuel and energy complex of Kazakhstan until 2030

The **Concept for development of fuel and energy complex of the Republic of Kazakhstan until 2030** was approved under No. 724 on June 28, 2014. The concept of FEC development takes account of the objective of active integration of renewable energy sources and alternative energy sources in the energy balance; energy and resource conservation, and enhancement of energy efficiency. As for the quantitative targets related to GHG emissions, the Concept reiterates the targets for the GDP energy intensity reduction specified in the Concept for the transition of the Republic of Kazakhstan to green economy.

Now, the Concept of FEC development is in the process of updating and approval.

Strategic plan of the Ministry of Energy of RK for 2017-2021

The main short-term policies and measures in the fuel combustion sector are determined by the Ministry of Energy of the Republic of Kazakhstan and are reflected in the directions of the Strategic Plan of the Ministry of Energy of the Republic of Kazakhstan. On December 28, 2016, the Strategic plan of the Ministry of Energy of the Republic of Kazakhstan for 2017-2021'No. 571

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[137] http://adilet.zan.kz/rus/docs/Z1200000541
[138] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

was approved. This plan undertakes the mission to improve quality of the environment, to ensure transition of the Republic of Kazakhstan to low-carbon development and a green economy to meet the needs of present and future generations.

The Strategic plan of the Ministry of Energy for 2020-2024 was approved by Order No. 421 of the Minister of Energy of the Republic of Kazakhstan on December 3, 2020. This document takes over all goals and objectives set out in previous strategic plans.

Policies and measures in the heat and power generation sector

The key measures affecting the reduction of GHG emissions in the heat and electricity generation sector are boosting the share of natural gas generation, development of renewable energy sources, commissioning of nuclear capacities and development of generation based on coal-bed methane.

Increasing the share of natural gas in power generation

The impact assessment of this measure is given in Table 4.2.

Table 4.2. *Assessment of the impact of increasing the share of natural gas in power generation*

Policy or measure	Sector affected	GHG affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Increasing the share of natural gas in power generation	Energy situation	CO_2, CH_4, N_2O	20% in 2020, 25% in 2030.	Regulatory	In progress	The Concept for the transition to green economy and the Concept for FEC Development (updated at the moment) aim at increasing the share of natural gas in power generation.	2013	ME RK	0	107	2712	1210

This measure has been implemented via the 'Sary-Arka' main gas pipeline construction completed in October 2019 and the conversion of Astana city heating plants to natural gas. Thus, according to the information provided by the A. Kulginov, mayor of the capital, on December 3, 2021, 13 hot-water boilers of CHPP-1 and CHPP-2 were converted to natural gas.[139] It is also planned to convert Almaty CHPP-2 to gas in the coming years.[140]

It is also possible to expand gas-fired power generation by developing electricity generation from coal-bed methane. For additional information, please see the Fourth Biennial Report.[141]

Increasing the share of RES in power generation

The impact assessment of this measure is given in Table 4.3.

[139] Central Communications Service under the President of the Republic of Kazakhstan. The Capital will be Completely Supplied with Gas – Altai Kulginov, December 3, 2021: https://ortcom.kz/ru/novosti/1638525115 .

[140] Central Communications Service under the President of the Republic of Kazakhstan. Power Infrastructure will be Reconstructed along with CHPP Transition to Gas – Akim of Almaty, December 8, 2021: https://ortcom.kz/ru/novosti/1638951981

[141] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

Table 4.3. *Assessment of the impact of increasing the share of RES in power generation*

Policy or measure	Sector affected	GHG affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Increasing the share of RES in power generation	Energy situation	CO_2, CH_4, N_2O	3% in 2020, 6% in 2025, 15% in 2030.	Regulatory	In progress	The goal is set in the Concept for the transition to green economy and in the Concept for FEC Development (updated at the moment). The target for 2030 was increased from 10% to 15% by the President of the Republic of Kazakhstan at the meeting on the development of the electric power industry in May 2021.	2013	ME RK	0	6,796	24,826	29,464

The implementation of this goal for the RES sector development began with the adoption of the law ‘On support for the use of renewable energy sources,’ setting targets for the RES sector development, setting fixed tariffs for the purchase of renewable energy, and replacing this mechanism with an auction mechanism. The 'Rules for providing targeted assistance to individual consumers' and 'Rules for planning the placement of facilities for the use of renewable energy sources' were approved as well. All these activities are described in detail in the Fourth Biennial Report.[142]

Reducing the share of coal in power generation

The impact assessment of this measure is given in Table 4.4.

[142] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

Table 4.4. *Assessment of the impact of reducing the share of coal in power generation*

Policy or measure	Sector affected	GHG affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Reducing the share of coal in power generation	Energy situation	CO_2, CH_4, N_2O	40% by 2030	Regulatory	Planned	The target was proclaimed for international audience in the speech by A. Mamin, the Prime Minister of RK, at the UNFCCC Conference of the Parties on November 2, 2021, in Glasgow.	2021	ME RK	0	209	16,473	13,498

The development of power generation decarbonization has always been associated with the indicators of gas supply and the RES sector development. The goal to achieve the indicator of coal share in power generation was first officially announced in 2021. The target was proclaimed for international audience in the speech by A. Mamin, the Prime Minister of the Republic of Kazakhstan, at the UNFCCC Conference of the Parties on November 2, 2021, in Glasgow (UK).

At the time of writing, this target has not been approved in any official strategic documents, therefore, it will be used in a scenario with additional measures when calculating the cumulative impact on GHG emissions reduction.

Construction of a nuclear power plant

The impact assessment of this measure is given in Table 4.5.

Table 4.5. *Assessment of the impact of the construction of a nuclear power plant*

Policy or measure	Sector affected	GHG affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Construction of a nuclear power plant	Energy situation	CO_2, CH_4, N_2O	1.5 GW by 2030, 2.0 GW by 2050	Regulatory	Planned	The goal was originally set in the Concept for the transition to green economy. In 2021, this topic was raised again due to increased electricity consumption and projected shortage of capacity in the near future. Specific figures on capacities are not given in any source except for the mentioned Concept for the transition to green economy.	2022	ME RK	0	0	13,855	13,074

The goal was set in the Concept for the transition to green economy. However, officials had not spoken definitely about any plans for the construction of a nuclear power plant until 2021. The statements mostly concerned the fact that there is no need for an NPP in the near future, or that a decision will be made only after approval by the population of the country. The history of the issue of the NPP construction until 2021 is described in detail in the article 'Talks Resumed on NPP. Revival of Kazakhstan's Nuclear Power Industry' in the Tengirnews.kz online news outlet.[143]

In early September 2021, K.-Zh. Tokayev, the President of the Republic of Kazakhstan, stated that ‘the time has come to consider this issue in substance, since Kazakhstan needs a nuclear power plant.’ Later, in November 2021, he made another statement that he would still have to make an ‘unpopular’ decision to build a nuclear power plant.

On December 3, 2021, the documentary Qazaq: History of the Golden Man was released, where N. Nazarbayev, the first President of the Republic of Kazakhstan, said in an interview with Oliver Stone, the US director, that Kazakhstan will build a nuclear power plant.

Thus, it would be true to say that the issue of the nuclear power plant construction will be resolved positively soon. Since the capacity and commissioning dates have not been set, the goals previously set in the Concept for the transition to green economy were used to assess the effect, and this activity related to the NPP construction was used in the scenario with additional measures when calculating the cumulative impact on GHG emissions reduction.

Policy and measures in the oil-refining sector

Refinery modernization

Modernization of Atyrau, Pavlodar and Shymkent refineries in 2018 allowed to increase the plants' capacity by 20% and improve the oil refining efficiency to 80-90%[144]. No other plans in the refining sector that can affect the reduction of GHG emissions are observed at the moment. The effect of this measure was not calculated as it relates to the past period, which is not included in the projected calculation horizon.

Policy and measures in the transport sector

Energy efficiency in transport

'Energy efficiency requirements for transport' (No. 389) were approved on March 31, 2015, in accordance with subparagraph 6-7) of Article 5 of the Law of the Republic of Kazakhstan ‘On energy conservation and energy-efficiency improvement’. They determine regulatory indicators for energy efficiency of transport The requirements apply to railway, road, maritime, inland waterway, air, and urban rail transport imported and produced after adoption of these requirements.

For detailed information, please see the Fourth Biennial Report.[145]

Efficiency improvement in the transport sector was not evaluated due to insufficient data on the transport sector.

International aviation

According to the Kyoto Protocol reporting manual, the Parties included in Annex I shall, in accord with paragraph 2, Article 2 of the Protocol, state the actions they have taken to

[143] Shokan Alkhabayev, 'Talks Resumed on NPP. Revival of Kazakhstan's Nuclear Power Industry,' September 8, 2021: https://tengrinews.kz/kazakhstan_news/vnov-zagovorili-aes-vozrojdaetsya-atomnaya-energetika-447830 /

[144] https://inbusiness.kz/ru/news/kak-minenergo-reshaet-voprosy-s-nebolshimi-npz

[145] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

support/implement decisions by ICAO and IMO on limitation or reduction of emissions of greenhouse gases from aviation and marine bunker fuels.

To achieve global goals and promote sustainable growth in international aviation, ICAO is implementing a range of measures, including aviation technology improvements, operational improvements, sustainable aviation fuel and market-based measures (CORSIA-the Carbon Offsetting and Reduction Scheme for International Aviation).

According to the information from the ICAO website,[146] Kazakhstan is included in the list of 107 countries that will participate in the CORSIA program starting from January 1, 2022.

This initiative was not evaluated as there is not enough information about the format of the country's planned measures under this program.

Marine bunkering

The International Maritime Organization (IMO)[147] was established based on the understanding that the international character of the shipping industry implies that operations aimed at improving the safety of maritime navigation will be efficient if carried out at the international level. The Conference convened by the UN in 1948 adopted the Convention establishing the IMO. The Convention entered into force in 1958.

Details on the relationship between Kazakhstan and IMO can be found in the Fourth Biennial Report.[148] At the moment, Kazakhstan does not participate in IMO initiatives related to GHG emissions reduction.

Pipeline transport

Natural gas is currently considered as a transition fuel in the decarbonization process, and the gasification process can significantly affect the reduction of GHG emissions.

The Concept of development of the gas sector of the Republic of Kazakhstan till 2030 and General scheme of gasification of the Republic of Kazakhstan for 2015-2030 have been adopted and put into force as part of the efforts to expand gasification in Kazakhstan. In October 2019, the construction of the 'Sary-Arka' main gas pipeline aimed at gasification of Central Kazakhstan was completed.

All the data from the mentioned documents were used to build a computational model for assessing GHG reduction measures in other sectors. The measures from these documents were not evaluated individually as they may vary in established ranges depending on the measures under consideration.

More details about the mentioned documents and gasification activities can be found in the Fourth Biennial Report.[149]

Policies and measures in the housing and utilities sector

In the housing and utilities sector, improvement of energy efficiency is the most significant measure that can affect the reduction of GHG emissions. The Law of the Republic of Kazakhstan 'On energy conservation and energy-efficiency improvement' introduced the concept of an energy service company (ESCo). However, the development of ESCo in Kazakhstan has not received

[146] https://www.icao.int/environmental-protection/CORSIA/Pages/state-pairs.aspx
[147] http://www.imo.org/en/About/Documents/IMO%20What%20It%20is%20Russian.pdf
[148] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf
[149] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

sufficient momentum due to low utility tariffs regulated by the state. In view of this, ESCo activities were not evaluated within the framework of this work.

Since the housing and utilities services sector is not currently covered by the GHG emission reduction regulation system, work was carried out to assess the impact of carbon tax introduction on the sectors that are not quoted by the emissions trading system. According to the results obtained, the housing and utilities sector would show the highest reduction in GHG emissions due to carbon tax introduction. Therefore, the carbon tax assessment is given in this subsection.

Carbon tax on sectors not covered by the emissions trading system

The impact assessment of this measure is given in Table 4.6.

Table 4.6. *Assessment of the carbon tax impact on the sectors not covered by the emissions trading system*

Policy or measure	Sector affected	GHG affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Carbon tax on sectors not covered by the emissions trading system	Agriculture, housing and utilities, transport	CO_2	USD3 per ton of CO_2 in 2023 onwards with an annual increase of USD3.	Fiscal	Planned	This measure was planned within the framework of the Roadmap for NDC implementation drafted with the support of the World Bank (see the section on Cross-sectoral Policies and Measures)	2023	Government of RK	0	19,624	39,175	50,544

The draft Roadmap for updated NDC implementation in the Republic of Kazakhstan for 2021-2025 provides recommended values of the carbon tax for each stage of the NDC implementation:

1st stage, 2021-2022: USD16.4 per ton of CO_2-eq.;

2nd stage, 2023-2025: USD24.2 per ton of CO_2-eq.;

3rd stage 3, 2026-2030: USD29.4 per ton of CO_2-eq.

This measure was used in the scenario with additional measures when calculating the cumulative impact on GHG emissions reduction.

Policy and measures in the fugitive emissions sector

According to IPCC, fugitive emissions are accidental or intentional release of greenhouse gases during extraction, processing, and delivery of fossil fuels to the end-use site.

Ban on gas flaring, development, and implementation of gas processing development programs

After the prohibition of flaring, annual volumes of flared gas in Kazakhstan were reduced by more than 3.5 times, while gas production volumes continued to grow steadily. These indicators were achieved due to the systematic implementation of gas utilization programs, which existed under the former Law of the Republic of Kazakhstan ‘On oil’ dated June 28, 1995.

The assessment was not carried out since the ban was adopted in the past period and has been in effect in Kazakhstan for a long time.

For detailed information, please see the Fourth Biennial Report.[150]

[150] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

Summary of policies and measures and their impact on the energy sector

Table 4.7. *Summary of policies and measures and their impact by fuel combustion and fugitive emissions sectors*

Policy or measure	Sector affected	GHGs affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity (s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
									2020	2025	2030	2035
Increasing the share of natural gas in electricity generation	Energy	CO_2, CH_4, N_2O	20% in 2020, 25% in 2030	Regulatory	Being implemented	The Concept for the transition to a green economy and the Concept for the development of the fuel and energy complex (currently being updated) set the goal of increasing the share of natural gas in electricity generation.	2013	ME RK	0	107	2712	1210
Increasing the share of renewable energy in electricity generation	Energy	CO_2, CH_4, N_2O	3% in 2020, 6% in 2025, 15% in 2030	Regulatory	Being implemented	The goal is laid down in the Concept for the transition to a green economy and in the Concept for the development of the fuel and energy complex (currently being updated). At a meeting on the development of the electricity industry in May 2021 President increased the target for 2030 from 10% to 15%	2013	ME RK	0	6796	24826	29464
Reducing the share of coal in electricity generation	Energy	CO_2, CH_4, N_2O	40% by 2030	Regulatory	Planned	The goal was officially announced at the international level by the Prime Minister of the Republic of Kazakhstan A. Mamin during his speech	2021	ME RK	0	209	16473	13498

						at the Conference of the Parties to the UNFCCC on November 2, 2021, in Glasgow.					
NPP construction	Energy	CO_2, CH_4, N_2O	1.5 GW by 2030, 2 GW by 2050	Regulatory	Planned	The goal was originally laid down in the Concept for the transition to a green economy. In 2021, this topic was raised again due to the growth in electricity consumption and the forecasted shortage of capacity in the near future. Specific figures for capacities are not given anywhere, except for the mentioned Concept.	2022	ME RK	0	0	13855	13074
Carbon tax on sectors outside ETS	Agriculture, housing and utilities, transport	CO_2	USD3 per ton of CO_2-eq in 2023 and an annual increase of USD3 thereafter.	Fiscal	Planned	This measure was planned as part of the NDC implementation roadmap, prepared with the support of the World Bank (see section on Cross-sectoral Policies and Measures)	2022	Government of the Republic of Kazakhstan	0	19624	39175	50544

C. Policies and measures in the energy sector that have been discontinued

Comprehensive plan for the development of the gas motor fuel market of the Republic of Kazakhstan until 2020

In accordance with subparagraph 5) of paragraph 2 of Section 3 of the Concept for the development of the gas sector of the Republic of Kazakhstan until 2030, on June 25, 2015, the Comprehensive plan for the development of the gas motor fuel market of the Republic of Kazakhstan until 2020, No. 433 was approved. The plan aims to increase the use of gas in transport.

For more details, see the Fourth Biennial Report.[151]

4.2. Policies and measures in Industrial Process and Product Use sector (IPPU)

A. Political decision-making process in the IPPU sector

Authority implementing policies and measures in the IPPU sector

It is necessary to note that there have been changes in the structure of public administration that have taken place since the publication of the latest (Seventh) National Communication on the regulation of policies and measures on climate change dated December 31, 2017.

The Decree of the President of the Republic of Kazakhstan dated June 17, 2019, established the Ministry of Ecology, Geology and Natural Resources (MEGNR RK). Under the new structure, climate change issues are now regulated by the Department for Climate Change of the MEGNR RK. The Ministry is the central executive body of the Republic of Kazakhstan, coordinating environmental protection, natural resource management, control, and supervision of the rational use of natural resources, control over the state policy for the green economy. Zhassyl Damu JSC (a reporting organization of the MEGNR RK) is an authorized national body responsible for assessing anthropogenic emissions by sources and removals by sinks of greenhouse ozone-depleting gases. It conducts an inventory based on the data provided by the Committee for Statistics under the Ministry of National Economy of the Republic of Kazakhstan and requests.

Industry not related to energy is supervised by the Ministry of Industry and Infrastructure Development, which, according to the Decree of the Government of the Republic of Kazakhstan dated December 29, 2018 No.936 is a government body that manages industry and industrial development, mining and metallurgy complex, development of local content, mechanical engineering, coal, chemical, pharmaceutical and medical industries, light industry, woodworking and furniture industry, construction industry and production of building materials, safety of machinery and equipment and safety of chemical products; export control; industrial safety; energy saving and energy efficiency, etc.

Structural subdivisions of the Ministry, i.e., the Committee for Investments, the Committee for Industrial Development and Industrial Safety, the Committee for Technical Regulation and Metrology, the Committee for Geology and Subsoil Use, indirectly deal with the issues of reducing GHG emissions as well.

By the Decree of the Government of the Republic of Kazakhstan dated April 19, 2019, Kazakhstan Institute for Industry Development JSC (subordinate organization of the Ministry) was renamed into Kazakhstan Center for Industry and Export JSC. The organization is responsible for increasing the competitiveness of the manufacturing industry at the international level and

[151] https://unfccc.int/sites/default/files/resource/Report_BR4_Updated.pdf

implementing a coordinated industrial and innovation policy. Currently, the Kazakhstan Center for Industry and Export is developing the third five-year industrialization program, which began in 2020. The current five-year plan (2020–2024) focuses on deepening industrialization, expanding production volumes and the range of processed goods. The achievement of target indicators under the State Program for Accelerated Industrial and Innovative Development for 2015–2019 is being monitored (the volume of manufactured products is expected to grow by 43% compared to 2012; labor productivity in the manufacturing industry is predicted to grow 1.4 times; energy intensity in the manufacturing industry is forecast to decrease by 15%).

Electric Power and Energy Saving Development Institute ('Kazakhenergoexpertiza') (subordinate organization of the Ministry of Energy of the Republic of Kazakhstan) is the operator of the State Energy Register[152] and the program 'Energy efficiency-2020' (since March 2015). 'Kazakhenergoexpertiza' is also the executor of the 59th step in the 'Plan of the Nation - 100 Concrete Steps'.[153] In industrial processes, energy efficiency potential means attracting strategic investors in the field of energy efficiency through the internationally recognized mechanism of energy service contracts. A legislative framework for energy service contracts has been created.

Address of the President to the people of Kazakhstan

On September 1, 2020, the President of the Republic of Kazakhstan delivered a message to the people of Kazakhstan: he instructed the Government of the Republic of Kazakhstan (in cooperation with the scientific community and the private sector) to develop a package of proposals for green growth, which would lay the foundations for a deep decarbonization of the national economy in the mid-term.[154] Kazakhstan intends to achieve carbon neutrality by 2060.

In February 2021 Zhassyl Damu JSC completed the PMR project of the World Bank 'Updating Kazakhstan's Nationally Determined Contribution (NDC) and developing a Roadmap for the implementation of NDC for the period after 2020'.[155]

Three main documents have been developed:

- draft updated NDC (obligations of Kazakhstan to reduce greenhouse gas emissions under the Paris Agreement until 2030);
- draft Roadmap for the implementation of the updated NDC of the Republic of Kazakhstan for 2021–2025;
- a long-term strategy for the decarbonization of the national economy involving all stakeholders in the development process. When developing the strategy, the updated NDC was taken into account.

B. Policies and measures and their impact on the IPPU sector

[152] Law of the Republic of Kazakhstan 'On Energy Saving and Energy Efficiency' (2012 г.),
[153] 'Nation Plan - 100 Concrete Steps': https://adilet.zan.kz/rus/docs/K1500000100
[154] President of Kazakhstan Kassym-Jomart Tokayev's State of the Nation Address. September 1, 2020 Kazakhstan in a new reality: time for action: https://www.akorda.kz/ru/addresses/addresses_of_president/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-1-sentyabrya-2020-g
[155] Technical report on the calculation of NDC achievement scenarios. Zhassyl Damu JSC, 24.02.2021

Summary of policies and measures and their impact on the IPPU sector

Updated NDC RK for 2022–2025

The Roadmap for the implementation of the updated NDC of the Republic of Kazakhstan for 2022-2025 has been developed with the involvement of all stakeholders in the discussion process. It includes sectoral and institutional decarbonization measures. For each measure, the document calculated the GHG emission reduction potential, investment need by funding source, spillover effects and risks in case if the measure is not implemented. In addition, the Roadmap describes measures to eliminate barriers (risks), responsible government agencies and deadlines.

In addition, it outlies measures to improve the national measurement, reporting and verification (MRV) system with key indicators that should be tracked for inventorying greenhouse gases and monitoring progress towards NDC.

Interagency coordination of the NDC roadmap implementation will be carried out by the NDC Implementation Project Office through the Unified Project Management System in the NPS, which is an information cross-platform ‘KZ 2050’ (Easy Project), launched in 2020 and currently managing more than 5,000 projects.

To accelerate the progress of decarbonization, Kazakhstan has requested assistance from the World Bank.

The Government of Kazakhstan, together with the World Bank, developed the Partnership for Market Readiness (PMR) program, which has provided short- and medium-term policy recommendations and capacity to support the country on its path to carbon neutrality.[156]

Emissions Trading System (ETS)

The PMR program helped Kazakhstan to strengthen the Emissions Trading System (ETS) and carbon markets and verified the functionality of the country's carbon inventory, as well as provided the comprehensive macroeconomic modeling needed to set caps for the 4th National Greenhouse Gas Quota Allocation Plan (NQAP) for 2021. Caps have also been proposed for the 5th and 6th National Allocation Plans for 2022-2030.

In preparation for the COP 26 UN Climate Change Conference, in November 2021 and for the Climate Change Conference in Glasgow, the PMR program has enabled the development of a Roadmap of the technical measures and investments that Kazakhstan will need to implement over the next decade in order to achieve an updated NDC.

According to the Roadmap, in the period from 2023 to 2030, Kazakhstan needs to implement targeted decarbonization measures in seven economic sectors: energy, agriculture and forestry, industry, utilities, coal industry, waste management and transport. The proposed measures to transform the electricity market, develop the heat supply market and form an energy consumption strategy in mining and metallurgy complex will be one of the most significant factors that will lead to a significant reduction in the country's energy intensity. The Roadmap also recommends increasing investment in renewable energy, energy efficiency and waste reduction.

New Environmental Code 2021

On July 1, 2021, a new Environmental Code came into force. The Code:

- outlines Kazakhstan's commitments to reduce greenhouse gas emissions;

[156] Partnership for Market Readiness (PMR), 17 July, 2021.: https://blogs.worldbank.org/ru/europeandcentralasia/paris-glasgow-and-beyond-towards-kazakhstans-carbon-neutrality-2060

– introduces requirements for the Category 1 enterprises (mostly energy sector) for the transition to integrated environmental permits and the introduction of the best available technologies (BAT).[157]

In the next 5 years, industry experts will conduct a comprehensive audit of the main polluting enterprises, to develop specific proposals for the introduction of BAT and reduction of emissions (BAT reference books).

From 2025 to 2035, it is planned to modernize and introduce new technologies, which should significantly reduce harmful emissions into the atmosphere. Natural resources users will be encouraged to install new available technologies through exemption from emissions fees for 10 years. In case of refusal to implement BAT, the rate of the fees will double every three years.

Enterprises in the sectors of energy, mining and metallurgy, cement industry, and chemical industry first will have to make the transition to BAT principles.

The Environmental Code mentions the implementation of the Emissions Trading System (ETS) and carbon markets as ways to reduce greenhouse gas emissions in Kazakhstan.

One of the main principles of the new environmental legislation is the 'polluter pays' principle. Instead of regulating all users of natural resources, the legislation focuses on the largest polluters.

Polluters that have a significant adverse environmental impact are included in Category 1. Categories 2, 3 and 4 include entities that have a moderate, insignificant, and minimal harmful impact, respectively. Payers are operators of Categories 1, 2, 3, and entities of Category 4 are excluded from tax regulation due to their insignificance.

The tax base for entities of Categories 1, 2 is determined using emission standards within the framework of an environmental permit, and entities of Category 3 are excluded from the permitting regime and payment must be made based on the declared amount of pollutant emissions.

At present, the Environmental Code of the Republic of Kazakhstan:

- maintains registers of pollution sources and sites, greenhouse gas emissions, import, export, and consumption of ozone-depleting substances;
- carries out inventory and certification of greenhouse gas emissions, issues quotas for greenhouse gas emissions and organizes quota trading and emission reductions.

On December 12, 2020, the Climate Ambition Summit was held timed to coincide with the fifth anniversary of the adoption of the Paris Climate Agreement. At the summit, the President of the Republic of Kazakhstan, Kassym-Zhomart Tokayev, announced the ambitious goal of Kazakhstan to achieve carbon neutrality by 2060

Action Plan for the Green Economy Concept for 2021–2030

On July 29, 2020, the Government of the Republic of Kazakhstan adopted Decree No. 479 'On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to green economy for 2021–2030' (Action Plan for 2021–2030), which is consistent with Kazakhstan's NDC.

[157] Environmental Code of the Republic of Kazakhstan dated January 2, 2021, No. 400-VI ZRK: https://adilet.zan.kz/rus/docs/K2100000400

Adopted long-term policy documents

State Program for Industrial and Innovative Development (SPIID) 2020–2025

SPIID for 2020-2025[158] is focused on addressing the problems in the manufacturing industry, in particular, increasing its competitiveness in the domestic and foreign markets.

The SPIID considers an integrated approach to the economic growth in the manufacturing industry, coupled with an increase in the efficiency of resource use, which, of course, should lead to a reduction in associated greenhouse gas emissions compared to the traditional development scenario. Among the measures to increase the innovative activity of enterprises are the development of innovative clusters, development of technological entrepreneurship, technology transfer, renovation of the essential equipment fleet (including based on domestic scientific developments) through the use of more efficient installations and equipment.

The program also contains several instruments to support the development, implementation, and financing of measures (including capital-intensive ones) for innovative development and improving the efficiency of manufacturing industries.

Digital Kazakhstan state program

Measures to digitalize the economic sectors within the framework of Digital Kazakhstan[159] state program allow increasing energy efficiency, thereby reducing greenhouse gas emissions.

The main task in the mining and manufacturing industry is the transition to a new technological level in accordance with the concept of Industry 4.0. This concept involves the integration of physical objects, processes, and digital technologies.

Below are the digitalization tasks within the framework of Digital Kazakhstan program in various areas that allow reducing greenhouse gas emissions.

Table 4.8. *Digitalization tasks within the framework of Digital Kazakhstan state program*

Task	Including by year		Unit
	2021	2022	
Growth in labor productivity in Mining and quarrying (compared to 2016)	30,4	38,9	%
Growth in labor productivity in Manufacturing industry (compared to 2016)	39,8	49,8	%

Emissions trading system (ETS) of Kazakhstan 2021

On January 1, 2021, the National Quota Allocation Plan for 2021 was put into effect.[160]

Kazakhstan's ETS was launched in 2013 as the first regulatory measure to meet its climate change mitigation commitments. It was introduced in 2013 but was suspended in 2016 due to system imperfections. Later in 2018, the work of the ETS was resumed, and the system is still functioning today. The current ETS quota for 2018-2020 is 485.9 mln. tons of CO_2. For the period 2021–2025, the ETS distributes quotas in the following way: in 2021, the quota must be less than the level of 1990 by 1.5%, and for each subsequent year it must be less than the level of the previous year by 1.5%. In the period from 2026 to 2030, each year the quota must also be less than the previous year by 1.5%.

[158] State program for industrial and innovative development for 2020–2025: https://idfrk.kz/ru/products/state-programs/gpiir-2020-2025/

[159] Digital Kazakhstan state program, 2018–2022.: https://digitalkz.kz/wp-content/uploads/2020/03/%D0%A6%D0%9A-%D1%80%D1%83%D1%81.pdf

[160] National Quota Allocation Plan for 2021: https://adilet.zan.kz/rus/docs/P2100000006

Although ETS has been in place in Kazakhstan since 2013, emissions at the national level continue to rise. In 2018, GHG emissions at the national level exceeded the 1990 figures by 4.05%. At the same time, some plant operators receive free quotas in excess. In 2021, this trend remained unchanged, with the number of allocated quotas increasing compared to previous years.

The MRV, adopted in January 2018, sets the total emissions for 129 companies for the period 2018-2020. Quotas are distributed in accordance with the national plan until 2020. The submitted data on greenhouse gas emissions are generated at the enterprise, confirmed by accredited bodies for verification and validation and transferred to the Register through an electronic digital signature.

C. Policies and measures in the IPPU sector that have been discontinued

In 2021, a new Environmental Code of the Republic of Kazakhstan came into force.

Regulations in force within the framework of the Environmental Code of 2007 have ceased to be in force in accordance with the following documents:

- By Decree of the Government of the Republic of Kazakhstan dated July 21, 2022, No. 512, the following decrees of the Government of the Republic of Kazakhstan have ceased to be in force:
    1. Decree of the Government of the Republic of Kazakhstan dated June 15, 2017, No. 370 'On approval of the Rules for allocating quotas for greenhouse gases emissions and forming reserves of the assigned amount and volume of quotas under the National Quota Allocation Plan'
    2. Decree of the Government of the Republic of Kazakhstan dated June 26, 2012, No. 841 'On approval of the Rules for examination, approval and implementation of projects aimed to reduce emissions and increase absorption of greenhouse gases';

- By Order of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated August 4, 2021, No. 289,[161] the following orders have become outdated:
    3. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 10, 2012, No. 148-ө 'On approval of the Rules for converting units of project mechanisms in regulation of greenhouse gas emissions and removals into quota units';
    4. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 10, 2012, No. 144-ө 'On approval of the Rules for standardization of GHG measurement and accounting';
    5. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 11, 2012, No. 150-ө 'On approval of the Rules for examination, approval and implementation of projects aimed to reduce emissions and increase absorption of greenhouse gases';
    6. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 14, 2012, No. 156-ө 'On approval of the Rules for the

[161] https://adilet.zan.kz/rus/docs/V2100023880#z54

development of internal projects to reduce greenhouse gas emissions and the list of industries and economic sectors for their implementation';

7. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 14, 2012, No. 157-ө 'On approval of the Rules for monitoring, accounting, and reporting on carbon units of greenhouse gas emissions for trading purposes';
8. Order of the acting Minister of Environmental Protection of the Republic of Kazakhstan dated August 7, 2012, No. 238-ө 'On approval of the rules and criteria for the recognition and admissibility of international standards and standards of the Republic of Kazakhstan used in the implementation of project mechanisms to regulate emissions and removals of greenhouse gases, greenhouse gas inventory, verification and validation';
9. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 14, 2012, No. 157-ө 'On approval of the Rules for monitoring, accounting, and reporting on carbon units of greenhouse gas emissions for trading purposes';
10. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 15, 2013, No. 122-ө 'On approval of the installation passport form';
11. Order of the Minister of Energy of the Republic of Kazakhstan dated February 12, 2015, No. 76 'On approval of the Rules for the implementation of project mechanisms in regulation of greenhouse gas emissions and removals'
12. Order of the Minister of Energy of the Republic of Kazakhstan dated February 12, 2015, No. 79 'On approval of the Rules for the creation and circulation of assigned amount parts, emission reduction units, certified emission reduction units, greenhouse gas absorption units and other derivatives provided for by international treaties of the Republic of Kazakhstan';
13. Order of the Minister of Energy of the Republic of Kazakhstan dated March 19, 2015, No. 221 'On approval of the Rules for monitoring and controlling GHG inventory'
14. Order of the Minister of Energy of the Republic of Kazakhstan dated June 13, 2016, No. 245 'On approval of the form of the greenhouse gas emissions monitoring plan';
15. Order of the Minister of Energy of the Republic of Kazakhstan dated December 28, 2016, No. 570 'On approval of the methodology for quota allocation from the reserve of quotas under the National Quota Allocation Plan';
16. Order of the Minister of Energy of the Republic of Kazakhstan dated July 28, 2015, No. 502 'On approval of forms for greenhouse gas inventory reports;
17. Order 'On approval of the Rules for the issuance, change and redemption of greenhouse gas emission quotas' dated June 28, 2016, No. 292;
18. Order 'On approval of the Rules for the implementation of mutual recognition of quota units and other carbon units on the basis of international treaties of the Republic of Kazakhstan' dated November 11, 2016, No. 486;
19. Order 'On approval of the list of specific greenhouse gas emission factors' dated June 28, 2017, No. 222.

- Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated June 10, 2021, No. 193:

    20. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 10, 2012, No. 147-ө 'On approval of the Rules for maintaining the state register of carbon units';
    21. Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 11, 2012, No. 151-ө 'On approval of the Rules for trading greenhouse gas emission quotas and carbon units'
    22. Order of the Minister of Energy of the Republic of Kazakhstan dated March 5, 2015, No. 176 'On approval of the Rules for maintaining and keeping the state register of emissions and removals sources';

The main provisions of the above Rules have been optimized into new regulations within the framework of the new Environmental Code by the Department for Climate Policy and Green Technologies under the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan

Below is a table of regulatory legal acts currently in force:

Table 4.8.a *Regulations under the 2007 Environmental Code*

#	Regulations under the new Environmental Code	Regulations under the 2007 Environmental Code
1.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated March 28, 2022, No. 91 'On approval of the Rules for state regulation in the field of emissions and removals of greenhouse gases'	Decree of the Government of the Republic of Kazakhstan dated June 15, 2017, No. 370 'On approval of the Rules for allocating quotas for greenhouse gases emissions and forming reserves of the assigned amount and volume of quotas under the National Quota Allocation Plan'
		Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 15, 2013, No. 122-ө 'On Approval of the installation passport form'
		Order of the Minister of Energy of the Republic of Kazakhstan dated June 13, 2016, No. 245 'On approval of the form of the greenhouse gas emissions monitoring plan'
		Order of the Minister of Energy of the Republic of Kazakhstan dated March 19, 2015, No. 221 'On approval of the Rules for monitoring and controlling GHG inventory'
		Order of the Minister of Energy of the Republic of Kazakhstan dated July 28, 2015, No. 502 'On approval of forms for greenhouse gas inventory reports'

		Order 'On approval of the Rules for the issuance, change and redemption of greenhouse gas emission quotas' dated June 28, 2016, No. 292
		Order of the Minister of Energy of the Republic of Kazakhstan dated December 28, 2016, No. 570 'On approval of the methodology for quota allocation from the reserve of quotas under the National Quota Allocation Plan'
2.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated February 22, 2022, No. 46 'On approval of the Rules for monitoring the completeness, transparency, and reliability of the state inventory of greenhouse gas emissions and removals'	Order of the Minister of Energy of the Republic of Kazakhstan dated March 18, 2015, No. 214 'On approval of the Rules for controlling the completeness, transparency, and reliability of the state inventory of greenhouse gas emissions and removals'
3.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated February 22, 2022, No. 46 'On approval of the Rules for maintaining the state carbon register'	Order of the Minister of Energy of the Republic of Kazakhstan dated March 5, 2015, No. 176 'On approval of the Rules for maintaining and keeping the state register of emissions and removals sources'
4.	Order of the acting Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated July 19, 2021, No. 260 'On approval of the List of benchmarks in the regulated economic sectors'	Order 'On approval of the list of specific greenhouse gas emission factors' dated June 28, 2017, No. 222'
5.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated July 14, 2021, No. 251 'On approval of the Rules for the formation and maintenance of the state register of carbon units'	Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 10, 2012, No. 147-ө 'On approval of the Rules for maintaining the state register of carbon units'
6.	Order of the acting Minister of Ecology, Geology and Natural Resources of the Republic of	Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 10, 2012, No. 148-ө 'On approval of the Rules for converting units of project

	Kazakhstan dated November 5, 2021, No. 455 ‘On approval of the rules for approving carbon offset and providing offset units’	mechanisms in regulation of greenhouse gas emissions and removals into quota units’ Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 11, 2012, No. 150-ө ‘On approval of the Rules for examination, approval and implementation of projects aimed to reduce emissions and increase absorption of greenhouse gases’ Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 14, 2012, No. 156-ө ‘On approval of the Rules for the development of internal projects to reduce greenhouse gas emissions and the list of industries and economic sectors for their implementation’ Decree of the Government of the Republic of Kazakhstan dated June 26, 2012, No. 841 ‘On approval of the Rules for examination, approval and implementation of projects aimed to reduce emissions and increase absorption of greenhouse gases’ Order of the Minister of Energy of the Republic of Kazakhstan dated February 12, 2015, No. 76 ‘On approval of the Rules for the implementation of project mechanisms in the field of regulation of greenhouse gas emissions and removals’ Order of the Minister of Energy of the Republic of Kazakhstan dated February 12, 2015, No. 79 ‘On approval of the Rules for the creation and circulation of assigned amount parts, emission reduction units, certified emission reduction units, greenhouse gas absorption units and other derivatives provided for by international treaties of the Republic of Kazakhstan’ Order of the acting Minister of Environmental Protection of the Republic of Kazakhstan dated August 7, 2012, No. 238-ө ‘On approval of the rules and criteria for the recognition and admissibility of international standards and standards of the Republic of Kazakhstan used in the implementation of project mechanisms to regulate emissions and removals of greenhouse gases, greenhouse gas inventory, verification and validation’
7.	Order of the acting Minister of Ecology, Geology and Natural Resources of the Republic of	Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 14, 2012, No. 157-ө ‘On approval of the Rules for monitoring, accounting, and

	Kazakhstan dated June 29, 2021, No. 221 ‘On approval of the Rules for trading carbon units’	reporting on carbon units of greenhouse gas emissions for trading purposes’; Order of the Minister of Environmental Protection of the Republic of Kazakhstan dated May 11, 2012, No. 151-ө ‘On approval of the Rules for trading greenhouse gas emission quotas and carbon units’
8.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated January 14, 2022, No. 12 ‘On approval of the Rules for validation and verification’	
9.	Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated September 13, 2021, No. 371 ‘On approval of the methods for calculating greenhouse gas emissions and removals in regulated economic sectors’	

4.3.Policies and measures in agriculture and LULUCF

This chapter describes the changes that have taken place in the legislation of the Republic of Kazakhstan, as well as institutional changes since the latest fourth biennial report on greenhouse gas emissions from agriculture and LULUCF.

A. Policy decision-making process in agriculture and LULUCF

Environmental code

In January 2021, a new Environmental Code[162] of the Republic of Kazakhstan was adopted. According to it, the main mechanism for regulating emissions is carbon quotas and a market mechanism for trading carbon quotas. The sector of land use, land-use change, and forestry is not subject to carbon quotas, according to articles 289-291 of the Environmental Code, as well as according to the National Quota Allocation Plan[163].

However, article 298 of the Code introduces the concept of carbon offset. Carbon offset refers to projects to reduce greenhouse gas emissions. A unit of carbon offset is equivalent to one ton of carbon dioxide. Further, carbon offsets can be sold on the commodity exchange between the subjects of quotas, as well as individuals and legal entities involved in the implementation of the carbon offset (Article 299 of the Environmental Code).

In view of the announcement by the President of the Republic of Kazakhstan on plans for Kazakhstan to achieve carbon neutrality by 2060, the land use, land-use change, and forestry (LULUCF) sector has significant potential to approach this ambitious goal through the implementation of offset projects. Also, in his address to the people of Kazakhstan on September 1, 2020, the President of the Republic of Kazakhstan called for a deep decarbonization of the economy.[164] Kazakhstan is systematically reducing the number of carbon quotas, which leads to

[162] Environmental code of the Republic of Kazakhstan. Dated January 2, 2021, No. 400-VI ZRK
[163] On approval of the National Quota Allocation Plan for 2021. Decree of the Government of the Republic of Kazakhstan dated January 13, 2021, No. 6.
[164] https://www.akorda.kz/ru/addresses/addresses_of_president/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-1-sentyabrya-2020-g

the search for alternative methods to reduce GHGs. The implementation of offset projects in the land use and forestry sector will allow enterprises receiving carbon credits to fit into the carbon budget in the face of reduced carbon credits.

According to the Rules for approving carbon offset and providing carbon units[165], offset projects can be implemented in the field of agriculture, planting greenery in forest and steppe areas, and preventing land degradation. Greenhouse gas emissions in offset projects in agriculture and forestry are calculated according to the methodology for calculating greenhouse gas emissions and removals.[166]

However, the implementation of offset projects by private investors and companies may conflict with Article 6 of the Constitution of the Republic of Kazakhstan.[167] Paragraph 3 of Article 6 of the Constitution of the Republic of Kazakhstan states that flora and fauna, other natural resources are state property. Also, a significant barrier to the development of the private forest fund is the complexity of the procedure for processing documents for the private forest fund.[168] As a result, there are only about 500 hectares of forest in the private forest fund in the Republic of Kazakhstan.

In view of the introduction of fines (5 MCI per ton of CO_2 equivalent) for exceeding the allocated quotas for enterprises of Category 1 in Article 329 of the Administrative Code[169] of the Republic of Kazakhstan and the gradual decrease in the number of allocated quotas, it is possible to increase the interest of industrial enterprises in offset projects in the field of forestry and agriculture.

The new Environmental Code pays special attention to land protection (Articles 228–238 of the Environmental Code). According to paragraph 3 of Article 228 of the Environmental Code, lands are subject to protection from degradation and depletion of soils, disturbance, and deterioration of lands (wind erosion, desertification, etc.). Additionally, Article 238 of the Environmental Code requires individuals and legal entities to prevent soil degradation and depletion when using land. Paragraph 4 of Article 228 of the Environmental Code obliges to prevent the degradation and death of forests, violation of the sustainability of ecological systems.

Articles 260-265 of the Environmental Code are dedicated to forest protection. According to Article 262, a protection zone 20 meters wide shall be established along the borders of state forest fund plots. Article 264 states that activities that have a negative impact on the green fund of urban and rural settlements shall be prohibited. According to Article 265, clear-cutting shall be prohibited in the green belts, as well as the disposal of hazardous waste and other substances that adversely affect the environment.

Forest Code and forestry

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[165] 'On approval of the Rules for approving carbon offset and providing offset units', Order of the acting Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated November 5, 2021, No. 455. Registered with the Ministry of Justice of the Republic of Kazakhstan on November 9, 2021 No. 25074.

[166] 'On approval of methodologies for calculating emissions and removals of greenhouse gases', Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated September 13, 2021, No. 371. Registered with the Ministry of Justice of the Republic of Kazakhstan on September 16, 2021 No. 24383.

[167] Constitution of the Republic of Kazakhstan.

[168] 'On approval of the Rules for the transfer of lands of other categories to the lands of the forest fund', Order of the Deputy Prime Minister of the Republic of Kazakhstan - Minister of Agriculture of the Republic of Kazakhstan dated August 28, 2017, No. 364. Registered with the Ministry of Justice of the Republic of Kazakhstan on October 17, 2017, No. 15901.

[169] Code of administrative offenses. Code of the Republic of Kazakhstan dated July 5, 2014 No. 235-V ZRK.

Forest fund protection and conservation now provides for the implementation of measures to adapt to climate change and reduce vulnerability to climate change in accordance with paragraph 10 of Article 62 of the Forest Code[170].

The President of the Republic of Kazakhstan Tokayev, in his Address to the people of Kazakhstan on September 1, 2020, instructed to plant 2 billion trees in the forest fund and 15 million trees in settlements over 5 years from 2021 to 2025, as well as to develop an interactive map to monitor the progress of these works.[171] He also called for more active protection of national natural parks. So far, 80 million trees have been planted. About 30% of the 2 billion trees will be saxaul.[172]

According to the national project 'Sustainable economic growth aimed at improving the well-being of Kazakhstanis,'[173] a systematic increase in the share of renewable energy, including biofuel, is planned in the country. In 2021, as part of the implementation of the policy to increase the share of renewable energy in the Republic of Kazakhstan, two biopower plants with a total capacity of 5 MW were contracted.[174]

The Green Kazakhstan project[175] was created to implement the initiative of the President of the Republic of Kazakhstan to plant two billion trees. The project provides for the planting of 133 thousand hectares of forest by 2025 (with a budget of KZT46.4 billion for 2021-2025). This project also provides for increasing the area of specially protected natural areas (SPNA) from 7,593 thousand hectares in 2021 to 7,767 thousand hectares in 2025. Another strategic goal of the Green Kazakhstan project is the effective use of water by reducing irrigation losses by 4 km^3 per year by 2025, as well as additional water storage of 1.7 km^3.

Since 2021, a system has been introduced for providing forests of the state forest fund for long-term forest management through auctions[176] and the State Register platform (www.gosreestr.kz). The land of the state forest fund will be available for long-term forest management to those individuals and companies that will offer the highest price for it. The State Register platform can be used in the future to allocate land of other categories for afforestation purposes.

The concept for the transition of the Republic of Kazakhstan to a green economy[177] provides for measures to improve the mechanism to create private industrial plantations and forest nurseries, green areas around regional centers and cities of national significance.

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[170] Forest Code of the Republic of Kazakhstan. Code of the Republic of Kazakhstan dated July 8, 2003 No. 477.

[171] https://www.akorda.kz/ru/addresses/addresses_of_president/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-1-sentyabrya-2020-g

[172] https://www.inform.kz/ru/posadka-dvuh-mlrd-derev-ev-po-kazahstanu-kak-vyraschivayut-sazhency-i-uhazhivayut-za-nimi_a3815404

[173] On approval of the national project 'Sustainable economic growth aimed at improving the welfare of Kazakhstanis'. Decree of the Government of the Republic of Kazakhstan dated October 12, 2021 No. 730

[174] https://vie.korem.kz/eng/

[175] On approval of the national project 'Green Kazakhstan'. Decree of the Government of the Republic of Kazakhstan dated October 12, 2021 No. 731

[176] On amendments to the order of the Minister of Agriculture of the Republic of Kazakhstan dated October 7, 2015, No. 18-02 / 896 'On approval of the Rules for conducting tenders for provision of forest resources to the long-term forest management in the state forest resources.'

Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated October 20, 2021 No. 414. Registered with the Ministry of Justice of the Republic of Kazakhstan on October 21, 2021 No. 24839

[177] On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a green economy for 2021-2030. Decree of the Government of the Republic of Kazakhstan dated July 29, 2020 No. 479

Land Code

Punishments for land users who destroy soil fertility have become tougher. Paragraph 5 of Article 93 of the Land Code states:[178] "In cases where the use of a land plot or its part, has led to a significant decrease in the fertility of agricultural land or environmental damage, the owner of the land plot or land user shall be obliged to eliminate the damage in accordance with the legislation of the Republic of Kazakhstan".

The Code of Administrative Offences of the Republic of Kazakhstan provides for fines for the deterioration of soil fertility (Article 337 of the Code of Administrative Offenses of the Republic of Kazakhstan).

According to the same article 93 of the Land Code (paragraphs 2, 4), if a land plot is used with violation of the legislation of the Republic of Kazakhstan, such a land plot is subject to expropriation. This way, the state increases attention to the loss of humus on the cultivated lands of the Republic of Kazakhstan

Ministry of Agriculture

According to the national project for the development of the agro-industrial complex (AIC) of the Republic of Kazakhstan for 2021–2025,[179] it is planned to subsidize breeding stock in the country. For example, the average weight of large cattle is planned to be raised from the current 336 kg to 400 kg in 2025. For these purposes, it is planned to allocate about KZT100 billion or about USD230 million annually from 2021 to 2025.

In addition, it is planned to increase fertilizer subsidies by 1.4 times from KZT27 billion in 2021 to KZT41 billion in 2025. The national project provides for an increase in subsidies for high-quality seeds by 1.2 times through subsidizing seed production. It is planned to spend KZT15-20 billion annually on subsidizing seed production, which will allow providing about 200 thousand tons of seeds every year.

In July 2021, changes were adopted in the rules for subsidizing livestock breeding, increasing the productivity and quality of livestock products.[180] These changes involve digitalization and automation in obtaining subsidies in livestock production.

The concept for the transition of the Republic of Kazakhstan to a green economy[181] approved the action plan of the Government of the Republic of Kazakhstan, which will be undertaken until 2030. In agriculture, it is planned to support organic farming, analyze land degradation, introduce mechanisms that ensure the sustainable use of land resources, and build biogas plants at poultry farms.

The government is currently reviewing a draft resolution 'On approval of Nationally Determined Contributions of the Republic of Kazakhstan (NDC)'. [182] If this resolution is adopted, the government of the Republic of Kazakhstan will stimulate the creation of private industrial

[178] Land Code of the Republic of Kazakhstan. Code of the Republic of Kazakhstan dated June 20, 2003 No. 442.
[179] On approval of the national project for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2025. Decree of the Government of the Republic of Kazakhstan dated October 12, 2021 No. 732.
[180] On amendments to the order of the Minister of Agriculture of the Republic of Kazakhstan dated March 15, 2019, No. 108 'On approval of the Rules for subsidizing the development of livestock breeding, increasing the productivity and quality of livestock products'. Order of the acting Minister of Agriculture of the Republic of Kazakhstan dated July 13, 2021 No. 207. Registered with the Ministry of Justice of the Republic of Kazakhstan on July 14, 2021 No. 23503
[181] On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a green economy for 2021-2030. Decree of the Government of the Republic of Kazakhstan dated July 29, 2020 No. 479
[182] https://legalacts.egov.kz/npa/view?id=11811525

forest plantations and nurseries. Moreover, it is planned to create pilot projects in the forest sector with public-private partnerships, as well as to take further measures to protect forests.

The draft resolution 'On approval of Nationally Determined Contributions of the Republic of Kazakhstan (NDC)' will also stimulate the rational use of soils of arable land and pastures, the transition to water-saving technologies and drip irrigation.

Auction cap prices for electricity from biogas plants remain unchanged, although auction caps for other forms of renewable energy have dropped significantly.[183]

[183] On amendments to the order of the Minister of Energy of the Republic of Kazakhstan dated January 30, 2018, No. 33 'On approval of the maximum auction prices'. Order of the Minister of Energy of the Republic of Kazakhstan dated March 15, 2021, No. 82. Registered with the Ministry of Justice of the Republic of Kazakhstan on March 17, 2021 No. 22348.

B. Policies and measures and their impact on agriculture and LULUCF

Summary of policies and measures and their impact on agriculture and LULUCF

Table 4.9. *Summary of policies and measures and their impact on agriculture and LULUCF*

#	Policy or measure	Sector affected	GHGs affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
										2021	2025	2030	2035
1	Offset projects in land use	LULUCF	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Measures to reduce GHG emissions in the LULUCF sector	2021	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan	0	70	350	350
2	Offset projects in forestry	LULUCF	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Forest cultivation, fighting fires	2021	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan	50	50	50	50
3	Prevention of land degradation and desertification	LULUCF	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Forest planting and sustainable land use	2021	MOA	50	50	50	50
4	Forest cultivation (2 billion trees)	LULUCF	CH_4	Reduction of GHG emissions	Regulatory	Adopted	Forest planting	2021	MOA, akimats	100	1400	1400	1400
5	Fertilizer subsidies	LULUCF	CO_2		Regulatory	Adopted	Subsidizing the purchase of fertilizers for farmers	2016	MOA	30	30	30	30

6	Support for livestock breeding	LULUCF	CH_4	Increasing livestock productivity	Regulatory	Adopted	Subsidizing the purchase of breeding stock	2021	MOA	0	180	180	180
7	Rational use of cultivated land	LULUCF	CO_2	Prevention of cultivated land degradation	Regulatory	Adopted	Crop rotation, fertilization, etc.	2021	MOA	0	180	180	180
8	Rational use of pastures	LULUCF	CO_2	Prevention of pasture degradation	Regulatory	Adopted	Even distribution of load on pastures	2021	MOA	0	180	180	180
9	Support for private industrial forest plantations	LULUCF	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Improving legislation for investors	2021	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan	0	30	60	90

C. Policies and measures in agriculture and LULUCF that have been discontinued

There were no measures to reduce GHG emissions in the LULUCF sector. Therefore, there are no policies and measures that have been discontinued.

4.4.Policies and measures in waste management

A. Political decision-making process in waste management

Environmental code

Below are the changes made to the legislation of the Republic of Kazakhstan since the latest fourth biennial report in the field of waste management regarding the reduction of greenhouse gas emissions. Most of the changes cover the new Environmental Code of January 2, 2021, which came into force on July 1, 2021.

According to article 33 of the Environmental Code, the collection, sorting and (or) transportation of waste shall be performed with prior notification, therefore, in accordance with article 173, it is subject to state environmental control.

According to Articles 38 and 41 of the Environmental Code, for enterprises of Category 1 and 2, limits on waste accumulation and disposal are introduced. Waste accumulation and disposal limits are set in an environmental permit to ensure environmental protection and favorable conditions for human life and (or) health, reduce the amount of waste to be disposed of and stimulate their reuse.

Changes have been made in Waste-to-Energy. From now on, in accordance with Article 130 of the Environmental Code, the state guarantees the purchase of electricity produced by waste-to-energy facilities by the financial settlement center to support renewable energy sources in accordance with the legislation of the Republic of Kazakhstan on the use of renewable energy sources. According to Article 324 of the EC, costs for the construction and operation of new waste-to-energy facilities are reimbursed through the purchase of electricity by the financial settlement center for the support of renewable energy sources.

In July 2021, Kazakhstan operator of electricity and power market operator (KOREM JSC) held the auction for waste-to-energy projects. As a result of the auction, six waste incineration plants with a total capacity of 100 MW will be built: in Astana, Almaty, Aktobe, Ust-Kamenogorsk, Karaganda and Shymkent. One kW of electricity produced at these plants will be purchased at 172.71 KZT.

The concept of an internal project aimed at reducing emissions and increasing the absorption of greenhouse gases was replaced by the concept of carbon offset in the new Environmental Code (Article 298). According to the Rules[184] for the implementation of projects aimed to reduce emissions and increase absorption of greenhouse gas emissions, it is possible to implement projects in the field of processing municipal and industrial waste.

Article 321 of the EC requires individuals and legal entities to perform separate waste collection. Separate waste collection refers to the collection of waste separately by type or group to simplify further specialized management. According to it, waste is divided into ‘dry’ and ‘wet’. ‘Dry’ waste includes 1) paper, cardboard, metal, plastic, and glass. ‘Wet’ waste, in turn, includes food waste, organics and more. To implement separate collection, a draft order ‘Requirements for separate waste collection, including types or groups of waste subject to mandatory separate

[184] On approval of the Rules for examination, approval and implementation of projects aimed to reduce emissions and increase absorption of greenhouse gases. Decree of the Government of the Republic of Kazakhstan dated June 26, 2012 No. 841.

collection, taking into account technical, economic and environmental feasibility' was developed. According to this draft order, which is expected to be adopted soon, individuals, individual entrepreneurs and legal entities that are waste generators shall collect waste separately at least by fractions, in accordance with paragraph 4 of Article 321 of the EC and transfer the separately collected waste to business entities engaged in waste management that sort, process, neutralize and restore waste. It is also prohibited to mix wastes subjected to separate collection at all further stages of waste management.

Article 344 of the Code of Administrative offences introduces fines for violations in the field of waste management and collection. Violation of environmental requirements for the accumulation, collection, transportation, accounting, recovery, and disposal of waste imposes a fine on individuals in the amount of forty monthly calculation indices (MCI), on officials, small businesses, or non-profit organizations - one hundred MCI, on medium-sized businesses - two hundred MCI, on large businesses - five hundred MCI.

According to Article 365 of the EC, separate waste collection shall be performed by local representative bodies of districts, cities of regional significance, cities of national significance, the capital.

Article 350 of the EC introduces environmental requirements for landfills. It is required to equip landfills with systems for collection and disposal of leachate and landfill gas. The landfill operator shall take steps to reduce methane emissions from landfills by reducing the amount of biodegradable waste landfilled and installing landfill gas collection and disposal systems. Biodegradable waste refers to any waste that can undergo anaerobic or aerobic decomposition, such as food and garden waste, and paper and cardboard as well as food waste comparable to food industry waste, wastepaper.

According to Article 351 of the EC, in addition to the ban on the disposal of plastic, paper and glass, from 2021a ban on the disposal of food waste came into force.

From now on, according to Article 354 of the EC, landfill operators have the right to accept for disposal only those types of waste that are allowed for disposal at this landfill and the right to dispose of which is confirmed by an environmental permit.

The regulation of various disposal fees is governed by articles 386-392 of the Environmental Code. Operator of extended producer (importer) responsibility ROP LLP is a legal entity determined by the decision of the Government of the Republic of Kazakhstan for the purpose of implementing the principle of producer (importer) extended responsibility. That is, the Operator accepts various disposal fees for recycling and processing from importers and manufacturers of auto components, vehicles, packaging (paper, plastic, glass, and others), cable and wire products. The amount of disposal fee to the Operator is calculated according to the Methodology for calculating fees for organizing the collection, transportation, processing, neutralization, use and (or) disposal of waste.[185]

In accordance with Article 366 of the Environmental Code, the Operator of producer (importer) extended responsibilities sends the money received to their bank account from producers and importers to reimburse the costs of entities that collect, transport, sort, process,

[185] On approval of the Methodology for calculating fees for organizing the collection, transportation, processing, neutralization, use and (or) disposal of waste. Order of the Minister of Energy of the Republic of Kazakhstan dated December 25, 2015 No. 762. Registered with the Ministry of Justice of the Republic of Kazakhstan on December 31, 2015 No. 12753.

process, neutralize and (or) dispose of waste, dispose of solid household waste, and liquidate spontaneous dumps.

B. Policies and measures and their impact on waste management

Summary of policies and measures and their impact on waste management

Table 4.10. *Summary of policies and measures and their impact on waste management*

#	Policy or measure	Sector affected	GHGs affected	Goal and/or activity affected	Instrument type	Progress	Brief description	Starting year	Implementing entity(s)	Mitigation impact assessment (non-cumulative, kt of CO_2-eq.)			
										2021	2025	2030	2035
1	Changes in the Environmental Code (prohibition of paper, plastic, glass, and food waste disposal)	Waste management	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Measures aimed at reducing GHG emissions in the waste management sector. Reducing the amount of waste that ends up in landfills	2021	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan and local representative bodies	50	100	150	200
2	Changes in the Environmental Code - separate waste collection	Waste management	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Measures aimed at reducing GHG emissions in the waste management sector. Reducing the amount of waste that ends up in landfills.	2021	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan and local representative bodies	50	50	50	50
3	Waste-to energy	Waste management	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Measures aimed at reducing GHG emissions in the waste management	2021	ME RK	0	180	180	180

							sector. Disposal of non-recyclable waste. Saving limited fossil fuel resources. Reducing the area allocated for waste disposal.						
4	Disposal of retired vehicles	Waste management	CO_2	Reduction of GHG emissions	Regulatory	Adopted	Measures aimed at reducing GHG emissions in the waste management sector.	2016	Operator of extended obligations of manufacturers (importers)	30	30	30	30

C. Policies and measures in waste management that have been discontinued

In this sector, there are no policies and measures that have been discontinued**.**

4.5.Integrating gender into relevant laws and policies related to climate change

Section II ‘Person and Citizen’ of the Constitution of the Republic of Kazakhstan states that “no one shall be subject to any discrimination for reasons of origin, social, property status, occupation, sex, race, nationality, language, attitude towards religion, convictions, place of residence or any other circumstances” (Article 14) and “no one shall be subjected to torture, violence, abusive or other treatment and punishment degrading human dignity” (Article 17).

In 2009, the Law ‘On state guarantees of equal rights and opportunities for men and women’ was adopted. Article 21 of the Criminal Procedure Code of the Republic of Kazakhstan dated July 4, 2014, stipulates: **“Justice is administered based on equality before the law and the court. During criminal proceedings, no one may be subjected to any discrimination on grounds of origin, social, official or property status, sex, race, nationality, language, attitude to religion, beliefs, place of residence or any other circumstances”.**

In November 2006, the National Gender Equality Strategy for 2006-2016 was adopted. The goal is to create conditions for equal rights and opportunities for men and women proclaimed by the Constitution of the Republic of Kazakhstan and international acts to which Kazakhstan has joined, as well as their equal participation in all spheres of society.

The strategic task is to unite the efforts of state bodies and the whole society to implement a socially just gender policy.

In December 2016, the Concept of family and gender policy in the Republic of Kazakhstan until 2030 was adopted. The concept of the policy is to achieve parity rights, benefits, duties and possibilities of men and women in all spheres of life, overcoming all forms and manifestations of sexual discrimination. The stated goals are achieved by implementing ten tasks:

Among them:

- Creating mechanisms and conditions for effective planning and coordination of central and local authorities in the implementation of gender policy;
- Examining and assessing the implementation of gender approaches in the system of state and budget planning; and
- Developing normative legal acts aimed at ensuring equal rights and equal opportunities for men and women.

Nine target indicators have been identified, the results of which will be summed up by 2020, 2023 and 2030. Subsections: Strategy for the implementation of family policy and Strategy for the implementation of gender policy. Gender aspects of the concept will be developed in the following areas:

- Strengthening gender equality through state regulation and the introduction of gender impact assessment in the system of state and budget planning, as well as in the development of regulatory legal acts;
- Preventing violence against women;
- Ensuring equal access of men and women to all types of resources necessary for conducting business;

- Creating conditions to ensure equal employment for men and women;
- Promoting gender education;
- Increased participation of women in peace and security.

The implementation period is divided into 3 stages: 2017 – 2019; 2020 – 2022; and 2023-2030 and is based on the implementation of the Action Plan for the implementation of the Concept.

Currently, the second stage (2020-2022) of the Action Plan (Decree No. 315 May 2020) is in progress.

Integrating a gender perspective into climate action at the national and subnational levels is essential to the implementation of gender policies in the country. The effectiveness of climate change policy depends on the extent to which the interests of men and women are considered in laws, programs, and projects, as well as the extent to which they are represented at decision-making levels. Gender policy is integrated with social policy. Based on this, an attempt was made to evaluate the mainstreaming of gender in documents that directly or indirectly deal with climate change issues. The level of gender mainstreaming was assessed according to the following criteria:

- Lack of gender reference
- Gender is recognized
- Gender sensitive

Below is a table listing the laws, policies, strategies, plans, and guidelines published on climate change, environment, gender, agriculture, forestry, and energy issues and assessing the extent to which climate change and gender considerations are integrated into policies and implementation processes.

Table 2.29. *Key policy documents relevant to climate change and gender issues.*

#	Name	Implementation period	Level of gender mainstreaming: • Lack of gender reference • Gender is recognized • Gender sensitive
1	2	3	4
1	Environmental Code of the Republic of Kazakhstan dated January 2, 2021, No. 400-VI ZRK.	From July 1, 2021	Chapter 20. State regulation in the field of GHG emissions and absorptions. Chapter 22. Public administration in the field of climate change adaptation. In accordance with the Environmental Code, priority areas for climate change adaptation and vulnerability assessment are agriculture, water and forestry, civil protection. Gender is indirectly presented in Article 4, paragraph 3. **Environmental security and environmental foundations for sustainable development of the Republic of Kazakhstan** – the participation of the Republic of Kazakhstan in the global response to the threat of climate change through the implementation of measures to prevent climate change and adapt to it, as well as to protect the ozone layer of the Earth’s atmosphere (implementation of UNFCCC gender decisions)

2	Rules for organizing and implementing the climate change adaptation process[186] Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated June 2, 2021, No. 170	From July 1, 2021	No gender references
3	Strategic plan of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan for 2020-2024[187]	2020–2024	Climate change issues are considered. One of the Plan´s goals is to create conditions for the transition to a ‘green’ economy, including the reduction of greenhouse gas emissions No gender references
4	Strategic plan of the Ministry of Agriculture of the Republic of Kazakhstan for 2020 – 2024, No. 476 dated December 31, 2019[188]	2020-2024	Climate change is recognized. No gender references.
5	State program for the development of regions for 2020–2025, Decree of the Government of the Republic of Kazakhstan dated December 27, 2019, No. 990.	2020–2025	No gender and climate references
6	Strategic plan of the Ministry of Energy of the Republic of Kazakhstan No. 445 dated December 31, 2019.	2020–2024	No gender references. Climate change is considered. Strategic direction 1. Development of the electric power industry, the use of nuclear energy and renewable energy sources.
7	Forecast scheme for territorial and spatial development of the country until 2030 [189] Decree of the Government of the Republic of Kazakhstan dated August 23, 2019, No. 625, submitted by the draft Decree of the		Climate change is recognized – paragraph 1.3. Analysis of challenges and trends affecting the territorial development of the country; environmental protection measures and water-saving technologies are planned. Gender references.

[186] https://adilet.zan.kz/rus/docs/V2100022974
[187] https://www.gov.kz/memleket/entities/ecogeo/documents/details/54833?lang=ru
[188] https://www.gov.kz/memleket/entities/moa/documents/details/123797?lang=ru
[189] https://adilet.zan.kz/rus/docs/P1900000625

	President of the Republic of Kazakhstan for approval		
8	Law of the Republic of Kazakhstan '**On Electric Power Industry'**, July 9, 2004, No. 588		References to climate change – **Article 3. Goals and objectives of state regulation in the field of electric power industry, paragraph 6:** use and development of renewable and non-traditional energy sources. No gender references.
9	Forest Code[190], July 8, 2003, No. 477		No gender references. Climate references. In accordance with Article 3. The principles of the forest legislation of the Republic of Kazakhstan recognize the national importance of forests that perform climate-regulating, environment-forming, field and soil protection, water protection and sanitary and hygienic functions.
	Water Code[191], July 9, 2003, No. 481		• Climate change is recognized, and action is planned. In accordance with **Article 37. Competence of authorized bodies, departments of the authorized body (paragraphs 1-2 – 1-5) and Article 39. Competence of local executive bodies of regions (cities of national significance, the capital) in the field of use and protection of the water fund, water supply and sanitation** (paragraphs 5.1-5.4). The mentioned bodies: • evaluate vulnerability to climate change within their competence; • define, within their competence, priorities, and measures for climate change adaptation; • implement climate change adaptation measures within their competence; • monitor and evaluate the effectiveness of climate change adaptation measures defined within their competence and adjust these measures based on monitoring and assessment. No gender references. Article 9. Principles of water legislation of the Republic of Kazakhstan, paragraph 3 stipulates fair and equal access of the population to water.

It would be useful to comprehensively analyze the current legislation, as well as legislation that is under preparation, from a gender equality perspective. The analysis is most useful in those sectors where gender asymmetry is especially strong, for example, energy, industry, agriculture, forestry, and water management, etc. Branches of legislation that have not previously been studied from a gender perspective should also be analyzed.

Policy effectiveness is affected by the limited capacity of line ministries and agencies to conduct in-depth gender analysis, advocacy, and gender mainstreaming.

[190] https://adilet.zan.kz/rus/docs/K030000477_
[191] https://adilet.zan.kz/rus/docs/K030000481_

There is a need for technical and financial support to scale up action at both the national and regional levels. The problems identified are related to the lack of knowledge and skills, as well as the lack of experience necessary for the systematic and holistic implementation of the gender mainstreaming mechanism.

There is limited coordination among relevant stakeholders coupled with an insufficient budget for the implementation of gender plans and activities.

V. FORECASTS AND OVERALL IMPACT OF POLICIES AND MEASURES

5.1.Forecasts and overall impact of policies and measures in the energy sector

A. Forecasts for the energy sector

Scenarios for GHG emissions in the energy sector

This section provides information on forecasts for without measures scenario, with current measures scenario and with additional measures scenario.

To obtain forecasts of GHG emissions and assess the overall effect of the energy sector, a model of the energy system of the Republic of Kazakhstan was used based on the TIMES (The Integrated MARKAL-EFOM System) tool, created as part of the project to develop the Low-Carbon Development Strategy of the Republic of Kazakhstan until 2060. A description of the model is given in the 'Methodology' subsection of this section.

The following scenarios for the development of the energy system of Kazakhstan were considered:

1) without measures scenario (WOM);
2) with current measures scenario (WCM);
3) with additional measures scenario (WAM).

General assumptions for all scenarios

Here are the general assumptions used for all scenarios:

- GDP in the period 2022-2026, according to the forecast of socio-economic development of the Republic of Kazakhstan (MNE RK), and further until 2030 will grow at 4.0% per year, until 2035 – at 3.5% per year.[192]
- Population growth in the period 2022–2026, according to the forecast of socio-economic development of the Republic of Kazakhstan (MNE RK) and further until 2035, will be annually in the range of 0.8–0.9% per year
- Quota trading system is not taken into account due to the lack of approved limits for the considered forecast period.
- Oil production will rise to a peak (115 million tons) by 2035
- Gasification of the country continues according to the forecast gas balance of the Republic of Kazakhstan, as a minimum and, according to the scenario assumptions, as a maximum.

Without measures scenario (WOM)

This scenario shows changes in greenhouse gas emissions with no measures taken to reduce them. Further economic growth is due to the use of coal as a fuel for energy production. This scenario assumes that greenhouse gas emissions depend on the overall growth rate of GDP and population.

With current measures scenario (WCM)

This scenario includes measures and policies adopted and planned that are aimed directly at reducing greenhouse gas emissions:

- share of electricity generation from natural gas is expected to be at the level of 20%

[192] https://www.gov.kz/memleket/entities/economy/documents/details/208527?directionId=201&lang=ru

and 25% in 2020 and 2030, respectively;

– share of electricity generation from RES is expected to be at the level of 3%, 6%, 15% in 2020, 2025 and 2030.

With additional measures scenario (WAM)

This scenario includes possible measures and policies that are aimed directly at reducing GHG emissions:

- share of coal production is to be at the level of 40% by 2030;
- commissioning of a nuclear power plant (NPP) with a capacity of 1.5 GW in 2030 and 2.0 GW in 2050;
- carbon tax on sectors outside ETS.

Table 5.1 *Scenario assumption matrix*

General assumptions for all scenarios	**Without measures scenario**	**With current measures scenario**	**With additional measures scenario**
General assumptions for all scenarios			
Emissions trading system	X	X	X
GDP in the period 2022-2026, according to the forecast of socio-economic development of the Republic of Kazakhstan (MNE RK), and further until 2030 will grow at 4.0% per year, until 2035 - at 3.5% per year	V	V	V
Population growth in the period 2022–2026, according to the forecast of socio-economic development of the Republic of Kazakhstan (MNE RK) and further until 2035, will be annually in the range of 0.8–0.9% per year	V	V	V
Oil production will rise to a peak (115 million tons) by 2035	V	V	V
Gasification of the country continues according to the forecast gas balance of the Republic of Kazakhstan, as a minimum and, according to the scenario assumptions, as a maximum	V	V	V
2020 – 24 587 mln m^3 (min)	V	V	V
2025 – 22 243 mln m^3 (min)	V	V	V
2030 – 21 016 mln m^3 (min)	V	V	V
Assumptions by scenario			
Share of electricity generation from natural gas is expected to be at the level of 20% and 25% in 2020 and 2030, respectively	X	V	V
Share of electricity generation from RES is expected to be at the level of 3%, 6%, 15% in 2020, 2025 and 2030	X	V	V
Share of coal production is to be at the level of 40% by 2030	X	X	V
Commissioning of a nuclear power plant (NPP) with a capacity of 1.5 GW in 2030 and 2.0 GW in 2050	X	X	V
Carbon tax on sectors outside ETS	X	X	V

Greenhouse gas emissions from the energy sector

Without measures scenario, with current measures scenario and with additional measures scenario are based on the technical and economic modeling of the energy sector. Greenhouse gas emissions for all three scenarios are presented in Figure 5.1.

According to the graph (Figure 5.1), the current measures allow emissions to stabilize at a level slightly higher than the current level until 2030, and then until 2035 there will be a further increase in GHG emissions.

To reduce GHG emissions from the energy sector to a level lower than minus 15% of the 1990 level (in the energy sector), additional measures are needed. In this analysis, such measures include reducing the level of coal in electricity generation to 40% by 2030 (after 2030 no more than 40%), the commissioning of a 1.5 GW nuclear power plant in 2030, and the introduction of a carbon tax on GHG emissions from non-quota sectors. The carbon tax is set at USD2 per ton of CO_2-eq in 2023, from 2024 to 2030 - an annual increase of USD2 per ton of CO_2-eq (in 2030 - USD16 per ton of CO_2-eq). From 2031 to 2035, the carbon tax should increase by USD2.5 annually, but already cover not only CO_2-eq, but also other GHGs (methane and nitrous oxide), reaching USD29 in 2035.

Figure 5.1. *Scenarios for greenhouse gas emissions in the energy sector, kt of CO_2-eq.*

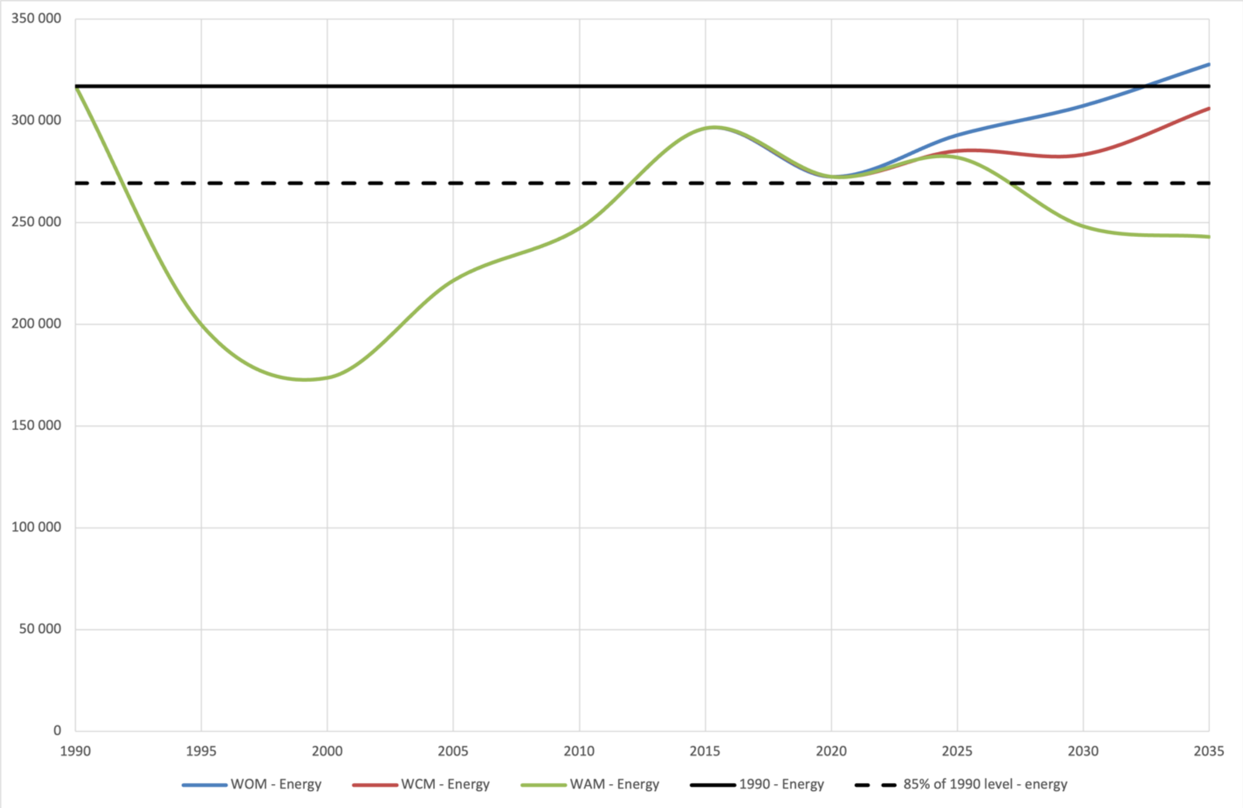


Table 5.2. *Scenarios for greenhouse gas emissions in the energy sector, Mt of CO2-eq.*

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
WOM – energy sector	316.9	199.8	173.8	221.6	247.1	296.3	272.5	292.9	307.3	327.7
WCM – energy sector	316.9	199.8	173.8	221.6	247.1	296.3	272.5	285.2	283.3	306.0
WAM – energy sector	316.9	199.8	173.8	221.6	247.1	296.3	272.5	282.0	248.2	243.0

GHG emissions from energy subsectors

This part of the analysis provides sectoral breakdowns of emissions in energy subsectors by scenarios, according to the IPCC classification.

Generation of heat and electricity

GHG emissions from this subsector by scenarios are presented in Figure 5.2 below.

Figure 5.2 *Scenarios for greenhouse gas emissions from electricity generation, kt of CO_2-eq.*

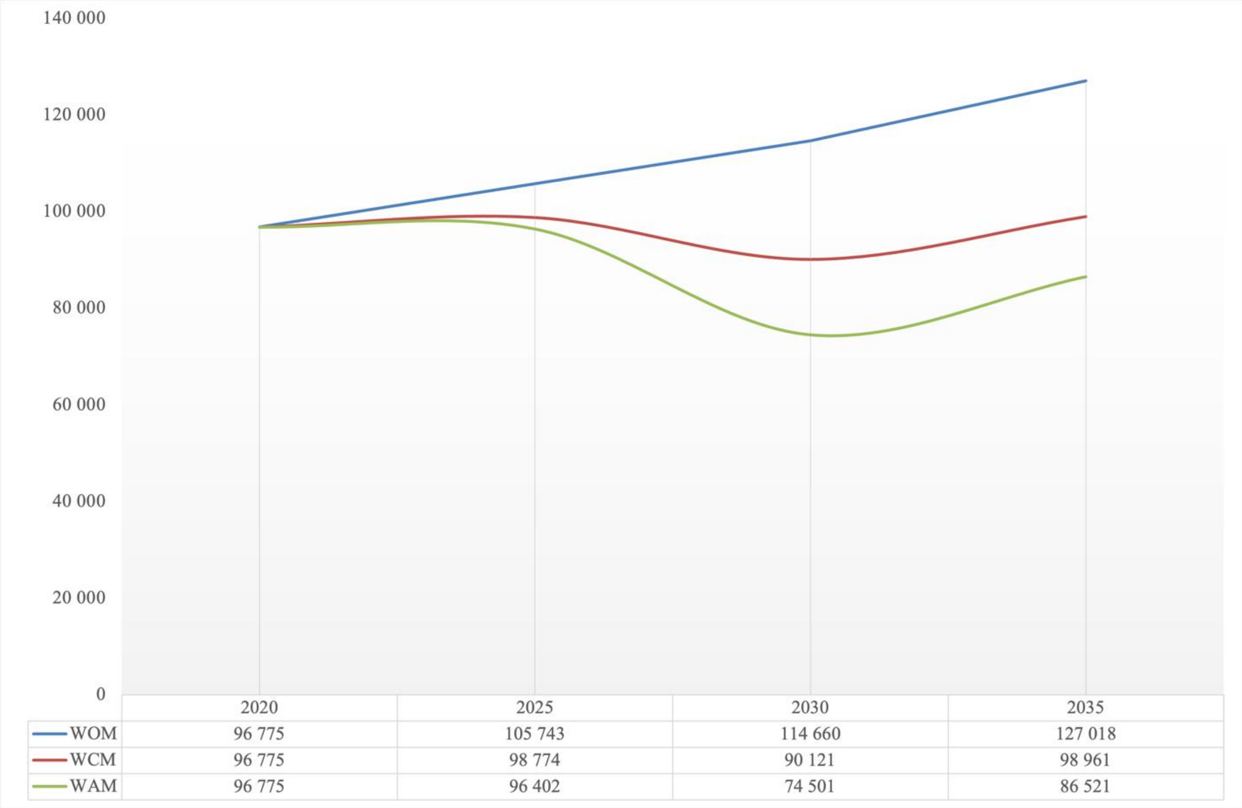


Figure 5.3. *Scenarios for electricity generation, billion kWh*

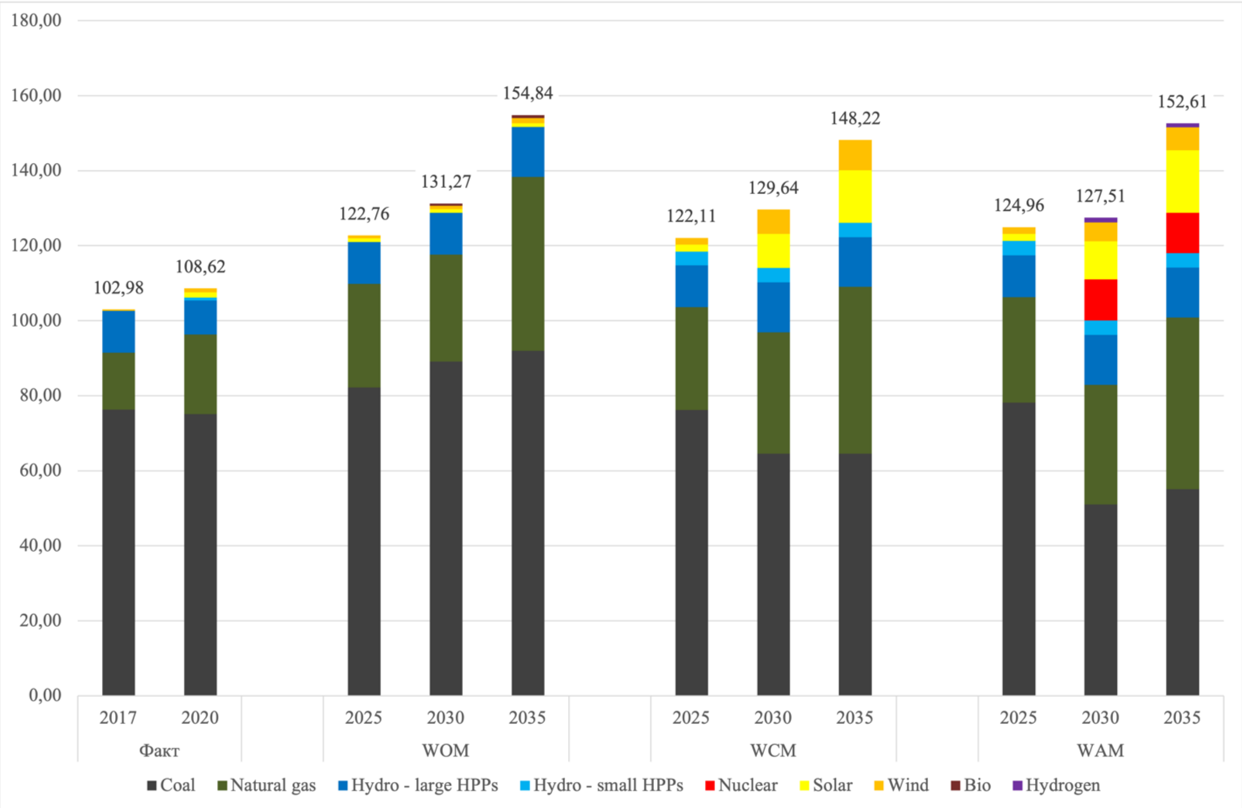


Table 5.3. *Electricity generation, billion kWh*

	Fact		WOM			WCM			WAM		
	2017	2020	2025	2030	2035	2025	2030	2035	2025	2030	2035
Coal	76.28	75.11	82.19	89.12	91.93	76.15	64.51	64.56	78.19	51.04	55.12
Natural gas	15.16	21.17	27.62	28.51	46.45	27.48	32.40	44.44	28.12	31.87	45.77
Hydropower - large HPPs	11.16	9.10	11.16	11.20	13.28	11.16	13.28	13.28	11.16	13.28	13.28
Hydropower – small HPPs	0.00	0.81	0.00	0.00	0.00	3.67	3.86	3.86	3.85	3.86	3.86
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.95	10.74
Solar	0.04	1.35	0.97	0.97	1.00	1.85	9.10	13.94	1.85	10.23	16.64
Wind	0.34	1.08	0.82	0.82	1.42	1.80	6.48	8.14	1.80	5.03	6.21
Bio	0.00	0.00	0.00	0.66	0.77	0.00	0.00	0.00	0.00	0.00	0.00
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	1.00
Total	**102.98**	**108.62**	**122.76**	**131.27**	**154.84**	**122.11**	**129.64**	**148.22**	**124.96**	**127.51**	**152.61**

Electricity generation should increase in all scenarios by about 20%, 30% and 50% in 2025, 2030 and 2035 respectively compared to 2017. In WCM, these levels are expected to reach 122.11, 129.64 and 148.22 billion kWh.

Electricity generation from coal in WCM and WAM scenarios is lower compared to that of WOM scenario. In these scenarios, coal production is predicted to decrease while natural gas, hydro, solar and wind power are anticipated to increase.

WAM scenario includes energy from nuclear power plants (included in the scenario) and hydrogen energy.

Table 5.4. *Electricity generation, %*

	Fact		WOM			WCM			WAM		
	2017	2020	2025	2030	2035	2025	2030	2035	2025	2030	2035
Coal	74.1	69.1	67.0	67.9	59.4	62.4	49.8	43.6	62.6	40.0	36.1
Natural gas	14.7	19.5	22.5	21.7	30.0	22.5	25.0	30.0	22.5	25.0	30.0
Hydropower - large HPPs	10.8	8.4	9.1	8.5	8.6	9.1	10.2	9.0	8.9	10.4	8.7
Hydropower – small HPPs	0.0	0.7	0.0	0.0	0.0	3.0	3.0	2.6	3.1	3.0	2.5
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	7.0
Solar	0.0	1.2	0.8	0.7	0.6	1.5	7.0	9.4	1.5	8.0	10.9
Wind	0.3	1.0	0.7	0.6	0.9	1.5	5.0	5.5	1.4	3.9	4.1
Bio	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Share of RES	0.4	3.0	1.5	1.9	2.1	6.0	15.0	17.5	6.0	15.0	17.5

The table shows that the share of coal is expected to decrease in all scenarios. The increase in WOM scenario is due to the higher growth rate of electricity generation from natural gas compared to the growth rate of coal.

Table 5.5. *Installed capacities of power plants, GW*

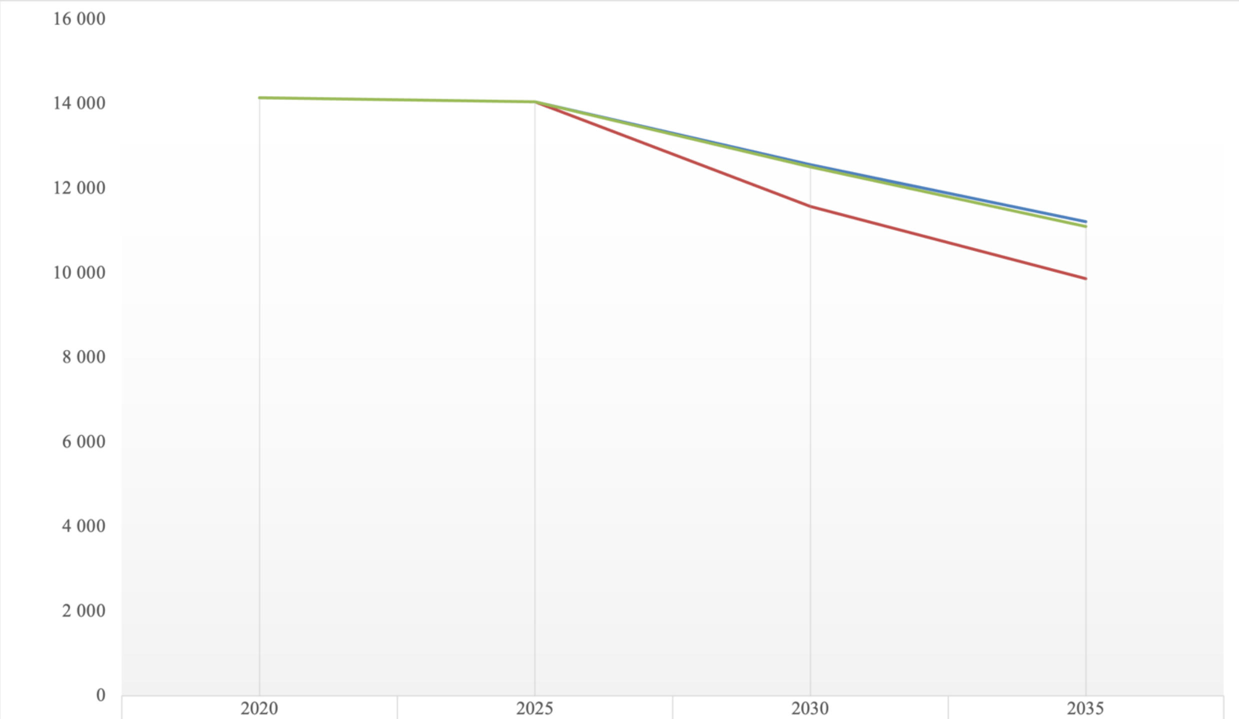
	Fact		WOM			WCM			WAM		
	2017	2020	2025	2030	2035	2025	2030	2035	2025	2030	2035
Coal	16.3	14.7	15.2	16.6	17.6	15.2	16.8	19.1	15.2	16.6	17.6
Natural gas	3.1	4.0	5.6	5.6	8.6	5.8	6.6	9.5	5.8	6.8	10.4
Hydropower - large HPPs	2.6	2.8	2.6	2.6	3.1	2.6	3.1	3.1	2.6	3.1	3.1
Hydropower – small HPPs	0.0	0.2	0.0	0.0	0.0	0.9	0.9	0.9	0.9	0.9	0.9
Nuclear	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5
Solar	0.1	0.9	0.6	0.6	0.6	1.1	5.3	8.0	1.1	5.9	9.5
Wind	0.1	0.5	0.3	0.3	0.5	0.6	2.5	3.1	0.6	1.7	2.1
Bio	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
Total	22.2	24.2	24.3	25.8	30.7	26.2	35.2	43.8	26.2	36.8	45.6

As can be seen from Table 5.5, the increase in renewable energy capacity leads to an increase in total capacity to a greater extent than conventional types of power plants. In WCM and WAM scenarios, the level of installed capacity is to be higher by about 10 and 15 GW in 2030 and 2035, respectively.

In the heat generation sector, emissions from boilers are presented, as emissions from combined heat and power plants were included in electricity generation. The GHG emissions from boiler houses by scenarios are presented below. As can be seen, emissions are decreasing under all scenarios, which is due to a large transition to heat supply from CHPPs.

When comparing GHG emissions between scenarios, emissions in WAM scenario are higher than WCM scenario. This is due to the fact that an increase in the share of electricity generation from nuclear power plants and a decrease in coal-fired electricity generation leads to a decrease in the share of CHPPs, and, accordingly, heat from them, which is replaced by an increase in the use of heat from boiler houses in WAM scenario.

Figure 5.4. *Scenarios for greenhouse gas emissions from heat generation, kt of CO_2-eq.*

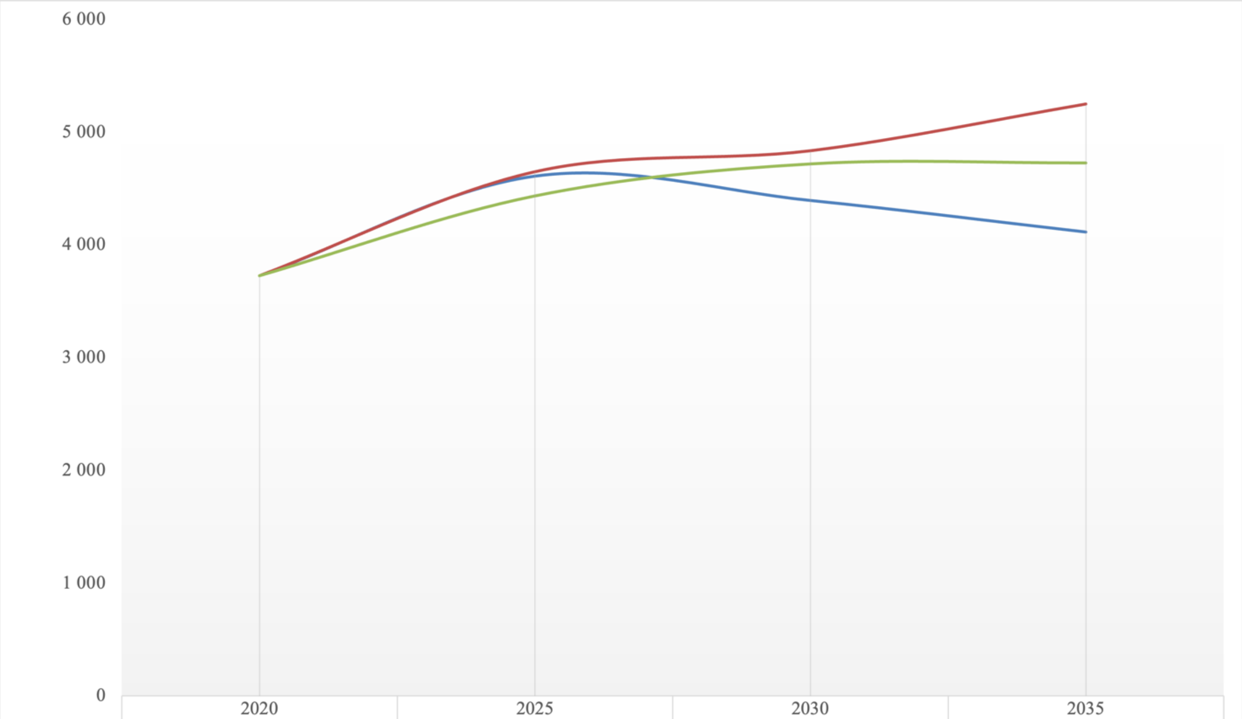


	2020	2025	2030	2035
WOM	14 143	14 044	12 558	11 216
WCM	14 143	14 044	11 573	9 863
WAM	14 143	14 044	12 505	11 095

Oil refining sector

GHG emissions from the oil refining sector are shown below.

Figure 5.5. *Scenarios for greenhouse gas emissions from oil refining, kt of CO_2-eq.*



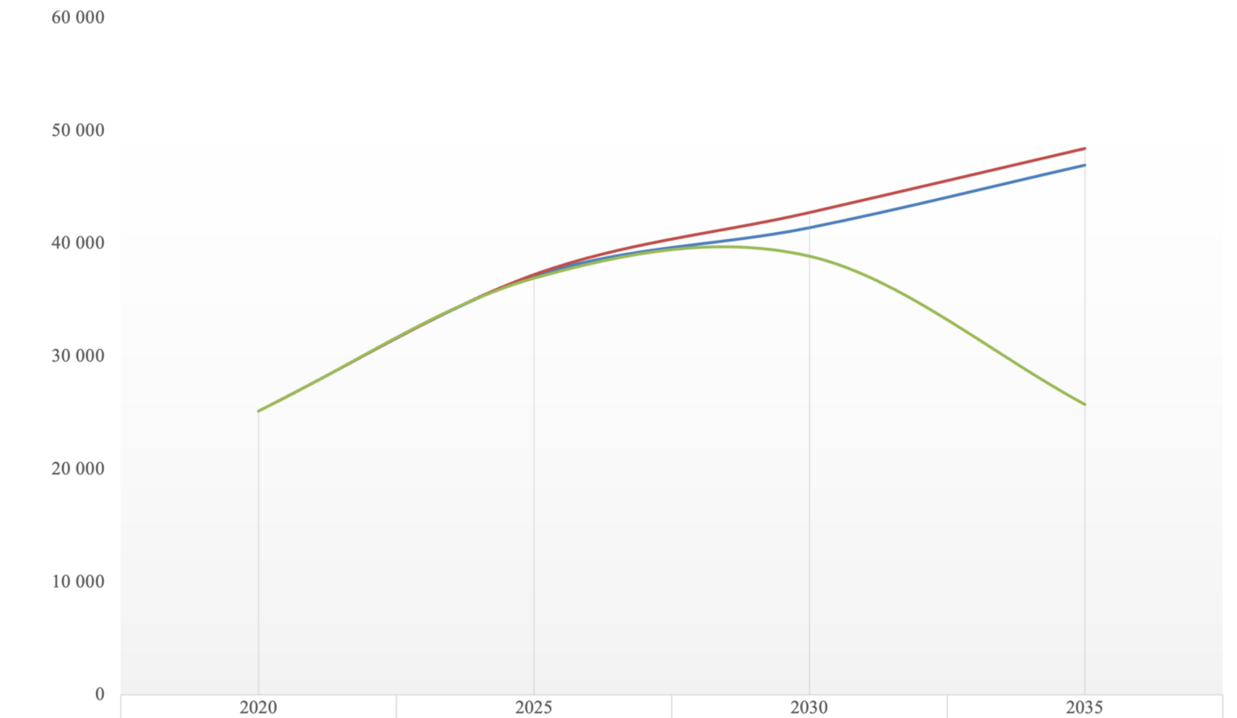
	2020	2025	2030	2035
WOM	3 725	4 609	4 393	4 113
WCM	3 725	4 647	4 833	5 247
WAM	3 725	4 433	4 717	4 726

Industry and construction sector

GHG emissions from the industry and construction sector are presented below.

As can be seen from Figure 5.6, emissions from the industry and construction sector are on the rise, due to economic growth. However, in WAM scenario, GHG emissions will be halved compared to other scenarios in 2030 and 2035. This is due to the introduction of steel production capacity using hydrogen into the industry. In the proposed technology, iron ore is reduced with hydrogen while in a solid state, to produce direct reduced iron (DRI) called sponge iron. Sponge iron is then fed into an electric arc furnace (EAF), where electrodes generate a current to melt the sponge iron to produce steel.

Figure 5.6. *Scenarios for greenhouse gas emissions in industry, kt of CO_2-eq.*



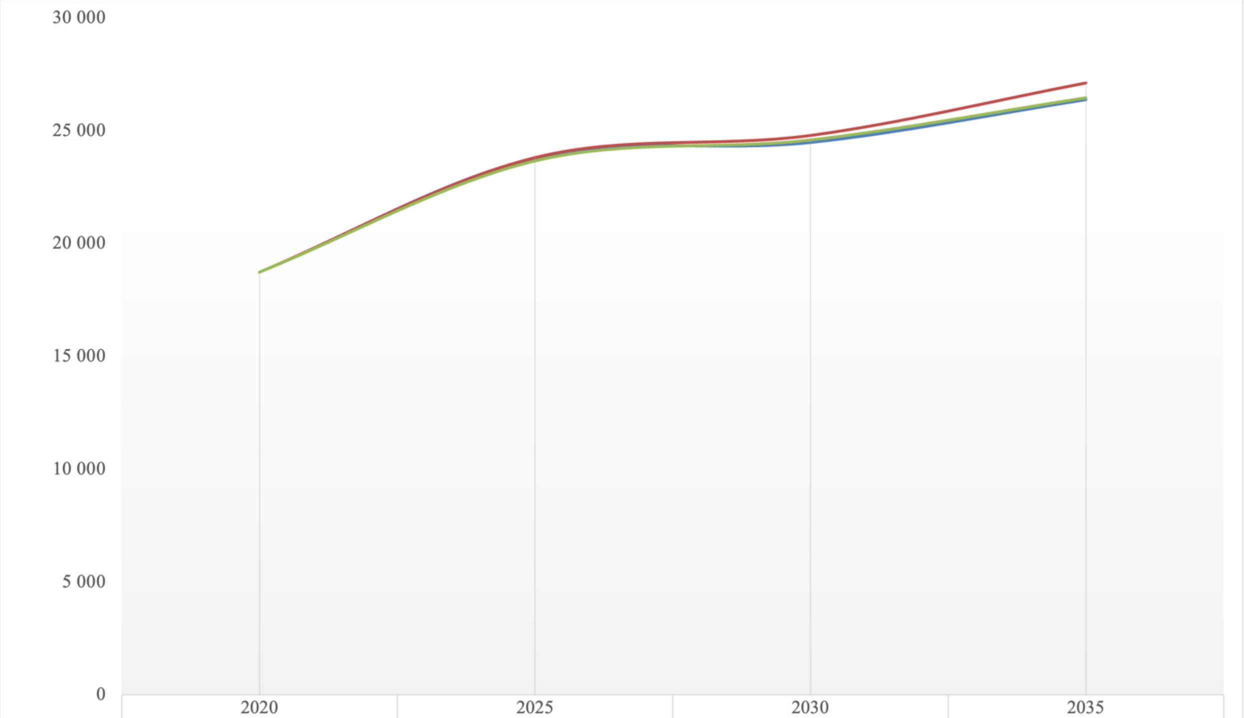
	2020	2025	2030	2035
WOM	25 130	37 067	41 376	46 922
WCM	25 130	37 220	42 729	48 410
WAM	25 130	36 906	38 860	25 716

Transport

GHG emissions from transport are presented below.

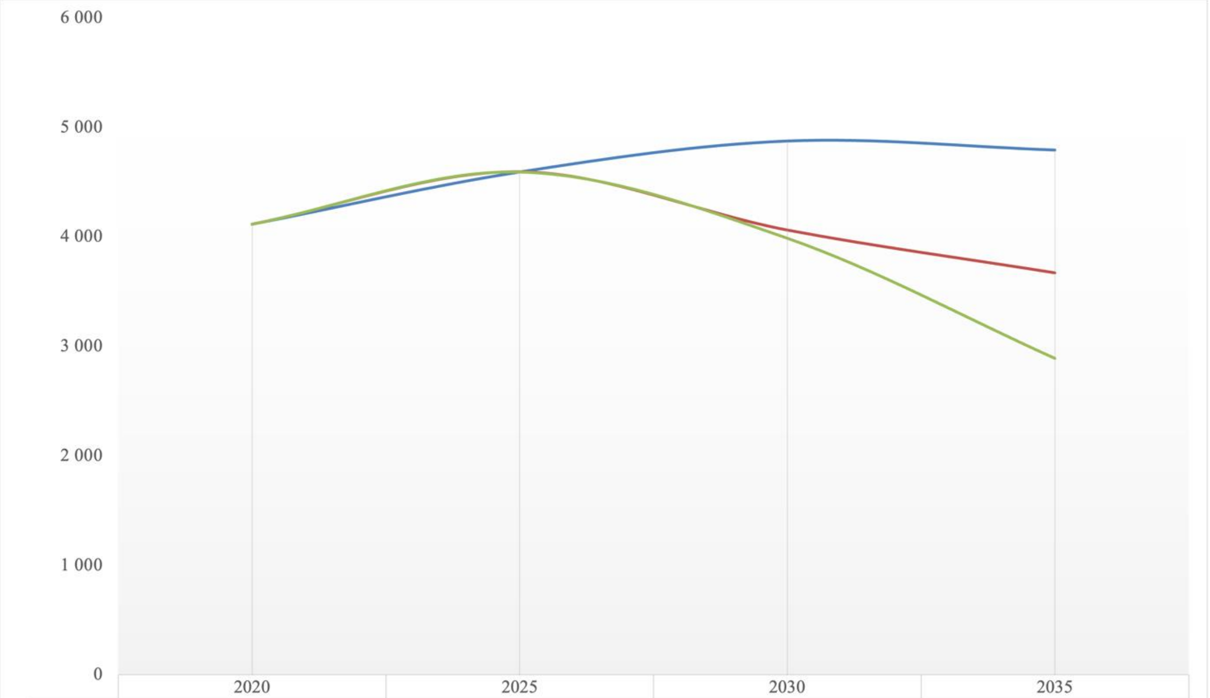
GHG emissions in all scenarios are growing, which is associated with economic growth and demand for freight and passenger transportation. The increase in gas use in WCM scenario leads to higher gas prices compared to gasoline, which entails a shift from gas-fueled hybrid vehicles (using gasoline as an alternative) to full use of gasoline, which in turn increases GHG emissions

Figure 5.7. *Scenarios for greenhouse gas emissions from transport, kt of CO_2-eq.*



	2020	2025	2030	2035
WOM	18 726	23 790	24 476	26 374
WCM	18 726	23 802	24 784	27 110
WAM	18 726	23 660	24 589	26 460

Figure 5.8. *Scenarios for greenhouse gas emissions from the commercial sector, kt of CO_2-eq.*



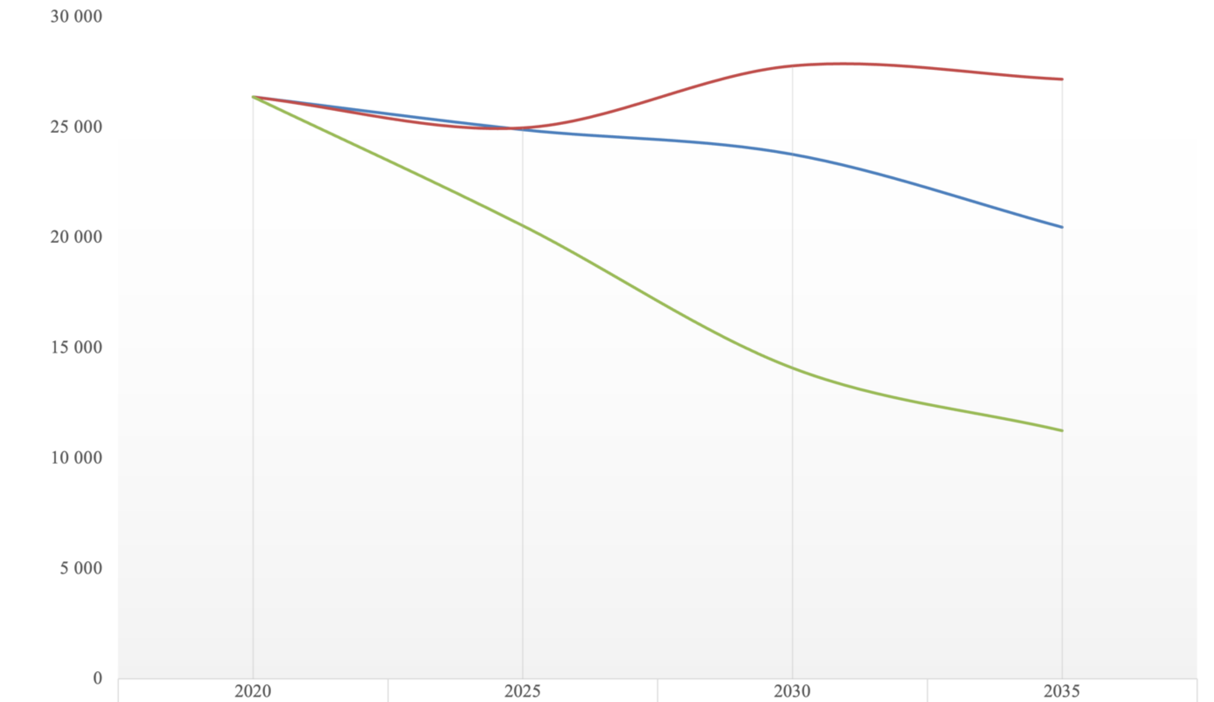
	2020	2025	2030	2035
WOM	4 114	4 592	4 875	4 793
WCM	4 114	4 592	4 061	3 671
WAM	4 114	4 592	3 986	2 888

GHG emissions in the commercial sector are to be reduced due to the increase in the energy efficiency of the technologies used and depending on measures by scenario. As can be seen, the introduction of a carbon tax should lead to a reduction in GHG emissions in the commercial sector.

Population

Below are the GHG emissions by population.

Figure 5.9. *Scenarios for greenhouse gas emissions by population, kt of CO_2-eq.*



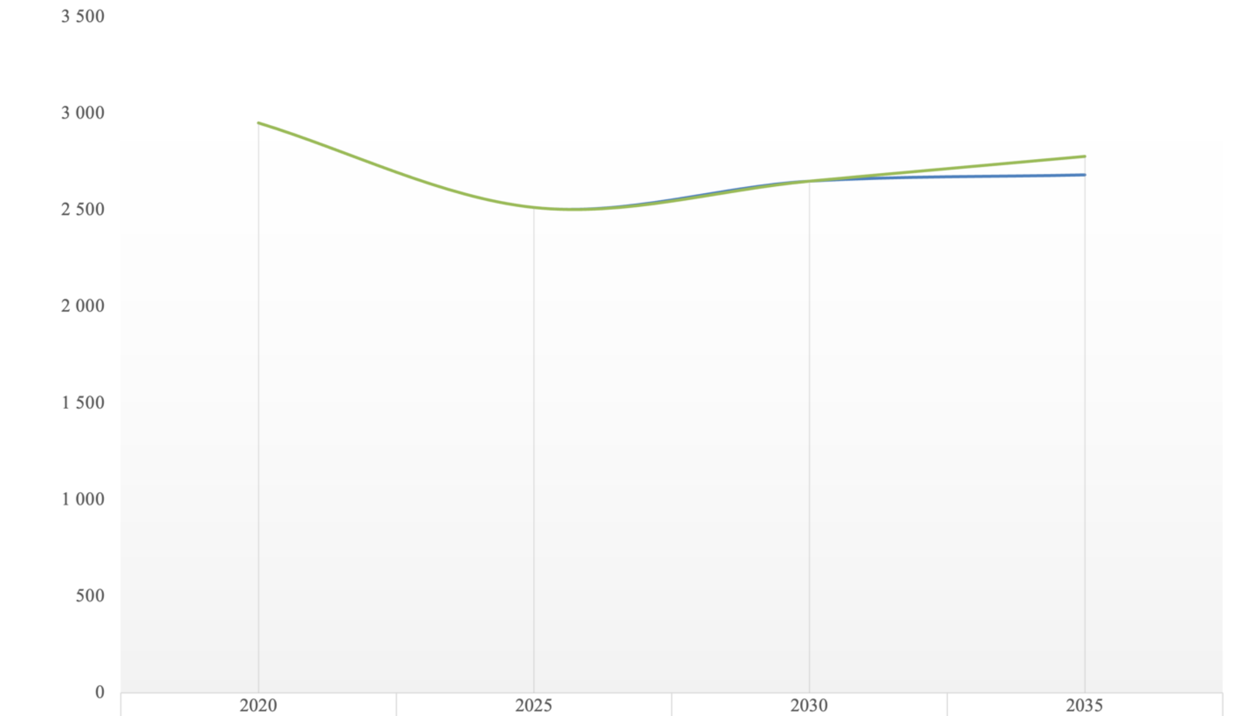
	2020	2025	2030	2035
WOM	26 365	24 879	23 763	20 464
WCM	26 365	24 969	27 770	27 166
WAM	26 365	20 536	14 089	11 250

Emissions from the population (buildings) are higher in WCM scenario than in WOM scenario. This is since there is a leakage of carbon from industrial sectors because of a lower cost of coal for the population. However, the introduction of a carbon tax is expected to reduce GHG emissions from households by almost half compared to WOM scenario, by 2035.

Agriculture

Below are the GHG emissions from agriculture.

Figure 5.10. *Scenarios for greenhouse gas emissions from agriculture, kt of CO2-eq.*



	2020	2025	2030	2035
WOM	2 951	2 513	2 649	2 682
WCM	2 951	2 513	2 649	2 778
WAM	2 951	2 513	2 649	2 778

GHG emissions from agriculture are growing in all scenarios since the growth of the industry as one of the most important for the country's economy is assumed.

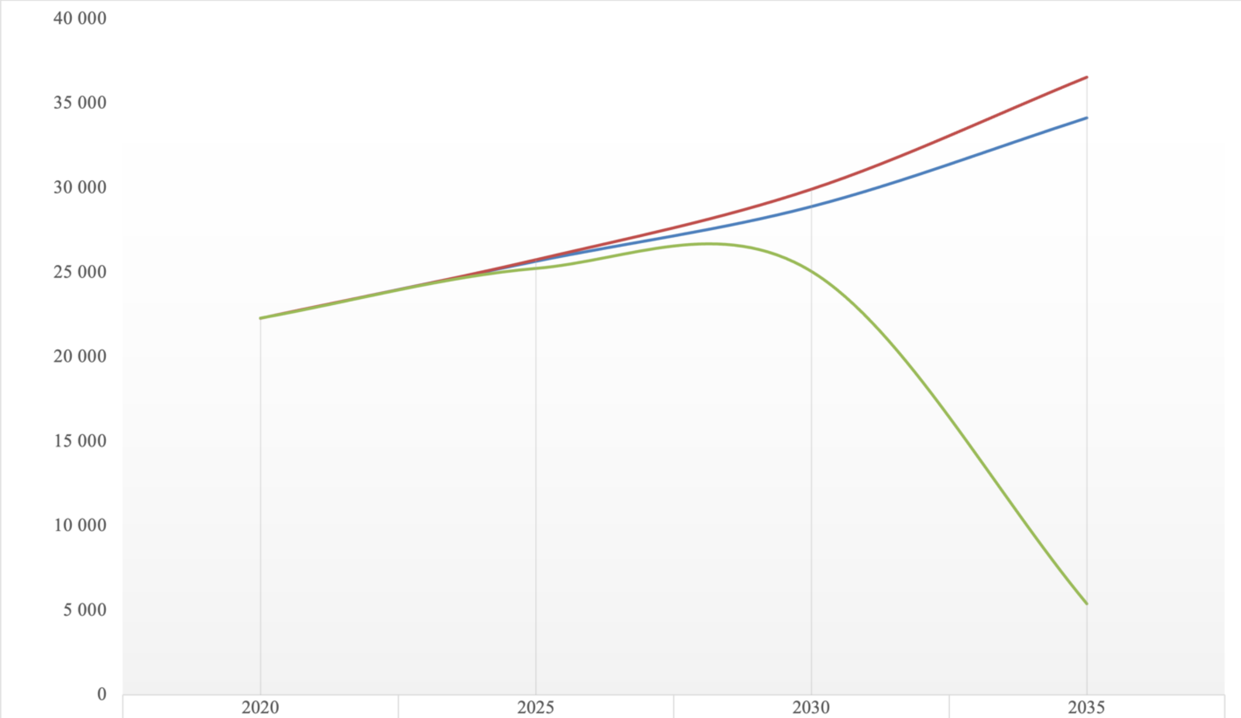
In WCM and WAM scenarios, GHG emissions after 2030 are to be higher than in the WOM scenario. This is due to the fact that in WCM and WAM scenarios the transition to electrified transport types occurs later due to the increased cost of electricity under current measures.

‘Other’ sector

GHG emissions in this sector refer to emissions, whose sources are not identified and not allocated to the respective sectors. This is due to the fact that there is no complete reporting on the use of fuel. In the GHG inventory provided to the UNFCCC, the description of this sector contains a list of energy products with emissions and an analysis of possible use. Based on this information, an attempt was made to model this sector by linking these emissions to the relevant activities. So, for the solid type there was a link to the activity that uses coke, for the liquid type - to the volume of oil products and for the gaseous type - to the use of natural gas in the system.

The resulting GHG emissions for this sector are shown below.

Figure 5.11. *Scenarios for greenhouse gas emissions from the 'Other' sector, kt of CO2-eq.*



	2020	2025	2030	2035
WOM	22 279	25 649	28 881	34 125
WCM	22 279	25 739	29 908	36 534
WAM	22 279	25 219	25 045	5 380

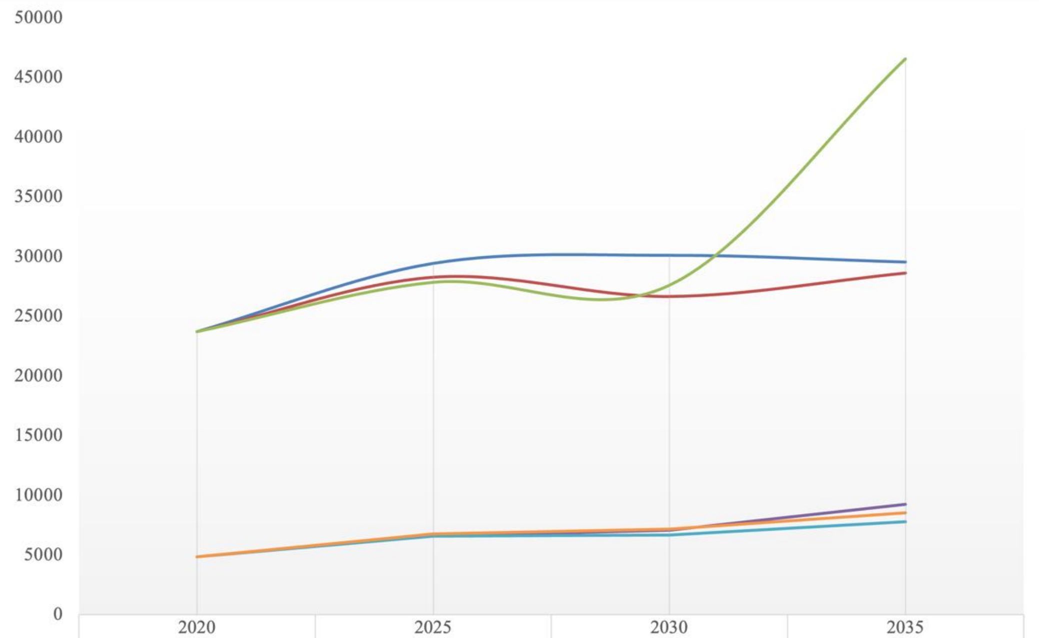
As can be seen, emissions in the 'Other' sector are highly dependent on the introduction of a carbon tax. In the WCM scenario, GHG emissions are seen to be slightly higher than in the WOM scenario, due to the greater use of gasoline in the transport sector.

Greenhouse gas emissions from the fugitive emissions sector

GHG emissions in this sector depend on policies and measures in other sectors.

In the WAM scenario, GHG emissions are to increase compared to other scenarios, due to the generation of hydrogen for iron production (see subsection 5.2. Industrial processes and product use sector. A. Forecasts).

Figure 5.12. *Scenarios for greenhouse gas emissions from the fugitive emissions sector, kt of CO_2-eq.*



	2020	2025	2030	2035
WOM - Solid fuels	23708	29411	30088	29526
WCM - Solid fuels	23708	28258	26651	28609
WAM - Solid fuels	23708	27837	27587	46548
WOM - Oil and natural gas	4845	6582	7067	9236
WCM - Oil and natural gas	4845	6582	6685	7772
WAM - Oil and natural gas	4845	6778	7153	8526

B. Assessing the cumulative impact of policies and measures in the energy sector

This section provides the total impact by calculating the differences between projections with measures and projections without measures.

Table 5.6. *Cumulative impact of measures by scenario, Mt of CO_2-eq.*

	2020	2025	2030	2035
WOM	272.5	292.9	307.3	327.7
WCM	272.5	285.2	283.3	306.0
Effectiveness of WCM compared to WOM	0.0	7.7	24.0	21.7
WAM	272.5	282.0	248.2	243.0
Effectiveness of WAM compared to WOM	0.0	11.0	59.2	84.7
Effectiveness of WAM compared to WCM	0.0	3.2	35.2	63.0

As can be seen from the table, the cumulative impact of current measures is not enough to achieve the NDC target by 2030; they can only stabilize emissions until 2030 at current levels, and after 2030 there will be a further increase.

The WAM scenario should reduce GHG emissions that contribute to economy-wide NDCs and reach levels below minus 15% of 1990 energy sector GHG emissions. It should be noted that the NDC target is set for all emissions; there are no separate NDC targets for sectors.

5.2.Forecasts and overall impact of policies and measures in the Industrial Processes and Product Use sector

A. Forecasts for the IPPU sector

Scenarios for GHG emissions in the IPPU sector

To predict greenhouse gas emissions in the sector of industrial processes and product use (hereinafter - IPPU) not related to fuel combustion, in WCM, WOM and WAM scenarios, a linear regression model was used. It considers the design capacities of industrial installations in the Republic Kazakhstan based on the forecasting Excel tools, which uses a series of historical data, expert forecasts of economic development and demand for products.

GHG emissions from the production of mineral raw materials come from three source categories: cement, lime, and glass production. In the chemical industry: production of ammonia, calcium carbide. In ferrous metallurgy: production of cast iron, steel, blast-furnace coke, ferroalloy (ferrochrome, ferrosilicon, ferrosiliconchrome and ferrosilicomanganese); in non-ferrous metallurgy: production of aluminum, lead, zinc. The use of non-energy fuel products and the use of solvents include: the use of lubricants, the production and use of asphalt, the use of solvents in paint products.

MMC will be developed with the view to process raw materials within the country and produce high value-added products that ensure the development of related industries, such as mechanical engineering, construction, and chemical industry, as part of the Roadmap for the development of the mining and metallurgy complex until 2025. In the ferrous metallurgy, to increase the load of domestic enterprises with strategic raw materials and the priority supply of scrap to the domestic market, as well as to increase production volumes, systemic measures will be taken. These include: a ban on the export of ferrous and non-ferrous scrap from the country by road for a period of 6 months; quotas for the export of scrap and waste of ferrous metals; licensing activities for the collection, storage, processing and sale of scrap and waste of non-ferrous and ferrous metals. In non-ferrous metallurgy, it is planned to abolish import customs duties on titanium raw materials and export duties on aluminum alloys.

In the chemical industry, the development of agrochemistry will continue with the aim of producing products for export. The production of chemicals for industry will remain as a base and oriented to the domestic market. With a view to the long-term development of the agrochemical sector, it is planned to produce complex mineral (NPK) fertilizers and plant protection products. The launch of large projects in the chemical industry will serve as a solid basis for the development of deep processing in the sector and will ensure growth in the medium term at the level of 2.8%.

Without measures scenario

This scenario reflects a possible change in greenhouse gas emissions with no measures taken, modernization not taking place, and national coefficients per unit of production remaining at their level. In this scenario, it is assumed that greenhouse gas emissions depend on the overall growth rate of GDP, population, and the current dynamics of the transition towards less energy-intensive sectors. It is assumed that this scenario does not include any measures and policies that have already been implemented in the country in recent years.

With current measures scenario

This scenario, in contrast to the WOM scenario, includes measures and policies to reduce greenhouse gas emissions that have been adopted and are planned to be adopted in the near future. These measures include the National Quota Allocation Plan for 2018-2020, 2020-2021

With additional measures scenario

This scenario takes into account current policies and measures, with the assumption of possible additional measures, for the transition to a carbon-neutral economic development of the Republic of Kazakhstan. Additional measures include:

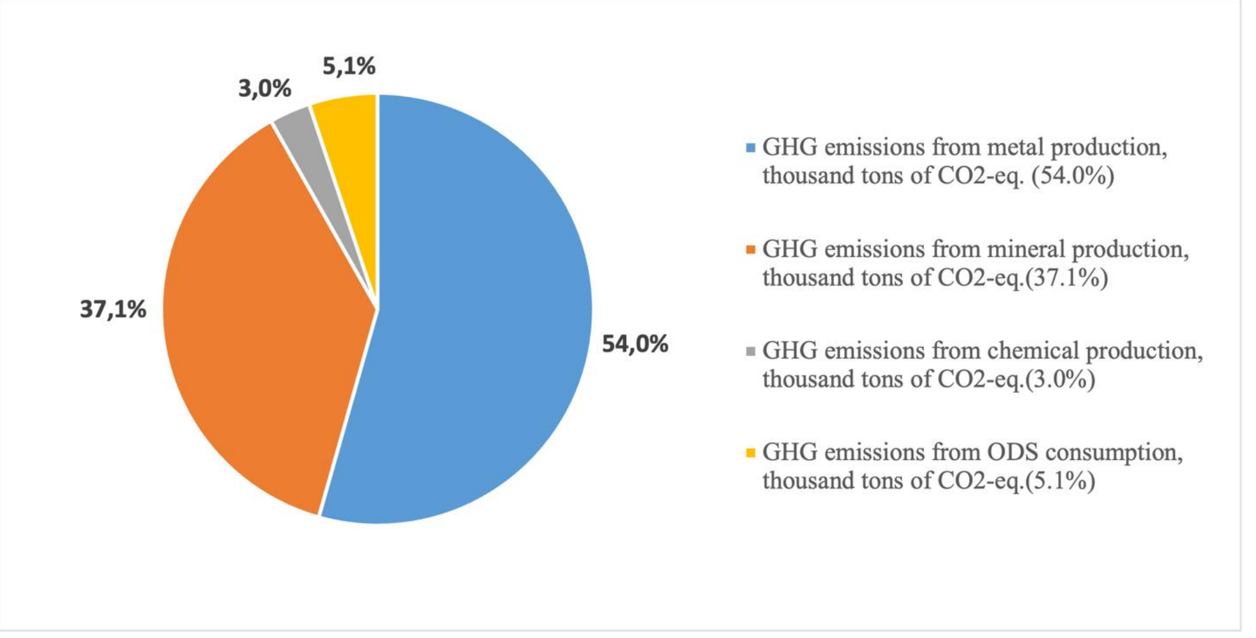
- Implementation of projects to improve air quality at the Zhezkazgan copper smelter from 2023. Development and implementation of a gasification project. Kazakhmys Smelting LLP. Reducing greenhouse gas emissions, replacing fuel oil with natural gas.
- Modernization and reconstruction of the workshops at the Aktobe ferroalloy plant of TNK Kazchrome JSC from 2023.
- Commissioning of gas treatment equipment and an automated monitoring system in the sintering, coal preparation shops and in the lime kilning shop of Arcelor Mittal Temirtau JSC in the Karaganda region.
- Replacement of gas treatment plants at the Aksu ferroalloys plant, TNK Kazchrome JSC and Aluminum of Kazakhstan JSC from 2023. Reducing emissions by 750 tons in Aksu and by 1000 tons in Pavlodar
- Approval of the National Quota Allocation Plan for 2022-2025 with an annual 1.5% carbon quota reduction rate.
- Online monitoring of emissions in the chemical industry.
- Use of ‘green’ hydrogen to produce ammonia, ammonium nitrate (PtX).
- Production of ‘green’ steel.
- Decreased proportion of clinker in cement and use of carbon-cured concrete as CCS in cement production

Actual GHG emissions from IPPU and comparison with base year

In Kazakhstan, industrial processes are sources of gas emissions such as CO_2 and CH_4, as well as the only source of emissions of PFCs, HFCs and SF6.

This forecast also takes into account N_2O emissions from the production of weak nitric acid (46%). Fluorine gases are emitted from aluminum production (CF4 and C2F6), refrigerants (HFCs, PFCs) and insulation in high voltage electrical engineering (SF6). The most significant source of greenhouse gas emissions in the reporting year in the industrial sector, as in previous years, is metallurgy. According to the results of the 2020 GHG inventory, its contribution to the total greenhouse gas emissions from the IPPU sector in 2020 amounted to 54.0%, excluding ODS consumption. The next largest source of GHG emissions is emissions from the production of mineral materials, which showed a significant increase (14.5%) and accounted for 37.1% of GHG emissions from the IPPU sector. Emissions from the chemical industry accounted for 33.0% (a decrease of 0.2%) of total greenhouse gas emissions from the IPPU sector in 2020. The share of GHG emissions from the use of ODS in 2020 slightly decreased and amounted to 5.1% (in 2019 – 5.5%) of GHG emissions from the IPPU sector as a whole (Figure 5.13).

Figure 5.13. *Share of selected categories in total greenhouse gas emissions from the IPPU sector in 2020*



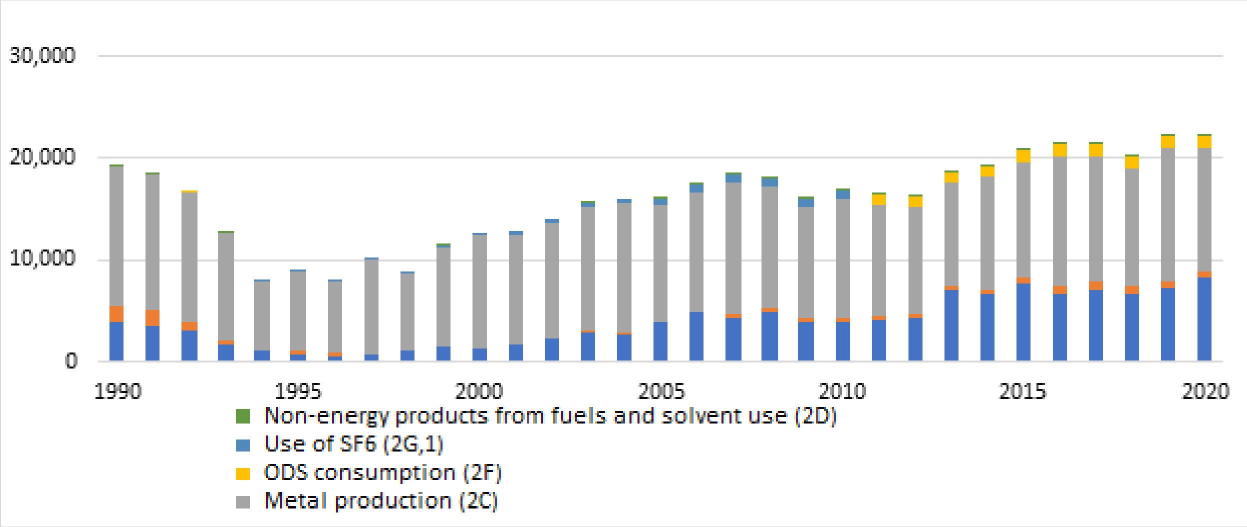
The contribution of the IPPU sector as a whole to total national GHG emissions in 1990 and 2020 (% excluding the LULUCF sector) is represented by the following figures. The share of GHG emissions from the IPPU sector in total national GHG emissions excluding the LULUCF sector in 2020 was 6.3%, which is 23.5% higher than the share of sector emissions in 1990 (5.1%).

Table 5.7. *Values of GHG emissions in the IPPU sector for the period 1990–2020, thousand tons of CO_2-eq.*

Year	GHG emissions by IPPU sector, thousand tons of CO2-eq.						
	Total emissions by IPPU sector	Production of mineral materials (2A)	Chemical industry (2B)	Metal production (2C)	ODS consumptio n (2F)	Use of SF6 (2G.1)	Non-energy fuel products and solvent use (2D)
1	**2**	3	4	5	6	7	8
1990	**19292.85**	3876.59	1659.12	13754.78	0.00	0.00	2.36
1991	**18365.53**	3470.20	1592.31	13300.79	0.00	0.00	2.24
…							
2011	**16483.28**	4028.57	430.01	10958.50	931.66	1.75	132.80
2012	**16302.76**	4372.83	336.55	10473.03	952.83	1.83	165.71
2013	**18797.85**	7108.86	364.97	10220.34	961.73	1.93	140.03
2014	**19345.23**	6623.02	542.28	10995.12	1083.99	2.01	98.81
2015	**20838.66**	7779.11	599.21	11190.74	1116.84	2.01	150.75
2016	**21607.40**	6778.69	667.28	12817.10	1156.46	2.06	185.80
2017	**21496.94**	7121.66	688.60	12401.80	1123.84	2.10	158.94
2018	**20351.31**	6752.01	666.34	11638.52	1130.61	2.15	161.69
2019	**20871.44**	7225.45	680.58	13064,47	1140.63	2.32	167.16
2020	**22 290.21**	8273.27	679.38	12028.78	1135.44	2.31	171.04

Figure 5.14 presents actual GHG emissions from the IPPU sector for 1990–2019. As can be seen from the graph, the main impact on GHG growth is provided by the metallurgy sector and the production of mineral products.

Figure 5.14. *Dynamics of greenhouse gas emissions from the IPPU sector for 1990–2019*



It should be noted that the industrial policy does not consider the need for Kazakhstan to fulfill its international obligations to reduce GHG emissions.

The State program for industrial and innovative development for 2020-2025, unlike the previous ones (SPFIID 2010-2014, SPIID 2015-2019), is not aimed at the energy-efficient development of the manufacturing industry, which may lead to an increase in GHG emissions, since it is planned to increase production capacities and increase production volumes.

The IPPU GHG inventory in Kazakhstan includes an estimate of emissions from the production of mineral materials (2.A), the chemical industry (2.B), the metallurgical industry (2.C), the use of solvents and non-energy fuel products (2.D), the use of fluorinated substitutes for ODS (2.F), and the use of sulfur hexafluoride (2.G.1). This chapter presents all industrial sources of GHG emissions (CO2 and CH4) available in Kazakhstan.[193] The main document used to calculate GHG emissions is the IPCC Guidelines, 2006.[194]

The total greenhouse gas emissions from the IPPU sector in 2020 amounted to **22,290.21 thousand tons of CO_2-eq**. This is 6.8% more than emissions in 2019 and 15.5% more than 1990 GHG emissions for the IPPU sector as a whole (Figure 5.14).

[193] National report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol for 1990-2019

[194] IPCC Guidelines for National Greenhouse Gas Inventories, 2006.

Figure 5.15. *Share of IPPU subsectors in GHG emissions in 2020*

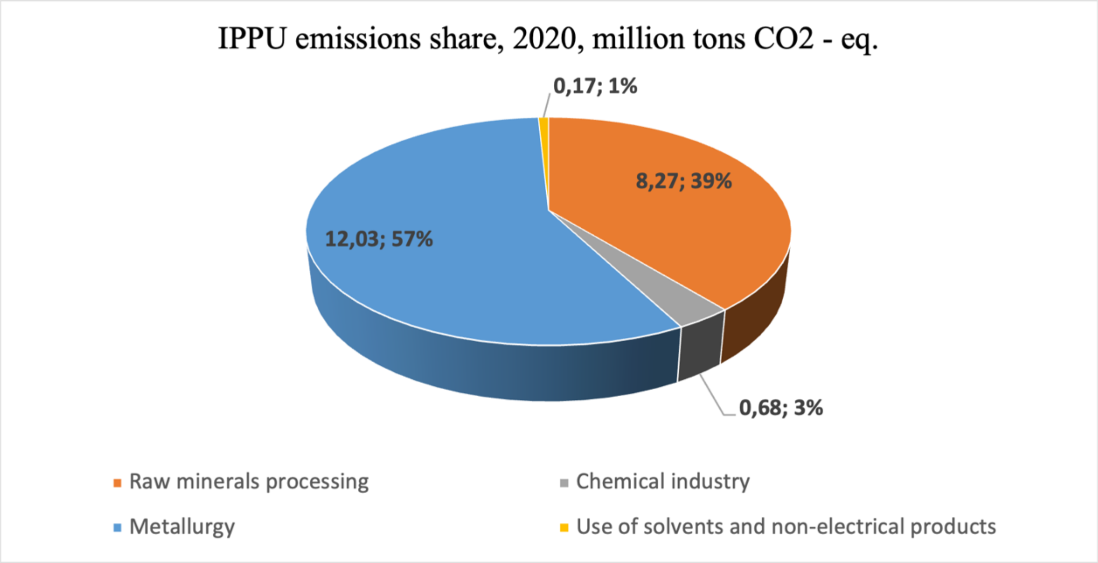
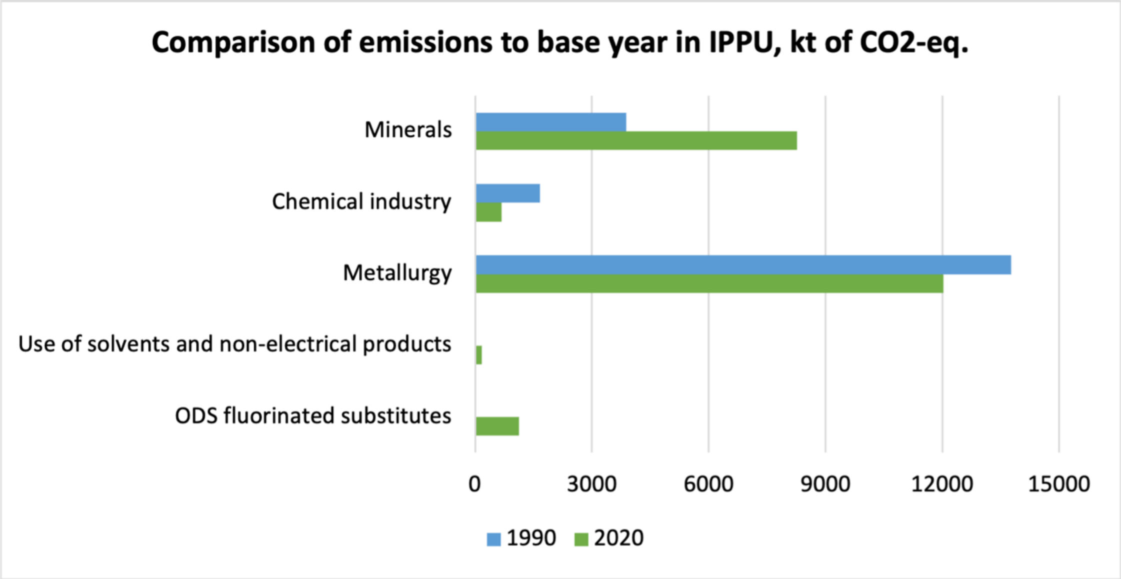


Figure 5.16. *Growth of emissions from the IPPU sector compared to the base year, thousand tons of CO_2-eq.*



B. Assessing the cumulative impact of policies and measures in the IPPU sector

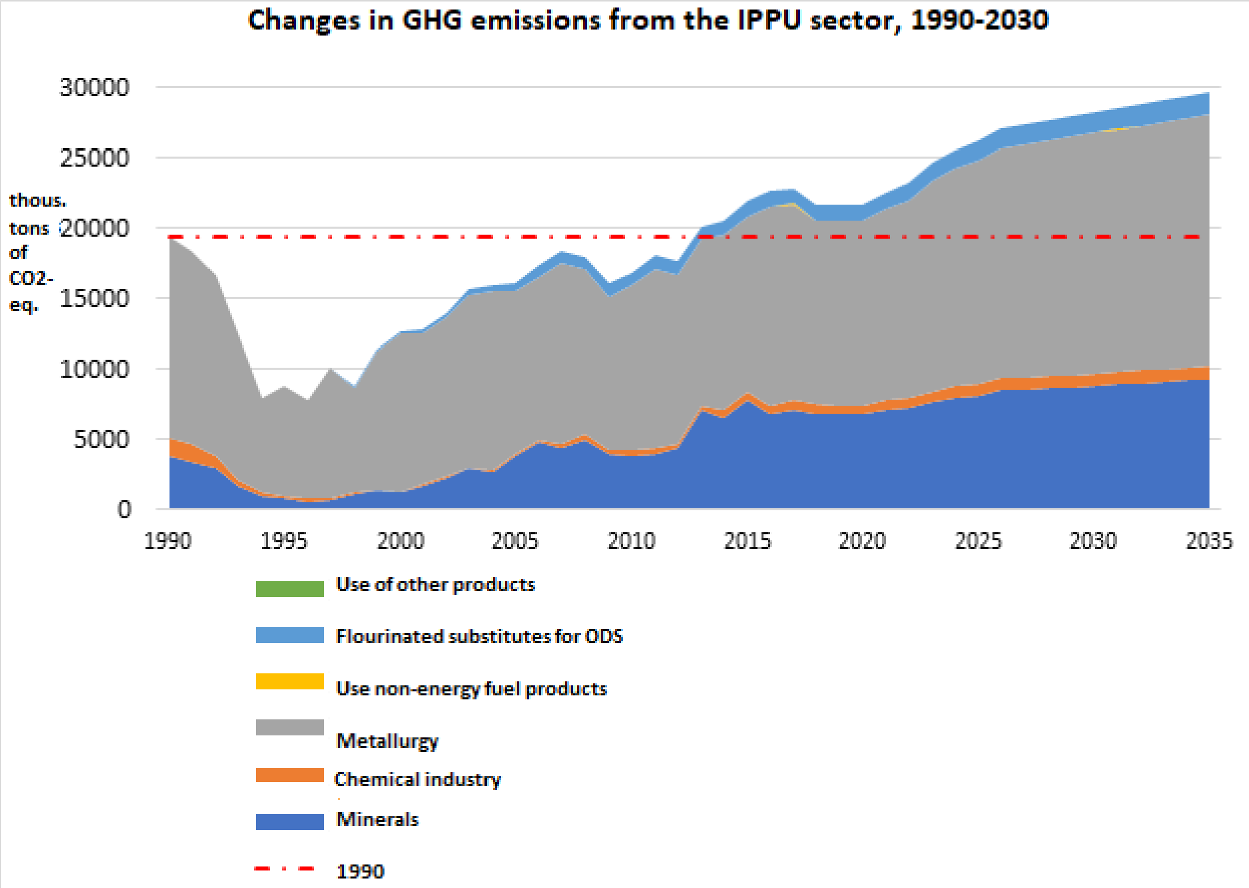
Forecasts for GHG emissions in the IPPU sector

Figure 5.17 presents GHG emissions forecast under the with current measures (WCM) scenario in the IPPU category for 1990–2020 and the forecast up to 2030 by subcategory. As can be seen from the graph, the main contribution to GHG growth is made by metallurgy and the production of mineral products. In 2020, emissions from the IPPU sector have already exceeded the level of the 1990 base year by 15.54% (Table 5.8).

Table 5.8. *Increase in emissions from the IPPU sector in 2020 compared to base year of 1990*

GHG sources, thousands tons of CO_2-eq.	Base year 1990	2020	Change compared to the base year (of the latest year according to the NIR), %
2. Industrial processes	19292.85	22290.21	15.54
Processing of mineral raw materials	3876.59	8273.27	113.42
Chemical industry	1659.12	679.38	–59.05
Metallurgy	13754.78	12028.77	–12.55
Use of solvents and non-energy products	2.361	171.04	7144.43
Use of ODS	NO	1135.44	100.00
Use of other products	NO, NE	2.31	100.00

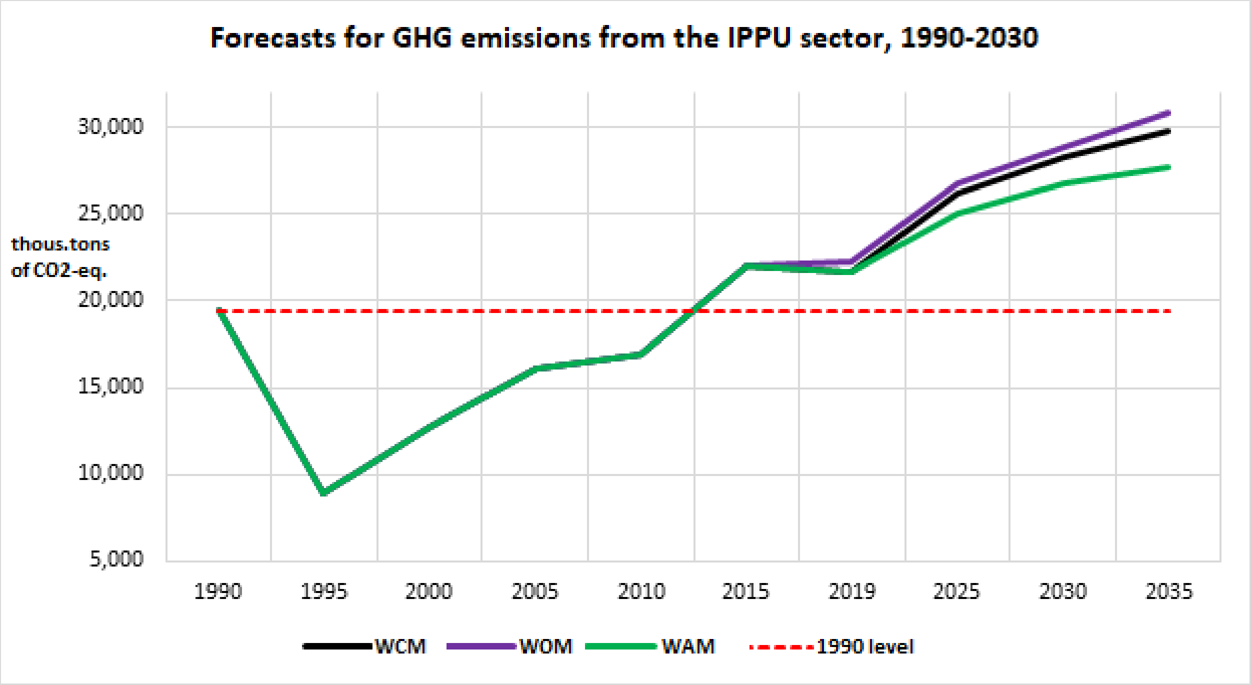
Figure 5.17. *Forecasts for GHG emissions from the IPPU sector until 2035 with current measures*



The growth rate of GHG emissions is associated with the expansion of the construction industry and the increase in demand for cement (clinker) with the increase in metallurgy production to the level of the base year.

Greenhouse gas forecasts under the without measures (WOM) scenario and under the with additional measures (WAM) scenario are shown in Figure 5.18. Emissions are seen to be on the rise in the years projected under the WCM scenario. With additional measures taken from 2023, there is an opportunity to reduce them by 10%, but emissions will remain above the baseline throughout the horizon. As can be seen from the graph, in the case of the WOM scenario, emissions should exceed the level under the WCM scenario by 5%.

Figure 5.18. *Comparative scenario analysis chart: actual vs. projected emissions from the IPPU sector, 1990-2035*



Calculations made to evaluate the consequences of response measures (CTF table 5.9) show that the policies and measures adopted by the Republic of Kazakhstan to reduce GHG emissions partially reduce emissions in this category. In all scenarios, total GHG emissions exceeded the 1990 base year level. Therefore, it is necessary to reduce specific emissions in the industrial sector through the transition to newer technologies (described above).

Figure 5.19 and Table 5.9 show the projected emission values for the industry/industrial processes sector by scenario.

Figure 5.19. *Emissions from the IPPU sector by scenario up to 2035, mln. tons of CO_2-eq.*

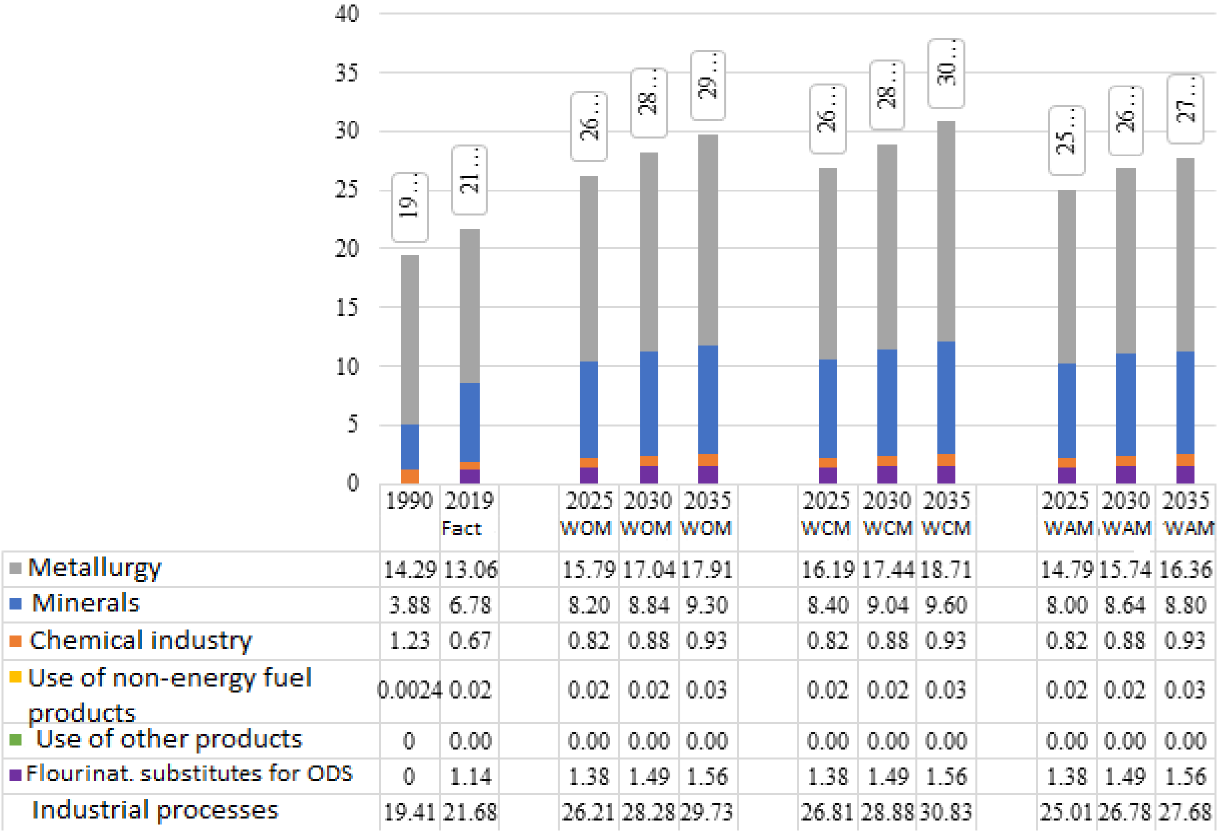


Table 5.9. *Emissions from the IPPU sector by scenario up to 2035, mln. tons of CO_2-eq.*

	year	Fact		WOM	WOM	WOM		WCM	WCM	WCM		WAM	WAM	WAM
	1990	2019		**2025**	**2030**	**2035**		**2025**	**2030**	**2035**		**2025**	**2030**	**2035**
Minerals	3.88	6.78		8.20	8.84	9.30		8.40	9.04	9.60		8.00	8.64	8.80
Chemical industry	1.23	0.67		0.82	0.88	0.93		0.82	0.88	0.93		0.82	0.88	0.93
Metallurgy	14.29	13.06		15.79	17.04	17.91		16.19	17.44	18.71		14.79	15.74	16.36
Use of non-energy fuel products	0.0024	0.02		0.02	0.02	0.03		0.02	0.02	0.03		0.02	0.02	0.03
Fluorinated substitutes for ODS	NO	1.14		1.38	1.49	1.56		1.38	1.49	1.56		1.38	1.49	1.56
Use of other products	NO	0.00		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00
Industrial processes	**19.41**	**21.68**		**26.21**	**28.28**	**29.73**		**26.81**	**28.88**	**30.83**		**25.01**	**26.78**	**27.68**

5.3. Forecasts and overall impacts of policies and measures in the Land use, Land-use Change and Forestry sector (LULUCF)

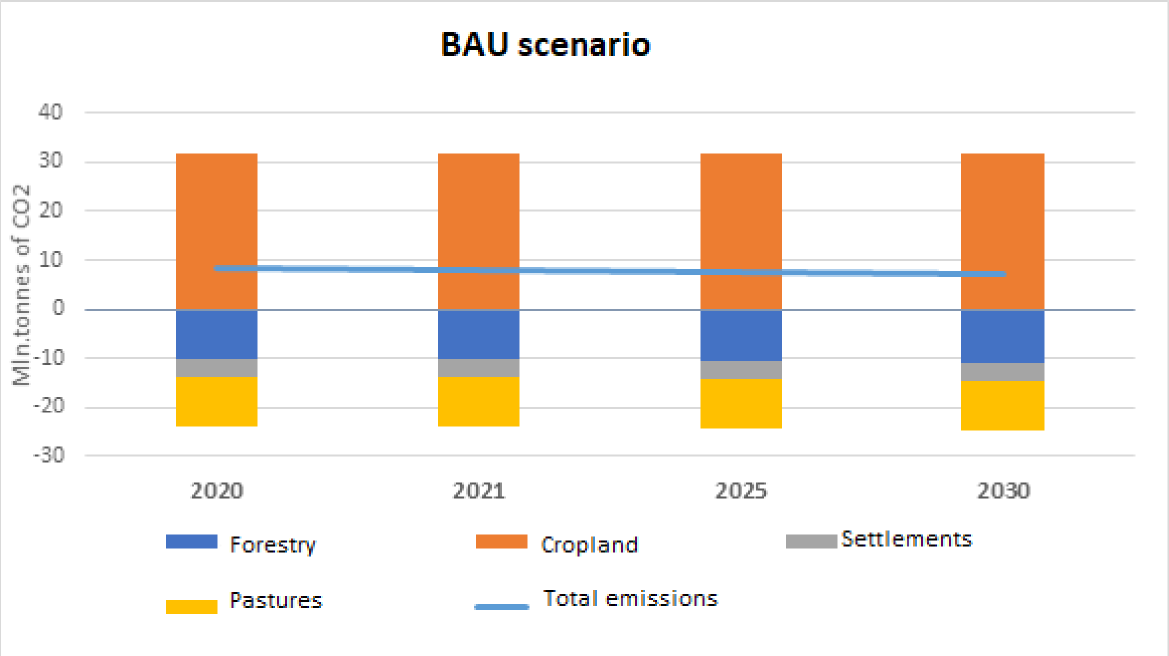
A. Forecasts for the LULUCF sector

This chapter describes measures taken in the LULUCF sector and assesses the potential impact of these measures. First, the WOM scenario was evaluated. Scenarios WCM and WAM were calculated. At the end of the chapter, general emission scenarios for the LULUCF sector are presented for all three scenarios

All CO2 emission calculations are made in accordance with the IPCC Guidelines.

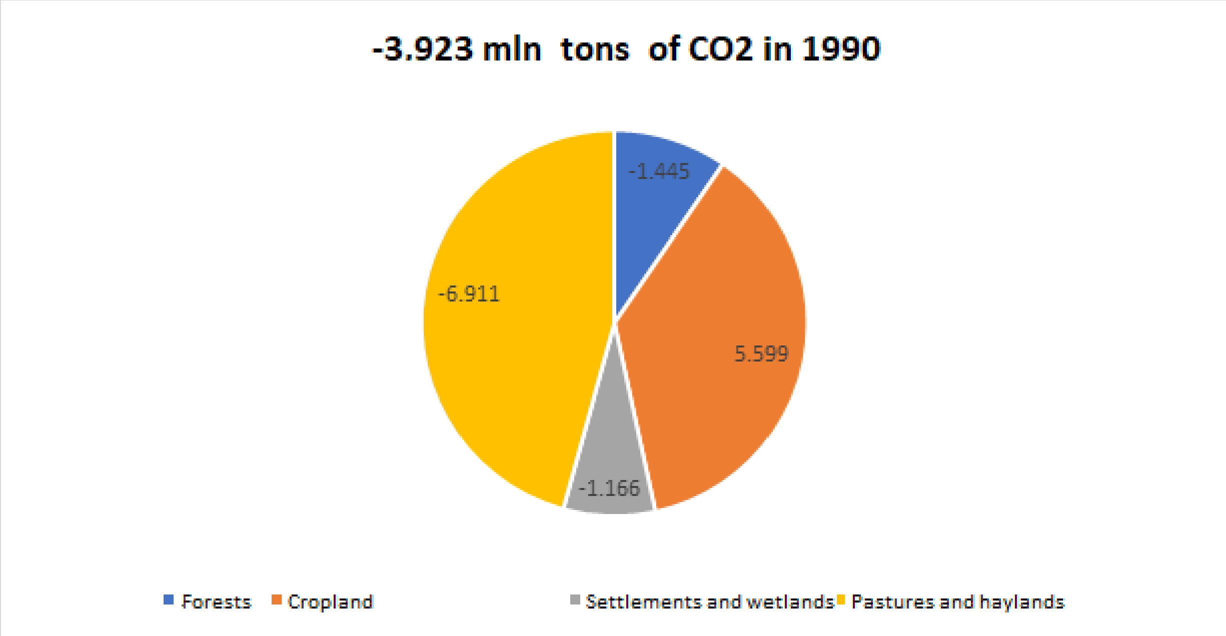
Without measures scenario

Figure 5.20. *Forecasts for GHG emissions from LULUCF under the WOM scenario until 2030*



As can be seen from Figure 5.20, the driver of GHG emissions under the WOM scenario is cropland, and the total emissions from the LULUCF sector until 2035 are expected to remain almost at the same level as the level of GHG emissions in 2020. The cropland subsector has a very large potential for reducing GHG emissions. In 2020, croplands emitted about 32 million tons of CO2 - eq. Given these figures, the reduction potential in the cropland subsector is around 30–35 million tons of CO2e. The reason for high GHG emissions in the cropland subsector is a decrease in humus levels and a large area of cropland

Figure 5.21. *Distribution of GHG emissions in the base year of 1990*



According to the GHG inventory in 1990, the LULUCF sector absorbed about four million tons of GHG in CO_2 equivalent.[195]

The list of main proposed measures aims to reduce the trend towards humus loss in arable soils. Below is a list of potential measures to assess which activities are most attractive, given that each individual measure has advantages and disadvantages.

Table 5.10. *List of potential measures to evaluate the most effective activities to reduce the trend of humus loss*

	Measure	Implemented by	Mitigation potential	Environmental and social consequences
1.	CO_2 tax for managing croplands	Ministry of Agriculture	4.5 mln. tons of CO_2	Increase in productivity and soil health
2.	Fines for the lack of fertilizers and crop rotation		3 mln. tons of CO_2	Increase in productivity and soil health
3.	Crop rotation		1.5 mln. tons of CO_2	Increase in productivity of restored soil
4.	Promotion of organic agriculture		1.5 mln. tons of CO_2	Increase in productivity and soil health
5.	Two billion of trees	Ministry of Agriculture, Ministry of Natural Resources and Environmental Protection	2 mln. tons of CO_2	Positive effect on population's health
6.	Subsidies to purchase fertilizers	Ministry of Agriculture	1.5 mln. tons of CO_2	Increase in productivity and soil health

[195] National report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol for 1990-2019.

With current measures scenario

The scenario provides for plans to plant two billion trees, announced by the President of the Republic of Kazakhstan in the Address to the people of Kazakhstan on September 1, 2020. The scenario also considers the state program for subsidizing agricultural fertilizers for cropland. In other LULUCF subsectors, such as settlements, pastures, removals are assumed to be constant at the 2020 level.

With additional measures scenario

Breakdown of measures

Short- and long-term measures (2021-2035), increasing fertilizer levels:

A1: Increasing government subsidies to purchase fertilizers

A2: Private fertilizers through loans

A3: International loans to purchase fertilizers

Short-term measures are aimed to increase the area of arable land cultivated with fertilizers, both organic and inorganic. Measures A1, A2 and A3 could raise funds to be spent on fertilizers for arable lands from the current USD50 million to 75 million per year. The overall effect of these measures is estimated to reduce GHG emissions by 2 million tons of CO2 per year.

Medium-term (2024-2027) and long-term (2028-2035) measures:

A4: Organic farming or no-tillage (0.5–1 million ha)

A5: Crop rotation (1 million ha)

A6: Forest plantation (0.4 million ha) and protection

In addition to short-term measures, several other support strategies aim to further reduce humus loss in croplands. Measures A4 and A5 encourage no-till and crop rotation practices. Both approaches maintain or increase soil humus levels. Measure A6, involving the plantation of about 400 thousand hectares of forests, are aimed at small farmers:

- submission by small farmers of plans for crop rotation (1 million ha);
- promotion of no-till among small farmers (0.5 million ha);
- public and private tree plantation and forest protection.

The total effect of measures A4, A5 and A6 is estimated at 5 million tons of CO_2 annually.

Medium-term (2024-2027) and long-term (2028-2035) measures, financial incentives:

A7: Carbon tax for large enterprises (2 USD/ha)

A8: Fines for large enterprises for lack of fertilizers

A9: Bond trading between large entities

Measures A7, A8 and A9 dedicated to medium and large farmers:

- carbon tax;
- fines for lack of fertilizing (USD4–6 for several years with subsequent lack of fertilizing);
- trade (trade in carbon credits, mutual trade to eliminate the carbon tax).

Measures A7, A8 and A9 are estimated to reduce GHG emissions by 9.5 million tons of CO_2-eq per year.

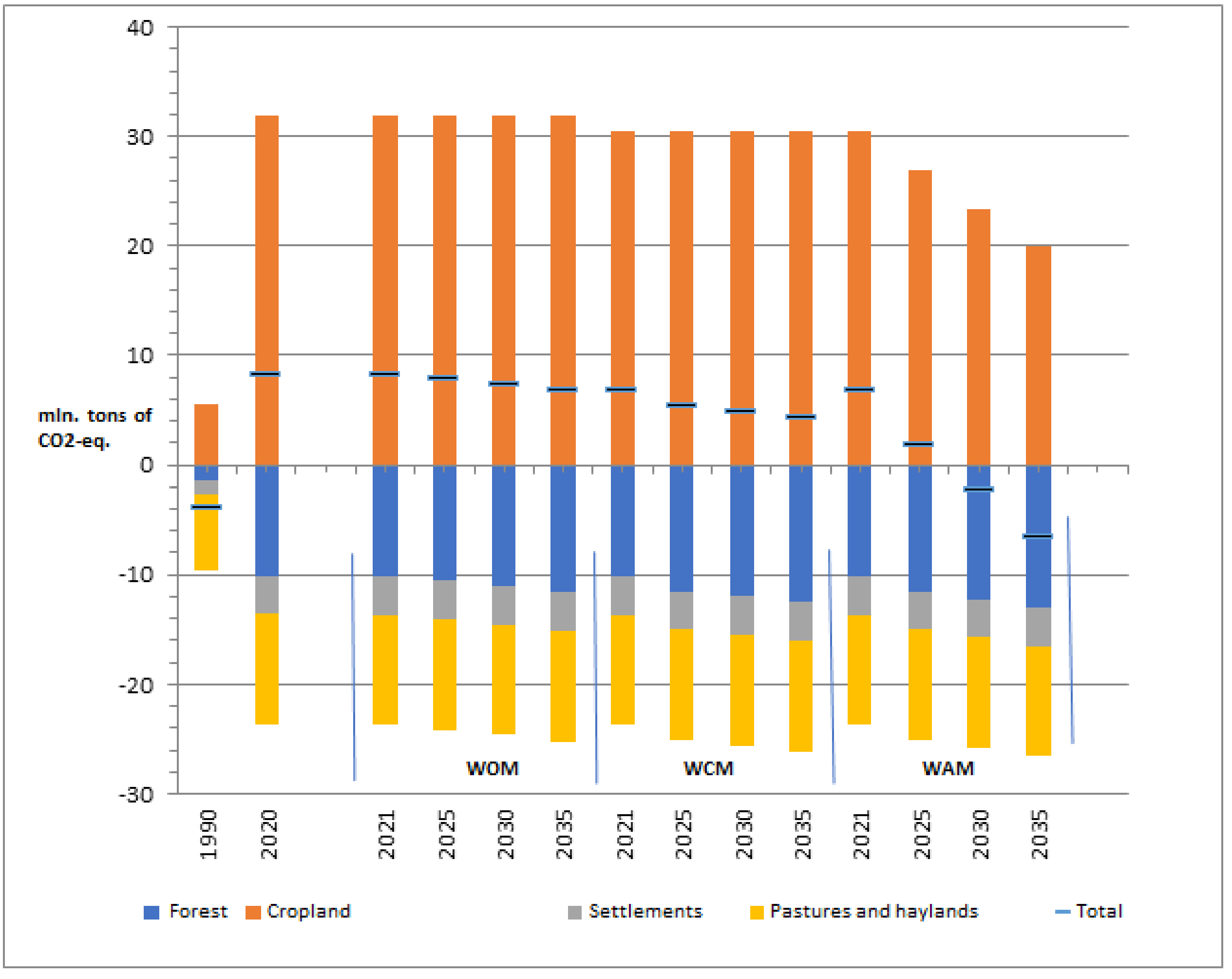
Forestry, pastures, and settlements

Other LULUCF subsectors, such as pastures, absorb CO2 at near maximum rates. Human settlements absorb a relatively small share of total LULUCF emissions. Changes in CO2 absorptions are unlikely for human settlements and wetlands. Therefore, emissions from these two subsectors are considered to be the same as in the WOM scenario.

B. Assessing the cumulative impact of policies and measures in the LULUCF sector

Emissions under all three WOM scenarios, unconditional and conditional, can be seen in Figure 5.22

Figure 5.22. *Cumulative GHG emissions under three scenarios*



Only under the WAM scenario, the level of absorptions can achieve the level of 1990 by 2035.

Table 5.11. *Total GHG emissions from LULUCF*

	Fact emissions		**WOM**				**WCM**				**WAM**			
	1990	**2020**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**
Forest, mln. tons of CO_2	-1.445	-10.057	-10.095	-10.49	-10.99	-11.55	-10.095	-11.49	-11.99	-12.49	-10.095	-11.49	-12.2	-12.95
Cropland, mln. tons of CO_2	5.599	31.905	31.905	31.905	31.905	31.905	30.4	30.4	30.4	30.4	30.4	26.9	23.4	19.9
Settlements, mln. tons of CO_2	-1.166	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541	-3.541
Pastures, mln. tons of CO_2	-6.911	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12	-10.12
Total, mln. tons of CO_2	-3.923	8.187	8.149	7.754	7.254	6.694	6.644	5.249	4.749	4.249	6.644	1.749	-2.461	-6.711

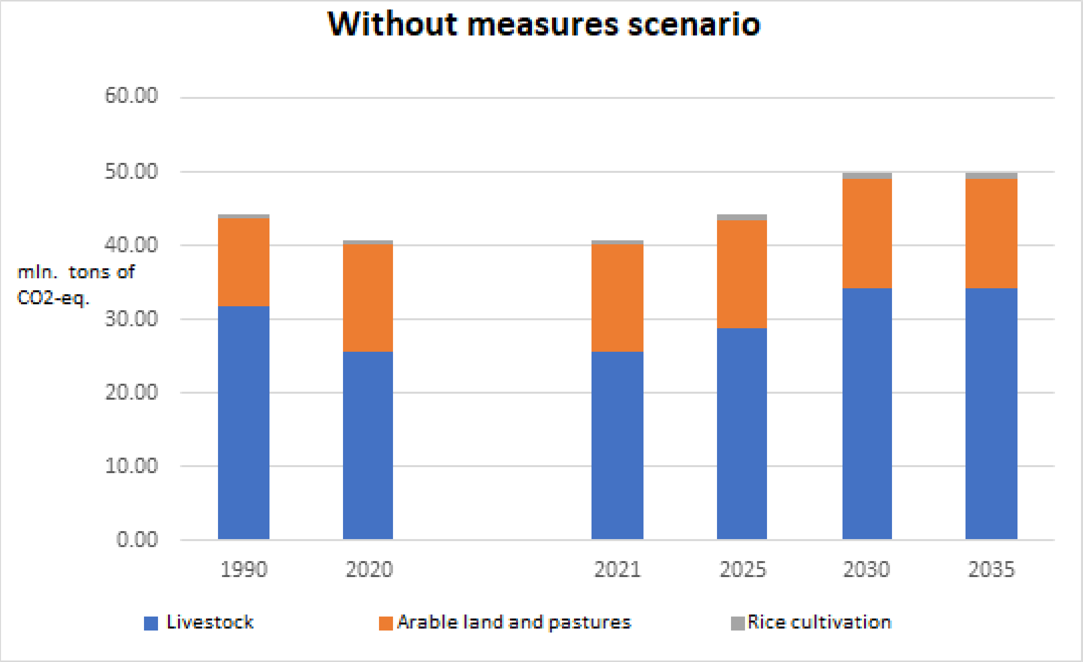
5.4. Forecasts and cumulative impact of policies and measures in agriculture

A. Forecasts in the agricultural sector

This chapter presents activities held in the agricultural sector. The impact of these measures is assessed under the three scenarios. The current emission trend is estimated under the WOM scenario and is based on the dynamics of the cattle population. The total emissions from the agricultural sector in all three scenarios are presented at the end of this chapter.

Without measures scenario

Figure 5.23. *Forecasts for GHG emissions in the agricultural sector under the WOM scenario until 2035*



According to the chart (Figure 5.23), in 1990 the level of emissions from agriculture was 44.18 million tons per year. In 2020, emissions amounted to about 40.72 million tons, which is still below the 1990 baseline. However, the number of cattle is expected to increase until 2035, and emissions will exceed 1990 levels by more than 5.5 million tons of CO2 in 2035. Emissions from livestock account for about 2/3, while arable land and pastures account for 1/3 of emissions from agriculture. Rice cultivation will not have a significant impact on total emissions.

With current measures scenario

Breakdown of measures

Short- and long-term measures (2021-2035), source reduction:

A1: Improving the breeds of large and small cattle, and horses

A2: Improving the feed

A3: Pasture management

Medium-term (2024-2027) and long-term (2028-2035) measures, processing sources:

A4: Installation of biogas plants

A5: Biogas and fertilizer production using anaerobic reactor plants

By improving livestock breeds it is possible to obtain the same amount of meat, milk, and other products with less cattle, which in turn will lead to a reduction in methane emissions due to less fermentation. Measure A1 can be achieved by importing the breed and establishing local breeding centers or by a combination of the first and second measures. In breeding centers, seed material from breeding cattle can be distributed to local farms upon request. Measure A1 is estimated to reduce emissions by 2%, or 800,000 tons of CO_2-eq annually.

Feeding cattle plays an important role in its productivity and in the fermentation process. Higher quality grass and special feeds can reduce the amount of methane produced by livestock. Measure A2 is estimated to reduce emissions by 400 thousand tons of CO2-eq per year.

It is expected that improving the efficiency of pasture management will contribute to a reduction of 200 thousand tons of CO_2-eq per year due to reduced soil erosion.

Biogas production using manure is another efficient way to generate electricity and heat instead of using electricity produced by coal-fired power plants. One ton of manure from biogas production can save about 40 kg of CO_2-eq, while reducing the cost of heating and electricity for farmers. Kazakh farmers can sell electricity generated from biogas to the state. However, there are some barriers such as the connection to the common power grid. Removing the barrier could also increase the spread of biogas plants. The installation of biogas plants is proposed to be carried out primarily on large and medium-sized livestock farms.

With additional measures scenario

Short-term mitigation measures (2021–2024):

The scenario assumes additional funding for mitigation measures. It will improve livestock production by importing more cattle. It is also expected that improved funding will improve pasture management. The effect of the overall improvement due to increased funding is estimated at 400 thousand tons of CO_2 annually.

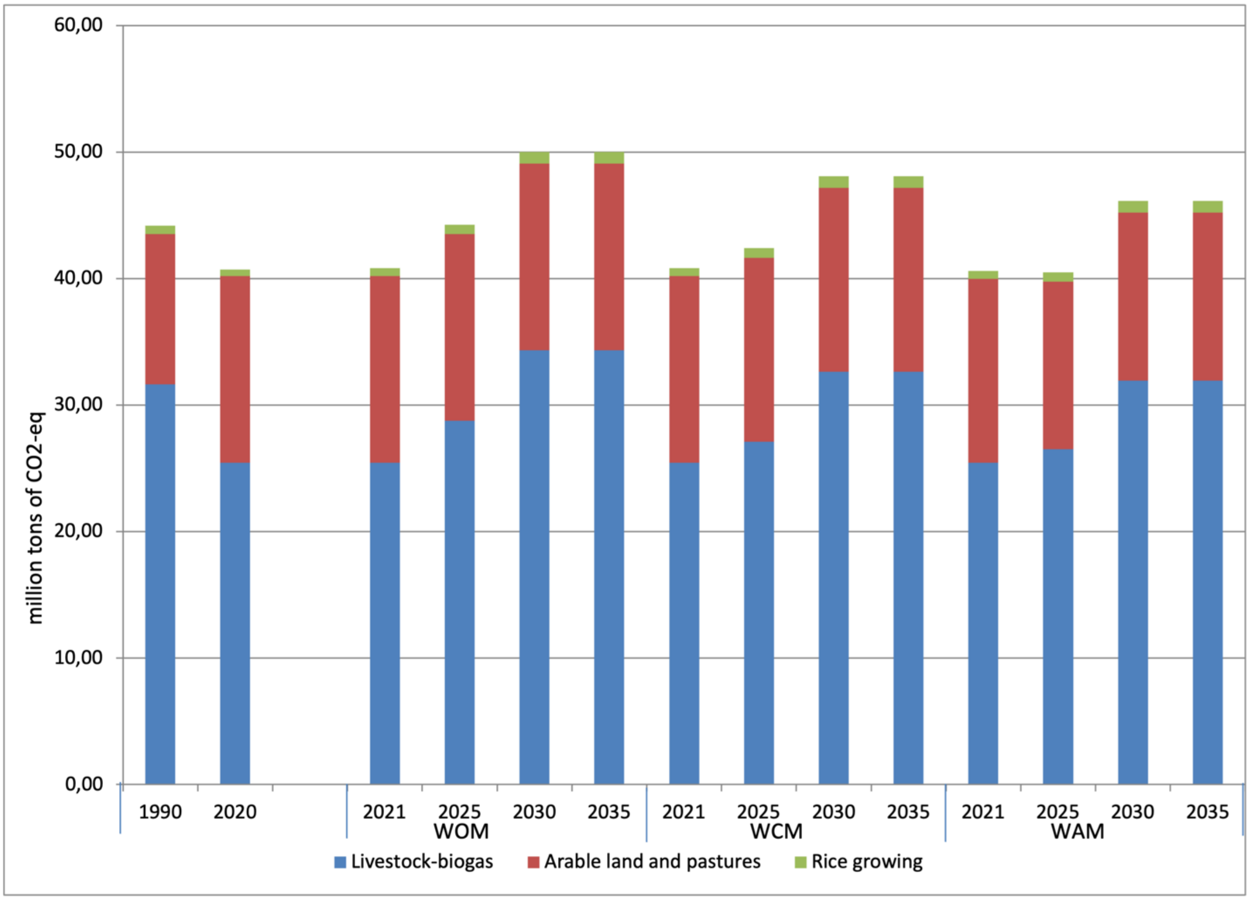
Additional funding could also help farmers to buy biogas plants through loans or partial subsidies. Biogas plants also make it possible to produce crop fertilizers from manure using anaerobic reactors in biogas plants. Such installations also produce electricity and heat. Reducing emissions from biogas plants in the scenario with additional measures will reduce emissions by about 400 thousand tons of CO_2-eq per year.

In general, the with additional measures scenario reduces emissions by 2.4 million tons of CO2 equivalent

B. Assessing the cumulative impact of policies and measures in the agriculture sector

Below are emission projections for three scenarios: without measures, with current measures, and with additional measures (Figure 5.24)

Figure 5.24. *Cumulative GHG emissions under three scenarios*



There is little difference between the WCM and WAM due to the low rate of reduction in GHG emissions from agriculture in Kazakhstan and the high level of investment required to improve such biogas plants in livestock farms.

Table 5.12. *Total emissions from agriculture*

	Fact emissions		WOM				WCM				WAM			
	1990	**2020**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**
Livestock, mln. tons of CO2	31.63	25.43	25.43	28.75	34.32	34.32	25.43	27.09	32.62	32.62	25.43	26.50	31.95	31.95
Arable land and pastures, mln. tons of CO2	11.90	14.76	14.76	14.76	14.76	14.76	14.76	14.56	14.56	14.56	14.56	13.26	13.26	13.26
Rice cultivation, mln. tons of CO2	0.65	0.54	0.62	0.75	0.91	0.91	0.62	0.75	0.91	0.91	0.62	0.75	0.91	0.91
Total, mln. tons of CO2	44.18	40.72	40.80	44.26	49.99	49.99	40.80	42.40	48.09	48.09	40.60	40.51	46.12	46.12

Table 5.2 shows the total emissions in the agriculture subsectors under the three scenarios, along with historical emissions in 1990 and 2020.

5.5. Forecasts and overall impact of policies and measures in the waste management sector
A. Forecasts for the waste management sector

Without measures scenario

The scenario includes the period from 2020 to 2035 for GHG emissions from MSW.

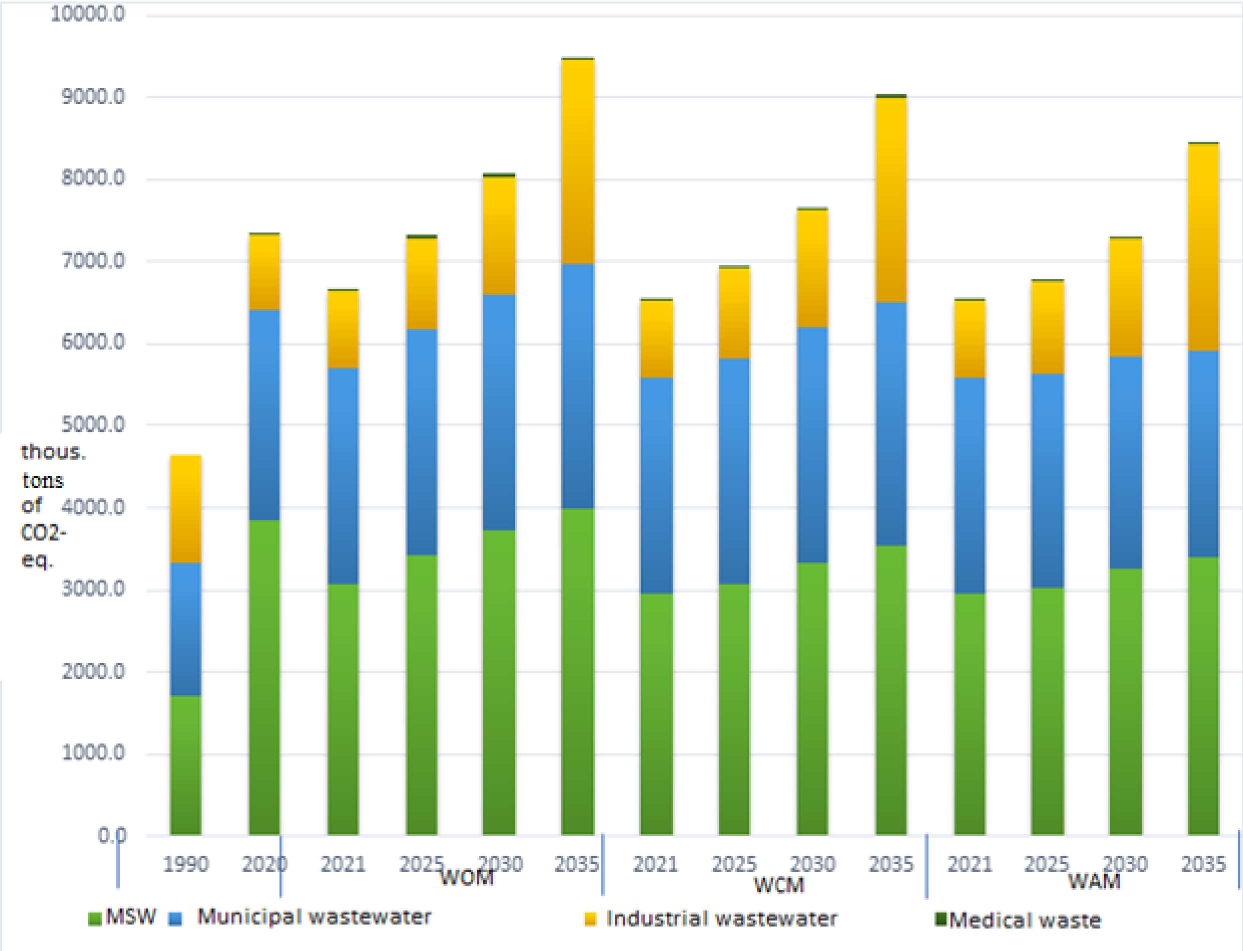
Table 5.13. *WOM scenarios for GHG emissions from MSW until 2035*

Year	**Food waste,** kt of CH_4	**Garden waste,** kt of CH_4	**Paper,** kt of CH_4	**Wood,** kt of CH_4	**Textile,** kt of CH_4	**Industrial waste, kt of CH_4**	**Total, MSW kt of CH_4**	**Total, MSW kt of CO_2**
2021	35.41	2.05	46.28	0.65	3.94	20	108	2701.03
2022	36.23	2.10	47.51	0.67	4.04	20	111	2762.74
2023	37.03	2.15	48.72	0.69	4.14	20	113	2823.85
2024	37.81	2.19	49.91	0.71	4.24	20	115	2882.93
2025	38.55	2.24	51.06	0.73	4.34	21	118	2940.08
2026	39.27	2.29	52.19	0.75	4.44	21	120	2995.38
2027	39.96	2.33	53.28	0.77	4.53	21	122	3048.94
2028	40.62	2.37	54.35	0.79	4.62	21	124	3100.83
2029	41.26	2.41	55.39	0.81	4.71	21	126	3151.13
2030	41.88	2.45	56.41	0.83	4.80	22	128	3199.92
2031	42.47	2.49	57.40	0.85	4.88	22	130	3247.27
2032	43.05	2.53	58.37	0.87	4.96	22	132	3293.41
2033	43.61	2.56	59.32	0.88	5.04	22	134	3338.41
2034	44.16	2.60	60.26	0.90	5.12	22	135	3382.31
2035	44.69	2.64	61.17	0.92	5.20	22.39	137.01	3425.16

As can be seen from Table 5.13, to calculate GHG emissions from MSW, a Simple First Order Attenuation (FOA) Spreadsheet Model was used which takes into account the population and growth forecast, GDP growth and other parameters from 2021 to 2035.

Figure 5.25 shows the results of calculations of GHG emissions from municipal, industrial wastewater and human waste products. In the final calculations, domestic wastewater will include GHG emissions from human waste products.

Figure 5.25. *Forecasts for GHG emissions from wastewater*



As can be seen from Figure 5.25, GHG emissions from industrial wastewater will almost double from 940.8 thousand tons of CO_2-eq in 2021 to 1851.9 thousand tons of CO2-eq in 2035. By 2035, GHG emissions from municipal wastewater will have increased from 2,185 thousand tons of CO2 in 2020 to just over 2,500 thousand tons of CO_2 -eq.

GHG emissions from medical waste incineration are assumed under the WOM scenario to be at the level of 2021, or equal to 30.9 thousand tons of CO_2-eq.

With current measures scenario

The scenario implies such policies and measures as a ban on landfilling food waste, paper and plastic, separate waste collection, construction of waste incinerators in 6 major cities of the Republic of Kazakhstan, packaging and tires fees, and a car recycling program.

With additional measures scenario

The scenario includes all measures from the WCM scenario, as well as additional measures in municipal wastewater treatment, namely the anaerobic (oxygen-free) treatment of municipal wastewater, which can significantly reduce greenhouse gas emissions and at the same time produce agricultural fertilizers. On the other hand, the scenario implies the distribution of food waste disposers to households and the disposal of food waste into wastewater. The implementation of these additional measures will reduce GHG emissions from MSW by reducing GHG emissions from food waste by up to 10% by 2035 and will also reduce emissions from wastewater due to anaerobic wastewater treatment by 15% by 2035. The implementation of these additional measures will require additional funding.

B. Assessing the cumulative impact of policies and measures in the waste management sector

Figure 5.26 shows scenarios of GHG emissions in the waste management sector under the without measures scenario (WOM), with current measures (WCM) and with additional measures (WAM). In addition, Figure 5.26 shows the level of GHG emissions in 1990 and 2020.

As can be seen from Figure 5.26, half of the GHG emissions in the waste management sector come from MSW. The other half of GHG emissions is accounted for by municipal and industrial wastewater. In the WCM, emissions from MSW are reduced by approximately 15%, while emissions from municipal and industrial wastewater remain at the same level. This is due to the construction of waste incineration plants and further waste-to energy. Also, the reduction in emissions from MSW in the WCM scenario is associated with an increase in the share of MSW recycling due to the ban on the disposal of food waste, paper, and plastic in landfills.

The reduction in emissions from municipal wastewater in the WAM scenario is associated with anaerobic treatment of wastewater.

In general, in the WOM scenario, GHG emissions in 2035 will almost double the level of 1990. In the WCM scenario, in 2035, GHG emissions will reach 9 million tons, and in the WAM scenario, emissions will amount to about 8.5 million tons in CO_2 equivalent.

Figure 5.26. *Forecasts for GHG emissions in the waste management sector without measures, with measures and with additional measures (thousand tons of CO_2-eq.)*

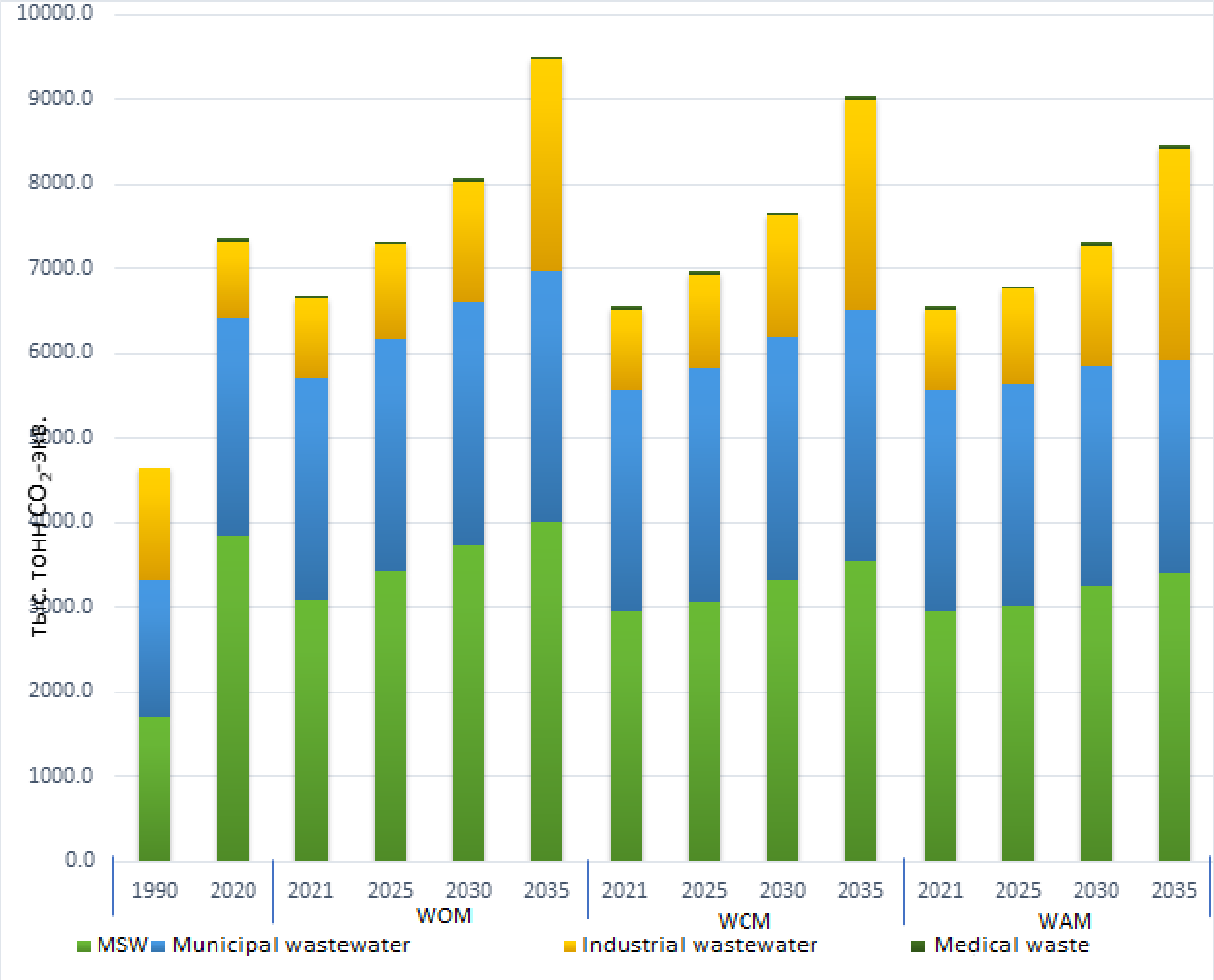


Table 5.14 presents the results of calculations in scenarios without measures, with current measures, and with additional measures.

Table 5.14. *GHG emissions in the waste management sector until 2035 in scenarios without measures, with current measures and with additional measures*

	Actual emissions		WOM				WCM				WAM			
	1990	**2020**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**	**2021**	**2025**	**2030**	**2035**
MSW (Municipal solid waste)	1716.0	3836.0	3076.0	3424.0	3732.0	3998.0	2947.3	3062.4	3320.4	3536.4	2947.3	3027.7	3257.6	3402.3
Municipal wastewater	1609.0	2580.0	2632.0	2752.6	2871.3	2968.2	2632.0	2752.6	2871.3	2968.2	2632.0	2615.0	2584.2	2523.0

Industrial wastewater	1324.0	909.0	941.0	1115.0	1437.0	2502.0	941.0	1115.0	1437.0	2502.0	941.0	1115.0	1437.0	2502.0
Medical waste	0.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0
Total	4,649.0	7,356.0	6,680.0	7,322.6	8,071.3	9,499.2	6,551.3	6,961.0	7,659.7	9,037.6	6,551.3	6,788.7	7,309.8	8,458.3

5.6. C. Methodology

The forecast for greenhouse gas emissions in this chapter are made in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[196].

Table 5.15 summarizes the basic assumptions about GDP growth and population change used in GHG emissions forecast. Based on the Forecast of the socio-economic development of the Republic of Kazakhstan for 2022–2026[197] by the Ministry of National Economy of the Republic of Kazakhstan, an annual GDP growth is predicted to be at an average of 5% until 2025 and 5.2% after that year. The population is projected according to the population forecast of the Center for Workforce Development. [198]

Table 5.15. *Summary of key variables and assumptions used in the forecasting (energy sector)*

Key assumptions		*Historical*	*Projected*			
Assumptions	*Measurement unit*	2017	2020	2025	2030	2035
Population	thousand people	17 918	18 739	19 752	20 675	21 693
GDP	annual growth rate	1.4	2.6	5.0	5.2	5.2

Gross value added (GVA) of industry will grow by an average of 3.2% in 2022-2030. GVA of the mining industry in the forecast period will increase by 1% in average annual terms.

Table 5.16. *Forecast of GVA increase in the mining industry*

Name	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2022–2026** (average)
	Fact	**Forecast**					
Goods production	**103.5**	**103.1**	**105.7**	**104.0**	**103.0**	**104.3**	**104.0**
Agriculture	97.8	104.5	104.7	104.9	105.3	105.5	105.0
Industry	**103.6**	**102.6**	**106.3**	**103.8**	**102.4**	**103.7**	**103.8**
Mining	**101.9**	**102.0**	**109.8**	**103.9**	**100.6**	**103.2**	**103.9**
Coal and lignite production	102.6	99.0	100.0	99.0	100.0	99.0	99.4
Oil production	101.1	102.2	112.7	104.6	100.0	103.6	104.6
Natural gas production	97.9	100.4	108.9	101.6	96.4	107.4	102.9
Processing	**104.7**	**103.5**	**103.6**	**104.3**	**104.3**	**104.5**	**104.1**
Food production	101.1	103.5	104.	105.0	105.0	106.0	104.6
Oil processing	106.0	100.0	100.0	100.0	100.0	100.0	100.0

[196] https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/index.html
[197] Forecast of the socio-economic development of the Republic of Kazakhstan for 2022–2026, dated September 1, 2021.: https://www.gov.kz/memleket/entities/economy/documents/details/208527?directionId=201&lang=ru
[198] https://iac.enbek.kz/ru/node/668

Chemical industry	101.9	102.0	103.0	103.0	103.0	104.0	102.8
Pharmaceuticals industry	116.5	105.	105.0	105.0	105.0	105.0	105.0
Non-metal mineral products	107.6	105.4	105.7	105.7	105.9	106.1	105.7
Metallurgy	98.5	103.1	104.4	104.4	104.8	104.9	104.2

To assess the impact of climate change mitigation measures in the Policies and Measures section, as well as to obtain forecasts and the overall impact of policies and measures, the TIMES-KAZ model was used, which was developed as part of the German Society for International Cooperation and Development (GIZ) project ‘Supporting green economy in Kazakhstan and Central Asia for low-carbon economic development’ funded by the Federal Ministry of Environment, Nature Protection and Safety of Nuclear Reactors (BMU) under the German Climate Initiative (IKI). The model was created to develop the Low-Carbon Development Concept of the Republic of Kazakhstan.

For more information on the TIMES family of models, see the website of the International Energy Agency.[199]

Within the framework of this document, the TIMES-KAZ model was used for combustion sectors, according to the UN IPCC classification, which covers all major greenhouse gases: CO2, CH4, N2O. The base year for the model is 2017, which was chosen because at the time of model development all data for this year were available. The model horizon covers the period up to 2060.

The TIMES-KAZ model is a holistic bottom-up technology model using linear programming over medium- and long-term time horizons to create the least costly energy system optimized to meet a range of user constraints. The TIMES-KAZ model describes the development of the energy system in Kazakhstan with detailed information on available technologies and their costs.

The TIMES-KAZ model is used to explore possible energy future based on various scenarios. The analysis used an updated version of the extended TIMES-KAZ model in 2021, which additionally introduced a set of advanced technologies, such as hydrogen production and the use of geothermal energy.

The advantage of the model is the detailed representation at the technological level of all combustion sectors of interest in terms of reducing GHG emissions. However, it should be borne in mind that the model does not consider the impact of combustion sectors on other economic sectors, and, accordingly, cannot consider intersectoral interaction with them.

The TIMES-KAZ model can be used for quantitively estimates, either individually or in combination. Moreover, in the latter case, the interaction of policies and measures can occur, thereby changing the effects on reducing GHG emissions.

To forecast greenhouse gas emissions in the IPPU sector not related to fuel combustion, in scenarios with current measures, without measures and with additional measures, a linear regression model was used. It considers the design capacities of industrial installations in the Republic of Kazakhstan based on Excel's forecasting tool, which uses a range of historical data, expert forecasts of economic development and product demand. The constructed emissions forecasting model allows for a long-term scenario analysis.

[199] https://iea-etsap.org/index.php/etsap-tools/model-generators/times

To calculate GHG emissions from forestry, the CBM-CFS3 (Carbon Budget Model of the Canadian Forest Sector) model was used. The model was developed to meet the operational needs of forest management and forest carbon accounting analysis.

CBM-CFS3 can be used to model the dynamics of all forest carbon stocks required under the United Nations Framework Convention on Climate Change. The model follows the methods for estimating carbon emissions as outlined in the IPCC Guidelines.

GHG emissions from municipal solid waste were calculated using the Simple First Order Attenuation (FOA) Spreadsheet Model. This model was developed by the IPCC and is in line with the IPCC guidelines for calculating GHGs in the waste management sector.

The FOA included historical and forecast data on the change in the population of the Republic of Kazakhstan until 2050, published by the Center for Workforce Development.[200]

GHG emissions from municipal wastewater, as well as indirect emissions, emissions from human waste products are taken to depend on the population of the Republic of Kazakhstan. GHG emissions from industrial effluents were linked to the country's GDP.[201]

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[200] https://iac.enbek.kz/ru/node/668

[201] Forecast of the socio-economic development of the Republic of Kazakhstan for 2022–2026.: https://primeminister.kz/ru/media/infographic/prognoz-socialno-ekonomicheskogo-razvitiya-kazahstana-na-2022-2026-gg-247941

VI. Vulnerability assessment, climate change impacts and adaptation measures

6.1. Assessing the impact of climate change

The Notre Dame-Global Adaptation Index (ND-GAIN) was used to analyze the country's current vulnerability to climate change and assess its readiness to attract private and public sector investments for adaptation actions.[202]

A country's vulnerability assessment considers six vital sectors: food, water, health, ecosystem services, human habitat, and infrastructure. Each sector is represented by six indicators that stand for three cross-cutting components: the sector's exposure to climate or exacerbating hazards; the sensitivity of the sector to the impacts of the hazard and the adaptive capacity of the sector to overcome or adapt to these impacts:

- **Country readiness** measures the likelihood of using the investment and converting it into adaptation action. ND-GAIN measures overall readiness by looking at three components: economic readiness, management readiness, and extent of readiness.
- **Economic:** covers the ability to apply the investment business environment for adaptation, Vulnerability reduction (reduces sensitivity and improves adaptive capacity).
- **Control:** strengthens institutional factors that increase the effectiveness of the use of investments for adaptation.
- **Social:** covers factors such as social inequality, information and communication technology infrastructure and systems (including software, hardware, firmware, networks, and websites), education and innovation that increase the mobility of investment and embrace adaptation actions.

Scheme 6.1. *Calculation of the ND-GAIN index*

(- +1)*50=GAIN

0–100, the higher the better

Readiness Indicator (0-1, the higher the better

Vulnerability Indicator (0-1, the lower the better

A country's ND-GAIN assessment consists of a vulnerability assessment and a readiness assessment. The index summarizes a country's vulnerability to climate change and other global challenges, combined with its willingness to build resilience, and aims to support governments, businesses, and communities to prioritize investment and better respond to upcoming global challenges.

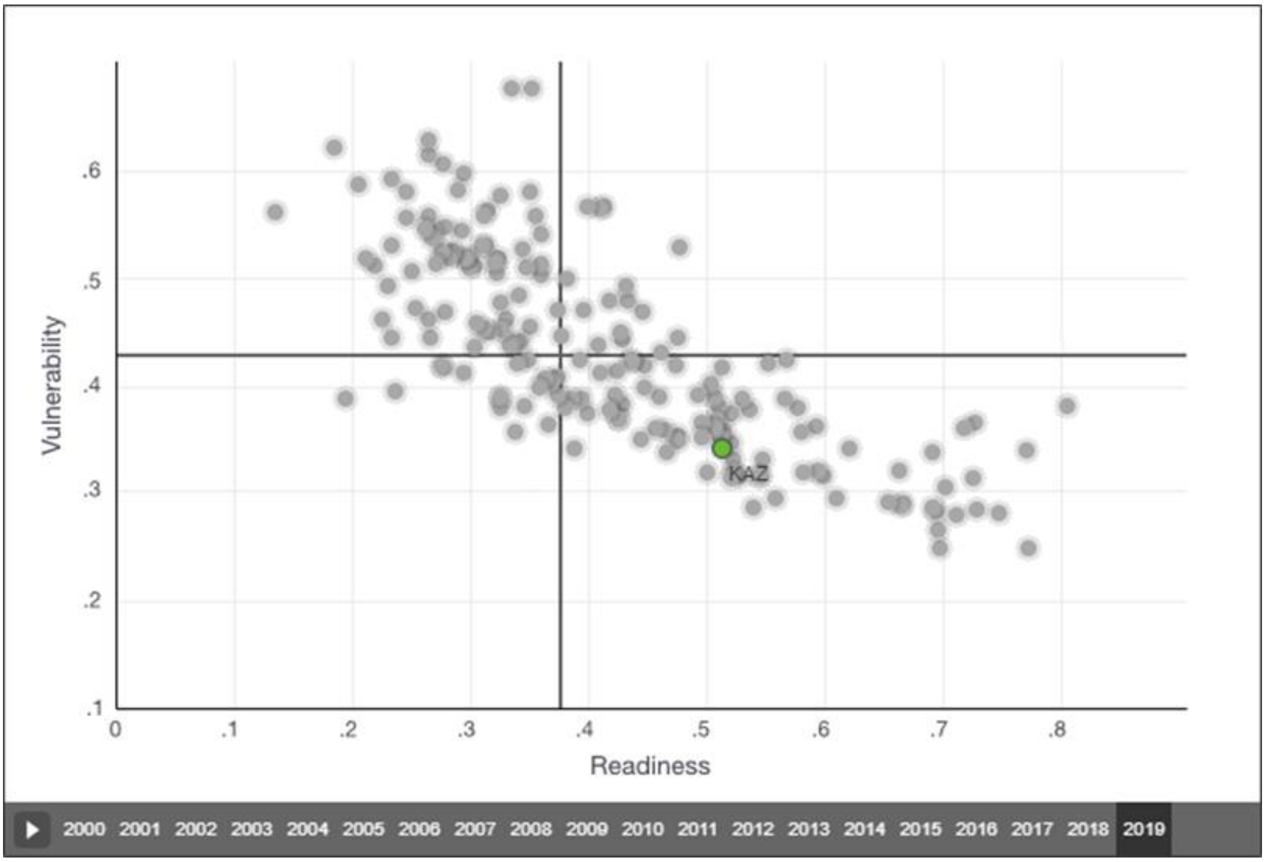
In Figure 6.1 below, the ND-GAIN index is presented as a scatter plot, i.e., a matrix divided into four quadrants, delineated by the average vulnerability score across all countries and for all

[202] https://gain.nd.edu/our-work/country-index/

years, and by the calculated median readiness score. The vertical axis shows the vulnerability score, and the horizontal axis shows the readiness score.

Kazakhstan[203] is in the lower right quadrant and is among the countries with ND-GAIN (57.9) above average, vulnerability level 0.358 (above average), and preparedness level 0.517 (above average). Countries such as Kazakhstan still need to adapt (none of these countries have a perfect vulnerability score), but they may be well placed to do so.

Figure 6.1. ND-GAIN Index Matrix (Kazakhstan, 2019)



Kazakhstan ranks 40th among the countries participating in the assessment, the index value of ND-GAIN - 58.7, vulnerability - 0.342, readiness - 0.516 (Table 6.1).

Table 6.1.

Place	Income level	Score	Vulnerability	Readiness
40	Above the average	58.7	0.342	0.516

To study modern changes in the regime of temperature and precipitation on the territory of Kazakhstan, homogeneous data series of instrumental observations at the state network of meteorological stations covering a fairly long period of years were used. The following estimates of climate change characteristics are obtained from data from more than 180 stations for periods since 1961 and from data from 121 stations if estimates are made for the period since 1941. To

[203] https://gain.nd.edu/our-work/country-index/matrix/

characterize climate change, we used the linear trend coefficient, which characterizes the rate of change of one or another climatic parameter over a specified period of years, and the determination coefficient, which determines the share of the trend component in the total parameter variability.

6.2. Changes in temperature mode

Global warming continues to break records. According to the World Meteorological Organization,[204] each of the last four decades has been warmer than any previous decade since 1850. The global surface temperature in 2011–2020 was 1.09°C higher than in 1850–1900, while over the land it was 1.59 °C higher and over the ocean 0.88°C higher.

On the territory of Kazakhstan, 2021 took 5th place among the warmest years with an air temperature anomaly of 1.58°C (table 6.2). Of the ten warmest years, nine occur in the 21st century. The absolute maximum temperature was observed in 2020, when the anomaly was 1.92°C, thereby updating the record of 2013 with an anomaly of 1.89°C.

Table 6.2. *The ten warmest years and the corresponding anomalies of average annual air temperature, averaged over the territory of Kazakhstan. Period for calculating ranks 1941–2021 The anomalies are calculated relative to the period 1961–1990.*

Year	Anomaly,°C	Rank
2020	1.92	1
2013	1.89	2
1983	1.76	3
2015	1.64	4
2021	1.58	5
2002	1.55	6
2004	1.53	7
2019	1.50	8
2016	1.48	9
2007	1.46	10

Table 6.3 shows the air temperature values for the warmest and coldest months and seasons on the territory of Kazakhstan for the period since 1941. It is noteworthy that the records of high air temperatures fall on the current 21st century, while records of low temperatures recorded in the last century. The warmest spring and winter seasons were in 2020.

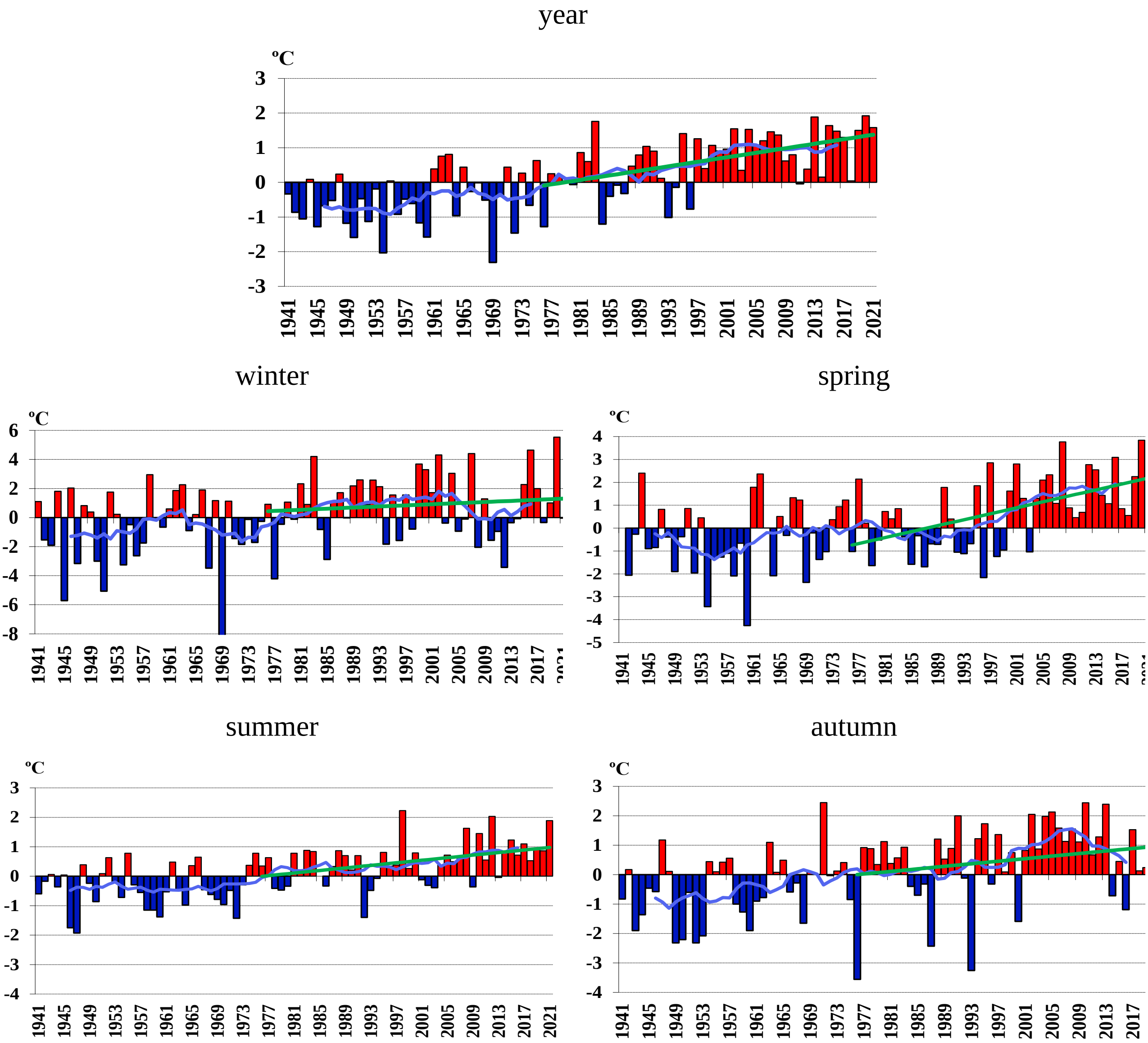
[204] https://library.wmo.int/index.php?lvl=notice_display&id=21804#.Y4R8H31Bw2w

Table 6.3. Air temperature values for the warmest and coldest periods in Kazakhstan, obtained by averaging data from meteorological stations over the territory of the republic for the period from 1941 to 2021

Period	warmest period			The coldest period		
	value, °C	record year	previous record year	value, °C	record year	previous record year
January	-5.8	2002	2007	-23.8	1969	1977
February	-3.9	2002	2020	-20.6	1969	1951
March	3.2	2008	2002	-10.5	1960	1954
April	13.2	2012	1997	4	1987	1964
May	19.2	2021	2020	10.8	1960	1958
June	23.4	1977	2015	17.4	1947	1946
July	24.4	1998	2008	19.7	1960	1972
August	23.0	2021	1998	18.3	1969	1992
September	16.9	1957	2016	11.1	1949	1967
October	10.9	1997	1991	0.5	1976	1987
November	1.9	2010	2013	-10.4	1993	1952
December	-3.8	2015	1989	-19.2	1984	1944
spring	9.98	2020	2008	1.9	1960	1954
summer	23.3	1998	2012	19.1	1947	1946
autumn	8.1	1971	2010	2.1	1976	1993
winter	-5.7	2020	2016	-19.4	1969	1945
year	7.3	2020	2013	3.1	1969	1954

The pace of climate change is not uniform across the globe. The territory of Kazakhstan, located in the middle latitudes of the Eurasian continent and far from the oceans at a considerable distance, is warming up at a faster rate than the average globe. Since 1976, the rate of increase in the average annual air temperature for the globe has been 0.18°C for every 10 years; the average rate for the territory of Kazakhstan was much higher: 0.32°C for 10 years (Table 6.4). Since the mid-1970s, mostly positive anomalies of the mean annual and mean seasonal surface air temperatures have been observed (Figure 6.2).

Figure 6.2. *Time series of anomalies of annual and seasonal air temperatures (ºC) averaged over the territory of Kazakhstan for the period 1941–2021 The anomalies are calculated relative to the base period 1961–1990. Linear trend over the period 1976–2021 highlighted in green. The smoothed curve was obtained by 11-year moving average.*



On the territory of all regions of Kazakhstan in the period of 1976–2021 there was a steady increase in the average **annual** air temperature (Figure 6.3). Linear trend coefficients range from 0.23°C/10 years (Karaganda region) up to 0.54°C/10 years (West Kazakhstan region) with a determination coefficient of 10–38%. All trends are significant at the 5% level (Table 6.4).

Figure 6.3. *The rate of change in the average seasonal surface air temperature (℃/10 years) on the territory of Kazakhstan in the period 1976–2021. The green circle marks the points, for which according to their data the trend coefficients are statistically significant at the 5% level*

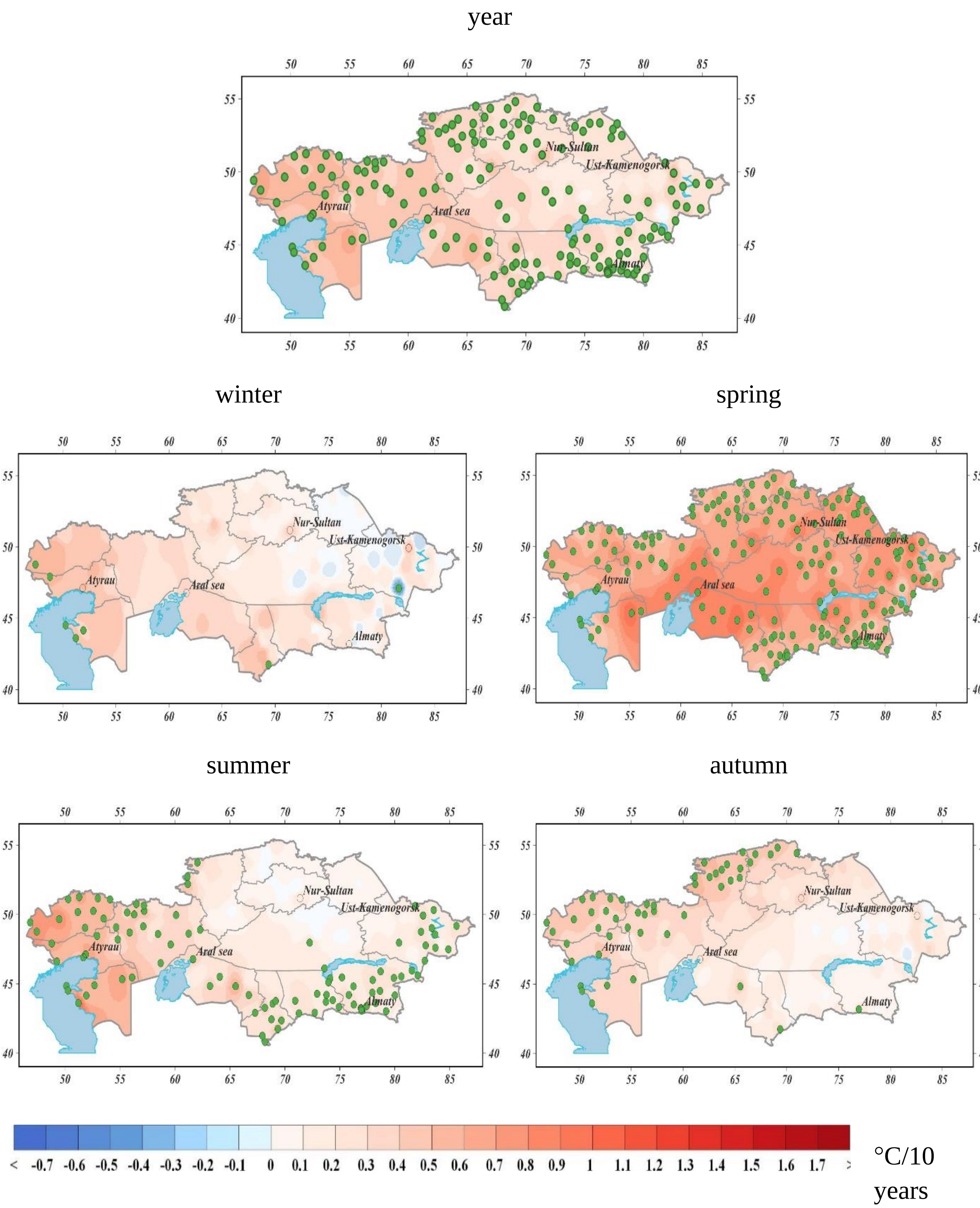


Table 6.4. *Estimates of the linear trend of average seasonal air temperatures averaged over the territory of Kazakhstan and administrative regions for the period 1976–2021:* ***a*** *– linear trend coefficient, ℃/10 years;* ***D*** *- the coefficient of determination (the proportion of the variance of the series taken into account by the trend, %). Bold font and dark color indicate statistically significant trends at the 5% level*

Region/oblast	Year		Winter		Spring		Summer		Autumn	
	a	**D**	**a**	**D**	**a**	**D**	**a**	**D**	**a**	**D**
Kazakhstan	**0.32**	27	0.19	1	**0.65**	31	**0.22**	17	0.22	5
Almaty	**0.28**	27	0.16	1	**0.62**	32	**0.22**	21	0.10	1
Akmola	**0.29**	16	0.14	1	**0.69**	23	**0.03**	0	0.28	5
Aktobe	**0.44**	32	0.33	3	**0.65**	20	**0.37**	14	**0.36**	9
Atyrau	**0.47**	38	**0.45**	7	**0.53**	23	**0.52**	38	**0.35**	11
East Kazakhstan	**0.24**	12	0.03	0	**0.67**	27	**0.15**	9	0.11	1
Zhambyl	**0.29**	25	0.21	2	**0.62**	31	**0.21**	18	0.07	1
West Kazakhstan	**0.54**	37	0.47	5	**0.61**	20	**0.59**	28	**0.43**	15
Karaganda	**0.23**	12	0.07	0	**0.71**	28	0.04	0	0.06	0
Kostanay	**0.37**	23	0.20	1	**0.65**	19	0.19	4	**0.41**	10
Kyzylorda	**0.44**	33	0.34	3	**0.87**	36	**0.33**	24	0.20	4
Mangystau	**0.50**	52	**0.42**	11	**0.43**	22	**0.65**	51	**0.45**	20
Pavlodar	**0.24**	10	-0.03	0	**0.72**	27	0.04	0	0.21	3
North Kazakhstan	**0.28**	14	0.08	0	**0.58**	18	0.04	0	**0.38**	8
Turkestan	**0.34**	38	0.33	5	**0.57**	31	**0.26**	20	0.15	3

On average, over the territory of Kazakhstan, the warming trend in the winter season is 0.19 °C/10 years, but it should be noted that the share of the trend is only about 1% of the total variance. Winter temperature trends were positive in all regions except Pavlodar, but the trends mainly explain up to 3% of the variance in the series. The most noticeable warming, by 0.33–0.47 °C/10 years, was noted in the western region of Kazakhstan - West Kazakhstan, Atyrau, Mangystau regions, as well as in the Turkestan region, where the coefficient of determination was 5–11%.

The most intense warming was observed in the **spring** season in all regions of Kazakhstan (Figure 6.3). The temperature rise rate range is from 0.43°C/10 years (Mangystau region) up to 0.87°C/10 years (Kyzylorda region) with 18–36% of trend-explained variance. On average, in Kazakhstan, the temperature during this season increased by 0.65°C/10 years (the contribution of the trend component is 31%).

In **summer** the average temperature in Kazakhstan steadily increased by 0.22°C/10 years. The most significant rates of temperature increase are observed in the western regions - by 0.37–0.65°C/10 years. Less intense warming is observed in the southern and southeastern regions of Kazakhstan, where temperatures increase by 0.22–0.26°C/10 years. Trends here describe from 14 to 51% of the dispersion of the time series. In the northern and central regions, there are practically no trends (Figure 6.3), the share of the trend component in the total variance of the series is almost zero, although the trend remains positive.

In **autumn** on average in Kazakhstan seasonal temperature rises by 0.22°C/10 years (Table 6.4). In the central, some southern and eastern regions, there are practically no trends (Figure 6.3), although the trend sign is positive, but the share of the trend component in the total variance of the series is not more than 5%. The most significant rates of temperature increase are observed in the western and northern regions - by 0.28–0.45°C/10 years, while the share of the variance explained by the trend is 5–20%.

Research materials have shown that, although the average annual surface air temperature is steadily increasing throughout Kazakhstan, the change in temperatures within the seasons is not so clear. There are regions where in some months the temperature has slightly decreased over the past 46 years. For example, in the winter period in December in the southern and southeastern regions there are zones of temperature decrease, albeit insignificant. In January, a vast area of decrease in the average monthly temperature covered the northern and northeastern regions. In February, the temperature increased throughout the republic, most significantly in the west and south. In March, this trend intensified, and as a result, the most significant warming occurred in March. In April and May, the temperature increase was no longer so significant, and in June, the decrease zone, as in January, covered the northern and northeastern regions. In July, September and November, there were practically no trends in temperature; in August and October, temperatures increased significantly throughout the republic.

Not only the average level of air temperature and precipitation is changing, but other characteristics are also changing, including the frequency and intensity of weather and climate extremes.

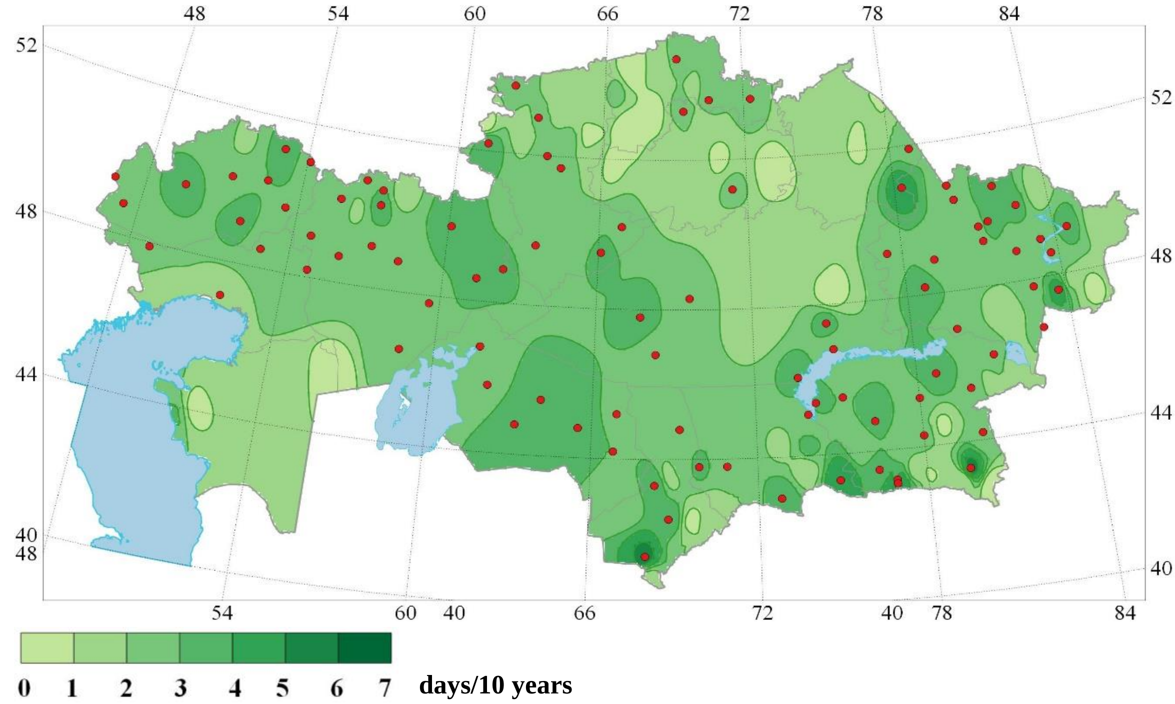
To assess changes in the characteristics of temperature and precipitation regimes, which are important for various sectors of the economy and ecosystems, climate change indices developed, including software for their assessment, by the World Meteorological Organization Expert Group on Sectoral Climate Indices (ET-SCI).[205] The indices are designed to help researchers provide users with useful and up-to-date climate information. Some indices are based on fixed uniform thresholds for all stations, others are based on thresholds that may vary from station to station. In the latter case, thresholds are defined as the corresponding percentiles of the data series. The initial data for calculating the indices are the daily maximum and minimum surface air temperature and the daily amount of precipitation. Thus, the indices make it possible to evaluate many important aspects of climate change, such as changes in the intensity, frequency, and duration of climate extremes. The calculations were performed using the ClimPact2 software package.[206]

An increase in air temperature leads to shifts in the timing of phenological events in plants and animals, the boundaries of vegetation zones, mainly to the north, and upwards in mountainous areas, as well as changes in the structure of ecosystems.

On the territory of the republic, there is an increase in the duration of the growing season (GSL index, Figure 6.4) by 2–5 days/10 years. A statistically significant increase of 3–5 days/10 years can be traced according to the data of most stations in the West Kazakhstan, Aktobe, Kyzylorda, Turkestan, Zhambyl, Almaty, Karaganda, and East Kazakhstan regions. In the northern regions, the increase in the length of the growing season is mostly statistically insignificant.

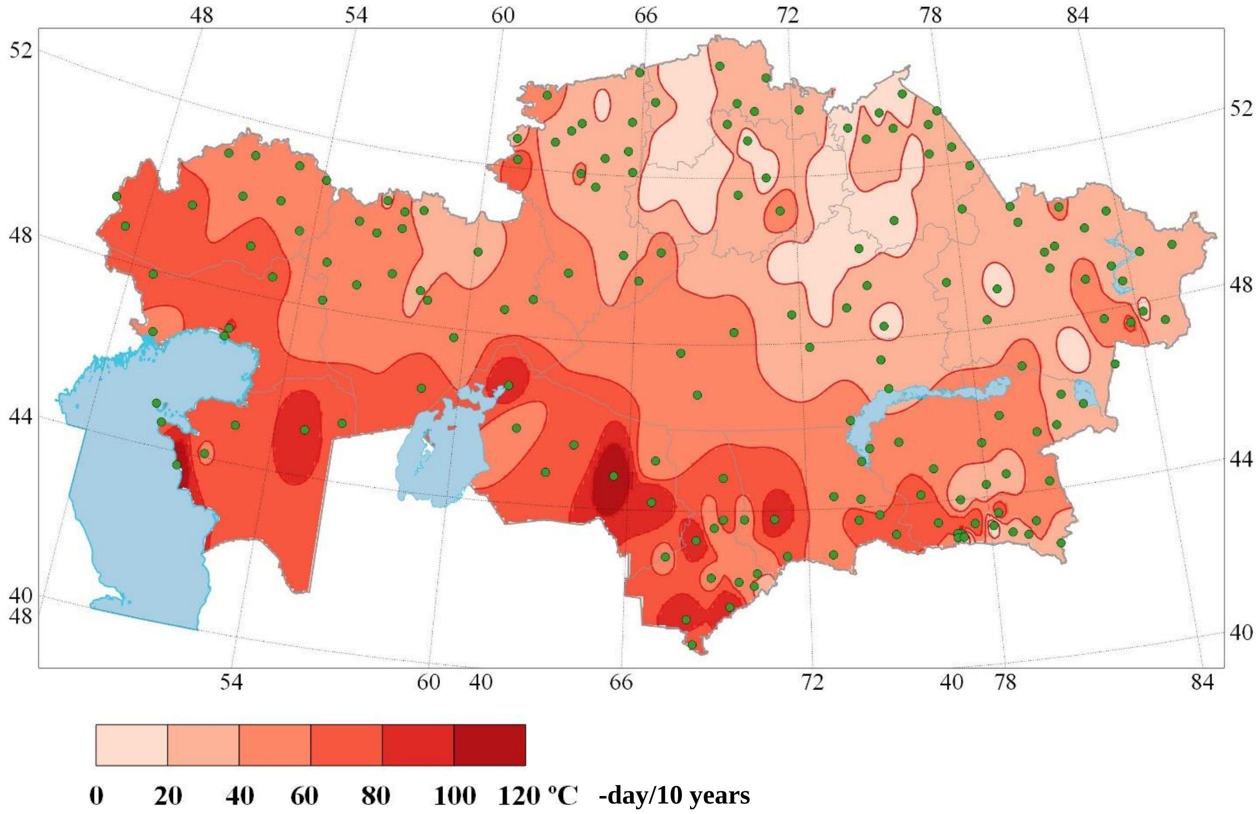
[205] https://climpact-sci.org
[206] https://github.com/ARCCSS-extremes/climpact2

Figure 6.4. *Change in the length of the growing season (days/10 years) calculated for the period 1961–2021 (GSL index). The red circles indicate the points for which according to their data the trend coefficients are statistically significant at the 5% level.*



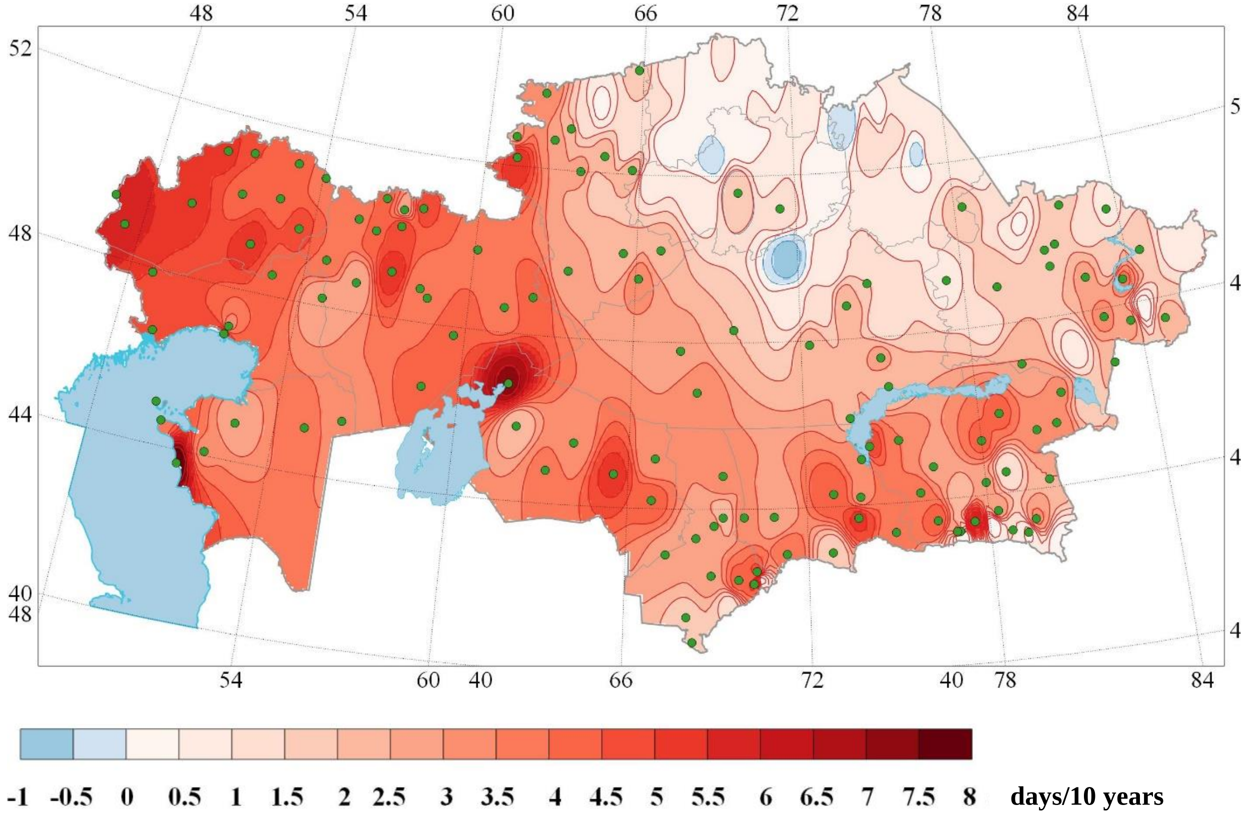
In addition to an increase in the length of the growing season, in the southern part of the territory of Kazakhstan, there is a statistically significant increase in the sum of temperatures during the growing season (GDDgrow10 index, Figure 6.5). The rate of increase in the sum of temperatures during this period in the southern part of the territory is much higher than in the northern part. The largest and statistically significant increase, more than 60 degree-days/10 years, can be traced according to the data of most stations in the Atyrau, Mangystau, Kyzylorda, Turkestan, Zhambyl and Almaty regions.

Figure 6.5. *Change in the sum of temperatures during the growing season (degree-days/10 years), calculated for the period 1961–2021 (GDDgrow10 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



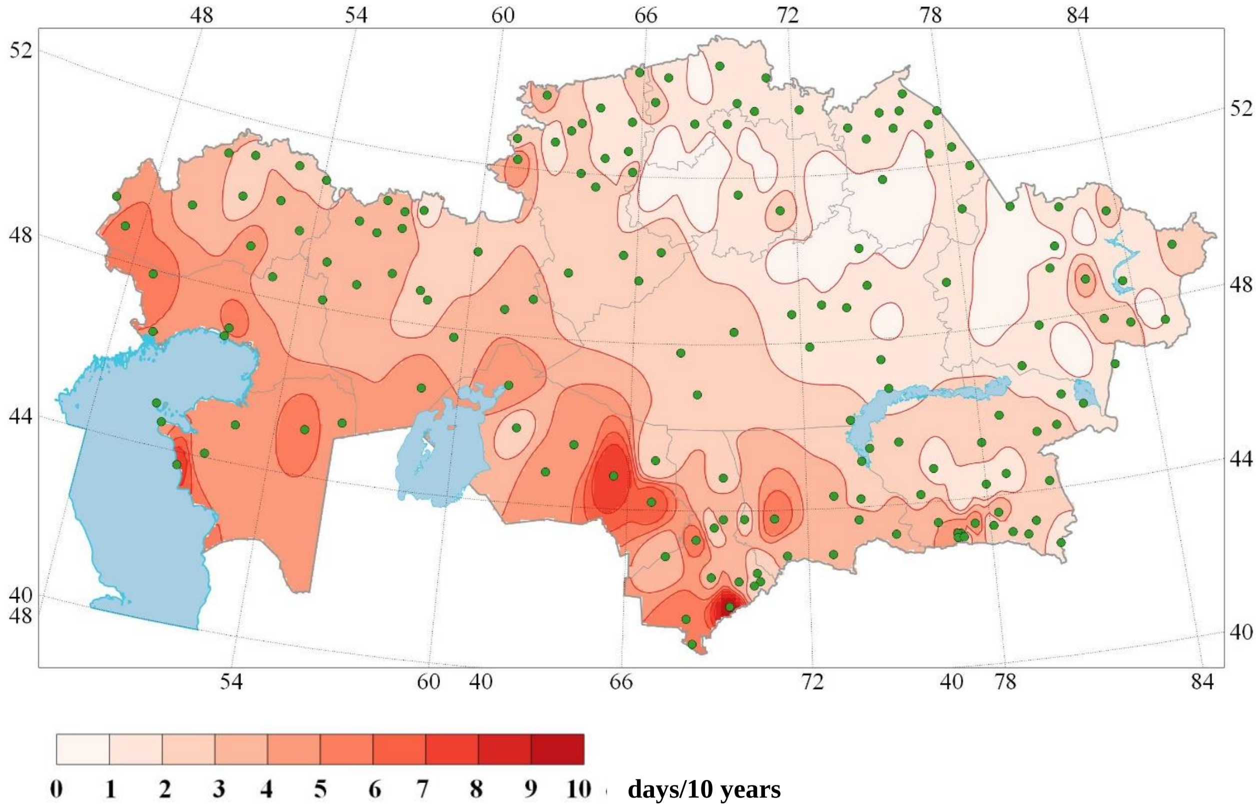
Not only is the average temperature rising, but the frequency of high summer temperatures is also increasing. In conditions of hot and dry summer in the western and southern regions of Kazakhstan, this has a negative impact not only on vegetation, but also on the human and animal organisms. For example, the frequency of days with temperatures above 30°C, especially noticeable in the western and southern regions of the republic - by 4–7 days in 10 years (Figure 6.6). At the stations of the North Kazakhstan and Akmola regions, a weak negative trend in the frequency of hot days was observed due to a decrease in temperature here in some summer months.

Figure 6.6. *Change in the number of days when the maximum daily temperature is equal to or higher than 30 °C (days/10 years), calculated over the period 1961–20210 (TXge30 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



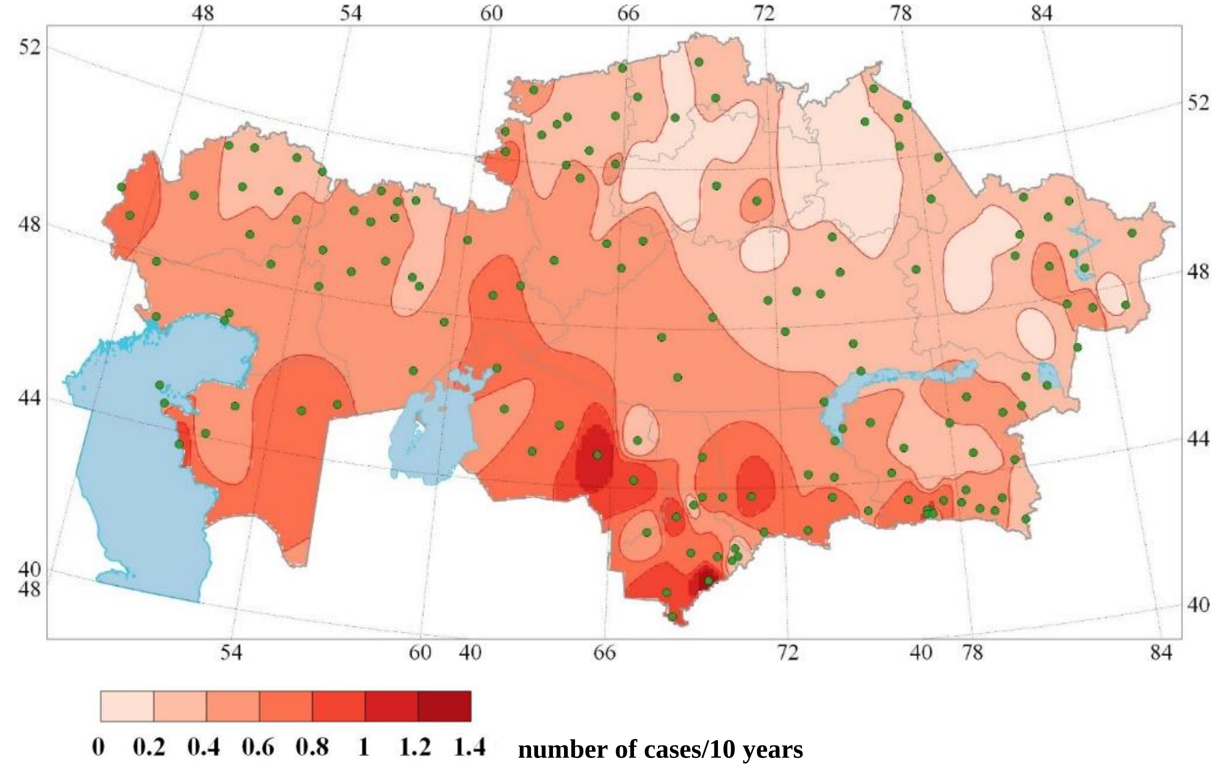
In most of the territory of the republic, *the number of days that make up all heat waves* during the warm period is growing significantly (a heat wave, when the coefficient of excess heat has a positive value for several days in a row, the HWF/EHF index, Figure 6.7). The greatest significant positive trend (more than 5 days/10 years) was observed at stations in the western and southern regions.

Figure 6.7. *Change in the total number of days that make up all heat waves in the warm period (days/10 years), calculated for the period 1961–2021 (index HWF/EHF). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



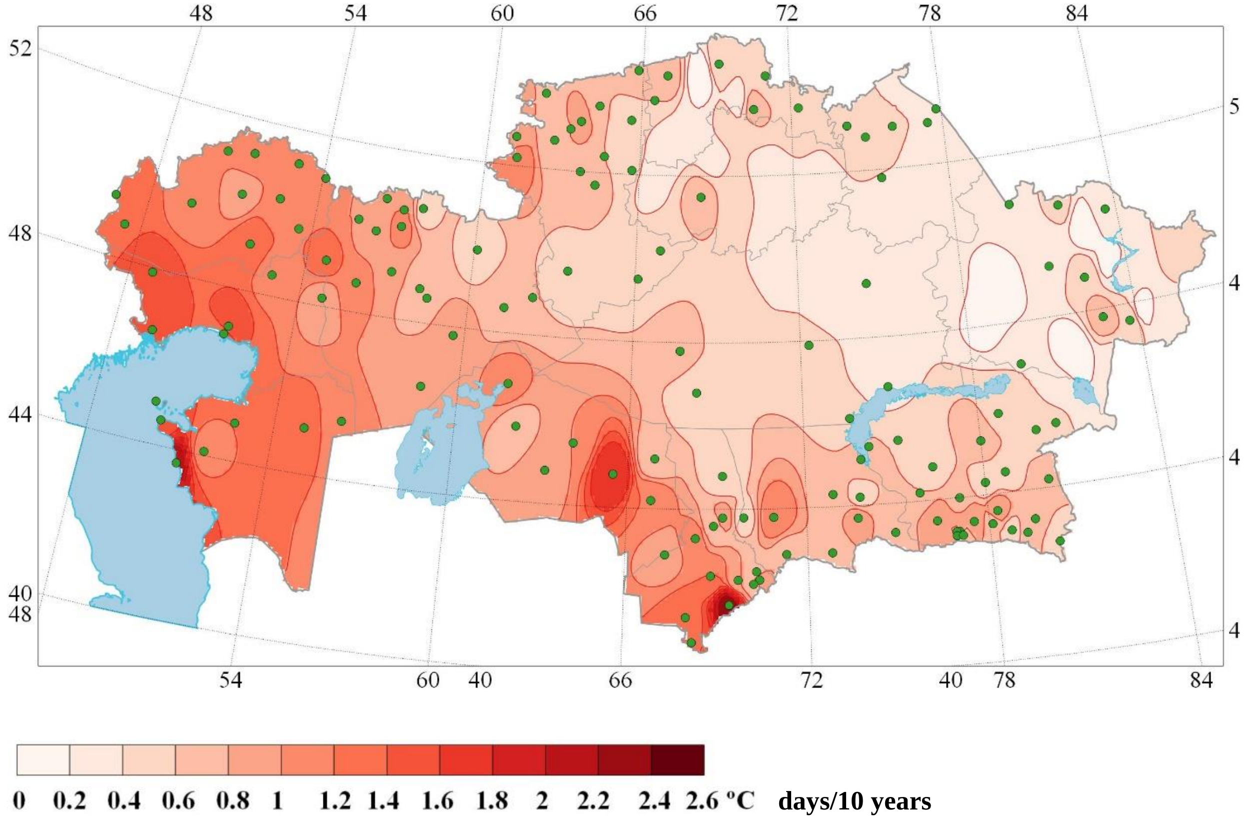
Almost throughout the entire territory of the republic, an increase in the *number of individual heat waves during the warm period* is observed (HWN index, Figure 6.8). At the stations of the southern regions, there is one more such waves on average every 10 years.

Figure 6.8. *Change in the number of heat waves in the warm period (number of events/10 years) calculated for the period 1961–2021 (HWN index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



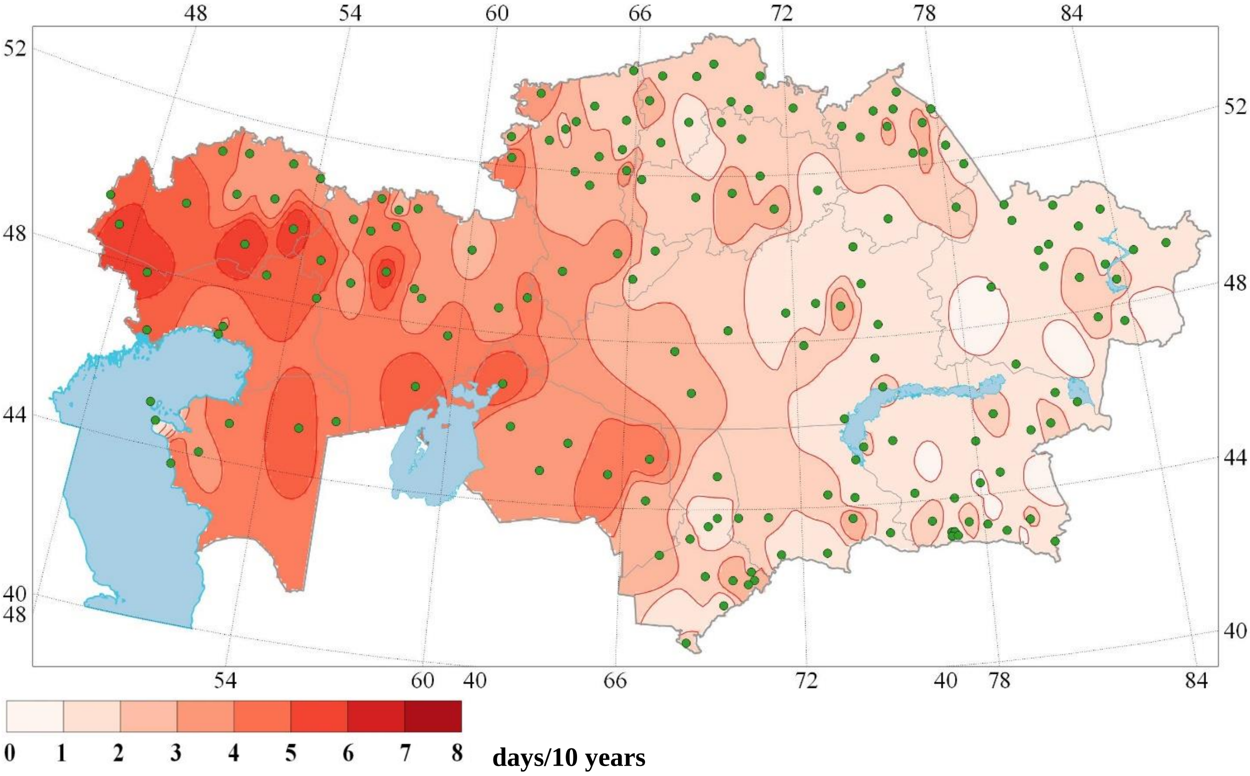
The duration of the maximum heat wave in the warm period is increasing everywhere (HWD index, Figure 6.9), in the western and southern regions the wave lengthens by more than one day on average every 10 years.

Figure 6.9. *Change in the maximum duration of heat waves in the warm period (days/10 years), calculated for the period 1961–2021 (HWD index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



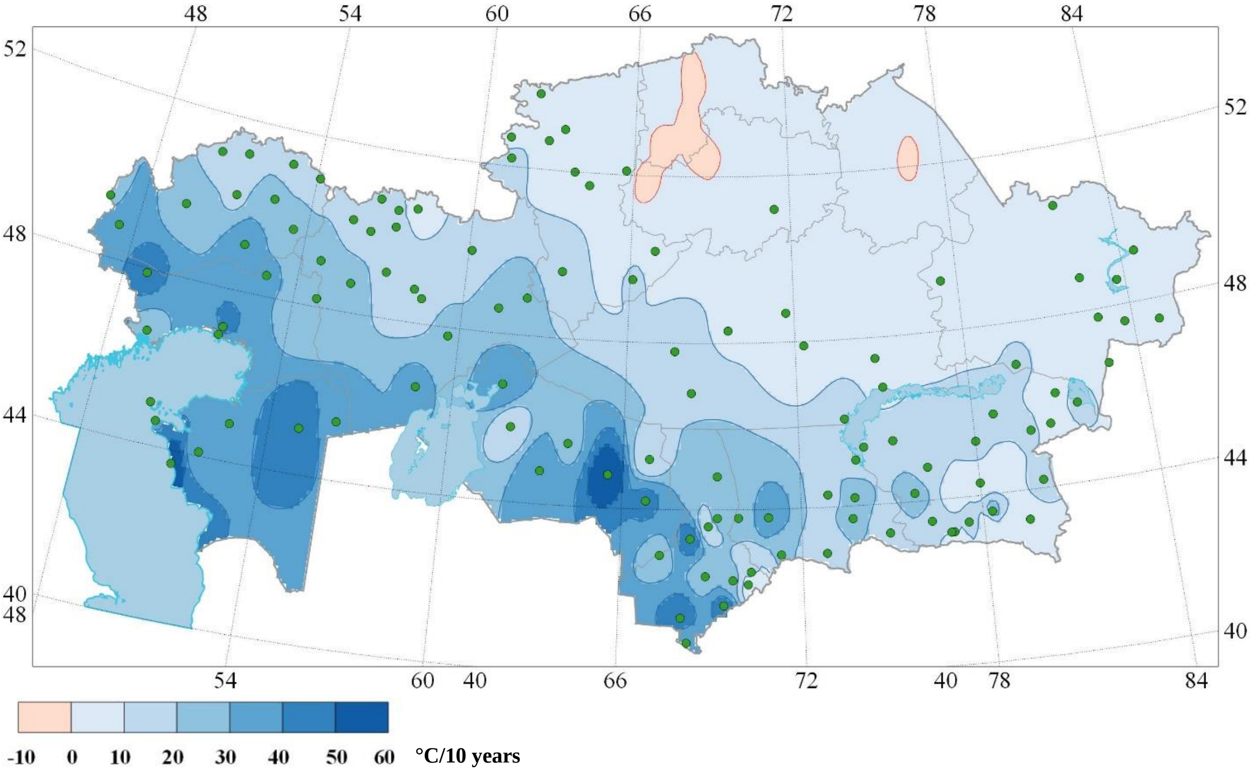
An increase in air temperature in all seasons of the year leads to an increase in the *total duration of heat waves during the year* (when at least 6 consecutive days the daily maximum air temperature was above the 90th percentile, WSDI index) throughout the country (Figure 6.10). The most significant increase is observed in the western half of the country – by 3–7 days/10 years.

Figure 6.10. *Change in the total annual duration of heat waves (days/10 years), calculated for the period 1961–2021 (WSDI index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



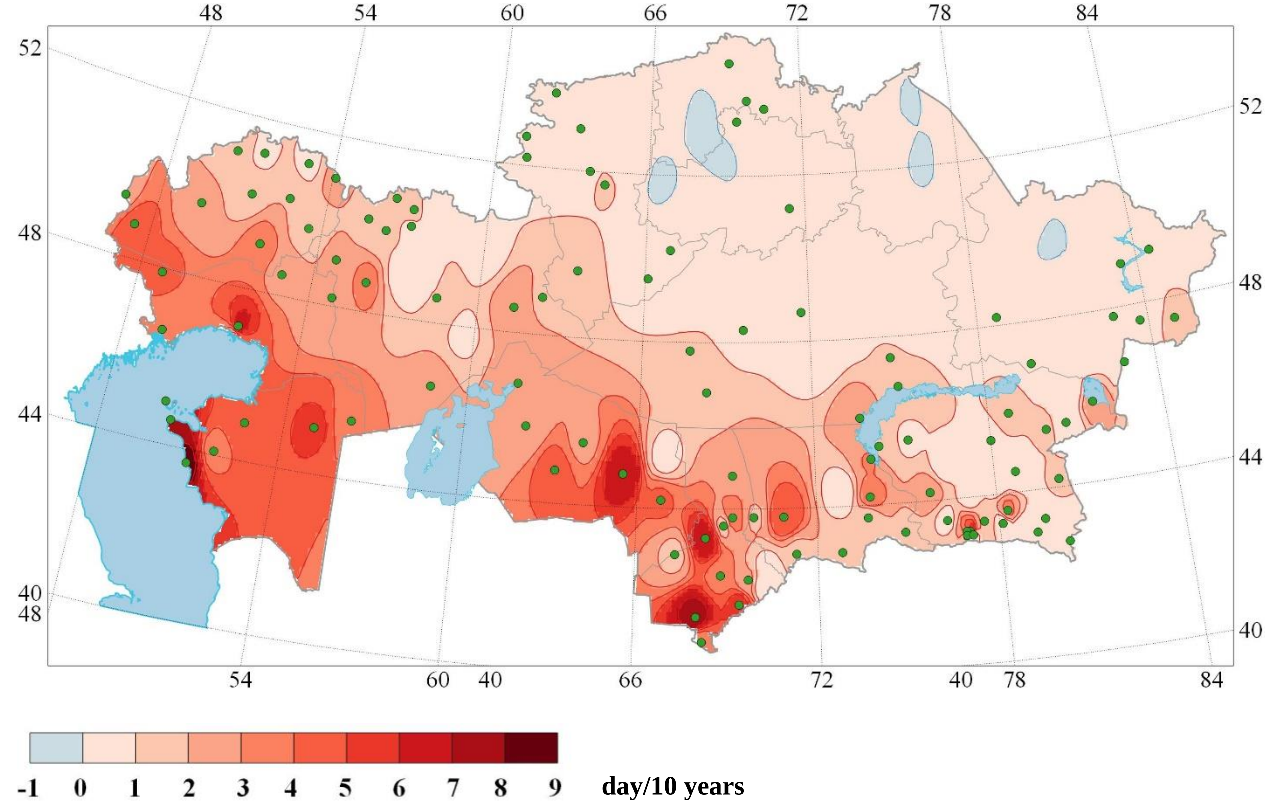
The consequence of the increase in air temperature in most months of the warm season is an increase in the *deficit of cold*, or the need to maintain a favorable temperature in the premises; in this case, a threshold of 23°C (index CDDcold23, Figure 6.11). This is especially true for the western, southwestern, and southern regions. The maximum increase in the cold deficit is observed in Atyrau, Mangystau, Kyzylorda, Turkestan regions (by 3050 degree-days/10 years). Only in the north of the republic there are small areas with some decrease in the cold deficit.

Figure 6.11. *Change in cold deficit (degree-day/10 years) calculated for the period 1961–2021 (index CDDcold23). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



In many regions of Kazakhstan, the value of the daily temperature minimum is increasing, in about half of the cases at a faster rate than the increase in the daily maximum. During the warm season, this leads to an increase in *the number of tropical nights* (when the daily minimum temperature exceeds 20 °C, TR index, Figure 6.12). In Atyrau and Mangystau regions, tropical nights increase by 4-8 on average every10 years, as well as in certain areas of the Kyzylorda, Turkestan and Zhambyl regions. Thus, the conditions for people's nighttime rest from the daytime heat worsen here, which, as shown above, also intensifies.

Figure 6.12. *Change in tropical nights (days/10 years) calculated over the period 1961–2021 (TR index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



An increase in the minimum daily temperatures leads to a decrease in *the number of days with a frost* (when the daily minimum temperature drops below 0 ºC, *FD0 index*, Figure 6.13) and with a *hard freeze* (when the daily minimum temperature drops below minus 2 ºC, *TNltm2 index*, Figure 6.14). The rate of decline varies across the territory, mainly from 2 to 4 days / 10 years, in some places the rate of reduction is higher.

Figure 6.13. *Change in the number of days with frost (days/10 years) calculated for the period 1961–2021 (FD0 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*

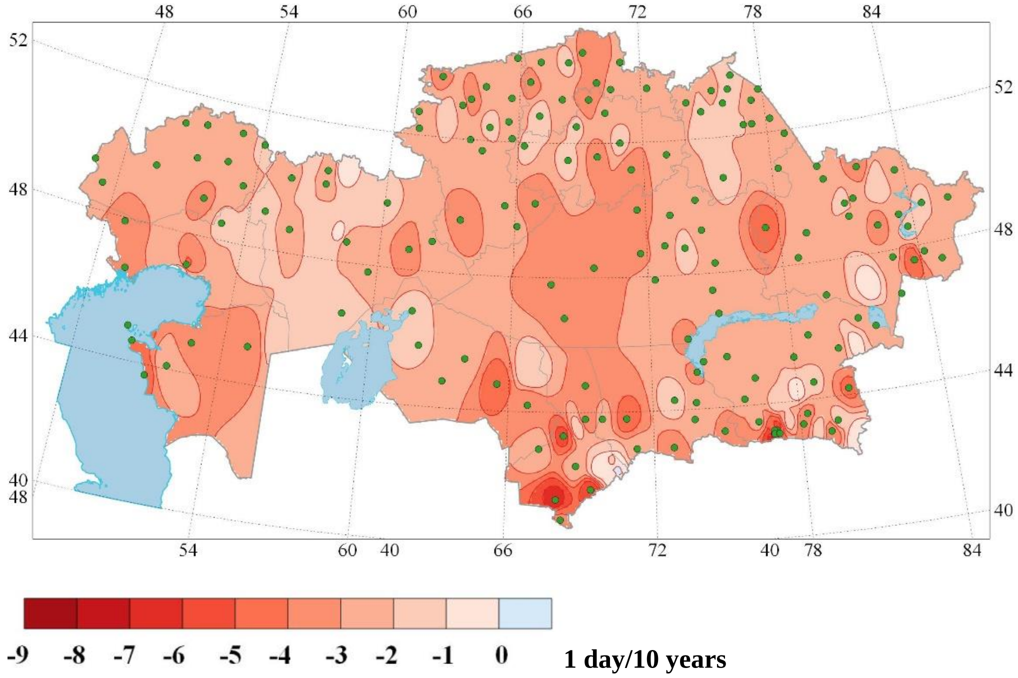
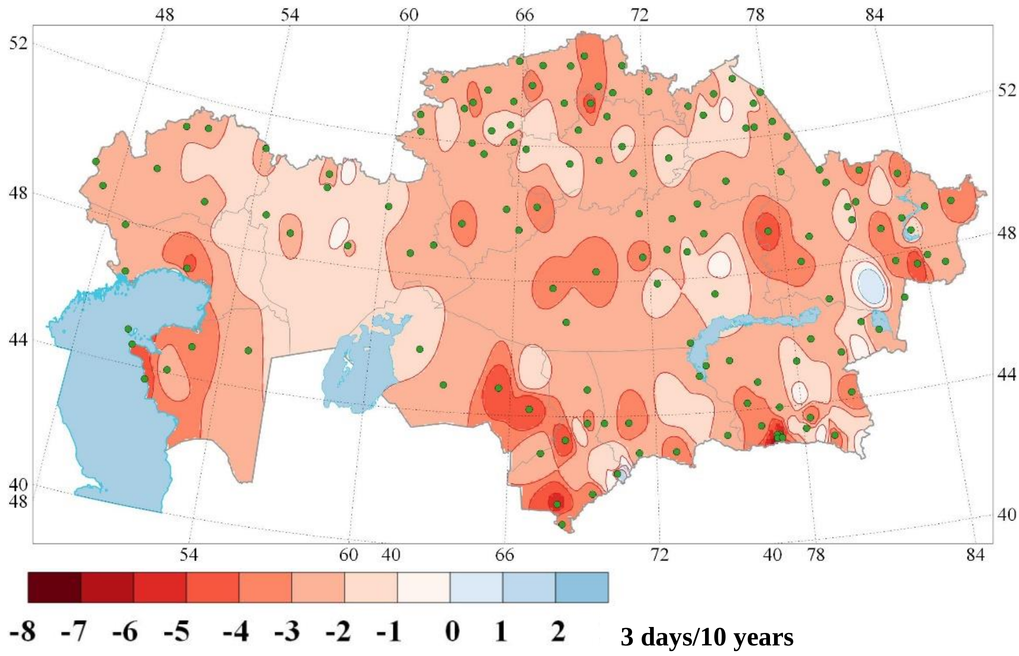
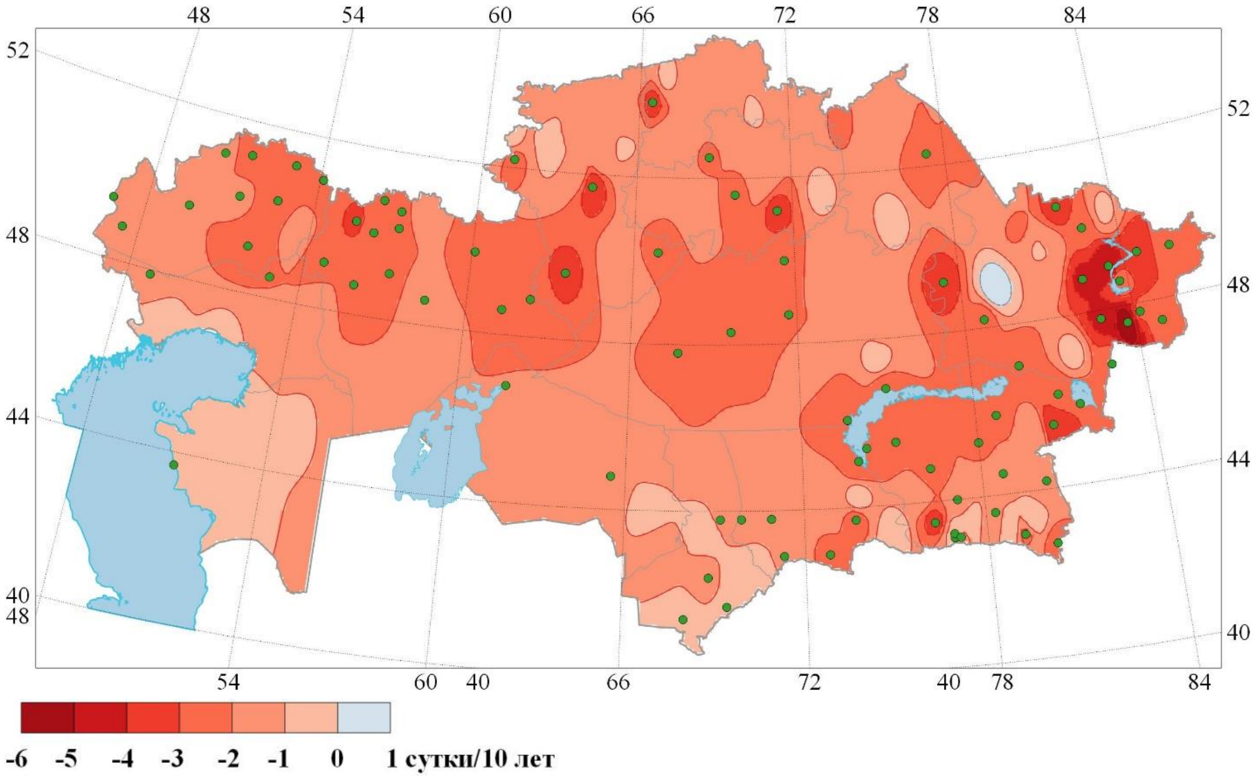


Figure 6.14. *Change in the number of days with a hard freeze (days/10 years) calculated for the period 1961–2021 (TNltm2 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



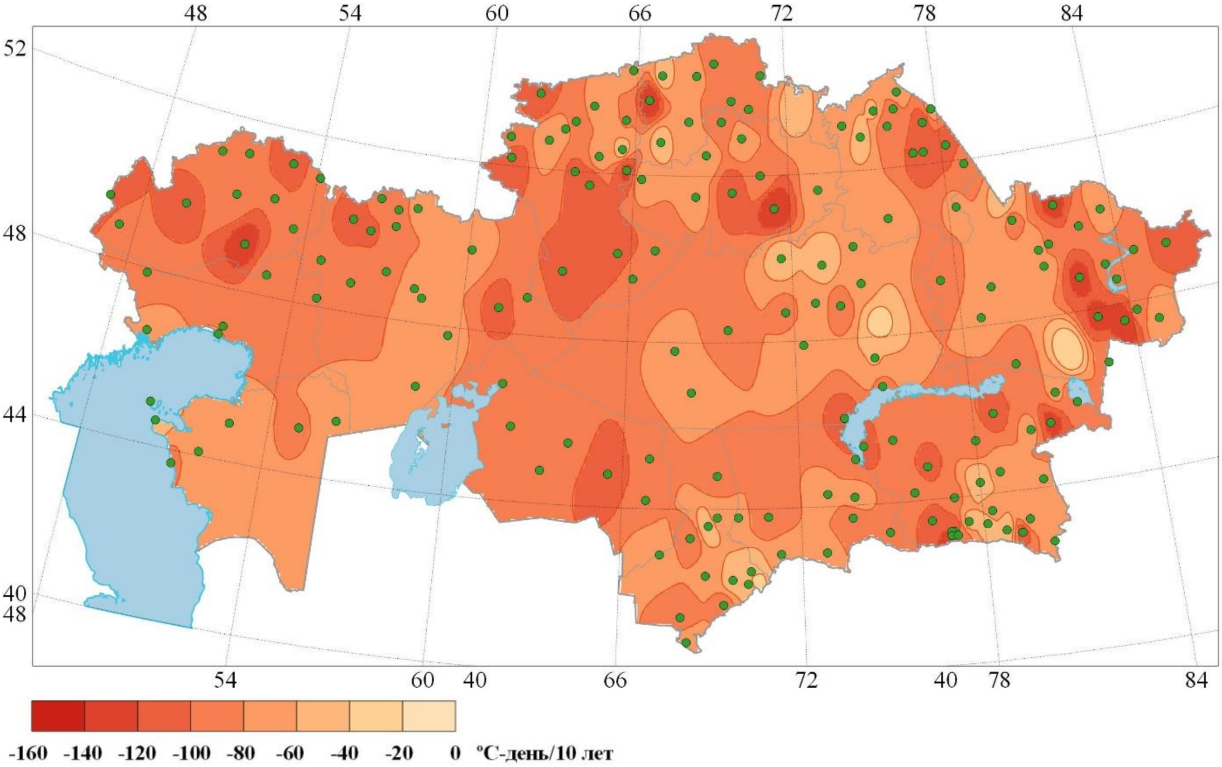
On the territory of the republic, the number of days with *very severe frosts* is reduced almost everywhere (when the daily minimum air temperature is below minus 20 °C, TNltm20 index, Figure 6.15). The number of such days is significantly reduced (by 2–3 days/10 years) in the northwestern, central, and southeastern regions. In some areas of the East Kazakhstan region, the frequency of days with very severe frosts decreases at a more significant rate - by 4–5 days / 10 years.

Figure 6.15. *Change in the number of days with very severe frost (days/10 years) calculated for the period 1961–2021 (TNltm20 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



Reduction in the number of days with negative temperatures leads to a general reduction in *heat deficit* during the cold season (HDDheat18 index, Figure 6.16). Here, a temperature of 18°C is taken as the threshold value of the air temperature that is desirable to be maintained in the room. The range for reducing the heat deficit is 60-100 degree-days for every 10 years. In certain places in various regions of Kazakhstan, this reduction was more than 120 degree-days/10 years.

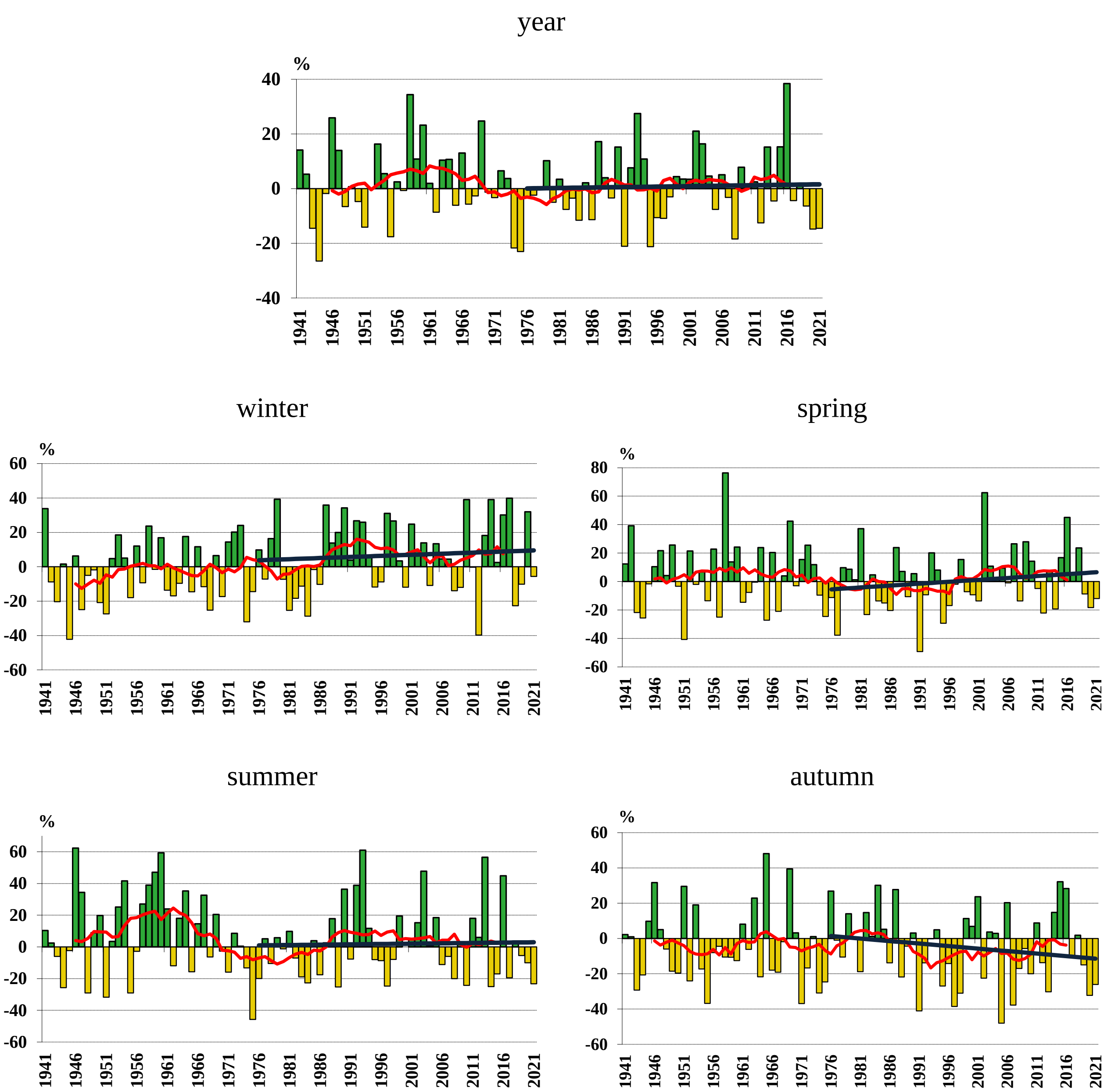
Figure 6.16. *Change in heat deficit (degree-days/10 years) calculated for the period 1961-2021 (HDDheat18 index). Green circles indicate points, for which according to their data the trend coefficients are statistically significant at the 5% level.*



6.3.Changes in precipitation patterns

On average, in the territory of Kazakhstan, **annual** precipitation decreased in the 1960s and 1970s, in the last 46-year period there were no long-term trends, only an alternation of short periods with positive and negative precipitation anomalies was observed. (Figure 6.17).

Figure 6.17. *Time series of anomalies of annual and seasonal precipitation (%) spatially averaged over the territory of Kazakhstan for the period of 1941–2021. The anomalies are calculated relative to the base period of 1961–1990. Linear trend over the period of 1976–2021 is highlighted in black. The smoothed curve was obtained by 11-year moving average.*



On average, for the territory of most regions, mostly insignificant trends of both signs were observed, the coefficient of determination is 3% or less (Table 6.5). The rate of increase in annual precipitation in the Akmola region is more noticeable (about 3% of the norm/10 years with a determination coefficient of 5%). In the Kyzylorda and Mangystau regions, the amount of precipitation decreased at a rate of 4–7% of the norm/10 years with a determination coefficient of 5–8%.

There are practically no trends in average seasonal precipitation over the territory of Kazakhstan - the share of the trend component in the total variance of the series does not exceed 3% (Table 6.5). In winter, spring and summer seasons, the average amount of precipitation over the territory of Kazakhstan slightly increased by 1–3% every 10 years, while in autumn, on the contrary, it decreased by about 3% every 10 years.

Table 6.5. *Estimates of the linear trend of annual and seasonal precipitation averaged over the territory of Kazakhstan and administrative regions for the period 1976–2021: **a** – linear trend coefficient, % norm/10 years; **D** - is the coefficient of determination (the proportion of the variance of the series taken into account by the trend, %). Bold type and dark color indicate statistically significant trends at the 5% level*

Region/oblast	Year		Winter		Spring		Summer		Autumn	
	a	**D**	**a**	**D**	**a**	**D**	**a**	**D**	**a**	**D**
Kazakhstan	0.3	0	1.3	1	2.7	3	0.4	0	-2.8	3
Almaty	0.8	0	5.3	5	1.0	0	0.4	0	-1.4	0
Akmola	3.3	5	**9.0**	10	3.6	3	2.7	1	0.4	0
Aktobe	-2.6	3	-2.1	1	5.1	2	-5.7	3	**-6.8**	10
Atyrau	2.2	1	6.4	4	16.6	12	-7.0	3	-5.3	3
East Kazakhstan	1.1	1	1.2	0	1.5	0	2.7	2	-0.7	0
Zhambyl	-1.9	1	0.0	0	-1.9	1	2.4	0	-4.8	3
West Kazakhstan	-1.6	1	-4.0	5	**9.2**	10	-5.9	4	-3.8	3
Karaganda	0.7	0	-0.7	0	0.6	0	5.2	4	-3.6	2
Kostanay	-0.7	0	-1.2	0	**8.6**	11	-2.2	1	**-5.9**	9
Kyzylorda	-4.4	5	-0.5	0	-1.7	0	-5.3	1	**-12.6**	16
Mangystau	**-6.8**	8	7.4	3	**-13.6**	10	-4.2	1	**-9.1**	6
Pavlodar	2.1	2	1.4	1	5.3	4	2.2	1	0.4	0
North Kazakhstan	2.4	3	3.9	2	**11.2**	17	0.6	0	-1.7	1
Turkestan	0.1	0	0.7	0	1.8	1	2.9	0	-3.6	1

In **winter**, the most significant trends towards an increase in precipitation are in Akmola region - 9.0% of the norm/10 years (determination coefficient is 10%), and in Almaty region - by 5.3% of the norm/10 years (determination coefficient is 5%). A noticeable decrease in precipitation is observed in the West Kazakhstan region - by 4.0% of the norm/10 years (determination coefficient is 5%).

In **spring** on average, over the territory of most regions, trends in precipitation are positive, but also insignificant. In the West Kazakhstan and Atyrau regions of the western part, in the Kostanay and North Kazakhstan regions of the northern part of the republic, precipitation increased at the highest rate - by 9.2–16.6% of the norm/10 years with a determination coefficient of 10–17% (Figure 6.18). The largest contribution to the increase in spring season precipitation falls on March (as well as temperature increase), when stable statistically significant trends are observed in most regions of the northern part of Kazakhstan, in some places in the south and southeast.

In **summer** there were practically no trends in the amount of precipitation in the territory of all regions of Kazakhstan since the contribution of the trend to the total dispersion is insignificant and did not exceed 4%.

In **autumn** on the territory of most regions, trends in precipitation are negative (Figure 6.18). The most significant rates of precipitation decrease are observed in Aktobe, Kostanay, Mangystau and Kyzylorda regions - by 5.9–12.6% of the norm/10 years with a determination coefficient of 6–16%. The greatest contribution to the decrease in precipitation of the autumn season falls on September and October when the amount of precipitation decreased over a significant part of the territory of Kazakhstan.

Figure 6.18. *The rate of change in seasonal precipitation (%/10 years) on the territory of Kazakhstan in the period 1976–2021. Colored circles indicate trend coefficients that are significant at the 5% level.*

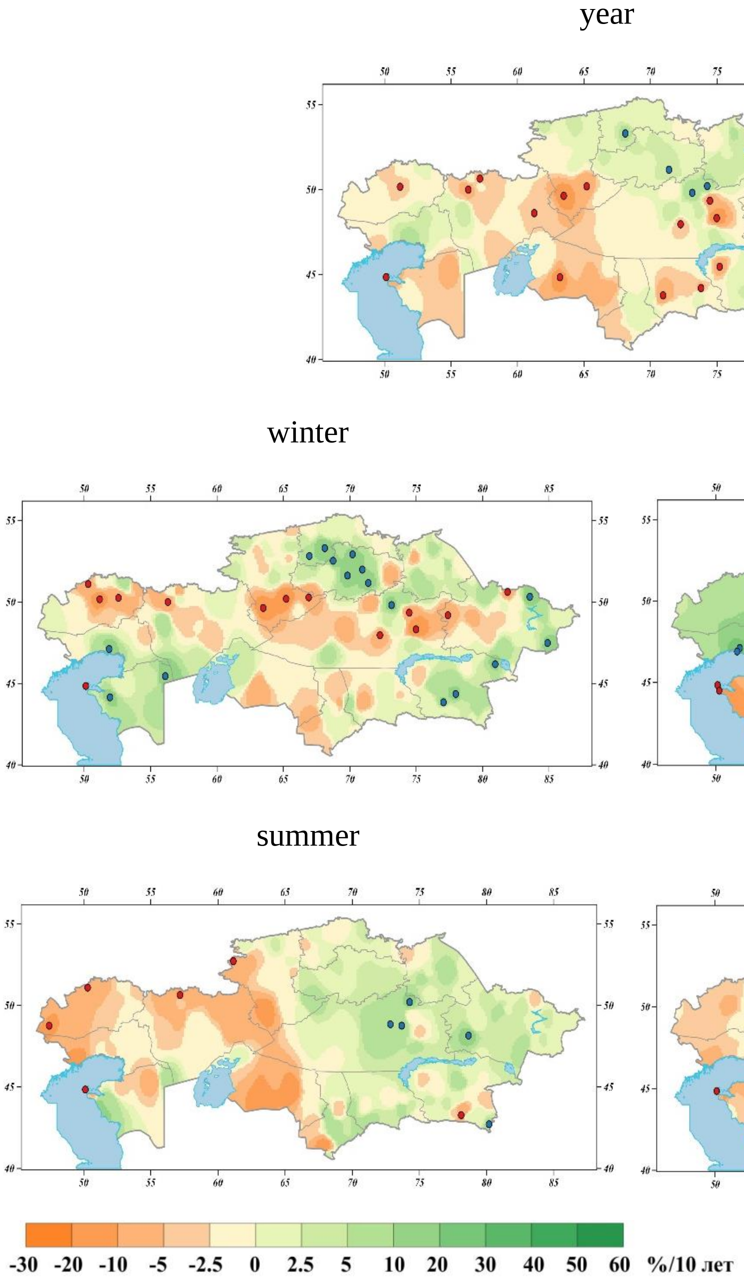


Table 6.6 shows the values of precipitation totals for the wettest and driest months and seasons on the territory of Kazakhstan for the period since 1941. The wettest periods were recorded mainly in the last century, except for the months from January to March and the whole winter season. The driest seasons were also observed mainly in the last century.

Table 6.6. *Estimates of the wettest and driest periods in Kazakhstan, obtained by averaging data from meteorological stations over the territory of the republic for the period from 1941 to 2021*

Period	The wettest period			The driest period		
	value, mm	record year	previous record year	value, mm	record year	previous record year
January	37.6	2014	1997	8.9	2011	2012
February	33.5	2021, 1993	1998	4.8	1942	1950
March	44.4	2018	2021	9.6	1951	1992
April	56.1	1958	2002	7.6	1995	1951
May	61.3	1983	1960	14.7	1957	2021
June	56.2	1954	1993	13.1	1955	1975
July	68.2	1960	2003	16.7	1980	1965
August	54.5	2013	1992	7.6	1976	1948
September	37.9	1946	1987	4.6	1957	1971
October	64.7	1969	1940	7.0	1974	1955
November	56.1	1994	1965	13.5	1952	1967
December	43.3	1978	1977	8.1	1974	1944
spring	153.9	1958	2002	44.3	1991	1951
summer	142.8	1946	1993	47.8	1975	1940
autumn	117.2	1965	1969	41.1	2005	1991
winter	88.6	2017	1979	36.6	1945	2012
year	439.6	2016	1958	233.6	1944	1975

Climate indices for the precipitation regime were also analyzed, such as the duration of periods without precipitation and with precipitation, the frequency of extreme precipitation. The results showed:

– in rare cases, the maximum duration of periods without precipitation has decreased, even more rarely it has increased (CDD index);
– the same conclusion was obtained for the maximum duration of periods with precipitation (CWD index);
– according to some weather stations, there was an increase in the frequency of extreme precipitation, according to others - a decrease (R10mm, R20mm);
– in some places there was a change in the amount of precipitation for consecutive days with rain, mostly downward (index Rx5day);
– in rare cases, the intensity of daily precipitation has changed, both upward and downward (SDII index).

The observed increase in the frequency and duration of periods with high air temperatures in the warm season leads to negative consequences not only for humans and animals, but also for transport infrastructure - for example, the road surface may be deformed; for the conditions of the urban environment and recreation areas; for the energy industry, as there is a need for additional energy generation for space cooling.

An increase in surface temperature leads to a reduction in the period with negative temperatures, as a result, precipitation more often falls in liquid form. This, in turn, can affect snow accumulation during the cold season. In mountainous areas, both the area and the period of solid precipitation are reduced, which affects glacial systems.

An increase in surface temperature during the cold period of the year leads to a decrease in the need for heat generation. Reducing the number of days with frost, on the one hand, leads to a positive effect on public health, on the other hand, heat waves during the cold season can lead to the formation of icy roads.

Extending the growing season in areas where this is combined with increased rainfall and reduced maximum dry periods (some northern and southeastern regions) improves crop production conditions.

The increase in the maximum daily precipitation recorded in some areas can lead to the destruction of the roadbed and storm systems in settlements, to landslides and mudflows in mountainous areas.

These are just some examples of the impact of climate change, which can affect almost all spheres of human activity and various processes in natural systems.

A correct assessment of such impacts of climate change should have a pronounced regional, and even local, character, since vulnerability to climate change, as well as adaptation capabilities, significantly depend on the physical-geographical, economic, and demographic characteristics of the regions.

Constant monitoring of the climate and its changes is one of the priority tasks of the National Hydrometeorological Service of Kazakhstan RSE ‘Kazhydromet’, which since 2010 has been issuing Annual Bulletins for monitoring the climate and its changes based on the constant updating of information on current climatic conditions in the territory of the republic.[207]

6.4.Kazakhstan climate projections

According to the estimates given in the IPCC Sixth Assessment Report (AR6), even if anthropogenic emissions of greenhouse gases are sharply reduced right now, global warming will continue due to the inertia of the Earth's climate system.

The consequences of climate change in the future can have both negative and positive consequences. Since the existing infrastructure has been created in general under the climatic conditions of past decades, climate change mainly leads to negative consequences, especially in arid regions, and often very significant. First, this is due to an increase in the probability and intensity of heat waves and changes in the hydrological cycle. To avoid the dangerous effects of climate change, we need to act in two directions: to reduce the impact on the climate system by reducing emissions of greenhouse gases into the atmosphere, and to adapt to changes already observed and expected. To adapt effectively, minimizing damage and fully reaping the benefits of climate change and its impact on economic sectors,

To develop climate projections for the territory of Kazakhstan, the Internet platform of the Interactive Atlas was used[208] to the report of the First Working Group of the IPCC (WGI) ‘Climate Change 2021: The Physical Science Basis’.[209] This platform, through the advantages of interactivity, allows flexible and expanded exploration of some of the key IPCC products that

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[207] https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana

[208] Gutiérrez, JM, RG Jones, GT Narisma, LM Alves, M. Amjad, IV Gorodetskaya, M. Grose, NAB Klutse, S. Krakovska, J. Li, D. Martínez-Castro, LO Mearns, SH Mernild, T. Ngo -Duc, B. van den Hurk, and J.-H. Yoon, 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, SL Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, MI Gomis, M. Huang, K. Leitzell, E. Lonnoy, JBR Matthews, TK Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1927–2058, doi:10.1017/9781009157896.021.

[209] https://www.ipcc.ch/report/ar6/wg1/

underlie the assessment of various characteristics of likely climate change, including indices of extreme events and climate forcing factors. Also, the interface of this Internet platform makes the results of the IPCC more accessible, greatly facilitating their use in climate services.

This analysis uses data from new versions of climate models,[210] that participated in the 6th phase of the international project for comparing coupled general circulation models and Earth system models (CMIP6 - Coupled Model Intercomparison Project, Phase 6).[211]

CMIP6 models include new and better representations of physical, chemical, and biological processes, as well as higher resolution than climate models reviewed in previous IPCC assessment reports. This has improved modeling of the recent average state of most large-scale indicators of climate change and many other aspects of the climate system. The CMIP6 multi-model global mean surface temperature change is close to the best estimate of observed warming. Increasing the horizontal resolution in global climate models improves the representation of fine-scale features and daily precipitation statistics (high confidence), but it should be noted that some differences from observations remain, for example in regional precipitation patterns.

Of the five illustrative scenarios (SSP: SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5), which are a combination of projected socio-economic trajectories of global change (Shared Socioeconomic Pathways)[212] and Representative Concentration Pathways used in the preparation of AR6, two scenarios were selected to describe regional climate change - SSP2-4.5 and SSP5-8.5which are the focus of most research.

Scenario SSP5-8.5 reflects a high CO2 path without climate mitigation, based on assumptions that annual global emissions will continue to rise throughout the 21st century. Scenario SSP2-4.5 calls for systematic global action to reduce greenhouse gas emissions over the 21st century enough to stabilize their concentrations by around 2100. Although the SSP5-8.5 scenario has been criticized as being very extreme and therefore unrealistic, its consideration is subject to the uncertainty of carbon cycle feedbacks, which, with nominally lower emission paths, could lead to projected concentrations above the average concentration levels under the SSP2-4.5 scenario.

The socio-economic assumptions underlying the scenarios differ in the assumed level of air pollution control. Together with differences in the severity of climate mitigation measures, this difference strongly influences the pathways of anthropogenic emissions of short-lived greenhouse gases, some of which are also air pollutants. For different SSP scenarios the results of a different number of models are available, but in all cases, it is sufficient in terms of the representativeness of the results obtained.[213]

Table 6.7 and Figure 6.19 below provide information on climate change projections for the territory of Kazakhstan for two different time horizons: 2041–2060 and 2081–2100, generalized

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[210]IPCC, 2021: Annex II: Models [Gutierrez, J M., A.-M. Treguier (eds.)]. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, SL Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, MI Gomis, M. Huang, K. Leitzell, E. Lonnoy, JBR Matthews, TK Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 2087–2138, doi:10.1017/9781009157896.016.

[211] https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6

[212]IPCC, 2021: Annex VII: Glossary [Matthews, JBR, V. Möller, R. van Diemen, JS Fuglestvedt, V. Masson-Delmotte, C. Méndez, S. Semenov, A. Reisinger (eds.)]. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, SL Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, MI Gomis, M. Huang, K. Leitzell, E. Lonnoy, JBR Matthews, TK Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 2215–2256, doi:10.1017/9781009157896.022.

[213] https://interactive-atlas.ipcc.ch/regional-information/about#datasets

for the territory of Kazakhstan. Changes are presented as changes in long-term averages from the 1986-2005 base period, for surface air temperature in degrees Celsius (°C) and as a percentage (%) for precipitation.

Expected changes in temperature regime

Surface air temperatures are expected to continue to rise in all seasons, and if the scenario ranges from 2.3 to 2.6°C by mid-century under the SSP2-4.5 scenario and 3.0-3.5 °C under the SSP5-8.5 scenario, an even greater warming of 3.3-3.9 °C and 6.2-7.3 °C can be expected by the end of the century under the relative scenarios.

Average annual temperatures will rise significantly by the end of the 21st century along all emission pathways considered (Table 6.7), with a larger increase in national temperature than the global average and most other Asian countries. According to the trajectory of the highest emissions (SSP5-8.5) by the end of the century, the average annual temperature in Kazakhstan is projected to increase by more than 6 °C, about 3 °C more than under the lower emissions scenario (SSP2-4.5), indicating a large difference in warming across Kazakhstan that can be achieved by controlling global emissions.

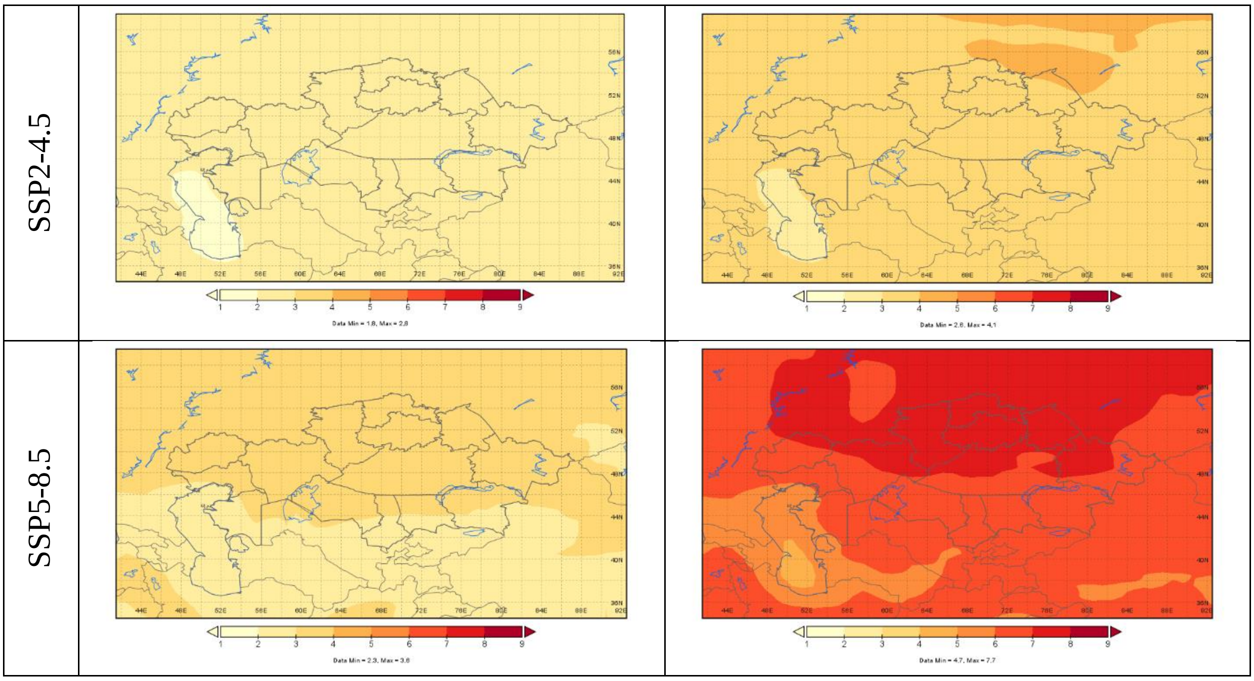
Table 6.7. *Projections of change in average annual and seasonal temperature (°C) on average for Kazakhstan for different time horizons and emission scenarios, showing the median estimates of the ensemble of models. Number of models in the ensemble: 34. In parentheses are the boundaries of the interval 5 and 95%.*

Scenario	Year	Winter	Spring	Summer	Autumn
2041–2060					
SSP2-4.5	2.5 (1.3-4.1)	2.6 (1.1-4.9)	2.3 (1.2-2.8)	2.6 (1.6-4.0)	2.3 (1.3-3.6)
SSP5-8.5	3.3 (1.9-5.0)	3.5 (2.2-5.6)	3.2 (1.5-4.8)	3.4 (1.9-5.1)	3.0 (1.7-5.0)
20812100					
SSP2-4.5	3.6 (1.9-5.3)	3.9 (2.2-5.8)	3.5 (1.6-5.2)	3.8 (2.2-6.1)	3.3 (1.9-5.2)
SSP5-8.5	6.8 (4.2-9.8)	7.3 (4.5-11.8)	6.5 (3.8-9.3)	7.2 (4.0-10.1)	6.2 (4.1-9.1)

The rate of increase in the average and seasonal annual temperatures is not the same across the territory of Kazakhstan - more significant warming is expected in the northern regions (Figure 6.19, Annex 2, Figures 3-4).

Figure 6.19. *Probable change in average* ***annual air temperature*** *(°C) under scenarios of changes in the concentration of greenhouse gases SSP2-4.5 and SSP5-8.5. Changes are calculated relative to long-term averages for the period 1986–2005.*

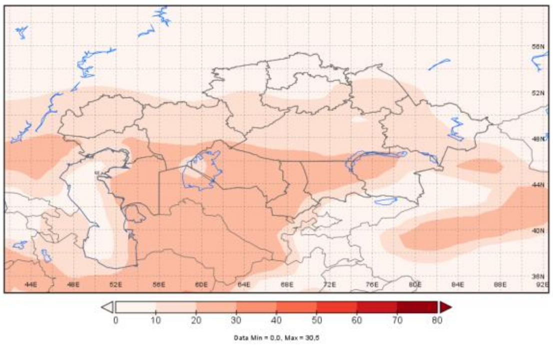
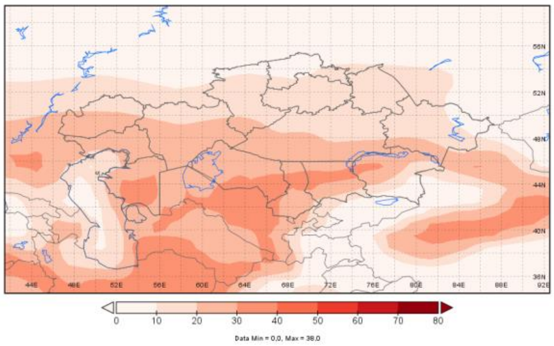
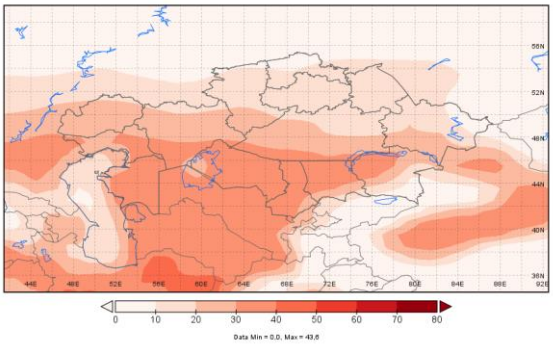
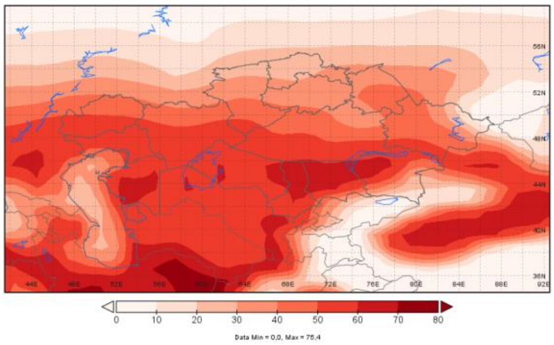
	2041–2060	2081–2100



While average monthly and average annual temperatures are the most commonly used general measure of climate change, climate indices based on daily highs and lows can explain how daily life in a region can change with climate change, influencing key variables such as ecosystem viability, health impacts, labor productivity and crop yield, which are often disproportionately affected by temperature extremes.

High maximum temperatures are regularly observed in Kazakhstan, especially in the southern regions. Heat-wave conditions are more likely to occur, in part, simply because of the long-term warming trend. The ensemble of models suggests that the likelihood of heat waves could increase significantly in the 21st century, especially under high emission scenarios (SSP5-8.5). Peak summer temperatures can reach levels that are dangerous to human health and many plant and animal species much more frequently. The frequency of days with temperatures exceeding the threshold of 35 °C will increase sharply by the end of the century, especially with a high level of global warming (Figure 6.20) - by 30–40 days in the north of the republic and by 50–60 days in the southern regions. By the end of the century in the southern regions, the frequency of days with even higher temperature (above 40°C, see Annex 2, figure 6) - for 20-30 days a year or even in some regions for 50-60 days.

Figure 6.20. *Change in the number of days when the maximum daily temperature is equal to or higher than 35 ℃ (SU35 index, days) under scenarios of changes in greenhouse gas concentrations SSP2-4.5 and SSP5-8.5. Changes are calculated relative to the period 1986–2005. Number of models in the ensemble: 26–27.*

SSP2-4.5	SSP5-8.5
2041–2060	
	
2081–2100	
	
	

Absolute maximums of air temperature (index TXx,°C) by the end of the century can increase by 3-6°C, maximum in the western regions of the republic - more than 4–7°C (Annex 2, Figure 7). Bigger increase expected in the values of absolute minima of air temperature (index TNn,°C), especially in the northwestern and central regions - by 6–7 and even more than 10–12°C (Annex 2, Figure 8).

Increase in daytime maximum and nighttime minimum temperatures during the warm season leading to increased demand for indoor air cooling (CDDcold index, degree-days). The maximum demand will increase in the southern regions - by 300-500 degree-days under the SSP2-4.5 scenario and by more than 900-1000 degree-days under the SSP5-8.5 scenario (Annex 2, Figure 9). This increase in demand for electricity during the warm period of the year will increase peak summer loads in the energy sector.

With climate warming, a decrease in the number of days with frost is expected, when the daily minimum temperature drops below 0°C (FD0 index, Annex 2, Figure 10) – for 20–60 days. This, in turn, leads to a decrease in the demand for space heating (HDDheat index, Annex 2, Figure 11), maximum in the northern regions by more than 900 degree-days under the SSP2-4.5 scenario and more than 1500 degree-days under the SSP5-8.5 scenario.

Thus, when the temperature level rises, on the one hand, the demand for energy for space cooling during the warm period of the year will significantly increase, on the other hand, the need for space heating will decrease, since the period when outdoor temperatures will be below the threshold comfortable values will be reduced, as well as the number of negative temperatures for the cold period of the year will be reduced. In the energy sector, such changes in seasonal peak loads need to be considered.

Expected changes in precipitation patterns

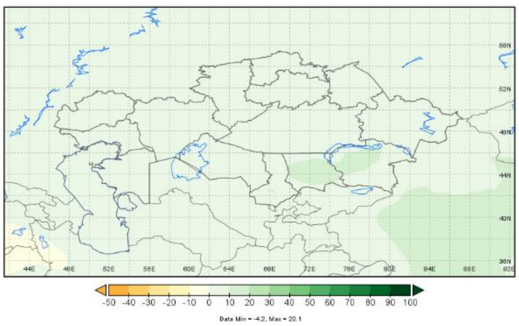
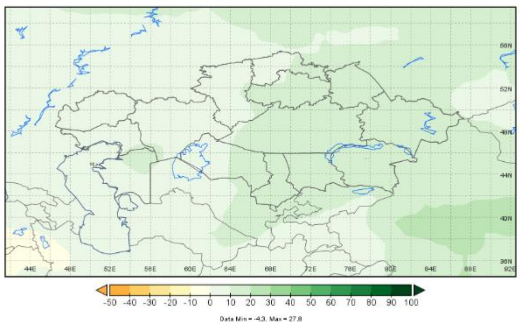
Most climate models predict some increase in annual precipitation in Kazakhstan (Table 6.8). By the middle of the current century, this increase on average in Kazakhstan will be 7-8%, depending on the scenario of GHG emissions, by the end of the century - in the range of 11-14%. On the territory of the republic, the change in annual precipitation is uneven (Figure 6.21), the minimum increase is expected in the west of Kazakhstan - less than 10%, the maximum in the southeast - slightly more than 20%.

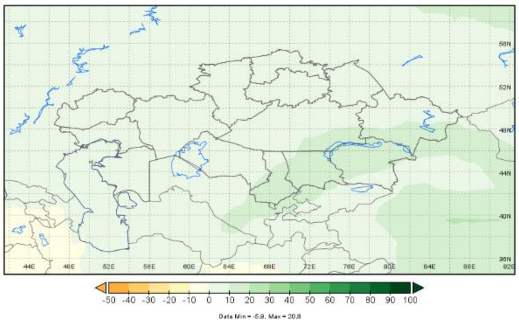
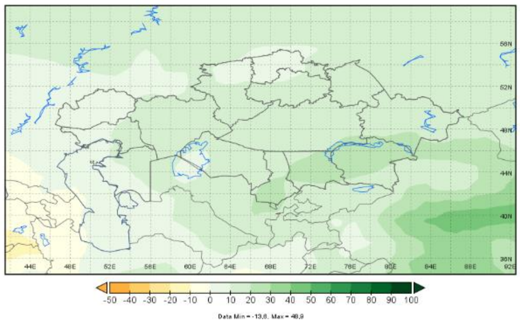
Table 6.8. *Projections of change in annual and seasonal precipitation (%) in Kazakhstan for different time horizons and emission scenarios, showing the median estimates of the ensemble of models. Number of models in the ensemble: 32-33. In parentheses are the boundaries of the interval 5 and 95%.*

Scenario	Year	Winter	Spring	Summer	Autumn
2041-2060					
SSP2-4.5	6.9 (-1.7…19.2)	14.0 (-3.3…31.7)	7.6 (-3.6…25.6)	-2.2 (-5.8…13.2)	5.1 (-3.4…24.0
SSP5-8.5	8.1 (0.9…21.6)	17.2 (4.1…30.8)	8.9 (-4.1…27.0)	-2.2 (-8.2…14.6)	4.3 (-6.8…17.8)
20812100					
SSP2-4.5	11.2 (1.3…22.8)	19.7 (-0.6…39.2)	13.3 (-2.0…36.0)	0.2 (-13.4…19.2)	7.1 (-5.7…23.4)
SSP5-8.5	13.8 (0.6…41.1)	35.2 (15.2…78.2)	16.5 (-2.9…46.6)	-12.1 (-15.9…10.6)	6.7 (-10.5…32.3)

The largest increase in average seasonal precipitation in Kazakhstan can be expected in winter - by the end of the century by 20-35%, in spring by 13-16%, in autumn by about 7% (Table 6.8). In the summer, an unfavorable scenario is expected - an average decrease in precipitation by 12% in Kazakhstan.

Figure 6.21. *Probable change in annual precipitation under scenarios of changes in greenhouse gas concentrations SSP2-4.5 and SSP5-8.5. Changes are calculated as a percentage relative to the mean long-term precipitation for the period 1986–2005.*

	2041–2060	2081–2100
SSP2-4.5		

SSP5-8.5		

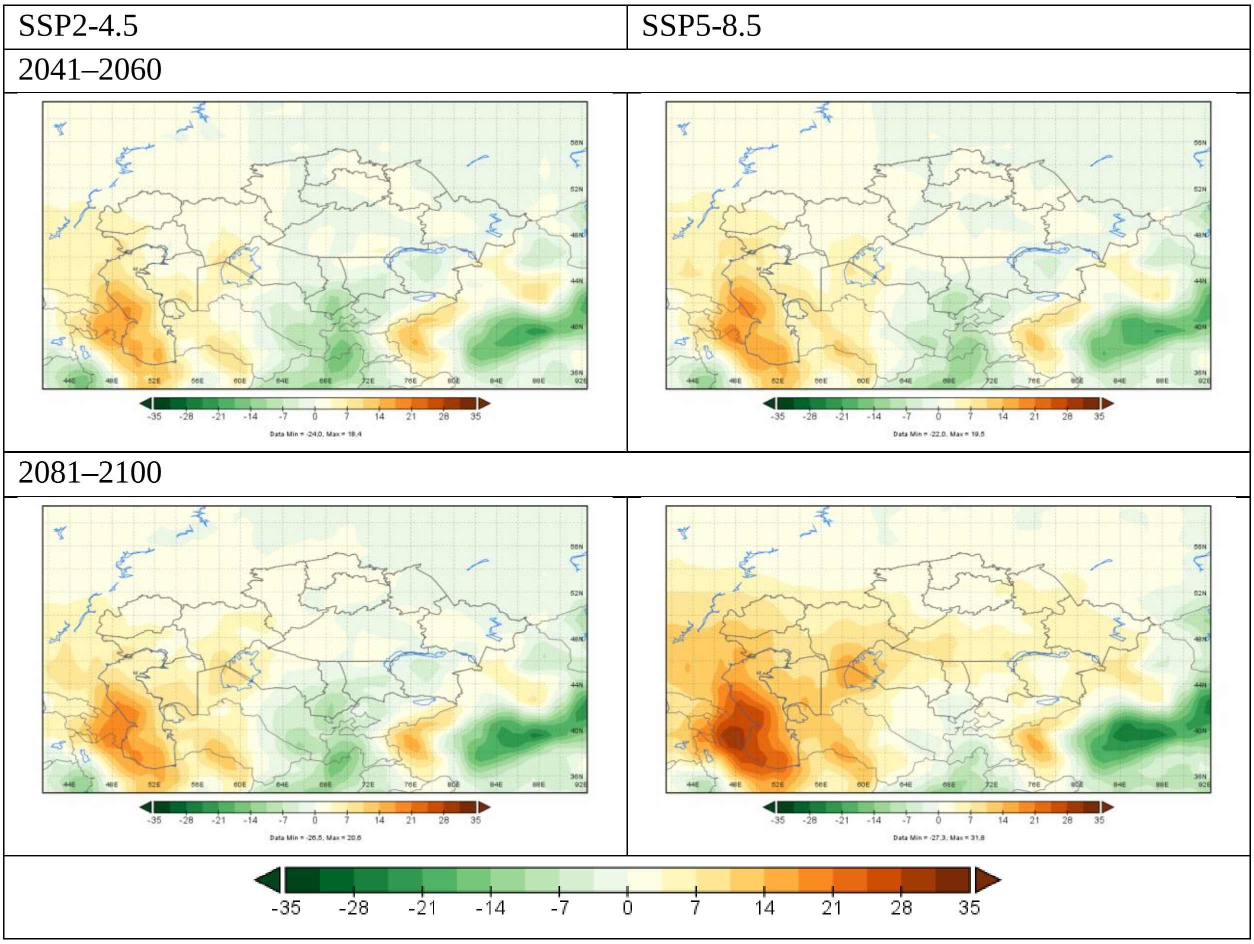
The smallest increase in seasonal precipitation is expected, as a rule, in the western and southern regions, in the summer season in these regions the largest decrease in precipitation by more than 20% is likely (Annex 2, Figures 12–14).

It should be noted that there are significant differences between the CMIP6 models in the direction and magnitude of precipitation changes, just as there were between the CMIP5 models. Although estimates of regional long-term trends in future precipitation are subject to considerable uncertainty, some global trends are evident.

An increase in air temperature in all seasons of the year, including the cold period, leads to a reduction in the amount of precipitation falling in the form of snow (Annex 2, Figure 12). This, in turn, leads to a reduction in snow accumulation, which is an unfavorable factor for the regions of rainfed agriculture, including the grain-growing regions of Northern Kazakhstan. This can also adversely affect irrigated agriculture, which is developed mainly in the foothill regions of the south and southeast, receiving water from rivers with snow and ice sources of food.

The intensity of extreme precipitation is likely to increase with rising temperatures, a conclusion supported by data from various regions of Asia. However, this phenomenon is highly dependent on local geographical conditions. Remarkably, the largest increase in precipitation amounts for 1 or 5 days (R×1day and R×5 days indices, Annex 2, tables 25–26), is expected, as a rule, in the arid regions of Kazakhstan. At the same time, a slight increase in the duration of periods without precipitation is expected (CDD index, Figure 13). The maximum increase in such periods is expected in the west and south-west of Kazakhstan in the areas of the Caspian and Aral Seas - by 10-15 days.

Figure 6.22. *Probable change in the maximum duration of periods without precipitation (CDD index, days) under scenarios of changes in greenhouse gas concentrations SSP2-4.5 and SSP5-8.5. Changes are calculated relative to the period 1986–2005.*



In Kazakhstan, droughts affect two-thirds of the territory and are a characteristic feature of the climate. Grain production in non-irrigated agricultural areas in the north often suffers from drought. So far, no strong signal of the impact of climate change on historical drought trends has been found. But in the future, under scenarios of global warming by 1.5 °C, 2.0 °C and 3.0 °C, a significant increase in the duration and extent of drought in Central Asia is expected at global warming levels.[214] According to warming scenarios, by the end of the 21st century, droughts of this magnitude, which are currently extremely rare in Central Asia (once every 100 years), will become 4-10 times more frequent. On the territory of Kazakhstan within the scenarios SSP2-4.5 and SSP5-8.5 by the end of the 21st century, the likelihood of years with severe drought conditions increases significantly.[215] An increase in the likelihood of drought is expected to affect the entire country, but most severely in the southern regions. Under higher emission scenarios (SSP5-8.5)

[214]Seneviratne, SI, X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, I. Iskandar, J. Kossin, S. Lewis, F. Otto, I. Pinto, M Satoh, SM Vicente-Serrano, M. Wehner, and B. Zhou, 2021: Weather and Climate Extreme Events in a Changing Climate. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, SL Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, MI Gomis, M. Huang, K. Leitzell, E. Lonnoy, JBR Matthews, TK Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1513–1766, doi:10.1017/9781009157896.013.

[215]Naumann, G., Alfieri, L., Wyser, K., Mentaschi, L., Betts, R.A., Carrao, H., Feyen, L. (2018). Global Changes in Drought Conditions Under Different Levels of Warming. Geophysical Research Letters, 45(7), 32853296. DOI: https://doi.org/10.1002/2017GL076521

the probability of severe annual droughts in most of the Kyzylorda and Mangystau regions may be more than 80%. This level of increase in droughts represents a transition to a drier environment, and some new areas are likely to suffer from chronic drought, which could lead to desertification.

When interpreting future climate projections, it must be kept in mind that this is not a climate forecast, but a modeled response of the climate system to a scenario of future emissions or concentrations of greenhouse gases and aerosols, land-use changes, and other anthropogenic forcings. The developers of socio-economic scenarios and scenarios of future emissions or concentrations of greenhouse gases did not ascribe any of the feasibility or likelihood of individual scenarios. The purpose of the analysis is to establish what the characteristics of the regional climate may be in the coming decades under the conditions laid down in the world development scenario.

6.5.Water resources

On the territory of the republic there are about 39 thousand rivers and temporary streams, of which more than 7 thousand have a length of more than 10 km. Most of the rivers of Kazakhstan belong to the internal closed basins of the Caspian and Aral Seas, lakes Balkash, Alakol and Teniz. Only the Yertis River belongs to the Arctic Ocean basin.

There are several thousand lakes in Kazakhstan. Most of them are concentrated in the north, the largest (Balkash, Zaisan, Alakol) are located in the eastern and southeastern regions. The increased mineralization of water in many lakes prevents their economic use.

In the last 5 years, the volume of annual water consumption in all sectors of the economy has averaged to 24 km^3, with 85% coming from surface water. More than 62% of water intake is used in agriculture, more than 22% in industry, and 4–5% of the total water intake was annually used for household needs. 0.8–0.9 km^3 of water (4–7%) is annually spent for household needs, of which: for consumption in cities - 55%, in rural areas - 11%, for supply losses - about a third of the entire water intake.

In 2020, the largest use of water falls on the agricultural, manufacturing and household sectors of the economy, and from 2014 to 2020 no significant changes are observed.

In 2020, the volume of water consumption for regular irrigation increased by 1,884 million m^3 compared to 2019. In the household and drinking industry, the growth amounted to 170.2 million m^3, and in industrial water consumption, the increase was 572.5 million m^3.

In addition, in 2020, there was a decrease in the use of water for irrigation of green spaces by more than 2 times, for agricultural water supply - by 1.4 times. A slight decrease was observed in the use of water for pond-fish farming and watering pastures, but at the same time, there was an increase in water consumption for estuary irrigation.

Provision of the population with centralized water supply in cities is 97.5%, in villages (according to SNP)[216] - 88.1%.

Table 6.9. *Provision of the population with water supply and sanitation services in the Republic of Kazakhstan*

	2016	2017	2018	2019	2020
Public access to water supply services					
in cities	88	93.8	94.5	97.2	97.5
in villages (according to SNP)	52.3	57.4	59.9	64.3	90.1

[216] Rural settlements

Providing the population with centralized water supply, including:					
in cities	88	93.8	94.5	97.2	97.5
in villages (according to SNP)	52.3	57.4	59.9	64.3	88.1
Public access to centralized wastewater systems, including:					
in cities	84	88			
in villages (according to SNP)	11.2	11.5			
Coverage of the population by wastewater treatment, including:					
in cities			68.7	70.5	70.5
in villages (according to SNP)			8.6	8.8	

The population connected to public water supply is 18 million people, and water consumption per capita is 32.2 m3 of water. Population, not connected to public water supply (self-sufficient), is 1.0 million people, and its per capita water consumption reaches 30.5 m3 (table 6.10).

Table 6.10. *Household water consumption per capita*

	2016	2017	2018	2019	2020
Public water supply					
Domestic water consumption in the country	470.4	493.1	516.9	536.1	573.7
Population connected to public water supply, million people	16.2	16.6	17	17.3	17.8
Water consumption per capita per year, cub. m	29.0	29.7	30.4	31.0	32.2
Self-sufficiency					
Population not connected to public water supply (self-sufficiency), million people	1.6	1.4	1.3	1.2	1.0
Estimated water consumption per capita, cub. m	26.4	27.4	28.2	29.0	30.5
Domestic water consumption in the country – self-sufficiency	42.3	38.4	36.7	34.8	30.5
Total water consumption (public water supply and self-sufficiency)					
Total water consumption	512.7	531.5	553.6	570.9	604.2
Total population, million people	17.8	18.0	18.3	18.5	18.8
Water consumption per capita per year, cub. m	28.8	29.5	30.3	30.9	32.1

Assessment of the impact of climate change on the water management basins of the Republic of Kazakhstan

Ile-Balkash water management basin

From a geographical point of view, the Ile-Balkash basin is an extremely vast region with an area of 413 thousand km^2 in the South-East of Kazakhstan and the North-West of China. It is located in the southeastern part of the Republic of Kazakhstan and the northwestern part of the Xinjiang Uygur Autonomous Region of China. The Kazakhstani part of the Ili-Balkash basin includes the territory of the Almaty region[217].

The large endorheic basin of Lake Balkash is the third largest (after the Caspian and Aral Seas) inland water body of the planet. Its length is 600 km, the average width is 30 km. The water surface area during the period of systematic observations on the lake (1937–2009) varied from 15.3 to 20.3 thousand km^2, the volume of the water mass – from 80.4 to 124.8 km^3, and the average depth – within 5.3–6.1 m. The active part of the catchment area is only about 182 thousand km^2; it includes the basins of the Ile, Karatal, Aksu and Lepsy rivers. The contribution of the Ile River to the total inflow is about 80%.

[217] The concept of sustainable development of the Ili-Balkash basin:http://www.cawater-info.net/bk/water_law/pdf/concept-ili-Balkash.pdf

A unique feature of Lake Balkash is the division into two separate parts: the western one is large in area (more than 10 thousand km^2), shallower (up to 11 m); and eastern - with an area of more than 7 thousand km^2 and a depth of up to 26 m, which are separated by the narrow Uzun-Aral strait. Almost all the water entering the lake is spent on evaporation, and in conditions of difficult water exchange between the western and eastern parts of the Balkash, a different salt regime and a different degree of water mineralization are created in them. In the eastern part of the lake, water mineralization exceeds 4 g/l. The western part, under the influence of an abundant inflow of relatively weakly mineralized waters of the Ile, is strongly desalinated and does not exceed 0.5–1.5 g/l.

On Lake Balkash, the amplitude of centuries-old water level fluctuations associated with cyclic climate fluctuations over the past millennium reaches 10–14 m, intrasecular (50–60-year) fluctuations - 2.5–4.0 m. During these fluctuations, the level rise phase water (20–30 years) are regularly replaced by phases of decline (30–40 years).

The water balance and level of the lake changes over the years under the influence of two factors: climatic and anthropogenic. The latter includes all types of economic activities related to water withdrawals (irrigation, technical and municipal water supply), regulation and transfer of river flow to the lake basin, as well as water withdrawals from the lake itself.

In the system of the economy of Kazakhstan, the basin is a diversified economic complex, which is characterized by environmentally hazardous enterprises in the extractive industry and non-ferrous metallurgy. On the territory of the basin, mainly enterprises of mechanical engineering, chemical, food, and light industries are represented. Environmentally hazardous enterprises are mainly located in the city of Balkash (copper production), Taldykorgan (battery plant), Tekeli (mining), Kapshagai (construction materials) and Almaty (engineering and metallurgy).

Irrigated agriculture is exercised on the territory of the basin, which is the most water-intensive branch of agriculture, and which, through pollution with pesticides and soil salinization, negatively affects the ecological situation in the basin. The ecological situation created in the Ile-Balkash basin is characterized as critical, with progressive vulnerability of the ecosystem and instability of the level of Lake Balkash caused by problems of water allocation, degradation of mountain ecosystems (deforestation, irreversible melting of glaciers, etc.) and other threatening factors. Pollution and mineralization of water are increasing. The areas of saline and flooded lands are increasing, desertification is progressing, and saxaul forests are being destroyed.

In the basin of Lake Balkash, climate change manifests itself in a significant increase in the average annual air temperature and some increase in precipitation. An increase in air temperature led to an increase in the degradation of mountain glaciation of river basins, which formed in the 16th–17th centuries. The degradation of mountain glaciation and an increase in the amount of precipitation over the past 25 years have led to an increase in the surface water resources of the considered region.

Studies of climate change in Kazakhstan were carried out based on calculations using global climate models CMIP5[218]. For the territory of Kazakhstan, an ensemble of 21 models was compiled. According to calculations, on the territory of Kazakhstan in the 21st century, further significant climate warming should be expected under all considered scenarios (Figure 6.23) and a slight increase in annual precipitation with a possible decrease in precipitation in summer from the

[218]Seventh National Communication and Third Biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change.

middle of this century (Figure 6.24). Probable changes in annual and seasonal air temperatures, annual and seasonal precipitation over the territory of the Ile-Balkash basin under scenarios of changes in greenhouse gas concentrations RCP 4.5 and RCP 8.5 are listed in Tables 1-4 of Annex 3.

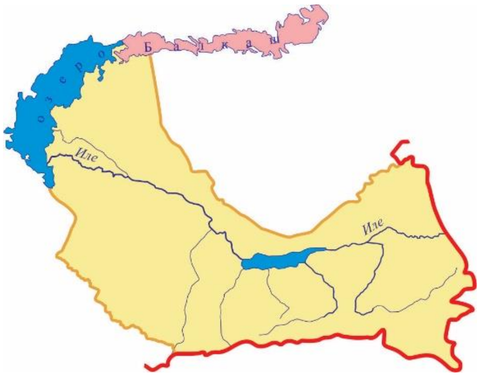
For the territory of the Ile-Balkash basin, projections of the average climate are proposed for RCP 4.5 and harsh RCP 8.5 emission scenarios for the periods of 2020–2039, 2040–2059, 2060–2079, 2080–2099 relative to the reference period of 1981–2000. Figures 6.23–6.24 present the results of modeling annual average monthly air temperatures and annual precipitation for the basin area. The analyses show that under the medium scenario, a temperature change from 1.7°C (2020–2039) to 3.2°C by the end of the century, under a harsh scenario, the magnitude of the change in air temperature will change by 1.5 - 2 times. The amount of precipitation over the territory of the basin for the scenarios RCP 4.5 and RCP 8.5 will not change significantly, but there is an increase in the second half of the 21st century up to 19%. A noticeable decrease is expected in summer and autumn.

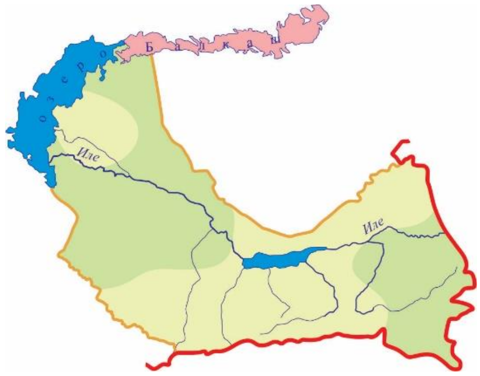
Figure 6.23. *Change in average annual air temperature (℃) and annual precipitation (%) under the average climate change scenario (RCP 4.5)*

Temperature **Precipitation**

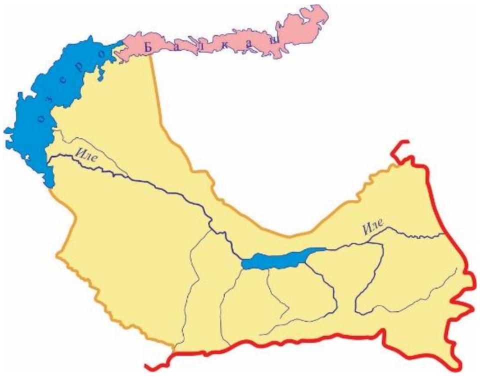
2020–2039

2040–2059





2060–2079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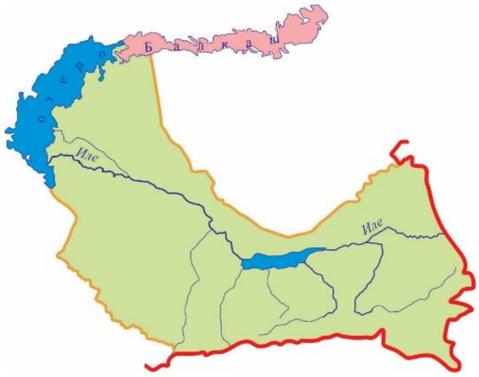
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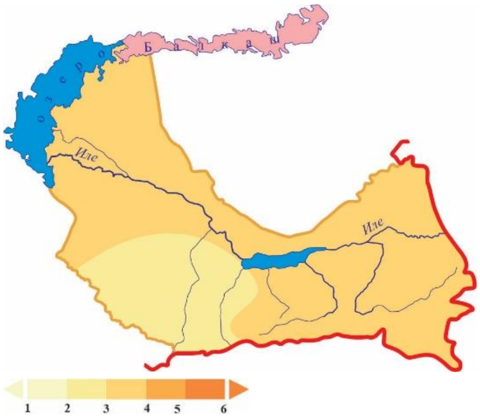
2080–2099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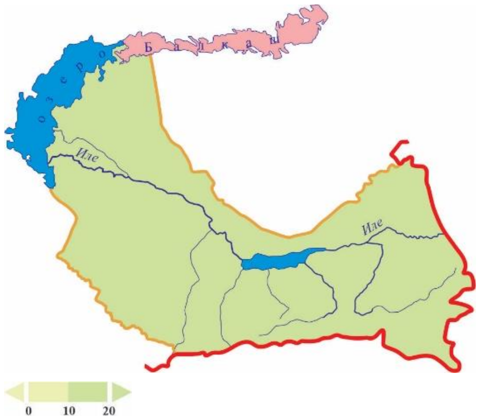
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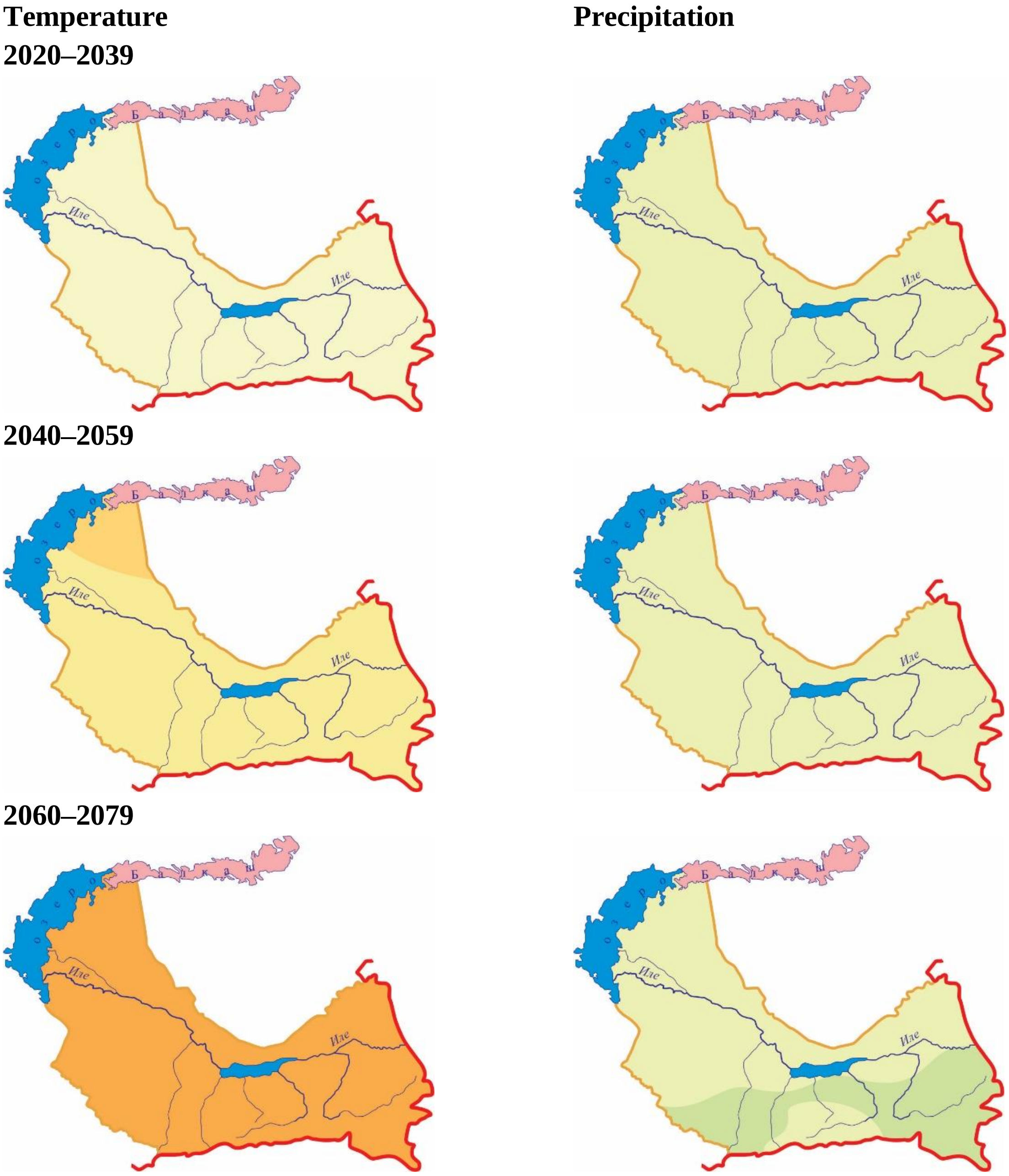
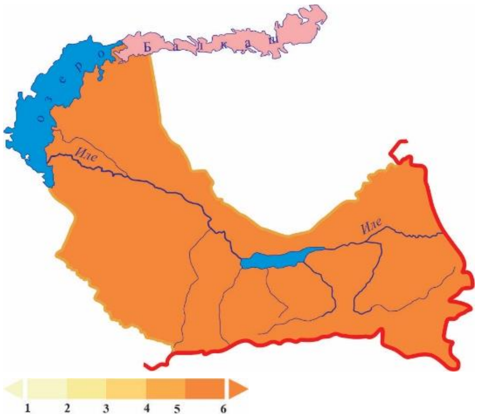
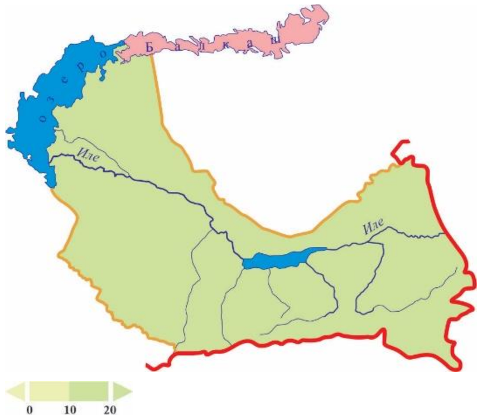
Figure 6.24. *Change in average annual air temperature (℃) and annual precipitation (%) under the average climate change scenario (RCP 8.5).*



2080–2099





River flow modeling in selected watershed areas was performed using the HBV hydrological model developed by Bergström at the Swedish Meteorological and Hydrological Institute as a conceptual watershed model that converts precipitation, air temperature and potential evapotranspiration into either snowmelt or runoff or inflow in reservoir.

*On the territory of Kazakhstan data from the National Hydrometeorological Service from 1960 to 2016 were used:

- meteorological data of MS Kyrgyzsay, Narynkol, Kegen (average daily air temperatures, daily precipitation, average long-term evaporation values);
- hydrological data of the GP r. Ile - Kapshagai tract, GP r. Ile - 164 km upstream of the Kapshagai HPP (water discharges) (Annex 3).
- *In China* data from the observation network since 1960:
- meteorological data of MS Zhaosu (until 1990);
- hydrological data of the GP r. Ile - s. Yamada (until 2010).

Climate projections for the territory of Central Asia were used from the NASA NEX platform (National Aerona) and scenarios RCP 4.5 and RCP 8.5 from global models, according to which (average daily air temperature and daily precipitation) water discharges were modeled for the period from 2007 to 2099.[219]

Figure 6.25 shows the average long-term runoff hydrographs for 2015–2049 and 2050–2099 for the river Ile - 164 km upstream of the Kapshagay HPP, according to the RCP 4.5 scenario.

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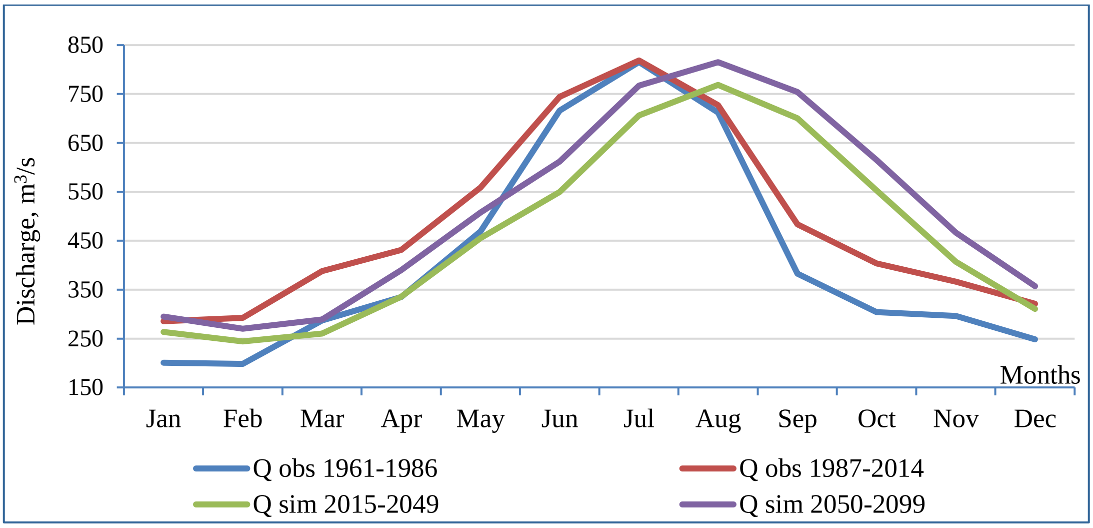
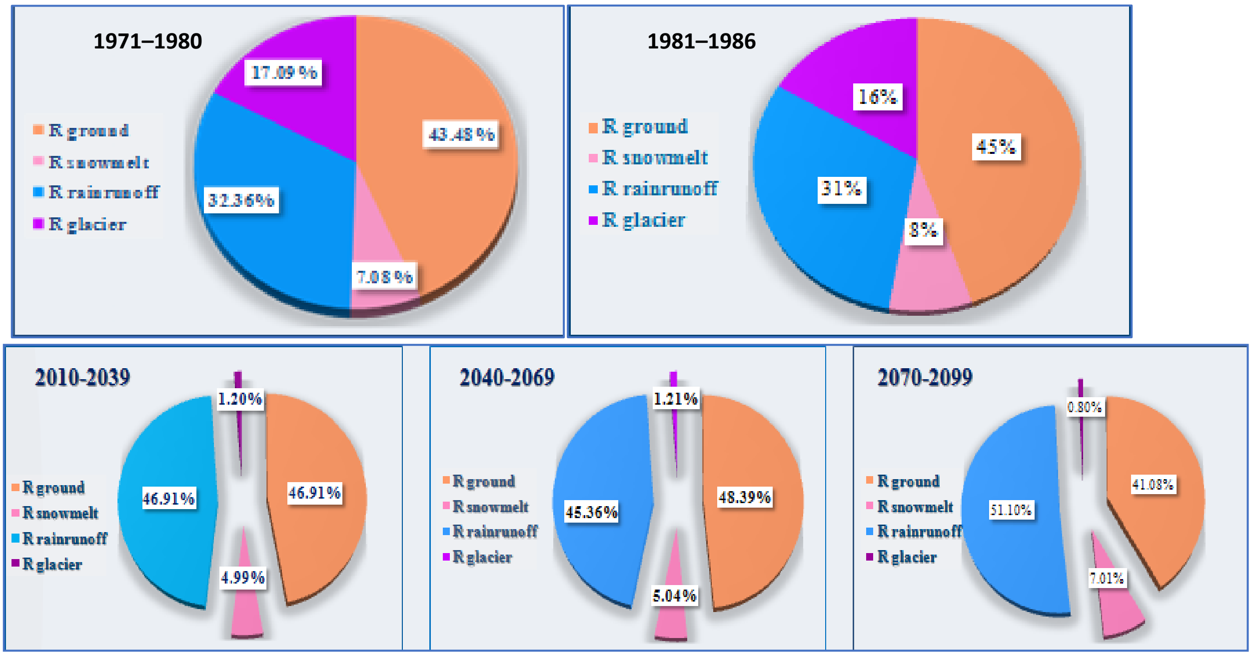
[219] https://cds.nccs.nasa.gov

Figure 6.25. *Seasonal distribution of river flow from observed data (1961–1986, 1987–2014) and simulated data under the RCP 4.5 scenario for the future (2015–2049, 2050–2099).*



According to the plot of runoff hydrographs over a multi-year period, under the medium scenario of climate change (RCP 4.5), the peak of the flood is shifted to a later period, and the water flow will decrease in the first half of the century. The glacial component of the river's nutrition will also decrease. Compared to the runoff components during the calibration and validation period (Figure 6.26), the glacial component decreases from 17.09% to 0.80% by 2070-2099.

Figure 6.26. Components of the runoff (ground, snowmelt, rain runoff, glacial) for Ile River for various periods.



Below is an assessment of the impact of climate change on water management basins using the climate projections of The Inter-Sectoral Impact Model Intercomparison Project – ISIMIP (ISIMIP, 2020). The projections were prepared for two scenarios: ssp 126 and ssp 370. Modeling of river flow in selected sections of the rivers of the water management basins was carried out using the HBV hydrological model. To adapt the model, data from a digital elevation model, average daily water discharge, average daily air temperature and precipitation from meteorological stations were used as initial data. Three-dimensional SRTM images were used for the altitudinal analysis of the basins. The subsequent processing of the 3D image was performed in the ESRIArcGISDesktop modules. Modeling results for each basin are given in Annex 3 (Figures 1–15, Tables 1–20).

As a result of forecasting climatic parameters and river flow in selected areas of water management basins, the following changes were revealed:

- in all water management basins, an increase in air temperature is expected, as well as an increase in precipitation to varying degrees depending on the basin;
- temperature increase affects the melting of glaciers, which leads to an increase in runoff in mountain rivers until the middle of the century and to its decrease until the end of the century as a result of the already depleted glaciers in the mountains. Such a trend in runoff change is typical for the following water management basins: Aral-Syrdarya, Yertis, Shu-Talas. However, the Balkash-Alakol water management basin is characterized by an increase in runoff towards the end of the century, which can be explained by the possible longer degradation of glaciers;
- all lowland water management basins, the Nura-Sarysu, Yesil, Zhayk-Caspian and Tobol-Torgai, tend to reduce water runoff by the end of the century, which is associated with an increase in air temperature, high evaporation, and a slight increase in precipitation. Thus, according to the modeling results for two scenarios ssp 126 and ssp 370, by the end of the century, a reduction in runoff is expected in all water management basins, except for the Balkash-Alakol basin, where the model shows an increase in water runoff until 2100;
- According to forecast estimates, water consumption is expected to increase because of an increase in the area of irrigated agriculture from 1.8 to 3 million hectares by 2030, while due to the increase in average annual temperature, water consumption per 1 ha of land will also increase.

Considering the planned increase in irrigated agricultural land in the country, it is necessary to note the possible shortage of water, in particular in the lowland rivers, and by the end of the century in the mountainous region. Therefore, when increasing the scale of irrigated agriculture, it is necessary to take into account the above-described results of forecasting climatic parameters, as well as the flow of water in rivers for each water management basin separately.

6.6. Agriculture

Agriculture plays an important role in the economic and social development of Kazakhstan. In 2020, agriculture, forestry and fisheries accounted for 5.4% in the structure of gross domestic product by type of economic activity. By categories of farms, the structure of gross output of products (services) of agriculture, forestry and fisheries is as follows: agricultural enterprises - 26.4%, households - 41.5%, individual entrepreneurs and peasant or farm enterprises - 32.1%.

The rural population as of February 1, 2022, amounted to 7,754.0 thousand people. (40.5% of the total population).

The area of agricultural land assigned to land users is 108.6 million hectares. The category of agricultural land includes the most valuable farmland for agriculture and the agro-industrial complex, including arable land, perennial plantations, fallow land, hayfields, and pastures. As of January 1, 2021, in the structure of agricultural land, farmland makes up 97.2%, including: arable land - 23.8%, perennial plantations - 0.1%, fallow land - 1.7%, hayfields - 2, 0%, pastures - 69.6%[220]

Over the past three years, there has been an increase in arable land by 5%, which is 26.3 million hectares, hayfields - by 5% or 2.2 million hectares, pastures - by 7.4% or 75.6 million hectares. There is a decrease in the fallow by 40% or 1.8 million hectares. In addition, over the past three years, 307 thousand hectares have been withdrawn from agricultural land to expand the boundaries of settlements and industry.

The current agricultural policy is focused on increasing domestic production to replace imports and promote exports.

Arable land is cultivated mainly by large agricultural enterprises. Livestock and vegetable growing is dominated by small agricultural enterprises (individual entrepreneurs, peasant farms and households)[221].

Wheat production is one of the most important segments of agriculture, ensuring the country's food security. Kazakhstan is also a leading exporter of wheat (UNDP, 2019).

At the same time, the process of diversification in the crop industry is not going at the proper level[222]: monoculture prevails in the main grain-growing regions of the country; insufficient attention is paid to the development of fodder production; the pace of expansion of irrigated lands and the introduction of modern moisture-saving technologies remains slow; shortcomings in the work to preserve soil fertility are revealed. The volume of applied mineral fertilizers is only 23% of the scientifically based norms, and organic - only 1.2%.

In addition, the pace of renewal of the technical park of agriculture is insufficient. So, in 2020, this figure was 4.1% with the standard of 6–8%. Currently, about 76% of the technical park has a service life of more than 10 years. Of the total area of agricultural crops of 22 million hectares, only about 1.5% is cultivated using organic crop production technologies.

The main problems of the crop industry are:

- low level of diversification;
- the backwardness of breeding work and the seed-growing system, the insufficiency of seeds of domestic selection;
- deterioration of soil fertility;
- low level of application of water-saving technologies in irrigation;
- low technical and technological equipment of the industry;
- high corruption component in the implementation of control and supervisory functions, and provision of public services;
- low level of digitalization of the industry;
- underdevelopment of organic farming, backwardness of technologies for the production and processing of organic raw materials,

[220] Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2030, Decree of the Government of the Republic of Kazakhstan dated December 30, 2021, No. 960.

[221]Preliminary data for 2021. Statistical Yearbook of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics.

[222] The concept of development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2030

– regulatory legal acts and national standards in force in the field of organic production do not meet the interests of domestic producers and do not comply with international practice.

Recommendations in the horticulture sector

In the formation of crop production, the main factors are agricultural technology and weather. Other factors - technical, scientific, educational, and informational support - contribute to raising the level of cultivation technology and extracting the maximum benefit from weather conditions (or reducing damage).

Analyzing the results of studies of past National Communications of the Republic of Kazakhstan on climate change and other sources, as well as the results of national studies, the following areas of measures to adapt agriculture to the effects of climate warming can be distinguished:

1. Technology;
2. Accounting for weather conditions;
3. Technical support of agriculture;
4. Scientific and educational support of agriculture;
5. Information support of agriculture;
6. Insurance system in agriculture.

Climate change adaptation measures for grain production

Regarding crop production (grain production), the directions of adaptation measures to the consequences of climate warming will be as follows:

1. Technology of cultivation of agricultural crops;
2. Accounting for the peculiarities of weather conditions;
3. Technical support of crop production;
4. Scientific and educational support of crop production;
5. Information support of crop production;
6. Improvement of the insurance system in crop production.

At the present stage, the productivity of crop production in Northern Kazakhstan depends up to 70% on the weather, and up to 30% on agricultural technology. At the same time, with an increase in the level of agricultural crop farming, the dependence of crop production on weather conditions will decrease.

Technology of cultivation of agricultural crops

The following measures can be attributed to the technology of cultivation of agricultural crops, which contribute to adaptation to the expected warming of the climate:

–introduction of resource-saving technologies;

–implementation of structural and technological diversification of crop production;

–selection work;

–introduction of efficient irrigation systems.

The main problems of the livestock industry are:

– a significant proportion of livestock in personal subsidiary plots of the population is not covered by technological processes and is not provided with a sufficient amount of feed; high proportion of outbred livestock, primarily in personal subsidiary plots of the population;
– shortage of pastures for the livestock of rural settlements;
– weakness of the forage base, low share of forage crops in crop rotation, on irrigated lands, as well as degradation and low productivity of pasture lands;
– difficult epizootic situation and low wages of veterinary specialists;
– low level of development of remote pastures due to their insufficient water supply. Depending on the regions, from 20% to 60% of pastures are degraded. 48% of pastureland is not used due to the lack of a watering place;
– limited environmental monitoring in the sector, in particular regarding greenhouse gas emissions;
– shortage of qualified personnel in animal husbandry.

Recommendations in the livestock sector

Similar to crop production, the following areas of adaptation measures in animal husbandry (sheep breeding) of Kazakhstan to the consequences of climate warming can be distinguished:

1. Technology of keeping farm animals;
2. Accounting for the peculiarities of weather conditions;
3. Technical support of animal husbandry;
4. Scientific and educational support of animal husbandry;
5. Information support of animal husbandry;
6. Introduction of an insurance system in animal husbandry.

In the formation of livestock products, the main factors are the technology of keeping animals, the state of pastures, and weather conditions. Other factors - technical, scientific, educational, and informational support - contribute to improving the level of technology for keeping animals and reducing damage from adverse weather conditions.

It should be noted that on February 20, 2017, the Law of the Republic of Kazakhstan on pastures was approved by the President of Kazakhstan. The law is based on the principles:

1) rational use of pastures;
2) availability of pastures for individuals and legal entities;
3) publicity in carrying out activities related to the provision and use of pastures;
4) participation of individuals and legal entities in solving issues of management and use of pastures.

According to the land balance, in 2020 there were 2.251 million hectares of irrigated land in the country[223], of which 1.779 million hectares were agricultural land and accounted for 40.5% of the land in use.[224] Relative to 2017, there is a growth tendency in the area of irrigated land from 2.181 million hectares.

[223] Official website of the Prime Minister of the Republic of Kazakhstan, 2021.
[224] http://cawater-info.net/bk/land_law/files/kz-land2019.pdf

By 2030[225] it is planned to bring irrigated agricultural land to 3 million hectares, which will entail an increase in water consumption for agricultural needs.

For the rational use of water in agriculture, it is planned to carry out work to diversify the sown areas of agricultural crops by reducing the share of water-intensive and monocultures, as well as increasing the areas of highly profitable alternative crops (vegetables, fodder, oilseeds). This will reduce the amount of water consumed for irrigation, in particular in the southern (arid) region of the republic, where regular irrigation is used, and moisture-loving crops (rice, cotton) are cultivated.

The efficiency of water resources use in irrigated agriculture is largely determined by the state of irrigation and collector-drainage systems. In Kazakhstan, only 14% of irrigated lands currently use modern drip and sprinkling irrigation. The rest of the areas are watered by outdated uneconomical methods - continuous flooding and surface irrigation.[226]

According to the National project for the development of the agro-industrial complex in Kazakhstan for 2021-2025, it is planned to increase the area of land using water-saving technologies (drip irrigation, sprinkling): in 2021, up to 235 thousand hectares; in 2022 up to 281 thousand hectares; in 2023 up to 327 thousand hectares; in 2024 up to 373 thousand hectares; in 2025 to 420 thousand hectares to reduce water withdrawal for irrigation of agricultural land. To encourage farmers to use modern water-saving irrigation methods, the state plans to subsidize farmers for half of the cost of irrigation systems.

However, increasing the amount of irrigated land from the current 1.7 million hectares to 3 million hectares by 2030 will correspondingly increase the amount of water consumed. At the same time, in conditions of a critical state of irrigation systems, water losses during transportation for agricultural needs reach 19% of water withdrawal (Target indicators for the Protocol on Water Problems, 2017).

In 2020, water withdrawal for agricultural needs amounted to 13.3 km^3, which is 1 km^3 more than in the previous 2019 According to the calculations of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, if the current trend in water consumption continues, the projected deficit by 2030 will be 11.7 km^3. Increasing the use of water-saving technologies, as well as the transition to drought-resistant crops, are key aspects of more efficient use of water resources in the country.

Most of the irrigated agriculture with regular irrigation is concentrated in the southern regions of the country, consuming 97% of the water intake, these are South Kazakhstan, Almaty, Zhambyl and Kyzylorda regions[227]. In these regions, water is taken from the rivers of two water management basins: Aral-Syrdarya and Shu-Talas. According to forecasts of river flow changes in the above basins, water flow will increase until the middle of the century as a result of intensive glacial melting and will decrease by the end of the century due to the depletion of glaciers. Such fluctuations in water should be taken into account when planning irrigated agriculture, in particular when introducing new types of crops, as well as irrigation methods.

It is important to note rising temperatures and changes in rainfall that will affect irrigation rates for certain crops. For example, under both scenarios, all watersheds will experience a

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[225]Order of the President of the Republic of Kazakhstan: https://kapital.kz/economic/99232/do-2030-goda-ploshchad-oroshayemykh-zemel-dovedut-do-3-mln-ga.html
[226] Official website of the Ministry of Agriculture of the Republic of Kazakhstan, 2021.
[227] https://www.gov.kz/memleket/entities/ecogeo/press/news/details/138615?lang=ru

significant increase in air temperature, which will require more intensive irrigation of certain crops.

Pastures

As of January 1, 2021, in the structure of agricultural land, farmland makes up 97.2%, including: arable land - 23.8%, perennial plantations - 0.1%, fallow land - 1.7%, hayfields - 2.0 %, and pastures - 69.6%.[228]

In 2017, pastureland in Kazakhstan amounted to 186.4 million hectares. Of these, 6.0 million hectares are used by land users in other states. 180.4 million hectares of pastures are in republican use, of which 5.9 million hectares have been improved, 105.2 million hectares have been watered. Accordingly, more than 111.1 million hectares of pastures are suitable for grazing. Of the 180.4 million hectares, 71.1 million hectares are currently used, including improved - 4.0 million hectares, watered - 43.3 million hectares.[229] More than 80% of the total livestock of farm animals is concentrated in private backyards, the owners of which, for economic reasons, graze their livestock within a radius of 5-7 kilometers from their place of residence. As a result, about 27 million hectares of pastures, most of them located near settlements, are degraded. Natural hayfields are land plots systematically used for haymaking. The area of hayfields is 4.9 million hectares, of which 43.9 thousand hectares have been improved, 727.5 thousand hectares are lands of firth irrigation.

Important characteristics of pasture lands, depending on weather conditions, are the productivity and livestock intensity of pastures (the number of animals (heads) per 1 ha of area, which can be fed for one month or for the entire grazing period), as well as optimal load on pastures. In well-moistened years, pasture yield are much higher than in dry years. Therefore, the pasture cattle intensity and the optimal load on pastures during summer sheep grazing are calculated for unfavorable and favorable years, when the pasture yield is higher or lower by 30% of its average value.

For yield forecast of pasture plants in climate conditions until 2030 and 2050, regression equations of dependence of productivity of pasture plants on air temperature and precipitation were established. For this, long-term series of yield, average monthly air temperatures and monthly total precipitation for the considered weather stations were used. The resulting regression equations were tested for reliability using the correlation coefficient, Student's coefficient, and Fisher's coefficient, and used for a probabilistic forecast of the impact of climate change on the productivity of pasture plants. Calculations were carried out for conditions up to 2030 under the RTC 4.5 and RTC 8.5 scenarios. Table 6.11 and Figure 6.27 below show the relative productivity of pastures, that is, as a percentage relative to the current level.

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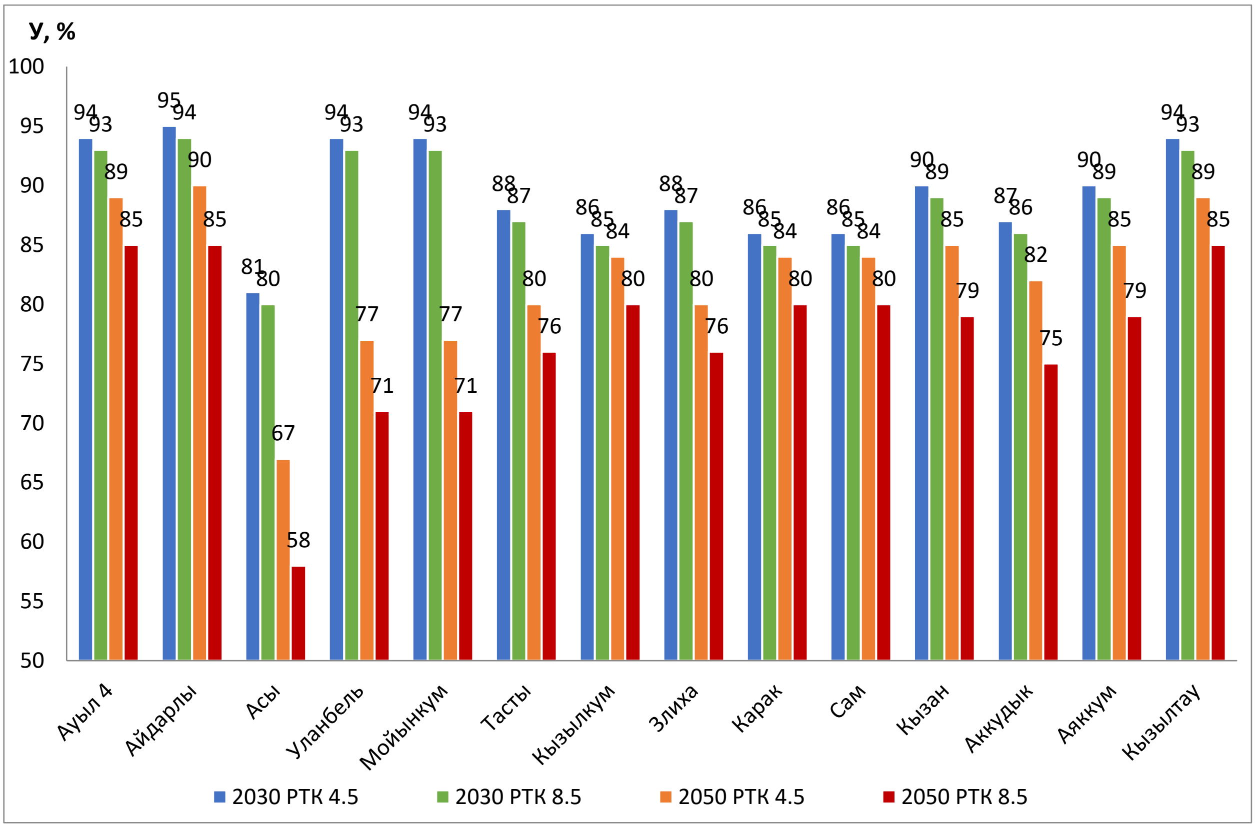
[228] Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021–2030, Decree of the Government of the Republic of Kazakhstan dated December 30, 2021 No. 960.

[229]Consolidated analytical report on the state and use of lands of the Republic of Kazakhstan for 2017. Agency of the Republic of Kazakhstan for land management. Astana, 2018. 273 p.

Table 6.11. *Average yield of pasture plants over the summer (U, c/ha), under the conditions of the modern climate (MC) and the climate of 2030 according to the RCP 4.5 and RCP 8.5 scenarios.*

weather stations	Productivity, c/ha		
	SC	RCP 4.5	RCP 8.5
Almaty oblast			
Auyl 4	4.2	3.9	3.9
Aidarly	2.1	2.0	1.9
Assy	27.7	22.5	22.2
Zhambyl oblast			
Ulanbel	3.6	3.3	3.3
Moyinkum	3.8	3.6	3.6
Turkestan oblast			
Tasty	2.3	2.0	2.0
Kyzylkum	1.1	0.9	0.9
Kyzylorda oblast			
Zlikha	4.3	3.8	3.8
Karak	4.2	3.6	3.6
Mangystau oblast			
Sam	1.9	1.6	1.6
Kyzan	1.5	1.3	1.3
Akkudyk	2.6	2.3	2.3
South of Aktobe oblast			
Ayakkum	3.3	3.0	3.0
South of Karaganda oblast			
Kyzyltau	7.0	6.6	6.5

Figure 6.27. *Expected yield of pasture plants by 2030 and 2050 under the RCP4.5 and RCP8.5 scenarios, in percent relative to current norms*



By 2030, a decline in yield is expected on the plain pastures of the southern part of Kazakhstan (Almaty, Zhambyl, Turkestan, Kyzylorda and Mangystau oblasts, south of Aktobe and Karaganda oblasts) by 5–14%, that is, the yield will be 86–95% of the current level (table 6.12, figure 6.27). At the same time, the expected changes under the RCP 4.5 and RCP 8.5 climate change scenarios are very close to each other.

Mountain pastures are more vulnerable to climate change. On mountain pastures, a more significant decrease in the yield of pasture plants is likely. For example, in the Assy tract, pasture productivity is expected to decrease by 20% by 2030, i.e., it will be 80% of the current level of productivity.

Thus, the expected warming of the climate by 2030 will lead to a slight decrease in pasture productivity in the plains and a more significant decrease in the mountainous areas of southern Kazakhstan.

The expected decrease in the productivity of pastures will naturally lead to a change in their livestock intensity and the optimal load on pastures. Based on the expected pasture productivity by 2030, the cattle intensity (N) and the optimal load on pastures (Ho) for summer sheep grazing were calculated (Table 6.12). At the same time, the average summer feed consumption rate for a flock (50% of young and 50% of adults) was taken equal to 1.6 kg/head.∗day

Table 6.12. Livestock intensity (N) and optimal load on pastures (Ho) during summer sheep grazing *under the conditions of the modern climate (MC) and the climate of 2030 according to the RCP 4.5 and RCP 8.5 scenarios.*

MS	**N, birds/ha**			**Ho, ha/head**		
	MC	**RCP 4.5**	**RCP 8.5**	**MC**	**RCP 4.5**	**RCP 8.5**
Almaty oblast						
Auyl 4	2.0	1.9	1.9	0.49	0.53	0.53
Aidarly	1.0	1.0	0.9	1.00	1.05	1.06
Assy	13.4	10.9	10.7	0.07	0.09	0.09
Zhambyl oblast						
Ulanbel	1.7	1.6	1.6	0.58	0.62	0.62
Moyinkum	1.8	1.7	1.7	0.54	0.58	0.58
Turkestan oblast						
Tasty	1.1	1.0	1.0	0.89	1.01	1.01
Kyzylkum	0.5	0.4	0.4	1.94	2.26	2.26
Kyzylorda oblast						
Zlikha	2.1	1.8	1.8	0.48	0.55	0.55
Karak	2.0	1.8	1.8	0.49	0.57	0.57
Mangystau oblast						
Sam	0.9	0.8	0.8	1.09	1.27	1.27
Kyzan	0.7	0.6	0.6	1.40	1.56	1.56
Akkudyk	1.3	1.1	1.1	0.80	0.92	0.91
South of Aktobe oblast						
Ayakkum	1.6	1.4	1.4	0.63	0.69	0.69
South of Karaganda oblast						
Kyzyltau	3.4	3.2	3.2	0.29	0.31	0.32

As can be seen from table 6.12, on lowland pastures in the southern part of Kazakhstan by 2030, a decrease in livestock intensity is predicted and a corresponding increase in optimal load on pastures, which implies an increase in the required pasture area for grazing a flock of sheep.

Decrease in cattle intensity and increase in the optimal load on pastures by 2030 relative to current standards is 5-14% on flat pastures, 20% - on mountain pastures. At the same time, the expected changes under the RCP 4.5 and RCP 8.5 climate change scenarios are very close to each other.

For example, in the southern Balkash region (Auyl 4) pasture capacity will decrease from 2.0 head/ha to 1.9 head/ha and, accordingly, the optimal pasture load will increase from 0.49 ha/head up to 0.53 ha/head, i.e., more pasture area will be required for grazing a flock of sheep.

The greatest change is expected in the mountain pasture of the Assy tract, where the pasture cattle intensity will decrease from 13 head/ha to 11 head/ha and, accordingly, the optimal pasture load will increase from 0.07 ha/head up to 0.09 ha/head, i.e., more pasture area will be required for grazing a flock of sheep.

Calculations for the expected yield by 2050 were also carried out under the RCP 4.5 and RCP 8.5 scenarios. The data obtained are presented in Table 6.13. For clarity, Figure 6.27 shows the relative productivity of pastures, that is, as a percentage of the current level of their productivity.

According to calculations until 2050, a decrease in the yield of flat pastures in the southern part of Kazakhstan (Almaty, Zhambyl, Turkestan, Kyzylorda and Mangystau oblast, south of Aktobe and Karaganda regions), according to the RCP 4.5 climate change scenario – by 10–23%, according to the RCP 8.5 scenario – by 25–29% of the current level (Table 6.13, Figure 6.27). As can be seen, a larger change is expected under the RCP 8.5 climate change scenario.

Mountain pastures are the most vulnerable to climate change. On mountain pastures, a more significant decrease in the yield of pasture plants is predicted. For example, in the Assy tract, pasture productivity is expected to decrease by 2050, according to the RCP 4.5 climate change scenario - by 33%, according to the RCP 8.5 scenario - by 42% of the current level.

Table 6.13. *Summer average (June–August) productivity of pasture plants (c/ha) under the conditions of the modern climate (MC) and the climate of 2050 according to the RCP 4.5 and RCP 8.5 scenarios.*

Weather stations	**productivity, centner/ha**		
	MC	**RCP 4.5**	**RCP 8.5**
Almaty oblast			
Auyl 4	4.2	3.7	3.6
Aidarly	2.1	1.9	1.8
Assy	27.7	18.6	16.1
Zhambyl oblast			
Ulanbel	3.6	2.7	2.7
Moyinkum	3.8	2.9	2.9
South Kazakhstan oblast			
Tasty	2.3	1.9	1.8
Kyzylkum	1.1	0.9	0.9
Kyzylorda oblast			
Zlikha	4.3	3.4	3.3
Karak	4.2	3.6	3.4
Mangystau oblast			
Sam	1.9	1.6	1.5
Kyzan	1.5	1.3	1.2
Akkudyk	2.6	2.1	1.9
South of Aktobe oblast			
Ayakkum	3.3	2.8	2.6

South of Karaganda oblast			
Kyzyltau	7.0	6.3	6.0

Climate warming, predicted by 2050, will lead to a decrease in the productivity of pasture plants in the southern half of Kazakhstan and an increase in the vulnerability of mountain pastures.

The expected decrease in the productivity of pastures will naturally lead to a change in their livestock intensity and the optimal load on pastures. Based on the expected pasture productivity by 2050, the livestock intensity (N) and the optimal pasture load (Ho) for summer sheep grazing were calculated (Table 6.14).

Table 6.14. *Livestock intensity (N) and optimal load on pastures (Ho) during summer sheep grazing under the conditions of the modern climate (MC) and the climate of 2050 according to the RCP 4.5 and RCP 8.5 scenarios.*

MS	N, birds/ha			Ho, ha/head		
	MC	**RCP 4.5**	**RCP 8.5**	**MC**	**RCP 4.5**	**RCP 8.5**
Almaty oblast						
Auyl 4	2.0	1.8	1.7	0.49	0.56	0.58
Aidarly	1.0	0.9	0.9	1.00	1.11	1.17
Assy	13.4	9.0	7.8	0.07	0.11	0.13
Zhambyl Oblast						
Ulanbel	1.7	1.3	1.2	0.58	0.75	0.82
Moyinkum	1.8	1.4	1.3	0.54	0.71	0.77
Turkestan oblast						
Tasty	1.1	0.9	0.9	0.89	1.11	1.17
Kyzylkum	0.5	0.4	0.4	1.94	2.26	2.43
Kyzylorda oblast						
Zlikha	2.1	1.7	1.6	0.48	0.60	0.63
Karak	2.0	1.8	1.6	0.49	0.57	0.61
Mangystau oblast						
Sam	0.9	0.8	0.7	1.09	1.27	1.36
Kyzan	0.7	0.6	0.6	1.40	1.65	1.78
Akkudyk	1.3	1.0	0.9	0.80	0.97	1.06
South of Aktobe oblast						
Ayakkum	1.6	1.4	1.3	0.63	0.74	0.79
South of Karaganda oblast						
Kyzyltau	3.4	3.0	2.9	0.29	0.33	0.35

On flat pastures of the southern part of Kazakhstan by 2050, a significant decrease in livestock intensity and an increase in optimal load on pastures is projected, which implies an increase in the area of pastures required for grazing a flock of sheep.

Decrease in cattle intensity and increase in the optimal load on pastures by 2050 relative to modern norms is 15–30% for flat pastures, 42% for mountain pastures. At southern Balkash (Auyl 4) the livestock intensity of pastures will decrease from 2.0 head/ha to 1.7 head/ha and, accordingly, the optimal pasture load will increase from 0.49 ha/head up to 0.58 ha/head, i.e., grazing a flock of sheep will require more pasture area. A more significant change is expected in the mountain pasture of the Assy tract, where the cattle intensity of pastures will decrease from 13 head/ha to 8 head/ha and, accordingly, the optimal pasture load will increase from 0.07 ha/head up to 0.13 ha/head. However, a larger change is expected under the RCP 8.5 climate change scenario.

Vulnerability of rangelands to climate change

The conducted studies demonstrate the negative impact on the rangelands of the southern part of Kazakhstan of the following factors expected by 2050:

1. Rise in air temperature. The average air temperature (summer) will increase relative to the current climate under the RCP 4.5 scenario by an average of 2.4°C, according to the RCP 8.5 scenario – by 3.0°C. Such an increase in air temperature in the middle of summer under conditions of a large moisture deficit will lead to an earlier burnout of pasture plants and a lengthening of the duration of their summer dormancy.
2. Reducing the moisture supply of the growing season to 16% relative to modern norms.
3. Increased climate aridity up to 17% compared to modern norms, which will lead to an increase in the frequency of drought.
4. Decrease in productivity of lowland pastures by 10–29%, mountain pastures – by 33–42%.
5. Decrease in cattle intensity and increase in the optimal load on flat pastures by 15-30%, mountain pastures - by 42%.

It is important to note other negative effects of climate change:

1) shift of humidification zones to the north;
2) an increase in the proportion of heavy rainfall;
3) increased incidence of hail;
4) an increase in the frequency of abnormally cold winters and hot summers;
5) increase in interannual and intraseasonal variability of the weather regime;
6) development of infectious diseases and pests of agricultural animals.

There are also positive aspects of climate change. Expected:

1. Increase in duration and heat supply of the growing season by about 15%, which can contribute to an increase in the total green mass of vegetation during the growing season.
2. Extension of the frost-free period.
3. An increase in the content of CO_2 in the atmosphere, necessary for photosynthesis.

Thus, the facts listed above prove the vulnerability of the rangelands of the southern part of Kazakhstan to climate change. This circumstance already today requires the introduction of adaptation measures to the consequences of the expected climate change.

Recommendations for adapting rangelands to climate change: the negative impact of climate warming on rangelands can be partially offset by adaptation measures. Analyzing the results of studies of past National Communications of the Republic of Kazakhstan on climate change and other sources,[230] as well as the results of research, it is possible to single out the main six directions of measures to adapt pastures to the consequences of climate warming:

[230]The Seventh National Communication and the third biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change. - Astana, 2017. 304 p.
Second National Communication of the Republic of Kazakhstan to the Conference of the Parties to the UN Framework Convention on Climate Change. - Astana. Agroizdat LLP, 2009. 192 p.
III-VI National Communication of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. - Astana,

1) compliance with the provisions of the Law of the Republic of Kazakhstan on pastures;
2) improvement of vegetation cover on degraded pastures;
3) pasture watering and firth irrigation;
4) introduction of a system of regulated animal grazing;
5) restoration of the distant-pasture system of keeping animals;
6) improvement of the monitoring system for pastures and agrometeorological support for pasture animal husbandry.

Innovative tools used at the international level, approaches to pasture management, proven mechanisms and processes were proposed at the First Practical Conference on Promoting Sustainable Pasture Management in Central Asia (November 17–19, 2014, Bishkek). Thus, pasture management reform in the Kyrgyz Republic was based on three main principles:

1. An ecosystem approach based on the fact that natural pastures consist of grazing systems that must remain unfragmented and managed through unified mechanisms. The use of this approach made it possible to move from a tenancy system, where people received long-term use rights on a first-come, first-served basis, to a common ownership regime, in which the rights to use resources are distributed among all users on an annual basis.
2. Devolution of management to the community level, i.e., from central to local government and resource users, in order to improve management efficiency and provide access for local residents.
3. Introduction of payment for the use of pastures per head of livestock. This principle encourages both sustainable use and fundraising for investment.

In addition, a number of mechanisms have been proposed to promote the rational use of pastures:

– Financial instruments include taxable pasture use at different levels, higher taxes on the use of degraded rural pastures, and lower taxes on grazing on remote pastures. Paying for the livestock, rather than the number of hectares, helps to reduce the concentration of livestock per unit area of land.
– Subsidies, including direct financial payments and incentives for movement, increased credit financing, and direct public investment in infrastructure (roads, water points, etc.). In Kyrgyzstan, the right to graze is paid for through the purchase of grazing tickets, which helps raise funds for investing in pastures.
– Legislative Instruments include developing a regulatory environment to ensure free movement. It is proposed to support the state ownership of pastures and the transition from the exclusive right of lease or private ownership to a system of management of common property. Local government regulations (officially establishing grazing periods for winter, summer, and spring pastures) will help regulate and enforce less formal pasture use rules that are not always enforced.

2013. - 274 p.
Baisholanov S.S. Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. - Astana, 2018. - 128 p.
Law of the Republic of Kazakhstan on pastures: http:///online.zakon.kz

Irrigated agriculture

In Kazakhstan, more than 1.6 million hectares of agricultural crops are irrigated, which are mainly located in the southern regions of Kazakhstan.

Irrigation rate – the total amount of water, which is necessary when irrigating an agricultural crop for the entire growing season. Irrigation rate compensates for the deficit of water balance of 1 hectare of crops, i.e., the difference between the total water consumption (water consumption for transpiration by plants and soil evaporation) and the natural water reserves of moisture in the soil. The value of the irrigation norm depends on weather conditions, the water-physical properties of the soil, the water demand of plants, as well as the technology of cultivation and irrigation.

A distinction is made between the net irrigation rate and the gross irrigation rate. The net irrigation rate does not take into account water losses on the way from the water source to the plant, i.e., filtration losses through the walls and bottom of channels, leakage through pipe joints, etc. These water losses are taken into account by the efficiency coefficient of the irrigation system. For example, the efficiency coefficient of closed irrigation systems is 0.90-0.95 of open systems - 0.60-0.80. The efficiency coefficient of drip irrigation is 0.90-0.98 of sprinkling - about 0.75. Gross irrigation rate includes net irrigation rate and water losses on the way from the water source to the plant.

In preparation of the Eighth National Communication of the Republic of Kazakhstan in the framework of the UNFCCC, Baisholanov S.S. has developed ‘Calculation model for irrigation rate of crops based on meteorological data» (hereinafter – the Model). The model is designed to calculate the total water consumption and net irrigation rate of agricultural crops, in the condition of deep groundwater (more than 3 m.). The model was implemented for 26 types of agricultural crops, taking into account their varieties by early maturity (early ripening, mid-ripening, late-ripening). When determining the irrigation norm for net rice, the water consumption for flooding the rice field, for evaporation from the surface of the rice field and for creating water flow is taken into account. In the model, the total water consumption in the flat areas is obtained by averaging by 3 methods (A.M. Alpatyeva, I.A. Sharova, D.A. Shtoiko), and in the foothill areas (height above sea level is more than 1000 m) - by 2 methods (D.A. Shtoiko and A.M. Alpatiev). The model was transferred to Kazhydromet RSE of the MEGNR RK.

This Model was used to assess the vulnerability of irrigated agriculture to climate change in southern Kazakhstan, i.e., the expected change in the net irrigation norm up to 2050 was estimated. To do this, using the Model, at the beginning, based on climatic data, the total water consumption of agricultural crops during the growing season was calculated. Next, the irrigation norms of the net crops were calculated. The calculations were carried out in the context of agricultural regions of 4 southern regions of Kazakhstan (Almaty, Zhambyl, Turkestan, Kyzylorda) for 26 types of crops, considering their varieties by early maturity.

Table 6.15 shows averaged in the context of the southern regions of Kazakhstan, the total water consumption of mid-ripening varieties of some agricultural crops (buckwheat, barley¸ spring wheat, sunflower, corn, rice, and cotton) in the conditions of the modern climate.

Table 6.15 - *Average regional (oblast) total water consumption, m^3/ha*

Region (oblast)	Buckwheat	Barley	Wheat	Sunflower	Corn	Rice	Cotton
Almaty	3100	3,570	4,050	5,010	5970	13820	-
Zhambyl	3060	3560	4060	5060	6060	-	-
Turkestan	3040	3550	4080	5140	6240	21960	9260
Kyzylorda	3340	3860	4420	5540	6630	21690	-

For example, for a mid-season wheat variety, the average total water consumption for the agricultural territory of Almaty oblast is 4050 m^3/ha, Zhambyl oblast - 4060 m^3/ha, Turkestan oblast - 4080 m^3/ha, Kyzylorda oblast - 4420 m^3/ha.

For a mid-ripening rice variety, the average regional total water consumption (considering water consumption for flooding, evaporation and creating water flow) is 13,820 m^3/ha in Almaty oblast, and about 22,000 m^3/ha in Turkestan and Kyzylorda regions. For a mid-ripening cotton variety, the average regional total water consumption in the Turkestan oblast is 9260 m^3/ha.

Part of the total water consumption of agricultural crops is replenished by precipitation. Considering the precipitation from the autumn of the previous year to the end of the growing season, the net irrigation rate was calculated.

Table 6.16 shows the net irrigation norms averaged in the context of regions for mid-ripening varieties of some crops in the conditions of the modern climate. For example, for a mid-ripening wheat variety, the average net irrigation rate for the agricultural territory of Almaty oblast is 2100 m^3/ha, Zhambyl oblast - 2290 m^3/ha, Turkestan oblast - 2140 m^3/ha, Kyzylorda oblast - 3650 m^3/ha.

Table 6.16 - *Average regional (oblast) irrigation norm net, m^3/ha*

Region (oblast)	Buckwheat	Barley	Wheat	Sunflower	Corn	Rice	Cotton
Almaty	1430	1710	2100	2900	3750	12330	-
Zhambyl	1380	1840	2290	3220	4150	-	-
Turkestan	1380	1630	2140	3000	4050	20490	8400
Kyzylorda	2630	3110	3650	4720	5770	20890	-

For a mid-ripening rice variety, the average regional irrigation net norm is 12,330 m^3/ha in the Almaty oblast, and about 20,800 m^3/ha in the Turkestan and Kyzylorda regions. For a mid-ripening cotton variety, the average regional irrigation net norm in the Turkestan oblast is 8400 m^3/ha.

The calculated irrigation norms for agricultural crops are the climatic norm. However, in cooler and wetter years, the net irrigation rate decreases by 20-25%, and in hot and dry years it increases by 20-25%.

It should be noted that the obtained net irrigation norms are applicable for lands with automorphic soils, i.e., with deep groundwater (more than 3 m.). For lands with hydromorphic soils, with a close occurrence of groundwater (1-2 m), to prevent the rise of soil salts to the surface, it is recommended to significantly (1.5-2 times) reduce the irrigation rate. It should be noted that in the southern part of Kazakhstan, groundwater is mainly located at a depth of more than 3 m.

Based on the air temperature and precipitation forecast for 2030 and 2050 under the RCP 4.5 and RCP 8.5 scenarios, the corresponding values of total water consumption and net irrigation norms of agricultural crops were calculated.

The obtained results showed that the net irrigation norms for 2030 and 2050 exceed their current values. At the same time, the value of the increase in the net irrigation rate increases with the growth of the heat demand of the crop, i.e., the greatest increase in the irrigation rate is observed in crops with a longer growing season. For example, the net irrigation rate of a mid-ripening wheat variety will increase by 150-240 m^3/ha by 2030 in the context of the southern regions, and by 300-500 m^3/ha by 2050. For a mid-ripening rice variety, the net irrigation rate will increase by 550-790 m^3/ha by 2030, and by 1000-1400 m^3/ha by 2050. For mid-season cotton varieties, the net irrigation rate will increase by 440-510 m^3/ha by 2030, and by 830-1100 m^3/ha by 2050. At the same time, the largest growth is expected under the RCP 8.5 scenario (Tables 6.17 and 6.18).

Table 6.17 - *Change in the average regional (oblast) irrigation norm of net crops by 2030 under the scenarios RCP4.5 and RCP8.5, m^3/ha*

Region (oblast)	Scenario	Buckwheat	Barley	Wheat	Sunflower	Corn	Rice	Cotton
Almaty	RCP 4.5	80	105	150	240	320	550	-
	RCP 8.5	110	140	190	290	380	690	-
Zhambyl	RCP 4.5	100	120	140	240	300	-	-
	RCP 8.5	120	140	170	280	350	-	-
Turkestan	RCP 4.5	140	160	180	230	300	670	440
	RCP 8.5	140	170	200	270	350	790	510
Kyzylorda	RCP 4.5	150	170	190	270	330	560	-
	RCP 8.5	190	210	240	330	400	730	-

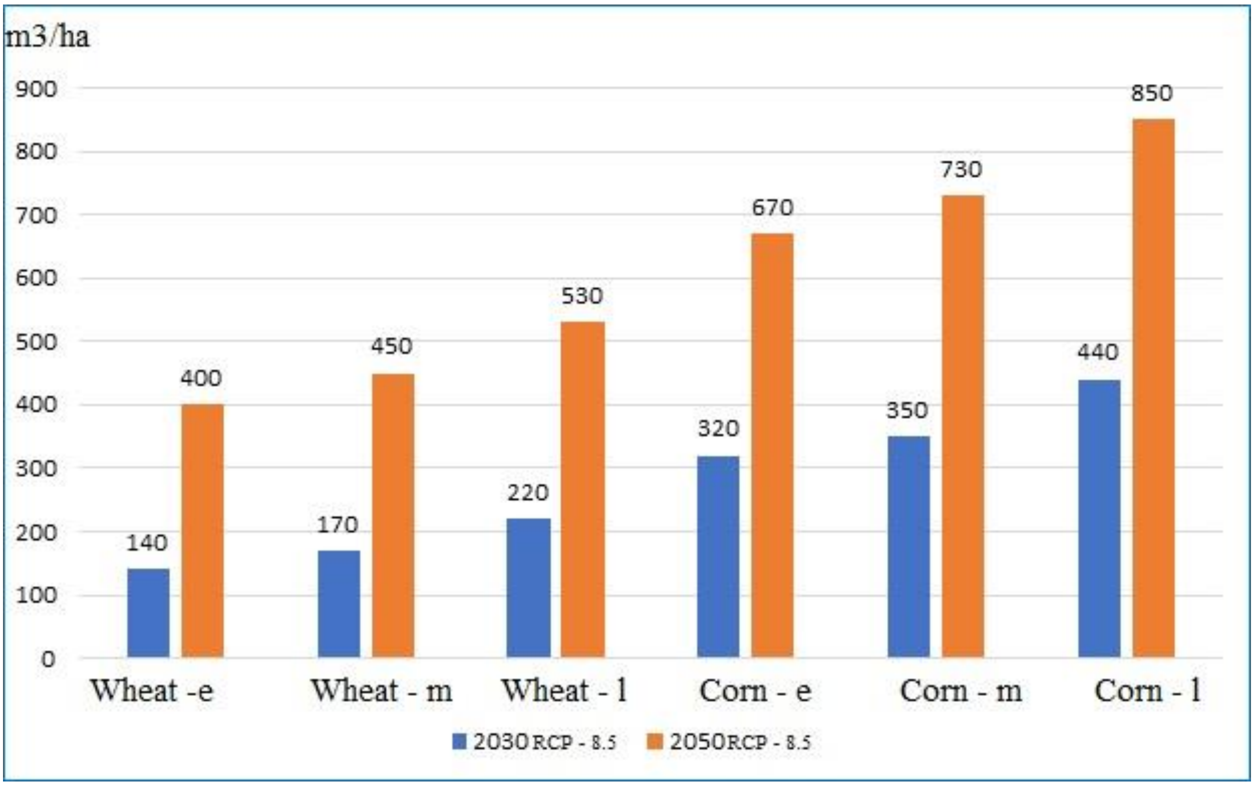
Table 6.18 - *Change in the average regional (oblast) irrigation norm of net crops by 2050 under the scenarios RCP4.5 and RCP8.5, m^3/ha*

Region (oblast)	Scenario	Buckwheat	Barley	Wheat	Sunflower	Corn	Rice	Cotton
Almaty	RCP 4.5	180	240	300	440	560	1000	

	RCP 8.5	280	350	430	600	760	1200	-
Zhambyl	RCP 4.5	240	280	320	460	560	-	-
	RCP 8.5	360	400	450	600	730	-	-
Turkestan	RCP 4.5	280	320	370	450	560	1100	830
	RCP 8.5	330	410	470	620	770	1400	1100
Kyzylorda	RCP 4.5	310	340	380	510	600	1000	-
	RCP 8.5	400	450	500	640	760	1200	-

As an example, Figure 6.28 shows the change in relation to current norms of the average regional net irrigation norm of early-ripening, mid-ripening and late-ripening varieties of wheat and corn in the Zhambyl oblast by 2030 and 2050 under the RCP 8.5 scenario. Later maturing crop varieties require more irrigation water.

Figure 6.28. *Change in the average regional irrigation rate net of wheat and corn in the Zhambyl oblast by 2030 and 2050 under the RCP 8.5 scenario, m^3/ha*



Thus, the expected climate warming will lead to an increase in the irrigation norm of the net agricultural crops by 2030 by 5-10%, by 2050 - by 10-20%. This will require the use of more water in irrigated agriculture than at present. The expected increase in the irrigation rate of net crops in the 4 southern regions of Kazakhstan indicates the vulnerability of irrigated agriculture to climate change. To reduce this negative impact of climate warming, the introduction of adaptation measures is required.

In irrigated agriculture, climate change adaptation measures are mainly aimed at the rational (economical) use of water when irrigating crops and at moisture-saving soil cultivation technologies.

Today, various irrigation systems are being introduced everywhere in the south of Kazakhstan: drip irrigation, subsoil irrigation, automatic irrigation system, furrow irrigation, sprinkler irrigation, etc. The choice of irrigation systems depends on the characteristics of the organization of water supply to the field, i.e., on the size and the relief of the field, the cultivated crop, and the financial situation of the economy.

To increase the efficiency coefficient of irrigation systems, it is necessary to reduce water losses for transportation using advanced water-saving irrigation technologies. Today in Kazakhstan, the efficiency coefficient of irrigation systems averages at 0.60 - 0.65.

The increase in the net irrigation rate due to climate warming can be compensated by an increase in the efficiency coefficient of the irrigation system. Calculations on the example of the Kyzylorda and Turkestan regions showed that if at present the efficiency coefficient is about 0.75%, then the increase in the net irrigation rate by 2030 can be compensated by an increase in the efficiency coefficient of the irrigation system by 6%, and by 2050 - by 13% (table 6.19).

Table 6.19 – *Irrigation system efficiency coefficient required to compensate for the increase in the net irrigation rate until 2050 (with an efficiency coefficient of ≈ 0.75 at present)*

Region (oblast)	Irrigation system efficiency coefficient		
	Modern climate	2030 – RCP 8.5	2050 – RCP 8.5
Kyzylorda	≈ 0.75	0.81 (+0.06)	0.87 (+0.12)
Turkestan	≈ 0.75	0.80 (+0.05)	0.88 (+0.13)

6.7.Tourism

Kazakhstan occupies an advantageous geopolitical position, has significant natural and recreational resources and many objects of world cultural and historical heritage, unique natural diversity, has the potential to develop new tourism products and all the necessary basic prerequisites to become a major player on the world tourism map.

In May 2019, the Decree of the Government of the Republic of Kazakhstan dated May 31, 2019, No. 360 approved the **State program for the development of the tourism industry of the Republic of Kazakhstan for 2019–2025.**[231] The program is aimed at improving the availability and quality of tourism services and products, the quality of life of the population through the development of places of tourist interest and the massive involvement of labor resources in the tourism industry, a dramatic increase in external and internal tourist flow, an increase in investment in the tourism industry based on the creation of a favorable tourism climate and promotion of the tourism potential of Kazakhstan in the domestic and international markets.

[231] https://adilet.zan.kz/rus/docs/P1900000360

The goal of the program is to ensure that the share of tourism in the total GDP of the Republic of Kazakhstan is at least 8% by 2025. The program defines the following target indicators: increase in the number of inbound visitors[232]and inbound tourists[233], domestic tourists, the number of people employed in the tourism industry, the volume of services provided by accommodation places, the volume of investments in fixed assets (billions), an increase in the ranking of the WEF Travel and Tourism Competitiveness Index (WEF Ranking), in the WEF rating for the development of tourism service infrastructure and effectiveness of marketing and branding.

To achieve this goal, solutions to the following tasks have been identified:

- development of tourism resources (increasing preferences for investors in priority tourism areas and priority investment projects in the tourism sector that have received investment preferences);
- ensuring transport accessibility of tourist destinations and facilities (development of airport and air transportation infrastructure);
- improving the quality and availability of tourism products and services (state educational order for the training of personnel with technical and vocational education, the number of foreign citizens treated in hospitals (scheduled treatment) and foreign citizens who received sanatorium-resort treatment, the number of medical organizations with international accreditation);
- creation of a favorable tourist climate (liberalization of visa and migration policy);
- formation of an effective system for promoting the country's tourism potential in the domestic and international markets;
- improvement of the system of management and monitoring of the development of the tourism industry.

In March 2022, the **Concept**[234] **for development of the tourism industry of the Republic of Kazakhstan until 2026** was approved**.** This document presents the results of the implementation of the State Program for the period of 2019–2021 and the achievements[235]:

- the ‘Tax free’ system was introduced;
- the list of visa-free countries has been expanded to 73 countries;
- migration cards and registration of foreigners for up to 30 days canceled;
- penalties for violating the visa and migration regime have been humanized;
- a survey was carried out, places for sanitary and hygienic units (hereinafter referred to as SHUs) were determined with indication of locations, maps of SHUs were drawn up at tourist destinations in Kazakhstan;
- within the framework of the Employment Roadmap program, the construction of 23 projects was financed in the amount of 14.8 billion tenge, as well as 99 SHUs in the amount of 1.0 billion tenge;
- a decision was made to transfer the checkpoints to the balance sheet of the MIID of the Republic of Kazakhstan for further modernization;
- the Program ‘Economy of Simple Things’ included 5 economic activity codes of

[232] Foreign citizen who crossed the state border of the Republic of Kazakhstan
[233] A foreign citizen who has spent more than 24 hours and stayed at places of accommodation on the territory of the Republic of Kazakhstan.
[234] https://www.gov.kz/memleket/entities/mcs/documents/details/276598?lang=ru
[235] https://www.gov.kz/memleket/entities/mcs/documents/details/276598?lang=ru

tourism and financed more than 58 projects worth more than 26 billion tenge credit term up to 10 years;

- within the ‘Business Roadmap-2025’ more than 177 projects funded worth more than 60 billion tenge credit term up to 5 years;
- work has begun on the reforming of state national natural parks (hereinafter referred to as SNNP), a concept for their development has been developed and detailed, which formed the basis of the adjusted master plans. 4 strategic investors were involved in the SNNP of Almaty oblast, who are successfully implementing their projects;
- at 12 airports in Kazakhstan, the ‘Open Sky’ regime was introduced;
- to develop the sectoral human resources potential of the country, the International University of Tourism and Hospitality was opened (Turkestan, 2020), which became the first Central Asian specialized educational institution for the training of specialists in tourism professions following the example of international schools of tourism and hospitality;
- in order to improve the legislative framework, the Law of the Republic of Kazakhstan dated April 30, 2021 No. 34-VII ‘On amendments and additions to certain legislative acts of the Republic of Kazakhstan on tourism activities’ was adopted, which provides for the introduction of systemic measures of state support for the tourism industry (with subsidizing tour operators for a foreign tourist); reimbursement for the purchase of machinery and equipment (cable cars, snow groomers, snow guns) for ski resorts; construction of tourist facilities, roadside service facilities; purchase of tour buses; subsidizing the maintenance of SHUs; reimbursement of a children's air ticket as part of a tour package (Kids Go Free);
- the new version of the Law introduces the concept of a priority tourist territory (hereinafter - PTT) - a territory with a special potential for tourism development, included in the list of objects of the republican level of the tourism map;
- the threshold for recognizing an investment project in the field of tourism implemented within the PTT as a priority has been lowered from 2 million MCI to 200 thousand MCI, which makes it possible to receive investment preferences;
- the Map of tourism with the territories of the republican and regional levels of interest to tourists was formed and approved;
- 80 projects implemented worth more than 120 billion tenge to improve engineering and communication and related infrastructure for the period of 2019-2021.

Despite the measures taken by the state to develop the tourism industry, to achieve these goals, it is necessary to solve the following tasks:

1) further development of tourism infrastructure,
2) creation of an effective mechanism for state regulation and support of tourism,
3) formation of an attractive tourist image of the country,
4) increasing tourism potential,
5) formation of PTT as destinations with its own recognizable brand in the country and abroad.

The Concept also describes the problems of development of the tourism industry:

- Insufficient development of infrastructure in places of tourist attraction, poor logistics, limited number of accommodation places.

– Lack of assortment and low quality of tourist products, insufficient level of tourist satisfaction and digitalization of tourist services. Ensuring the safety of tourists in tourist facilities.
– Lack of professional staff in the industry.
– Insufficient level of promotion of tourism potential at the regional and international levels, lack of regular international events in Kazakhstan, insufficient development of MICE tourism.

In the section of the Concept ‘Creating a favorable climate and improving the quality of service’, a special emphasis is noted, which will be placed on increasing the availability and quality of tourist services and products through the development of tourist destinations and the massive involvement of labor resources in the industry, creating a favorable tourist climate, popularizing the tourism potential of Kazakhstan; the issues of improving and enhancing the quality of tourist services are also considered in detail.

Unfortunately, the above documents do not mention the issues of climate change and adaptation to climate change. It is important to note that the safest type of tourism development is one that has a low level of pollution (both local and global environment), resilient to climate change and able to withstand it. The consequences of climate change are very diverse and will also affect the tourism industry in Kazakhstan. Although there is currently little attention paid to the impacts of climate change, they are clearly already affecting the tourism industry in Kazakhstan.

In general, tourism industries in Kazakhstan are likely to be affected by seasonal changes (changes in the characteristics, timing, and length of seasons) that may harm or benefit tourism activities. These industries can be affected by unseasonal weather and extreme events (e.g., storms, blizzards, hail, etc.) that damage infrastructure. The closer the tourism sector is to the natural environment, the more vulnerable it is to climate impacts. The following are regional and sectoral projections of the impact and impact of climate change on tourism. The success or decline of tourism in Kazakhstan, of course, depends on many factors, not just the impact of climate change.

What follows is a discussion of the likely impacts of climate change on five key tourism sectors in Kazakhstan and adaptation strategies and options.

Key Tourism Sectors in Kazakhstan and Climate Change

Beach tourism

Kazakhstan has no access to the seas and oceans, but has large natural and man-made lakes, which are popular places for summer (and winter) tourism. During hot and dry summers, beach tourism is popular among local tourists and often attract tourists from abroad.

Caspian Sea: The season opens in May and ends in September. There are recreation areas Kenderli, Bautino, recreation centers ‘Komarovo’, ‘Sunset’ and others. Vacation on the Caspian Sea combines swimming and spending time on the beach, visiting the Mangyshlak nature reserve with hot geysers, balneological procedures, fishing (salmon, mullet, carp, and other valuable fish species) and spearfishing.

Lake Balkash has numerous sandy beaches, swimming in it is possible from the end of May to mid-September. Rich flora and fauna provide exciting leisure for fishermen and hunters in specially designated areas with the provision of accommodation and the necessary equipment. More than 20 species of commercial fish live in the reservoir, the best time for fishing is spring and the period from July to September. Recently spearfishing has become popular. In addition, hunting for duck, goose, black grouse, hare, wolf, fox, and pheasant is allowed in the Balkash region, hunting for wild boar is also offered.

Lake Alakol (East Kazakhstan oblast) - a relict reservoir. There is a nature reserve here, on the territory of which 300 species of birds live, including those from the Red Book.

Borovoye lakes (Borovoye, Pike, Big and Small Chebache, Kotyrkol, Zhukei, etc.). Due to the large number of lakes and mountains, as well as the unique microclimate, Borovoye is considered one of the most beautiful places in Kazakhstan.

Lake Shalkar - salty, crystal-clear lake (North Kazakhstan oblast), attracting tourists from all over the world for beach holidays and fishing. The lake is famous for its healing mud.

Bayanaul lakes - these are four lakes: Zhasybay, Toraigyr, Birzhankol, Sabandykol (Pavlodar oblast), surrounded by rocky mountains and pine forests.

Lake Kambash – a unique reservoir with rich flora and fauna (Kyzylorda oblast) and a popular holiday destination.

Shardara reservoir is the third largest in Kazakhstan (South Kazakhstan oblast). The reservoir, located in a desert area, offers tourists 40 kilometers of sandy shore.

Bukhtarma reservoir - favorite vacation spot for residents and visitors of East Kazakhstan oblast.

Kapchagay reservoir - one of the largest reservoirs on the territory of Kazakhstan, which occupies the second place in terms of area. One of the most popular all-season vacation spots for Almaty residents and guests of the Almaty oblast. The most popular Kapchagay reservoir in the summer. On its coasts there are many recreation areas with sandy beaches, cafes, bars, and water activities. In winter, ice fishing is organized here.

Plans for the development of beach tourism include the development of some resort areas of the Caspian Sea (primarily Kenderli), beach resorts on the northern and southern coasts of Lake Alakol and the development of coastal infrastructure on Lakes Balkash and Kamystybas (Kambash). Beach tourism is one of the most popular recreational activities among the local population and continues to attract both public and private investment.

Ski tourism

The ski resort Chimbulak (Shymbulak) is located in the picturesque gorge of the Zailiysky Alatau at an altitude of 2260 m above sea level, 25 km from the center of Almaty. The time of occurrence of snow cover is from November to May. Ski slopes are serviced by cable cars, as well as a ski lift. The ski slopes of Chimbulak are certified by the International Alpine Skiing Federation (FIS). The downhill and giant slalom courses are among the ten most difficult tracks in the world.

Ski resort Ak-Bulak is located to the east of the city of Almaty. It is considered the second most popular after Chimbulak. Its slopes are located in the gorge of the Zailiyskiy Alatau. They are open to visitors throughout the year.

Tabagan - a ski resort near Almaty, located in the Kotyrbulak gorge of the Talgar region, at an altitude of 1530 m above sea level. The complex is unique and offers a wide range of services in the field of outdoor activities. The family resort specializes in winter sports, so the ski base is open only during the cold season. In the summer, the resort provides all the conditions for the development of mountain tourism, quad biking and mountain biking, family vacations.

Mountain resort 'Lesnaya Skazka' is located in the Talgar region of the Oi-Karagai gorge (Almaty region) and is located at an altitude of 1650 m above sea level in the zone of the coniferous forest of the Zailiyskiy Alatau. Lesnaya Skazka has ski and balloon slopes, an ice arena, a climbing park, a zip line, a paintball base, and ATVs.

Ski base 'Elik-Sai'- tow rope, balloon tracks, skiing training (Talgar district, Almaty region).

Ski resort 'Almatau' located 30 km from the city, in the foothills of the Zailiysky Alatau in the Kotyrbulak gorge (Almaty region) at an altitude of 1860 m above sea level. The Almatau camp site has two slopes for skiing and snowboarding, there is a ski lift, as well as slides for sledding and ballooning.

Ski resort 'Altai Alps' located in the Gornaya Ulbinka tract of the Altai Mountains (East Kazakhstan region) and is one of the most important objects of winter recreation in the tourist services market. All tracks for the professional level of skiing have an international FIS certificate. Extremals are offered descents through virgin lands and forests.

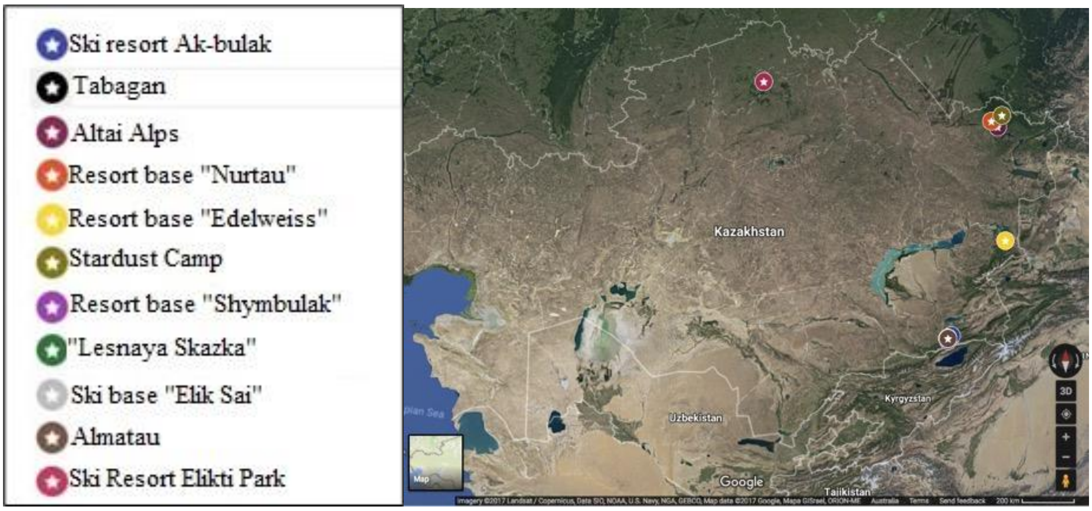
Recreation center 'Edelweiss' (East Kazakhstan region) is the center of development of skiing in East Kazakhstan. In winter, there is a ski lift and slopes, a skating rink, and equipment rental. In the summer period, trips are organized in the Western Altai: one-day and multi-day trips, individual tours, and weekend tours.

Ski base 'Stardust Camp' in the Altai Mountains of East Kazakhstan is equipped with a cable car and a lift.

Ski resort Elikti Park - ski center and recreation center offering active winter holidays with snow park, alpine skiing (a wide range of slopes of any complexity, for all skiers and snowboarders), snowboarding, rope tow, snow tubing, equipment rental, instructor services. Located in the Akmola region.

Ski tourism mainly develops exclusively around the mountain snow peaks and mountain resorts of Kazakhstan. They are mainly clustered around Almaty (Figure 6.29).

Figure 6.29. *Map of popular places for ski tourism in Kazakhstan. Created using Google Maps.*



The two main areas for the development of ski tourism are the Northern Tien Shan (Almaty) and the Altai Mountains. The Northern Tien Shan is planned to be developed with government support, including large investments. The Altai Mountains region is developing mainly due to private investment. There are also certain plans for the development of ski resorts in the Dzungarian Alatau (Tekeli) and the Western Tien Shan (Kaskasu), but these projects have been suspended.

Medical and health resort tourism

Kazakhstan has significant potential for the development of both medical and health tourism.

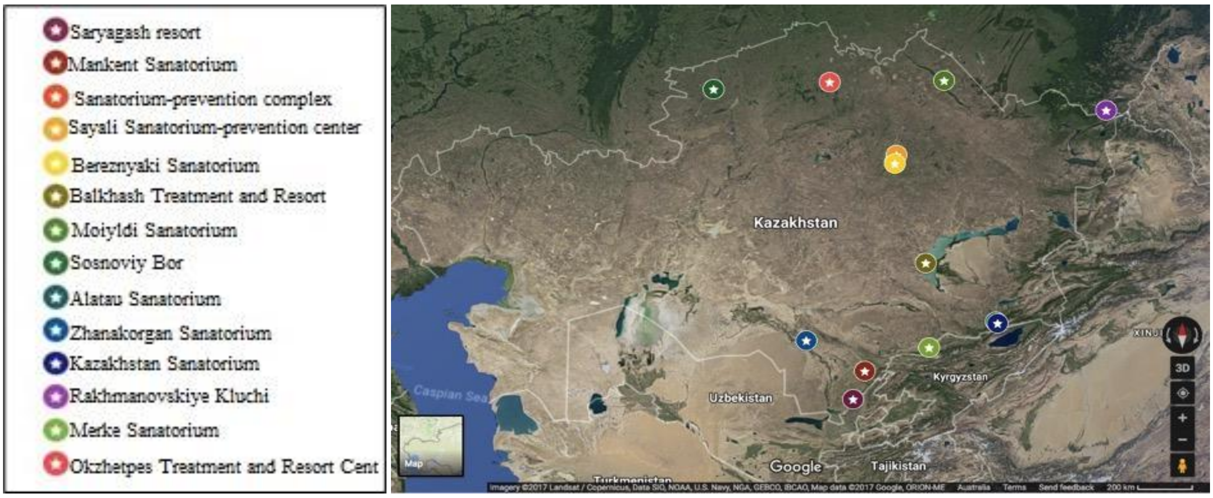
So, in the city of Astana there is a modern medical cluster that provides high-tech medical services; there is a developed network of modern medical, dental, cosmetology clinics and IVF centers, etc. Seven clinics in Kazakhstan are certified by the international accreditation commission JCI (Joint Commission International), which is the gold standard for the quality of medical services and patient safety, one clinic is certified by EFQM (European Foundation for Quality Management).

There are 20 resort areas registered and functioning in Kazakhstan, more than 10 of them have explored and studied natural healing factors and are balneological, mud therapy, climatic resorts. Resort areas with the presence of such natural healing factors as more than 500 sources of medicinal mineral waters, 78 mud lakes, 50 climatic areas allow the development of recreational and health tourism in Kazakhstan.

According to the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan, there are144[236] health resort organizations in Kazakhstan.

Health tourism in Kazakhstan is concentrated mainly in sanatoriums and resorts. It is especially popular among citizens of Kazakhstan (Figure 6.30). Most often, health tourism is used by local tourists for various spiritual and physical practices, massage, mud masks, drinking mineral water and bathing in thermal springs.

Figure 6.30. *Map of popular health tourism destinations in Kazakhstan. Created using GoogleMaps.*



Sector of meetings, motivational events, conferences, and exhibitions (MICE), business tourism

The most popular type of tourism in terms of attracting foreign tourists to Kazakhstan are MICE and business tourism. Every year, business meetings, conferences, and exhibitions, such as the successful international exhibition Astana EXPO-2017, attract thousands of foreign visitors from neighboring countries and far abroad.

[236] State Program for the Development of the Tourism Industry of the Republic of Kazakhstan for 2019–2025.

This tourism sector is the least affected by climate change. However, the most significant impact may come from changes in temperature (summer and winter mean temperatures), which contribute to a reputation for inhospitable and uncomfortable climates during both summer heat and winter cold, as well as an increase in the intensity and frequency of extreme events that damage relevant industry infrastructure.

Ecotourism

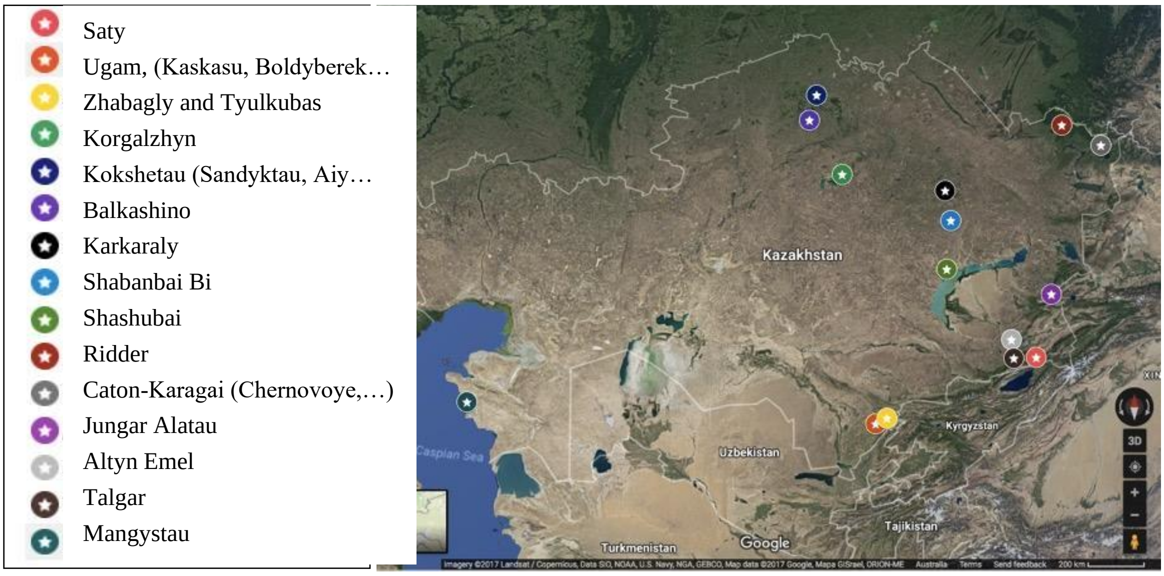
Ecotourism in Kazakhstan is a relatively modest but developing sector. It is an important component of recreation and leisure for domestic and foreign tourists.

In recent years, the number of ecotourism facilities has increased markedly (Figure 6.31). In some small ecotourist businesses the share of foreign tourists is about 100%. An example of the growing popularity of ecotourism is the eco-site (eco-village) of Saty near the Kolsai Kolderi National Park located about 300 km from Almaty. The level of quality of Kazakhstan's ecotourism is recognized internationally: for example, in 2014 the Kyzylarai Shabanbai-Bi eco-site (Central Kazakhstan) was included in the Sustainable Global Top 100 Destinations.

Over the past five years there has been a significant increase of foreign tourists' interest in Kazakhstan's recreational resources. Thus, the share of inbound tourism has significantly increased in the provision of recreational services.

There is an increase in demand for services of botanical gardens and zoos, tourist services provided by natural reserves and wildlife conservation sites. Specially protected natural areas (SPNA) play a prominent role in the development of ecological tourism in Kazakhstan.

Figure 6.31. *Popular ecotourism sites in Kazakhstan. Based on information from the Ecotourism Information Resource Center, created with Google Maps.*



Ecotourism activities in Kazakhstan include lodging in rural communities, walks in nature and national parks, sightseeing in places of natural beauty, hiking and horseback riding, making/observing the production of traditional handicrafts and souvenirs, and cooking workshops to prepare dishes of traditional Kazakh cuisine. Although ecotourism activities may also take place in winter, the current high season for ecotourism is considered to be from May to September.

Ecotourism is the least resource- and fuel-intensive of all the types of tourism considered here, but the sector is the most exposed to climate change, hence adaptation in this sector is important to ensure its continued success.

Despite ecotourism's vulnerability to climate change, the sector can be used for community development as a tool to diversify income and reduce dependence on climate-sensitive agriculture. Ecotourism can support a transition to less climate-sensitive activities and increase the adaptive capacity of local communities. It can also help create additional jobs for residents of rural communities, thereby reducing the need to seek employment elsewhere, especially during periods of low or unreliable harvests or other agricultural hardship and mitigate the effects of climate change at the local level. Ecotourism has significant potential for the sustainability of rural and regional communities in Kazakhstan.

Climate change and tourism

The primary projections for the future effects of climate change in Kazakhstan include:

- an increase in mean annual temperature, with particularly high seasonal temperatures forecast for summer and fall;
- slight changes in precipitation patterns: increasingly drier springs and summers, but probably with a slight increase in winter precipitation, although the general trend is toward more aridity;
- changes in the bioclimatic zones in the country, with a reduction in cold zones (‘cold and moderately humid’ and ‘cool and dry’) in favor of a spread of more arid zones (‘cool and arid") and expansion into warmer zones (‘moderately warm and humid"). This could affect the spread of plant and animal species, agriculture, and socio-economic activities;
- increase in the number of cases of abnormal heat waves with negative consequences for human health, which may lead to an increase in mortality;
- increased frequency and intensity of extreme weather events (such as droughts, floods, storms, strong winds, extreme blizzards, extremely heavy precipitation (rain, snowfall, rain with snow, large hail), sandstorms and avalanches), which, in turn, can damage human lives, livelihoods and infrastructure;
- continued water scarcity due to water constraints (climatic factors), as well as high demand, shortages (economically driven) and failure to adequately manage water resources;
- increased aridity;
- rapid loss of glacier area;
- increased risk of glacial lake outburst floods (GLOF) due to increased glacial melt;
- changes in vegetation distribution (throughout Asia);
- Increased existing and future pressures on natural resources and the environment (across Asia).

The impacts of climate change are already being felt in Kazakhstan and will continue to increase according to substantial projections of future impacts under all climate scenarios. The tourism industry in Kazakhstan has far-reaching development plans and will benefit from understanding the nature of current and future climate change impacts to a) develop adaptation strategies and protective measures for the industry, and b) ensure a continuous flow of investments that can be made to develop the sector.

Assessment of climate change impacts on tourism sectors, adaptation measures and strategies are based on various climate scenarios, including the development scenarios[237], outlined in the IPCC Special Report on Emissions Scenarios (SRES; A1B, A2, B1) and the IPCC Representative Concentration Pathways (RCP; RCPs 4.5, 6.0, 8.4). The likely effects of climate change, factors affecting the tourism sector are shown in Annex 2: coastal tourism - Table 9, ski tourism - Table 10, wellness tourism - Table 11, MICE, and business tourism - Table 12, ecotourism - Table 13.

The tourism sector should be aware of the impacts to which it may be exposed and be prepared to take measures to mitigate the effects of climate change, especially such as atypical changes of the seasons, to capitalize on or protect itself from these changes. Rising seasonal temperatures can benefit coastal tourism by extending the length of the beach season, but the sector must be prepared to inform the public about these changes instead of passively waiting for tourists to notice on their own. Similarly, an increase in the incidence of abnormal heat waves and the number of hot days can bring many tourists to the beaches, and the beach tourism sector must be prepared to provide a safe and comfortable environment for the increased number of visitors. Investment in lower- and mid-range services can also encourage the development of communities around beach vacation destinations, as opposed to the development of large resorts that cater only to the very rich and monopolize revenues in this area.

Increased snowfall in some mountain areas may benefit the ski tourism sector, although it should be kept in mind that the likely increase in the percentage of precipitation may correspond to only a small increase in snow cover. Rising temperatures and slight increases in precipitation can also have negative consequences when precipitation falls as rain rather than snow, and snow drifts can be potentially hazardous to infrastructure. Overall, however, the trend supports more tourists and encourages longer ski tourism seasons.

Since MICE and business tourism mainly requires large and resilient buildings, of all the tourism sectors considered here, this sector is the most protected from the effects of climate change. Wellness tourism, which is mainly concentrated around spa retreats with medical services, also seems to be highly protected from the effects of climate change, although since many spa retreats are in remote locations, it will also be more affected than city hotels, which host MICE and business tourism events. While adaptation to climate change may not be a priority for the MICE and business tourism sector, mitigating its effects (i.e., reducing greenhouse gas emissions) should certainly be an important task in this segment.

Ecotourism, as one of the most environmentally sensitive sectors, is likely to be more affected by climate change, and will benefit from preventive planning and ongoing environmental monitoring to develop a better understanding and adaptation to climate change. While the traditional tourism season may expand due to the warm spring and fall, the ecotourism sector will have to deal with extreme events and the damage they cause to infrastructure, as many ecosites are in remote areas that are often accessed by unpaved roads. Changes in ecosystems and loss of biodiversity will also be key challenges that the sector will increasingly face in the future.

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[237] Adaptation to Climate Change in the Tourism Industry in Kazakhstan: Understanding the Impacts of Climate Change and its Potential Impacts on Five Key Tourism Sectors. // Adaptation Strategies and Solutions for Government and Stakeholders, UNDP, Avalon Public Foundation.

Adaptation measures and strategies

Coastal tourism

Rising summer temperatures and a likely increase in the length of the beach season mean that, with effective planning, the coastal tourism industry could benefit from climate change. Operators and industry employees could benefit from understanding the effects of climate change in the coastal tourism sector, which could be key to changing the advertising when the season is longer.

Future increases in average spring, summer and fall temperatures could lead to consequences such as more frequent, longer, and more intense episodes of abnormal heat waves. In this case, coastal tourism operators benefit from investing in strategies/sustainable infrastructures that provide protection from heat and adverse sun exposure. Consideration should be given to solutions that leverage 'green engineering,' such as reforestation or hedges and canopies.

However, not all effects of climate change will be positive for the coastal tourism sector. Extreme weather conditions, such as rains, storms, and abnormal heat in summer, can discourage tourists if they are not offered safe shelter from possible threats and a range of alternative activities. The fact that people on the beach are at high risk and particularly vulnerable must also be considered. Therefore, it is important to invest in protection strategies/sustainable protection infrastructure for life safety and injury prevention for tourists on beaches.

In the coastal tourism sector, it would be useful to develop a long-term ongoing adaptation strategy that can be developed and expanded as temperatures rise. Initial investments in adaptation measures/infrastructure could be developed in stages with increasing temperatures based on GHG emission scenarios. The sector should already be planning now and starting to implement adaptation measures consistent with the 2030 high emission climate scenario. Prior to 2030, planning should focus on adaptation measures sufficient to respond to the impacts of the corresponding 2050 emissions scenario.

From an international perspective, the nature of coastal tourism in some places in Kazakhstan is very unusual. Here, the development of beach tourism is mainly focused on the construction of high-profit and high-quality resort hotels near the beach area on the principle of 'luxury or nothing': large resort complexes are built in areas with some set of attractions, and tourists are expected to arrive to the resort rather than to the beach - in fact in some beach resorts tourists cannot access the beach or the lake as such, but rather sit in the pool next to them, or lie on the sand brought from somewhere.

Meanwhile, other tourists use the neglected, unmaintained beach areas outside the resort areas for free. This style of development, though supported by a small number of large businesses, prevents the more organic development of smaller businesses that could more effectively support the local economy, and results in rapid environmental degradation as it harms natural areas. Globally, many communities built on coastal tourism form a wide range of low and mid-priced businesses around the beaches. Tourists have access to protected comfortable beaches for free, but spend their money in cafes, bars, stores, and other minor activities such as children's games and clubs, golf, mini golf, etc. This, in turn, indirectly supports other industries (cleaners, drivers, stores, food vendors).

Ski tourism

The effects of climate change on the ski tourism industry in Kazakhstan require further research. Increased precipitation, and heavy precipitation in some areas, will affect sustainability and lead to a longer winter season, providing popular ski areas with enough snow. At the same time, the rapid increase in average seasonal temperatures, especially in winter, suggests that the ski season could become shorter.

The most likely scenario is that ski seasons may be unpredictable and longer during periods of heavy snowfall and shorter during periods of low snowfall, with higher seasonal temperatures leading to early snow melt in the spring. Addressing this problem presents significant challenges for resorts and operators in Kazakhstan, as good seasons and bad seasons can often follow each other without any pattern, and it will be difficult to make major investments in resorts and other facilities in this tourism segment.

Nevertheless, diversity will always provide more stability to the sector, and some resorts are already investing in this strategy, providing year-round operations, or creating small ski bases that can function with less snow.

The increase in winter precipitation in some areas will be dramatic in all climatic scenarios, especially in the second half of this century. It is likely that steppe areas and areas outside the traditional mountain resorts will see an increase in snow cover in winter, which may be a source of development of snow-related recreation in the flat areas of the country as well, which have not previously been considered as major destinations for such tourism.

Extreme events of increasing intensity and frequency during the ski season must be taken seriously, given the nature of the impacts to which people (e.g., skiers and snowboarders) are exposed on the slopes. Extreme storms, blizzards, snow drifts, heavy rains, and hail will pose a real danger to the lives and health of tourists. Infrastructure will also be at risk. These effects of climate change in the future will be amplified in all climate scenarios, so it is necessary to consider them when planning in a progressive manner and based on an appropriate climate scenario.

Wellness tourism

Owing to the country's well-developed resort infrastructure, wellness and spa tourism tend to be relatively well protected from the effects of climate change. However, due to the location characteristics of many health resorts, which may be in isolated or rural areas, these types of tourism may also face some of the effects of climate change. Supporting the infrastructure of health resorts and accessibility during periods of severe spring flooding and other extreme events will be of great importance. Providing protection for visitors to the health resorts during periods of extreme events is also vital, but is likely to be easily achieved through some additional measures, since health resorts tend to be located in large sheltered buildings. These measures may become more widespread in the future as extreme events become fiercer and more frequent (under all climate scenarios).

Health resorts built around natural resources, such as water or mud sources, require careful consideration of the management and sustainability of these resources. While climate change may have some impact on them, local use and management will be major factors. Health resorts should strive to use resources sustainably and diversify treatment methods to reduce dependence on any one resource.

MICE and business tourism

Since the MICE and business tourism sector mainly requires large and resilient buildings, of all the tourism sectors considered here, these segments are remote from the natural environment and are therefore the least exposed to the effects of climate change. Nevertheless, increasingly frequent, and severe impacts of extreme events (all climate scenarios) are likely to affect all tourism segments, including MICE and business tourism, and may cause injuries and damage to infrastructure. Repair costs may be particularly high in this sector because the infrastructure of the sector is large and expensive.

There is a possibility that extreme weather conditions, such as abnormal heat waves, will lead to Kazakhstan's reputation as a country with abnormally hot summers, which is a factor hindering summer tourism. Therefore, MICE and business tourism spheres can develop most successfully in the spring and autumn periods, as these seasons have more favorable temperatures, as opposed to the scalding heat of summer or the freezing winds of winter, especially in popular destinations such as Astana and Almaty.

MICE and business tourism have for many years been the only tourism sector actively supported by the Government of Kazakhstan, which is evident from the country's visa policy. This subsector is built around long-haul flights, short stays, and intensive use of local resources. Therefore, reducing emissions and making better use of resources in the MICE and business tourism segment will do more to reduce climate impacts than any adaptation strategy within this or other tourism segments.

Ecotourism

Ecotourism, being closely linked to the natural environment, is likely to feel the impact of climate change more strongly than other sectors that also depend on nature and the environment for their activities.

The increasing length of the ecotourism season (all scenarios) can bring financial benefits with adequate publicity and information campaigns both domestically and abroad. This will require planning new trails/routes/tours, especially during new seasonal periods (e.g., early spring or late autumn). However, the spring flooding period will need to be factored in, recognizing that flooding can occur at different times depending on the year and emission scenario. For example, until 2030, spring flooding is likely to increase in some areas. However, post-2030, flooding is likely to decrease and occur closer to the beginning of the year (late winter) in the future.

Likely, abnormal and extreme weather events will have a greater impact on ecotourism, since both tourists and tourism infrastructure are located in places exposed to them, often in very remote areas. The ecotourism sector needs to improve planning for unexpected and extreme storms, hail, rain, wind, etc. to protect tourists from injury and to plan alternative activities during periods when infrastructure or natural features are affected. It is likely that the development and implementation of an adaptation strategy with action plans and the continued development of this area in the future will be key to protecting against extreme events of an even more frequent and severe magnitude, especially under conditions of high GHG emissions.

Biodiversity loss and ecosystem change can have serious implications for the ecotourism industry in Kazakhstan, especially regarding the observation of rare plants and animals. Change could be abrupt or slow, and ecotourism operators will need to carefully monitor emission scenarios, likely impacts, and changes to ecosystems on the ground. In this domain, however, operators could benefit more from focusing on conservation and preservation activities, a key element of ecotourism. Ecotourism operators could also reduce sensitivity to climate change by offering many different types of activities or flora/fauna trips that involve several places to visit and draw attention to climate change and its effects. In addition, such activities can support ecotourism by engaging visitors in conservation and learning activities. For example, the opportunity to see firsthand the effects of climate change or to observe efforts to protect endangered species has proven popular with tourists in other regions and can serve both as a conservation (including resilience building) and adaptation strategy. However, the ambiguity of such activities, where intensive travel and large quantities of fossil fuel are used to learn about the effects of climate change and undertake conservation activities, must be considered.

Ecotourism activities may be increasingly affected by the spread of ticks, so changes in their spread need to be understood and acted upon. Currently, specially protected natural areas around Almaty are partially closed to visitors for one month per season. An increase in the length of the tick activity season or their spread to other areas could be detrimental to ecotourism activities.

In Kazakhstan, the relative underdevelopment of the ecotourism sector allows operators to be flexible in their product offerings, and tourists themselves may have lower expectations than in well-developed industries. From this point of view, ecotourism in Kazakhstan has a good adaptive capacity, as operators can change and shape customer expectations. Operators should take advantage of this opportunity and start planning adaptation strategies immediately.

6.8. Assessment of risks associated with climate change impacts and economic benefits

Water consumption in irrigated agriculture (risks of irrigated agriculture)

The multifactor regression model of stationary time series estimated using the least squares method was used for predicting the volume of water consumption. The irrigated agricultural land area and average annual air temperature of the most representative meteorological point in the southern region of Kazakhstan (aul [rural settlement] named after Turar Ryskulov), which is the largest fraction of irrigated land in the country, were chosen as variables. The corresponding indicator of the Bureau of National Statistics of the Agency for Strategic Development and Reforms, which reflects annual volume of freshwater consumption in agriculture from 2000 to 2019 in million m^3, was used as a dependent variable.

The model assumes that the volume of water consumption in agriculture depends linearly on the area of agricultural land, where fresh water is used, as well as on the air temperature, with the increase (decrease) of which more (less) water is needed for irrigation of soils. The retrospective model evaluation period covered 2010-2019 because statistically significant relationships between the dependent and explicative variables were found during this period. The forecast period was limited to 2030 due to the availability of official data from the plans of the Government of Kazakhstan related to the expansion of irrigated lands.

Table 1 (Annex 2) shows the assessment results of the theoretical model of dependence of water consumption on the area of irrigated land and average annual air temperature.

The following interpretation was made based on the assessed model:

- growth of the irrigated area in agriculture by 1 thousand hectares increases the volume of water consumption by 21 mln m^3;
- growth of average annual air temperature by 1 ^{0}C increases water consumption in agriculture by 176 mln m^3.

As a result, for the period to 2030, in accordance with the plans of the Government of Kazakhstan to increase the area of irrigated agricultural land from the current 1.8 to 3 mln ha and with a rise in mean annual air temperature from 7.4 to 7.8 0C, the projected values of water consumption in agriculture in Kazakhstan from 2020 to 2030 show an increase from 16,366 to 41,575 mln m3. (Figure 6.32). With a projected increase in temperature, water consumption per hectare is expected to increase because of increased area of irrigated agriculture from 1.8 mln hectares to 3 mln by 2030 (Figure 6.33).

Figure 6.32. *Water consumption in agriculture, million m*^{3}.

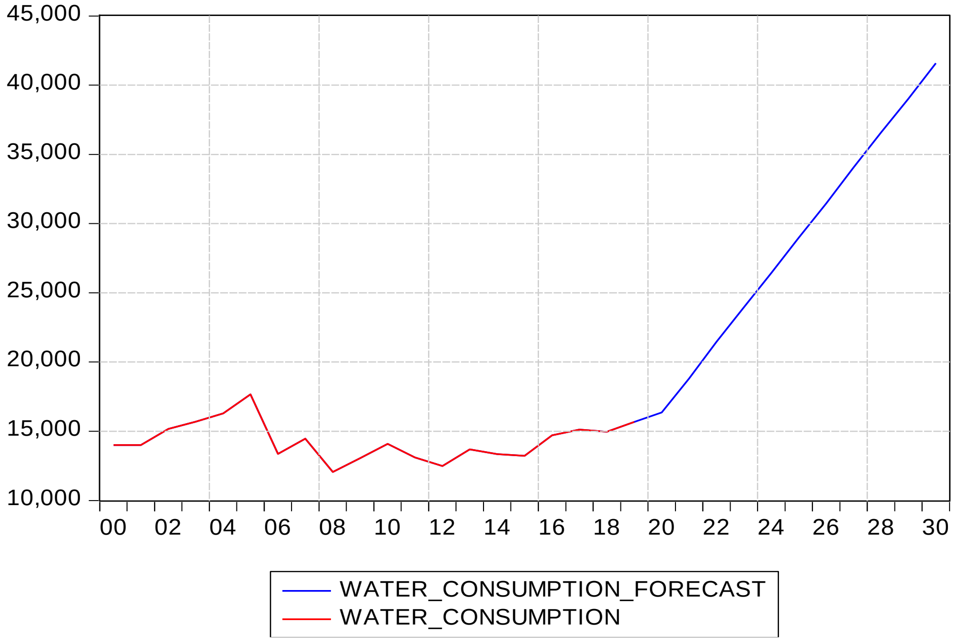
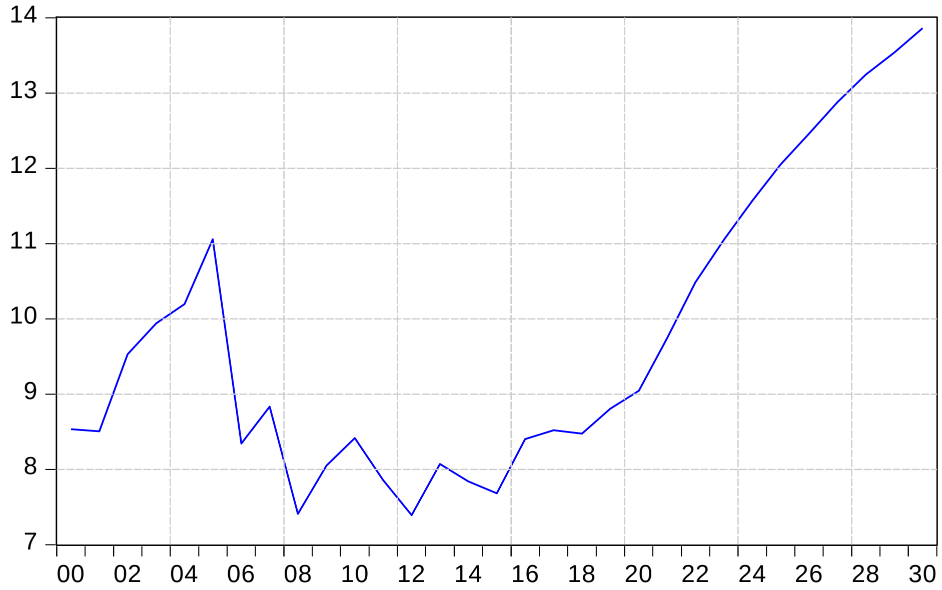


Figure 6.33. *Water consumption per thousand hectares, mln m³*



Economic losses

The FAO methodology, with minor adaptations, was used to estimate economic losses from climate change in the wheat, sunflower, and pasture subsectors. The need for adaptation is necessitated by differences in the causes of losses (in the case of climate change) and assessment of losses only, without assessment of damages.

The volume of production reduction associated with climate change in the subsectors of spring wheat production, sunflower seeds and pasture yield in Kazakhstan was assessed for the computed forecasts of productivity changes in the subsectors under consideration until 2030 and 2050 to determine the losses. The main logic of the adapted methodology for assessing losses in the agricultural subsectors from climate change includes following aspects:

1. Identification of the level of climate change impact on agricultural productivity based on climate change forecasts.
2. Assessment of agricultural losses associated with changes (decreases) in productivity as a result of climate change based on the forecasts.

The following key assumptions are used to estimate losses:

– Estimation of losses is made in fixed prices as of the date, at agricultural producer prices.

– Changes in yield and changes in the size of the harvested area are assumed to be independent.

– The assessment is limited to the impact of climate change, but does not address the forecasts and effects of possible changes in production equipment and technology, market conditions, changes in the structure and preferences of product consumption, other environmental, political, demographic, economic or technological factors, etc.

To determine economic losses from climate change in the wheat, sunflower and pasture subsectors in Kazakhstan, we used a forecast of wheat, sunflower seeds, and pasture yield under climate conditions up to 2050.[238] The basic data of this forecast was used to estimate economic losses according to the RCP 4.5 scenario.

Depending on specific conditions and data for calculations, adjustments and detailing of calculations can be made in the methodology for assessing climate change associated economic losses in the relevant sector.

Methodology adopted for estimating economic losses from climate change in the wheat growing subsector

The key tasks for estimating economic losses from climate change in the wheat growing subsector in Kazakhstan includes calculations of:

1) changes (reduction) in the area of the crops under study, due to a decrease in yield under the influence of climate and the lack of economic feasibility of its cultivation under the assumption of fixation of current prices for the main items of costs of agricultural production and the output;
2) projected gross output of agricultural products in physical terms, given the projected changes in yield, changes (reductions) in the crop acres;
3) losses for the industry due to reduction in the projected gross output, compared to the baseline (current) level of production at current prices.

The model of current distribution of spring wheat yield by harvested area is compiled for the following oblasts of Kazakhstan: Akmola, Aktobe, West Kazakhstan, Karaganda, Kostanay, Pavlodar and North Kazakhstan oblasts, and is a distribution of the harvested area of individual crops (hectares) depending on the yield of individual crops in the original crop weight (centner per hectare), made according to statistics for 2012-2019 with a breakdown by district, by farm category for the following categories of crops:

- spelt (Triticum spelta),
- soft spring wheat,
- hard spring wheat,
- spring durum wheat,
- spring wheat.

Estimated economic losses for wheat growing subsector are summarized in Table 6.20 by oblasts of Kazakhstan.

[238] Baysholanov S.S. Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change // UNDP - Astana, 2017. – p. 94.

Table 6.20. *Estimated economic losses for the wheat growing subsector by oblasts of Kazakhstan*

Oblast	Decrease in wheat yield, %						Projected losses of spring wheat gross production, thousand tons			
	From the values of the baseline period - 2000-2016.		Ideal model (conditions of ideal economic efficiency		Game model (reduction of harvested areas		Ideal model (conditions of ideal economic efficiency)		Game model (wheat production losses)	
	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
Akmola	75.0	58.0	49.7	14.5	97.7	87.3	2,285.1 (65.7 %)	3,111.5 (89.5 %)	971.4 (28.0 %,)	1,928.4 (55.5 %)
Aktobe	87.0	80.0	40.2	37.6	77.2	72.8	224.1 (88.1 %)	231.0 (90.8 %)	53.5 (21.0 %)	82.9 (32.6 %)
West Kazakhstan	65.0	57.0	9.0	7.2	63.8	51.9	165.7 (91.6 %)	168.6 (93.2 %)	96.8 (53.5 %)	115.7 (63.9 %)
Karaganda	80.0	64.0	53.5	16.6	97.8	92.3	369.0 (79.7 %)	443.7 (95.9 %)	126.0 (27.2 %)	214.1 (46.3 %),
Kostanay	63.0	51.0	38.3	10.5	85.1	73.3	827.6 (70.8 %)	3,578.1 (89.5 %)	1,525.0 (38.2 %)	2,157.4 (54.0 %)
Pavlodar	82.0	71.0	50.0	34.0	91.1	89.9	71.1 (22.0 %)	135.4 (41.8 %)	201.1 (62.1 %)	232.1 (71.6 %)
North Kazakhstan	66.0	52.0	77.0	29.3	99.8	97.7	2,064.7 (58.2 %)	3,068.9 (86.4 %)	1,208.4 (34.0 %)	1,754.4 (49.4 %)

Predicted losses of gross output of wheat (game model) by oblasts of Kazakhstan for 2030 vary from 21.0% to 62.1%, and from 32.6% to 71.6% – for 2050.

The results of estimation of economic losses for the wheat yield by oblasts of Kazakhstan with the use of the above models and corresponding formulas are listed in Table 2, Annex 2.

Methodology adopted for estimation of economic losses associated with climate change in the sunflower seeds industry in Kazakhstan

FAO methodology was used to assess losses in the subsector, and to determine economic losses associated with climate change in the sunflower seeds industry in Kazakhstan – Sunflower Seeds Yield Forecast in the conditions of climate change until 2050. The forecast sunflower seeds yield for the three oblasts of Kazakhstan for 2030 and 2050 under RCP 4.5 climate change scenario has been used as the main data to estimate economic losses.

The baseline value of the harvested area for the model used in the forecast is based on available statistical data, assuming that calculations for the forecast use the reference data of average multi-year observations for the period from 2000 to 2016.

The baseline value of the harvested sunflower seeds area (ha) is calculated on the basis of all observations made on the data broken down by:

- types of crops (sunflower seeds);
- periods (from 2000 to 2016, the data for which is publicly available in the reports of the Statistic Committee of the MNE of Kazakhstan);
- districts of the oblasts under study;
- categories of farms (individual entrepreneurs and peasant or private farm, agricultural enterprises, households)

Table 6.21. *Results of the estimation of economic losses for the sunflower seeds subsector by oblasts of Kazakhstan*

	Baseline yield value for 2000-2016, thousand tons	Forecast of changes in the gross yield of sunflower seeds as a result of climate change			
		Growth of sunflower seed production, thousand tons		Growth of sunflower seed production, bln KZT	
		2030	**2050**	**2030**	**2050**
East Kazakhstan	195.2	17.9	7.8	1.6	0.7
Kostanay	17.8	0.4	0.0	0.04	0.0
Pavlodar	39.4	2.4	2.0	0.21	0.17

The results of calculations for each oblast: East Kazakhstan, Kostanay and Pavlodar are summarized in Table 3 of Annex 2.

According to the climate change forecast sunflower seeds yield under the influence of climate change in the East Kazakhstan oblast will increase to 109% of the baseline period by 2030 and up to 104% by 2050, in Kostanay oblast yield will increase to 102% by 2030 and 100% by 2050, in Pavlodar oblast yield will increase to 106% of the baseline period by 2030 and 105% by 2050.

Methodology adopted for estimating economic losses associated with climate change in the pasture subsector

The FAO methodology with carrying capacity forecast to 2050 was used to estimate economic losses from climate change in the pasture subsector. The main data of this forecast, which are used to estimate economic losses, is the forecast of carrying capacity for seven oblasts of Kazakhstan under climate change scenarios RCP 4.5 and RCP 8.5 (Annex 2, Tables 4-6). Order No. 3-3/332 of the Minister of Agriculture of the Republic of Kazakhstan ‘On approval of the maximum allowable grazing load on total pasture area’ dated April 14, 2015, specifies, that the provisions shall be based on calculations of ‘average rate of pasture area per 1 head of livestock on restored and degraded lands, hectare’ as well as on the ‘average duration of pasture period, days’. [239] Calculation is carried out for each of the following oblasts:

1) Aktobe,
2) Almaty,
3) Zhambyl,
4) Karaganda,
5) Kyzylorda,
6) Mangystau,
7) South Kazakhstan.

Average area of agricultural pastures is calculated for each of the oblasts under study for the period from 2000 to 2016, based on the data of the Committee for Land Resources Management of the Ministry of Agriculture of Kazakhstan.

The results of calculations for seven oblasts are presented in Table 6.22.

Estimated forecast of economic losses for the pasture subsector for the seven oblasts of Kazakhstan is provided in Annex 2, Table 6.

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Table 6.22. *Estimates of economic losses for the pasture subsector by oblasts of Kazakhstan*

	Year	Aktobe	Almaty	Zhambyl	Karaganda	Kyzylorda	Mangystau	Turkestan
Potential number of small ruminants on pastures for the baseline period, thousand heads		8,921.8	5,274.9	4,051.3	11,861.8	2,797.5	3,704.3	3,790.6
The number of small ruminants for the baseline period, thousand heads		941.7	2,796.3	2,017.5	916.1	645.2	437.1	3,190.6
Level of carrying capacity utilization of pastures, %		10.6	53.0 %	49.8%	7.7 %	23.1 %	11.8 %	84.2 %
Cattle weight gain on pastures during the grazing period (live weight), thousand tons		365.8	211.9	183.0	484.2	138.9	211.7	167.5
Production potential in 2019 prices, bln KZT		227.5	143.1	109.2	299.8	80.4	162.0	93.4
Potential output losses in 2019 prices with projected reduction of carrying capacity under RCP 4.5, %	2030	12.5 %	7.9 %	5.7 %	5.9 %	12.1 %	13.6 %	14.5 %
	2050	12.5 %	17.6 %	22.9 %	11.8 %	14.5 %	16.2 %	19.1 %
Potential output losses in 2019 prices with projected reduction in	2030	28.4	11.3	6.2	17.6	9.8	22.0	13.6
	2050	28.4	25.2	25.0	35.3	11.7	26.2	17.8

[239] Development of input norms per unit of the main types of agricultural products in crop and livestock production / / Kazakh Research Institute of the economy of the agro-industrial complex and development of rural areas LLP - Almaty, 2009. - p. 332.

carrying capacity under RCP 4.5, billion KZT								
Potential output losses in 2019 prices with forecast of reduction of carrying capacity under RCP 8.5, %	2030	12.5%	11.7 %	5.7 %	5.9 %	12.1 %	13.6 %	14.5 %
	2050	18.8%	22.3 %	28.6 %	14.7 %	21.9 %	22.4 %	19.1 %
Potential output losses in 2019 prices with forecast of reduction of carrying capacity under RCP 8.5, bln KZT	2030	28.4	16.8	6.2	17.6	9.8	22.0	13.6
	2050	42.7	31.9	31.2	44.1	17.6	36.3	17.8

In both RCP 4.5 and 8.5 scenarios, by 2030 and 2050 there is likely to be a decrease in the livestock carrying capacity of pastures. Under the RCP 4.5 scenario, by 2030 the reduction in the areas under consideration will be from 5.7% to 14.5%, by 2050 the reduction is likely to range from 11.8% to 22.9% (Table 6.22).

Under the RCP 8.5 scenario, the decline is expected to range from 5.7% to 14.5% by 2030, and from 14.7% to 22.4% by 2050 (Table 6.22).

Increasing climate change resilience in agriculture

Rising temperatures, changing precipitation, and northward shifting arid zones are expected to increase the risk of land degradation and erosion, resulting in lower agricultural productivity in Kazakhstan. Drought also poses a significant risk for the entire industry, but especially for wheat production in rainfed areas. Climate change will increase vulnerability of national development, food security and natural environment.

The problem of water scarcity will be exacerbated by a combination of low precipitation and extreme temperatures in summer, which will accelerate desertification processes in the lowlands of Western, Northern and Central Kazakhstan. At the same time, rising temperatures are causing glaciers to melt; in the medium term this will increase flood risks in the southern and eastern regions, and by mid-century it will become a threat to water availability. Since 1950, the mass of glaciers in Kazakhstan has decreased by 14-30% (USAID, 2017).

Long-term climate projections show a further increase in air temperatures and an expansion of arid zones in the central and northern parts of the country. In addition, average annual precipitation is expected to increase, with less precipitation during the summer. Extreme weather events such as heat waves, droughts, floods, landslides, and mudslides are also expected to increase (MNE, 2017; USAID, 2017; Navarro, Jordà, 2021).

In the future, some regions can expect better conditions for agriculture due to increased rainfall, while other areas will suffer from droughts.

According to UNDP (2020), economic losses in wheat yield are estimated at 33% (or KZT457 billion in 2019 prices) of current potential by 2030 and 12% (KZT608 billion in 2019 prices) by 2050.

A similar picture is projected for pasture yield: livestock productivity will decrease by 10% (or KZT108 billion) by 2030, and up to 15% (or KZT170 billion) by 2050 of the current potential. In the most severe climatic scenario, the reduction could reach from 10% to 20%. Meanwhile, climate warming is expected to have a positive impact on sunflower seeds yield, with production increasing by 8% (almost two billion KZT) by 2030 and about 4% (almost one billion KZT) by 2050 compared to the current gross output. In general, crop production is more vulnerable to risks than livestock production (World Bank, 2016).

The *Ecosystem approach for adaptation to climate change in high mountain regions of Central Asia (2017-2018)* GIZ Regional Project developed the e3.kz model for Kazakhstan to analyze the impact of climate change and sector-specific adaptation measures for the economy as a whole in order to identify the most effective adaptation measures that have a positive impact on the economy, employment, and the environment. This is achieved if social and economic linkages are recognized, as well as the relationship between economic activity, energy, and the environment, as it is in the so-called E3 (economy, energy, emissions) models.

The scenarios make assumptions about the frequency and intensity of extreme weather events in combination with the damage from climate change for a particular sector, consider the costs and benefits of adaptation measures, calculated on the basis of data from existing expert studies. In the absence of explicit data, the study made independent assumptions, which can be adjusted and updated later. **The results of the model show not only direct impacts, but also indirect and induced macroeconomic effects** originating from economic interactions (GDP, jobs, imports, production volumes in the sectors) for Kazakhstan. On the one hand, the model results show **what can happen under climate change scenarios** (contribute to awareness). On the other hand, through modeling, **policymakers can identify the most effective adaptation measures with positive effects on the economy**, employment, and the environment ('win-win options"). Thus, they will be better prepared to make decisions.

The macroeconomic effects of the adaptation measures 'Rehabilitation and Expansion of Irrigation Systems' and 'Precision Farming: Parallel Driving' are presented as examples. Irrigation system is a good measure to reduce drought damage, but it will require large investments, as the area of irrigated land needs to be expanded, and in addition, the existing systems are in poor condition due to lack of maintenance. Parallel driving as one of the aspects of precision farming requires less investment, which is beneficial for small farmers who do not have significant financial resources.

Investments in the reconstruction and expansion of water infrastructure (e.g., canals, drainage, reservoirs) and in water-saving technology can serve as the basis to increase agricultural productivity. Table 6.23 below summarizes the key assumptions for investments in irrigation systems that serve as inputs for the e3.kz model.

Table 6.23. *Key assumptions on investment in irrigation systems used as inputs for the e3.kz model*

Adaptation measure	Total investment (2021-2050)	Adaptation benefits per year (in terms of increased agricultural production)
Investments to rehabilitate canals and reservoirs	KZT2,894 billion	KZT537 billion
Investments in drip irrigation	KZT105 billion	KZT47 billion

The general economic effect of investments in water infrastructure in agriculture appears to be **positive:**

- Intensification of construction activities and increased crop yield due to additional irrigation facilities will have a positive impact on GDP and its increase to 1.2% (KZT833 billion, respectively) against drought cases, but adaptation measures are not taken.
- Missed opportunities for exports and increased imports of agricultural products to compensate for crop losses in years of drought can now be partially prevented.

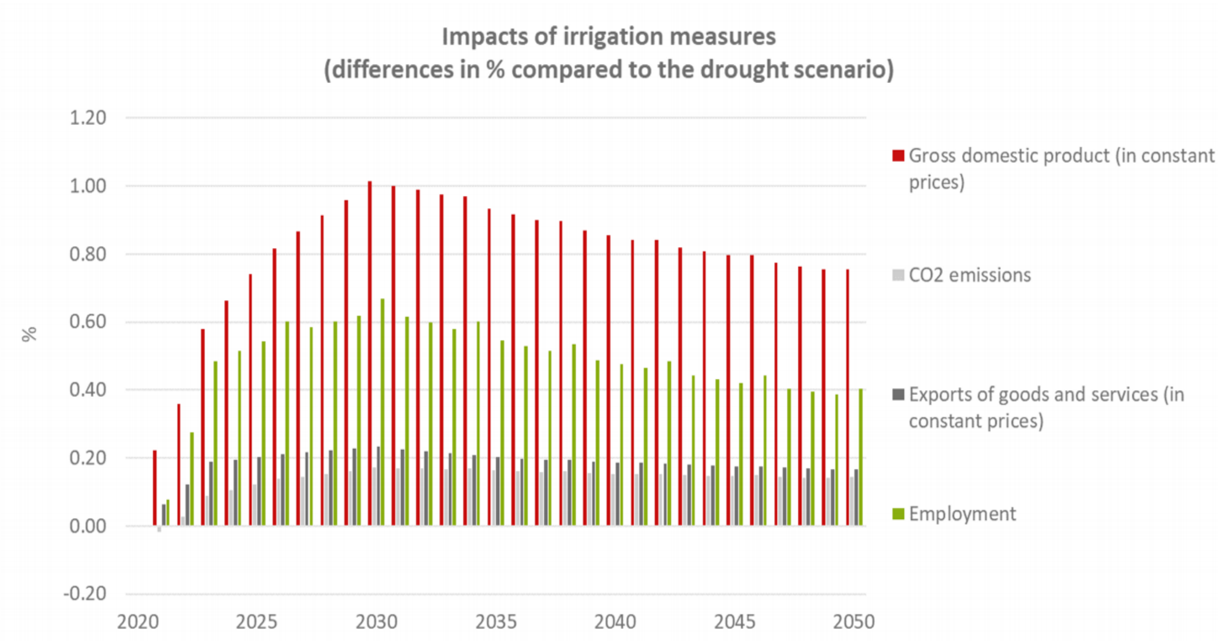
– The import of drip irrigation systems has a negative effect by itself but does not dominate. Total exports increase by 0.24% (KZT30 billion), while total import growth is 1.1% lower (KZT133 billion) than without adaptation.
– Intensification of construction activity will increase demand for construction materials, such as concrete. Additional jobs in the construction sector are created during the construction period. After that, regular investments in maintenance and replacement of equipment are needed, which will keep jobs.
– In agriculture, permanent jobs are created through rehabilitated and additional irrigated land. Farmers can earn additional income from selling their products on the world market or domestically.
– Supplying industries (e.g., fertilizer producers) and buying industries (e.g., flour producers) also profit in the form of additional turnover and jobs as a result of increased agricultural productivity not only in drought years.

According to the results of the e3.kz model, the **construction of irrigation facilities would create a total of 78,000 additional jobs** (equivalent to 0.8 percent), compared to a situation where droughts occur, and no adaptation takes place.

The increase in economic activity, on the one hand, has a positive impact on incomes and, consequently, on the spending capacity of households, as well as on the investment plans of companies. On the other hand, energy demand and GHG emissions increase by 0.4%, as no additional measures to reduce greenhouse gas emissions are considered.

Long-term economic benefits of investment in irrigation

Figure 6.34. *Economic impact of investment in irrigation systems on GDP and employment components (difference in % compared to the drought scenario)*



Precision farming: Parallel driving. The parallel driving system is a key element of precision farming (European Bank for Reconstruction and Development (EBRD) et al., 2018).

Existing machinery is upgraded using GPS and computer systems. The costs can be minimal compared to buying new vehicles, which are usually equipped with GPS by default. Farmers benefit from reduced repetitive passes and reduced costs. Thus, yield increases, and fuel consumption can be reduced.

Equipping machinery with GPS is gradual. The government supports the investment, which limits other government expenditures but does not affect the price of agricultural products. The more machinery is upgraded, the greater the benefit. This translates into less imports of agricultural products and more exports. Since GPS and computer systems are mostly imported (EBRD et al., 2018), total imports increase by 0.012 % compared to the situation without adaptation. Table 6.24 summarizes the key assumptions on parallel driving investments that serve as inputs to the e3.kz model.

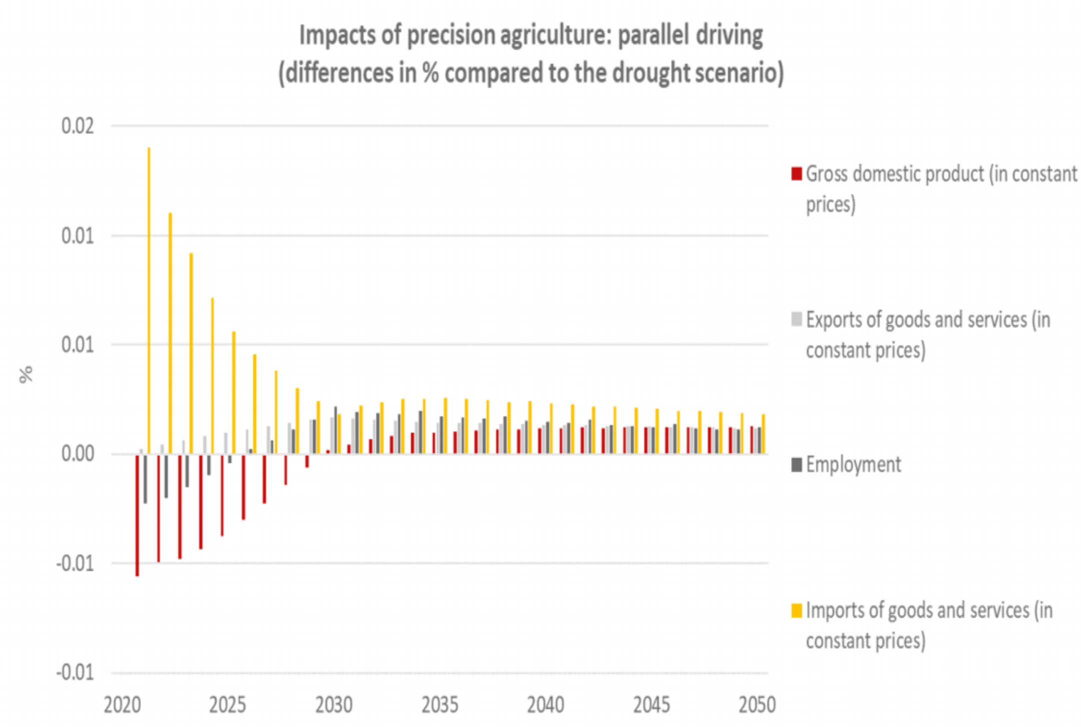
Table 6.24. *Key assumptions for parallel driving investments used as inputs to the e3.kz model*

Adaptation measure	**Total investments (2021-2050)**	**Adaptation benefits per year (in terms of increased agricultural production)**
Investment in precision farming: parallel driving	KZT100 billion	KZT4 billion

The impact of this measure on the national economy is not very significant. If the benefits of the adaptation measure cannot be fully utilized, economic growth is at a lower level. After GDP becomes slightly higher (0.002%, or KZT1,800 million), compared to the situation without this measure. Employment, food, and energy security can be improved to a limited extent. Employment increases by 0.003 % or 1,800 people per year, correspondingly, compared to the situation without the adaptation. According to EBRD et al. (2018), up to 122,000 tons of CO_2 equivalent per year could be avoided.

Long-term economic benefits of investing in parallel driving

Figure 6.35. *Economic impact of investments in parallel driving on GDP and employment components (difference in % compared to the drought scenario)*



Investments in adaptation provide co-benefits, as clearly demonstrated by the analysis of two adaptation measures in the e3.kz model. Economic losses can be reduced not only in agriculture, but also in related supplying or consuming industries.

Measures aimed primarily at supporting the domestic economy are even more beneficial.

For example, construction activities create jobs in Kazakhstan. **Products such as drip irrigation systems are mostly imported and reduce these benefits.** Nevertheless, in both cases, permanent jobs can be created in agriculture and related industries.

Combating climate change requires a holistic approach that includes both greenhouse gas mitigation and adaptation measures. Simulation results with e3.kz show that higher economic activity leads to higher emissions. Reduction of GHG emissions can be achieved by improving efficiency and the use of renewable energy sources. Kazakhstan's Low-Carbon Development Strategy, currently under development, recognizes sustainable development as the main context for climate policy and points to a close link between adaptation and mitigation measures as well as their reinforcing and negative impacts on each other.

A combination of adaptation measures, such as the expansion of irrigated land, water collection, and the creation of water-saving infrastructure, **is very important when water is scarce.** Adaptation measures that provide small benefits at low costs are also important, especially for small farmers who do not have large financial resources

The modeling did not factor in the funding of adaptation measures by international funds. Given the promise of industrialized countries to allocate USD100 billion per year to support climate action, including adaptation, Kazakhstan has good prospects for obtaining (partial) funding for adaptation measures. In this case, **the macroeconomic effect of adaptation measures will be even stronger**.

While financial and economic arguments are important for policy makers, other criteria, such as impacts on human health and ecosystem services (biodiversity, water balance regulation), should also be considered when choosing the most effective adaptation measures.

6.9. Adaptation policy and progress in the implementation of adaptation policies, strategies or plans in Kazakhstan

The Water Code of Kazakhstan240 dated July 9, 2003, No. 481, recognizes climate change and plans to address it. Pursuant to articles 37, 39, the competence of authorized bodies, departments of the authorized body, local executive authorities in the regions ('cities of republican significance' and the capital city) in water use and protection, water supply and sanitation includes: Authorized body, within its competence:

- assesses climate change vulnerability;
- identifies priorities and measures for adaptation to climate change;
- implements measures for adaptation to climate change;
- monitors and evaluates effectiveness of adaptation measures and adjusts them based on monitoring and evaluation results.

At present, the Government of Kazakhstan is developing a new Water Code, where the priority will be given to improving interstate water relations by strengthening water diplomacy, digitalization, accounting, and monitoring of water resources, as well as introduction of water-saving technologies.[241]

The Environmental Code of Kazakhstan, adopted in January 2021, includes a section on Public administration in the field of adaptation to climate change in order to prevent and reduce adverse effects and damage to human health, ecological systems, society, and the economy, reduce vulnerability to climate change, as well as the use of opportunities associated with climate change (Article 313). Priority areas for adaptation to climate change include agriculture, water and forestry, as well as civil protection. The process of adaptation to climate change is based on the following principles:

- obligatory consideration of the impacts of climate change in medium- and long-term socio-economic development plans;
- phased implementation of the process of adaptation to climate change, starting with priority areas;
- cross-sectoral approach of local executive authorities to climate change adaptation, covering all the priority areas mentioned above;
- ensuring a coherence between the implemented measures on adaptation to climate change and the reduction of adverse impacts of climate change.

The climate change adaptation process (Article 314) includes the following stages:

1) data collection, vulnerability assessment;
2) planning for climate change adaptation;
3) development of climate change adaptation measures;
4) implementation of climate change adaptation measures;

[240] https://adilet.zan.kz/rus/docs/K030000481
[241] https://kapital.kz/gosudarstvo/95535/v-kazakhstane-nachali-razrabatyvat-novyy-vodnyy-kodeks.html

5) monitoring and evaluating the effectiveness of climate change adaptation measures;
6) reporting on climate change impacts and effectiveness of climate change adaptation measures;
7) adjustment of climate change adaptation measures based on the results of monitoring and assessment.

Authorized central executive bodies on areas of state administration identified as priorities for adaptation to climate change, and local executive bodies of oblasts, cities of republican significance, and the capital are implementing these stages under the Rules for organization and implementation of climate change adaptation process, approved by the Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan in June 2021. The authorized body in the field of environmental protection reports on the results of climate change adaptation as required by the international treaties on climate change.

Article 315 (of the Environmental Code) outlines requirements for collection of information and assessment of climate change vulnerability. Authorized central executive bodies responsible for priority areas of state administration for adaptation and local executive bodies of regions, cities of republican significance, and the capital shall organize an assessment of climate change vulnerability for planning, development, and implementation of adaptation measures. Paragraph 2 of this article stipulates that the climate change vulnerability assessment shall be based on the collection of information and data on:

1) current and past climate trends and events;
2) projections of future climate change;
3) current and past climate impacts;
4) projected climate change impacts.

Climate change vulnerability assessment by priority areas at the national level is organized by authorized bodies in the field of agriculture, water management, forestry, and civil protection, as defined in their competencies.

Vulnerability assessment at the local level is organized by local executive bodies of regions, cities of republican significance and the capital on public administration domains prioritized for climate change adaptation.

The authorized body in the area of environmental protection provides information and methodological support for the vulnerability assessment in accordance with the rules of organization and implementation of the climate change adaptation process.

Adaptation planning (Article 316) is carried out according to the main directions of the state policy of the Republic of Kazakhstan in the area of climate change adaptation and is based on the results of the climate change vulnerability assessment.

At the national level, adaptation planning is implemented through consideration of the climate change impacts and consideration of adaptation measures in the relevant state programs in the adaptation priority areas of state administration, as specified in paragraph 2 of Article 313 of the Environmental Code.

At the local level, climate change adaptation planning is conducted by the local executive bodies of regions, cities of republican significance, and the capital through consideration of the climate change impacts and consideration of climate change adaptation measures as part of the implementation of state environmental policy at the local level.

The Ecosystem Approach for Adaptation to Climate Change in High Mountain Regions of Central Asia (2017-2018) GIZ Regional Project supported the Ministry of Energy and the Akimat of East Kazakhstan oblast in developing the Regional Adaptation Plan as a basis for adaptation planning processes at the national level with further vertical integration into the structure of the National Adaptation Plan. The purpose of the study is to identify and analyze existing institutional mechanisms for strengthening adaptation planning capacity at the regional level for the successful implementation of adaptation measures. Regional executive authorities in Kazakhstan, while striving to initiate the process of adaptation planning, usually face three major problems:

1) collection of information on future climate trends and climate change scenarios;

2) building capacity to conduct a comprehensive risk and vulnerability assessment and identify priority adaptation measures;

3) budget availability to implement adaptation measures.

The implementation of an adaptation planning project in East Kazakhstan oblast highlighted three main lessons:

1. Despite the limited availability information on climate change scenarios, this information is still sufficient to undertake risk and vulnerability assessment.
2. It is necessary to build capacity in conducting risk and vulnerability assessment for climate change adaptation at the regional level.
3. Budget allocation is critical to ensure the implementation of any type of climate change adaptation planning and its implementation.

The study suggests two entry points for creating strategic links between the national and regional levels in Kazakhstan to ensure adaptation planning at the sub-national level:

- first, promoting the integration of climate change adaptation into first-level national strategic documents;
- second, integrating climate risk assessment and adaptation measures into regional development programs coordinated by the Ministry of National Economy.

6.10. Extreme hydrometeorological events in Kazakhstan

The rate of climate change is not the same throughout the globe. The territory of Kazakhstan, located in the center of the Eurasian continent and located at a considerable distance from the ocean, is warming at a faster rate than the globe on average. Between 1976 and 2021, the rate of increase in mean annual air temperature for the globe was + 0.18 ºC every 10 years. On the territory of Kazakhstan, the rate of increase in mean annual air temperature was much higher: 0.32 ºC for every 10 years. Anomaly of air temperature of 1,58 ºC in Kazakhstan in 2021 took the 5th place in a row of the warmest years observed in the country (Table 6.2). Nine of the ten warmest years occurred in the XXI century. The absolute maximum temperature was observed in 2020, when the anomaly was 1.92 ºC, thereby updating the record of 2013 with an anomaly of 1.89 ºC.

Kazakhstan, ranked ninth in the world in terms of territory, is highly exposed to natural disasters associated with climatic and weather conditions. In the west of the country, in the coastal areas of the Caspian Sea, economic activities can be damaged by positive and negative surges, in the central part of the country floods on the lowland rivers pose a significant risk in the spring, and in the eastern and south-eastern mountainous areas are exposed to almost all types of natural disasters, such as earthquakes, landslides, mudflows, avalanches, floods, windstorms, hail, heavy rainfall, etc.[242]

[242] Kozhakhmetov P.Zh., Nikiforova L.N. // Extreme weather events in Kazakhstan in the context of global climate change. - Astana, 2016. - p. 36

1. There are several sources of information on: natural hazards; severe hydrometeorological phenomena; natural emergencies, extreme hydrometeorological events: and recorded by observation stations of Kazhydromet RSE. This information is periodically published by the Hydrometeorological Service.
2. Natural hazards [243] – statistical data (number of events) provided by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The primary source of information is the Ministry of Emergency Situations.
3. Natural emergencies – information received from the population to the 112-emergency phone number of the Crisis control center. Periodically published by MES RK in the Review digests about emergencies of natural and man-made character, which occurred in the territory of the country on a monthly, quarterly, annual basis.

However, it should be noted that currently there is no single database of recorded natural phenomena with an indication of the physical characteristics and the extent of the socio-economic damage. The list, descriptions of extreme hydrometeorological events in Kazakhstan in 2017-2021 and their consequences are provided in Annex 2 Table 8.

Table 6.25 summarizes the number of extreme meteorological events in Kazakhstan for 2017-2021. The total number of extreme meteorological events in these years was slightly higher (156 EMEs) than in 2017- 2019 (91-138 EMEs). 2017 was notable for the frequency of recurrence of heavy precipitation in the form of rain and snow (42 events) and heavy snowstorms (39 events). The highest number of strong winds was recorded in 2021 (96 events), severe dust storms were also observed (5 events).

Table 6.25. *The number of extreme weather events in Kazakhstan for 2017-2021.*

Extreme hydrometeorological events	**Year**				
	2017	**2018**	**2019**	**2020**	**2021**
Strong wind	49	50	32	48	96
Heavy rain	32	22	30	22	10
Heavy snowstorm	39	10	14	32	26
Heavy snow	10	11	8	2	11
Heavy fog	4	1	6	3	3
Hail	1	0	0	3	4
Severe dust storm	0	0	0	0	5
Slush build-up and ice formation	3	1	1	0	1
Total	**138**	**95**	**91**	**110**	**156**

Source: Kazhydromet RSE

All these phenomena were the main causes of emergencies in Kazakhstan.

For example, very heavy rain and thunderstorm were observed in Mangystau oblast on August 5-6, 2020 (Figure 6.36). As a result, more than seven months' worth of rain had fallen overnight. On August 5, 23 mm of precipitation was recorded in Fort-Shevchenko, while the

Key definitions
Emergency situation is a situation in a certain territory resulting from an accident, fire, adverse effect of hazardous industrial factors, a natural hazard, catastrophe, natural or other disaster, which may cause or have caused human casualties, harm to human health or the environment, significant material damage and disruption of the living conditions of people.
[243] https://stat.gov.kz/official/industry/157/statistic/7

monthly norm is 7 mm, and 66 mm of precipitation has fallen in 6 hours at Aktau weather station on August 6, which is 11 times the monthly norm.

Figure 6.36. *Thunderstorm over the Mangystau oblast on August 6, 2020*

Source: https://www.inform.kz/radmin/news/2020/08/06/200806132142655e.jpg

Damage caused to the city: 12 locations were flooded, 5 of which were roadways, where 13,700 m3 of water was pumped out, the roofs of some apartment buildings leaked, flooding the entrance halls (Figure 6.37).

Figure 6.37. *Flooded Streets in Aktau, 6 August 2020*

Source: social media

Table 6.26. *Number of natural hazards in 2014-2020.*

Oblast/year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Akmola	6	12	4	13	7	4	4
Aktobe	2	-	7	2	1	1	3
Almaty	17	7	7	7	17	5	9
Atyrau	1	2	3	-	-	1	-
West Kazakhstan	2	10	4	1	1	4	6
Zhambyl	1	13	8	14	4	1	4
Karaganda	1	3	-	2	-	5	6
Kostanay	-	2	4	9	-	4	15
Kyzylorda	-	-	1	9	1	4	3
Mangystau	1	1	-	-	-	-	1
Pavlodar	1	5	17	2	3	4	3

North Kazakhstan	11	11	11	5	2	6	13
Turkestan	5	11	-	9	5	3	21
East Kazakhstan	5	20	25	15	12	10	22
Astana	2	-	-	-	3	-	1
Almaty city	5	7	3	8	7	3	8
Shymkent					5	1	4
Kazakhstan	**60**	**104**	**94**	**96**	**68**	**56**	**123**

Source: Ministry of Emergency Situations of Kazakhstan

During the period under consideration from 2014 to 2020 (Table 6.26) the greatest number of natural hazards was observed in 2015 and 2020 (104 and 123 cases). The largest number of victims and fatalities was observed in 2017 (Table 6.27).

Table 6.27. *Natural emergencies in 2017-2021*

Year	Registered cases	Consequences
2017	Natural emergencies – 2,464.	Casualties - 1,852, fatalities – 440 people.
	Of these, dangerous hydrometeorological events:	No data.
2018	Natural emergencies – 2,023.	Casualties – 1,921, fatalities – 351 people.
	Of these, dangerous hydrometeorological events – 40.	Casualties – 8, fatalities – 1 person.
2019	Natural emergencies – 1,589.	Casualties – 1,057, fatalities – 16 people
	Of these, dangerous hydrometeorological events	No data
2020	Natural emergencies – 1,389.	Casualties – *1,036*, fatalities – *403* people.
	Of these, dangerous hydrometeorological events	No data.
2021	Natural emergencies – 1,476.	Casualties – 783, fatalities– 436 people.
	Of these, dangerous hydrometeorological events	No data.

Source: Ministry of Emergency Situations of the Republic of Kazakhstan

There is a growth trend in expenditures allocated for emergency response and relief (Table 6.28).

Table 6.28. *Expenditures aimed at liquidation of natural emergencies and their consequences for various periods, thousand KZT*

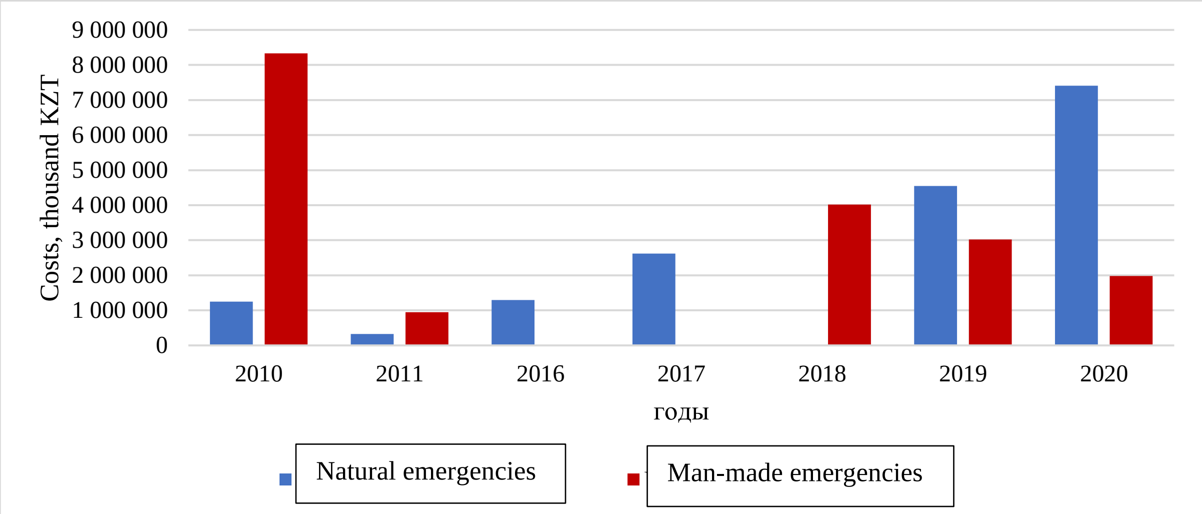
Oblast/year	2010	2011	2016	2017	2018	2019	2020
Akmola	20,000.0	578.3	41,496.0	126,663.1	143,191.2	-	565,149.2
Aktobe	5,055.0		13,704.8	315,259.9	34,530.4	699.5	0.0
Almaty	900.0	280.0	881,939.0	1,213,899.0	674,039.0	487,687.0	1,006,824.0
Atyrau			99,505.4	4,589.4	-	-	-
West Kazakhstan			-	77420.2	-	464,678.1	19,241.8
Zhambyl	60.8	64.9	1.3	17.9	71.7	21.0	0.0
Karaganda	11,256.0		12,260.0	162,781.3	21,981.0	61,401.5	50,781.5
Kostanay	20,900.0		26,500.0	27,200.0	48,704.0	35,377.9	508,056.5
Kyzylorda	4,400.0	4,500.0	62,604.0	72,418.0	60,881.0	38,342.0	-
Mangystau	44,918.2	120,853.4	-	-	-	-	0.0
Pavlodar	75,492.0	91,298.6	38,518.5	503,358.1	47,217.7	-	0.0
North Kazakhstan			-	2,600.0	1,500.0	1,000.0	193,492.9
Turkestan	61,300.0		25,102.0	9,705.0	-	-	348,687.0
East Kazakhstan	1,005,100.0	108,000.0	90,300.0	107,600.0	187,480.0	101,398.2	486,711.6

Astana			-	-	-	-	2,256,052.9
Almaty city			-	-	-	3,361,639.4	1,687,618.1
Shymkent			0.0	0.0	0.0	0.0	285,580.0
Total	1,249,382.0	325,575.2	1,336,550.7	2,623,511.9	1,219,596.0	4,552,244.6	7,408,195.3

Source: Bureau of National Statistics. Primary source of information: local executive authorities.

Figure 6.38, reflecting the total costs of emergencies and their consequences in Kazakhstan for certain years from 2010 to 2020, shows an increase in damages from natural emergencies. At the same time, there is a decrease in the cost of man-made emergencies.

Figure 6.38. *Costs of emergency response and relief across Kazakhstan* [244]*, thousand KZT*



Source: Bureau of National Statistics. Primary source of information: local executive authorities: https://stat.gov.kz/official/industry/157/statistic/7

Table 6.29 provides information on weather alerts issued by Kazhydromet RSE on natural hydrometeorological events, abrupt weather changes on the territory of Kazakhstan. The average number of weather alerts for the period under review is 46. The reliability and efficiency of the warnings was 99-100%.

Table 6.29. *Number of weather alerts issued on NHMP, AWC in Kazakhstan*

	Number of weather alerts NHMP, AWC in Kazakhstan	**Reliability, %**	**Efficiency, %**
2016	43	99	100
2017	44	100	100
2018	48	99	100
2019	42	99	100
2020	47	99	99
2021	53	100	100

Analysis and assessment of the frequency and intensity of extreme meteorological events

[244] **Key definitions**
Natural and man-made emergency - an event resulting from an accident, fire, adverse effect of hazardous industrial factors, an accident, a natural hazard, catastrophe, natural or other disaster, which may cause or have caused human casualties, harm to human health or the environment, material damage and disruption of the habitable conditions.

Extreme meteorological events, which are typical for the territory of Kazakhstan in the cold period - heavy snowfalls and blizzards, accompanied by storm and even hurricane winds, strong long frosts, glaze-ice and rime deposition, late spring frosts. Cloudburst accompanied by thunderstorms, hail and strong winds are recorded during the warm period. In the summer period there are cases of extreme fire danger. In addition, severe droughts are common in Kazakhstan, leading to a sharp decrease in crop yield.

Abnormally low air temperatures pose a significant threat to the normal life activity of the population and lead to emergencies associated with accidents at heat and power systems, engineering networks.

Drought

According to research of leading agro-climatology experts of Kazakhstan, drought occurs very often on the territory of the country 245. Drought, which affected the predominant grain-cultivating territory of the country, for the period 1966-2016, has occurred 8 times: in 1975, 1977, 1984, 1991, 1995, 1998, 2010 and 2012246. Thus, the probability of occurrence of drought in the predominant grain-cultivating area of Kazakhstan is 16%, i.e., it has a recurrence probability of once every 7 years. In the main grain-growing regions of Kazakhstan recurrence of drought ranges from 20 to 39% and has a recurrence probability as follows:

- 1 every 3 years in West Kazakhstan, Aktobe, Karaganda, Pavlodar, and Akmola oblasts;
- 1 in 4 years in Kostanay and East Kazakhstan oblasts;
- 1 in 5 years in North-Kazakhstan oblast.

Severe drought, leading to reduced grain yield by 50% or more, has a high recurrence in Aktobe, West Kazakhstan, Karaganda, Kostanay and Pavlodar oblasts (10-18%), and low recurrence (2-6%) - in North Kazakhstan, Akmola, and East Kazakhstan oblasts, i.e., severe drought is recurring:

- 1 in 6-7 years in West Kazakhstan, Aktobe and Karaganda oblasts;
- 1 in 10 years in Kostanay and Pavlodar oblasts;
- 1 in 17 years in Akmola and East Kazakhstan oblasts;
- 1 in 50 years in North-Kazakhstan oblast.

Thus, the likelihood of recurrence of drought in the west, center and northeast of the country is about once every 3 years, in the north and east of the country - once every 4-5 years. At the same time, in the far north of the country severe drought recurs once in 50 years, in the east - once in 17 years, and in the west - once in 6 years (Figure **6**.39, Table 6.30).

Table 6.30. *Frequency of droughts in 1966-2016, %*

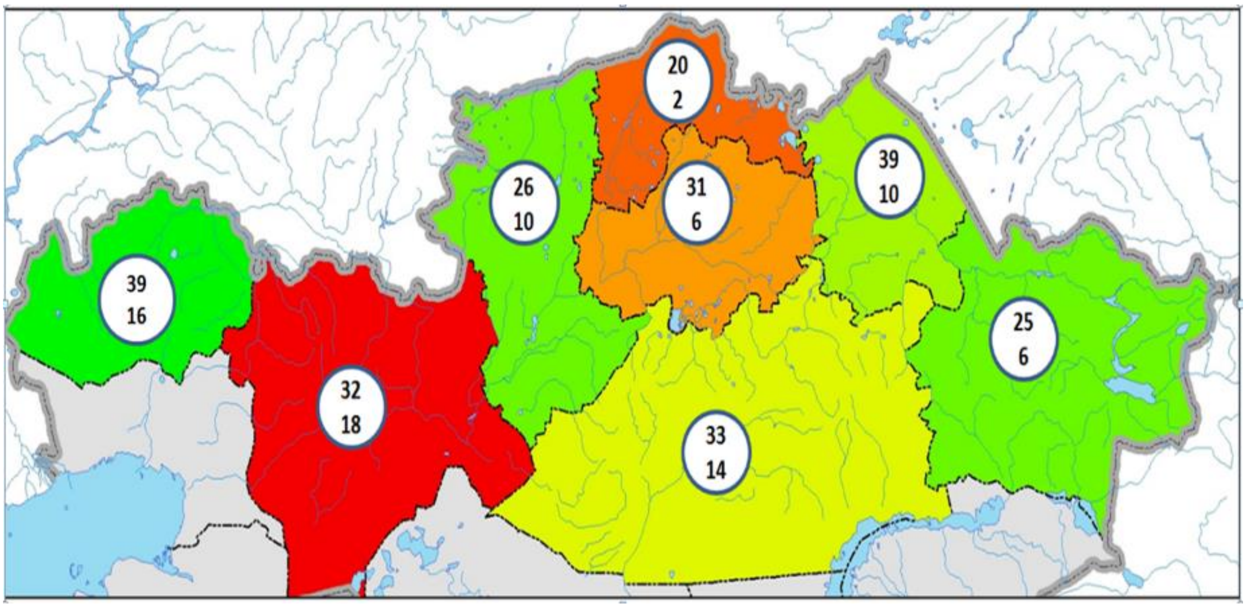
Oblast	**Frequency, %**			**Probability, 1 in … years**		
	drought	medium drought	severe drought	drought	medium drought	severe drought
North Kazakhstan	20	18	2	5	6	50
Kostanay	26	16	10	4	6	10
Akmola	31	25	6	3	4	17

[245] Baysholanov S.S. On the recurrence of droughts in grain-growing regions of Kazakhstan // Hydrometeorology and ecology. № 3. Almaty, 2010. Kazhydromet RSE, pp. 27-38.
[246] Baysholanov S.S., Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. Astana, 2017. - p. 128.

Pavlodar	39	29	10	3	3	10
Aktobe	32	14	18	3	7	6
West Kazakhstan	39	24	16	3	4	6
Karaganda	33	20	14	3	5	7
East Kazakhstan	25	20	6	4	5	17

Source: *Baysholanov S.S., Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. Astana, 2017. - p. 128*

Figure 6.39. *Frequency of drought/severe drought, %*



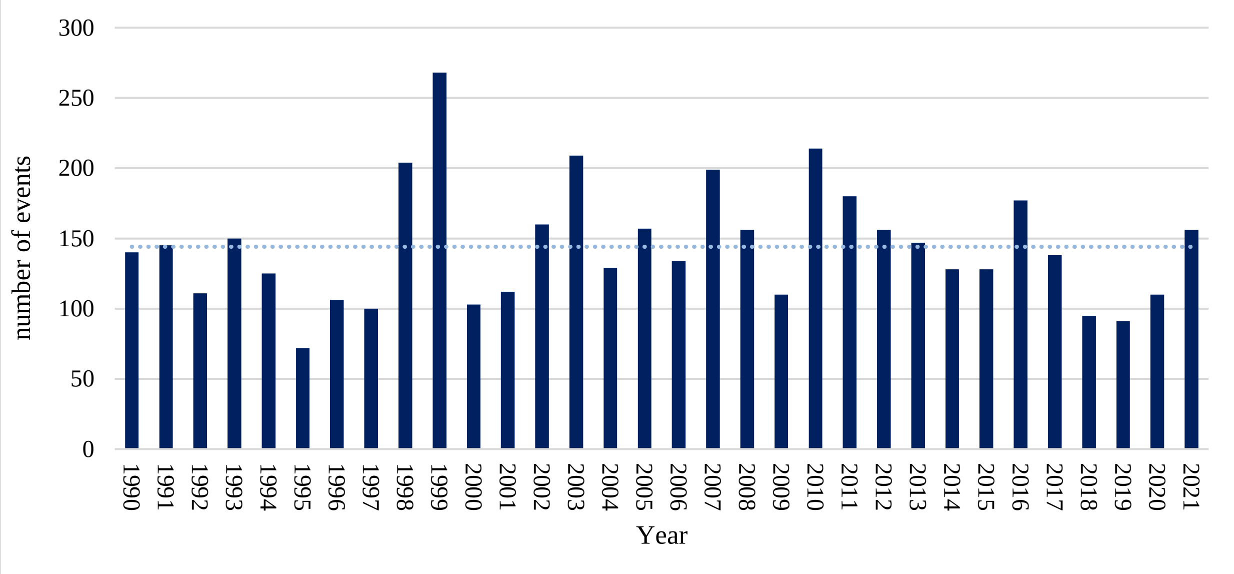
Source: *Baysholanov S.S., Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. Astana, 2017. - p. 128.*

Dynamics of extreme meteorological events

Kazhydromet RSE annually publishes data on natural hydrometeorological phenomena (NHMP) occurring in Kazakhstan. There is a criterion for each event by its intensity and duration (Annex 2, Table 7).

In the period under consideration, 1990-2021 (31 years) 6,059 EMEs were registered in Kazakhstan, i.e., on average **135** events per year.

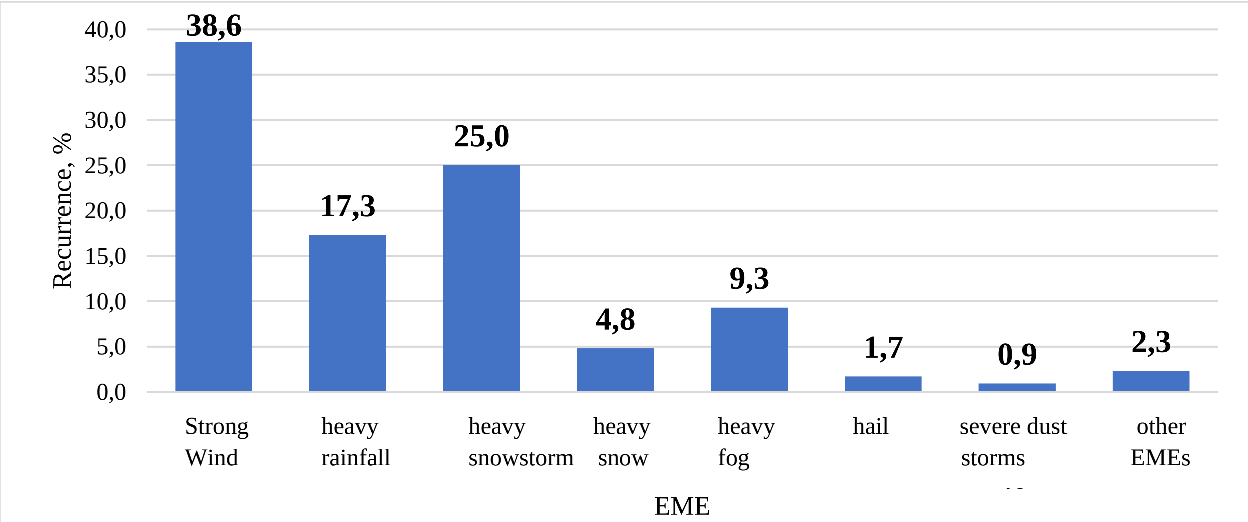
Figure 6.40. *Dynamics of the total number of EMEs in Kazakhstan in 1990-2021*



The largest number of EMEs (268) was observed in 1999 due to high frequency of heavy precipitation, strong snowstorms, and hail (Figure 6.40). The smallest number of EMEs (72) was observed in 1995. Overall, there has been a slight downward trend in the total number of EMEs, but until 2010 the trend in the total number of EMEs was going up.

The most frequently recurring EMEs are strong wind, heavy rainfall, heavy snowstorm, heavy snowfall and thick fog, and hail (Figure 6.41). The total frequency of these events is 96.8 %.

Figure 6.41. *Average share of EMEs in Kazakhstan (%) in 1990-2021.*



The series of annual average EMEs reviewed from 1990 to 2021 were divided into two groups: the first group from 1990 to 2005 and the second group from 2006 to 2021. The results are summarized in Table 6.31. Thus, in 2006-2021 versus 1990-2005, the average annual occurrence of heavy snowfall (24.7) increased 4-fold, heavy rainfall (48.6) – 2-fold, hail – 1.5-fold. Strong wind increased insignificantly – by 5%. In contrast, the following EMEs have decreased in recent years: strong blizzard (1.3 times), thick fog (2.5 times) and strong dust storm (28%).

Table 6.31. *Average annual number of EMEs in Kazakhstan in different periods*

EME	Number of EMEs	
	1990–2005	2006–2021
Strong wind	57.0	59.9
Heavy rainfall	25.1	48.6
Strong blizzard	40.6	30.8
Heavy snowfall	6.0	24.7
Thick fog	18.9	7.5
Strong dust storm	1.4	1.0

Analysis of frequent EMEs by oblasts (heavy rainfall, wind, snowfall, and blizzard), indicate that the highest frequency of EMEs in the country is observed in Almaty oblast (Table 6.32). Nearly half of all heavy rainfalls, heavy snowfalls and strong wind events in Kazakhstan occurred in this oblast. In addition, in 2006-2021 compared to the previous period (1990-2005) the average annual number of events with heavy rainfall increased by 1.3 times, with heavy snow – by 1.1 times, with hail – by 6.5 times.

Table 6.32. *Frequency (%) of EMEs by oblasts of Kazakhstan*

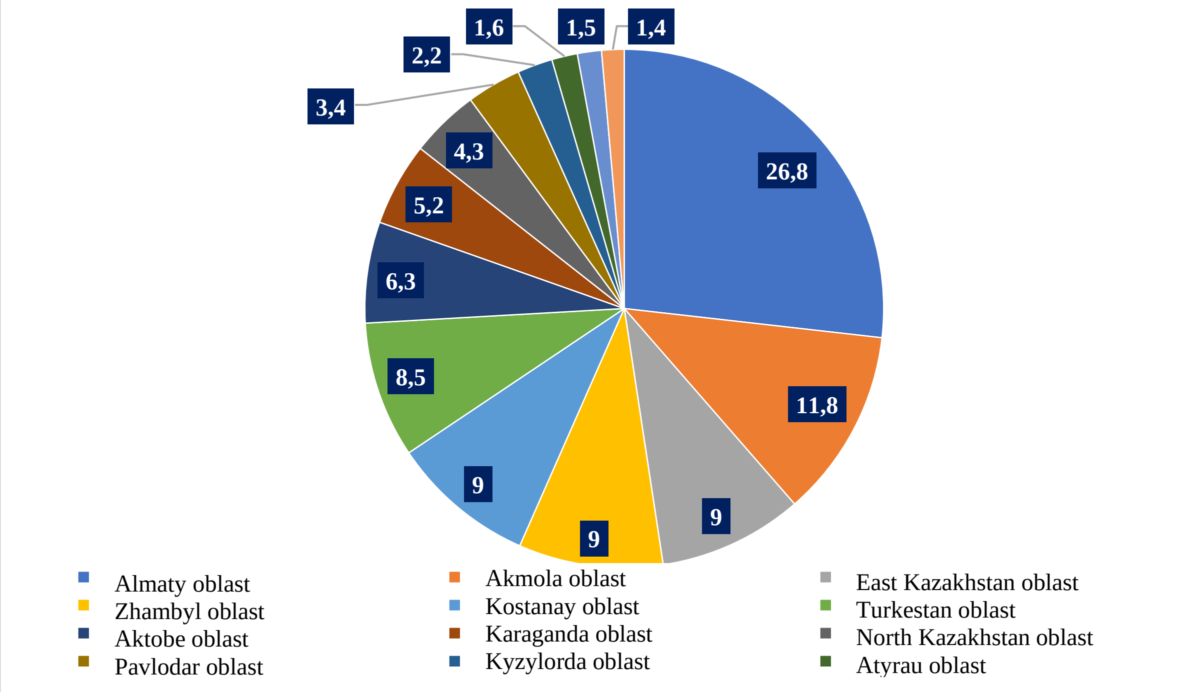
Oblast	Strong wind	Heavy rainfall	Strong blizzard	Heavy snowfall
Almaty	36.7(1.1)	57.8(0.8)	1.0(0.4)	42.2(1.1)
Akmola	15.7(0.4)	3.4(1.2)	24.9(1.0)	2.9(0.4)
Aktobe	1.0(0.9)	0.9(1.8)	20.6(0.8)	
Atyrau	0.1	1.6(0.7)	2.7(1.4)	1.0
East Kazakhstan	8.6(2.4)	4.1(0.8)	9.5(0.9)	7.8(1.1)
Zhambyl	12.2(0.6)	4.7(1.6)	2.0(0.9)	4.9(1.2)
West Kazakhstan	0.7(0.9)	0.6(5.9)	2.0(0.9)	0.0
Karaganda	4.7(0.6)	2.5(0.3)	10.4(1.1)	1.0(1.2)
Kostanay	3.2(1.5)	3.8(0.9)	16.9(1.0)	0.0
Kyzylorda	3.3(0.8)	0.9(0.6)	2.2(0.3)	0.0
Mangystau		0.9(1.2)	0.3(2.8)	
Pavlodar	2.4(1.1)	2.8(1.8)	2.2(2.3)	
North Kazakhstan	8.6(0.2)	3.4(0.9)	4.7(1.5)	
Turkestan	2.7(2.4)	12.5(1.6)	0.5(1.4)	40.2(0.8)

Note. The multiplicity factor of the number of EWEs is given in parenthesis for the two periods (2006-2021 versus 1990-2005).

The most favorable oblasts in terms of EMEs are West Kazakhstan, Atyrau, Mangystau, Kyzylorda and Pavlodar oblasts, although each oblast has an average of 1-3 EMEs per year.

If all the EMEs registered in Kazakhstan are broken down by oblasts, Almaty oblast ranks the first in the number of registered EMEs, 26.8% of all EMEs occurring in Kazakhstan. It is followed by Akmola oblast – 11.8%. The shares of Zhambyl, South Kazakhstan and East Kazakhstan oblasts are 9%; Turkestan oblast – 8.5%, Aktobe oblast – 6.3%, Karaganda oblast – 5.2%, North Kazakhstan oblast – 4.3%, Pavlodar oblast – 3.4%, Kyzylorda oblast – 2.2%. The lowest share is registered in East Kazakhstan, Mangystau and Atyrau oblasts, where the frequency ranges from 1.4 % (Mangystau oblast) to 1.6 % (Atyrau oblast). (Figure 6.42).

Figure 6.42. *Frequency of EMEs in Kazakhstan by oblast*



In recent years, with climate change affecting most of Kazakhstan, a decrease in wind speeds resulted in the reduced frequency of dust storms. The average wind speed in the last 20 years (2001-2021) decreased at most meteorological stations of Kazakhstan, and that led to a decrease in the number of dust storms days. Only Dzhusaly meteorological station registered increase in the number of dust storms days, by 12 days. Four meteorological stations (Shyganak, Akkuduk, Kazaly, Beineu) registered a slight increase in the number of dust storms days (by 0.2-2 days) due to an increase in wind speed at these stations. Since the Aral Sea and Lake Balkash have experienced the greatest anthropogenic impact in recent years and the fact that Aral Sea and Lake Balkash areas are characterized by higher frequency of dust storms, we studied them more thoroughly and obtained the results presented in Table 6.33 and in the figures below.

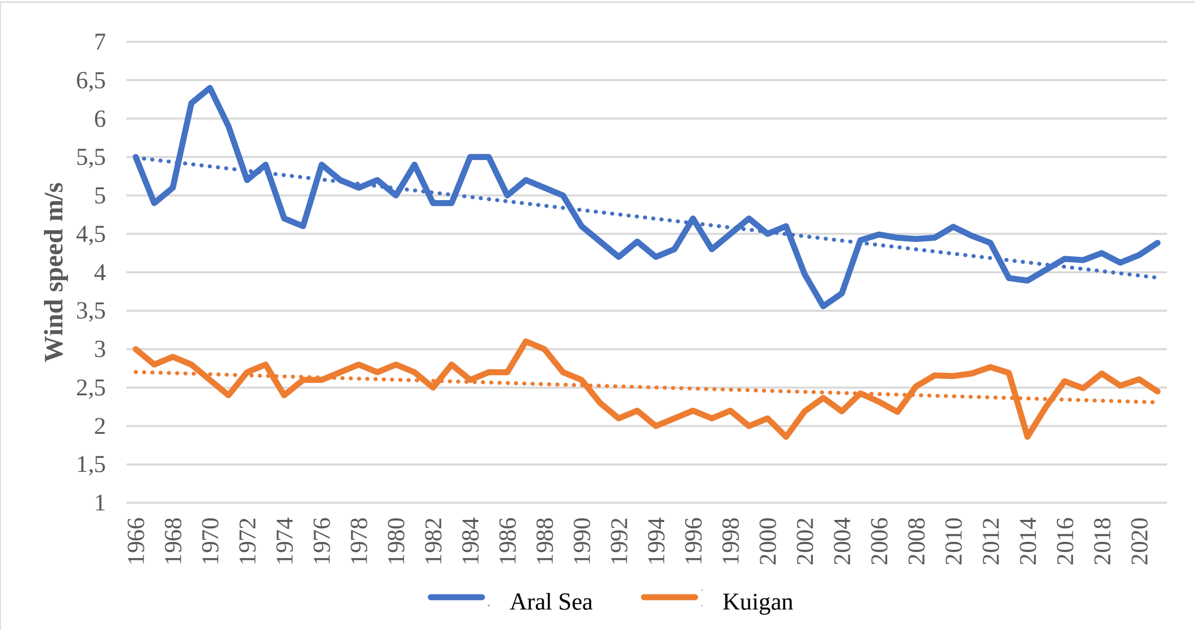
Table 6.33. *Average annual wind speed and average number of dust storm days in different periods at Kazakhstan meteorological stations*

Station	Wind speed (m/s)			Dust storm (number of days)		
	1971–2000	2001–2021	difference	1971–2000	2001–2021	difference
Akkum	2.1	1.1	-1	3	0.3	-2.7
Turkestan	3	2.3	-0.7	5.3	4	-1.3
Aral Sea	4.9	4.2	-0.7	64.1	36	-28.1
Bakanas	1.6	1.4	-0.2	42.6	34	-8.6
Matai	2	1.5	-0.5	27.9	13	-14.9
Shalkar	4.4	3.8	-0.6	18.7	1	-17.7
Zharkent	2.2	1.5	-0.7	3	3	0
Karashoky	4.9	4.4	-0.5	3.7	0.2	-3.5
Inderborskiy	5.4	4.9	-0.5	10	10	0
Baskuduk	4.5	3.8	-0.7	8.1	2	-6.1

Dzhambeity	4.2	3.7	-0.5	4.3	2	-2.3
Balkash	4.4	4.1	-0.3	9.1	3	-6.1
Aul n4	2.7	2.6	-0.1	5.2	1	-4.2
Kyzylkum	2.5	1.9	-0.6	9.3	2	-7.3
Ushtobe	1.8	1.6	-0.2	8	2	-6
Otar	1.8	1.7	-0.1	4.2	2	-2.2
Kuigan	2.5	2.4	-0.1	39.7	28	-11.7
Dzhusaly	4.2	4.7	0.5	15.8	28	12.2
Shymkent	1.8	1.8	0	3.9	1	-2.9
Arys	2	2.1	0.1	6.2	2	-4.2
Beineu	3.3	3.4	0.1	4	6	2
Chiganak	2.1	2.2	0.1	1.8	2	0.2
Kazalinsk	2	2	0	0.8	2	1.2
Kulzhambai	3.2	3.4	0.2	4.4	3	-1.4
Sam	3.4	3.5	0.1	3.7	3	-0.7
Yegindykol	3.4	3.8	0.4	5	4	-1
Aktogai	2.1	2.8	0.7	25.4	1	-24.4
Zhezkazgan	3.1	3.4	0.3	2.3	2	-0.3
Kzylzhar	2.5	3	0.5	9.2	6	-3.2
Akkuduk	2.6	3.8	1.2	4.8	5	0.2

It is well known that in early 1970-s the Aral Sea started to quickly shrink due to human activity. Figure 6.43 shows that average annual wind speed in north-eastern part of the Aral Sea varied within the range of 5-6 m/s (Aral Sea MS). In 2000-2021 average annual wind speed at the Aral Sea MS decreased to 4-4.2 m/s.

Figure 6.43. *Average annual wind speed dynamics in 1971-2021 at the Aral Sea and Kuigan MSs*

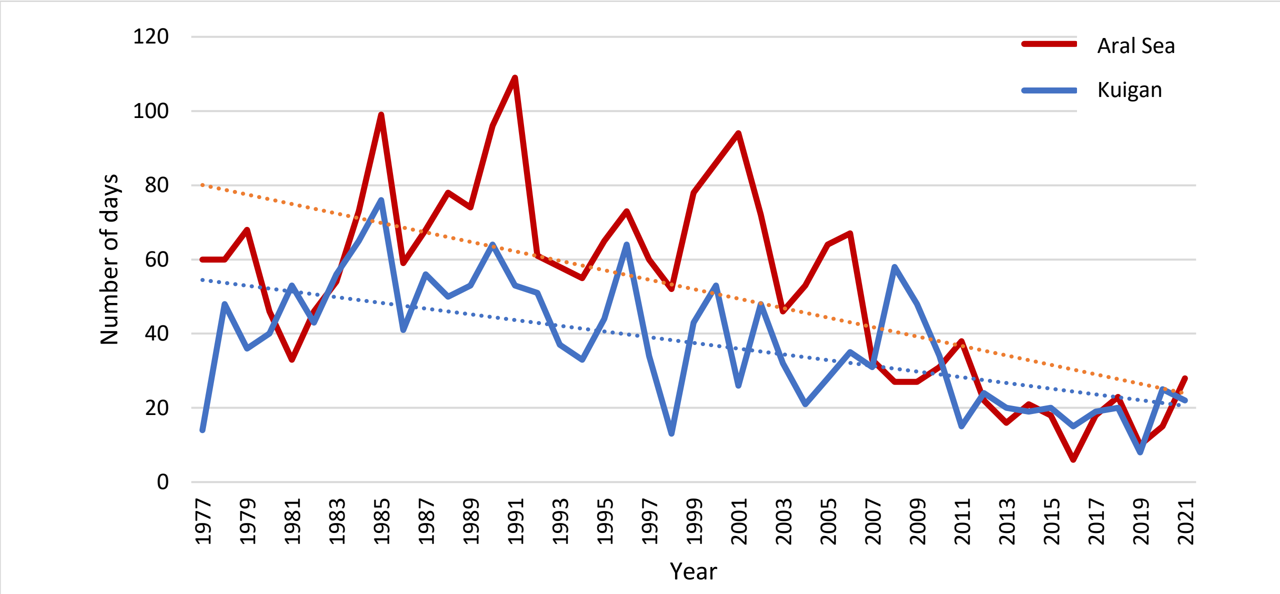


However, despite the downward wind speed trend in the period from 1977 to the end of the 1990s, the number of dust storms days increased, exceeding 100 days in some years (Figure 6.43).

Lower frequency of dust storms at the Aral Sea MS in recent years is probably linked not only to wind speed decrease, but also to reduction of carrying load on pastures and the Aral Sea rescue measures taken in recent years (planting of saxaul, sand fixation, etc.).

The Kuigan MS located in the southern part of the lake (Figure 6.43) was selected for dust storm studies around the Balkhash Lake. Average annual wind speeds at Kuigan MS in the period till 90th varied within 2.5-3 m/s. In 1990-2021 the average annual wind speed at Kuigan MS decreased to 2-2.5 m/s.

Figure 6.44. *Dynamics of the number of dust storms days in 1977-2021 at the Aral Sea and Kuigan MSs*



Dynamics in the number of dust storms days at Kuigan MS correlates well with the data of Aral Sea MS (Fig. 6.44). Reduction of the number of dust storm days from year to year in the area of Lake Balkash seems to be associated not only with wind speed reduction, but also, probably, with reduction of carrying load, increase and further stabilization of the Lake Balkash level.

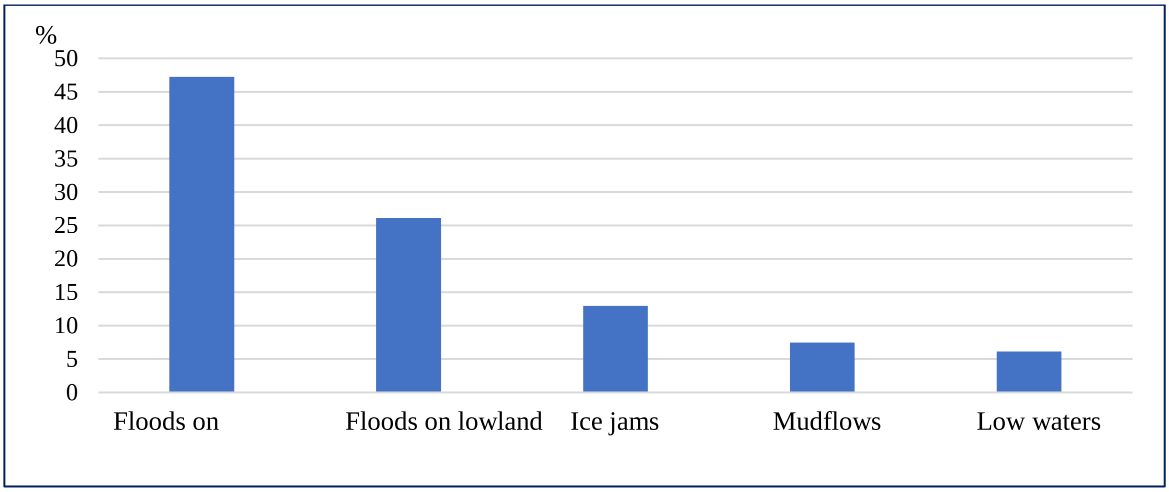
Extreme hydrological events in Kazakhstan

Of all hazardous hydrological events the most frequent in Kazakhstan are floods on mountain rivers, they take up 47% of total number of NHMP; floods on lowland rivers - 26 %; ice jams - 13%; mudflows and extremely low waters - 7 % and 6 %, respectively (Table 6.34, Figure 6.45).

Table 6.34. *Types of natural hydrological phenomena and their shares in % of the total number NHMPs*

Type of NHMP	% of total NHMPs occurrence in 1967-2021
Floods on mountain rivers	47
Floods on lowland rivers	26
Ice jams	13
Mudflows	7
Low waters	6

Figure 6.45. *Shares of different natural hydrological phenomena as a % of the total NHMPs occurrence*

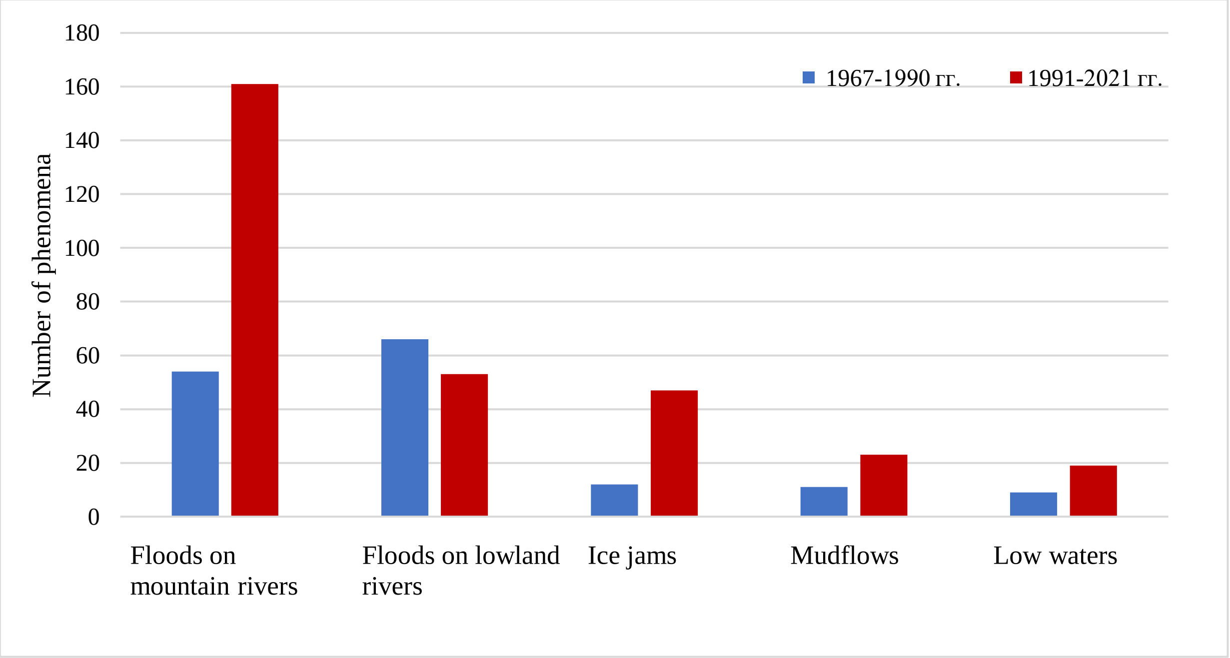


In 1991-2021, the number of floods on mountain rivers, ice jams, mudflows and low water phenomena have increased compared to the previous period of 1967-1990. The number of floods on lowland rivers decreased (Table 6.35, Figure 6.46).

Table 6.35. *Number of different types of NHMPs in 1967–1990 and 1991–2021*

NHMPs / period	**1967–1990**	**1991–2021**
Floods on mountain rivers	54	161
Floods on lowland rivers	66	53
Ice jams	12	47
Mudflows	11	23
Low water	9	19
TOTAL	152	303

Figure 6.46. *NHMPs occurrence on Kazakhstan rivers in 1967-1990 and 1991-2021*



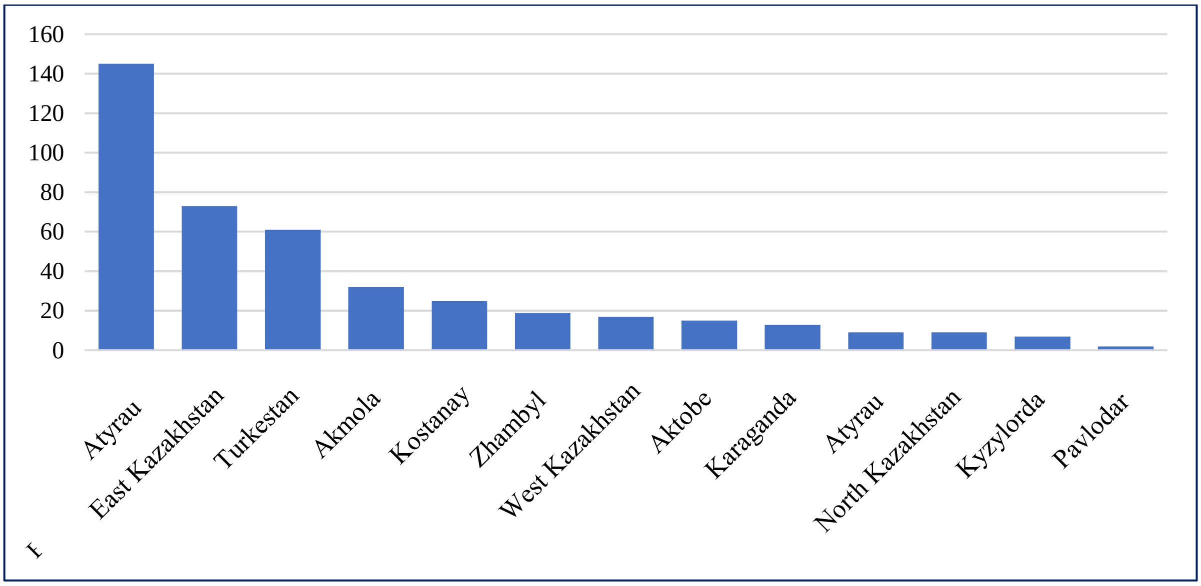
Analysis and evaluation of hydrological phenomena

Kazakhstan river network is distributed extremely unevenly, hence, the number of natural hydrological phenomena in different regions varies significantly (Table 6.36, Figure 6.47).

Table 6.36. *Total number of hazardous hydrological event broken down by oblasts*

Oblast	**Number of natural hydrological phenomena (1967-2021)**
Almaty	145
East Kazakhstan	73
Turkestan	61
Akmola	32
Kostanay	25
Zhambyl	19
West Kazakhstan	17
Aktobe	15
Karaganda	13
Atyrau	9
North Kazakhstan	9
Kyzylorda	7
Pavlodar	2
TOTAL	427

Figure 6.47. *Number of natural hydrological phenomena in Kazakhstan in 1967-2021 by oblasts*



The tables below summarize the data on extreme hydrological phenomena for the period of 1967-2021 on the lowland and mountain rivers of Kazakhstan (Tables 6.37, 6.38).

Table 6.37. *Extreme hydrological phenomena on lowland rivers of Kazakhstan, 1967-2021*

Oblast	**Number of phenomena**		
	High floods	**Extreme low water**	**High floods**
West Kazakhstan	11	6	
Aktobe	9	3	3
Atyrau	5	4	
Kostanay	20	4	1

Akmola	28	4	
North Kazakhstan	8	1	
Karaganda	8	4	1
Pavlodar		2	
Kyzylorda			7
TOTAL	89	28	12

Table 6.38. *Extreme hydrological phenomena on mountain rivers of Kazakhstan, 1967-2021*

Oblast	**Number of phenomena**			
	High floods	**Mudflow**	**High floods**	**Low water**
Almaty	92	33	19	1
Turkestan	54	1	6	
Zhambyl	16		2	1
East Kazakhstan	52		22	
TOTAL	214	34	49	2

The total number of hazardous events in Kazakhstan in 1967-2021 equals 455 (Tables 6.33, 6.34). Of them high floods on lowland rivers and hazardous high floods on mountain rivers accounts for 73%, floods caused by ice jams – 13%, mudflows – 7%, low water – 6%.

The highest number of NHMPs is observed in mountainous regions with a developed river network – in Almaty oblast (high floods and mudflows), East Kazakhstan (floods and ice jams), Turkestan (floods). The lowest number of NHMPs is observed in regions with limited number of rivers and water resources - Kyzylorda, Aktobe, Atyrau oblasts. In Pavlodar oblast, where the only major water body is the Yertis River, serious damage was caused by extremely low waters.

Areas where NHMP-related risks are higher regardless of the oblast are river bottomlands actively developed despite the fact that they fall into the flooding areas with 5-10% or more probability rate.

Table 6.39. *Number of different types of NHMPs by oblasts of Kazakhstan in 1967-1990 and 1991-2021 (mountainous area)*

Oblast/NHMP type, mountains	**Floods**		**Mudflows**		**Ice jams**		**Low waters**		**TOTAL**
	1967–1990	1991–2021	1967–1990	1991–2021	1967–1990	1991–2021	1967–1990	1991–2021	
Almaty	20	72	11	21	3	16		1	144
Turkestan	16	38		1	1	5			61
Zhambyl	9	7			1	1		1	19
East Kazakhstan	9	44			3	17			73
Total for mountains	54	161	11	22	8	39		2	297

Table 6.40. *Number of different types of NHMPs by oblasts of Kazakhstan in1967-1990 and 1991-2021 (lowlands)*

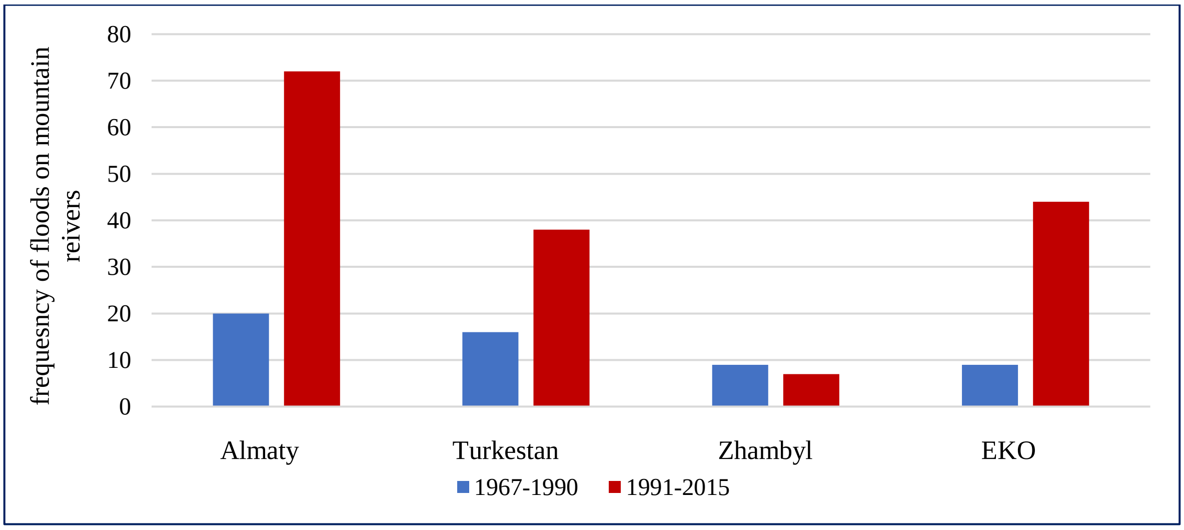
Oblast/NHMP type, lowlands	**Floods**		**Mudflows**		**Ice jams**		**TOTAL**
	1967–1990	1991–2021	1967–1990	1991–2021	1967–1990	1991–2021	
West Kazakhstan	6	5	4	2			17
Aktobe	6	3	1	2	3		15

Atyrau	4	1	2	2			9
Kostanay	6	14		4		1	25
Akola	20	8		4			32
North Kazakhstan	4	4		1			9
Karaganda	3	5		4		1	13
Pavlodar			1	1			2
Kyzylorda						7	7
Total for lowland	49	40	8	20	3	9	129

Floods causing damage to Kazakhstan economy have become more frequent (Figure 6.48). This is primarily explained by increase in water content in most Kazakhstan mountain rivers observed over the recent decades relative to the previous period. Floods are usually triggered by heavy precipitation, but with low water content rainfall flood wave is not that high to cause any damage. And vice versa, flood on a river with increased water content can be disastrous. Therefore, there is a direct correlation between the growth of water levels of rivers and the frequency of high floods.

Territory affected by high floods are mountainous and piedmont areas of Turkestan, Zhambyl, Almaty and East Kazakhstan oblasts. The most significant increase in high floods is observed in East Kazakhstan oblast t (4.9 times); Glubokov, Zyryanov, Katon-Karagay, Urdzhar, Abay and other EKO districts were flooded in 2015. The number of floods on rivers in Almaty oblast increased by 3.6 times, in Turkestan oblast – by 2.4 times, while in Zhambyl oblast decreased by 22 % (Figure 6.48).

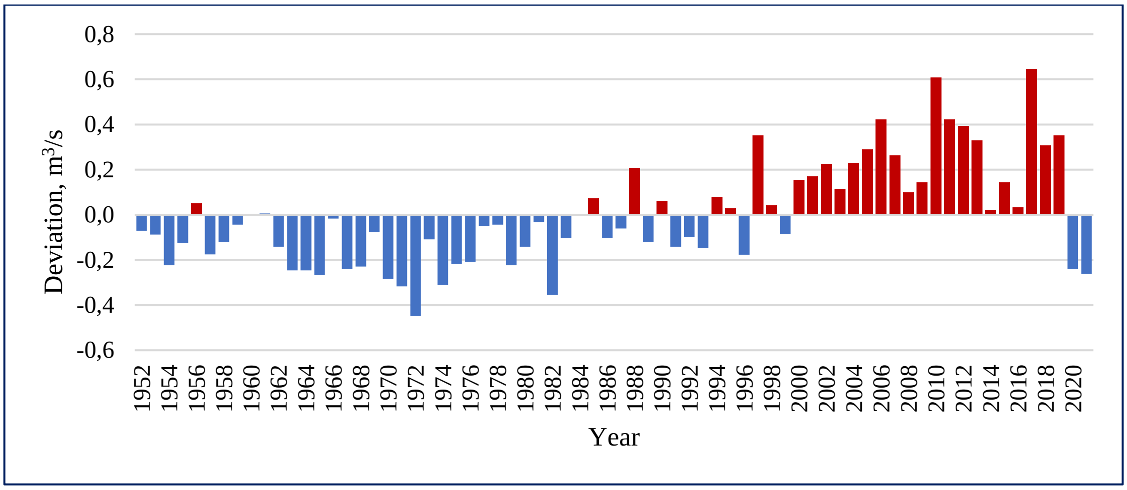
Figure 6.48. *Changes in the frequency of floods on Kazakhstan mountain rivers in 1991-2021 versus 1967-1990*



Increase in water content in the majority of mountain rivers and floods frequency results from climate change, temperature rise, degradation of mountain glaciation and increased water loss from glaciers. Besides, due to universal warming upper limit of liquid precipitation is going up to expand the area of rainfall flood formation. Figure 6.49 shows the magnitude of deviations of average annual water discharge on the Ulken Almaty River (Almaty oblast, Ile-Alatau range) from normal values calculated for the period of 1952-2021. The gauging station on the Ulken Almaty River – 1.1 km above the lake – is located at the height of 2.6 thousand meters. The river on this level is mainly fed by melting snow and glaciers. Active degradation of mountain glaciation has led to a steady increase in river runoff since 1970-s.

When deviation of the Ulken Almaty River annual flow from the long-term average annual value (1.83 m^3/s) was calculated it turned out that since 1990-s runoff in the highlands is above the norm, and the subject deviation is increasing (Figure 6.49).

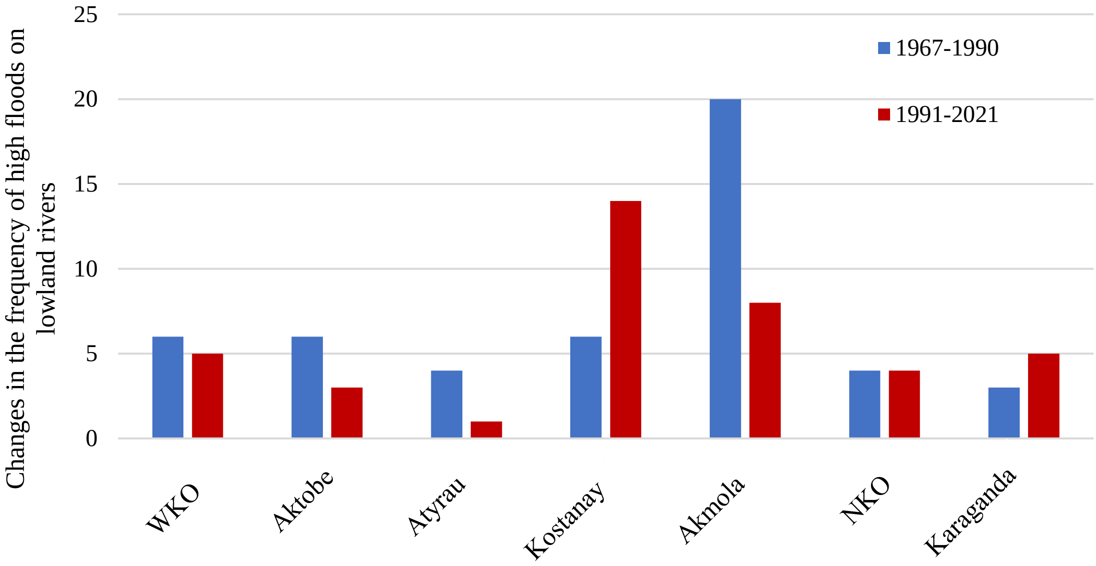
Figure 6.49. *Deviation of the Ulken Almaty River annual flow from the long-term average annual value of water discharge.*



Flood-related damage is not increasing only due to flood frequency. Over the last years new areas built up and developed and exposed to floods that are not necessarily infrequent floods.

Occurrence of high spring floods on the majority of lowland rivers has gone down over the recent decades (Figure 6.50). This is a result of decrease in water content of lowland rivers. One of the reasons of lowland river runoff reduction is climate change, first of all – temperature increase. Due to increase in March-April air temperature snow melts and Kazakhstan rivers in recent decades are flooded earlier than before mid-1980s. This factor impacts the spring flood volume. Annual runoff volume largely depends on the time snow starts to melt. The later spring comes, the longer is the period of snow accumulation, the less are the runoff losses in snow melting and the more is the water content in rivers. And vice versa, earlier spring that drags on as the cold returns causes major losses of moisture content in river basins and, consequently, annual runoff reduction.

Figure 6.50. *High floods frequency changes on lowland rivers of Kazakhstan in 1991-2021 compared to 1967-1990*



The year 2017 can be used as an example of the destructive power of high floods. That year, about 3,000 people and more than 3,000 heads of livestock were evacuated from settlements in flooded areas on the Esil river to prevent the casualties. Preventive measures such as removing more than 1 million m^3 of snow from settlements were taken. 380 houses in 15 settlements and over 5 thousand garden plots were flooded, 10 houses were completely destroyed. 1,050 m of roadway were washed out and 11 culverts were destroyed. Engineering protection of 61 settlements was ensured by construction of earth dumps, drainage ditches with a total length of more than 68 km. A total of 950,000 m^3 of water was pumped out. The embankment dam near the town of Atbasar was destroyed on Zhabai River, which is a first order tributary of Esil river. Photos of the destructions are illustrated below (Figure 6.51).

Figure 6.51. *Destruction of the embankment dam near the town of Atbasar in 2017* *https://tengrinews.kz/kazakhstan_news/pavodki-v-kazahstane-live-316268/*

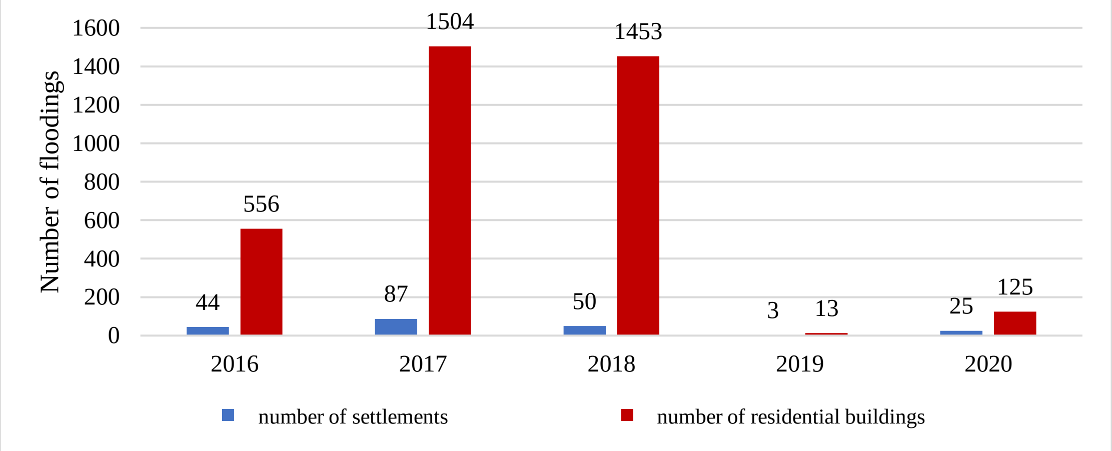
On top of that, about 2,500 people were evacuated from settlements in flooded areas on Nura River to prevent casualties. 140 houses were flooded. About 7,000 farm animals were evacuated to safe locations. About 10 km of roads and 3 km of railroads were washed out. More than 30 km of protective dikes and embankments were built, about 30,870,000 sandbags were placed, more than 700 m^3 of water were pumped out to divert melt water and protect settlements. Due to increased water level of Sergiopol and Nurinsk water intakes, Sarytobe village was flooded in Temirtau (Figure 6.52).

Figure 6.52. *A flooded house in the village of Sarytobe, Karaganda oblast. April 17, 2017*[247]

Figure 6.53 shows the dynamics of flooding of settlements in 2016-2020 on the territory of Kazakhstan.

[247] *https://rus.azattyq.org/a/karagandinskaya-oblast-pavodki-v-2017-godu/28435096.html*

Figure 6.53. *Dynamics of flooding of settlements and residential buildings in 2016-2020, units.*



Measures to protect settlements from floods (minor flooding) are implemented in the framework of Territorial Development Plans (Programs), the Roadmap for Flood Control Measures, the regional plans for flood control measures. Detailed information on flood protection measures taken in Kazakhstan for 2017-2020 is presented in Table 6.41.

Table 6.41. *Information on flood control measures in Kazakhstan* [248]

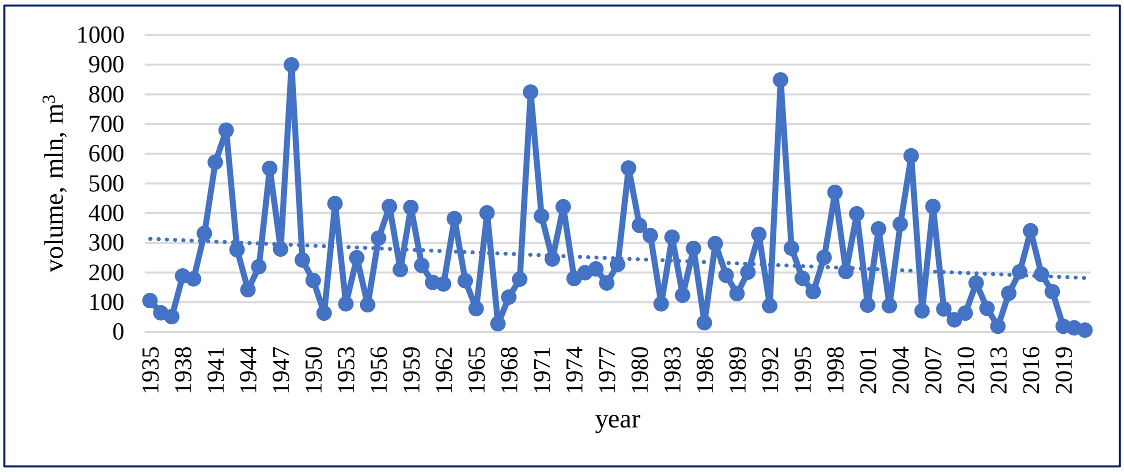
Measures	**2017**	**2018**	**2019**	**2020**
Construction and repair of protective dams, km	268	80	584.4	163
Bank protection, dredging and lining of riverbeds, km	121.7	163	237	330
Diversion channel (flood bypass), km	304	159	225.5	116
Cleaning of canals and ditches, km	3,029	2,538	1,423.8	2,006
Cleaning of culverts under roads and railroads, thousand km	26.6	13.6	24.5	10.3
Snow removed from settlements, mln m^3	16.5	6.2	6.3	15

Source: Ministry of Emergency Situations of the Republic of Kazakhstan

A vivid example of decrease in the water content of lowland rivers is the Uil river in Aktobe oblast (Figure 6.54). The trend line in the annual runoff chart for the Uil River is downward.

[248] National report on the state of the environment and the use of natural resources of the Republic of Kazakhstan for 2020.

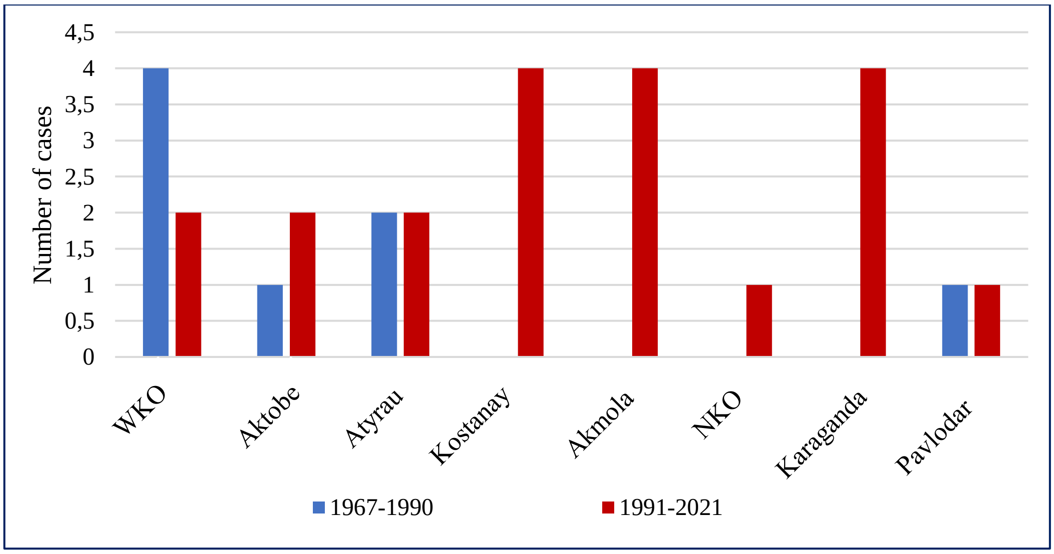
Figure 6.54. *Uil River (Oyyl village) annual runoff chart*



The downward trend of water content in lowland rivers doesn't rule out rare but extremely high floods, like those registered in Karaganda oblast in 2015. On average the number of high floods in Kazakhstan lowlands in 1991-2021 has decreased by 18% against 1967-1990. In Atyrau and Aktobe oblasts high floods frequency has gone down by 75% and 50% respectively, in WKO – by 17%. In NKO high floods frequency hasn't changed, in Kostanay oblast floods occurrence increased twofold against the previous period, and in Karaganda oblast two more events were registered.

Due to decrease in water content of lowland rivers mentioned above extremely low water events have become more frequent (Figure 6.55).

Figure 6.55. *Change in frequency of extreme low water events on Kazakhstan rivers*



No extremely low water events on rivers of Kostanay, Akmola, North Kazakhstan, Karaganda, Almaty, and Zhambyl oblasts were registered in preceding of 1967-1990, while, such events have occurred in 1991-2015. The number of low-water years has decreased twofold in WKO, but hasn't changed in Atyrau and Pavlodar oblasts, and bas doubled in Aktobe.

Ice jams on lowland rivers and depression floods they cause are mostly observed on rivers flowing from the south to the north (rivers Syrdarya, Yertis, Esil, Tobol). Climate change and air temperature increase result in earlier ice break-up on the upper reaches while downstream is still covered with ice. Barely a single ice jam occurred on the Ural River flowing across Kazakhstan from the north to the south.

In the period from 1967 through 1990 3 ice jam events and floods they caused were registered in Aktobe oblast (all three occurred in 1981). In 1991-2021 1 event was registered in Kostanay oblast, 1 – in Karaganda oblast, 7 – in Kyzylorda oblast on the Syrdarya River.

Ice dams raise the level of water and cause waterside floods. In the last period the number of ice jams has increased by 5.3 times in Almaty oblast, but hasn’t changed in Zhambyl oblast. In 1967-1990 1 ice jam event was registered in Turkestan oblast on the Arys River and 5 ice jam events – on the Syrdarya River in 1991- 2021. Both ice dams (on Yertis and other rivers) and ice jams (on mountain rivers Bukhtarma, Oba, etc.) are observed in the East Kazakhstan oblast. Their total number for the last period has increased by 5.7 times.

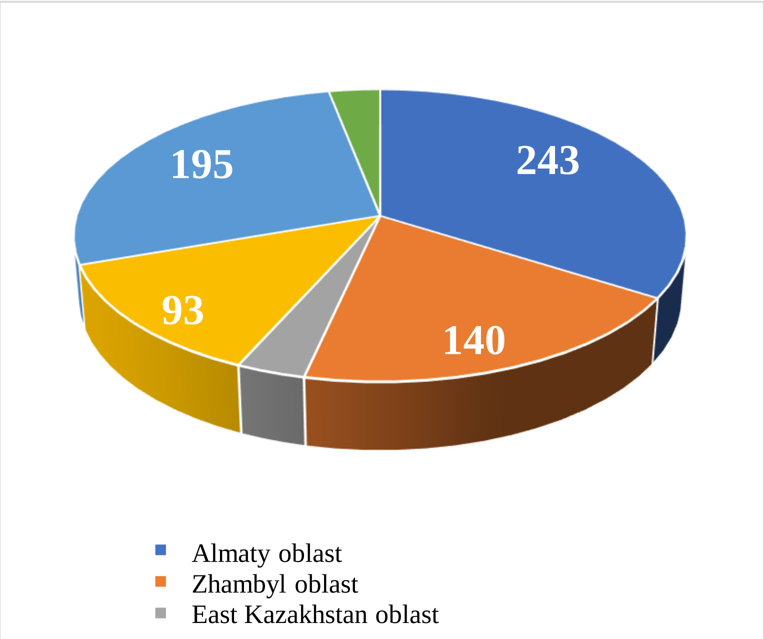
Mudflows are the most serious among dangerous natural phenomena in terms of prevalence, recurrence, and destructive impact in Kazakhstan.

The territory of mountains and foothills of Kazakhstan, where mudflows are mainly formed and cause damage, accounts for about 13% of the total territory. The foothills area by its natural qualities is the most suitable for permanent residence, so the population density there is higher: more than 1/3 of the population of the country live on such territories.

Mudflows in the mountains of Kazakhstan are formed as a result of intense and prolonged rainfall, outburst of surface and underground water bodies of moraine-glacial complexes, soil liquefaction during landslides and strong earthquakes, irrational economic activities.

According to the MES RK, there are 609 mudflow-prone areas in Kazakhstan (Figure 6.56), with more than 9.6 thousand facilities and 46.7 thousand inhabitants.

Figure 6.56. *Number of mudflow zones in the territory of Kazakhstan, ea.*



Continuous monitoring of the mudflow situation is carried out by 113 stations and 30 control points of the Kazselezaschita SE of the Ministry of Emergency Situations.

Preventive measures undertaken by the Kazselezaschita SE of MES RK allow reducing the threat of outbursts of moraine lakes, formation of mudflows and ensuring the safety of settlements.

In less than 100 years hundreds of events of various force and genesis of mudflows were registered, about 20 of them were catastrophic with human casualties. The greatest mudflow activity in the XX century was registered in Ile-Alatau.[249] Climate change has begun to play the dominant role in the intensity of mudflows. Thus, if in the first half of the XX century, the time interval between the heavy mudflows of rainfall genesis was 15 years, then in the late XX and early XXI centuries, it decreased to 6 years. [250]

Dangerous positive and negative surges in the Caspian Sea

The Caspian Sea is characterized by a complicated course of natural processes. First, it is expressed in sharp changes of its level and positive and negative surges, evolving along with it. Short-term level fluctuations of the Caspian Sea are mainly caused by positive and negative surges of anemobaric origin, during which the level may change by 1.5-2.5 m in a short period of time (within several hours). Statistics of positive and negative surges in the area of the Caspian Sea under study, based on data from marine stations Shalyga Z.V. and Peshnaya M. Marine Hydrometeorological Station for the observation period of 1940-2018, show that an average of 3-5 up and 4-5 negative surges of different intensity occur each month. Therefore, 80-85 % of the time the coastline along the northeastern coast of the Northern Caspian is unstable and migrates almost all the time. Under medium wind conditions the range of this migration is 3-5 km, under extreme conditions - during the negative surge the amount of dewatering can reach 8-12 km, and during the positive surge the water penetrates up to 15 km inland. With a strong positive surge, the coast is flooded for more than 30 km from the permanent water edge (Figure 6.57). The highest positive surge waves (2-2.5 m) are observed in Komsomolsky Bay, on the coastal parts of Buzachi Peninsula as well as the Mertvyi [Dead] Kultuk sor.[251]

Figure 6.57. *a) Coastline position in the northeastern part of the Caspian Sea in 2005 and 2018. - NASA satellite image of 08.07.2005; b) NASA satellite image of 09.07.2018*

During negative surges, the sea level drop in the Northern Caspian Sea can reach 2.5 m. This leads to disruption of water intakes, shallowing of harbors and maritime navigable waterways, reduction of spawning grounds and feeding areas of valuable commercial fish, primarily sturgeon, change of landscape structure of coastal areas, and desertification of coastal areas. During negative surges, vast shallow waters along the shores, as well as at the river mouth bar of the Zhaiyk River

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[249] Baimoldaev T., Vinokhodov V. Kazselezaschita - operational measures before and after the natural disaster. - Almaty: Bastau, 2007. - p. 283.

[250] Yafyazova R. K. Assessment of mudflow activity and predicting its changes in the global warming climate: author's abstract of the Doctor of Technical Sciences. - Almaty, 2009. - p. 36.

[251] https://www.kazhydromet.kz/ru/kaspiyskoe-more/gidrometeorologicheskie-issledovaniya-kaspiyskogo-morya

(Ural) dry up, and as a result, fish die in cutoff water bodies and puddles, fishing gear dries up, and fishery is interrupted. With significant negative surges in the open, more remote part of the sea, the conditions for the passage of ships deteriorate, and they go with underloading. The negative surges limit the passage at the Mangyshlak Threshold.

At marine stations and posts (Peshnoy, Kulaly Island, Fort-Shevchenko, Aktau) on the Caspian Sea leading observations for a long period since the beginning of observations until 2020, registered 1352 negative surges, including 734 positive and 618 negative surges.

As shown in Figures 6.58, 6.59, the number of positive and negative surges in the period 1990-2020 is higher than before 1990 at all stations, except for Kulaly Island, as can also be seen in the dynamics of changes in the number of positive and negative surges by years (Figures 6.60, 6.61).

Figure 6.58. *Number of the positive surges*

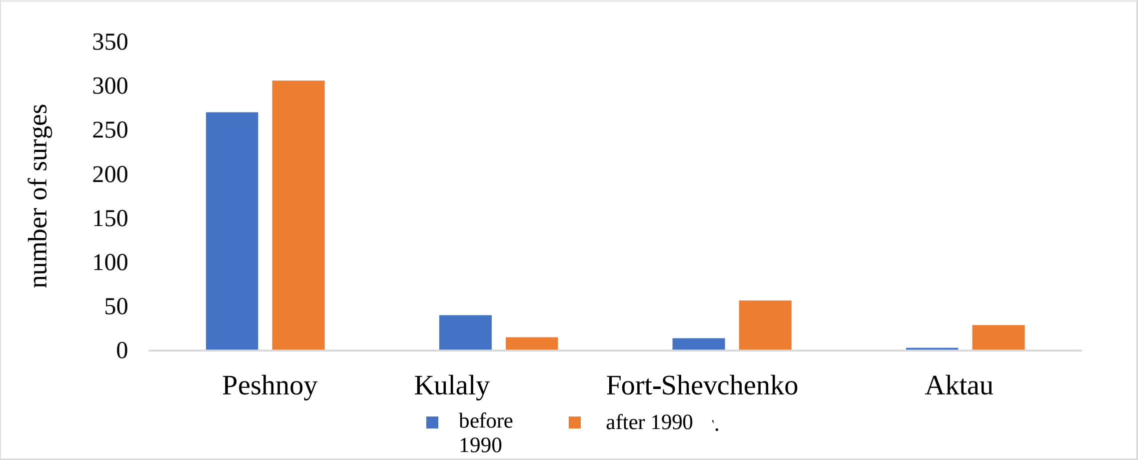


Figure 6.59. *Number of negative surges*

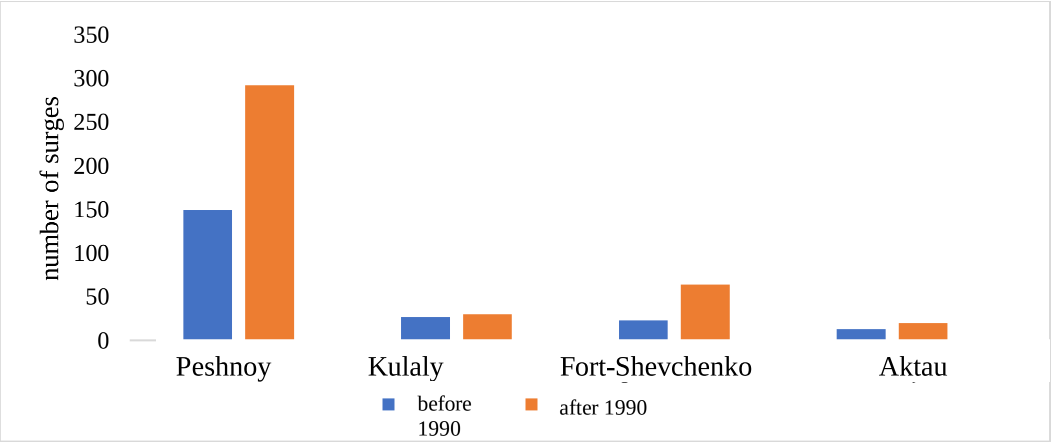


Figure 6.60. *Dynamics of changes in the number of positive surges by years*

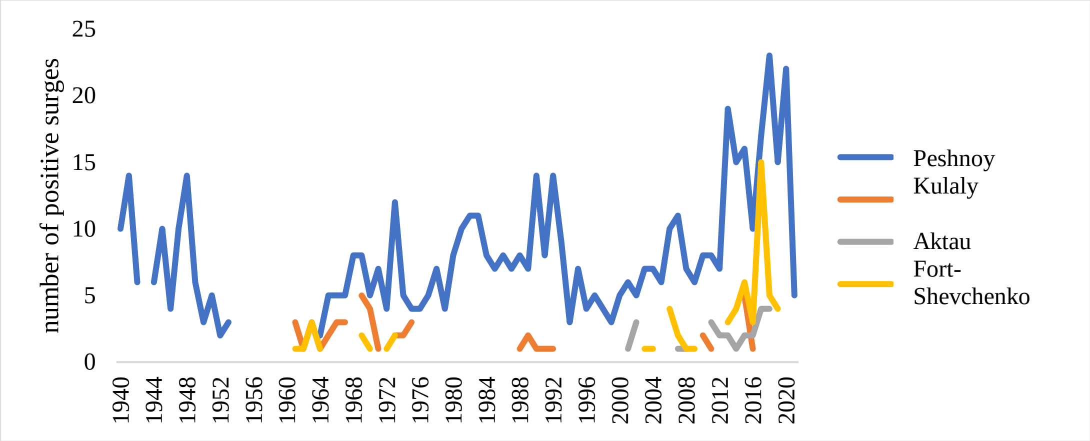
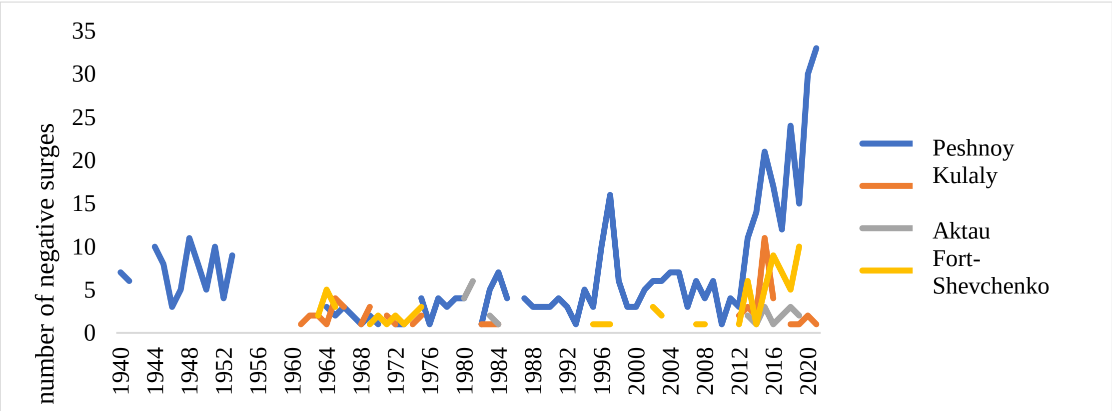


Figure 6.61. *Dynamics of changes in the number of negative surges by years*



The largest number of both negative and positive surges is observed in the northeastern part of the Caspian Sea (Peshnoy M). Thus, 27.2 % of positive and 41.7 % negative surges were registered during the last 10 years.

Storm positive surge on the eastern coast of the Northern Caspian Sea, March 5-7, 2022, near Dead Kultuk Bay

This positive surge was caused by a western quarter wind. Data from Beineu meteorological station indicate that average wind speed in the south-western direction was 16 m/sec with gusts up to 18-23 m/sec. Data from the Fort-Shevchenko marine station indicate that a western quarter wind with a speed of up to 20 m/s prevailed at the time, and that caused a 17 cm increase in sea level near Fort-Shevchenko. In the area of Kultuk field the force of the positive surge wave resulted in washout of the infield road section. The width of the washout was 40 m, there was washout and crumbling of soil on the outer perimeter of the well pads, slopes of intra-field roads, narrowing of the width of the roadbed, formation of ruts and potholes on the road.[252]

The results of numerical simulation showed that the sea level in the Dead Kultuk Bay area in the period from March 5 to 7 rose by 71 cm, causing flooding of part of the coast.

Changes in the coastline position as a result of the surge were also recorded by satellite imagery (Figure 6.62).

[252] Eureka Oleum LLP Subsoil user.

Figure 6.62. *TERRA MODIS satellite image of NASA Worldview: a) March 3, 2022; b) March 7, 2022*

An extreme case of negative surge was observed in Peshnoy M between August 20 and 23, 2020. The wind speed from the north during this period reached 8 m/s. The sea level drop was 123 cm (Figure 6.63). Changes in the coastline position as a result of the positive surge were also recorded by satellite images (Figure 6.64).

Figure 6.63. *The Caspian Sea level fluctuations, according to Peshnoy MS, in August 2020*

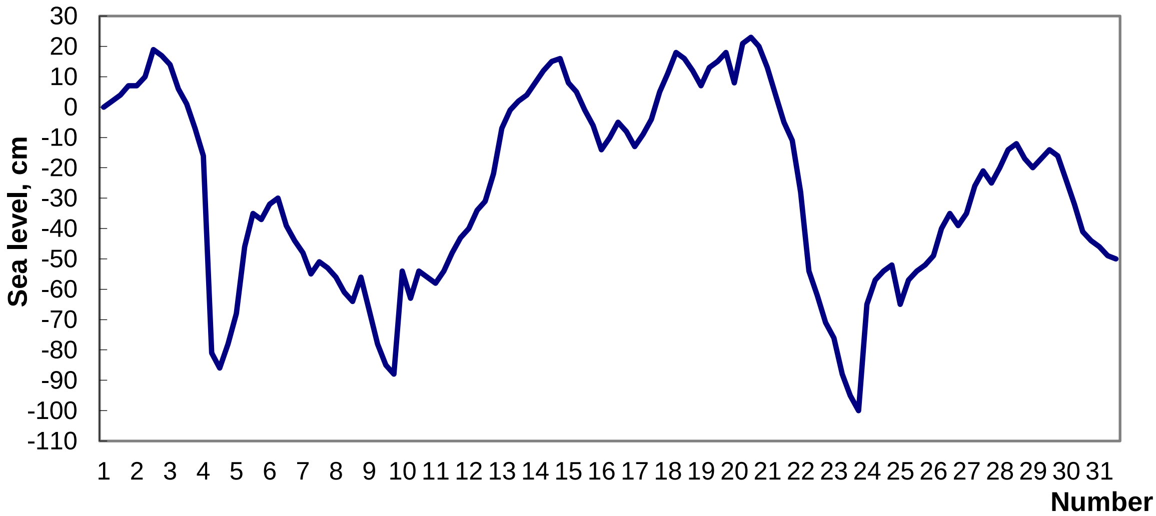
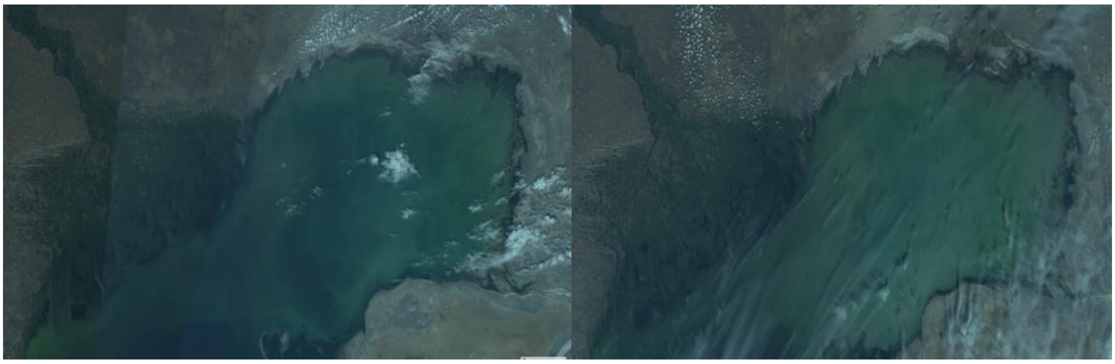


Figure 6.64. *Sentinel-3 OLCI EFR satellite image: a) August 19, 2020; b) August 23, 2020*



6.11. Assessment of climate change impact on morbidity and mortality in the Republic of Kazakhstan

Weather and climate are inseparably linked to some of the most important determinants of health. Waves of heat and cold, floods and droughts claim many lives every year. Many more people die or fall ill due to indirect effects of extreme weather and climatic events and their link to non-communicable and communicable diseases. As the global climate changes, people in many areas are exposed to increasing risk of infectious diseases. Scientists are also concerned about the increased risk of the spread of cholera and leptospirosis as higher temperatures are recorded, which can lead to changes in the survival rates of pathogens in combination with more intense precipitation and frequent floods. Excessive heat, especially during heat waves, contributes to human body dehydration, exacerbates chronic pulmonary and heart failure (especially in combination with air pollution). Climate is the essential factor determining the timing of pollen transfer by air, which is one of the main causes of allergic reactions and bronchial asthma caused by airborne allergens. Understanding the relationship between climate and health is fundamental to taking protective measures against climate-related health risks[253].

The list of climate change impacts on public health has been studied in some detail and presented in various reports and methodologies for assessing the impact of climate change on public health[254].

Below is a list of diseases associated with climate change that occur in the Republic of Kazakhstan:

1. Injuries, poisoning, accidents.
2. Cardiovascular diseases: arterial hypertension, myocardial infarction, strokes.
3. Respiratory diseases: bronchitis, bronchial asthma, allergic reactions.
4. Communicable diseases: cholera, dysentery, acute intestinal infections, tick-borne encephalitis, malaria.
5. Mental illnesses: exacerbation of existing mental illnesses, depression, anxiety-depressive disorders, post-traumatic stress disorders.

Methodology

This assessment was based on the analysis of statistical data on morbidity and mortality presented in the annual statistical digest of the Ministry of Health of the Republic of Kazakhstan 'Public health of the Republic of Kazakhstan and activities of healthcare institutions'. The latest relevant information for 2020 was used, as by the time of review, the Ministry of Health had not published statistics for 2021[255].

The pandemic of the new coronavirus infection COVID-19 has significantly contributed to higher incidence of infectious diseases, respiratory and cardiovascular diseases, as well as a decrease in the incidence of injuries and intestinal infections due to the introduction of quarantine measures. Nevertheless, 2020 data was included in this analysis to demonstrate that certain trends

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[253] https://gfcs.wmo.int/sites/default/files/Fact_Sheets/Health/GFCS_healthflyer_ru.pdf

[254] https://apps.who.int/iris/bitstream/handle/10665/104200/9789241564687_eng.pdf
https://www.euro.who.int/__data/assets/pdf_file/0010/91099/E81923R.pdf
https://www.who.int/globalchange/publications/climchange.pdf
https://wedocs.unep.org/bitstream/handle/20.500.11822/32746/HMCCIAAS.pdf?sequence=1&isAllowed=y
https://documents1.worldbank.org/curated/en/552631515568426482/pdf/122328-WP-PUBLIC-WorldBankClimateChangeandHealthDiagnosticMethodologyJan.pdf
https://www.cdc.gov/climateandhealth/docs/ClimateAndHealthInterventionAssessment_508.pdf
https://health2016.globalchange.gov/high/ClimateHealth2016_FullReport.pdf
https://ehia.curtin.edu.au/wp-content/uploads/sites/42/2018/05/cc-guideline-10615.pdf
https://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Environmental%20health/Climate%20change/Health-impacts-of-climate-change.pdf

[255] http://www.rcrz.kz/index.php/ru/statistika-zdravookhraneniya-2

in morbidity rates had become apparent more than 5 years ago and the pandemic did not change the existing situation drastically.

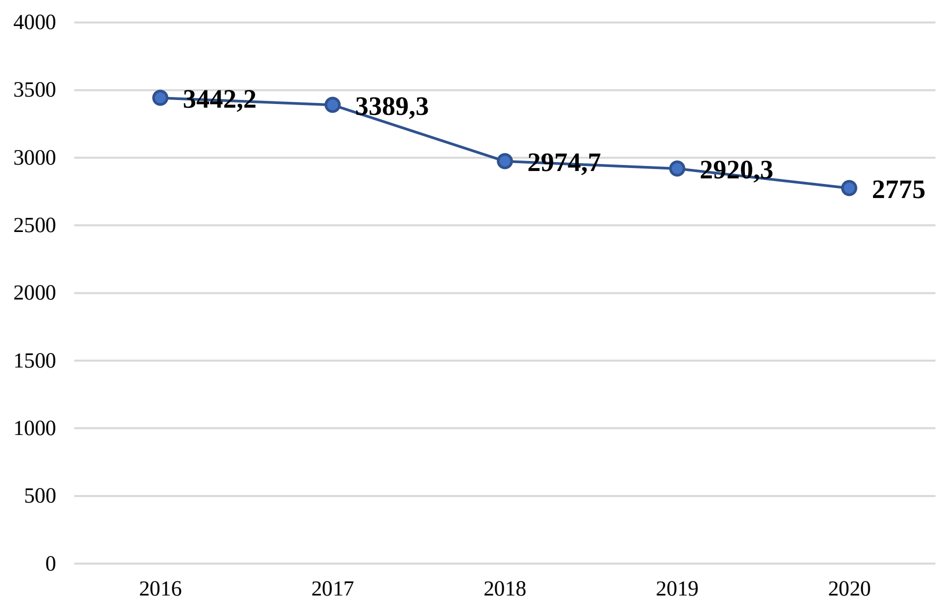
1. Injuries, poisoning, accidents

Floods are the most prevalent natural disasters. They lead to diverse and grave consequences for human health, both short-term and long-term, from drownings and injuries to the progression of communicable diseases and mental health problems. Most of the deaths are due to drowning, the rest are caused by injuries, electric shock, carbon monoxide poisoning and fires, both at the stage of preparation for the anticipated natural disaster and after it. In addition, the probability of activation of mudflow and landslide increases, as well as the appearance of new mudflow hazards due to glacier melting. The longer-term health impacts are associated with forced displacement from residence, water shortage, injuries, lack of access to medical services and prolonged convalescence.

A study conducted in 2012 in Astana revealed that an increase in the average daily effective air temperature by 1 °C is associated with an increase in the number of deaths from intentional self-harm by 2%, from accidental drowning and immersion in water by 9.55%. An increase in relative humidity by 1% is associated with an increase in drownings by 4.87%[256].

Gradual decrease in injuries, poisoning and accidents has been observed in the Republic of Kazakhstan from 2016 to 2020 (Figure 6.65). These indicators reflect all possible cases recorded by medical institutions without cause specifications.

Figure 6.65 – *Newly diagnosed cases of injuries, poisoning and some other impacts of exposure to external causes in 2016-2020 (per 100 thousand people)*



As Table 6.41 shows, a decrease in injuries, poisoning and accidents is observed in urban and rural areas.

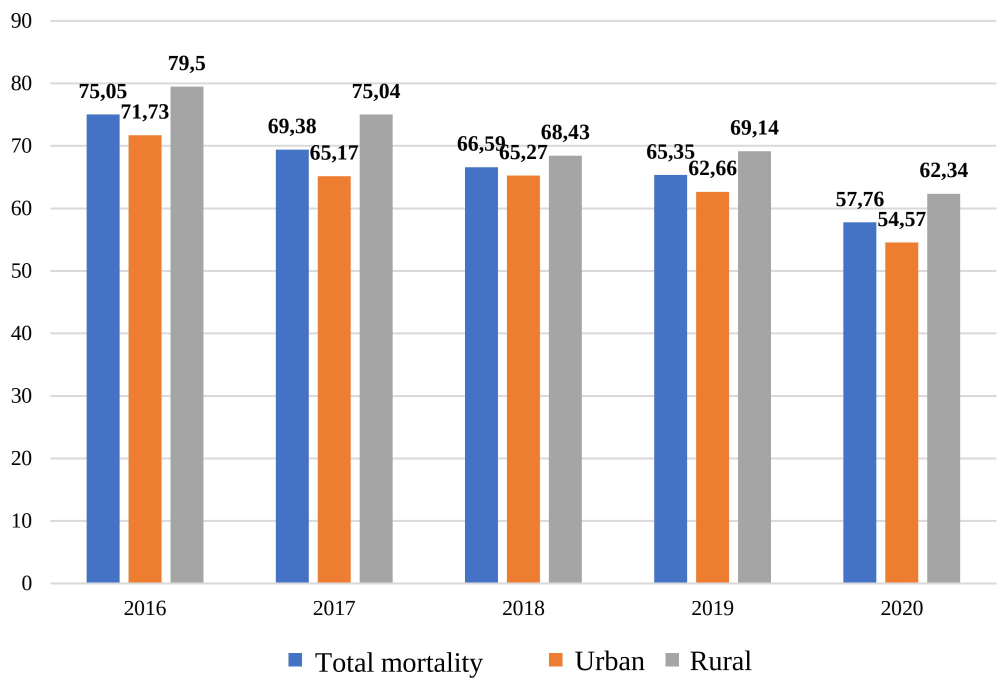
Table 6.41 – *Newly diagnosed cases of injuries, poisoning and some other impacts of exposure to external causes in 2016-2020 in urban and rural populations (per 100 thousand people)*

[256] Report 'Impact, vulnerability and assessment of adaptability of the healthcare system of the Republic of Kazakhstan to climate change', Ministry of Health of the Republic of Kazakhstan, Astana, 2012

Year	2016	2017	2018	2019	2020
Urban	4,267.7	4,203.7	3,658.1	3,482.9	3,344.7
Rural	2,340.3	2,295.7	2,030.0	2,075.5	1,958.9

Affected urban population is expected to be higher due to higher density and more intensive activities of the residents. Industrial and street injuries, sports injuries, as well as road accidents show higher rates in cities. Thus, according to the data of the Committee for Legal Statistics and Special Records of the Prosecutor General's Office of the Republic of Kazakhstan, 10,974 people were killed in road accidents in the country during the period from 2016 to 2020. In 2021, 2,270 people died, which is 6 deaths daily[257].

Figure 6.66 – *Death rates for accidents, injuries and poisoning in 2016-2020 (per 100 thousand people)*



Despite lower morbidity, higher mortality from accidents, injuries and poisoning is observed in rural areas (Figure 6.66). This may partly be due to the lack of access to emergency medical care, insufficient staffing and technical equipment of regional and district hospitals, poor roads, and remoteness of certain rural settlements.

It is the rural areas, where injuries and accidents would be observed during floods, inundations, and mudflows due to terrain features, which is also true about forest fires, drought, and heavy rains.

2. Cardiovascular diseases

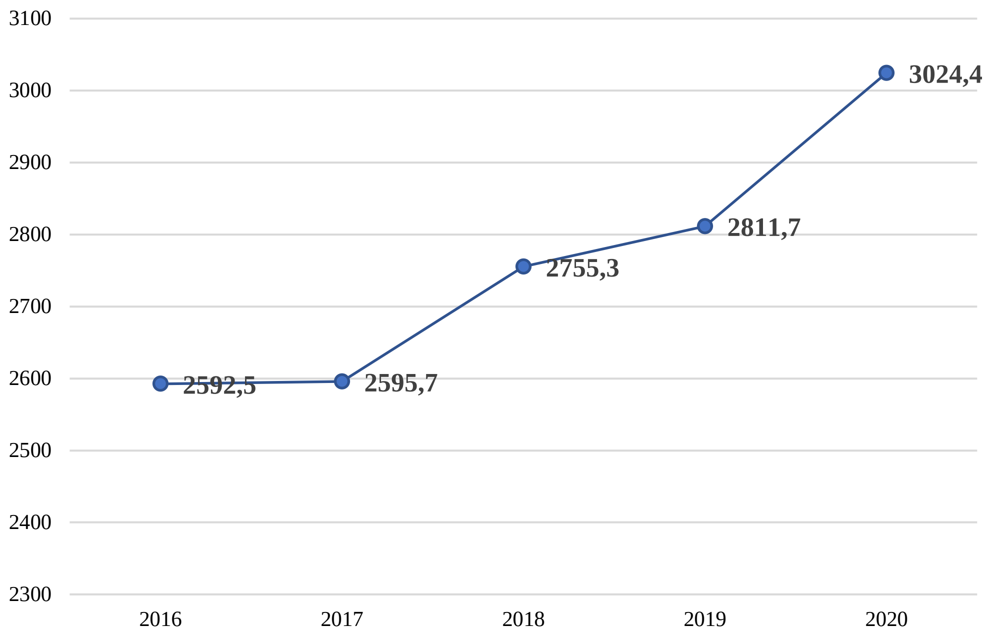
Increased ambient temperature can aggravate the course of chronic pulmonary and heart failure. Even in healthy people, prolonged and intense heat may lead to significant health disorders accompanied by heat or sunstroke, muscle cramps, or vascular spasms. The elderly and young children are the most vulnerable. In addition, people working outdoors exposed both to high temperatures and ultraviolet radiation fall into the risk zone. Urban residents are more affected by the heat than rural residents.

257 https://qamqor.gov.kz/crimestat/indicators/accident

According to many studies, most deaths globally are caused by cardiovascular diseases. Among other meteorological variables, air temperature and atmospheric pressure have been proven to show effects on the course of cardiovascular diseases. Such impact is associated with both anomalies (deviation from the long-term average value) of these variables and their day-to-day spikes. Significant statistical relationship between the number of patient admissions and day-to-day air temperature spikes - both up and down in summer - was revealed[258]. On such days, connection is observed with aggravated course of existing cardiovascular diseases, like cardiac angina, with such symptoms as chest pain, headache, dizziness, nausea, fatigue, etc. High temperatures have been confirmed to cause from 1 to 10% of deaths annually among senior age groups in Europe. A 10 °C increase in the maximum daytime temperature drives the number of requests for medical help and mortality due to individual causes to increase by 100%, while total mortality goes up 8%[259].

Today, Kazakhstan faces increase in the incidence of circulatory diseases from 2,592.5 cases per 100 thousand people to 3,024.4 cases per 100 thousand people in 2020 (Figure 6.67). Morbidity is a medico-statistical indicator that determines the number of diseases registered for the first time in a calendar year among the population residing in a particular territory. It is one of the criteria for assessing the population health[260].

Figure 6.67 – *Incidence of circulatory diseases in 2016-2020 (per 100 thousand people)*



Morbidity is apparently growing among both urban and rural populations. As can be seen from Table 6.42, the incidence of circulatory diseases is higher among the urban population, however, the difference from rural indicators is not drastic.

Table 6.42 – *Circulatory diseases incidence among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	2016	2017	2018	2019	2020
Urban	2,730.8	2,736.3	3,037.4	3,068.4	3,419.1

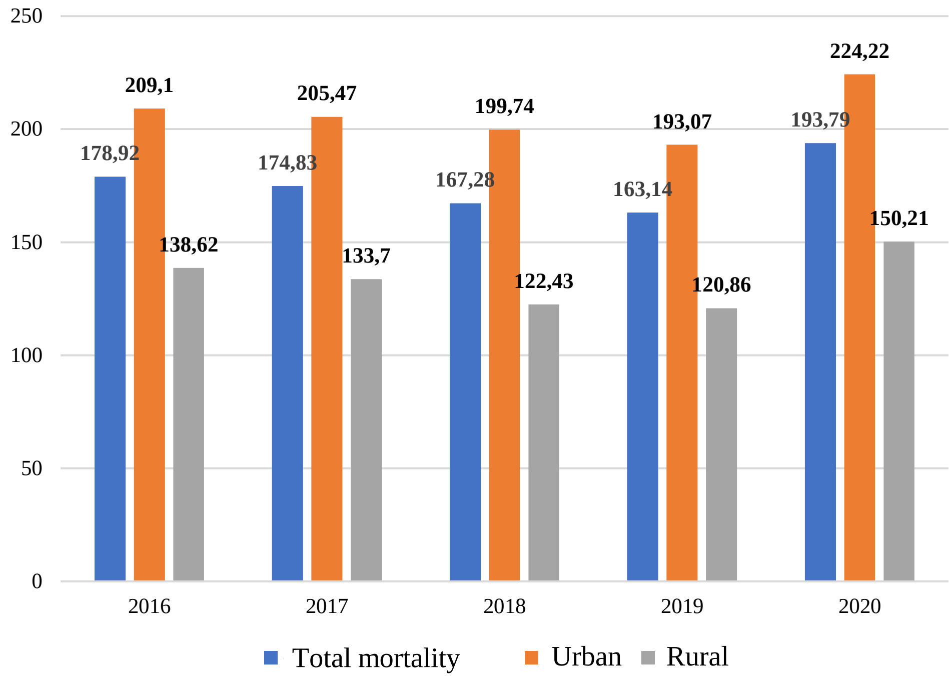
258 https://omnidoctor.ru/upload/iblock/a5d/a5d7fc41da863007963d0dee2305bfcb.pdf
259 https://meteoinfo.ru/meteo-medic/2920-meteo-med-revithc

260 https://dic.academic.ru/dic.nsf/ruwiki/230169

Rural	2,408.0	2,406.8	2,365.6	2,403.5	2,458.9

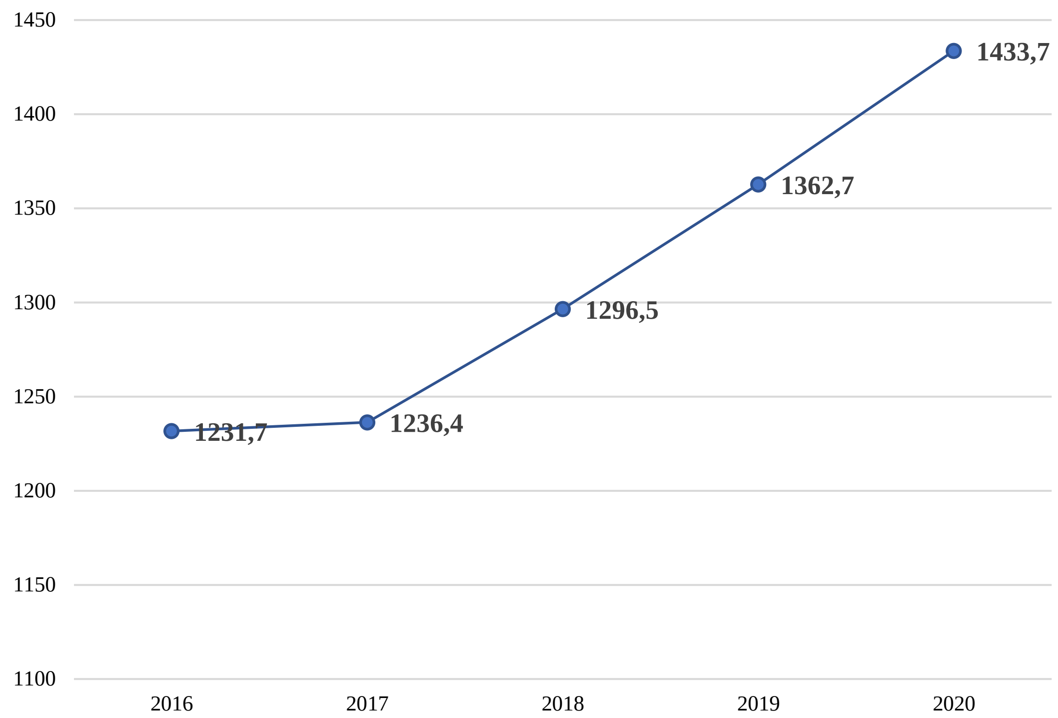
Figure 6.68 shows the total mortality rate from circulatory diseases in the Republic of Kazakhstan in 2016-2020 additionally disaggregated by urban and rural areas. Figure 4 shows uniform decrease in mortality from cardiovascular diseases in 2016-2019, but these indicators went up in 2020. This change is most likely due to the pandemic of the new coronavirus infection COVID-19.

Figure 6.68 – *Mortality rates from circulatory diseases in 2016-2020 (per 100 thousand people)*



It should be noted that the indicators presented in Figure 6.69 cover all causes of mortality associated with the cardiovascular system, namely, acute and chronic heart failure, myocardial infarction, various types of strokes, sudden death associated with cardiac arrhythmia, etc. Below are statistical indicators directly related to cases of arterial hypertension, heart attacks and strokes.

Figure 6.69 – *Incidence of arterial hypertension in 2016-2020 (per 100 thousand people)*



Incidence of hypertension has been growing steadily in the country for 5 years, from 2016 to 2020 (Figure 6.69). Higher ambient temperature, "heat islands" in cities may be drivers of hypertensive crises and, accordingly, stimulate a surge in ambulance calls and walk-ins. However, increased morbidity rates may be caused by higher diagnose rates associated with the commissioning of new out-patient clinics, enhanced screening programs, operation of special "health trains" providing medical care in remote rural areas. Interestingly, he incidence of hypertension was higher in rural areas in 2016 and 2017 (Table 6.43), while since 2018, there has been an increase in the urban incidence.

Table 6.43 – *Arterial hypertension incidence among urban and rural residents in 2016-2020 (per 100 thousand people)*

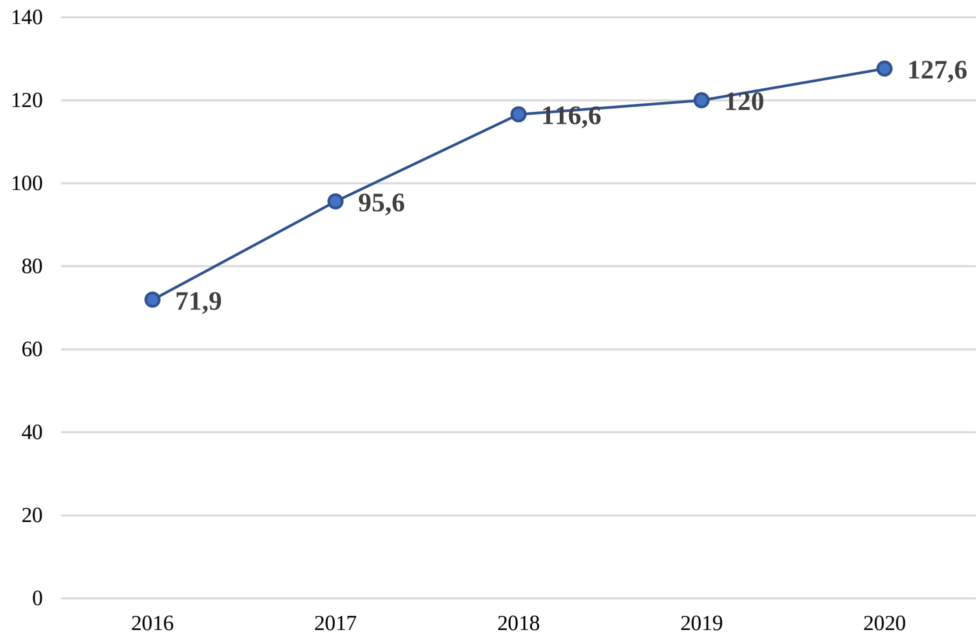
Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	1,223.9	1,231.6	1,360.8	1,443.4	1,566.8
Rural	1,242.1	1,242.8	1,207.6	1,227.0	1,243.0

Assessment of ambulance calls in Nur-Sultan in 2019 revealed that the number of calls due to hypertensive crises increases by 30% in the daily interval from 20:00 to 24:00 under the influence of changes in air temperature, atmospheric pressure, air humidity and seasons. Analysis of the relationship between climatic variables and daily mortality rates from diseases characterized by high blood pressure under the same study revealed that an increase in the maximum effective temperature by 1 °C in the warm season is associated with a decrease in the number of deaths from hypertension by an average of 2.2%. Thus, the study has found no evidence of an increase in the number of deaths with an increase in air temperature, unlike other similar works.

The study included a survey of 453 respondents (308 women (67.39%), 145 men (32.61%)); the average age of female respondents was 60.3±12.7 years, male respondents - 58±11.9 years. Almost 78% (353 respondents) answered positively to the question about the change in blood pressure during weather changes. Almost 74% of patients (335 respondents) indicated that they feel the worst in cold weather[261].

The incidence of myocardial infarction has almost doubled in 5 years (Figure 6.70). Myocardial infarction occurs mainly in the population of middle-aged and elderly people, however, in recent years, the disease has been progressing more often in people younger than 45 years, which, apparently, is associated with modern lifestyle changes. The group at increased risk of early development of myocardial infarction is primarily young men, smokers, people with a hereditary predisposition to early development of cardiovascular pathology and those experiencing problems with employment[262]. Predisposing factors are obesity, diabetes mellitus, hypertension, smoking, alcohol and drug addiction, excess meat in the diet, and peripheral vascular diseases.

Figure 6.70 – *Incidence of acute myocardial infarction in 2016-2020 (per 100 thousand people)*



Comparison of the incidence rates of myocardial infarction in urban and rural residents (Table 6.44) show that this disease is less common in rural residents. This is probably associated with a higher level of physical activity, lower incidence of obesity, even though the incidence of hypertension in rural regions is almost as high as in cities, which is a risk factor for acute myocardial infarction.

Table 6.44 – *Incidence of acute myocardial infarction among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	84.6	113.1	144.2	145.2	153.8
Rural	53.7	70.4	75.8	81.1	87.8

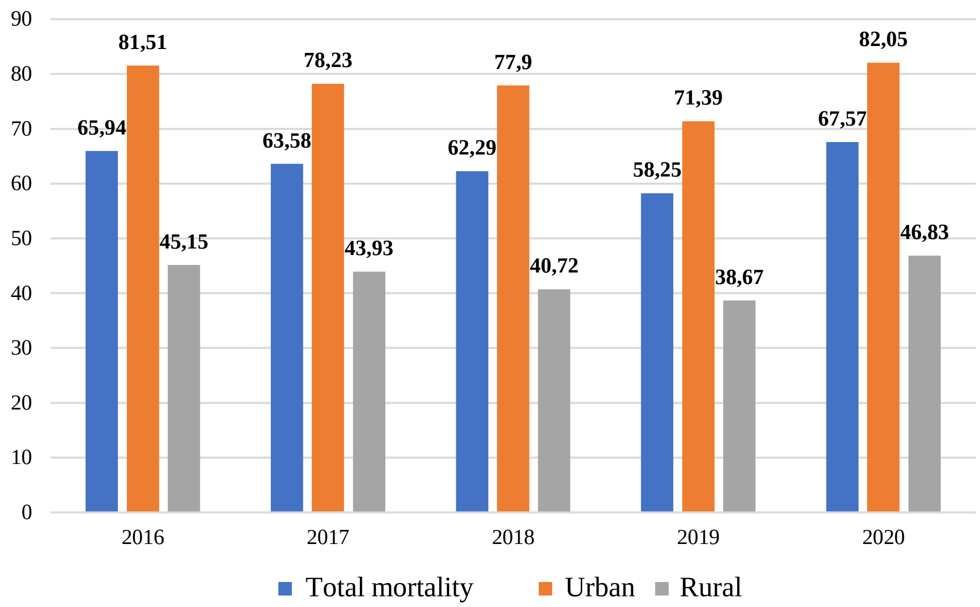
It can be assumed that relatively low rates of myocardial infarction in rural residents may also be associated with insufficient number of cardiologists at medical facilities and lack of specialized cardiology departments in district hospitals, which, accordingly, complicates the

[261] Research report 'Comprehensive prevention and reduction of mortality from major cardiovascular diseases in primary health care with the account of climatic, meteorological and environmental factors of the region', Astana Medical University, Nur-Sultan, 2020

[262] https://klinitsist.abvpress.ru/Klin/article/view/287

diagnosis of this pathology. Among urban residents, there is a stable increase in the acute myocardial infarction incidence from 84.6 per 100 thousand people in 2016 to 152.8 per 100 thousand people in 2020.

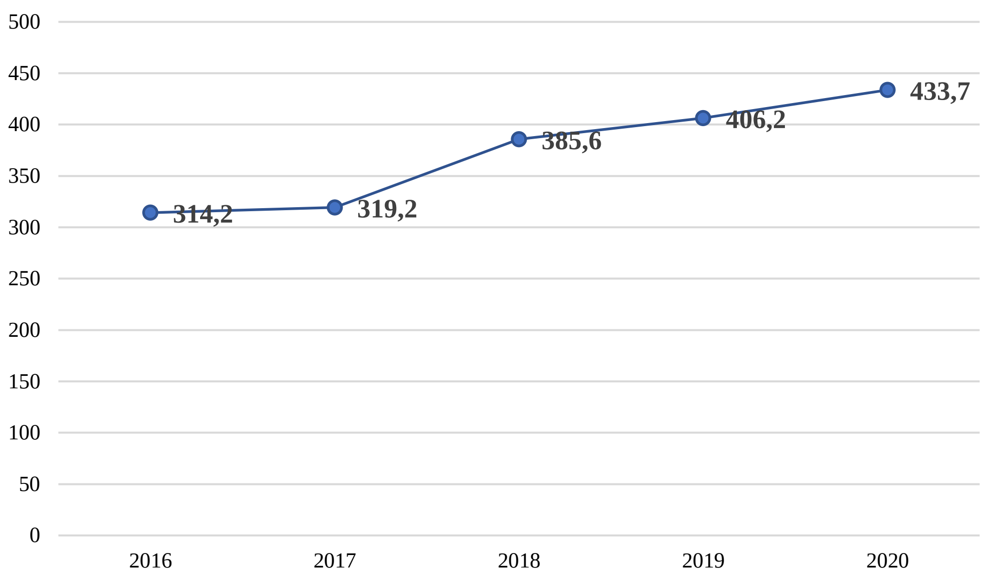
Figure 6.71 – *Mortality rates from acute myocardial infarction in 2016-2020 (per 100 thousand people)*



Assessing the mortality rates from acute myocardial infarction, one can see a slight decrease in mortality rates in 2016-2019 and an increase in mortality rates in 2020, which may be associated with the COVID-19 pandemic. The indicators of 2020 are comparable with 2016 (Figure 6.80).

Assessing the incidence of acute cerebral circulatory disorders (strokes), one can also see steady increase in the incidence from 2016 to 2020. (Figure 6.72).

Figure 6.72 – *Stroke incidence in 2016-2020 (per 100 thousand people)*



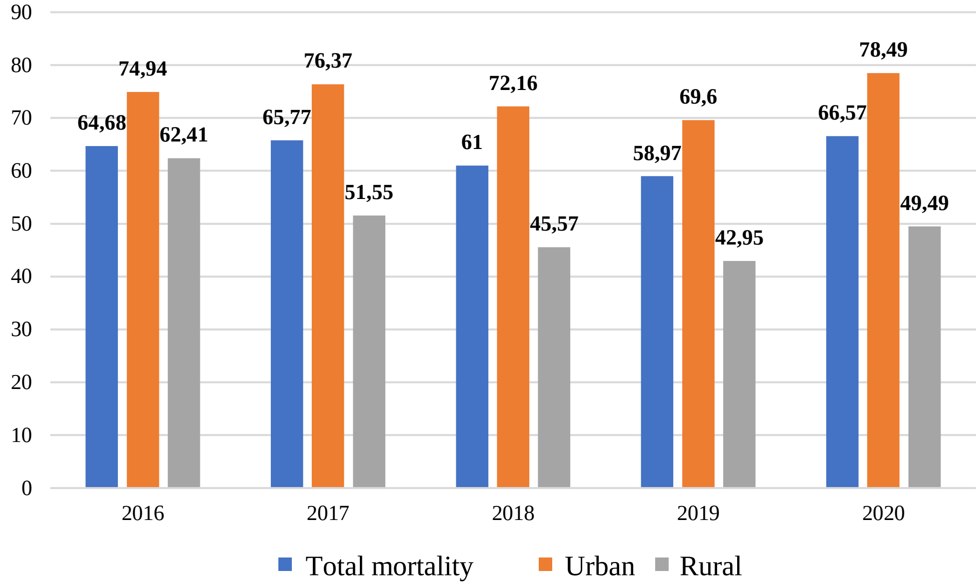
Comparison of stroke incidence with acute myocardial infarction incidence (Figures 6.71 and 6.72) shows that acute cerebrovascular events occur 3.5-4 times more often than myocardial infarction. Stroke is the most common cause of primary disability. According to various data, the disability rate in stroke survivors is 70-85%. In addition, people suffering from stroke consequences are in urgent need of medical rehabilitation (in 100% of cases), which is due to the need for medical correction of the underlying disease that caused the violation of cerebral circulation and the need to restore impaired body functions[263].

Table 6.45 – *Incidence of stroke among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	2016	2017	2018	2019	2020
Urban	360.3	355.4	428.9	448.5	499.1
Rural	248.2	267.1	321.7	339.2	334.3

Relatively high incidence of strokes among rural residents compared with urban residents deserves attention (Table 6.45). In this case, we can assume the influence of the peculiarities of rural lifestyle: difficult working conditions, their dependance on natural and climatic conditions, uneven employment, etc.; in addition, a serious disadvantage is that there are fewer opportunities for full-fledged diagnosis of predictors of vascular diseases and their treatment in rural areas. The low income of rural residents also limits their access to treatment in large cities[264].

Figure 6.73 – *Mortality from stroke among urban and rural residents from stroke in 2016-2020 (per 100 thousand people)*



Mortality rates of Kazakhstani residents from acute cerebral circulatory disorders (Figure 6.72) are comparable with mortality rates from acute myocardial infarction, however, mortality from heart attacks in cities is higher than from strokes, while in rural areas, strokes are more likely to cause death than myocardial infarction.

A 2012 study conducted in Astana showed that an increase in the average daily effective temperature by 1°C in the warm season is associated with an increase in deaths from

[263] http://www.almazovcentre.ru/wp-content/uploads/Диссертация-Гафурова-Д.-У..pdf
[264] https://nnp.ima-press.net/nnp/article/viewFile/163/166

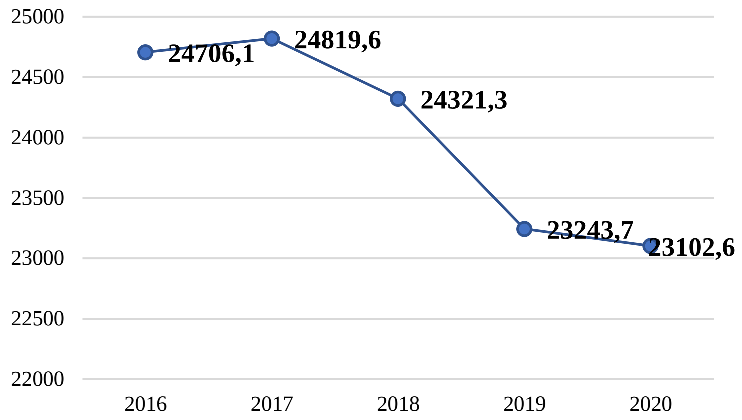
cerebrovascular diseases by an average of 2.5% among women and 1.4% for both sexes. An increase in the maximum effective temperature by 1°C in the warm season is associated with an increase in death from cerebrovascular diseases by an average of 1.9% for women and 1.2% for both sexes[265].

In 2020, a study revealed a strong correlation between the incidence of coronary heart disease and the average air temperature, a strong correlation between the incidence of acute myocardial infarction and the average air temperature in North Kazakhstan oblast, a strong correlation between the incidence of cerebrovascular diseases and wind speed in Zhambyl oblast, a strong correlation between mortality from circulatory diseases and relative humidity in Kyzylorda and South Kazakhstan oblasts[266].

3. Respiratory diseases

Respiratory diseases are among the most common causes of requests for medical assistance. This group of diseases includes a fairly large number of different pathologies with different clinical pictures and causes of occurrence. They may include pneumonia, bronchitis, tracheitis, laryngitis and pharyngitis, pleurisy, bronchial asthma, and chronic obstructive pulmonary disease. The causes of respiratory diseases may include bacteria, viruses, fungi, various allergens, including household, animal hair, pollen, etc., as well as various environmental factors, such as inhalation of air pollutants.

Figure 6.73 – *Incidence of respiratory diseases in 2016-2020 (per 100 thousand people)*



In Kazakhstan, a fairly large number of newly diagnosed respiratory diseases are registered annually (Figure 6.73). Almost every 4th resident of Kazakhstan annually suffers from a disease belonging to this group. From 2017 to 2020, there has been a slight decrease in the incidence of respiratory diseases, however, against the background of the total number of annually registered cases of diseases, this decrease is quite moderate (from 4,476,864 first diagnosed cases in 2017 to 4,333,052 cases in 2020).

As Table 6.41 shows, a decrease in respiratory diseases is observed in urban and rural areas. In 2020, there was a slight increase in morbidity among urban residents. Relatively high rates of respiratory diseases among rural residents may be due to the use of pesticides, mineral and organic fertilizers, which are widely used in agriculture and have both toxic and cumulative properties.

[265] Report 'Impact, vulnerability and assessment of adaptability of the healthcare system of the Republic of Kazakhstan to climate change', Ministry of Health of the Republic of Kazakhstan, Astana, 2012

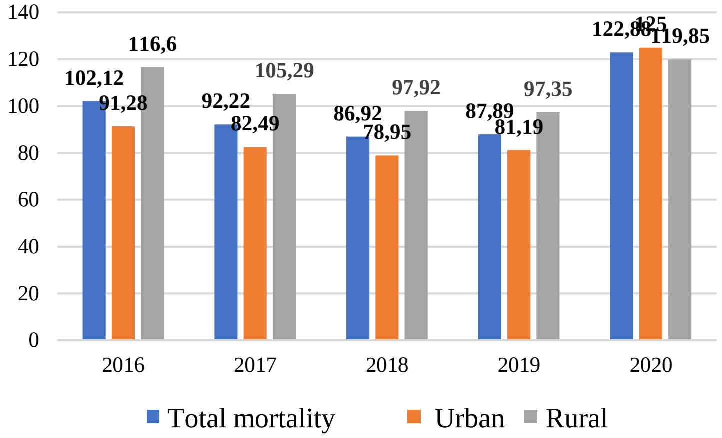
[266] Research report 'Comprehensive prevention and reduction of mortality from major cardiovascular diseases in primary health care with the account of climatic, meteorological and environmental factors of the region', Astana Medical University, Nur-Sultan, 2020

Table 6.46 – *Incidence of respiratory diseases among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	27,730.7	27,830.8	27,888.9	25,868.5	25,948.8
Rural	20,668.9	20,776.4	19,390.6	19,154.7	19,025.6

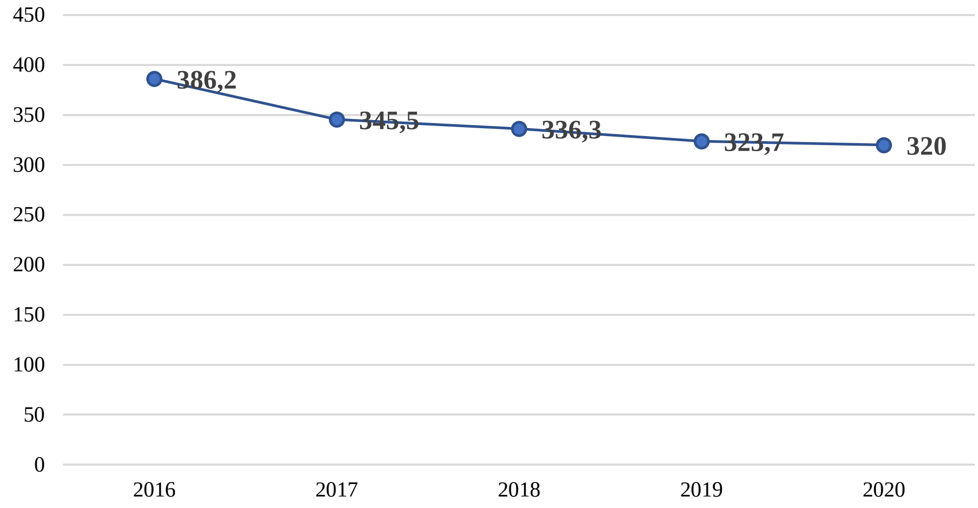
Mortality from respiratory diseases gradually decreased from 2016 to 2018, but in 2019 there was a slight increase in this indicator. In 2020, mortality from respiratory diseases increased significantly (Figure 11), which, as mentioned above, is most likely due to the COVID-19 pandemic and, accordingly, to higher incidence of pneumonia with significant lung damage resulting in bigger number of fatal cases. It should be noted that mortality rates in rural areas exceed those in the city. This may presumably be due to the remoteness of certain rural settlements from district and regional hospitals affecting the timeliness of medical care, scarce availability of modern medications, low sanitation level leading to the spread of respiratory diseases, high prevalence of tobacco smoking, low awareness of the population, as well as high credibility of traditional medicine methods.

Figure 6.74 – *Mortality rates from respiratory diseases in 2016-2020 (per 100 thousand people)*



Climate change can exacerbate drought-induced dust storms in Central Asia, which transfer sand dust from the bottom of the Aral Sea contaminated with chemical fertilizers and other hazardous substances over considerable distances. This can lead to a more severe progression of bronchial asthma, skin and eye irritation, exacerbation of chronic bronchitis both locally and in neighboring countries. In addition, periods of heat and drought lead to an increase in forest and peat fires, which occur more often after heat waves and drought, emit solid particles, sulfur dioxide, nitrogen oxides, which may keep affecting many people for several days or months. Smog may be lethal for people suffering from bronchopulmonary diseases (allergies, asthma, or lung emphysema).

Figure 6.75 – *Bronchitis incidence in 2016-2020 (per 100 thousand people)*



Air quality is one of the factors affecting the incidence of bronchitis in the population. The incidence of bronchitis in Kazakhstan tends to gradually decrease (Figure 6.75). Until 2018, the incidence of bronchitis in rural areas was higher than in cities, however, since 2018, there has been an increase in the incidence of bronchitis among the urban population (Table 6.47). One of the proven reasons for bronchitis development in the urban population is the increased content of particle matter in the ambient air. The reasons for higher bronchitis incidence among rural residents in 2016 and 2017 require clarification. One of the assumed causes is the application of various fertilizers and pest control means.

Table 6.47 – *Incidence of bronchitis among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	321.6	314.4	340.9	330.9	357
Rural	472.5	387.3	330.1	308.4	267

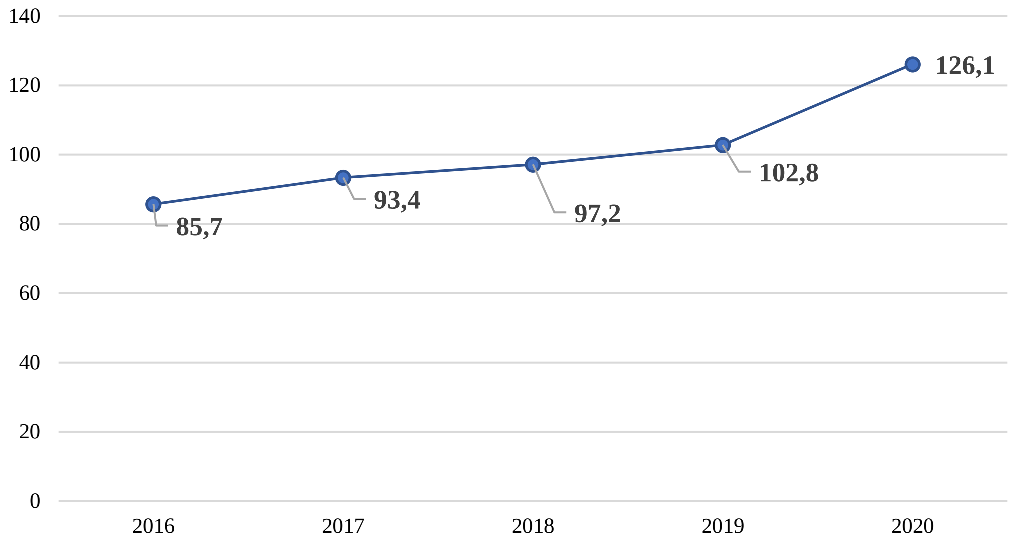
Asthma attacks are usually caused by pollutants and allergens, including pollen or animal hair, exhaust fumes and air pollution caused by forest fires, particulate matter, and high levels of ozone. Climate change entails an increase in the prevalence of bronchial asthma, allergic diseases, exacerbation of chronic obstructive pulmonary disease. Moreover, an increase in ambient temperature may result in a thicker ground layer of ozone. Ground-level ozone emerges as a result of a chemical reaction between nitrogen oxide and organic compounds when exposed to sunlight. The rates and volumes of ground-level ozone formation are influenced by emissions from industrial enterprises, car exhaust gases and gasoline vapors. Ground-level ozone grows on hot sunny days in urban conditions and is one of the components of urban smog. Even a small increase in the concentration of ground-level ozone in the atmosphere may affect human health. Namely, it may cause diseases of the respiratory tract and cardiovascular system, damage to lung tissues.

A 2012 study conducted in Astana revealed that, in the warm season, a link exists between an increase in temperature by 1 °C and a decrease in ambulance calls for bronchial asthma from 0.5% to 3.6% in different age and gender groups. In the cold season, a connection was found between a decrease in air temperature by 1 °C and an increase in ambulance calls for bronchial asthma from 1.7% to 2.0% in various age and gender groups[267].

[267] Report 'Impact, vulnerability and assessment of adaptability of the healthcare system of the Republic of Kazakhstan to climate change', Ministry of Health of the Republic of Kazakhstan, Astana, 2012

Kazakhstan has faced a steady increase in the incidence of bronchial asthma in 2016-2020 (Figure 6.76).

Figure 6.76 – *Incidence of bronchial asthma in 2016-2020 (per 100 thousand people)*



According to numerous studies, women are more likely to suffer from bronchial asthma, which is associated with the different effects of testosterone and estrogen on the power of immune response. This trend can also be traced in Kazakhstan. Table 6.48 shows the incidence rate of bronchial asthma in Kazakhstani women in 2016-2020.

Table 6.48 – *Incidence of bronchial asthma in women in 2016-2020 (per 100 thousand of the relevant population)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
General morbidity	85.7	93.4	97.2	102.8	126.1
Of which women	87.5	94.7	101.1	104.7	122.3

Urban residents are more likely to suffer from allergic diseases, including bronchial asthma, than rural residents. This is due to several reasons: a rural resident is exposed to more numerous and diverse allergens in childhood. The child's immune system learns to recognize, and then ignore, either animal hair, or flowering of various plants, or other allergens[268]. Moreover, the ambient air in urban areas contains many chemicals and suspended particles in addition to natural allergens. When combined with chemicals, natural allergens have a more pronounced aggressive effect on the body, which causes a greater number of allergic reactions. Genetic factors play a significant role here too. Thus, the probability of having an asthmatic child in a pair where both the man and woman suffer from this disease is approximately 75%[269].

This trend can be observed in Kazakhstan too: the incidence of bronchial asthma among urban residents is about two times higher than among rural residents, as can be seen from Table 6.49.

Table 6.49 – Incidence of bronchial asthma among urban and rural residents in 2016-2020 (per 100 thousand people)

[268] https://bobruisk.ru/news/2018/05/23/allergiya
[269] https://ria.ru/20140506/1006687785.html

Year	2016	2017	2018	2019	2020
Urban	105.8	117.9	124	130.4	156.3
Rural	59	60.6	60.2	62.1	82.8

A spike in the incidence of bronchial asthma among both urban and rural residents in 2020 attracts attention. This can again be linked to the COVID-19 pandemic. Viral infection is one of the key potential drivers of bronchial spasm and can be both a trigger for exacerbation of bronchial asthma and an etiological factor that causes the development of bronchial asthma in people predisposed to it[270].

Allergic diseases are quite widespread, some of them are sensitive to climate change. Thus, warmer conditions usually contribute to the production and release of airborne allergens (plant pollen) and, therefore, can cause exacerbation of bronchial asthma and other allergic reactions, such as allergic rhinitis, conjunctivitis, and dermatitis.

The annual statistical digest of the Ministry of Health of the Republic of Kazakhstan 'Public health of the Republic of Kazakhstan and activities of healthcare institutions', which was the main source of information, there is no data on the frequency of allergic reactions. Therefore, it is not possible to assess the dynamics of allergic diseases in Kazakhstan at this stage of the assessment.

4. Communicable diseases

Increase in ambient temperature affects the frequency in the prevalence of natural focal diseases, changing the existence conditions of vector populations and the development conditions of pathogens in the vector, which entails a change in the possible ways of transmission of many human and animal diseases.

Kazakhstan is a territory exposed to a real threat of cholera importation, since cargo is imported and passengers arrive daily from countries with adverse epidemiological situation for this infection, and climatic conditions do not prevent its spread.

Moreover, a 2012 study revealed that an increase in the average monthly air temperature by 1 °C in Astana is associated with an increase in salmonellosis cases by 5.5% in the same month, and an increase in the average monthly precipitation by 1 mm is associated with an increase in salmonellosis cases by 0.5% after 2 months[271].

From 2016 to 2020, 14 cases of cholera were registered in Kazakhstan: 5 cases in 2017, 5 in 2018 and 4 cases in 2019[272]. Since the beginning of 2020, no cases of plague, cholera, typhoid fever, rabies, tularemia, diphtheria, or tetanus have been recorded in Kazakhstan[273].

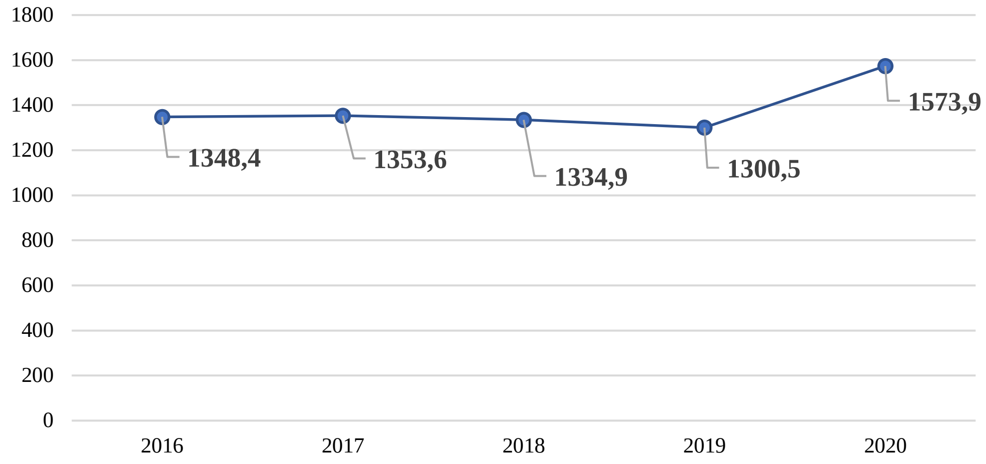
Figure 6.76 – *Incidence of infectious and parasitic diseases in 2016-2020 (per 100 thousand people)*

[270] https://umedp.ru/articles/virusindutsirovannaya_bronkhialnaya_astma_osobennosti_techeniya_i_lechebnaya_taktika.html

[271] Report 'Impact, vulnerability and assessment of adaptability of the healthcare system of the Republic of Kazakhstan to climate change', Ministry of Health of the Republic of Kazakhstan, Astana, 2012

[272] https://stat.gov.kz/official/industry/157/statistic/7

[273] https://tengrinews.kz/kazakhstan_news/kakih-bolezney-stalo-menshe-v-kazahstane-411258/



In general, the incidence of communicable diseases in 2016-2019 was fairly stable (Figure 6.76); in 2020, there was an increase obviously associated with the COVID-19 pandemic.

As can be seen from Table 10, the growth of the overall incidence of infectious diseases in 2020 is due to a significant increase in morbidity among urban residents. In rural areas, people are at a greater distance from each other, apartment buildings are fewer, while territory is larger, which had a positive effect in terms of the rate of the new coronavirus infection spread.

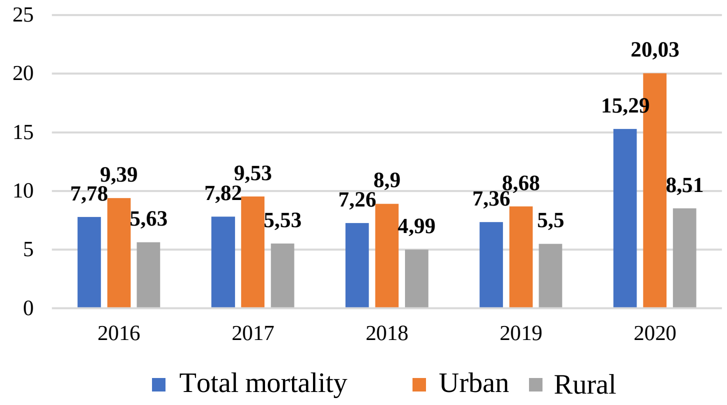
Table 6.50 – *Morbidity from infectious and parasitic diseases among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	1,682.4	1,698.8	1,674.8	1,582.8	2,057.6
Rural	902.5	890.0	865.1	879.0	881.0

Despite a slight change in the incidence of communicable diseases in rural areas, an increase in mortality from infectious diseases was observed in 2020 (Figure 6.77). The total mortality from infectious diseases has doubled. Comparison of morbidity and mortality rates shows that every hundredth case died in 2020.

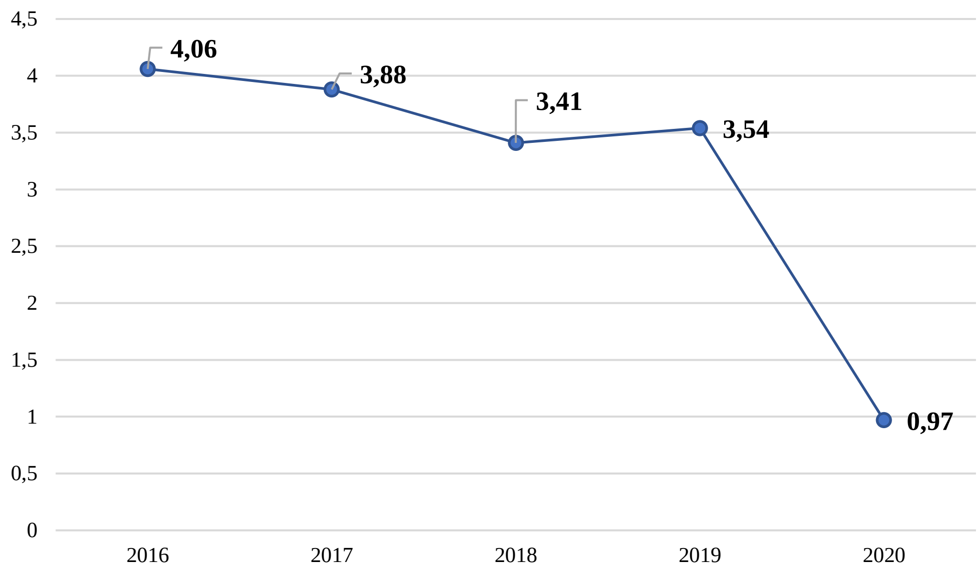
The risk of deterioration of sanitary conditions of people affected by natural factors becomes more prominent because of natural disasters, such as floods or heavy rains. This situation may result in higher incidence of infectious diseases with fecal-oral route: cholera, hepatitis A, amoebic and bacterial dysentery. Climate change can affect the growth, survival, resistance, transmission, or virulence of pathogens. After floods or prolonged rains, outbreaks of hepatitis A are possible, especially in cases where water supply systems are partially or completely destroyed.

Figure 6.76 – *Mortality rates from infectious and parasitic diseases in 2016-2020 (per 100 thousand people)*



Many infectious diseases are sensitive to either temperature or precipitation and, in many locations, show pronounced seasonal fluctuations. The cases of many intestinal infectious diseases peak during the hottest months of the year. Climate change may have pronounced impact on water resources and their sanitary condition where water supply and storage are affected. Drought events may cause increased concentrations of pathogenic microorganisms in water reservoirs. Moreover, water scarcity may necessitate the use of fresh water sources of inferior quality. The frequency and degree of contamination of potable water may be affected by rainfall and especially heavy downpours. Intensive rainfall may cause flooding and inundation of sewer systems. All these factors may drive the incidence of intestinal infections.

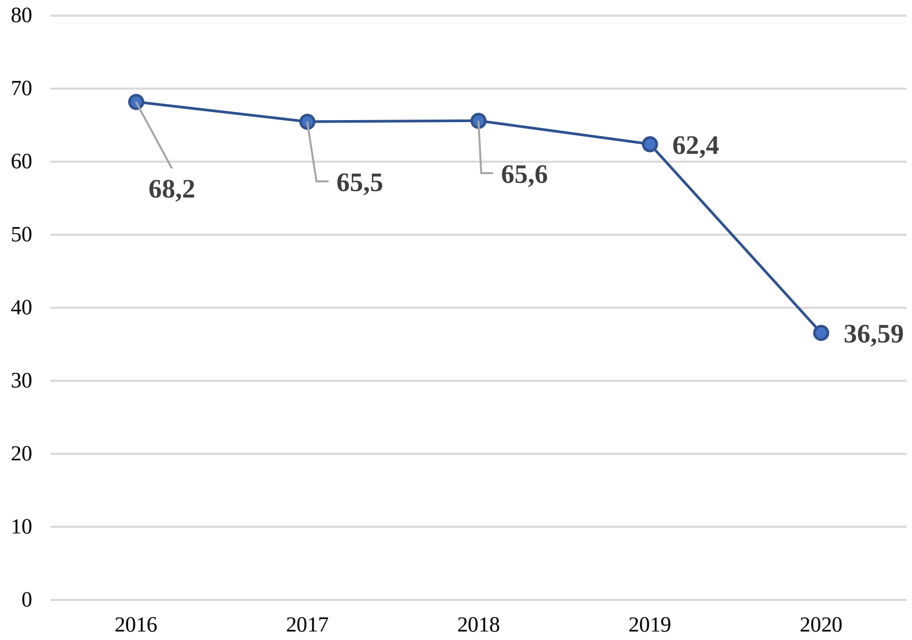
Figure 6.78 – *Incidence of bacterial dysentery in 2016-2020 (per 100 thousand people)*



In 2020, there was a significant (3.5 times) decrease in the incidence of bacterial dysentery in Kazakhstan (Figure 6.78). Higher incidence of dysentery, as a rule, occurs in the spring-summer period and is associated with bigger consumption of vegetables and fruit, bathing in water bodies and larger flow of tourist to various countries. The sharp decrease in morbidity can be explained by the isolation of the population and the implementation of anti-coronavirus measures in the country.

The incidence of acute intestinal infections also decreased in 2020 for similar reasons (Figure 6.79).

Figure 6.79 – *Incidence of acute intestinal infections in 2016-2020 (per 100 thousand people)*



In absolute numbers, the cases of acute intestinal infection went down from 12.1 thousand in 2016 to 6.9 thousand in 2020.

The Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan cites another indicator characterizing the impact of infectious diseases on public health: mortality from the lack of safe water, safe sanitation, and hygiene (due to lack of safe services in the field of water supply, sanitation, and hygiene). In 2016, this indicator was 0.8 cases per 100 thousand people, in 217 – 0.99 cases per 100 thousand people, in 2018 – 0.83 cases per 100 thousand people, and in 2019 and 2020 – 1.28 cases per 100 thousand people[274].

Ticks are a significant source of infectious diseases associated with climate change. They exist in many countries and carry more zoonotic pathogens than any other vector. Ticks mainly inhabit the external environment away from the host, so they are expected to be affected by climate change. Climate change contributes to the shifting of the habitat border of tick-borne encephalitis vectors to the north and the extension of their active period, thus aggravating the epidemiological hazards in the areas where ticks could not survive before. Lyme disease and tick-borne encephalitis are the most relevant human tick-borne infections. During the epidemiological season of 2020, 21 cases of tick-borne encephalitis were registered, compared to 15 cases in 2019, in seven endemic territories of East Kazakhstan oblast (Glubokovsky, Zaisan, Katon-Karagay, Kokpekty districts, Ridder, Ust-Kamenogorsk and the Altai) [275].

Climate change can increase the likelihood of malaria transmission in areas traditionally infected with malaria, in areas where the disease is under control, as well as in new areas that have not traditionally been infected with malaria. Increase in temperature, precipitation and humidity may cause the spread of malaria mosquitoes at high elevations, which would lead to an increase in malaria transmission in malaria-free areas. At lower elevations, where malaria is already a problem, higher temperatures will alter the parasite's growth cycle in the mosquito allowing it to develop faster. In arid climate, heavy rains may provide good breeding conditions for mosquitoes.

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274 https://stat.gov.kz/official/industry/157/statistic/7

275 https://www.gov.kz/memleket/entities/departament-kkbtu-vko/press/news/details/204012?lang=ru

On March 20, 2012, the World Health Organization (hereinafter – WHO) issued a certificate to recognize Kazakhstan as a malaria-free country[276].

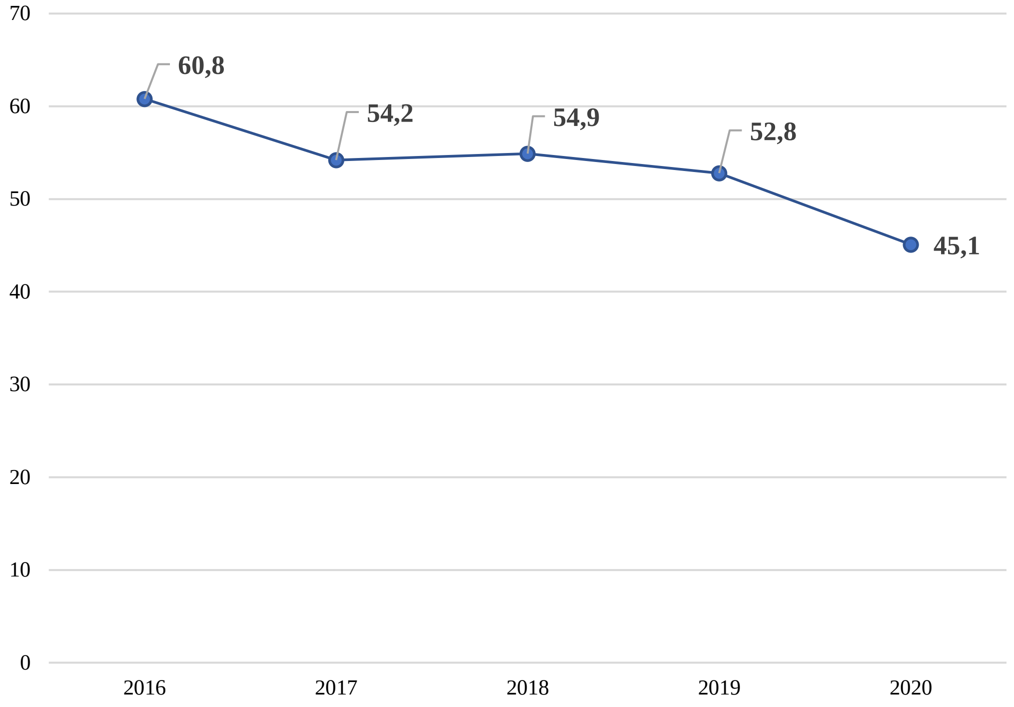
5. Mental disorders

People with mental illnesses and those taking medications to treat various mental disorders, such as depression, anxiety, and other mood disorders, are particularly vulnerable to extreme weather events. Severe heat, as a rule, aggravates existing mental illnesses (impaired mood, increased anxiety, emerging aggression, more intense hallucinations in patients with schizophrenia, dementia, organic brain lesions). As a result, suicides tend to rise during periods of intense heat.

Prolonged exposure to stress due to the need to change the place of residence, loss of livelihood, poor access to food and drinking water, may cause various depressive disorders, increase anxiety levels, cause sleep disorders, aggressiveness, irritability, thoughts of suicide.

Many people with mental health problems prefer not to seek psychiatric help because they feel stigmatized and discriminated against. The negative experience of contacting psychiatrists can also be a factor that causes many people to postpone seeking help[277].

Figure 6.80 – *Incidence of mental disorders in 2016-2020 (per 100 thousand people)*



As can be seen from Figure 6.80, gradual decrease in the incidence of mental disorders is observed in the Republic of Kazakhstan. However, it is generally assumed that the number of people suffering from chronic mental disorders in countries with different levels of social and economic development is approximately the same; in addition, developed countries have recently faced a steady increase in morbidity due to patients with depression, anxiety, and neurotic disorders. Thus, according to WHO, 3.8% of the world's population suffers from depression, of which 5% are adults and 5.7% are over 60 years old[278]. Thus, it can be assumed that lower

[276] https://www.gov.kz/memleket/entities/departament-kkbtu-almaty-obl/press/article/details/47604?lang=ru
[277] https://www.euro.who.int/en/countries/kazakhstan/news/news/2019/06/closing-the-mental-health-treatment-gap-in-central-asia
[278] https://www.who.int/ru/news-room/fact-sheets/detail/depression

incidence of mental disorders is not due to a reduction of mental disorder cases; it is rather a decrease in the rates of calls and diagnoses due to a current option of private appointments with psychiatrists and psychotherapists treating patients with depression, anxiety disorders, neurotic symptoms, who are not included in the general morbidity statistics.

In the context of the urban/rural disaggregation, higher morbidity among the urban population and a decrease among the rural population in 2020 attracts attention (Table 6.51). This may be due to some changes in approaches to accounting for patients suffering from mental disorders in Turkestan oblast. Thus, the statistical digest of the Ministry of Health of the Republic of Kazakhstan, which is the main source of information on morbidity and mortality, indicates that all individuals with mental disorders in Turkestan oblast were taken into account exclusively under 'Rural population' through 2019, while "0.0" was indicated under 'Urban population' until 2020. Since 2020, the situation has changed to the opposite: all mental disorders recorded in Turkestan oblast became reflected only under the 'Urban population' section. For other groups of diseases, such a situation is not observed. Assessing the ratio of morbidity in urban and rural areas, it is necessary to keep in mind a large cohort who are observed by private specialists without requesting assistance from public medical institutions providing psychiatric care. In addition, one should remember the stigmatizing attitude towards psychiatrists in general, therefore, both urban and rural people are rather reluctant to seek medical help, especially from public institutions, even if mental disorders are obvious.

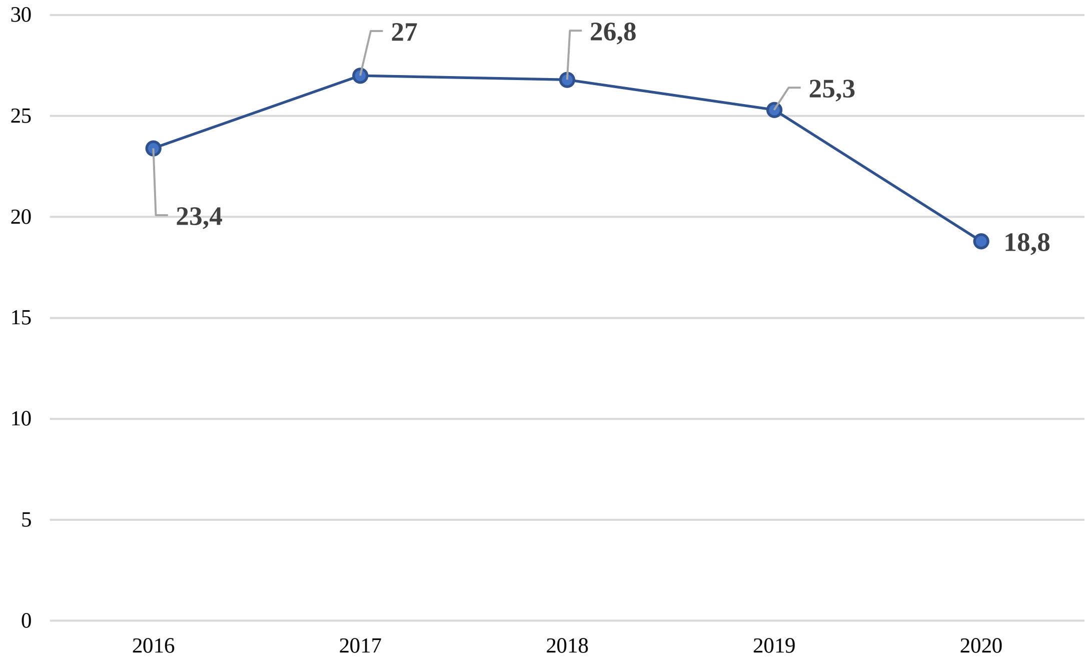
Table 6.51 – *Morbidity rates of mental disorders among urban and rural residents in 2016-2020 (per 100 thousand people)*

Year	**2016**	**2017**	**2018**	**2019**	**2020**
Urban	65.5	58.2	58.5	55.8	60.8
Rural	54.5	48.8	49.9	47.8	22.6

At the end of 2020, 189,546 people suffering from mental illnesses were under medical supervision in the Republic of Kazakhstan[279]. As can be seen from Figure 19, almost every fifth person under dispensary supervision was hospitalized in 2020. Since 2017, the number of hospitalizations has been gradually decreasing. Presumably, this is due to the provision of modern medications under guaranteed free medical care, which ensures longer and better remission and more stable condition of patients so that they do not need hospital treatment.

Figure 6.81 – *Hospital admissions per 100 individuals with mental disorders under dispensary observation*

[279] http://www.rcrz.kz/index.php/ru/statistika-zdravookhraneniya-2



In the context of assessing data on the mental disorder incidence and the number of admissions, it is worth noting that the number of psychiatrists in Kazakhstan has been decreasing gradually since 2018: in 2018, 940 psychiatrists worked in Kazakhstan, in 2019 - 896, while in 2020, the number of psychiatrists decreased to 757.

Conclusion

1. The following trends were identified during the assessment of diseases affected by climate factors:

i. Mortality rates from accidents, injuries and poisoning in rural areas are higher than those in urban areas.
ii. Higher incidence of circulatory diseases in general.
iii. Growing incidence of arterial hypertension.
iv. Growing incidence of acute myocardial infarction.
v. Growing incidence of strokes.
vi. Mortality rates from respiratory diseases in rural areas are higher than mortality rates from the same pathology among urban residents.
vii. Growing incidence of bronchial asthma.
viii. Prevalence of urban women among the total number of people suffering from bronchial asthma.
ix. Lower incidence of bacterial dysentery and acute intestinal infections.
x. Lower incidence of mental disorders.

2. The statistical data used in this review are presented by healthcare institutions in reporting forms approved by Order No. KR DSM-313/2020 of the Minister of Health of the Republic of Kazakhstan dated December 22, 2020, 'On approval of forms of reporting documentation in healthcare'. The annual statistical digest of the Ministry of Health of the Republic of Kazakhstan 'Public health of the Republic of Kazakhstan and activities of healthcare institutions' is based on the data obtained this way.

For a more reliable assessment of the climate impact on morbidity and mortality, it is advisable to compare monthly indicators of average air temperature in the regions of the country with monthly indicators of morbidity and mortality in these regions. To identify trends, it is preferable to conduct analysis for at least 5 years. However, considering that the completed statistical forms on morbidity and mortality are submitted by healthcare institutions once a year, it is not possible to conduct such a study today. One of the options for conducting such an assessment may be local prospective data collection in an individual region in coordination with the oblast akimat. An example is a study conducted in South Kazakhstan oblast in 2011 and aimed at investigating various (including climatic) factors affecting the incidence of strokes. The study revealed a reliable relationship between seasonal differences in the stroke incidence with fluctuations in the absolute maximum temperature and the frequency of days with relative humidity of more than 80%[280].

Statistical forms filled out by healthcare institutions contain a more extensive list of diseases than the one presented in the statistical digest of the Ministry of Health. Data is collected annually on diseases, the occurrence and course of which may be influenced by climatic factors, but information about these diseases is not available in the annual statistical digest. As an example, the following diseases can be cited: allergic rhinitis, acute allergic conjunctivitis, cholera, tick-borne viral encephalitis, Dengue fever, hepatitis A, malaria, affective disorders (including depression), neurotic, stress-related, disorders. Thus, for a more in-depth and qualitative study of the relationship of morbidity and mortality with climate change, access is required to expanded volume of the information collected as well as its disaggregation by months.

3. Globally, there are diseases and negative impacts that can apparently be attributed to climate change, for instance, emerging infectious diseases that have not historically been observed in a certain territory, or the expansion of the range of any disease (for example, malaria), or the coastal line displacement due to glaciers' melting, or the aftermaths of floods or regular droughts. Currently, no such effects of climate change are observed in Kazakhstan.

When conducting such assessments, it is necessary to try to differentiate changes caused by climatic factors from changes caused by other factors of non-climatic nature - ecological, demographic, and socio-economic. The universally accepted ratio determining the degree of impact of various factors on human health is as follows: 50% – lifestyle, 20% – environmental situation, 20% – hereditary factors and 10% – state of the health system.

At the moment, it is possible to observe higher incidence of diseases, the occurrence and exacerbation of which may be associated with climate change, but it is difficult to confirm such relationship because the development of diseases can also be influenced by living in an ecologically unfavorable area, harmful habits, heredity, non-participation in existing screening medical programs, remoteness from healthcare institutions, or vice versa, improved quality and accessibility of medical care enable better diagnostics, and, accordingly, increase the number of cases of newly detected diseases.

Thus, certain trends can be noticed, however, it is impossible now to view climate change as the sole cause of these changes, therefore, the conclusions drawn are probabilistic and require further study and confirmation.

[280] https://www.mediasphera.ru/issues/zhurnal-nevrologii-i-psikhiatrii-im-s-s-korsakova-2/2013/3/031997-72982013319

VII. FINANCIAL RESOURCES AND TECHNOLOGY TRANSFER

A. Finance

7.1.New and additional financial resources

The concept for transition of the Republic of Kazakhstan to Green Economy, aimed at increasing innovation and competitiveness of the state, was adopted on May 30, 2013. Greening the economy and environmental protection were identified as one of the main directions of the economic course of the country, which is reflected in the development of the ‘Green Kazakhstan’ national project for 2021-2025. Tree planting has begun in the regions of the country. Over 2 billion trees in the forests and 15 million trees in settlements are planned to be planted within five years to increase carbon sequestration and curb increasing desertification.

As part of the country's Concept for transition to green economy, Kazakhstan plans to increase the share of alternative and renewable energy in the country's energy mix to 50% by 2050.

In 2020, 25 renewable energy projects were commissioned with a total capacity of almost 600 MW. Investments exceeded USD510 million. Over 60 new renewable energy projects with a total capacity of 2,400 MW and investments of more than USD2.5 billion are scheduled to be commissioned over the next four years. At present there are 124 RE facilities in Kazakhstan with installed capacity of 1,922 MW: 31 wind power plants, 48 solar power plants, 40 hydropower plants and 5 biofuel power plant.[281]

According to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, the current environmental protection costs by oblasts are as follows:

Table 7.1. *Current environmental protection costs by oblasts, thousand KZT*

	2018	2019	2020
Kazakhstan	**191,015,579**	**221,670,479**	**210,397,122**
Akmola	2,715,372	3,165,432	3,261,696
Aktobe	23,454,296	24,811,608	26,847,144
Almaty	841,212	1,287,082	1,786,108
Atyrau	38,408,581	51,198,333	39,940,657
West Kazakhstan	9,659,834	12,631,764	13,685,551
Zhambyl	3,629,200	4,782,879	4,591,362
Karaganda	24,045,627	26,874,954	28,503,150
Kostanay	8,400,631	8,797,401	10,423,346
Kyzylorda	2,639,628	2,853,868	2,863,434
Mangystau	11,809,507	11,127,425	9,632,475
South Kazakhstan	-	-	-
Pavlodar	29,016,058	33,159,437	25,259,670
North Kazakhstan	2,700,396	3,688,821	3,102,405
Turkestan	1,279,159	1,581,227	1,294,883
East Kazakhstan	21,125,691	22,885,867	25,635,452
Astana	2,032,590	1,678,216	1,032,748
Almaty	3,918,314	4,512,795	4,984,200

[281] https://primeminister.kz/ru/news/sovet-po-uluchsheniyu-investklimata-rassmotrel-voprosy-razvitiya-alternativnoy-energetiki-894227

Shymkent	5,339,483	6,633,370	7,552,841

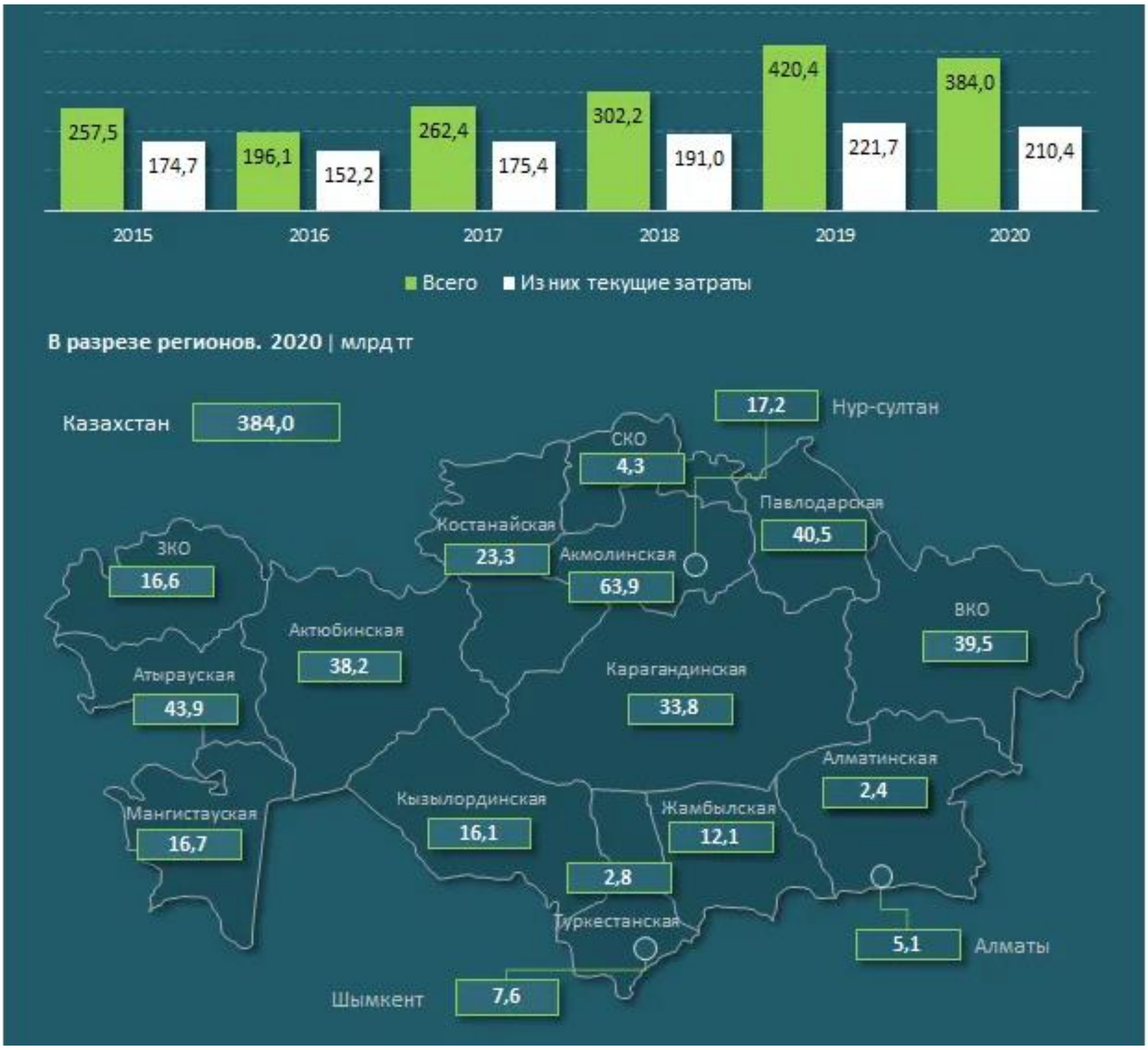
Source: Current costs on environmental protection for 2018-2020. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics.

The methodology of the Statistics Committee of the Ministry of National Economy of Kazakhstan stipulates that environmental protection costs include investments in fixed assets aimed at environmental protection and rational use of natural resources, as well as current costs on environmental protection.

Thus, environmental protection costs of enterprises decreased to KZT384 billion in 2020 compared to KZT420.4 billion in 2019. Total current costs accounted for 54.8%, or KZT210.4 billion, and investments in fixed assets accounted for the remaining 45.2%.

Among regions of Kazakhstan the highest environmental protection costs of enterprises in 2020 were in Akmola oblast (KZT63.9 billion), Atyrau (KZT43.9 billion) and Pavlodar (KZT40.5 billion); the lowest costs were in Almaty (KZT2.4 billion), Turkestan (KZT2.8 billion) and Northern Kazakhstan (KZT4.3 billion) oblasts.

Figure 7.1. Environmental protections costs, 2020, billion KZT



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics*

Almost 60% of environmental protection costs of enterprises together were related to air protection and climate change (KZT88.5 billion), waste management (KZT73.2 billion) and wastewater treatment (KZT67 billion).

A significant amount of costs also came from environmental protection activities in the field of renewable energy sources: KZT115.4 billion, or 29.2% less than the previous year.

Table 7.2. *Environmental protection costs by type of environmental protection activity. 2020, bln. KZT*

	2020	**2019**	**Growth for the year**
Total	384.0	420.4	-8.7%
Atmospheric air protection and climate change challenge	88.5	85.4	3.6%
Waste management	73.2	75.4	-2.8%
Wastewater Treatment	67.0	58.8	13.9%
Soil, Ground and Surface Water Protection and Rehabilitation	16.2	22.5	-28.1%
Biodiversity and Landscape Protection	6.0	6.3	-3.7%
Environmental Protection Research and Development	4.5	4.2	6.8%
Radiation Safety	1.0	0.9	5.5%
Noise and vibration abatement	0.0	0.1	-26.9%
Other areas of environmental protection activities	127.6	166.9	-23.5%
Activities in the sphere of renewable energy sources	115.4	163.0	-29.2%
Activities in the sphere of energy saving technologies and increasing of energy efficiency	6.9	1.2	483.7%

Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics

More than 91% of environmental protection costs of enterprises were incurred in the sphere of industry, amounting to KZT349.8 billion, which is 7.8% less than in 2019. Of these, KZT126.6 billion was spent on electricity, gas, steam, hot water, and conditioned air supply, KZT114.2 billion on manufacturing industry, KZT98.7 billion on mining industry and KZT10.3 billion on water supply, waste collection, treatment, and disposal as well as pollution response activities.

The remaining areas of activity spent KZT34.2 billion on environmental protection. Almost half of this amount was spent on public administration and defense, as well as compulsory social security (KZT15.3 billion). In addition, significant amounts were spent on construction (KZT8.8 billion), transport and storage (KZT3.8 billion), as well as agriculture, forestry, and fisheries (KZT2.6 billion).

Table 7.3. Environmental protection costs by type of economic activity, 2020, billion KZT

	2020	2019	Growth for the year
Total	**384.0**	**420.4**	**-8.7%**
Industry	349.8	379.5	-7.8%
Mining and quarrying	98.7	102.9	-4.1%
Manufacturing industry	114.2	138.6	-17.6%
Supply of electricity, gas, steam, hot water, and conditioned air	126.6	127.1	-0.3%
Water supply; waste collection, treatment and disposal, pollution abatement activities	10.3	10.9	-6.0%
Public administration and defense; compulsory social security	15.3	7.0	117.5%
Construction	8.8	16.1	-45.2%
Transport and storage	3.8	3.8	-0.2%
Agriculture, forestry, and fisheries	2.6	0.6	314.7%
Professional, scientific, and technical activities	0.9	7.2	-87.6%
Public health and social services	0.7	0.7	-3.2%
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.7	0.9	-23.6%
Education	0.4	1.1	-62.8%
Real estate operations	0.2	0.7	-66.9%
Administrative and auxiliary service activities	0.2	0.3	-27.1%
Art, entertainment, and recreation	0.2	0.2	-16.1%
Accommodation and catering services	0.1	0.1	13.8%
Information and communication activities	0.1	0.1	5.3%
Financial and insurance activities	0.04	0.1	-31.5%
Provision of other services	0.02	1.9	-99.0%

Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics

7.2. Financial contributions to GEF

Since March 30, 1998, Kazakhstan is a member of the Global Environmental Facility (GEF).

During this time, GEF has allocated funding of USD118,646,610 for 36 national level projects (total co-financing amount of USD994,659,756) and funding of USD674,326,919 for 36 regional/global level projects (total co-financing amount of USD4,306,315,409).[282]

STAR GEF-6 (2014-2018) funded projects address such challenges as:

- Land degradation (total allocated amount – USD5,134,631, disbursed – USD4,000,000 and USD1,134,631 – not disbursed);
- biodiversity (total allocated amount – USD5,043,171, disbursed – USD5,000,000 and USD43,171 – not disbursed);

[282] https://assembly.thegef.org/country/kazakhstan

– Climate change (total allocated amount – USD11,808,681, disbursed – USD10,917,700 and USD890,981 – not disbursed).

Total allocated funds are USD21,986,483, with USD19,917,700 disbursed and USD2,068,783 not disbursed.

Current STAR GEF-7 portfolio (2018-2022) includes eight projects [283] (Table 7.4).

[283] https://assembly.thegef.org/projects-faceted?f%5B0%5D=field_p_regionalcountrylist%3A83&f%5B1%5D=field_gef_period%3A881

Table 7.4. *Current STAR GEF-7 projects (2018–2022)*

GEF Project ID	Title	Country	Focal areas	Agencies	Project Type	GEF Project grant thousand USD	Co-financing total thousand USD	Status
10458	Global Cleantech Innovation Programme in Kazakhstan - Promoting cleantech innovation and entrepreneurship in SMEs for green jobs in Kazakhstan	Kazakhstan	Climate Change	United Nations Industrial Development Organization	Medium-size Project	1 775 000	25 850 000	Project approved
10408	Global Cleantech Innovation Programme (GCIP) to accelerate the uptake and investments in innovative cleantech solutions	Cambodia, Indonesia, Kazakhstan, Moldova, Morocco, Nigeria, South Africa, Türkiye, Ukraine, Uruguay, Global	Climate Change	United Nations Industrial Development Organization	PFD	17 972 633	137 960 110	Concept Proposed
10299	Kazakhstan Resilient Agroforestry and Rangeland Management Project	Kazakhstan	Climate Change, Land Degradation	The World Bank	Full-size Project	6 284 404	191 954 424	Project approved
10265	Promotion of sustainable food systems and improved ecosystems services in Northern Kazakhstan Landscape	Kazakhstan	Biodiversity, Land Degradation	United Nations Development Programme	Full-size Project	10 467 000	132 307 166	Project approved
10206	Sustainable Forest Management Impact Program on Dryland Sustainable Landscapes	Angola, Botswana, Burkina Faso, Kazakhstan, Kenya, Malawi, Mongolia, Mozambique, Namibia,	Biodiversity, Climate Change, Land Degradation	Food and Agriculture Organization	PFD	95 844 674	809 137 990	Concept Proposed

		Tanzania, Zimbabwe, Global						
10201	Food Systems, Land Use and Restoration (FOLUR) Impact Program	Brazil, Burundi, China, Cote d'Ivoire, Ethiopia, Ghana, Guatemala, Guinea, India, Indonesia, Kazakhstan, Kenya, Liberia, Madagascar, Malaysia, Mexico, Nicaragua, Nigeria, Papua New Guinea, Paraguay, Peru, Tanzania, Thailand, Uganda, Ukraine, Uzbekistan, Viet Nam, Global	Biodiversity, Climate Change, Land Degradation	The World Bank	PFD	306 439 005	2 734 077 390	Concept Proposed
10140	Development of Kazakhstan's Eighth National Communication and preparation of two (Fourth and Fifth) Biennial Reports to the UNFCCC	Kazakhstan	Climate Change	United Nations Development Programme	Enabling Activity	852 000	916 768	Project approved
10077	Strengthening the Resilience of Central Asian Countries by Enabling Regional Cooperation to Assess High Altitude Glacio-Nival Systems to Develop Integrated Methods for Sustainable Development and	Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan, Regional	International Waters	United Nations Development Programme	Full-size Project	6 192 694	30 218 890	Concept approved

	Adaptation to Climate Change							

International Green Technologies & Investments Center has been designated as the national operator of the three-year Global Cleantech Innovation Program (GCIP). The project started in February 2020 and is aimed at acceleration of promising 'green start-ups' in the following areas: RES, waste management, energy efficiency, green construction, water efficiency, transportation and advanced materials, and chemicals.

Kazakhstan is not in the list of donors to the GEF trust fund as of the reporting period.[284]

7.3. Contributions to the Adaptation Fund

On October 15, 2020, the Adaptation Fund Board approved a project proposal for Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan to reduce vulnerabilities associated with glacial lake outburst floods (GLOFs) in a changing climate in the Central Asian region. The project is being jointly developed by the United Nations and UNESCO. The project has received USD6,500,000 in funding.[285]

Kazakhstan is not on the list of donors to the Adaptation Fund as of the reporting period.[286]

7.4. Contributions to the Green Climate Fund

The Green Climate Fund is implementing two projects in Kazakhstan at a total cost of USD148,700,000 with co-financing of USD408,300:[287]

– FP140. High Impact Program for the Corporate Sector

This program is GCF's first at-scale investment to promote the uptake of low-carbon technologies in the industrial sector. It has been designed to facilitate a transformational shift within energy-intensive industries, agribusinesses, and the mining sector in Armenia, Jordan, Kazakhstan, Morocco, Serbia, Tunisia, and Uzbekistan. It seeks to forge a low-carbon pathway by promoting the uptake of high climate impact technologies and stimulating behavioral change at the corporate governance and management level. This includes integrating climate change considerations into strategic, financial, and technological decision making.

Program timeline: August 21, 2020 - August 27, 2027

– FP047. GCF-EBRD Kazakhstan Renewables Framework

The program entails support for the construction of 8-11 renewable energy projects in Kazakhstan with a total capacity of 330 MW.

Program timeline: October 2, 2017 - May 8, 2023

Kazakhstan is not on the list of donors to the Green Climate Fund as of the reporting period.[288]

7.5. Contributions to multilateral climate funds

The CIF (Climate Investment Funds) Investment Plan in Kazakhstan is designed to provide USD200 million in concessional financing for efforts to modernize district heating systems in targeted cities, including energy efficiency improvements and stimulating transformative investments in the untapped potential of renewable energy sources. The plan will also support the

[284] https://www.thegef.org/projects-operations/donor-countries
[285] https://www.adaptation-fund.org/wp-content/uploads/2020/10/AFB-Decision-B.35.a-35.b.83_Approval_of_proposal_for_Central-Asia.pdf
[286] https://www.adaptation-fund.org/about/partners-supporters/
[287] https://www.greenclimate.fund/countries/kazakhstan
[288] https://www.greenclimate.fund/about/resource-mobilisation/irm

legal and regulatory framework for renewable energy development and the construction of Kazakhstan's first major wind and solar projects with a total capacity of 100 MW.[289]

Table 7.5. *CIF Investment Plan in Kazakhstan*

Project title	Agency	Financing (USD million)	Co-financing (USD million)
BDF: Promoting Investment Roadmaps for Low-Carbon Infrastructure Development in Central Asia Regional Economic Cooperation Program Cities	Clean Technology Fund		
BDF: Renewable Energy Project Preparation	Clean Technology Fund		
District Heating Modernization Framework (DHMFF)	Clean Technology Fund	12.09	117.60
Kazakh Railways: Sustainable Energy Program	Clean Technology Fund	0.10	3.95
Renewable Energy Finance Facility (KAZREFF)	Clean Technology Fund	45.86	115.00
Renewable Energy Infrastructure Program	Clean Technology Fund	1.20	2.70
TAF: Capacity building for renewable energy integration in Kazakhstan	Scaling Up Renewable Energy Program in Low Income Countries (SREP)	0.75	
Waste Management Facility (KWMF)	Clean Technology Fund	3.02	374.84
Yermentau Large Wind Power Plant	Clean Technology Fund	0.10	97.20

Kazakhstan is not on the list of CIF donors as of the reporting period.[290]

Kazakhstan currently has three World Bank programs related to climate change. [291]

Table 7.6. *The World Bank programs related to climate change in Kazakhstan*

Title	Date	Financing, USD million	Co-financing, USD million
Kazakhstan Resilient Landscapes Restoration Project	June 14, 2021	4.34	
Second Irrigation and Drainage Improvement Project	June 27, 2013	102.9	240.11
Kazakhstan Energy Efficiency Project	May 22, 2013	21.76	1.30

Kazakhstan is not on the list of donors to the World Bank as of the reporting period.[292]

According to the Eurasian Development Bank's quarterly reviews, based on information from 15 international development banks, Kazakhstan received USD2.8 billion in financing in

[289] https://www.climateinvestmentfunds.org/country/kazakhstan
[290] https://www.climateinvestmentfunds.org/finances
[291] https://projects.worldbank.org/en/projects-operations/projects-list?countrycode_exact=KZ&os=0&status_exact=Active
[292] https://thedocs.worldbank.org/en/doc/5493abde11e71ece6d45a368d48b44a6-0410012020/original/ida19-contributors-list-april-2020.pdf

2020, with USD1.8 billion in sovereign loans and another USD1 billion in private sector financing.[293]

Table 7.7. *Quarterly Review of the Eurasian Development Bank, 2020*

Total funding from development banks, USD billion	**Sovereign loans, USD billion**	**Private sector financing, USD billion**
2.8	1.8	1

The volume of financing increased by 35.4% in Kazakhstan in one year. At the same time, sovereign funding, technical assistance, and grants increased from USD1 million to USD1.8 billion. However, financing in the private sector in Kazakhstan has decreased by 2 times.

The largest development banks that approved financing in Kazakhstan were the Asian Development Bank - ADB (USD1 billion) and the Asian Infrastructure Investment Bank - AIIB (USD750 million). ADB provided financing to mitigate the social, economic and health sector impacts of the COVID-19 pandemic, while AIIB approved a loan to provide budget support to mitigate the negative impacts of the COVID-19 pandemic.

Table 7.8. *Financing received by Kazakhstan from international development banks, USD billion*

ADB	**AIIB**	**EBRD**	**EDB**
1 003.2	750	604,6	437

Kazakhstan has been a member of the EBRD since July 27, 1992. Kazakhstan's share in the authorized capital of the EBRD is 69 million EUR (0.23 %). In total, the EBRD has financed more than 300 projects worth over €8 billion during the period of its operations in Kazakhstan.

In May 2014, the Government of Kazakhstan signed Framework Partnership Agreements with international financial institutions for 2014-2017 (EBRD, World Bank, ADB, IDB), which provide financial and technical support to Kazakhstan to ensure sustainable economic growth and structural reforms. In December 2017, the Government of Kazakhstan and the EBRD signed a new three-year agreement, which is a continuation of the Enhanced Partnership Framework Agreement and will give great impetus to joint activities between the EBRD and Kazakhstan in municipal infrastructure, green economy and renewable energy development, improvement of Kazakhstan's global competitiveness, preparation for privatization in the country and many other areas.

New energy efficiency and green technology projects emerged in the EBRD's portfolio in Kazakhstan during this period.[294]

Table 7.9. *EBRD projects in Kazakhstan in 2019-2021*

Date	**Title**	**Category**	**Status**
9 Nov 2021	Borey Wind	Private	Concept Reviewed
6 Aug 2021	Almaty Electric Public Transport	State	Concept Reviewed
8 Jun 2021	Ust-Kamenogorsk Solid Waste Management	State	Signed
28 Dec 2020	Semey Solid Waste Management	State	Signed
11 Nov 2020	Integrated Approach MREK II	Private	Signed

[293] https://kapital.kz/finance/98440/finansirovaniye-bankov-razvitiya-v-stranakh-tsa-vyroslo-za-god-v-poltora-raza.html
[294] https://www.ebrd.com/work-with-us/project-finance/project-summary-documents.html?c15=on&s2=on&s8=on&d0=on&d6=on&d12=on&keywordSearch=

1 Oct 2020	Shymkent Water II	Private	Complete
3 Sep 2020	Risen Solar	Private	Repaying
4 Aug 2020	Zhanatas Wind Farm	Private	Disbursing
30 Jun 2020	Karaganda Solar Phase II	Private	Repaying
6 Apr 2020	KazTransGas Solidarity Loan	State	Signed
20 Jun 2019	Kazakhstan Renewables Framework Phase II	Private	Approved
19 Mar 2019	Universal Energy Zhangiz Solar	Private	Repaying

Table 7.10 breaks down the main EBRD Banking credit risk exposures in their carrying amounts for Kazakhstan.

Table 7.10. Distribution of credit risk in the EBRD Banking portfolio in Kazakhstan

Year	Loans, € million	Undrawn loan commitments and guarantees, € million	Total, € million
2019[295]	1 685	917	2 602
2020[296]	1 589	838	2427

A statement of capital subscriptions showing the amount of paid-in and callable shares subscribed to by Kazakhstan, together with the number of votes, is set out in the Table 7.11.

Table 7.11. *The Statement of capital subscriptions for Kazakhstan as an EBRD shareholder*

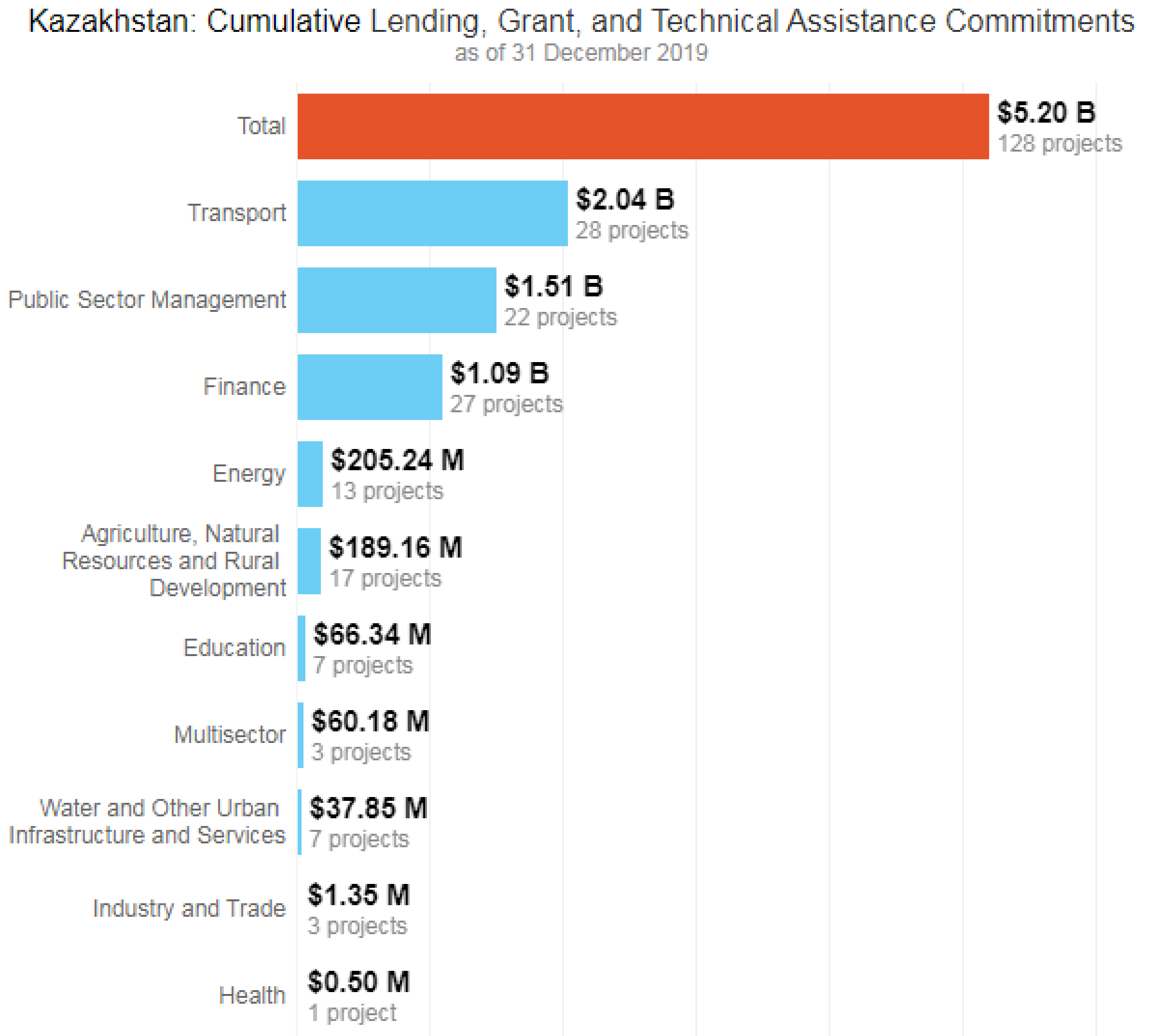
Year	Total shares (number)	Resulting votes (number)	Total capital, € million	Callable capital, € million	Paid-in capital, € million
2019[297]	6 902	6 902	69.02	54.62	14.40
2020[298]	6 902	6 902	69.02	54.62	14.40

Kazakhstan became an ADB member in 1994. Over the past 27 years, ADB has assisted Kazakhstan through financing, technical assistance, and knowledge support in its country operations. Priority areas of investment have included budget support, the transport sector, the financial sector, agriculture, and renewable energy.

ADB's current activities in Kazakhstan are carried out under the Country Partnership Strategy for 2017-2021, which includes three pillars: economic diversification, inclusive development, and sustainable growth. Kazakhstan is an active participant in the Central Asia Regional Economic Cooperation (CAREC) Program, with the largest portfolio among member countries at USD9 billion, including USD2 billion financed by ADB.

295 https://www.ebrd.com › financial-report-2019-russian
296 https://www.ebrd.com › financial-report-2020-russian
297 https://www.ebrd.com › financial-report-2019-russian
298 https://www.ebrd.com › financial-report-2020-russian

Figure 7.2



Source: Asian Development Bank. ADB and Kazakhstan: Fact Sheet (May 2020)

Table 7.12. *ADB's portfolio of climate projects in Kazakhstan* [299]

Title	Description	Sector	Partners	Cost	Status
Advanced Gas Metering Project	The proposed loan will enable the borrower to procure and install up to 1 million advanced smart gas meters across Kazakhstan	Energy	KazTransGaz JSC	KZT42,558 mln	Approved
Supporting Renewable Technology-Inclusive Heat Supply Legislation	The knowledge and support technical assistance will support the development of the renewable technology-inclusive heat supply legislation for the Republic of Kazakhstan	Energy	1) Republic of Korea e-Asia and Knowledge Partnership Fund 2) Clean Energy Fund under the Clean Energy Financing	1. USD500 000 2. USD1 mln 3. USD300 000	Active

[299] https://www.adb.org/projects/country/kaz/theme/environmentally-sustainable-growth-1666/status/approved-1359/status/active-1367

			Partnership Facility 3) Technical Assistance Special Fund		
Preparing the Green Investments Finance Project	Technical Assistance	Finance	Financial Sector Development Partnership Special Fund	USD225,000	Active
Developing the Central Asia Regional Economic Cooperation Water Pillar	The Technical Assistance (TA) will support the development of the CAREC water pillar, with an emphasis on economic aspects and sustainable financing of water resources management	Agriculture natural resources and rural development	Technical Assistance Special Fund	USD413,000	Active
Regional: Preparing Sustainable Energy Projects in Central Asia	The TA Facility will provide high-level screening, due diligence, and formulation of the components for the Sector Development Project in Kazakhstan.	Energy	1) Technical Assistance Special Fund 2) People's Republic of China Poverty Reduction and Regional Cooperation Fund	1) USD175,000 2) USD1,60 mln	Active
Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System - Modernization of Coordinating Dispatch Center Energiya (Subproject 1)	The technical assistance (TA) subproject will have the following outcome: cross-border clean energy trade increased using high-level technology (HLT) by coordinating dispatch center (CDC) Energiya.	Energy	1) Asian Clean Energy Fund under the Clean Energy Financing Partnership Facility 2) Technical Assistance Special Fund 3) High Level Technology Fund 4) Regional Cooperation and Integration Fund	1) USD1 mln 2) USD750 000 3) USD1 mln 4) USD450 000	Active
Total Eren Access M-KAT Solar Power Project	The project comprises the design, construction, commissioning, and operations and maintenance (O&M) of a 100-megawatt (MW) (direct current) ground-mounted, solar power plant with single axis tracking system (along with associated infrastructure) and grid integration for further electricity sale per a fixed tariff.	Energy	M-KAT Green Limited Liability Partnership - borrower	KZT15,310 mln	Active

Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System	The regional knowledge and support technical assistance cluster will support an increase in regional power trade among Afghanistan, Kazakhstan, the Kyrgyz Republic, Tajikistan, Uzbekistan, and Turkmenistan	Energy	1) Technical Assistance Special Fund 2) High Level Technology Fund 3) Regional Cooperation and Integration Fund 4) Asian Clean Energy Fund under the Clean Energy Financing Partnership Facility	1) USD2,550 mln 2) USD1 mln. 3) USD1,050 mln 4) USD1 mln	Active
Supporting Environmental Safeguards in the Central and West Asia Region	This technical assistance (TA) is to foster more effective infrastructure development in the Central West Asia developing member countries (DMCs) by improving their environmental safeguards performance.	Agriculture natural resources and rural development	Technical Assistance Special Fund	USD2,087 mln	Active
Astana Integrated Water Master Plan	Integrated water resources management (IWRM) is a holistic approach to integrating water resources management within the broader environmental, socioeconomic, and political framework	Agriculture natural resources and rural development	Japan Fund for Poverty Reduction	USD1,2 mln	Active
Promoting Low-Carbon Development in Central Asia Regional Economic Cooperation Program Cities	This regional capacity development technical assistance (TA) aims to support cities in Central Asia Regional Economic Cooperation (CAREC) program countries to strengthen their capacity to undertake climate actions to further enhance sustainable, inclusive, and prosperous economic development.	Energy	1) Regional Cooperation and Integration Fund 2) Republic of Korea e-Asia and Knowledge Partnership Fund 3) People's Republic of China Poverty Reduction and Regional Cooperation Fund 4) Clean Energy Fund under the Clean Energy Financing Partnership Facility	1) USD500 000 2) USD500 000 3) USD700 000 4) USD800 000 5) USD348 000 6) USD700 000	Active

			5) Governance Cooperation Fund 6) Clean Technology Fund		
Baikonyr Solar Power Project	The project comprises construction, commissioning, and operations of a 50-megawatt solar power plant and its grid integration for further electricity sale per a fixed tariff.	Energy	Loan	KZT4,140 mln	Active

Kazakhstan: 2020 Loans, Grants, Equity Investments, Technical Assistance, and Trade and Supply Chain Finance and Microfinance Program Commitments (USD million):[300]

Table 7.13. *Kazakhstan ADB commitments by type of product*

Product	Sovereign	Non-sovereign	Total
Loans	1,227.57	-	1,227.57
Grants	3.00	-	3.00
Technical assistance	12.61	0.33	12.94
Total	1,243.17	0.33	1,243.51

Kazakhstan: 2020 Loans, Grants, Equity Investments, Technical Assistance, and Trade and Supply Chain Finance and Microfinance Program Commitments (USD million):

Table 7.14. *Kazakhstan ADB commitments by sector*

Sector	Number	Total amount	% of total amount
Projects and technical assistance	142	6,545.95	99.77
Agriculture, natural resource, and rural development	19	190.32	2.90
Education	8	67.34	1.03
Energy	14	207.08	3.16
Finance	29	1,195.61	18.22
Health	2	6.04	0.09
Industry and trade	3	2.01	0.03
Information and communication technology	-	0.23	0.00
Multisector	3	60.29	0.92
Public sector management	26	2,589.46	39.47
Transport	31	2,189.12	33.37
Water and other urban infrastructure and services	7	38.46	0.59
Trade and Supply Chain Finance and Microfinance	24	15.02	0.23
Finance	13	7.51	0.11
Industry and trade	11	7.51	0.11
Total	166	6,560.97	100.00

ADB began co-financing operations in Kazakhstan in 1999. Since then, sovereign co-financing commitments to Kazakhstan have been USD4.58 billion for six investment projects and USD7.15 million for nine technical assistance projects. Non-sovereign co-financing for

300 https://www.adb.org/sites/default/files/publication/59610/kaz-2020-ru.pdf

Kazakhstan is USD134.02 million for three investment projects. In 2020, Kazakhstan received co-financing from the Asian Infrastructure Investment Bank in the form of a USD750 million loan under the COVID-19 Active Response and Expenditure Support Program.

Table 7.15. *Co-financing of ADB projects by Kazakhstan for the period from January 1, 2016, to December 31, 2020:*

Co-financing	**Number of projects**	**Amount, USD mln**
Sovereign	8	2,028.20
Loans	3	2,023.00
Technical assistance	5	5.20
Non-sovereign	3	131.88

Table 7.16. *Total ADB financing of non-sovereign operations by product*

	2020	**2016–2020**
Number of Transactions Signed (OCR)	-	3
Number of Transactions Signed (Programs)	-	17
		Amount (USD million)
Loans	-	161.25
Equity Investments	-	-
Guarantees	-	-
Trade and Supply Chain Finance Program and Microfinance Program	-	11.67
Total	-	172.92

The AIIB has 57-member states, including Kazakhstan. The main goal of the Bank is to stimulate financial cooperation in the Asia-Pacific region, as well as to finance infrastructure projects in Asia. In 2019, a number of discussions were held with Kazakhstan's government and the Bank's representatives on the AIIB project financing facility in the country.

Currently, the AIIB has approved one non-sovereign project in Kazakhstan in the field of climate change (energy sector). It is the Zhanatas 100 MW wind farm at a cost of USD46.7 million. The project will involve the development, construction, and operation of a 100 MW Zhanatas wind farm worth USD46.7 million, where the AIIB loan is about USD46.7 million and the rest is to be financed by sponsors and other financial institutions.[301] The project involves the design, construction, and operation of a 100 MW wind farm in South Kazakhstan, about 9 km southwest of Zhanatas in Zhambyl oblast.

Eurasian Development Bank (EDB) is an international financial institution designed to promote economic growth of member states, expansion of trade and economic relations between them and development of integration processes in the Eurasian space by carrying out investment activities.

The Bank was founded based on the intergovernmental agreement signed on January 12, 2006, by authorized representatives of the Russian Federation and the Republic of Kazakhstan. The initiative to create the Bank belongs to the presidents of Russia and Kazakhstan.

In the structure of the country's investment portfolio, Kazakhstan accounts for 36.1%.[302]

[301] https://www.aiib.org/en/projects/approved/2019/_download/kazakhstan/Kazakhstan-100-MW-Zhantas-Wind-Power-Project.pdf
[302] https://eabr.org/about/facts-and-figures/

2019, the Bank financed the Sary-Arka gas pipeline project by assuming financial liabilities of AstanaGas KMG JSC in the amount of KZT102 billion.[303]

In 2013-2019, the Bank financed a 45 MW wind-powered generating plant in Yerementau at a cost of KZT14.167 billion.

From 2010 to date, USD385 million has been allocated for the expansion and reconstruction of Ekibastuz SDPP-2 Plant.

Since 2015, KZT7.7 billion has been allocated to finance the improvement and construction of the gas distribution network in Aktobe oblast under the investment program of KazTransGas Aimak JSC.

7.6. Official development assistance provided by Kazakhstan to foreign countries

Kazakhstan assists developing countries as part of the implementation of 'Official Development Assistance' Law dated December 10, 2014, and in accordance with the status of invitee in the development assistance Committee (hereinafter DAC) of the OECD.

The total amount of official development assistance (hereinafter - ODA) provided by Kazakhstan to foreign countries through bilateral and multilateral channels in 2019 was USD34.21 million[304].

Out of this amount, USD26.73 million in assistance was provided to the following countries in the form of commodity assistance and educational grants:

- Tajikistan (USD1,727,101),
- Afghanistan (USD212,124),
- Kyrgyzstan (USD141,705),
- Mongolia (USD46,166),
- Ukraine (USD28,871),
- Türkiye (USD14,587),
- Egypt (USD9,339),
- Vietnam (USD8,681),
- Belarus (USD5,551),
- Azerbaijan (USD1,815),
- Central Asian countries (USD639,379),
- developing Asian countries (USD1,037,676),
- Far East Asian countries (USD54,848),
- Other developing countries (USD22,859,000).

This amount is transferred to the above-mentioned countries for the purpose of development assistance, and in such focus areas as:

- social infrastructure - USD19,330,000 (including education - USD770,000, health - USD2,000,000, water and sanitation - USD1,000, public administration and civil society - USD14,760,000, conflict resolution and security - USD1,030,000 and other social infrastructure - USD76,000);

[303] https://eabr.org/en/projects/eabr/

[304] https://stats.oecd.org/qwids/#?x=1&y=6&f=4:1,2:1,3:51,5:3,7:1&q=4:1+2:1+3:51+5:3+7:1+1:204+6:2012,2013,2014,2015,2016,2017,2018,2019

– economic infrastructure - USD2,500,000 (transportation, communications, and power supply);

– manufacturing sector - USD52,000 (agriculture, fisheries, industry);

– multi-sector/ cross-cutting sector - USD61,000 (environmental and other multidisciplinary sectors);

– commodity/program assistance - USD2,170,000 (food assistance, etc.);

– humanitarian aid - USD12,000 (emergency response for recovery and reconstruction, and disaster prevention);

– other types of assistance - USD1,480,000.

The remainder of ODA in the amount of USD7,480,000 was transferred as voluntary and mandatory contributions to various regional international organizations to aid the development of developing countries.

Kazakhstan's contribution, under the UNFCCC Convention for 2020, amounted to €45,530.[305]

Kazakhstan's contribution under the Kyoto Protocol for 2020 was EUR6,724.[306]

Voluntary contributions of Kazakhstan to UNEP amounted to:[307]

– 2020: USD100 000;

– 2021: USD100 000.

Kazakhstan's voluntary contributions to the United Nations amounted to:

– 2020: USD4,993,497;[308]

– 2021: USD5,148,755.[309]

On December 15, 2020, KazAID Kazakhstan International Development Agency was established by the decision of the Government of the Republic of Kazakhstan. The authorized body in the field of official development assistance is the Ministry of Foreign Affairs of the Republic of Kazakhstan.

Challenges of global development, national capacity and available resources were considered in determining the geographical priorities of the ODA of Kazakhstan. Kazakhstan has decided to prioritize development assistance to Central Asian countries and Afghanistan.

At the same time, to achieve maximum synergy in the activities of Kazakhstan as part of the global ODA development efforts, Kazakhstan's ODA system can also be focused on the Caucasus region, Africa, Latin America, Small Island Developing States, least developed countries, landlocked countries, as well as other regions.

Official development assistance is provided to support:

1) further integration of Kazakhstan into the system of regional and international relations;

2) creation of favorable external conditions for the successful implementation of strategies and development programs of Kazakhstan;

3) strengthening of peace, regional and global security;

4) socio-economic development of the partner country and improvement of the welfare of its citizens;

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305 https://unfccc.int/sites/default/files/resource/sbi2021_inf01.pdf
306 https://unfccc.int/sites/default/files/resource/sbi2021_inf01.pdf
307 https://www.unep.org/about-un-environment/funding-and-partnerships/check-your-contributions
308 https://www.un.org/en/ga/contributions/honourroll_2020.shtml
309 https://www.un.org/en/ga/contributions/honourroll.shtml

5) gradual transition of the partner country to priority implementation of environmental protection and climate action.

The official development assistance objectives are:

1) to contribute to the achievement of international goals in the sphere of official development assistance supported by Kazakhstan;
2) to ensure national security of Kazakhstan;
3) to develop political, economic, educational, social, cultural, scientific, and other relations of Kazakhstan with a partner country;
4) assistance in the development of a partner country determined in view of national interests of Kazakhstan and international situation;
5) development of regional cooperation and assistance in addressing regional challenges;
6) reduction of poverty;
7) assistance in addressing environmental and climate actions;
8) addressing other issues in the framework of international treaties and other commitments of Kazakhstan in the area of official development assistance.

Official development assistance is allocated to the following sectors of the partner country:

1) agriculture and food security;
2) environmental protection, including promotion of global and regional environmental initiatives;
3) rational use of natural resources;
4) promotion of solutions to transboundary water problems;
5) facilitation of border crossing procedures;
6) conflict prevention and security;
7) countering illicit drug trafficking and transnational organized crime, including human trafficking, illegal migration, and illicit arms trafficking;
8) education and science;
9) public health;
10) improvement of the public administration system;
11) support of entrepreneurship and improvement of the business climate;
12) development of regional and international trade, by improving the access of landlocked countries to transport and other infrastructure;
13) other sectors determined by the main directions of the state policy of Kazakhstan in the sphere of official development assistance.

Official development assistance comes in the following forms:

1) international grants;
2) creation (construction) of new or reconstruction of existing facilities in priority sectors;
3) loans on concessional terms;
4) voluntary contributions to international organizations for official development assistance;
5) establishment of joint funds with partner countries;
6) technical assistance;
7) other forms accepted by Kazakhstan in the frameworks of international treaties and other commitments in the sphere of official development assistance.

To develop international cooperation in the field of ODA, meaningful partnerships have been established with key donors and international development institutions. That includes cooperation with UNDP, USAID, Japan International Cooperation Agency JICA, German Society for International Cooperation and Development GIZ, Korean International Cooperation Agency KOICA, Slovak International Development Agency SlovakAID, Czech International Development Agency CzDA.

In 2018, a project was implemented to enable foreign students to study at the Nazarbayev University through the ODA facility. This project provided educational grants for Central Asian countries and Afghanistan for the 2018-2020 and 2020-2022 academic years.

In 2020, Kazakhstan jointly with UNDP and UNODC implemented a project to equip Tajikistan's penitentiary institutions with security equipment.

Over the past 20 years Kazakhstan has allocated more than USD542 million to foreign countries. Over the past 20 years Kazakhstan has allocated USD542 million to foreign countries for purposes similar to official development assistance[310].

B. Technology development and transfer

Regional workshop on the Development Finance Assessment in the framework of the regional platform on Sustainable Development Goals (SDGs) in Central Asia was held on December 8, 2021. The main objective of the Regional Workshop on the Development Finance Assessment (DFA) was to provide an overview of the DFA tool, which is an integral element of the first building block of the Integrated National Financing Facility 'Assessment and Diagnostics". The national partners from Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan presented their approaches and experience in conducting DFA and the potential benefits of this process for monitoring and forecasting of financial flows relevant for achieving the SDGs.

On November 25, 2021, Kazakhstan hosted the International Environmental Forum 'Kazakhstan - Benelux', it was organized by the Benelux Chamber of Commerce together with the KAZENERGY Association and the EcoJer Kazakh Association of Regional Environmental Initiatives. The Forum discussed global environmental issues, the tools needed to reduce the negative impact of industry on the environment, the development of green energy and technologies for a low-carbon economy, including industrial waste management.

Furthermore, Qazaq Green RES Association held a round table on "The current situation in the power industry of Kazakhstan: challenges and solutions" in November 2021. The round table covered the important topics and problems for the industry: the growing energy shortage, the needs of the economy in electricity, the impact of new trends in generation (RES with energy storage systems) and consumption (digital mining of cryptocurrencies) on the power sector, the need for new shunting capacity, the use of market mechanisms (demand management, balancing market), issues of investment in the electricity sector, the goal of carbon neutrality and readiness of both the government and businesses for the transformation in the sector.

On November 18, 2021, the Ministry of Energy of the Republic of Kazakhstan hosted a discussion of the prospective electricity balance of Kazakhstan and the sustainable development of the energy sector until 2035. Developers of the draft of Energy Balance of the Republic of Kazakhstan until 2035 together with the national system operator KEGOC JSC provided the working group of the authorized body with the calculated vision of optimal placement of new

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310 https://www.gov.kz/memleket/entities/mfa-frankfurt/press/news/details/166862?lang=ru

capacities and reconstruction of the existing generation facilities to ensure the dynamic growth of electricity consumption in Kazakhstan.

On November 11, 2021, a meeting of the Coordinating Council for Ecology and Low-Carbon Development was held under the chairmanship of Mr. Dastan Abdulgafarov, Deputy Chairman of the Board for Strategy, Investment and Business Development of NC KazMunayGas JSC. The Coordinating Council was attended by over 90 representatives of companies in the energy, oil and gas sector, government agencies and organizations, etc. The meeting discussed the Emission Trading Scheme in the framework of the National Carbon Plan 2022-2025; processes of development, approval of BAT Reference Documents and further implementation of the best available techniques.

The annual meeting of the World Energy Council (WEC) Executive Assembly was held online on November 2, 2021, and it was attended by representatives of the National Committees of the member countries of the organization. The Kazakhstan National Committee of the WEC was represented by its Secretary, Executive Director of the KAZENERGY Association – Mr. Talgat Karashev.

On October 26, 2021, Uralsk hosted the IV International Environmental Uralsk Green Forum organized by Karachaganak Petroleum Operating B.V. (KPO) together with the West Kazakhstan Oblast Akimat. The forum was attended by representatives of oil and gas producing companies, experts in waste management and ‘green transformation’, regional companies engaged in waste recycling, and heads of relevant ministries and agencies. The main topic was the discussion of current issues in the field of waste management as an important factor in the sustainable development of the West Kazakhstan oblast, the new principles of environmental legislation in the field of waste management, increasing levels of waste recycling and the development of green businesses in the region.

On October 13, 2021, President Kassym-Jomart Tokayev attended the international conference on the ways to achieve the goals of the Paris Agreement and carbon neutrality of Kazakhstan, which was held in Astana. The President noted that Kazakhstan's transition to a low-carbon economy will require decisive measures, large financial investments, and consolidated efforts of the whole society. Tokayev spoke about the large-scale gasification of the country, the potential for the development of renewable and alternative energy and green finance, as well as measures to address hydrological and environmental problems of transboundary rivers.

In October 2021, Astana hosted the World Energy Week and the XIV KazEnergy Eurasian Forum, which was attended by 90 countries. As part of the Forum, the Head of State delivered a video address at the global plenary session ‘World Energy Trilemma 2021 - Balancing Dimensions: Navigating Change across Energy Geographies". While speaking about the national priorities and commitments in this direction, President Tokayev emphasized Kazakhstan's strong commitment to global efforts to combat climate change and the goals of the Paris Agreement. The Forum also discussed partnership prospects and opportunities for improving energy security in the Central Asian countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, especially in the field of electricity and water resources management.

On October 26, 2021, Kazakhstan presented its experience in implementing solutions to transform public and private sector finances to reduce the negative impact on nature at the global Nature for Life Hub, organized by the UNDP, the UN Environment Program, the Secretariat of the Convention on Biological Diversity, and other partners.

Every year the KAZENERGY Association and Shell Kazakhstan organize the Student Energy Challenge-Junior competition in Kazakhstan. The competition is focused on the development of ideas covering energy, oil and gas and mining industries, environmental protection, and ecology.

In August 2021, Kazakhstan hosted the International Forum on Decarbonization of Extractive Industry and Carbon Border Adjustment Mechanism (CBAM). The forum discussed international experience of decarbonization of the basic industries and the feasibility of possible ways to decarbonize the national economy. The event was organized by the EU Delegation in Kazakhstan, Minister of Ecology, Geology and Natural Resources, Green Academy SEC, Atameken National Chamber of Entrepreneurs with the support of GIZ.

In July 2021, the first auction bidding for the selection of Waste-to-Energy projects with a total capacity of 100.8 MW was successfully held on the KOREM JSC trading platform. In 2020, Kazakhstan adopted its first legislative initiatives providing incentives for Waste-to-Energy projects. The changes affected the norms of the legislation of Kazakhstan in the field of ecology and energy, which assume the possibility of implementing the Waste-to-Energy project to convert MSW into energy. In order to increase the investment attractiveness of the new Waste-to-Energy (WtE) sector and create a holistic infrastructure for waste management, the use of a similar mechanism operating in the field of renewable energy sources is envisaged. The application of the mechanism of auction bidding for the selection of WEEE projects enables the creation of a competitive field, lower prices, and the selection of the most viable projects.

On July 8, 2021, the International Renewable Energy Agency (IRENA) hosted a Virtual Webinar on ‘Advancing the Energy Transition in Central Asia through Nationally Determined Contributions (NDCs) and Long-Term Strategies (LTS)’. The main objectives of the webinar were to identify solutions to improve energy efficiency in Central Asian countries, including presentation of updated long-term climate/energy strategies, enhance understanding of energy sector opportunities for increased decarbonization; discuss the key role of large-scale financing for renewable energy; and discuss research by regional and international organizations on decarbonization issues.

On June 28, 2021, an online-meeting was held with participation of the Secretary General of the World Energy Council – A. Wilkinson and representatives of the Kazakhstan National Committee under the WEC – Chairman of the Board of Samruk-Energy JSC – S. Yesimkhanov and General Director of the KAZENERGY Association – K. Ibrashev. The parties discussed issues of bilateral cooperation, participation of Kazakhstan National Committee in WEC projects, as well as upcoming events.

‘Women in ecology and sustainable initiatives’ session was held on June 3, 2021, within the framework of the ECOJER International climate congress ‘Shape a Sustainable Future”. The speakers were deputies of the Mazhilis of the Parliament of Kazakhstan, representatives of the Presidential National Commission for Women, Family and Demographic Policy, the European Union Delegation in Kazakhstan, KAZENERGY Association, Damu Entrepreneurship Development Fund, business, and social organizations. The participants of the session noted the importance and relevance of commitment to the SDG principles and discussed the trends and issues of gender balance in the field of sustainable development and the environment.

On May 30, 2021, Astana hosted Green Economy – the paradigm of innovative and sustainable development of Kazakhstan round table, organized by the Elbasy Library in cooperation with the UN Partnership for Action on Green Economy (PAGE) and the Ministry of

Ecology, Geology and Natural Resources of the Republic of Kazakhstan. The event was attended by the Chairperson of the Presidium of the Association of Ecological Organizations of Kazakhstan A. Nazarbayeva, Director of the Elbasy Library B. Temirbolat, Minister of Ecology, Geology and Natural Resources of Kazakhstan M. Mirzagaliyev, member of the UN PAGE Board of Directors, Director of UNITAR's Division for Planet A. MacKay, Deputy of the Majilis of the Parliament of Kazakhstan Y. Abakanov, Professor of Lomonosov Moscow State University, Academician of the Russian Ecological Academy S. Bobylev, UNDP Resident Coordinator in Kazakhstan Y. Berish and other well-known figures and experts in the field of environmental protection and conservation, as well as representatives of territorial departments of the Ministry of Ecology, Geology and Natural Resources of Kazakhstan, youth work teams ‘Zhassyl Yel’, master and PhD students of the departments of ecology and biology of Kazakh universities and volunteers of the Elbasy Library.

On April 27-28, 2021, a national seminar was held with the participation of representatives of the Presidential National Commission for Women, Family and Demographic Policy, ministries, the renewable energy sector, the energy sector, and education. The seminar was organized within the framework of the EBRD project to support renewable energy and promote gender equality in Kazakhstan under the auspices of the second phase of the EBRD's Kazakhstan Renewable Energy Financing Facility, by EY together with Ergon Associates.

At the 6th Annual International Climate Bonds Awards 2021, Damu Entrepreneurship Development Fund (Damu Fund) of Kazakhstan was recognized as one of the leading organizations in the world promoting green finance. This annual award recognizes the leading organizations, financial institutions and governments that promote the green finance market. The ‘Green Market Pioneer’ award was received by the Damu Fund for the issue of green bonds placed on the Astana International Exchange (AIX) platform with the support of the United Nations Development Programme (UNDP) in Kazakhstan on August 11, 2020.

On January 2, 2021, the President of Kazakhstan Kassym-Jomart Tokayev signed the new Environmental Code of the Republic of Kazakhstan. This document includes legal norms aimed at the conservation and sustainable use of biodiversity on the principle of equitable distribution of and access to environmental goods and services. Among these norms are compensations for loss of biodiversity, voluntary payments for ecosystem services, principles of sustainable ecological tourism and competence of the authorized body represented by the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan to develop and approve methods for calculation of greenhouse gas emissions and absorption, including the forestry sector.

In November 2020, UNDP together with the Government of Kazakhstan began developing GIS tools to promote conservation and sustainable land use as part of the global project Mapping Nature for People and Planet, aimed at identifying Essential Life Support Areas (ELSA). The workshop with the participation of representatives of the Forestry Committee of the MEGNR RK, the Information and Analytical Center for Environmental Protection, Protected areas of Kazakhstan summed up the results of joint work on Phase II of the project to map ELSA in the online mode. As part of the workshop, the working group on national databases reviewed the capabilities of systematic environmental planning programs such as PrioritizR, Marxan and Zonation, and identified the data needed to monitor progress in the main areas of life support in Kazakhstan.

VIII. RESEARCH AND SYSTEMATIC OBSERVATIONS

A. General research and systematic observation policy and funding

A new version of the Environmental Code of the Republic of Kazakhstan came into force in 2021, the new Code includes a new chapter – ‘State management in the sphere of adaptation to climate change’, covering such topics as: 1) information collection and climate change vulnerability assessment; 2) climate change adaptation planning; 3) development of climate change adaptation measures; 4) implementation of climate change adaptation measures; 5) monitoring and evaluation of effectiveness of climate change adaptation measures; 6) reporting on climate change impacts and effectiveness of climate change adaptation measures; 7) adjustment of climate change adaptation measures based on monitoring and evaluation results.

According to Article 315 of the Environmental Code, section ‘Information collection and climate change vulnerability assessment requirements”, the climate change vulnerability assessment is based on the collection of information and data on:

1) current and past climate trends and events;
2) future climate change forecasts;
3) current and past climate impacts;
4) projected climate change impacts.

Climatic data series with sufficient spatial resolution and coverage are necessary for decision-making in planning and management of various sectors of the economy that are sensitive to climate impacts.

Climate observations in Kazakhstan are conducted within the budget program № 039 of the Ministry of Ecology, Geology and Natural Resources ‘Development of hydrometeorological and environmental monitoring’ (Table), which has two subprograms: № 039-100 ‘Conducting observations of environmental conditions”, № 039-102 ‘Conducting hydrometeorological monitoring”. The objectives of the program are:

- collection of hydrometeorological and environmental data through monitoring and development of the network of stations, including their technological re-equipment and improvement of metrological support of observations;
- development of technologies for collection, processing, and dissemination of data of operational and routine observations, including maintenance and development of the National Fund of data on hydrometeorology and environmental pollution;
- maintenance and management of climatic data, including preparation of regime and reference information and provision of climatic information to the population and various sectors of economy for use in forecasting purposes.

Table 8.1. *Budget of program # 039 ‘Development of hydrometeorological and environmental monitoring”, KZT*

	2014	2015	2016	2017	2018	2019	2020	2021
039 ‘Development of hydrometeorological and environmental monitoring’	7,012,634	5,479,731	5,718,125	5,742,451	5,757,922	7,804,441	7,799,132	7,804,223
100 ‘Conducting environmental observations’	2,230,164	1,370,119	1,642,763	1,585,583	1,517,082	1,794,177	1,794,278	1,794,278

102 'Maintenance of hydrometeorological monitoring'	4,782,470	4,109,612	4,075,362	4,156,868	4,240,840	6,010,264	6,004,854	6,009,945

Systematic climate observations are made by Kazhydromet Republican State Enterprise (RSE) that is a structural division of the RK Ministry of Energy. RSE is made up of 15 branches located in all oblast centers of Kazakhstan and in Almaty.

The National Hydro-Meteorological Service provides environmental monitoring, meteorological and hydrological monitoring using the state observation network, which includes the provision of services of national and international importance, and special purpose services as well as the preparation of specialized information.

Services of national and international importance are the services that are important for the security of the population and the state, sustainable functioning of the economy and social sphere, provided using the state observation network.

Special purpose services are services in the field of meteorological and hydrological monitoring, environmental monitoring, not related to services of national and international importance and rendered with the use of data of the state observation network on the basis of paid contracts for the provision of services.

Specialized information - targeted information obtained as a result of the provision of services of special purpose using data from the state observation network.

Hydro-meteorological network of Kazakhstan consists of 341 weather meteorological, including 228 conventional meteorological stations (hereinafter - MS) and 119 automatic stations (hereinafter - AMS). Aerological observations are carried out at 9 aerological stations. 241 meteorological stations (213 MS and 28 AMS) transfers information on a daily basis to the Global Observing System of the World Meteorological Organization (WMO). Forty-two meteorological stations belong to the WMO Regional Basic Climatological Network. The hydrological network consists of 377 observation sites - 330 river, 37 lake, 7 sea stations and 3 hydrometeorological stations. In addition, Kazhydromet RSE provides information on agrometeorological and ecological state of environment.

The Institute of Geography and Water Security JSC of the Ministry of Education and Science (MES) of the Republic of Kazakhstan conducts studies to assess and of Kazakhstan surface water resources with due regard to climate change and economic activity. The problem of drought monitoring for agricultural purposes is also addressed by the National Center for Space Research and Technology JSC. Studies of natural hazards in mountainous areas and glaciological studies are also conducted by the Institute of Geography and Water Security Joint Stock Company of the Ministry of Education and Science of Kazakhstan. Monitoring of areas prone to mudflows and landslides is conducted by Kazhydromet RSE and posts of the Observation and Alert Service of Kazselezaschita State Enterprise of the Ministry of Emergency Situations of the Republic of Kazakhstan.

8.1.International cooperation

International cooperation with the National Hydrometeorological Services of various countries is carried out within the framework of bilateral and multilateral agreements, memorandums, cooperation programs and protocols.

The main areas of international operations of the National Hydro-meteorological Service of the Republic of Kazakhstan:

– cooperation in the framework of international organizations and conventions;
– cooperation within the WMO;
– cooperation on Caspian Sea related issues, including the Coordinating Committee on Hydrometeorology and Pollution Monitoring of the Caspian Sea (CASPCOM);
– multilateral cooperation in the framework of the Interstate Council on Hydrometeorology of the Commonwealth of Independent States (CIS ICH);
– cooperation with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT);
– cooperation with the Regional Environmental Centre for Central Asia (CAREC), ECMWF (the European Centre for Medium-Range Weather Forecasts), USAID and the World Bank;
– participation in the activities of other international organizations and conventions.

Bilateral cooperation is continuously maintained with countries near and far abroad (Azerbaijan, Belarus, China, Kyrgyzstan, Russia, Slovakia, Tajikistan, Turkmenistan, Uzbekistan, Finland, Türkiye, Ukraine, etc.).

As a representative of the Republic of Kazakhstan to the World Meteorological Organization, Kazhydromet RSE participates in all its major programs and projects in the field of meteorology, climatology, and hydrology.

Kazhydromet RSE is also a member of CIS ICH which was established on February 8, 1992 in accordance with the Agreement on cooperation in the field of hydrometeorology for solving problems on timely reception and use of hydrometeorological information which is necessary for forecasting of hydrometeorological processes, their impact on environment, timely informing and alerting of management bodies and population, effective use in economic sectors and defense of member-states of the Commonwealth.

In 1994 the Coordinating Committee on Hydrometeorology and Pollution Monitoring of the Caspian Sea (CASPCOM) was established between the national hydrometeorological services of the littoral states of the Caspian Sea: Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan.

On September 29, 2014, at the Summit of the Heads of State of the Caspian littoral states the Agreement on Hydrometeorological Cooperation in the Caspian Sea was signed, which entered into force on January 31, 2016.

The purpose of cooperation is to ensure the safety of navigation and other activities in the water area and coast of the Caspian Sea, depending on weather and climate changes.

Kazhydromet RSE signed a License Agreement with EUMETSAT in November 2018 for 2019-2021. As part of this Agreement, EUMETSAT provides satellite images to Kazhydromet on a free-of-charge basis.

Also, as part of the Agreement, on April 10 - 11, 2019, Astana hosted the EUMETSAT Information Day International Conference for the countries of Central Asia, Eastern Europe, and the Caucasus.

Kazakhstan is the leader in international climate financing among Central Asian countries, and in this area, it cooperates with such organizations as:

– United Nations Development Programme (UNDP);
– Food and Agriculture Organization of the United Nations (FAO);
– Regional Environmental Centre for Central Asia (CAREC);
– German Agency for International Cooperation (GIZ);

– United Nations Economic Commission for Europe (UNECE);
– World Bank (WB), other regional banks;
– International Fund for Saving the Aral Sea (IFAS), etc.

In order to improve the efficiency and capacity of hydrometeorological services, to improve technologies and methods of hydrometeorological, climatological observations, synoptic forecasts, development of new technologies of collection, processing and distribution of hydrometeorological and environmental information as well as experience and research exchange, scientific and technical base in the field of hydrometeorology, there is a mechanism for cooperation of the National Hydrometeorological Service of Kazakhstan with hydrometeorological services of other countries.

The bilateral form of cooperation includes:

1.) Agreements and cooperation programs with the countries of Central Asia;
2.) Agreements, Cooperation Programs and MOUs with EU countries (Austria, Germany, Switzerland, Türkiye, Finland, Belarus, etc.)

Multilateral form includes cooperation with:

1. member countries of Interstate Council for Hydrometeorology of CIS countries[311;]
2. Caspian countries in the framework of the Coordinating Committee on Hydrometeorology and Pollution Monitoring of the Caspian Sea (CASPCOM), [312]
3. the framework of meetings, conferences, seminars held by the World Meteorological Organization in the RAII Region (Asia) and RAVI (Europe)[313.]

The three-day introductory workshop conducted by the National Hydrometeorological Service of the Republic of Kazakhstan within the framework of the 'Program of cooperation in the exchange of hydrometeorological information between the Kazhydromet Republican State Enterprise of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan and the Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan for 2021-2024' was one example of collaboration.

Hydrometeorological service of Kazakhstan facilitated a tour for the representatives of Tajikhydromet in a consultative format, involving visits to the financial-economic division and production departments.

As a result, the delegation of Tajikhydromet got acquainted with the Kazhydromet team, with the activities of production departments involved in hydrometeorological monitoring and forecasting.

In addition, the meeting was more specifically focused on serving the population and enterprises of Kazakhstan with climate information.

[311] https://e-cis.info/cooperation/3212/77770/
[312] http://www.caspcom.com/
[313] https://public.wmo.int/ru/%D0%BE-%D0%BD%D0%B0%D1%81/%D1%87%D0%BB%D0%B5%D0%BD%D1%8B

B. Research

Forecasting

The primary and most important task of Kazhydromet RSE in case of the threat of dangerous weather phenomena and natural meteorological phenomena is the timely and prompt preparation of weather alerts and communication of relevant information with maximum advance notice to state agencies, economic sectors, and population to prevent casualties and to reduce economic damage.

The ‘Communication chart of alerts and warnings on the threat of dangerous phenomena, natural meteorological phenomena, abrupt weather changes to public administration bodies and relevant organizations of the economic structure of Kazakhstan’ is approved on an annual basis.

The average alerts success rate on hazardous phenomena (hereinafter referred to as HP) is 95 %, on natural hydro-meteorological phenomena (hereinafter referred to as NHMP) - 98 %.

The following forecasts are published at present:

- short-term weather forecast for 1, 2-3 days;
- medium-term weather forecast for 7 days;
- In case of threat of occurrence: weather alerts on dangerous, natural meteorological phenomena and abrupt weather changes;
- daily meteorological bulletin.

When making short-term and medium-term weather forecasts, weather alerts, forecasters use synoptic actual and prognostic weather maps, satellite images of the European Center, Chinese Meteorological Agency and Roshydromet's SRC Planeta, the WRF mesoscale numerical model, and the global numerical model of the European Center for Medium-Range Weather Forecasts.

Long-term weather forecasts for the decade, month and season are also issued. Monthly and seasonal weather forecasts are based on the analog method, numerical hydrodynamic models of 13 world prognostic centers, products of hydrodynamic models of the North Eurasian Climate Center, Main Geophysical Observatory and Hydrometeorological Center of Russia.

The average success rate of weather forecasts and weather alerts for HP, NHMP and abrupt weather changes (hereinafter - AWC) for the period from 2017 to 2021 was: for the first day in the city - 92 %; for the first day in the oblast - 97 %; for 2-3 days in the oblast - 93 %; HP, NHMP, AWC - 96-99 %. The average forecast success rate for the period from 2017 to 2021 was: for one month for temperature - 75%, for precipitation - 63%; for 10 days - 88%.

The Kazhydromet RSE conducts daily operational assessment of hydrometeorological conditions and forecasts of various elements of the hydrological regime of water bodies of the Republic of Kazakhstan.

The following types of forecasts are currently available:

- timing of freezing and breaking up of the ice in rivers;
- volumes of spring floods (preliminary and major);
- weekly hydrological forecasts during spring floods;
- water inflow to reservoirs for a month, quarter, year;
- discharge of mountain rivers during vegetation period;
- weather alerts on NHMP;
- daily hydrological bulletin.

The average success rate for weather alerts for 2018-2021 was 79.5 percent.

Table 8.2. *The number of weather alerts and the forecast success rate for the year*

Year/month	Number of weather alerts												Success rate, %
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2018	4	5	19	11	5	3	4	3	2	1	1	4	94
2019	10	7	12	6	2	7	3	2	4	1			76
2020	5	2	5	3	3	1	1	1	1				66
2021	1	3	3	6	1	6	6	4	1				82

Modeling of hydrometeorological processes

Kazhydromet RSE continues to improve the work on modeling of hydrometeorological processes.

Since 2013, the WRF model, which is one of the most versatile and modern atmospheric modeling systems, has been used for numerical weather forecasts. In operational mode, with WRF model resolution of 2, 4, 13 and 18 km and forecast advance from 24 to 168 hours, the following meteorological parameters are produced:

1) air temperatures near the ground and at different altitudes;
2) precipitation;
3) surface pressure;
4) surface wind and its gusts;
5) severe frost (in the cold half of the year);
6) heat wave (in warm half of the year);
7) prognostic aerological charts, with CAPE - Convective Available Potential Energy for 36 hours, every 3 hours (with a model resolution of 13 km) for 26 cities in Kazakhstan;
8) meteograms (wind, temperature and precipitation forecast) for more than 300 cities of Central Asia.

Hydrological modeling

Prediction of hydrological processes based on modern techniques of numerical modeling of watershed discharges is of great practical importance and is one of the main tasks of modern hydrology. The solution of this problem is especially urgent for the purposes of timely alerting the population about flood danger and enabling the Ministry of Emergency Situations to prevent or mitigate its consequences.

Relying on its accumulated knowledge in the field of hydrological processes occurring in water bodies of Kazakhstan, as well as on the experience of foreign specialists and their developments, Kazhydromet RSE has been using numerical modeling methods since 2018 to make hydrological forecasts.

Such hydrological models as HBV-light, SWIM, MIKE 11, MODSNOW are used for modeling river discharges of Kazakhstan, and SWAN, MIKE 21 are used for marine hydrometeorological modeling of the Caspian Sea.

To improve and enhance the quality of hydrological forecasts, numerical mathematical models of hydrological forecasting are adapted to the conditions of the rivers of Kazakhstan every year.

At present, the Swedish conceptual model HBV-light has been adjusted for 54 mountain and 15 lowland rivers in Kazakhstan. Whereas ecohydrological model SWIM (Soil and Water Integrated Mode) is adjusted for 6 lowland and 8 mountain rivers of Kazakhstan.

Thus, HBV-light model is adjusted for **70** and SWIM - for **14** rivers of Kazakhstan. These adjusted models are successfully used in river discharge forecasting during the spring floods.

In the future, to improve the quality of hydrological forecasts, Kazhydromet RSE plans to increase the number of adjusted models for different conditions in order to alert of hydrological threats.

Yield forecast models

In 2020, the yield forecast model for sugar beet and corn (yield model by Polevoy A.N., Ukraine) was introduced for the southern regions of Kazakhstan. The first pilot forecasts were released in 2021, and it is planned to introduce them into the operational practice after the end of pilot testing.

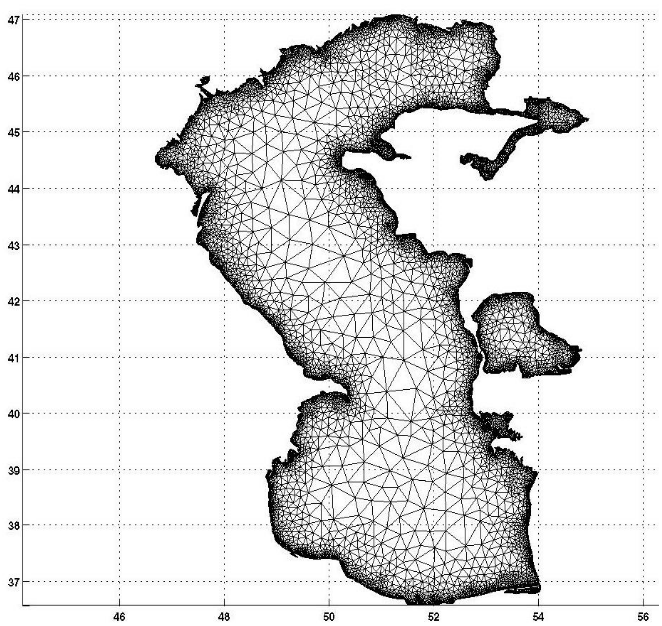
Two models were introduced in 2021: CGMS crop yield model (Italy) for grain crops (oilseeds, pulses, etc.) for different climatic zones of the area, and DSSAT plant growth model (USA), which will simulate growth and yield of grain, oilseeds, pulses, and other crops under different conditions of moisture and fertilizer application.

Wave modeling

Kazhydromet RSE specialists adjusted the wave spectral model SWAN to the conditions of the Caspian Sea for improvement of wave forecasting and introduced it into the operational practice. This model was created by Delft University of Technology (Netherlands). Computation according to SWAN model is carried out in the grid nodes (regular and irregular), please refer to

Figure 8.1. Wave forecast is done both for separate spots of the Caspian Sea and for the whole sea area 2 times a week.

Figure 8.1. *Triangulation grid of the Caspian Sea*



The forecast of concentrations of pollutants in the atmospheric air of the cities of Kazakhstan was developed and implemented with the support of the Finnish Meteorological Institute based on the SILAM model. The visual model is combined with an interactive air quality map and offers an hour-by-hour view of the atmospheric air condition up to 48 hours in advance.

8.2. Cryosphere climate monitoring systems

The Central Asian Regional Glaciological Center under the auspices of UNESCO was established on May 28, 2020, based on an agreement between the Government of Kazakhstan and the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the order of the Institute of Geography and Water Security JSC.

Glaciers are monitored by the Central Asian Regional Glaciological Center under the auspices of UNESCO. At the initial stage, the Center combines the efforts of specialists from Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, and Russia. The structure of the Center includes four laboratories and three high-altitude research stations of year-round monitoring with data series of continuous observations ranging from 45 years (challenges of geocryology with measurement of seasonally and perennially frozen rocks in 32 wells in the highlands of the Ulken Almaty River basin) to 65 years (challenges of glaciology and hydrometeorology with measurement of components of mass balance of Tuyuksu glacier).[314]

Also, Kazselezaschita SE, a subdivision of the Ministry of Emergency Situations, is constantly monitoring moraine lakes to protect regions, economic facilities, and the population from the effects of glacial mudslides.

8.3. Observation systems from space

The National Company Kazakhstan Garysh Sapary Joint Stock Company (NC KGS JSC)[315] s the National Operator of the Earth Remote Sensing Space System of the Republic of Kazakhstan, consisting of high and medium resolution spacecrafts KazEOSat-1 (with a resolution of 1 m) and KazEOSat-2 (with a resolution of 6.5 m) to provide space images to individuals and legal entities, as well as the National operator of the high-precision satellite navigation system for the implementation of tasks of providing satellite navigation services throughout the territory of the Republic of Kazakhstan. Since 2018, NC KGS JSC has been providing space monitoring services to solve several sectoral tasks of the economy.

[314] https://ca-climate.org/news/tsentralno-aziatskiy-regionalnyy-glyatsiologicheskiy-tsentr/
[315] https://www.gharysh.kz/saytru2022/okompanii/aboutcompanyru/

Figure 8.22. *KazEOSat-1 image. 2014. City of Atyrau, Kazakhstan, Ural River, Retro Park*

k.

Source: https://www.scanex.ru/data/satellites/kazakhstan/

8.4. Research on Climate Change and Adaptation

In addition to measures to combat climate change by reducing anthropogenic emissions of greenhouse gases, adaptation to climate change is also a great challenge for Kazakhstan, as climate change affects all areas of human activity and ecosystems. So far, Kazakhstan has taken a number of steps to strengthen climate change adaptation.

In July 2021, Kazakhstan enacted updated version of the Environmental Code, which contains a new chapter entirely dedicated to adaptation: Chapter 22 – 'Public administration for adaptation to climate change' (Articles 312-316). The process of adaptation is integrated into the state planning system, namely in the process of development and implementation of relevant state programs and implementation of state environmental policy at the local level.

Article 313 lists the priority areas of state administration and the basic principles of adaptation to climate change. The priority spheres have been identified based on numerous vulnerability studies of regions and sectors of the economy to climate change. The following spheres of public administration are priorities for adaptation to climate change: agriculture, water management, forestry, civil protection.

Article 314 defines the general requirements for the process of adaptation to climate change and the stages of this process, which constitute the following cycle:

1) information collection and climate change vulnerability assessment;
2) planning of climate change adaptation;
3) development of adaptation measures;
4) implementation of adaptation measures;
5) monitoring and evaluating the effectiveness of climate change adaptation measures;
6) reporting on climate change impacts and effectiveness of climate change adaptation measures;
7) adjustments to climate change adaptation measures based on the results of monitoring and evaluation.

Climate change adaptation process, as defined in the Ecocode, is carried out by authorized central executive bodies for areas of public administration identified as priorities for climate change adaptation, and by local executive bodies of oblasts, cities of republican significance, and the capital city.

Rules for organization and implementation of climate change adaptation process has been developed and adopted (Order № 170 of MEGNR dated June 2, 2021).

Kazakhstan has several key strategies, concepts, and related action plans, which outline the strategic directions of climate change mitigation and adaptation activities in the country.

Kazakhstan ratified the UNFCCC in 1995 and became its fully-fledged Party. In accordance with the conclusion of the Conference of the Parties, following ratification of the Kyoto Protocol on 19 June 2009 and its entry into force on 17 September 2009, Kazakhstan is considered a Party to Annex I for the purposes of the Kyoto Protocol.

On August 02, 2016, Kazakhstan signed the Paris Agreement, adopted on December 15, 2015, as a result of the 21st Conference of the UN Framework Convention on Climate Change in Paris. On November 04, 2016, President Nursultan Nazarbayev signed the Law ‘On Ratification of the Paris Agreement".

Under the Paris Agreement, Kazakhstan has committed to reduce greenhouse gas emissions by 15-25% by 2030 compared to the base year of 1990 on an economy-wide basis (15% is an unconditional target, 25% is a conditional target that can be achieved if international support is obtained).

In December 2020, at the Climate Ambition Summit dedicated to the fifth anniversary of the Paris Agreement and preparations for the next UN Climate Change Conference (COP26) in Glasgow (UK) in November 2021, Kazakhstan President Kassym-Jomart Tokayev announced the goal to achieve carbon neutrality by 2060.

National Allocation Plan for greenhouse gas emission quotas for 2018-2020 came into force in Kazakhstan on January 01, 2018[316].

In 2020, the Republic of Kazakhstan prepared reports on the implementation of the requirements of the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer.

Kazakhstan acceded to the Vienna Convention for the Protection of the Ozone Layer in 1997[317].

In accordance with the Paris Agreement, a component on climate change adaptation was added to the nationally determined contributions (NDCs) at the stage of its renewal in order to increase ambition.

In July 2020, the Government of the Republic of Kazakhstan approved the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a ‘Green economy", which is fully aligned with the NDCs of Kazakhstan.

With the support of UNDP and GIZ, the Government is preparing an application to the Green Climate Fund (GCF) to implement the Initiation and implementation of medium and long-term adaptation policy in Kazakhstan project. This project will help to create and strengthen the capacity to integrate climate risks into planning, to assess climate risks and vulnerability as a basis for further action, as well as to introduce effective methods, tools, and information systems to improve the quality of information used in decision-making on adaptation.

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[316] Decree of the Government of the Republic of Kazakhstan No. 873 dated 26.12.2017.

[317] Law of the Republic of Kazakhstan dated 30.10.1997 № 177-I ‘On accession of the Republic of Kazakhstan to the Vienna Convention for the Protection of the Ozone Layer.’

The results of the adaptation work should help to create an institutional framework and start the process of adaptation to climate change in vulnerable sectors and support sustainable development of the country and the economy.

In accordance with the obligations under the UN Framework Convention on Climate Change and implementation of the Paris Agreement, Kazakhstan, in partnership with the UN Development Program, has developed a Roadmap for Climate Change Adaptation. The recently adopted Environmental Code stipulates that the Roadmap will be used as a basis for planning and integration of climate change adaptation measures in economic sectors, legally defined as a priority, as well as in regional programs implemented by local governments. The Roadmap proposes to consider water resources management as a key and cross-cutting factor for climate change adaptation in all sectors of the economy, especially in the agriculture and environmental protection sectors. Consequently, in sectoral and administrative-territorial planning of climate change adaptation measures envisaged by the Eco-Code it is proposed to use the basin approach based on the natural integrity of natural ecosystems. This approach is especially important for Kazakhstan, as limited water resources are of strategic importance and require cross-sectoral and cross-regional cooperation, as well as broad public participation. The basin approach also helps to clarify objectives and strengthen mutual links of sectoral and territorial programs and increase their effectiveness for the purposes of climate change adaptation.

Currently, the Adaptation Roadmap includes a number of activities on climate change adaptation in the priority areas, identified in the Ecocode, in such domains of public administration as agriculture, water management, forestry, and civil protection.

In June, the Ministry of Ecology, Geology and Natural Resources approved the relevant rules for organizing and implementing the climate change adaptation process.

The climate change adaptation process is coordinated by the authorized central and local executive bodies under the coordination of MEGNR.

A Methodological Guidebook on Climate Change Adaptation is being developed, offering background information on all stages of the process, from collection of information on climate and its impacts to assessment of the effectiveness of the implementation of adaptation measures.

Since the process of adaptation is integrated into the state planning system, namely in the process of development and implementation of relevant state programs and implementation of state environmental policy at the local level, state bodies have new competencies for ensuring the adaptation process:

- MEGNR is responsible for methodological and informational support for vulnerability assessment; and for the international reporting;
- authorized central executive bodies in the spheres of state administration identified as priorities for climate change adaptation shall implement the adaptation process within the framework of relevant state programs;
- local executive bodies of oblasts and cities of republican significance implement the process of adaptation within the framework of the state environmental policy at the local level.

In a sharply continental climate with rather harsh winters and hot summers, with a high degree of climate and weather variability in all seasons, adaptation is relevant even in the current climate. Therefore, development programs in most sectors of Kazakhstan's economy include measures that relate to climate change adaptation.

The Concept of the State Water Resources Management Program of Kazakhstan for 2020-2030 outlines, among others, such targets that serve the adaptation goals:

- Water savings of up to 5 km^3, reduction of water consumption per unit of GDP from USD91.2 to USD73 m^3/thousand.;
- construction of 26 new hydraulic structures;
- reconstruction of 182 national and 300 municipal hydraulic structures;
- construction of new irrigation systems to increase irrigated land from 1.7 to 3 million hectares;
- an increase in the length of lined trunk and distribution canals from 3,423 to 19,000 kilometers to reduce losses;
- improving the material and technical equipment of the basin inspections to 100% capacity;
- increasing the forest cover of catchment areas from 1 to 200 thousand ha.

In the agricultural sector, the 2017-2021 State Program for the Development of the Agro-Industrial Complex includes such measures as breeding and introduction of drought-resistant crops, agroforestry reclamation, drip irrigation, improving water efficiency by increasing water volume in reused and recycled water supply systems in industry and reducing water consumption for irrigation while increasing the irrigated land area.

In the forestry sector, a program to increase forest cover from 4.7% to 5% by 2030 is being implemented; it also includes measures to combat forest fires and pests; and commercial forest cultivation.

The plan to plant more than 2 billion trees by 2025 in the forest fund and 15 million trees in settlements is being implemented from 2020.

Electronic registers of urban green spaces are being introduced. For example, it is estimated that there are 2 million 352 thousand trees in Almaty, including red book trees.

A unique project to create a green belt around Astana is ongoing. The decision to create a large-scale ‘green’ project was approved in 1997. ‘Green Belt’ expands its territory: trees are planted annually, creating habitat for birds and animals:

- the ‘green belt’ today has more than 9 million 600 thousand trees and about 1 million 800 thousand bushes;
- Astana's ‘green belt’ serves as the “lungs” of the city, the forest has helped improve air quality. The climate has become softer, and the city is better protected from wind and dust, from piercing storms in winter;
- in addition, it is a unique research site - 104 species of trees and shrubs were tested in the green zone, and 28 species have been recommended for further planting.

In the priority sphere of civil protection, there is currently no functioning state program specifically designed for climate change adaptation. However, the Ministry of Emergency Situations, due to its specifics, is the most informed and prepared body to address this issue.

On April 12, 2013, the Center for Emergency Situations and Disaster Risk Reduction was opened in Astana.

In August 2013, the Ministry and mobile operators signed a ‘Unified Agreement on the organization of notification of the population about emergencies of natural and man-made character via SMS-messages”.

Due to the changing climate, there is a need to regularly update information on disaster risks and, accordingly, safety data sheets.

A good example of ongoing climate change adaptation is the activity aimed at the conservation of the northern part of the Aral Sea - the Small Aral Sea.

First on the local initiative and then with the support of the World Bank the Kokaral dam was built, which helped to establish the water level in the Northern Aral Sea at 42 m BSL, increasing the volume and area of the water body.

As a result, several positive effects for the ecology of the sea and economic activity were obtained:

- water salinity has decreased; therefore, many biological species are restored, some fish species that previously disappeared in the Aral Sea have recovered;
- 19 lakes have been revived, including 8 of fishery importance;
- increased volume of fish production, including for export;
- water supply to irrigated lands has improved;
- the flow capacity of the Syrdarya River in winter has increased;
- saline dust drifts from the dried seabed were reduced and, in general, the microclimate began to change.

The ‘Scientific and technological validation of the rational use of water resources while increasing the areas of regular and basin irrigation in all water management basins of the Republic of Kazakhstan until 2021’ program was carried out in 2018-2020. Client - the Committee of Water Resources of MEGNR RK. Result - introduction of technologies on the total area of 3000 ha in Turkestan oblast.

Since 7 of 8 water basins are transboundary, there is active cooperation on research in transboundary river basins, including for the purpose of climate change adaptation.

The Republics of Kyrgyzstan and Kazakhstan jointly implemented the Enhancing Climate Resilience and Adaptive Capacity in the Transboundary Chu-Talas Basin project. The partners of the Project were the joint Chu-Talas Water Commission, local administration, UNDP, UNECE, NGOs.

The project conducted a detailed transboundary diagnostic analysis and developed a Strategic Adaptation Plan, which has already been approved by Kazakhstan. The proposed adaptation measures are aimed at ensuring sufficient water quantity, adequate water quality, preservation of ecosystems, enhancing preparedness for climate change, including natural disasters, and developing capacity for cooperation and institutional transformation.

Together with the Russian Federation, Kazakhstan has developed and is implementing a ‘Unified road map to enhance cooperation on research in the basins of major rivers Ural (Zhaiyk) and Yertis for 2021-2024". One of the areas of research is to identify the causes of changes in the annual discharge, discharge during flood and low-water periods. As a result, there will be a conclusion about the need for additional protection of settlements and economic facilities located near water bodies.

Cooperation between China and Kazakhstan affects the basins of the transboundary major rivers Yertis and Ile on several issues. Several scientific studies have been carried out, including an assessment of climate change impact on the discharge regime of transboundary rivers. There is a working group on rapid response to emergencies and pollution prevention. The main issue of cooperation between Kazakhstan and the PRC is the development of legal framework for the division of water resources of transboundary rivers, including climate change considerations.

C. Systematic observations

8.5. Atmosphere observation systems, including the Atmosphere composition measurement system

According to the Environmental Code of the Republic of Kazakhstan, the Unified State System of Environment and Natural Resources Monitoring is a multi-purpose system provided by the state, which brings together all existing in the Republic of Kazakhstan systems, subsystems and types of monitoring, directly or indirectly covering environmental protection, preservation, reproduction and use of natural resources, protection of human life and/or health from environmental hazards and anthropogenic environment, as well as climate change impacts.

The Unified state system of monitoring of the environment and natural resources includes the following monitoring systems:

1) ecological monitoring;
2) monitoring of natural resources;
3) special monitoring;
4) meteorological and hydrological monitoring;
5) environmental monitoring.

Detailed information on meteorological, hydrological, agrometeorological monitoring is provided below.

8.6. Meteorological monitoring

Meteorological monitoring[318] is the activity in the field of meteorology, including observations, collection, processing, analysis, storage of data, production of meteorological and agrometeorological information, including the preparation of meteorological and agrometeorological forecasts and providing this information to state agencies, individuals, and legal entities.

Meteorological information is the primary data obtained from the results of meteorological observations, as well as operational, regime, climatic and prognostic information, which is the result of processing and analysis of primary meteorological data.

Meteorological monitoring is conducted in order to determine the state and development of natural meteorological parameters, atmospheric phenomena and processes in the atmosphere during their interaction with other components of the natural environment and the determination of climatic characteristics to provide state agencies, individuals and legal entities with weather information, to prepare short-term, medium-term, long-term meteorological, agrometeorological forecasts and alerts of possible occurrence of dangerous and natural disasters (including avalanches).

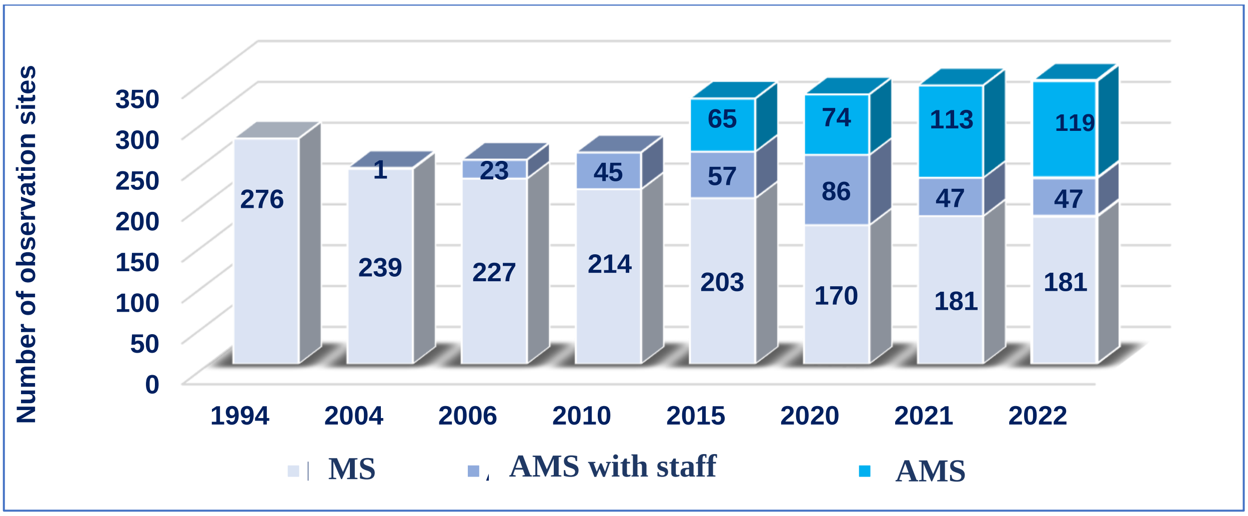
The ground-based meteorological network of Kazakhstan includes 347 stations with routine regime observations at eight synchronous periods (00, 03, 06, 09, 12, 15, 18 and 21 hours of Coordinated Universal Time (UTC). Precipitation measurements are made at 09 and 15 hours of Coordinated Universal Time (UTC). This enables description of the daily variations of the main meteorological characteristics with necessary accuracy: air temperature and humidity, wind speed and direction, atmospheric pressure, soil temperature, visibility, quantity and form of clouds, and cloud base height.

[318] Environmental Code of Kazakhstan.

Figure 8.3. *Big Almaty Lake meteorological station*

Figure 8.4 shows the dynamics of development of the meteorological network. It should be noted that Kazhydromet RSE, at present is increasing the number of observation network's sites and focuses on the efficiency and quality of observations.

Figure 8.4. *Dynamics of meteorological network development*



The National Hydrometeorological Service has a large database and maintains a state climatic cadaster - a systematic set of data based on the results of multi-year observations.

Collection and processing of data of rapid, daily, decadal, and monthly resolution is conducted with CLIWARE and Persona MIS climate database management systems. The databases of rapid, daily, decadal, and monthly data are regularly replenished with both current and historical data. Metadata on all meteorological stations are collected in parallel: catalog of data availability, station history, physical and geographical description, affiliation of the station to a WMO observing system, indication of one or another type of observations, equipment, etc.

The meteorological series are sampled from the databases listed above. In a changing climate, the problem of analyzing the homogeneity of the obtained meteorological series is the highest priority. The next most important problem is assessing the influence of gaps in these series. After data verification, the multiyear data is computed with the use of modern methods of climatological processing of meteorological information, which is the final stage of meteorological data processing. The calculated multi-year data is published every 10 years electronically in the form of the Reference book on Climate of Kazakhstan. Reference book on Climate of Kazakhstan includes eleven separately published sections, which contain characteristics of individual meteorological variables:

Section I - Air temperature;
Section II - Precipitation;
Section III - Atmospheric precipitation;
Section IV - Glaze-ice and rime deposition;
Section V - Winds;
Section VI - Atmospheric pressure;
Section VII - Soil temperature;
Section VIII - Solar radiation;
Section IX - Snow cover;
Section X - Air humidity;
Section XI - Clouding.

The modern ‘Reference Book on Climate of Kazakhstan’ is a continuation of the ‘Reference Book on Climate of the USSR’ of 1966, ‘Scientific-Applied Reference Book on Climate of the USSR’ of 1989, ‘Reference Book on Climate of Kazakhstan’ of 2003-2015 edition.

The rules of maintaining the state climatic cadaster, as well as the composition of data in the state climatic cadaster and the procedure for providing its data to state bodies, other organizations and individuals were approved by the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan in accordance with paragraph 4 of Article 166 of the Environmental Code of the Republic of Kazakhstan.

The state climatic cadaster is maintained on the basis of this document, and it is formed based on the results of all stages of processing of meteorological information and consists of three parts:

1. Meteorological monthly publications;
2. Meteorological yearbooks;
3. Reference books on climate in Kazakhstan.

Data from the state climatic cadaster include:

1) average values of meteorological parameters for a certain observation period, day, month, year;
2) extreme values of meteorological parameters for a certain observation period, day, month, year;
3) average and ultimate timing of occurrence of meteorological phenomena;
4) recurrence of meteorological phenomena or values of meteorological parameters.

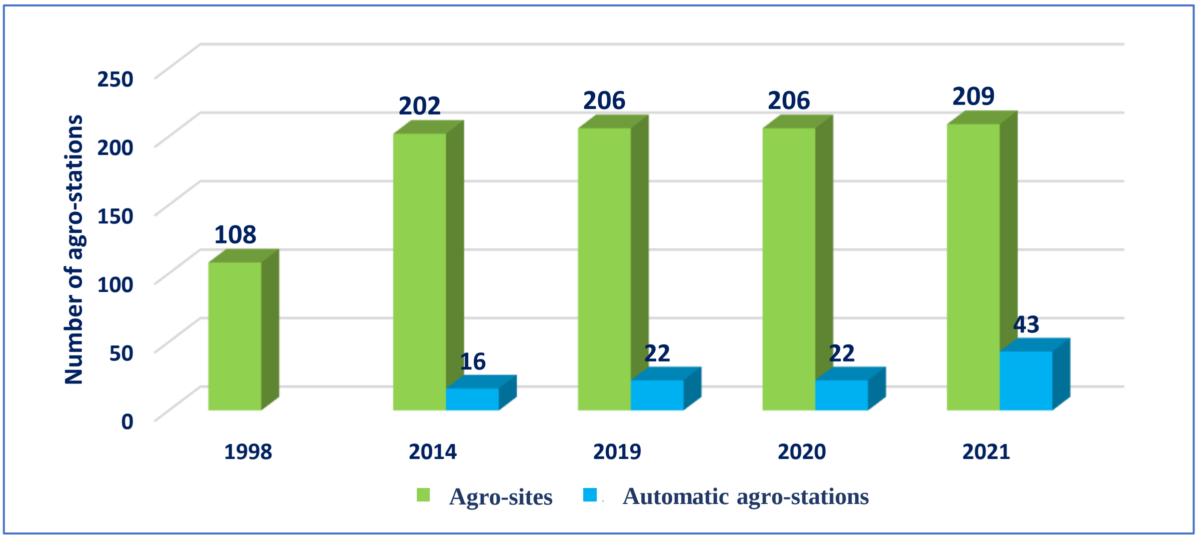
8.7. Agrometeorological monitoring

Agrometeorological support of agriculture is one of the most important tasks of Kazhydromet RSE. Agriculture operates in a complex system of natural conditions, where meteorological factors are the most variable, active, and important for agricultural production. They determine the quality and quantity of crops.

Consideration of weather and climatic conditions plays an important role in the areas of high-risk agriculture in Kazakhstan. The success of agricultural production depends on the weather by 70% and on agricultural technology by 30%. Assessing the impact of weather conditions on crops, predicting their yield and validation of measures to reduce the impact of adverse weather is the main task of agrometeorology.

Agrometeorological observations are carried out at 209 sites, with 121 stations and 88 posts, and the reserves of productive moisture are determined at 127 sites. The dynamics of the agrometeorological network development is presented in Figure 8.5.

Figure 8.5. *Dynamics of agrometeorological network development*



Agrometeorological observations of crops are carried out on the basis of a full or reduced program, in line with the state of the knowledge of agrometeorological regime of the territory. The presence of crops, plantings or pastures near the observation stations is also considered. Regular agrometeorological observations are carried out at special stations, which are selected or refined annually each spring on the fields, vegetable gardens, melons, pastures, hayfields, and orchards. Survey of the observation station is carried out every other day under the full program and twice every ten-day – under the reduced program.

Agrometeorological observations at the stations begin before sowing and continue throughout the year. From the beginning of the warm period, observations of soil temperature are carried out on one of the main crop fields. During the vegetation period, the onset of the main phases of plant development, their condition, height and density of stems, elements of productivity, soil moisture, damage to crops by adverse meteorological phenomena, agricultural pests and diseases are visually assessed. Winter crop fields also require observations of overwintering: how well a crop survived the winter. On pastures, observations of growth conditions and conditions of pasture vegetation, as well as grazing conditions are conducted. In addition, route surveys are conducted during the vegetation season to assess conditions for crop growth and development within the area.

Figure 8.6. *Automatic agrometeorological stations*

8.8. Hydrological monitoring

Hydrological monitoring is an activity in the field of hydrology, which includes observation of regime and conditions of surface water bodies, collection, processing, analysis, storage of data, production of hydrological information, including preparation of hydrological forecasts, and provision of relevant information to the state bodies, individuals, and legal entities.

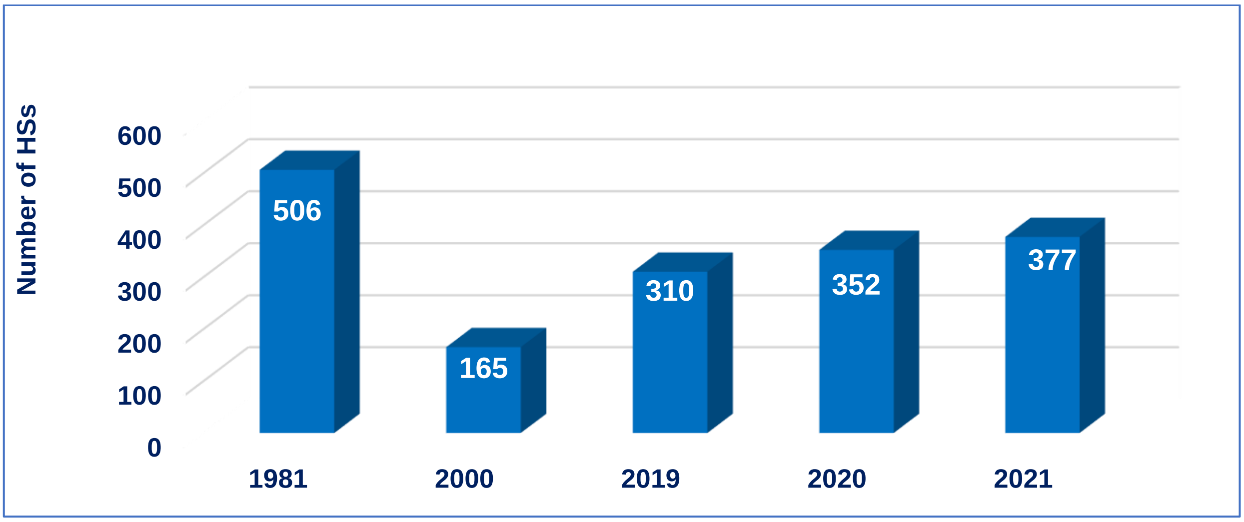
Hydrological information is the primary data, obtained as the result of hydrological observations, as well as regime, operational and prognostic information, which is the result of processing and analysis of primary hydrological data.

Hydrological monitoring shall be carried out on a regular and/or periodic basis to collect data on the condition and regime of rivers, lakes, seas, reservoirs, canals, and other surface water bodies and includes observations on the snow course and sediment measuring routes in the mountains, carried out to determine snow reserves in the mountainous parts of the river basins.

The hydrological network of Kazhydromet RSE includes 377 hydrological stations (HS), with 329 river stations, 38 lake stations and 10 maritime stations. The dynamics of development of the hydrological network is presented in Figure 8.7. Observations of water level, water temperature, and air temperature are made 2 times per day on a daily basis. Water discharge measurements are made on a ten-day basis (more frequently during floods).

In autumn, winter and spring time ice conditions are monitored, in wintertime ice thickness and snow depth on ice are monitored.

Figure 8.7. *Dynamics of hydrological network development*



Hydro-posts are furnished with different equipment depending on the type and category, as well as the characteristics of water bodies.

Figure 8.8. *Observation at the hydrological station*

Data collection, processing and analysis are carried out. Information is continuously collected, stored, and disseminated; a data bank of surface water monitoring is maintained for basins of rivers, lakes, reservoirs, and seas. The following reference and information publications are issued as a result:

1) 'Annual land surface water regime data' (average daily monitoring data);

2) 'Multiyear data on land surface water regime' (summarizes multiyear monitoring data for the whole observation period);

3) 'Materials on evaporation from water surface' (average ten-day monitoring data).

Monitoring of the Caspian Sea

At present, coastal marine observations are carried out at four marine hydrometeorological stations and six marine hydrometeorological posts (Figure 8.9).

Figure 8.9. *Location of coastal observation stations*

To monitor the levels of the Caspian Sea and predict its fluctuations, Kazhydromet RSE uses an automated method of forecasting the Caspian Sea level and flow fields in a given area for each hour with an advance of up to 120 hours, including negative and positive surges.

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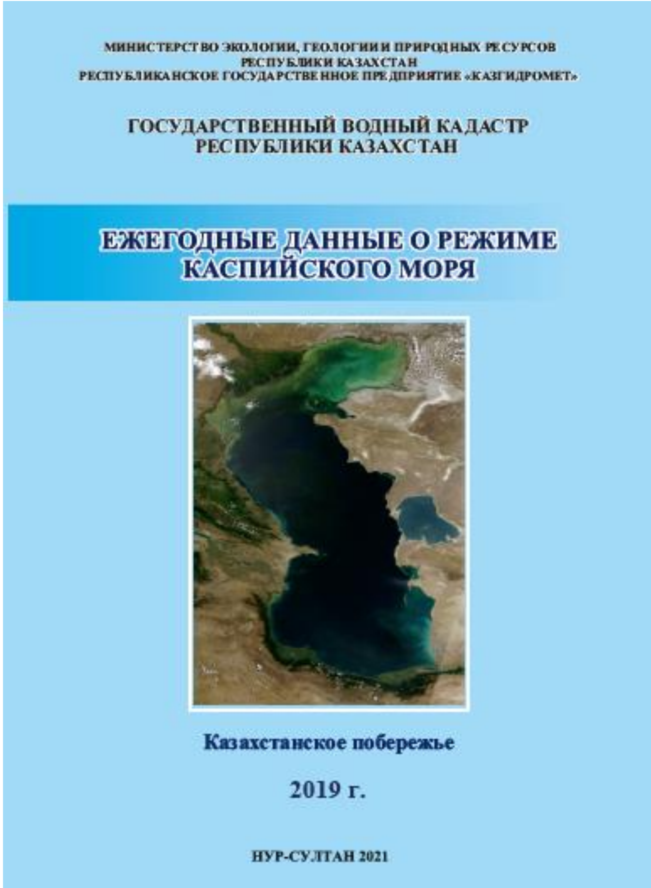
Level forecasts are made for eight sites in the Kazakh and two sites in the Russian part of the sea using the Danish hydrodynamic model Mike21. Weather alerts are issued if there is a threat of particularly dangerous negative and positive surges. If necessary, specialized forecasts of wind currents are also prepared. The Caspian Sea Bulletin is issued on a weekly basis.

Wave forecasts are of great importance for the Middle Caspian Sea regions. Kazhydromet RSE issues wave forecasts for three quadrants of the open water area and two ports. The Bulletin on sea state is issued on a weekly basis.

Since the Caspian Sea belongs to the seas with seasonal ice cover, ice regime studies and monitoring of ice conditions in the Caspian Sea are conducted. During the winter period, reviews of ice conditions are issued, which are based on data obtained 2 times a day from Kazakh and Russian stations and posts, and on the analysis of satellite images.

Kazhydromet RSE publishes a reference book 'Annual data on the Caspian Sea regime. Kazakhstan coast' (Figure 8.8). The Caspian Sea is also included in the bi-annual publication of reviews of natural hydrometeorological phenomena observed on the territory of the Republic of Kazakhstan.

Figure 8.10. *Reference book 'Annual data on the regime of the Caspian Sea. Kazakh coast"*



The analysis of the state of the water surface and ice conditions is included in the National Report and the Annual Bulletin on the State of Climate Change in the RA6 region.

8.9.Monitoring of climate conditions and changes in Kazakhstan

Monitoring of the climate system is carried out by national, regional, and international organizations under the coordination of the World Meteorological Organization (WMO) and in cooperation with other environmental programs.

The study of regional climate and continuous monitoring of climate change is one of the priority tasks of the Kazhydromet RSE National Hydrometeorological Service of Kazakhstan. Since 2010, Kazhydromet RSE has been issuing annual bulletins to provide reliable scientific information on the regional climate, its variability and change. Given the geographic location of Kazakhstan and its vast territory, the observed changes in climatic conditions in different regions of the country can have both negative and positive impacts on biophysical systems, economic activity, and the social sphere. Consideration of climatic conditions and assessment of their changes are necessary to determine the potential consequences and to take timely and adequate adaptation measures to ensure sustainable development of Kazakhstan.

Each issue of the bulletin describes climatic conditions of a particular year, including an assessment of the extremes of temperature and precipitation regimes, and provides historical information about changes in surface air temperature and precipitation that have occurred since 1941.

The bulletin uses the following data from the Republican Hydrometeorological Fund of Kazhydromet RSE:

1) series of average monthly air temperatures and monthly precipitation totals since 1941;
2) series of daily maximum and minimum air temperatures and daily precipitation.

The norm in the Bulletin means the average multi-year value of the climatic variable in question for 1961-1990. Temperature anomalies are calculated as deviations of the observed value from the norm. Precipitation anomalies are usually considered both as deviations from the norm (similar to air temperature) and as percentage of the norm. Non-Exceedance Probability characterizes the frequency (in %) of occurrence of the corresponding value of the anomaly in the series of observations.

Linear trend coefficients, determined by the least squares method, are used as an assessment of changes in climate characteristics over a certain time interval. Coefficient of determination (R2) is a measure of trend significance, which characterizes contribution of trend component to total variance of climatic variable for the considered period (in %).

Climate indices recommended by World Meteorological Organization are also used to describe surface air temperature and atmospheric precipitation regimes in specific year and their change in time. Some indices are based on fixed uniform threshold values for all stations, others - on threshold values, which may vary from station to station. In the latter case, the threshold values are defined as the corresponding percentiles of the data series. The indices allow assessing many aspects of climate change, such as changes in intensity, frequency, and duration of extremes in air temperature and precipitation.

Trends in surface air temperature and precipitation are assessed both based on data from individual stations and on average over the territory of oblasts of Kazakhstan.

Express monitoring

Kazhydromet RSE issues monthly bulletins that assess anomalies in the average monthly air temperature and monthly precipitation on the territory of Kazakhstan[319].

The bulletin uses data from observations of the meteorological monitoring network of Kazhydromet RSE: series of monthly average air temperatures and monthly precipitation totals for the period since 1941.

Anomalies of the average monthly surface air temperatures and monthly precipitation amounts are determined relative to the long-term average values (norms) calculated for the period 1981-2010, recommended by the WMO as a baseline for monitoring the anomalies of the current climate. Air temperature anomalies are calculated as deviations of the observed value from the norm. Precipitation anomalies are represented as a percentage of the norm, that is, as a percentage of the observed precipitation to the corresponding norm value.

For the characterization of climate extremes there are maps where each station displays a range of empirical probability of non-exceedance of the current value in the time series of the considered variable for the period from 1941 to the current year (empirical probability of non-exceedance is the percentage of time series values that are lower or equal to the current value). If

[319] https://www.kazhydromet.kz/ru/klimat/ekspress-monitoring

the non-exceedance probability of the current value of a variable is in the extreme ranges (0-5% or 96-100%), then this value has not occurred more often than in 5% of cases since 1941. If the non-exceedance probability of the current value of air temperature is in the range of 0-5%, this indicates that extremely low temperatures were observed in this place; if the range is 96-100%, then, on the contrary, it’s extremely high temperatures. If we consider the amount of precipitation, in the first case it indicates an extremely small amount, in the second-an extremely large amount.

IX. EDUCATION, PERSONNEL TRAINING AND AWARENESS-RAISING CAMPAIGNS

9.1.General policy in the field of education, training, and public awareness

A new Concept of Education Development in the Republic of Kazakhstan until 2025[320], was developed in November 2021, however its analysis and review of the new state compulsory standards of education covering all levels of education (Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018)[321] shows that there have been no significant changes in the reflection of climate change in the educational system.

During his speech at the enlarged meeting of the Government of Kazakhstan on July 10, 2020, the Head of State Kassym-Jomart Tokayev said: "We need to introduce environmental education for children as a discipline in schools"[322], however, at the time of preparation of this report, there was no separate subject in the curriculum.

An important moment for the development of the educational system in general and the potential promotion of knowledge on climate change issues through non-formal education system is the adoption of 'Lifelong Learning Concept' in July 202.[323] The goal of this Concept is: "to create a system of lifelong learning, ensuring the inclusion of the population of the country in formal, non-formal and informal learning to improve their competitiveness and basic competencies to the level of the OECD countries".

Among the objectives of the lifelong learning system development is the introduction of recognition mechanisms of the results of formal and non-formal learning, in particular the recognition of knowledge, skills and competencies acquired through various forms of non-formal education, including massive open online courses. Implementation of the concept will be held in several phases.

The first phase (2021-2022) – development of regulatory and legal framework for the implementation of lifelong learning, as well as the creation of a model of lifelong learning for adults. Work will be done to update and revise educational training programs.

The second phase (2023-2024) – creation of a cumulative system (bank) of credits and mechanisms for the recognition of non-formal education for the validation of the results and confirmation of training achievements. In parallel, work will be organized to create a model that will regulate the procedure for the recognition of qualifications and certification of skills and competencies.

The third stage (2025) – institutionalization of lifelong learning, that involves finalization of the lifelong learning institutions development.

There has been slightly greater progress since the previous national communication in providing public access to climate change awareness through state information resources.

The new Environmental Code of the Republic of Kazakhstan (dated January 2, 2021) adopted new provisions regulating access to environmental information, with Chapter 4 fully

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[320] https://legalacts.egov.kz/npa/view?id=12629438

[321] Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018 'On Approval of the State Compulsory Standards of Education": https://adilet.zan.kz/rus/docs/V1800017669

[322] https://liter.kz/prezident-pro-ekologiyu/

[323] Resolution No. 471 of the Government of the Republic of Kazakhstan, dated July 8, 2021, 'On Approving the Lifelong Learning Concept": https://adilet.zan.kz/rus/docs/P2100000471

devoted to this issue[324]. Article 17, which defines environmental information, has subparagraph 8 of paragraph 1, stipulating that information "on climate change vulnerability, on existing and projected climate change impacts, as well as measures on climate change adaptation" refers to environmental information and therefore shall be publicly available and shall not be subject to restriction and classification, according to paragraph 2 of article 17.

Similarly, in case of information related to climate change issues, the provisions enshrining the obligations of holders of environmental information are applicable, and they are recognized as:

1) agencies and institutions of the legislative, executive, and judicial branches, local government, and municipal government;
2) public agencies other than government bodies directly responsible for environmental activities or services;
3) quasi-public sector entities with activities or services related to the environment;
4) natural persons and legal entities - with respect to environmental information possessed by them (paragraph 3 of Article 18).

According to paragraph 4 of Article 18: "the public also has the right to have unrestricted and free of charge access to publicly available state electronic information resources containing environmental information".[325]

Also, in accordance with the ratification by the Republic of Kazakhstan of the Protocol on Pollutant Release and Transfer Registers (PRTRs), the new Environmental Code provides for the maintenance of PRTR - a structured electronic database on the status of pollutant emissions into the environment and levels of environmental pollution, which is publicly available on the official Internet resource. Data from this database allows a wide range of interested parties to obtain information on greenhouse gas emissions by individual large enterprises, required to provide data to the PRTRs.

A special section 'Climate of Kazakhstan' appeared on the website of Kazhydromet RSE of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan[326].

The Climate Change section in the interactive version of the National Report on the State of the Environment and the Use of Natural Resources became more extensive[327].

9.2. Elementary, secondary, and higher education

The network of preschool organizations in 2021 amounted to 10,848 facilities, including 7,304 kindergartens and 3,544 mini-centers. By attracting private business and placing state educational orders, the network of private preschool organizations grew by more than 13 times: from 347 facilities in 2010 to 4,881 – in 2021.

The total number of children enrolled in preschool organizations reached 900,670, including 45.4 per cent of children attending private preschool organizations. Coverage of children from 1 to 6 years of age was 81.6 per cent, and 98.7 per cent of children aged 3 to 6. Children at the age of 5 are enrolled in compulsory pre-school training. According to the formula of

[324] Environmental Code of the Republic of Kazakhstan dated January 2, 2021, #400-VI 3PK: https://adilet.zan.kz/rus/docs/K2100000400
[325] Environmental Code of the Republic of Kazakhstan dated January 2, 2021, #400-VI 3PK: https://adilet.zan.kz/rus/docs/K2100000400
[326] https://www.kazhydromet.kz/ru/
[327] http://newecodoklad.ecogosfond.kz/2016/izmenenie-klimata/

gross coverage of preschool age children by UNESCO, Kazakhstan has been included in the group of countries with average coverage level only in 2020.[328]

The number of teachers – 96 863 people[329]

Figure 9.1 shows a significant increase in the number of preschool organizations. However, Figure 9.3 shows a decline in growth over the past three years, which is associated with high birth rates in the country.

Figure 9.1. *Dynamics of the number of preschool organizations and schools* [330]

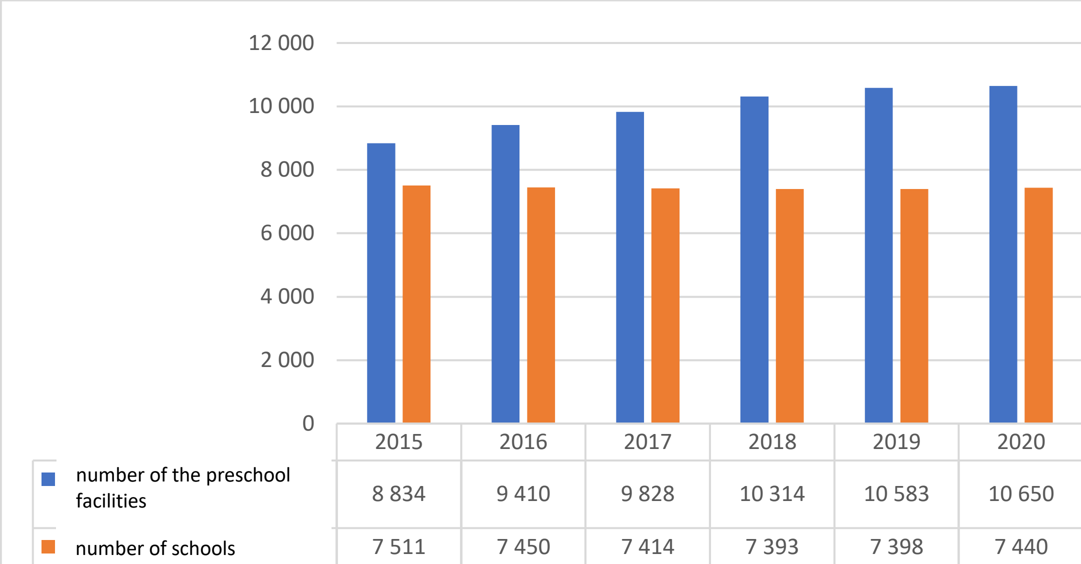
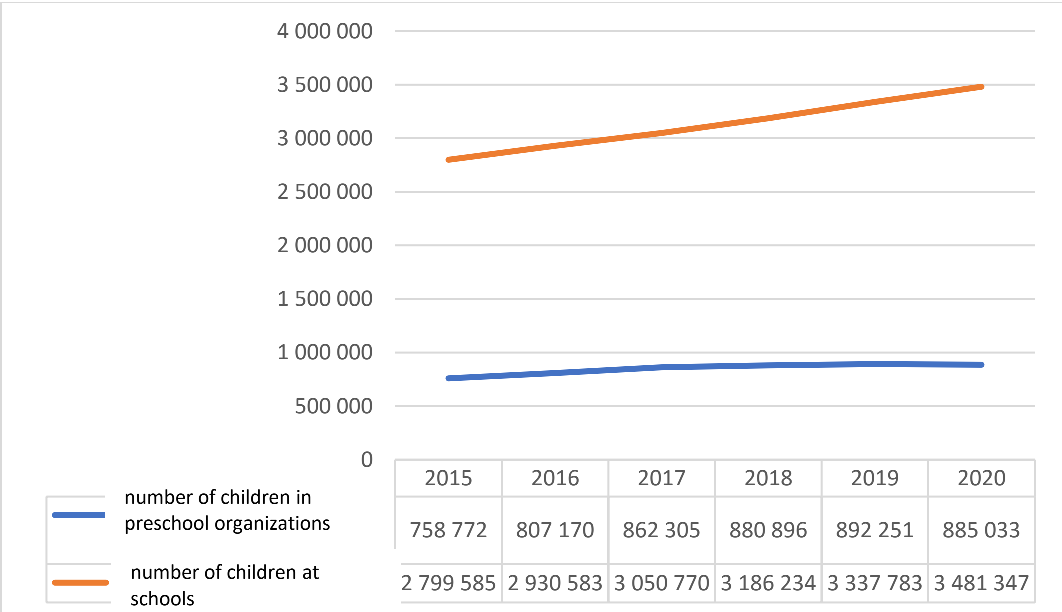
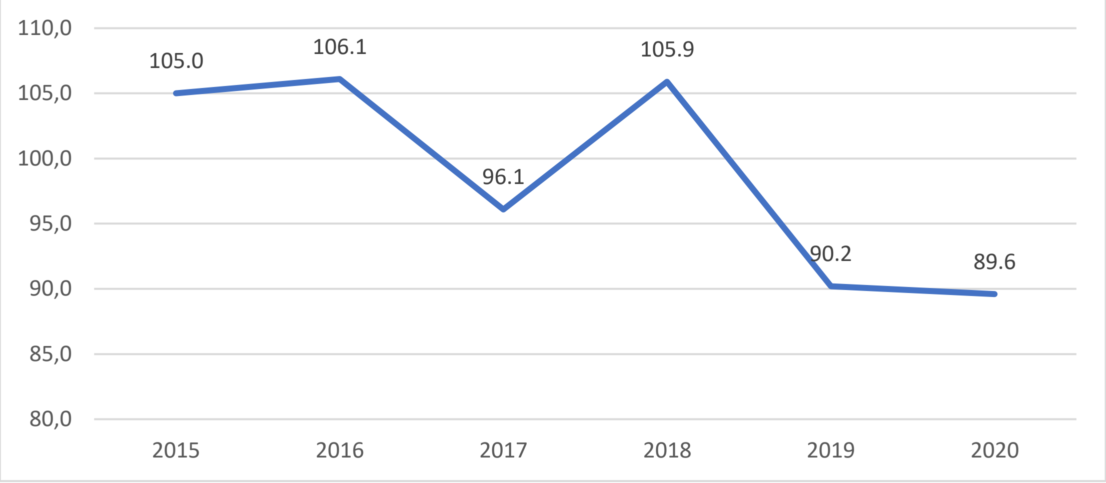


Figure 9.2. *Dynamics of the number of children in preschool organizations and schools* [331]



[328] The Concept of Education Development in Kazakhstan until 2025: https://legalacts.egov.kz/npa/view?id=12629438
[329] Ministry of Education and Science of Kazakhstan: https://www.gov.kz/memleket/entities/edu/activities/158?lang=ru
[330] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7
[331] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7

Figure 9.3. *Provision of places for children in preschool institutions (number of children per 100 places), %*[332]



In 2021, general secondary education system included of 7,549 different schools with a total of 3,594,972 students. [333]

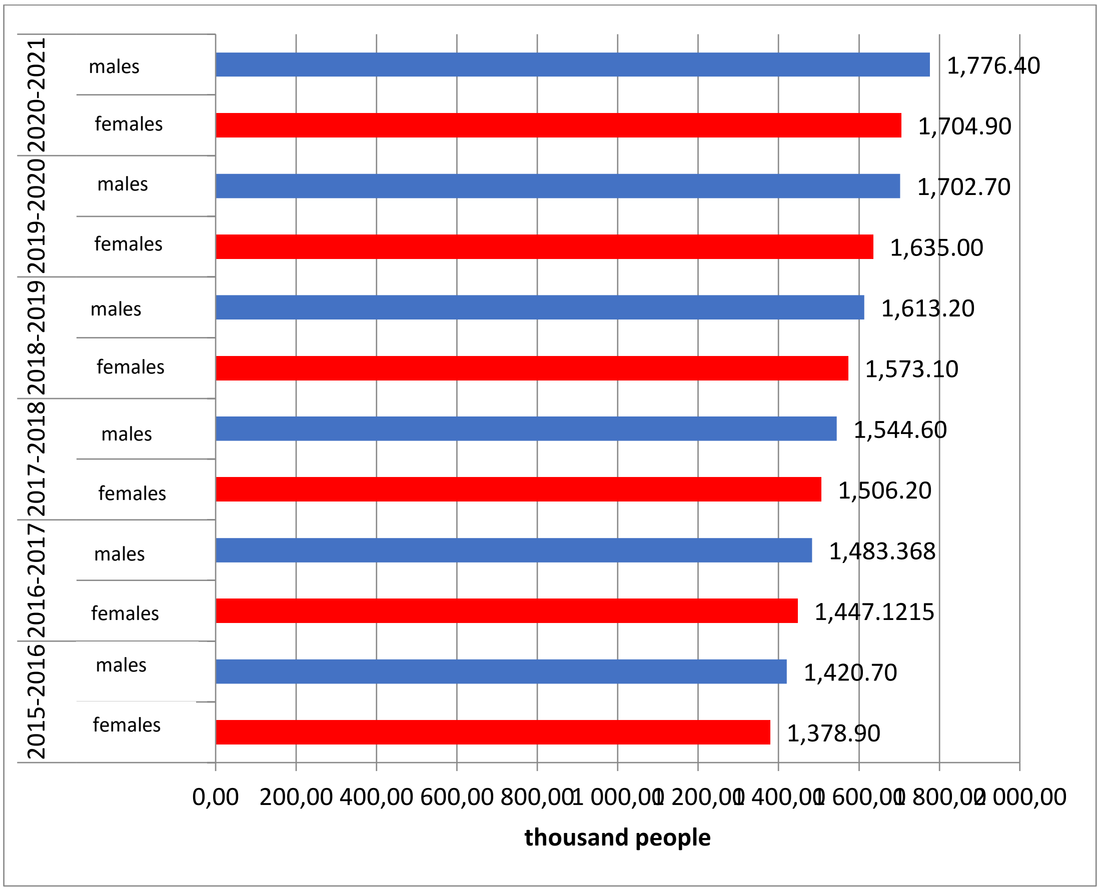
Enrollment of children in elementary school remains consistently high at 98-100%, and coverage of children aged 11-17 years by public secondary education - 105%.

The total number of students enrolled in educational institutions in 2020-2021 academic year was 4,583,100, 49.5% – females and 50.5% – males. The number of students in secondary schools was 76% of the total number of students, 10.4% in technical and vocational educational institutions, 12.6% in higher education institutions, 0.8% in master's degree programs, 0.2% in PhD programs, and 0.1% in residency programs.

The number of males enrolled in secondary education is slightly higher than that of females. Between 2015 and 2021, male enrollment ranged from 50.5% to 51%.

[332] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7
[333] Ministry of Education and Science of Kazakhstan: https://www.gov.kz/memleket/entities/edu/activities/158?lang=ru

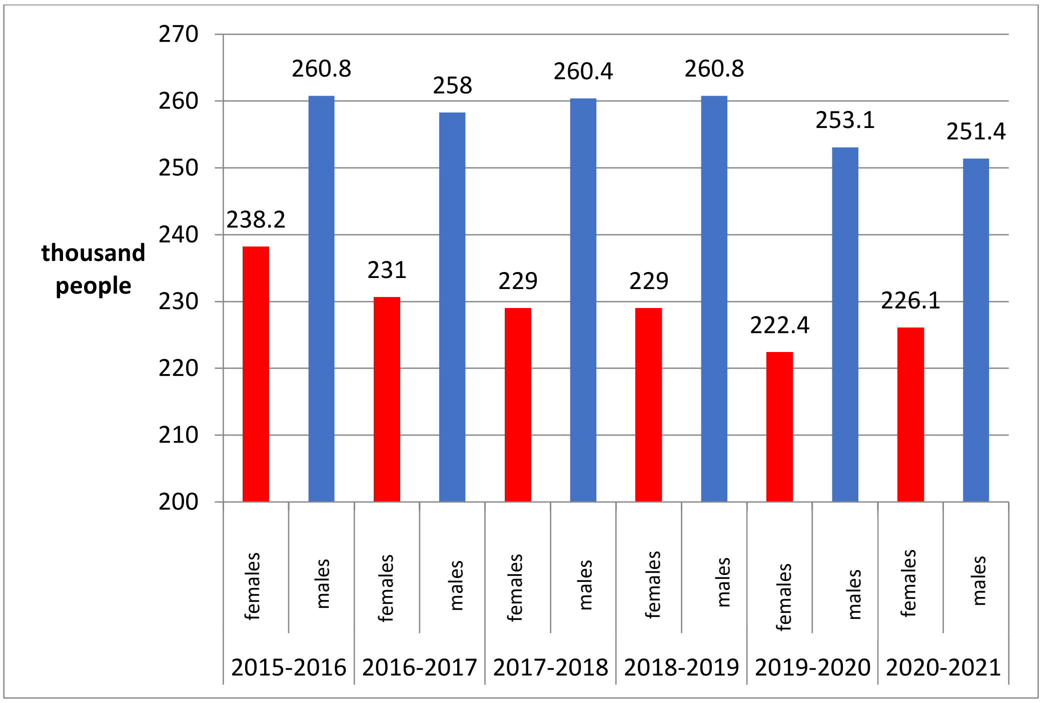
Figure 9.4. *The number of males and females enrolled in secondary schools in 2015-2021.*



Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

The share of female students in technical and vocational educational organizations from 2015 to 2021 ranged from 46.8% to 47.7%, and the share of males from 53.2% to 52.6%, respectively (Figure 9.5).

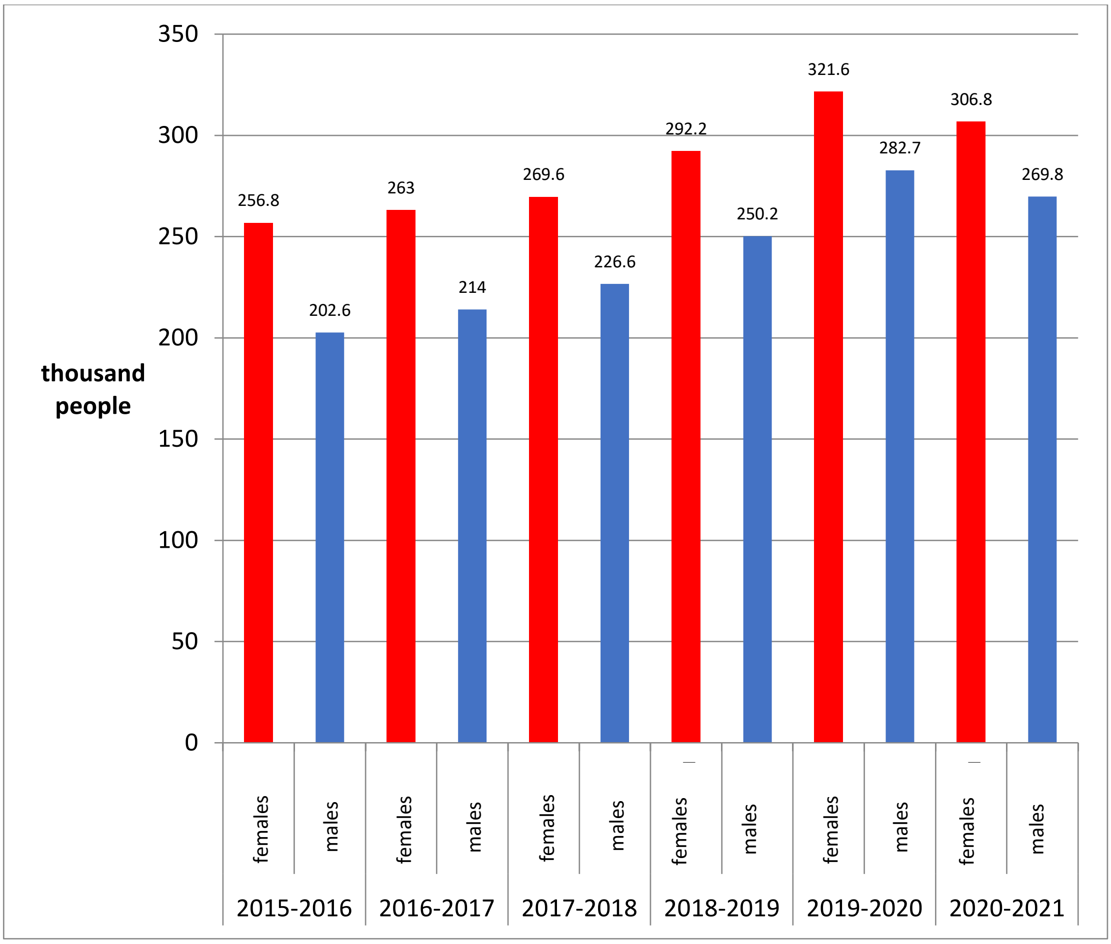
Figure 9.5 The number of students in technical and vocational educational organizations in 2015-2021



Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

The number of females studying in higher education institutions is higher than that of males (Fig. 9.6). This ratio is maintained throughout the period from 2015 to 2021. In 2020-2021 academic year the ratio of males and females was 46.8% and 53.2%, respectively.

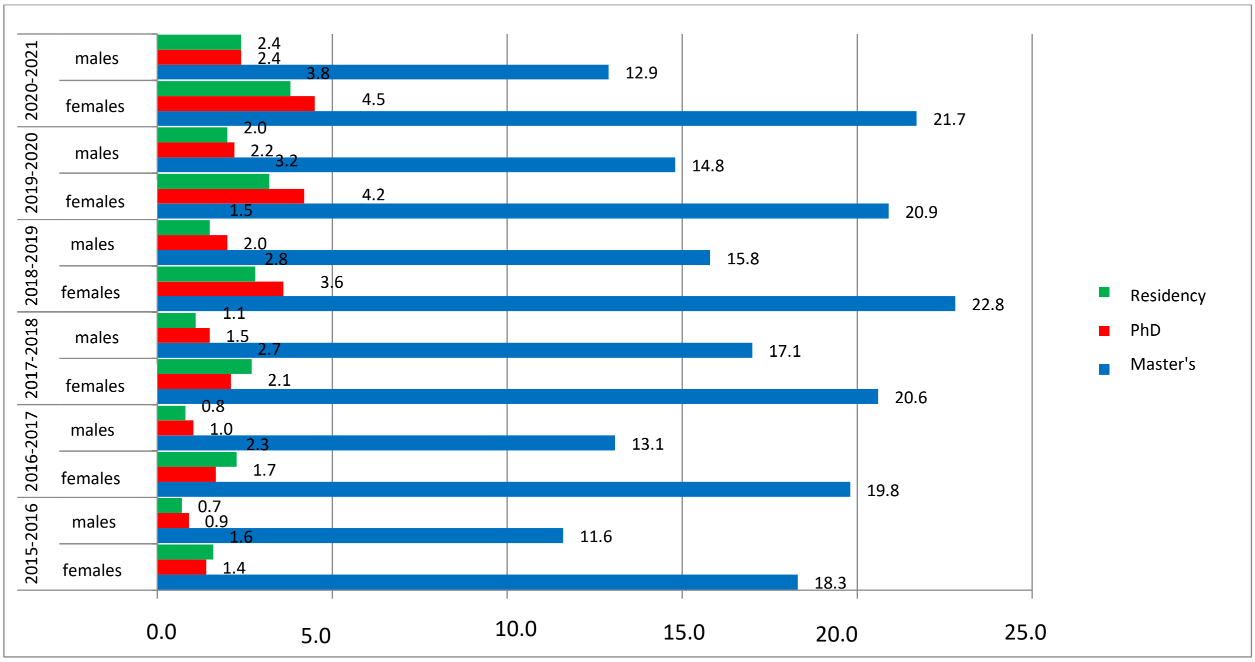
Figure 9.6. Number of students enrolled in higher education institutions in 2015-2021



Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

A high proportion of female students continue to be enrolled in master's, PhD, and residency programs. For 2020-2021 academic period, the percentages of females and males enrolled in master's programs were 62.7% and 37.3%, PhD – 65.2% and 34.8%, and residency programs – 61.3% and 38.7%, respectively (Figure 9.7).

Figure 9.7 Number of male and female students in master's, PhD, and residency programs in 2015-2021



Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

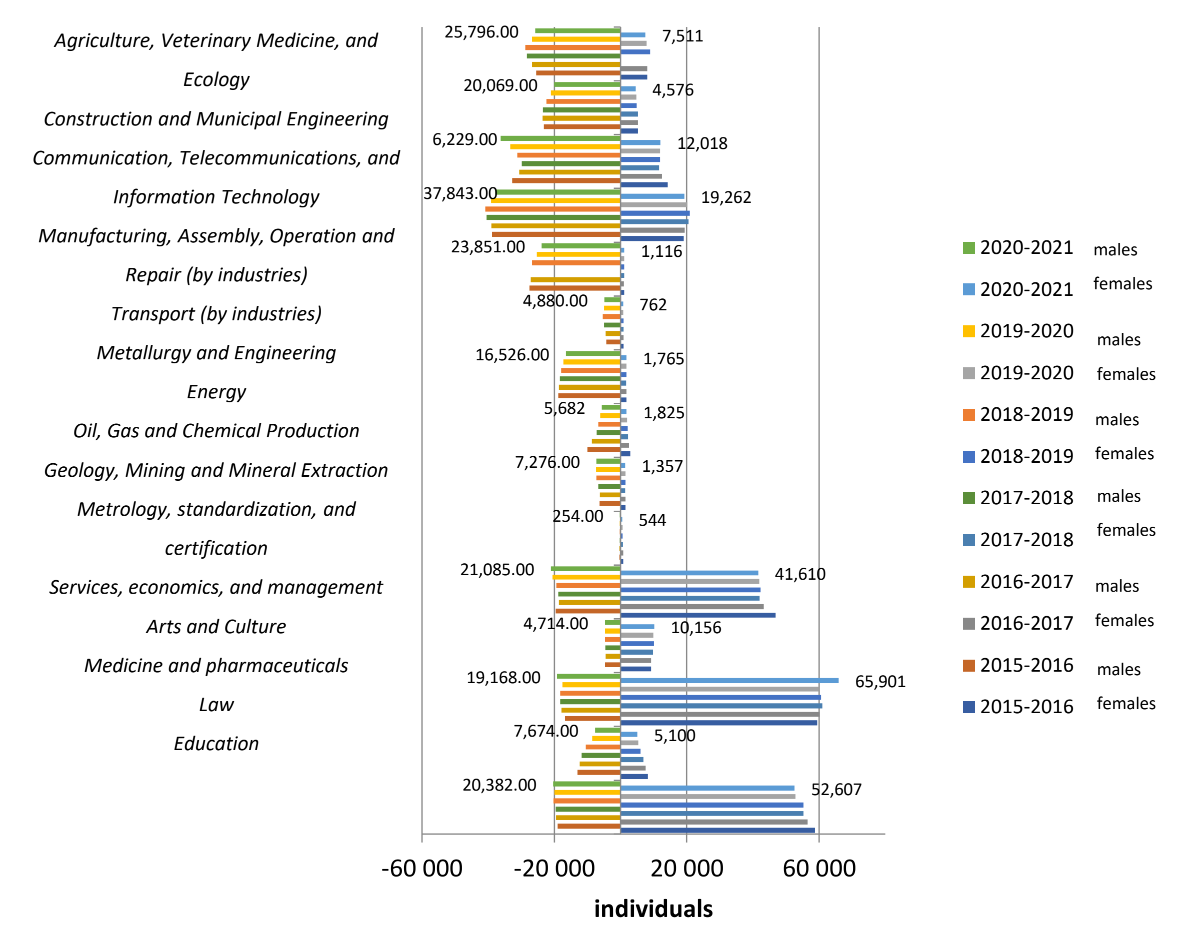
At present in Kazakhstan, the number of females who entered and received higher, technical, and vocational education is usually higher in social, humanitarian, and medical sciences, and the number of males is higher in technical and technological sciences.

Figure 9,8 shows the distribution of students by gender in technical and vocational education organizations by major group of specialties, where a large proportion of males are majoring in: Agriculture, Veterinary Medicine and Ecology (77.4%), Construction and Municipal Engineering (81.4%), Communication, Telecommunications and Information Technology (75.1%), Manufacturing, Assembly, Operation and Repair (by industries) (66.3%), Transportation (95.5%), Metallurgy and Engineering (85.5%), Energy (90.4%), Oil, Gas and Chemical Production (75.7%), Geology, Mining and Mineral Extraction (84.3%).

Women dominate in the following occupational groups: education (72.1%), medicine and pharmaceuticals (77.5%), services, economics, and management (66.4%) and metrology, standardization, and certification (68.2%).[334]

[334] Data as of the beginning of the 2020/2021 academic year

Figure 9.8. *Students enrolled in technical and vocational education organizations, by occupational groups from 2015 to 2021*



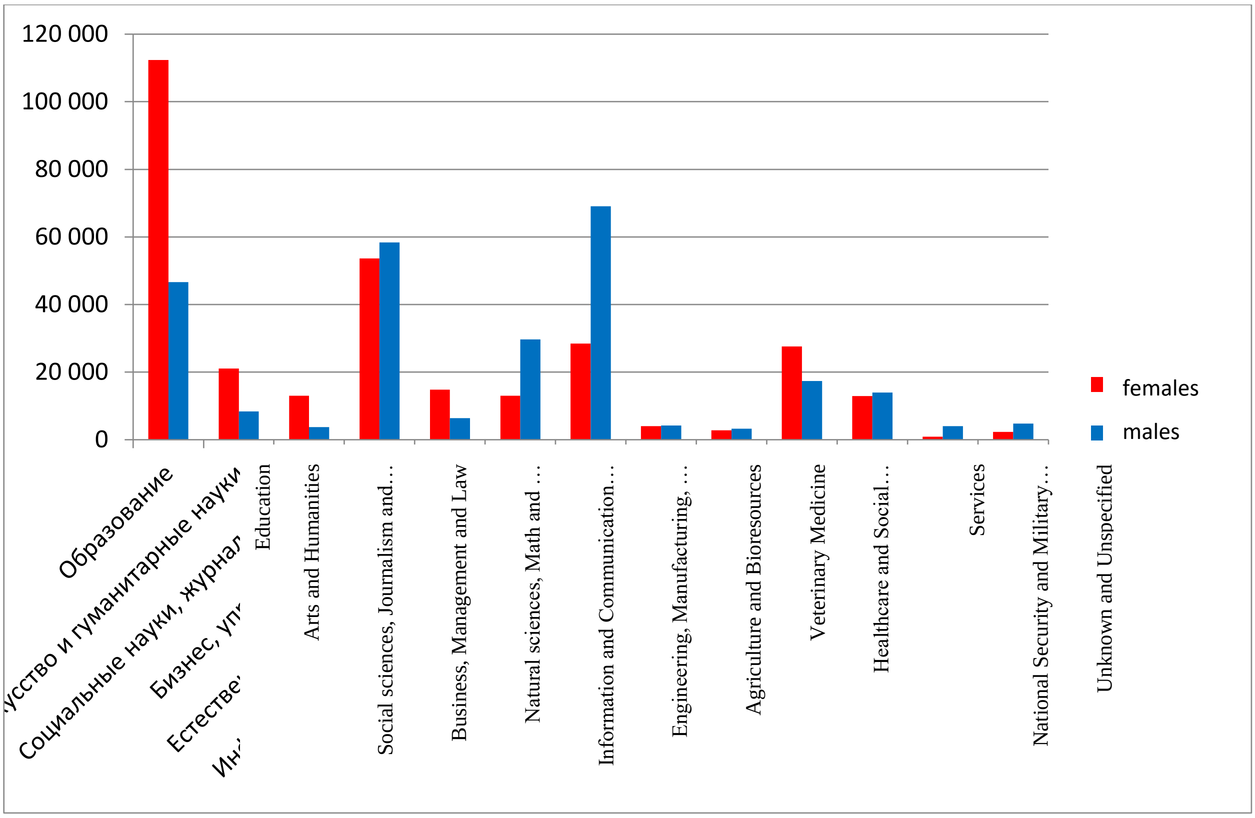
Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

The distribution of males and females in higher education generally echoes the previous figure. Figure 9.9 shows data for the last 2 years (2019-2021), which reflects changes in the category of specialties by the statistical authorities.

In the higher education category, there is a higher proportion of males in the group of occupations such as: agriculture and bioresources (51.3%), veterinary medicine (53.3%), engineering, manufacturing, and construction (70.9%), information and communication technology (69.6%), national security and military affairs (81.3%), business, management, and law (52.1%), and services (51.9%).

Female representation is highest in the following fields: education (70.7%), health care and social welfare (61.3%), arts and humanities (71.6%), social sciences, journalism, and information (77.8%) and natural sciences, mathematics, and statistics (69.8%).

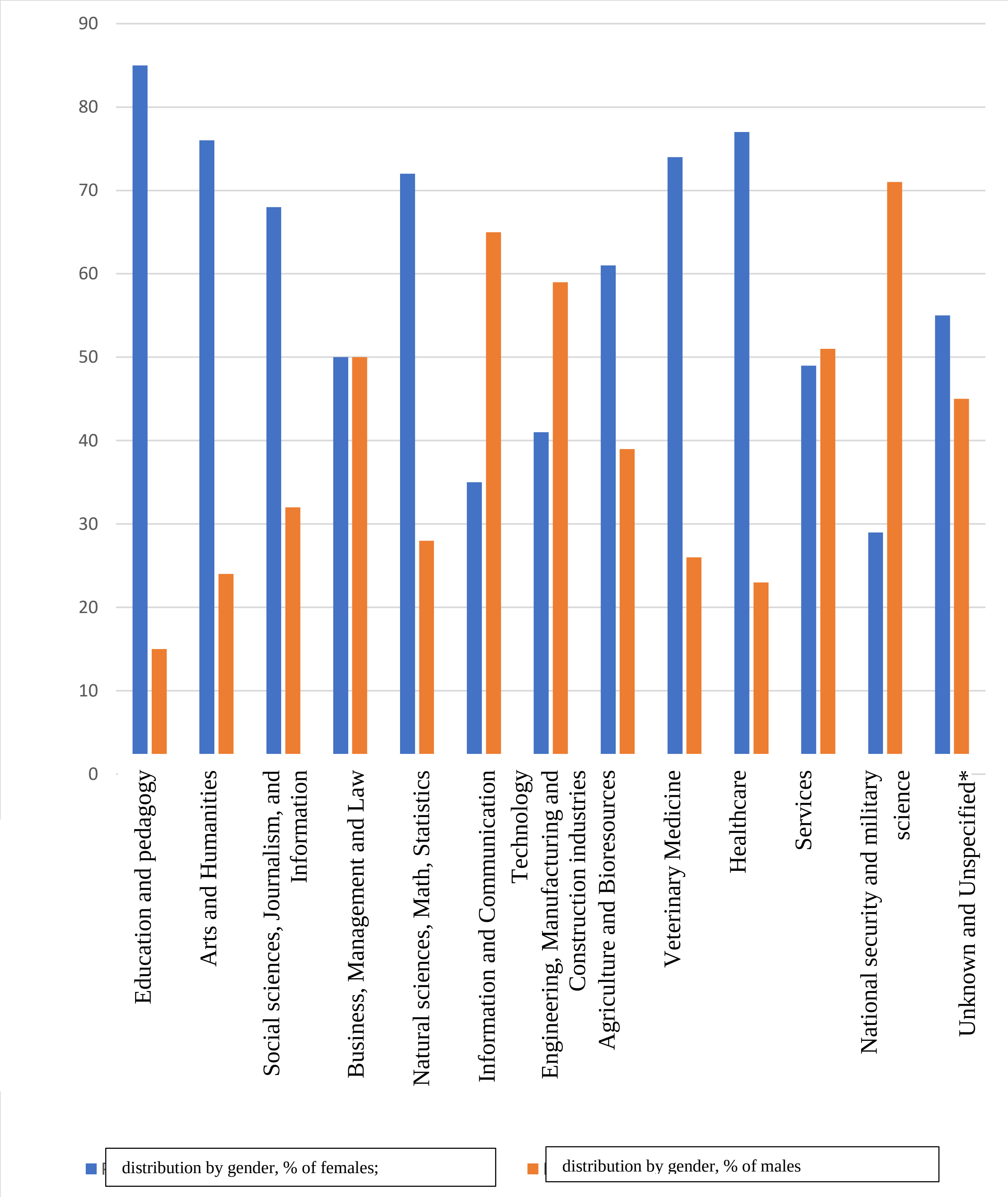
Figure 9.9. University students by majors in 2019-2021



Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

The distribution of master's students by majors in the gender aspect repeats the distribution of students in technical and vocational education and undergraduate programs of higher education.

Figure 9.10. Distribution of master's students by major from a gender perspective, 2020

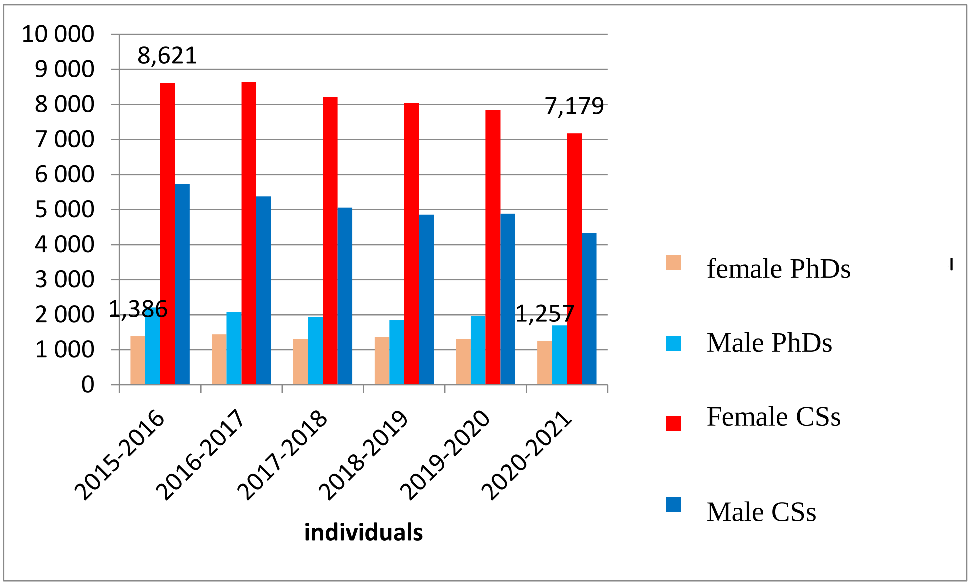


Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

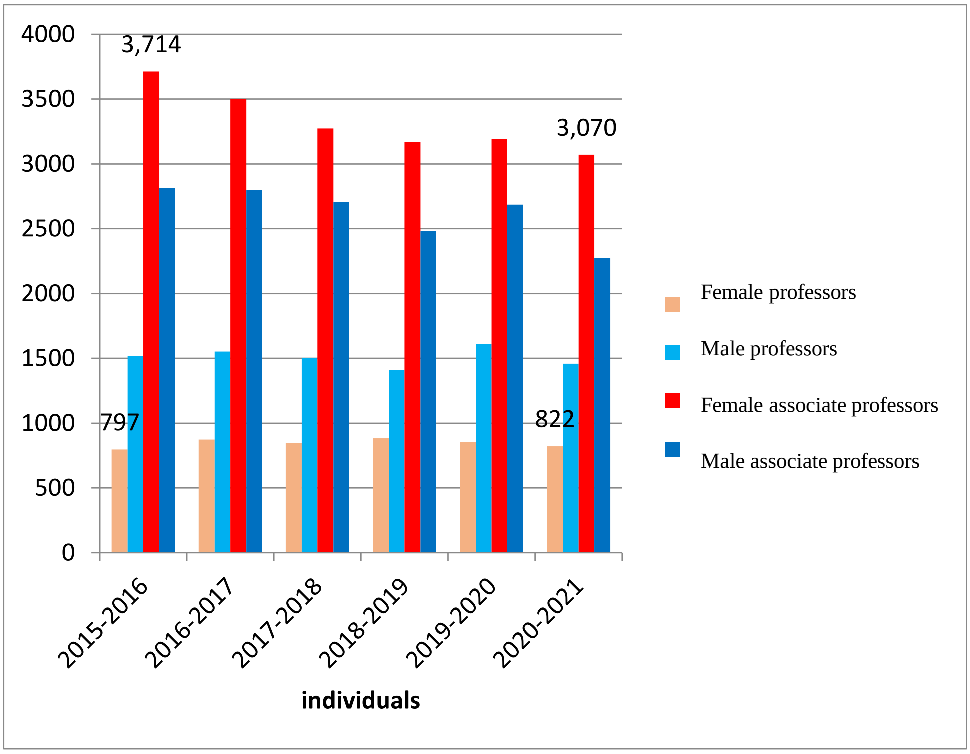
The data on the employment of academic staff shows a predominant number of females with the degree of candidate of sciences and an inverse ratio of a large number of males with a higher PhD degree. The same distribution is observed with the title of associate professor and professor.

The number of women with the title of associate professor is greater than the number of men, and males predominate in the category with the title of professor. It should also be noted that there is a decreasing trend in the employment of women with the degree of candidate of science and the title of associate professor.

Figure 9.11. *The number of faculty members of tertiary educational institutions with higher education degrees.*



a) academic degree



b) academic rank

Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.

Figures 9.1 and 9.2 demonstrate a significant lag in the dynamics of increase in the number of schools compared to the growth in the number of students. Over 60% of schools in Kazakhstan were commissioned in 1930-1990, and the lack of a systematic approach in the regions to evaluations of their technical condition and for major repairs may affect the unsafe condition of school buildings.

As noted in the Concept of Education Development until 2025:

"The problem of overcrowding in schools and three-shift education has not yet been completely solved - the number of continues to grow. Although during the years of independence 2,466 new schools have been built in the country.

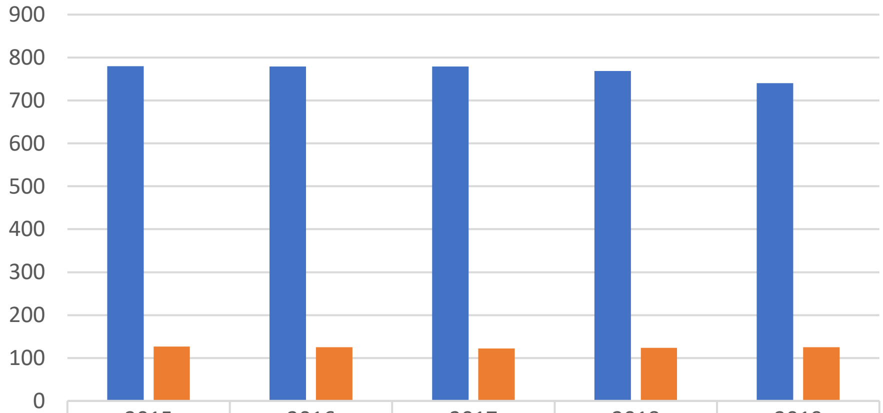
According to the results of 2020, 137 schools operate in three shifts, accordingly, there is still a deficit of slots for students. 635 schools require major repairs, including 224 in the city and 411 in the rural areas. 2% of schools operate with a deficit of student places.

Development of internal infrastructure of schools requires immediate solution due to deterioration and aging. Over the last 3 years 770 school buildings have undergone major repairs aimed at ensuring healthy conditions".

The updated content of secondary education has been implemented since the 2015-2016 academic year. The principle of transition from the knowledge-based approach to competence-based learning has been implemented. The state compulsory standards of education, model curricula and model educational programs were updated, the criterion system of evaluation of students' learning achievements was introduced, teaching methods and technologies were improved. However, as it is noted in the Concept of Education Development till 2025, the content of secondary education does not fully meet the tasks of development of functional literacy of students. For example, in the subjects of natural and mathematical cycle there are few contextual tasks in the PISA format, there are no elements of STEM-education.

The concept also points to the presence of a significant gap in the quality of school education in the regional dimension and in the context of urban-rural inequalities.

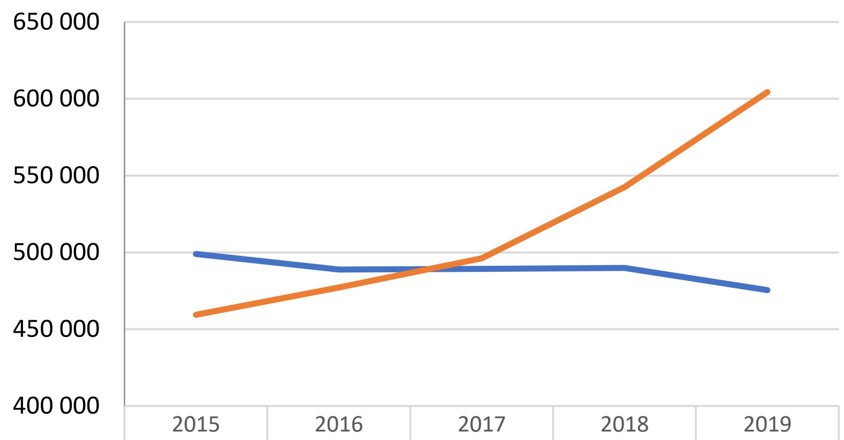
Figure 9.12. *Dynamics in the number of colleges and universities*[335]



	2015	2016	2017	2018	2019
number of colleges	780	779	779	769	740
number of universitites	127	125	122	124	125

[335] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7

Figure 9.13. *Dynamics of the number of students in colleges and universities* [336]



	2015	2016	2017	2018	2019
number of students incolleges	498 965	488 926	489 337	489 818	475 443
number of students in universitites	459 369	477 074	496 209	542 458	604 345

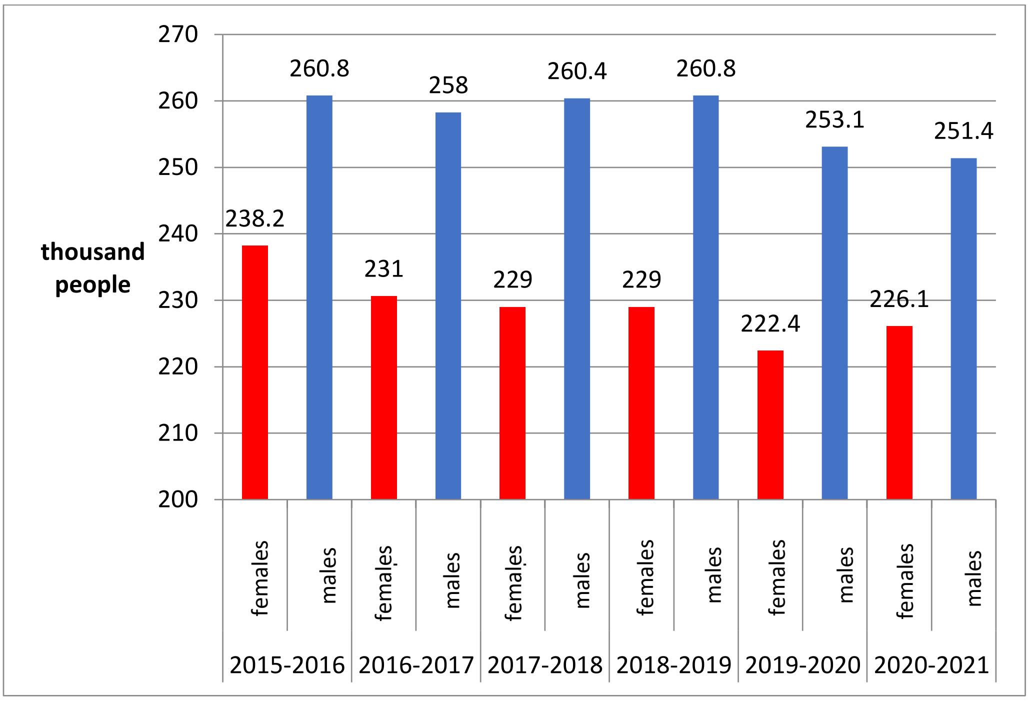
Analysis of the dynamics of the number of colleges shows a downward trend (Figure 9.12), as well as the number of students in colleges (Figure 9.13). According to the Ministry of Education and Science of the Republic of Kazakhstan, in 2021 only 42% of students from the total number of graduates of secondary education (in 2020 - 40%) and 32% of graduates from general high school education (in 2020 - 20%) enrolled in colleges.[337]

The share of females in technical and vocational educational organizations from 2015 to 2021 ranged from 46.8% to 47.7%, and males from 53.2% to 52.6%, respectively

[336] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7

[337] https://www.gov.kz/memleket/entities/edu/activities/271?lang=ru

Figure 9.14. *The number of males and females studying in Kazakhstan universities, technical and vocational educational organizations*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.*

The implementation of academic independence is carried out in accordance with the State Compulsory Educational Standard (SCES). Educational programs are developed by organizations of vocational education and training (VET) independently with the participation of employers based on the requirements of SCES, professional standards, WorldSkills standards and regional context.

Currently, colleges can exclude certain modules and replace them with new ones to build the necessary competencies.

If previously there was a strict regulation and fixed training periods for various qualifications, on average from 2 years to 3 years and 10 months, currently this norm is excluded from the Law ‘On Education’. Now the period of training depends on the specific educational program and the required learning outcomes.

In recent years, access to higher education has significantly increased. Over the past four years, the number of scholarships for bachelor's programs has increased by 1.7 times, for master's programs by 1.8 times, and for PhD programs by 3.7 times.

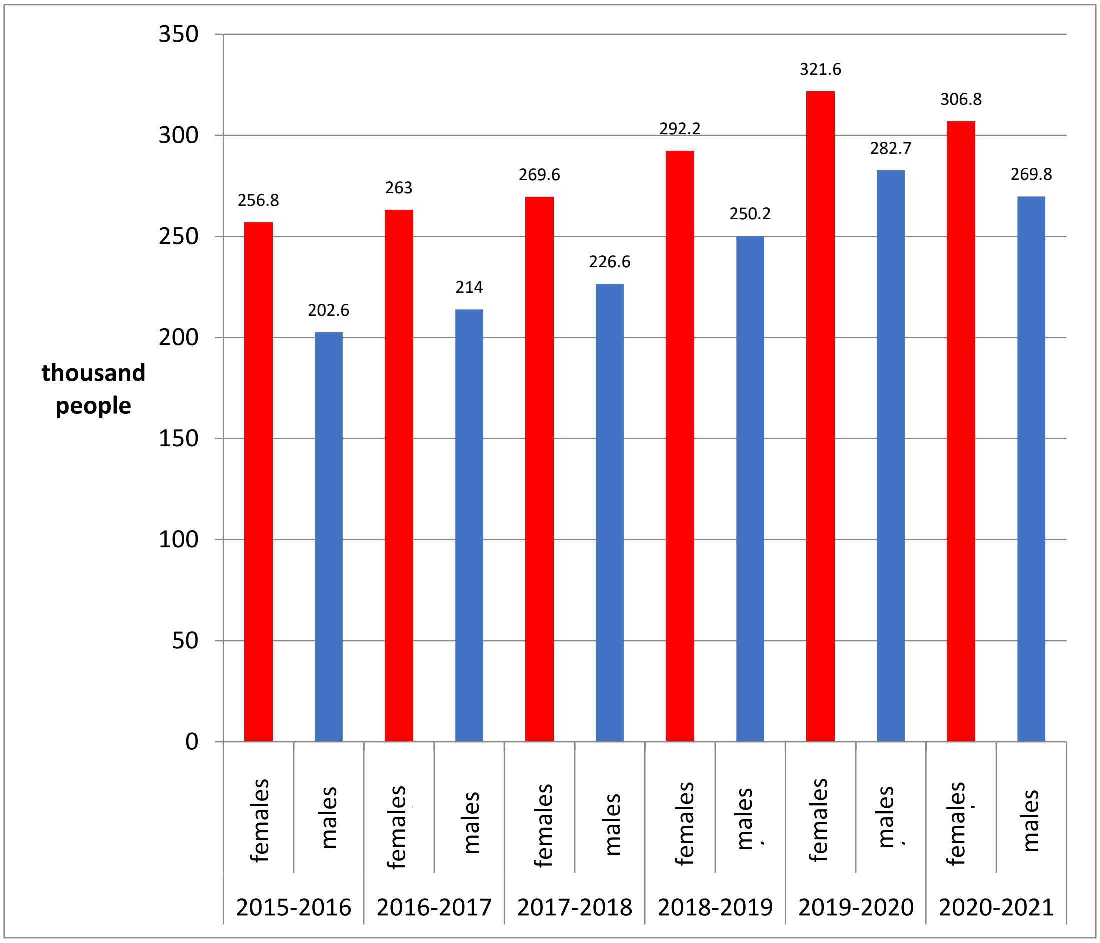
Kazakhstan is fulfilling its commitments to ensure equitable access to higher education for those with low socioeconomic status. In 2021, the list of admission quotas for higher education includes categories of persons from socially vulnerable groups. In addition, in 2021 the Law of the Republic of Kazakhstan ‘On Education’ adopted a norm on introduction of the state educational loans for students to pay for higher education.

the Law on expansion of academic and managerial independence of universities was adopted in the system of higher education. The law allows universities to independently develop educational programs. The educational programs of higher and postgraduate education in all areas were updated, based on the demands of the labor market. Nevertheless, the results of the international survey of adult skills PIAAC showed that higher education does not sufficiently develop the competences of the adult population compared to the OECD countries.

In addition, Kazakhstan ranks 95th out of 141 countries in higher education according to the 'Graduate skills' indicator in the GIC WEF- 2019. A potential reason for this is the fragmented nature of universities' cooperation with employers under academic policy.[338]

The number of females enrolled in higher education is higher than that of males. This ratio persists throughout the 2015-2021 period. For the academic period 2020-2021 the ratio of males and females was 46.8% and 53.2%, respectively

Figure 9.15. *Number of females and males enrolled in higher education, thousand people*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.*

The representation of Kazakhstani universities in global rankings is increasing. Since 2016, the number of universities marked in the QS World University Rankings has increased from 8 to 14. Three national universities are recognized by the Times Higher Education rating publication (Kazakh National University named after Al-Farabi, Kazakh National Research Technical University named after K. Satpayev, Kazakh National Pedagogical University named after Abay).

In terms of quality assurance, the majority of educational programs (73.3%) are accredited by national quality assurance providers. 8.2 % of educational programs have international accreditation.

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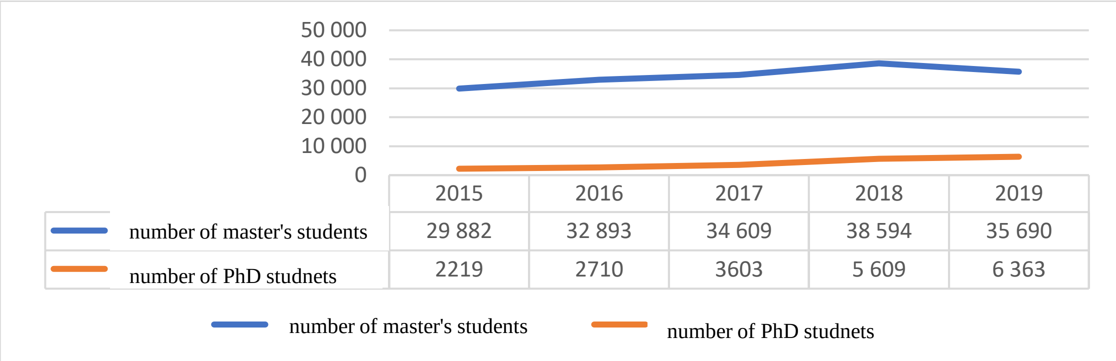
[338] The Concept of Education Development in Kazakhstan until 2025: https://legalacts.egov.kz/npa/view?id=12629438

In 2020 Kazakhstani universities implemented 152 double degree programs with 77 partner universities. The number of partner universities includes the universities of the CIS, Europe, Asia, and the USA. The number of students studying on such programs is 1120: Bachelor’s degree - 674, master’s degree - 435, PhD - 11.

The Green Bridge Institute, as part of the Green Bridge Partnership Program, is doing a lot of work to analyze the curricula of universities, helping the educational institutions participating in the program to introduce green economy issues into their curricula, including a number of climate change-related aspects.[339]

Figure 9.16. *Number of master's and PhD students*[340]



	2015	2016	2017	2018	2019
number of master's students	29 882	32 893	34 609	38 594	35 690
number of PhD studnets	2219	2710	3603	5 609	6 363

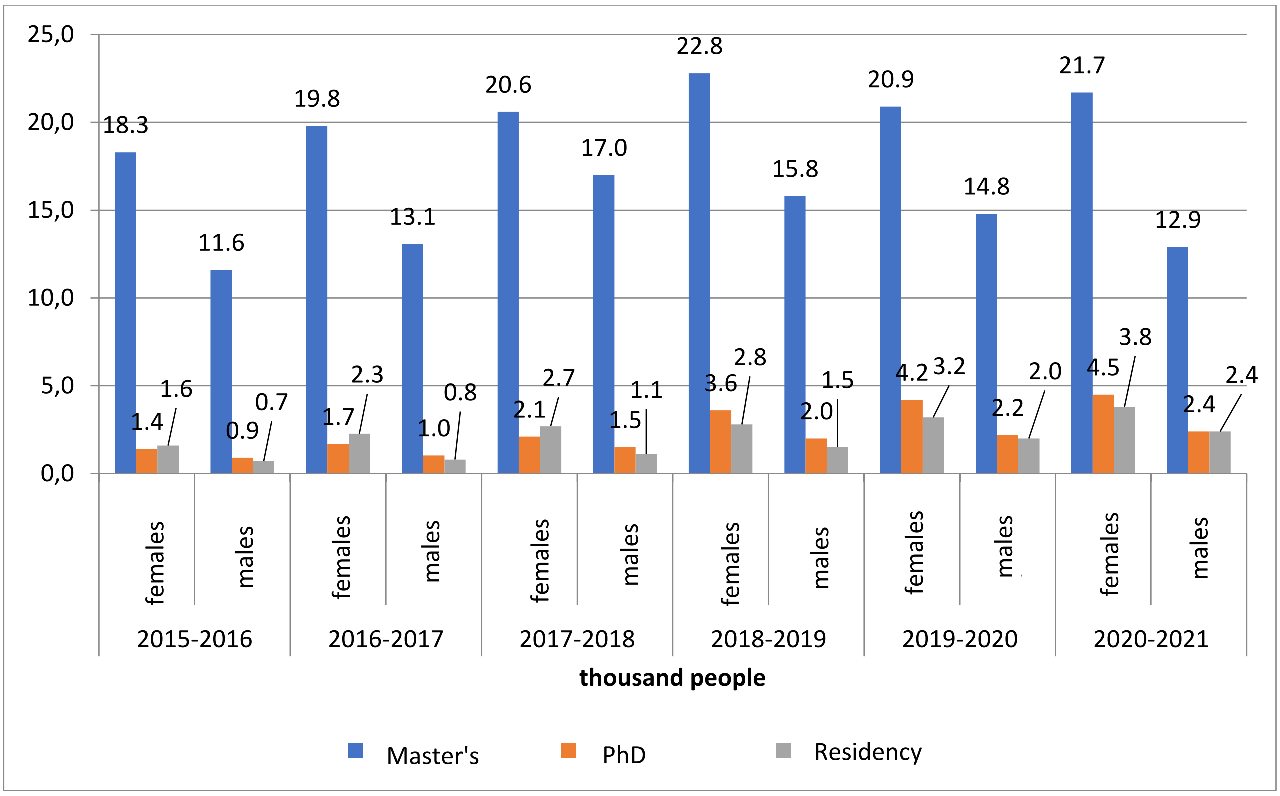
At the beginning of 2020-2021 academic year there were 34,619 master's degree students with 15,245 students enrolled and 21,372 master's degree students graduating. In PhD programs the number of students reached 6,914 people. There were 2,094 admission and 1,446 graduates, of whom 33.4% (483) - with a thesis defense.

A higher number of females are enrolled in master's, doctoral and residency programs. In 2020-2021, the ratio of males to females in master's programs was 62.7% and 37.3%, PhD programs 65.2% and 34.8%, and residency programs 61.3% and 38.7%, respectively.

Figure 9.17. *Number of female and male students in residency, PhD, and master's programs*

[339] https://bilimdinews.kz/?p=166627

[340] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan: https://stat.gov.kz/official/industry/62/statistic/7

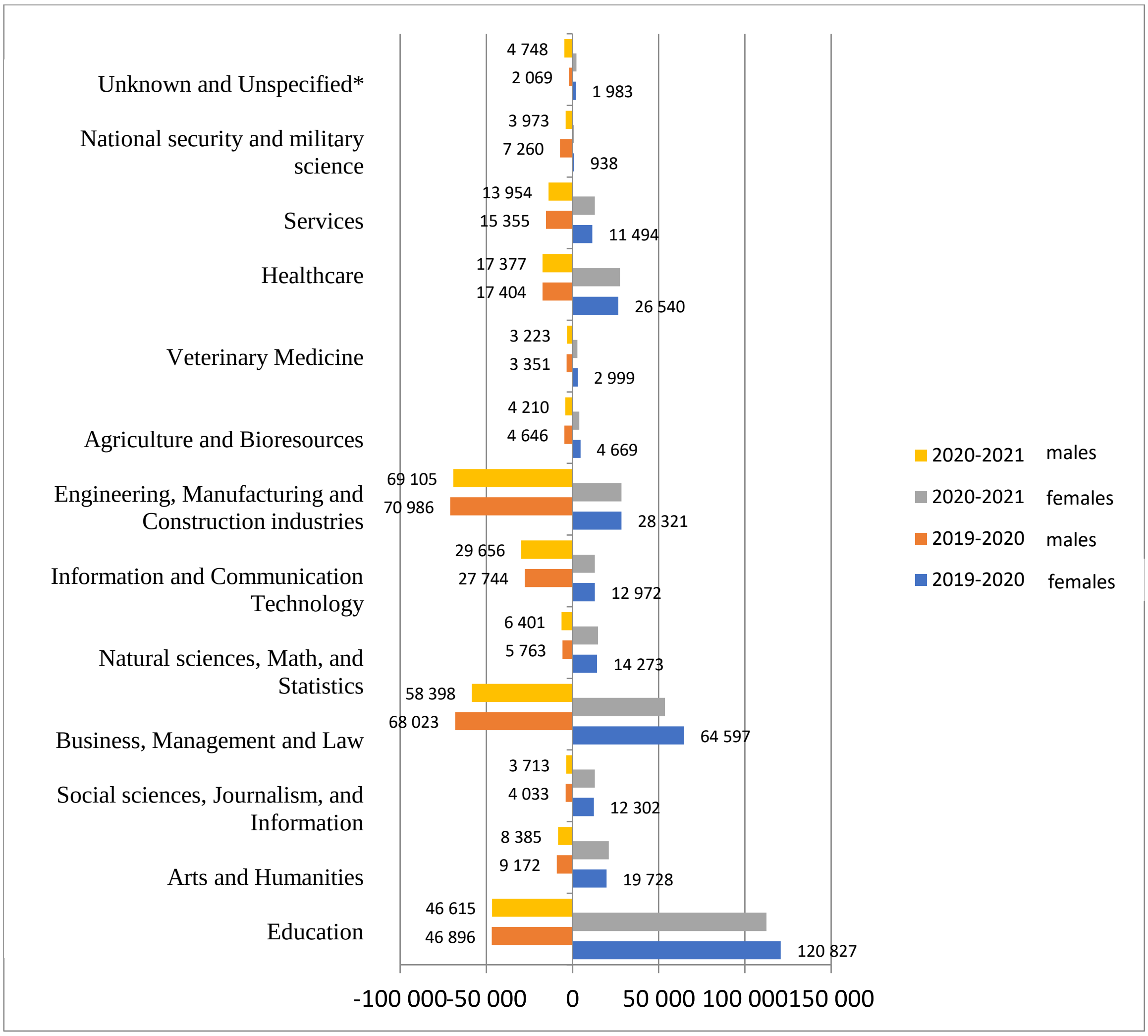


Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.*

There are more males in the following fields of study: agriculture and bioresources (51.3%), veterinary medicine (53.3%), engineering, manufacturing, and construction (70.9%), information and communication technology (69.6%), national security and the military (81.3%), business, management, and law (52.1%), services (51.9%).

More females are found in higher education in the following fields: education (70.7%), health and social services (61.3%), arts and humanities (71.6%), social sciences, journalism, and information (77.8%), natural sciences, mathematics, and statistics (69.8%).

Figure 9.18. *Number of female and male students majoring in different subjects*



Source: *Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Bureau of National Statistics, statistical digests.*

COVID-19 pandemic and the need to introduce quarantine measures had a notable impact on the education system. The active phase of development of digitalization in education began in 2017-2018 with the implementation of the objectives of the Address of the Head of State and the adoption of the Digital Kazakhstan State Program. In March 2020, the Ministry of Education and Science of the Republic of Kazakhstan approved the minimum requirements for hardware and software installed in educational organizations. The intensive development of educational courses in digital format has been accelerated. The transition to a distance format had the greatest impact on students and teachers in terms of building digital competencies.

Among all levels, higher education was the most adapted to distance learning. According to the monitoring results published by Atameken National Chamber of Entrepreneurs, 41% of educational programs were fully, and 43% were partially ready for the transition or implementation of distance learning with the use of online technologies.

But the pandemic has suspended opportunities for academic mobility and internships abroad for university students. The share of foreign students in the pool of university students fell from 40,043 to 29,069, reducing to 5% (6.8% in OECD countries).

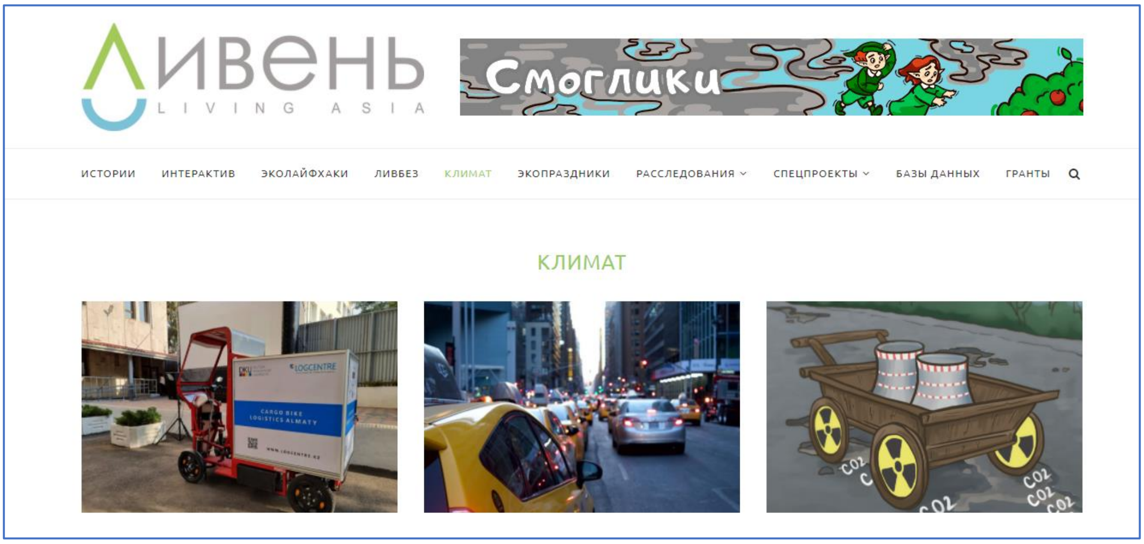
However, as outlined in the Concept of Education Development until 2025, such challenges as unequal opportunities for schools to access digital resources, unequal access of secondary education organizations to broadband Internet, lack of digital educational content and integration into the international education system persist.

9.3. Public awareness campaigns

Plenty of climate information presented in a format appealing to public is posted on the website of the online eco-magazine 'LIVEN. Living Asia' published by the Ecoforum of Public Organizations of Kazakhstan and the Social-Ecological Foundation. The online Living Asia eco-journal was developed as part of the ‘Media for Improved Reporting on Environment and Natural Resources in Central Asia’ project (2016-2017), which was funded by the European Union and implemented by Internews. The project was aimed at strengthening regional efforts to improve access to information on environmental and natural resources in Central Asia.

Under the terms of the Memorandum, upon completion of the ‘Media for Improved Reporting on Environment and Natural Resources in Central Asia,’ the Living Asia online magazine was handed over to the Ecoforum of Public Organizations of Kazakhstan. Since October 2017, Ecoforum of Public Organizations of Kazakhstan and Socio-Ecological Foundation are maintaining the magazine as its operators. Living Asia continues to operate in accordance with the objectives mentioned above in the five countries of Central Asia. The portal contains a lot of interesting information, introducing readers both to general knowledge on climate change in Central Asia and individual countries, and to climate change related activities, including public events.

Figure 9.19. *The climate section of the Living Asia eco-magazine*[341]



The eco-magazine received support in the preparation of many materials from the ‘European Union – Central Asia Water, Environment and Climate Change Cooperation’ (WECOOP) project, the third phase of which began in October 2019 and is to continue until October 2022.

A lot of useful information on climate change, mitigation and adaptation measures is available on the YouTube channel ‘UNDP Kazakhstan Climate Learning Video Portal’.[342]

[341] https://livingasia.online/category/climate/page/1/
[342] https://www.youtube.com/channel/UCWj-QJOO7QlI7NnlOHd33qw

On 2-3 June, UNDP organized an online training for journalists. The training covered the main challenges and threats of climate change in the context of Kazakhstan, as well as international trends in this area. Participants learned how to prepare accessible information about climate change and create multimedia projects.[343]

A significant event in raising public awareness of environmental issues was the presentation of the collective monograph 'Tomorrow was Too Late: Environmental Risks of Kazakhstan,' which was presented in Astana in June 2021 with the participation of the Head of the Committee on Ecology of the Ministry of Ecology, Geology and Natural Resources,[344] and in September 2021[345] in Almaty. The project was implemented by the Kazakh-German University in partnership with the Private Fund of Dosym Satpayev, with the support of the OSCE Programme Office in Astana, the Friedrich Ebert Foundation in Kazakhstan, and the Living Asia eco-portal. Along with a story about the problems of pollution in different areas of the environment, degradation of ecosystems and water resources in the country, the book contains a chapter titled 'What Place will Kazakhstan Take in the Climate Competition,' authored by Vadim Ni and Svetlana Dolgikh. The chapter introduces readers to both general ideas about the causes of climate change and more detailed information about Kazakhstan's contribution to the impact on the climate system, climate change forecasts and their impact on human health and the economy, as well as measures that will reduce the impact on the climate system and adapt to the inevitable changes.[346]

Before the 26th UN Climate Change Conference of the Parties (COP26), there were quite a few awareness-raising events, including those for young people. Thus, on October 2-8, 2021, the Climate Week student online festival was held with dedication to COP26. The festival was organized by the National Conservation Initiative Corporate Fund and the Nazarbayev University Office of Sustainable Development**.**

In addition, in October 2021, British and Italian Embassies in Kazakhstan in partnership with Nazarbayev University organized student debates Voice of Youth: Uniting the World to Tackle the Climate Change.[347]

To discuss the proposals on adaptation to climate change in Kazakhstan UNDP has also organized consultations with experts, representatives of governmental, international and public organizations through the Regional Platform on Water Management with participation of more than 250 experts, representatives of governmental bodies, scientists and NGOs as well as international and academic organizations,[348] through the Climate Change Group in Kazakhstan and CA - over 100 representatives of ministries and agencies as well as NGOs of Kazakhstan and CA.[349]

9.4.Curricula

As mentioned above, Kazakhstan has no special 'Ecology' discipline in the school curricula. It is recommended to include environmental issues as a cross-cutting topic in other school subjects. It is also recommended to cover environmental education during homeroom periods. In 2020 the Republican educational and methodological center of additional education of

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343 https://www.youtube.com/watch?v=-K57Y6eG074&ab_channel=ClimateLearningPortal
344 https://www.gov.kz/memleket/entities/ecogeo/press/news/details/218342?lang=ru
345 https://centralasiaclimateportal.org/event/90
346 https://drive.google.com/file/d/1_AImxG4FUsm019GpCbwjuo99TOjKQS_l/view
347 https://www.inform.kz/ru/konferenciya-cop26-oon-velikobritaniya-i-italiya-proveli-diskussii-s-kazahstanskimi-studentami_a3854950
348 https://groups.google.com/g/cawatercouncil/
349 https://groups.google.com/g/climate-change-in-kazakhstan

the Ministry of Education and Science of the Republic of Kazakhstan has developed the 'Curriculum of advisory hours on environmental education for schoolchildren of 1st to 11th grades". However, climate issues are presented only by one topic recommended for the 10th grade: 'Global climate change. Causes and Consequences of Glacier Melting'.[350]

The methodological manual 'Climate Change - I care!' by L.N. Bushman, S.A. Bylinskaya, E.P. Varganova, E.P. Ignatovich, I.A. Moskvichyova and M.V. Tyuryushcheva can be of great help to schoolteachers. The manual is part of a set of educational and methodical materials on 'Climate Change' for students in grades 7-9 and teachers, who teach subjects in both natural and mathematical sciences and other areas. The methodological manual 'Climate Change - I care!' by L.N. Bushman, S.A. Bylinskaya, E.P. Varganova, E.P. Ignatovich, I.A. Moskvichyova and M.V. Tyuryushcheva can be of great help to schoolteachers. The manual is part of a set of educational and methodical materials on 'Climate Change' for students in grades 7-9 and teachers, who teach subjects in both natural and mathematical sciences and other areas. The Manual was prepared by the 'Center for Coordination and Information on Environmental Education EkoObraz NGO with the assistance of the 'Human Health Institute' NGO commissioned by the Ecosystem Approach for Adaptation to Climate Change in High Mountain Regions of Central Asia regional project implemented by the German Agency for International Cooperation (GIZ) and funded by the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.[351] In addition to presenting the essence of climate change and its manifestations and impacts, the manual includes many interesting activities that not only help to deepen the understanding of the issues, but also provide an opportunity to develop an attitude towards climate change that promotes knowledge and awareness about climate change. It is worth noting that some of the authors of the publication are experienced teachers, enabling them to integrate the proposed topics into the curriculum for various school disciplines.

Also, several environmental programs are offered by the 'Republican educational and methodological center of additional education', which is responsible for the development of additional education for children through improving approaches to the formation and development of the creative abilities of children by means of software and methodological, organizational, content and information support. The Center works to create courses and teaching materials as part of tourism, local history and ecology and biology activities.[352] Information about the experience of introducing environmental education is presented in the EkoAlem magazine.[353]

Kazakh-German University offers an educational program 'Energy and Environmental Engineering' implemented by the Faculty of Engineering and Information Technology together with the University of Applied Sciences Hamburg, which is a partner university in the dual degree program.[354]

The course teaches students how to design and operate energy and environmental equipment, how to save energy, and how to implement new technologies. They will be introduced to methods of treating and reusing wastewater and a wide range of industrial waste and household waste. In addition, students will learn the basics of economics as well as environmental and energy

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[350] https://docs.google.com/document/d/11iShYqdoRGA9Us7ClnDhCw1T9AO3kdiFz7afoj7NNfQ/edit

[351] Climate Change - I care! methodological manual for teachers 'Climate change/ Contributing authors: Bushman L.N., Bylinskaya S.A., Varganova E. P., Ignatovich I.O., Moskvichyova I.A, Tyuryushcheva M. V. - Karaganda: EkoObraz, 2020. https://drive.google.com/file/d/1aD-C5XuNJN1RKC3W7uHf-W7zdygL8yZL/view

[352] https://www.ziyatker.org/tourist-and-ecological-direction

[353] https://www.ziyatker.org/204

[354] Kazakh-German University, https://dku.kz/ru/content/programm-view/?id=7

management. The university has a modern German laboratory where students can practice their knowledge. The core modules are taught by guest professors and associate professors from Germany.

Several online training courses on the topic of climate change are available on the Central Asian Climate Information Platform (CACIP).[355]

In particular, the Climate Change Adaptation in the Republic of Kazakhstan[356] course offers free access to online learning resources consisting of 15 lessons with a total duration of five hours on climate change adaptation in general, the impacts of climate change in the Republic of Kazakhstan, the provisions of the Environmental Code of the Republic of Kazakhstan related to adaptation, the relevant Rules, and the Methodological Guidelines. In particular, the course is designed to familiarize managers and specialists with the norms and processes of climate change adaptation, as well as to develop the capacity of staff to implement the adaptation-related provisions contained in the Environmental Code of the Republic of Kazakhstan.

This training course was prepared in cooperation with the Department of Climate Policy and Green Technologies of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan with financial support from the United States Agency for International Development (USAID).

Another course 'Affordable Climate Resilient Technologies and Practices"[357] provides descriptions of sustainable technologies and practices for independent application at the local level, in households and farms, as well as by experts, entrepreneurs and any other interested parties for the purposes of adaptation to climate change in Central Asia. This course was prepared with the support of CAREC/World Bank Climate Change Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB) Program and will be useful for a wide range of public.

The Department of Climate Policy and Green Technology of the Ministry held an online training course on Climate Change Adaptation in the Republic of Kazakhstan from August 28 to September 7, 2020. The online course was prepared with the support of USAID together with the U.S. Environmental Law Institute. The aim of the training is to raise awareness and provide knowledge on climate change adaptation, the impact of climate change on various areas closely related to possible significant economic, environmental, social losses and affecting people's health and quality of life. The main objective of the training was to ensure understanding of the new provisions of the Environmental Code on climate change adaptation by the central government agencies, local authorities, and all stakeholders.[358]

UNDP organized a series of trainings on access to finance, calculation of greenhouse gas emissions in Kazakhstan.

In December 2018, Astana hosted a technical training workshop, where participants were presented with information on opportunities for cooperation with the Green Climate Fund (GCF) and the prospects for Kazakhstan, as well as on the procedures to prepare and submit projects to the Fund.[359]

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[355] https://elearn.centralasiaclimateportal.org/courses
[356] https://elearn.centralasiaclimateportal.org/courses-details/17/adaptaciya-k-izmeneniyu-klimata
[357] https://elearn.centralasiaclimateportal.org/courses-details/11/dostupnye-klimaticeski-ustoicivye-texnologii-i-praktiki
[358] https://www.gov.kz/memleket/entities/ecogeo/press/news/details/92020?lang=ru
[359] https://www.youtube.com/watch?v=KIMSBGRlFS0&ab_channel=ClimateLearningPortal

On June 9, 2021, a training course was held for participants of the energy system of Kazakhstan, which presented the emission factor, developed by the UNDP Kazakhstan for all three energy zones (North, South and West).[360]

All training courses are posted on the Climate Learning Portal on YouTube.[361]

The Investor's Guidebook, prepared to assist Central Asian specialists in preparing economically sound project proposals for international WECOOP[362] project financing, can be considered a valuable training tool. The guidebook educates on general principles and best practices for preparing project proposals, as well as information on requirements and conditions, including project appraisal, appropriate project cycles and applicable environmental and social criteria established by the relevant International Financing Institutions and donors that provide financing for environmental, water and climate change adaptation projects in the Central Asian region.

9.5. Research or information centers

The climate section on Kazhydromet RSE's website provides great resources both for informing the public and for educational and research purposes. In particular, the section publishes monthly bulletins assessing anomalies of the average monthly air temperature and precipitation in Kazakhstan. Meteorological monitoring data of the Kazhydromet RSE are used for the bulletin, specifically, series of average monthly air temperatures and monthly precipitation amounts since 1941. The Kazhydromet website also presents Annual Bulletins for monitoring climate and climate change in Kazakhstan since 2008.[363]

Also, the Kazhydromet website has a section on Agro-climatic maps, which provides valuable information for both scientists and agricultural professionals.[364] Site users can look at maps on ‘Length of Growing Period’, ‘Aridity of Growing Period", ‘Precipitation During the Warm Period’, ‘Moisture Availability of the Growing Season’, ‘Heat Supply of The Growing Season In a Number of Regions of the Republic of Kazakhstan’.

The New Environmental Code of the Republic of Kazakhstan, among the mandatory items of the National Report on the Environment and use of Natural Resources of the Republic of Kazakhstan, specifies a section on the impacts of climate change, projected impacts of climate change, vulnerability to climate change and measures to adapt to climate change (Article 23)[365]. The Code also establishes the need for an annual interactive report (article 24). The Climate and Climate Change section of the report provides an excellent opportunity to learn about the climate of Kazakhstan and its changes in a visual way for the non-specialist reader.[366]

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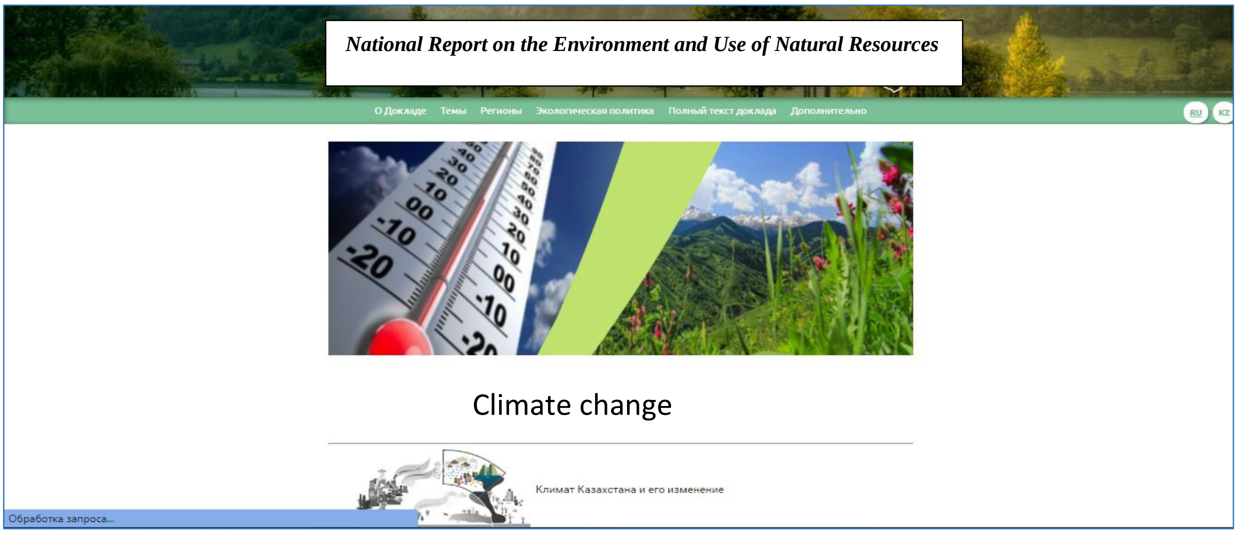
360 https://www.youtube.com/watch?v=KIMSBGRlFS0&ab_channel=ClimateLearningPortal
361 https://www.youtube.com/watch?v=KIMSBGRlFS0&ab_channel=ClimateLearningPortal
362 https://wecoop.eu/wp-content/uploads/2020/04/Investor-guide-RU_2021.pdf
363 https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana
364 https://www.kazhydromet.kz/ru/agrometeorology/agroklimaticheskie-karty
365 Environmental Code of the Republic of Kazakhstan, https://adilet.zan.kz/rus/docs/K2100000400#z264
366 http://newecodoklad.ecogosfond.kz/2016/izmenenie-klimata/

Figure 9.20. *Climate change section of the Interactive National Report on the Environment and Use of Natural Resources*



CACIP website provides lots of information for users of different groups – from NGO activists to government officials and researchers. It was funded by the World Bank as part of the 'Climate Change Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)", implemented by CARECO and The International Center for Agricultural Research in the Dry Areas [367].

The CACIP platform contains data on climate change, soil types, land degradation, local weather, and much more, including information on greenhouse gas emissions, soil moisture, soil carbon density, temperature, precipitation, historical climate data statistics, weather forecast, and vegetation indices.

Advanced search filters by topic, category, and geography allow users to navigate better. The portal is divided into the following topics: water management, climate change, risk assessment, food security, sustainable agricultural systems, land degradation. Users can access maps, datasets, training materials, reports, case studies, atlases, and event information. The portal covers Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and other countries.

The platform serves several purposes:

– Website: main entry point displaying climatic overview, recent news, blogs, social media feeds, and more. From here, users can navigate to other areas of the platform;

– Knowledge Hub: digital library that collects and displays a variety of documents such as journal articles, reports, training materials, multimedia, infographics, spatial and statistical data, and more. As of this writing, the portal provides information about 71 databases that allow users to access valuable sources of information, such as, for example, The Aral Sea Database [368] or Annual Statistics for Kazakhstan, from NOAA data analysis: Global Unified Precipitation Data provided by NOAA/OAR/ESRL PSD, Boulder, Colorado, USA.[369] The presented databases can be useful both to a wide range of the public and to specialists related to climate change issues;

[367] https://centralasiaclimateportal.org/ru/aboutus/
[368] http://www.cawater-info.net/aral/data/index.htm
[369] NOAA from the NOAA/OAR/ESRL PSD website, Boulder, Colorado, USA, https://www.esrl.noaa.gov/psd /

– Geo Portal: collects, manages, and displays geospatial data and allows select types of analytics. Users can upload data from the field directly.

The Geo Portal is home to the GeoExplorer, an interactive tool for searching, composing, and publishing maps and layers. Users can query the spatial data and the information linked to the geographical features, select different layers, overlap information and more. It features interactive tables of source data. GeoExplorer includes data from MODIS satellite images of the Central Asia region, including vegetation index and surface temperature This high-quality data is checked by National Aeronautics and Space Administration and is available from 2000 until today in near real-time (one-month processing time) GeoExplorer can be accessed through the browser and from a GIS desktop application.

The WECOOP project website also contains knowledge on climate change adaptation technologies.[370] **First, WECOOP provides information about the best practices in the European Union.**

The website of the Climate Change Coordination Centre continues to operate,[371] although there is no recent relevant news there.

9.6. Participation of the public and non-governmental organizations

Opportunities for public participation in decision-making affecting the environment, including climate change issues, are guaranteed to the Kazakhstani society by the fact that the country participates in the Aarhus Convention, and are also enshrined in the updated Environmental Code of January 2, 2021.

The public can participate in the environmental impact assessments (including the assessment of transboundary impacts), in relation to draft reports on possible impacts, while paying attention to the reduction of the impact of the assessed objects on climate change. There is a new opportunity for the public to participate in the discussion of action plans for environmental protection by oblast LEBs, cities of republican significance, and the capital city for a three-year perspective, where it will also be possible to influence measures that reduce the impact and ensure adaptation to climate change[372].

The mechanism for strategic environmental assessment of state programs gives the public even more opportunities, but the implementation of strategic environmental assessment norms has been postponed until 2023.

The introduction of norms obliging State bodies, LEBs, and officials to assist the public in the enjoyment of environmental rights, as well as the introduction of liability of officials who do not ensure or hinder the enjoyment of public rights within their competence, is also becoming an important enhancement for the public (article 16).[373]

Since July 1, 2021, the ‘Rules for the organization and implementation of the process of adaptation to climate change’ have come into effect. The rules indicate that “the development of measures for adaptation to climate change is carried out by the central or local executive bodies of oblasts, cities of republican significance, the capital city, implementing the process of adaptation to climate change, with stakeholders representing public organizations, the public, businesses,

[370] https://wecoop.eu/ru/regional-knowledge-centre/library/
[371] http://www.climate.kz/rus/
[372] Environmental Code of the Republic of Kazakhstan: https://adilet.zan.kz/rus/docs/K2100000400#z264
[373] Environmental Code of the Republic of Kazakhstan: https://adilet.zan.kz/rus/docs/K2100000400#z264

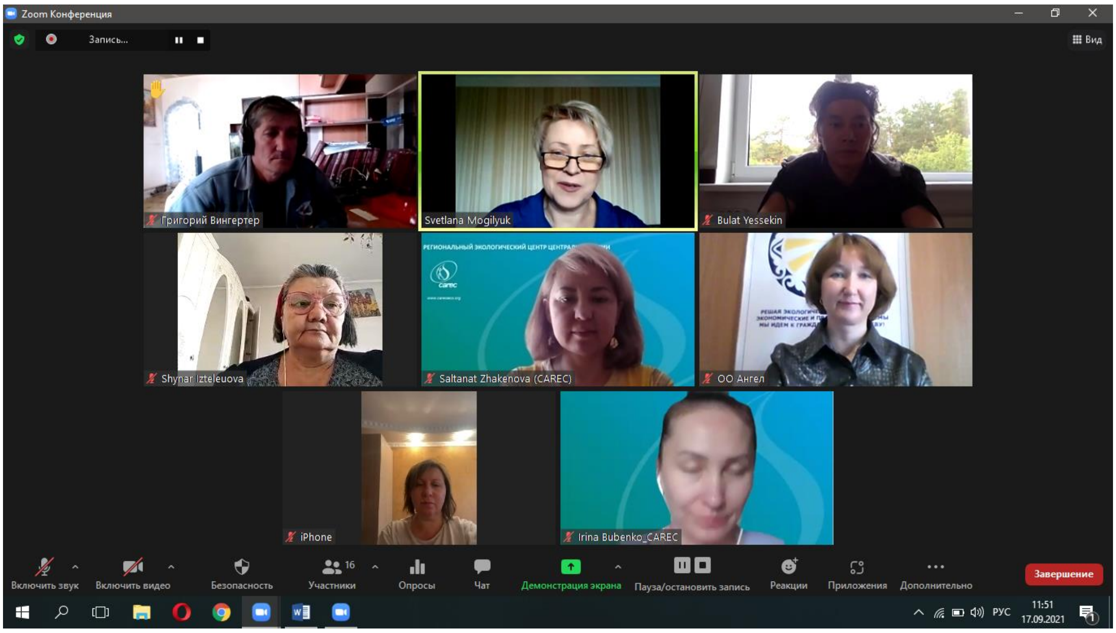
scientific and expert organizations with which focus groups are held on specific vulnerability factors or other topics related to the measures under development.[374]”

Efforts to unite representatives of civil society at the national and regional levels are being undertaken by CARECO within the framework of the project ‘Climate Change Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)’. The project leads the activities of the regional Climate Network of Central Asia and supports some of the Network's activities under the Association ‘Environmental Forum of the Republic of Kazakhstan’ ALE. CARECO supports public involvement in major regional forums, such as the Central Asian Climate Change Conference. The fourth conference was held in Dushanbe in July 2021.[375]

CARECO also supports national civil society meetings. In early February 2020, a public meeting was held in Astana, resulting in a national network and public awareness strategy.[376] In September 2021, a meeting organized by the Climate Network of Kazakhstan was held remotely. At the meeting, a public Statement was prepared in which NGOs urge Kazakhstan to develop green energy in the interests of people, without new risks for future generations, reducing the use of coal, abandoning the construction of nuclear power plants, and incineration of garbage for energy.

Public organizations also noted the need to strengthen adaptation measures and, most importantly, the effectiveness of water resources management. Public representatives separately noted the remaining weak involvement of civil society in the development of national and regional programs to prevent the climate crisis and adapt to the effects of climate change in the region and called for ensuring the inclusiveness of the decision-making process and tackling obstacles for stakeholder involvement, as well as to significantly increase the role of the civil community in this process at all levels.

Figure 9.21. *Meeting of the Climate Network of Kazakhstan to prepare Civil society statement for the 26th Conference of the Parties to the UN Framework Convention on Climate Change*



[374] Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated June 2, 2021, No. 170 ‘Rules for the organization and implementation of the process of adaptation to climate change", https://adilet.zan.kz/rus/docs/V2100022974

[375] https://ca-climate.org/news/27-iyulya-sostoyalsya-segment-vysokogo-urovnya-tsakik-2021/

[376] https://carececo.org/main/news/news/izmenenie-klimata-kakova-rol-obshchestvennykh-organizatsiy/

On November 5, 2021, during a side event, **'The Position of Central Asian Civil Society on Climate Change', which was held online and offline as** part of the Central Asia Pavilion at the Conference of the Parties to the UN Framework Convention on Climate Change, public representatives once again stressed the need for more active involvement of civil society in decision-making on reducing the impact and adaptation to climate change and called for focusing national programs and strategies on the population, and not only on economic sectors.[377]

Another example of involving civil society in the discussion of carbon neutrality is the First Climate Dialogue between Kazakhstan and Ukraine held on May 25-26, 2021 ('Towards COP-26: Decarbonization and economic mechanisms').

The event was attended by representatives of the Governments of Kazakhstan and Ukraine, international organizations (UNDP, EU, OECD, World Bank), environmental activists and NGOs, academic institutions, universities, business representatives and climate experts of the two countries.

The event was held in a hybrid format. Two offline platforms (M.S. Narikbayev KAZGUU University in Astana and the Parkovy Convention and Exhibition Center in Kyiv) were involved. Members of the Climate Network for Eastern Europe, Caucasus and Central Asia and members of the public, including NGOs of the Center for Support of Civil Initiatives of Kazakhstan,[378] joined via ZOOM.

9.7. International activities

An important area in international cooperation on climate is the activity of the National Hydrometeorological Service of the Republic of Kazakhstan (Kazhydromet RSE) within the framework of international organizations and conventions, the World Meteorological Organization (WMO), CASPCOM, the Interstate Council on Hydrometeorology of the Commonwealth of Independent States; cooperation with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), ECMWF, CARECO, USAID and the World Bank.

Kazhydromet RSE, as the representative of the Republic of Kazakhstan to the WMO, participates in all major programs and projects in meteorology, climatology, and hydrology. Hydrometeorological data is transmitted to global and regional centers for international data exchange. Representatives of Kazhydromet participate and share the international experience with the WMO member countries within Regional Association sessions organized by the WMO (territorially, Kazakhstan belongs to RA II and VI), as well as global conferences and seminars. WMO annually awards scholarships to technical specialists for short-, medium- and long-term training.

In November 2018, Kazhydromet RSE signed a License Agreement with EUMETSAT for 2019-2021, under which EUMETSAT provides high-precision satellite images to Kazhydromet free of charge, which makes it possible to provide end users with digital weather data and monitors climate change.

Also, within the framework of the Agreement, the 'EUMETSAT Information Day' conference for the countries of Central Asia, Eastern Europe and the Caucasus was held in Astana on April 10-11, 2019.[379]

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[377] https://cop26.carececo.org/2021/11/05/ks-26-golos-npo-stran-centralnoj-azii/
[378] https://www.gov.kz/memleket/entities/ecogeo/press/news/details/206822?lang=ru
[379] https://www.kazhydromet.kz/ru/activity/mezhdunarodnaya-deyatelnost

Kazakhstan takes an active part in cooperation on climate change in Central Asia, being an active member of regional organizations such as the Interstate Commission on Sustainable Development, the International Fund for Saving the Aral Sea (IFAS) and supports joint projects.

Kazakhstan leads many initiatives regionally. During his speech on July 27th, 2021, at the fourth Central Asian Conference on Climate Change held in Dushanbe, the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan M. Mirzagaliyev reported not only on the measures taken in the country to improve climate policy, introduction of green technologies, prevention of desertification and land degradation, but also touched upon the issues of integrated solutions to environmental problems of the Aral region. The Minister proposed to create a Regional Climate Hub of Central Asia located in Kazakhstan aimed at solving issues of green growth in the region through the implementation of projects, technology transfer and knowledge exchange.

Figure 9.22. *Fourth Central Asian Climate Change Conference, Dushanbe, Tajikistan, July 2021*

In addition, the Minister proposed to establish a regional mechanism for cooperating with climate funds (Green Climate Fund, GEF, etc.), to develop new projects and introduce modern approaches to integrated water resources management, biodiversity conservation, as well as to improve data exchange in the region.[380]

Regional cooperation on climate change has been developing very effectively within the 'Climate Change Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)' since 2015. The project is aimed at solving common problems and challenges related to the effects of climate change in Central Asian countries by strengthening access to improved climate change knowledge and data for key stakeholders (decision makers, expert communities, etc.), as well as by increasing investments and building technical capacity.[381]

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[380] https://www.gov.kz/memleket/entities/ecogeo/press/news/details/234819?lang=ru

[381] https://carececo.org/upload/%D0%BF%D1%80%D0%BE%D1%84%D0%B8%D0%BB%D1%8C%20%D0%BF%D1%80%D0%BE%D0%B5%D0%BA%D1%82%D0%B0.pdf

The Republic of Kazakhstan actively participated in organizing the first-ever Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), Regional Pavilion of Central Asia, organizing two side events on behalf of the country: 1) launch of green investments (partners: Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan; Astana International Financial Center; UNDP Kazakhstan), 2) RES and energy conservation: contribution to carbon neutrality (Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan – UNDP Kazakhstan),382 and participating in regional meetings with key officials.

Figure 9.11. *Summary of the Central Asia Pavilion activities at the 26th Meeting of the Parties to the Framework Convention on Climate Change, Glasgow, UK, November 2021*

Moreover, Kazakhstan's carbon neutrality was discussed during the side event ‘Central Asia - Kazakhstan's cooperation towards carbon neutrality and business opportunities", organized jointly by the Climate Change Coordination Center, Nazarbayev University, the National Conservation Initiative Corporate Foundation, the U.S. Chamber of Commerce, where international and Kazakhstani climate change and energy experts discussed the most effective and feasible ways of Kazakhstan's transition to carbon neutrality.[383]

9.8. Monitoring, review, and evaluation of the implementation of article 6 of the Convention

The Republic of Kazakhstan fulfills its obligations and implements the following measures in training and public awareness:

At the national level:

As for the "development and implementation of public education and awareness programs on climate change and its impacts", separate programs and manuals for additional education are being developed, however, climate change has not yet been sufficiently reflected in

[382] https://cop26.carececo.org/#main-agenda
[383] https://cop26.carececo.org/2021/11/05/pavilon-ca-na-ks-26-kak-dostich-kazahstanu-uglerodnoj-nejtralnosti/

the mandatory educational component at all levels to ensure a good level of knowledge and competence on the topic.

As for "public access to information on climate change and its impacts", legislative measures have been taken to establish information on climate change as environmental information not subject to restriction. Significant progress has been made in providing information on climate change through government resources: the Kazhydromet website, an interactive national report on the Interactive National Report on the Environment and Use of Natural Resources of the Republic of Kazakhstan.

As for "public participation in the consideration of climate change and its impacts and in the development of appropriate response measures", legislative measures have been taken to ensure public participation in the development of measures for adaptation to climate change. However, so far, the public highlights insufficient involvement in the discussion of programs related to climate change issues. The strategic environmental assessment mechanism, which provides for public participation, has not yet been implemented.

As for "training of research, technical and managerial personnel": there are no separate areas of climate change training in the country, but climate change issues are included in the training programs for specialists in the following areas: ‘Ecology", ‘Vital safety and environmental protection", ‘Geography", ‘Water resources and water use", ‘Hydrology", ‘Geodesy and cartography".

At the international level, cooperation in:

Development of materials to educate and inform the public about climate change and its impacts and knowledge exchange on: Kazakhstan's contribution supports CARECO activities by providing pro-bono premises, assisting in CARECO project implementation, providing materials for education and public awareness, in particular, digitally through the CACIP platform.

Developments and educational and training programs, including strengthening of national institutions and the exchange of personnel or their secondment, especially for the benefit of developing countries supports the national Hydrometeorological Service in staff development and data exchange programs at the regional and global level through regional projects supported by UNDP, the World the Bank, and the European Union.

Particular attention should be paid to how **education, training and public awareness activities were implemented in the context of the COVID-19 pandemic:**

- The public hearings on EIA were held remotely, and to ensure proper organization of this process, Kazakhstan applied to the secretariat of the Aarhus Convention, and received recommendations from the Aarhus Convention's Compliance Committee;
- classes in schools, vocational institutions and universities were held remotely for a long time, while strengthening the technological infrastructure to use digital technology;
- training, education, and public awareness events were held remotely;
- access to information on climate change on government Internet resources was improved;
- most of the informational materials and training courses have been issued in digital format.

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AIC	Agro-Industrial Complex
AIIB	Asian Infrastructure Investment Bank
ALE	Association of Legal Entities
AMS	Automatic Meteorological Stations
AWC	Abrupt Weather Changes
BAT	Best Available Technologies
BMU	Federal Ministry of Environment, Nature Protection and Safety of Nuclear Reactors
BREF EU	EU Best Available Techniques Reference Documents
BRM	Business Roadmap
BSH	Baltic System of Height
CA	Central Asia
CACIP	Central Asian Climate Information Platform
CAMP4ASB	Climate Change Adaptation and Mitigation Program for Aral Sea Basin
CAO RK	Code of Administrative Offences of the Republic of Kazakhstan
CAPE	Convective Available Potential Energy
CAREC	Central Asian Regional Economic Cooperation
CARECO	Regional Environmental Center for Central Asia
CASPCOM	Coordinating Committee on Hydrometeorology of the Caspian Sea
CBAM	Carbon Border Adjustment Mechanism
CCEA	Common Classifier of Economic Activity
CCS	Carbon Capture and Storage
CHPP	Combined Heating and Power Plant
CIF	Climate Investment Funds
CIS	Commonwealth of Independent States
CLM MA RK	Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan
CNS	Carbon neutrality scenario
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRF	Common Reporting Format
CRFT	Common Reporting Format Tables
CS	Committee for Statistics
CTF	Common Tabular Format
CzDA	Czech Agency for International Development
DAC	OECD Development Assistance Committee
DFA	Development Finance Assessment
DMC	Developing Member Country
DRI	Direct Reduction of Iron
EAF	Electric Arc Furnace
EBRD	European Bank for Reconstruction and Development

EC	Environmental Code
ECMWF	The European Centre for Medium-Range Weather Forecasts
EDB	Eurasian Development Bank
EEE	Electrical and electronic equipment
EF	Efficiency Factor
EFQM	European Foundation for Quality Management
EKO	East Kazakhstan Oblast
EME	Extreme Meteorological Events
EPR	Extended Producer (Importer) Responsibility
ERT	Expert Review Team for Reports under UNFCCC
ES	Emergency Situation
ESCo	Energy Service Company
ETS	Emissions Trading System
EU	European Union
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization of the United Nations
FEC	Fuel and Energy Complex
FIS	International Ski and Snowboard Federation
FL	Fuel and Lubricants
FOA	First-Order Attenuation
FOLUR	Food Systems, Land Use and Restoration Impact Program
FS	Feasibility Study
FSC	Financial Settlement Center
FWC	Forestry and Wildlife Committee
GCF	Green Climate Fund
GCI	Global Competitiveness Index
GCIP	Global Cleantech Innovation Programme
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GIS	Geographic Information System
GIZ	German Society for International Cooperation and Development
GLO	Glacial Lake Outburst
GM	Global mechanism of the United Nations Convention to Combat Desertification
GVA	Gross Value Added
HEB	Hydroeconomic Basins
HFC	Hydrofluorocarbons
HLT	High-Level Technologies
HP	Hazardous Phenomena
HPP	Hydro Power Plant
HS	Hydrological Station
HTC	Hydrothermal Coefficient

HU	Housing and Utilities
ICAO	International Civil Aviation Organization
ICH CIS	Interstate Council on Hydrometeorology of the Commonwealth of Independent States
IDB	Islamic Development Bank
IFAS	International Fund for Saving the Aral Sea
IGTIC	International Green Technologies and Investment Projects Center
IKI	German Climate Initiative
IMO	International Maritime Organization
INDC	INDC, Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRENA	International Renewable Energy Agency
ISIMIP	The Inter-Sectoral Impact Model Intercomparison Project
IWRM	Integrated Water Resources Management
JCI	Joint Commission International
JICA	Japan International Cooperation Agency
JSC	Joint Stock Company
KAZGUU	M. S. Narikbayev Kazakh Humanitarian Law University
KMG	KazMunayGas
KOICA	Korean Agency for International Cooperation
KOREM	Kazakhstan Electricity and Power Market Operator
KPO	Karachaganak Petroleum Operating B.V.
LC	Large Cattle
LCDC	Low-Carbon Development Concept
LCDS	Low-Carbon Development Strategy
LEB	Local Executive Bodies
LLP	Limited Liability Partnership
LULUCF	Land Use, Land Use Change and Forestry
MA	Ministry of Agriculture
MCI	Monthly Calculation Index
ME	Ministry of Energy of the Republic of Kazakhstan
MEDC	Mangystau Electric Grid Distribution Company
MEGNR RK	Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
MES RK	Ministry of Education and Science of the Republic of Kazakhstan
MES RK	Ministry of Emergency Situations of the Republic of Kazakhstan
MHS	Marine Hydrometeorological Station
MICE	Meetings, Incentives, Conferences, Exhibitions
MIID RK	Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan

MMC RK	Mining and Metallurgy Complex of the Republic of Kazakhstan
MNE RK	Ministry of National Economy of the Republic of Kazakhstan
MRV	Measurement, Reporting and Verification System
MS	Meteorological Station
MSU	Lomonosov Moscow State University
MSW	Municipal Solid Waste
NC	National Company
NCE	National Chamber of Entrepreneurs
ND-GAIN	Notre Dame-Global Adaptation Index
NEC	National Educational Center
NGO	Non-Governmental Organizations
NHMN	National Hydrometeorological Network
NHMP	Natural Hydrometeorological Phenomena
NIR	National Inventory Report
NKO	North Kazakhstan Oblast
NPP	Nuclear Power Plant
NPS	National Planning System
NAP	National Allocation Plan
NRC	National Research Center
ODA	Official Development Assistance
ODS	Ozone Depleting Substances
OECD	Organization for Economic Cooperation and Development
OMF	Organo-Mineral Fertilizers
OR	Oil Refinery
PA	Public Association
PF	Public Foundation
PFC	Perfluorocarbons
PIAAC	Program for the International Assessment of Adult Competencies
PISA	Program for the International Student Assessment
PMR	Partnership for Market Readiness
PRC	People's Republic of China
PTA	Priority Tourist Area
QA/QC	Quality Assessment/Quality Control
RA	WMO Regional Associations
RCP	WMO Representative Concentration Pathway
RE	Republican Enterprise
RES	Renewable Energy Sources
RK	Republic of Kazakhstan
RS	Rural Settlements
RSE	Republican State Enterprise
SC	Small Cattle
SCES	State Compulsory Education Standard
SDG	Sustainable Development Goals

SDPP	State District Power Plant under State-Approved Standard
SE	State Enterprise
SES	Sanitary-Epidemiological Station
SME	Small and Medium Enterprises
SNNP	State National Nature Park
SPAIID RK	State Program for Accelerated Industrial and Innovative Development of the Republic of Kazakhstan
SPIID RK	State Program for Industrial and Innovative Development of the Republic of Kazakhstan
SPNA	Specially Protected Natural Areas
SRES	Special Report on Emission Scenarios
STEM	Science, Technology, Engineering and Mathematics
SWIM	Soil and Water Integrated Model
TA	Technical Assistance
TIMES	The Integrated MARKAL-EFOM System
TNC	Transnational Company
TVE	Technical and Vocational Education
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFCCC PA	UNFCCC Paris Agreement
UNODC	United Nations Office on Drugs and Crime
USA	United States of America
USAID	United States Agency for International Development
USSR	Union of Soviet Socialist Republics
UTC	Coordinated Universal Time
WAM	With Additional Measures Scenario
WB	World Bank
WC	Water Closet
WCM	With Current Measures Scenario
WEC	World Energy Council
WECOOP	European Union – Central Asia Water, Environment and Climate Change Cooperation
WEF	World Economic Forum
WKO	West Kazakhstan Oblast
WMO	World Meteorological Organization
WOM	Without Measures Scenario
WPP	Wind Power Plant
WRF	Weather Research Forecasting
WtE	Waste-to-Energy

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Annex 1

Table 1. *Energy sector. Information on updated greenhouse gas forecasts under the Without Measures Scenario*

	GHG emissions and absorption								Emissions forecasts		
	(CO2 Equivalent)								(CO2 Equivalent)		
	Base year (1990)	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Sector											
Energy	**316, 919**	**316, 919**	**199, 753**	**173, 759**	**221, 553**	**247, 137**	**296, 297**	**272, 499**	**292, 924**	**307, 344**	**327, 684**
Fuel combustion-related activities	**225, 075**	**225, 075**	**145, 538**	**110, 705**	**153, 347**	**196, 852**	**246, 912**	**225, 221**	**233, 140**	**245, 713**	**262, 548**
Energy industries	142, 369	142, 369	96, 573	60, 805	92, 263	103, 753	133, 166	144, 383	138, 441	144, 169	153, 562
Industries and construction	17, 428	17, 428	15, 565	20, 855	27, 033	28, 017	36, 238	25, 130	37, 067	41, 376	46, 922
Transportation	22, 318	22, 318	8, 947	9, 591	16, 648	21, 366	21, 744	18, 726	23, 790	24, 476	26, 374
Other sectors	56, 345	56, 345	31, 986	9, 522	13, 072	16, 533	29, 041	33, 429	31, 984	31, 287	27, 939
Miscellaneous	8, 934	8, 934	1, 414	19, 522	20, 979	48, 549	48, 467	22, 279	25, 649	28, 881	34, 125
Volatile fuel emissions	**69, 526**	**69, 526**	**45, 268**	**53, 463**	**51, 558**	**28, 918**	**27, 642**	**28, 553**	**35, 994**	**37, 155**	**38, 762**
Solid fuels	45, 860	45, 860	26, 411	26, 097	23, 377	24, 312	23, 478	23, 708	29, 411	30, 088	29, 526
Oil and natural gas	23, 666	23, 666	18, 857	27, 367	28, 180	4, 606	4, 164	4, 845	6, 582	7, 067	9, 236
Industry/Industrial processes											
Agriculture											
Forestry/LULUCF											
Waste management/waste											
Other (specify)											
Gas											
CO2 emissions, including net CO2 emissions in the LULUCF sector											
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	259, 842	259, 842	168, 426	135, 381	184, 876	232,539	282,070	257, 830	278, 197	292,107	310,974

CH_4 emissions, including CH_4 emissions in the LULUCF sector											
CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	55, 276	55, 276	30,560	37, 753	35, 799	13, 399	12,841	13, 373	13, 642	14, 124	15, 579
N_2O emissions, including N_2O emissions in the LULUCF sector											
N_2O emissions, excluding N_2O emissions in the LULUCF sector	1,801	1,801	767	625	878	1,199	1,386	1,296	1,085	1,113	1,131
HFC											
PFC											
Indivisible combination of HFCs and PFCs											
SF_6											
NF_3											
Total with LULUCF	316, 919	316, 919	199, 753	173, 759	221,553	247, 137	296, 297	272,499	292, 924	307, 344	327, 684
Total without LULUCF	316, 919	316, 919	199, 753	173, 759	221,553	247, 137	296, 297	272,499	292, 924	307, 344	327, 684

Table 2. *Energy sector. Information on updated greenhouse gas forecasts under the With Current Measures Scenario*

	GHG emissions and absorption (CO2 Equivalent)								Emissions forecasts (CO2 Equivalent)		
	Base year (1990)	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Sector											
Energy	**316, 919**	**316, 919**	**199, 753**	**173, 759**	**221,553**	**247, 137**	**296, 297**	**272,499**	**285, 184**	**283,338**	**305 984**
Fuel combustion-related activities	**225, 075**	**225, 075**	**145, 538**	**110,705**	**153,347**	**196, 852**	**246, 912**	**225, 221**	**226, 543**	**225, 218**	**242,493**
Energy industries	142,369	142,369	96, 573	60,805	92,263	103, 753	133, 166	144, 383	131,510	118, 100	123,934
Industries and construction	17, 428	17, 428	15, 565	20,855	27, 033	28, 017	36, 238	25, 130	37, 220	42,729	48, 410
Transportation	22,318	22,318	8, 947	9, 591	16, 648	21,366	21,744	18, 726	23,802	24,784	27, 110
Other sectors	56, 345	56, 345	31,986	9, 522	13, 072	16, 533	29, 041	33, 429	32,074	34,480	33,614

Miscellaneous	8, 934	8, 934	1,414	19, 522	20,979	48, 549	48, 467	22,279	25, 739	29, 908	36, 534
Volatile fuel emissions	**69, 526**	**69, 526**	**45, 268**	**53, 463**	**51,558**	**28, 918**	**27, 642**	**28, 553**	**34,840**	**33,335**	**36, 380**
Solid fuels	45, 860	45, 860	26, 411	26, 097	23, 377	24, 312	23, 478	23, 708	28, 258	26, 651	28, 609
Oil and natural gas	23, 666	23, 666	18, 857	27, 367	28, 180	4, 606	4, 164	4, 845	6, 582	6, 685	7, 772
Industry/Industrial processes											
Agriculture											
Forestry/LULUCF											
Waste management/waste											
Other (specify)											
Gas											
CO2 emissions, including net CO2 emissions in the LULUCF sector											
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	259, 842	259, 842	168, 426	135, 381	184,876	232,539	282,070	257, 830	270,692	268, 749	290,200
CH_4 emissions, including CH_4 emissions in the LULUCF sector											
CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	55, 276	55, 276	30,560	37, 753	35, 799	13,399	12,841	13,373	13,435	13,541	14,663
N_2O emissions, including N_2O emissions in the LULUCF sector											
N_2O emissions, excluding N_2O emissions in the LULUCF sector	1,801	1,801	767	625	878	1,199	1,386	1,296	1,057	1,048	1,121
HFC											
PFC											
Indivisible combination of HFCs and PFCs											
SF_6											
NF_3											
Total with LULUCF	316, 919	316, 919	199, 753	173,759	221,553	247, 137	296, 297	272,499	285, 184	283,338	305,984
Total without LULUCF	316, 919	316, 919	199, 753	173,759	221,553	247, 137	296, 297	272,499	285, 184	283,338	305,984

Table 3. *Energy sector. Information on updated greenhouse gas forecasts under the With Additional Measures Scenario*

	GHG emissions and absorption								Emissions forecasts		
	(CO2 Equivalent)								(CO2 Equivalent)		
	Base year (1990)	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Sector											
Energy	**316, 919**	**316, 919**	**199, 753**	**173,759**	**221,553**	**247, 137**	**296, 297**	**272,499**	**281,964**	**248, 186**	**24,2,984**
Fuel combustion-related activities	**225, 075**	**225, 075**	**145 538**	**110,705**	**153,347**	**196, 852**	**246 912**	**225, 221**	**223,689**	**188, 857**	**161,449**
Energy industries	142,369	142,369	96, 573	60,805	92,263	103,753	133,166	144,383	133,923	104,228	113,437
Industries and construction	17, 428	17, 428	15, 565	20,855	27, 033	28, 017	36, 238	25, 130	36 906	38, 860	25, 716
Transportation	22,318	22,318	8, 947	9, 591	16, 648	21,366	21,744	18, 726	23,660	24,589	26, 460
Other sectors	56, 345	56, 345	31,986	9, 522	13,072	16, 533	29, 041	33,429	27, 640	20,724	16, 915
Miscellaneous	8, 934	8, 934	1,414	19, 522	20,979	48, 549	48, 467	22,279	25, 219	25, 045	5, 380
Volatile fuel emissions	**69, 526**	**69, 526**	**45, 268**	**53,463**	**51,558**	**28, 918**	**27, 642**	**28, 553**	**34,615**	**34,740**	**55, 074**
Solid fuels	45, 860	45, 860	26, 411	26, 097	23,377	24,312	23,478	23,708	27, 837	27, 587	46, 548
Oil and natural gas	23,666	23,666	18, 857	27, 367	28, 180	4,606	4,164	4,845	6, 778	7, 153	8, 526
Industry/Industrial processes											
Agriculture											
Forestry/LULUCF											
Waste management/waste											
Other (specify)											
Gas											
CO2 emissions, including net CO2 emissions in the LULUCF sector											
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	259, 842	259, 842	168, 426	135, 381	184,876	232,539	282,070	257, 830	267, 776	235, 322	228, 414

CH_4 emissions, including CH_4 emissions in the LULUCF sector											
CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	55, 276	55, 276	30,560	37, 753	35, 799	13,399	12,841	13,373	13,149	11,954	13,706
N_2O emissions, including N_2O emissions in the LULUCF sector											
N_2O emissions, excluding N_2O emissions in the LULUCF sector	1,801	1,801	767	625	878	1,199	1,386	1,296	1,039	909	863
HFC											
PFC											
Indivisible combination of HFCs and PFCs											
SF_6											
NF_3											
Total with LULUCF	316, 919	316, 919	199, 753	173,759	221,553	247, 137	296, 297	272,499	281,964	248, 186	242,984
Total without LULUCF	316, 919	316, 919	199, 753	173,759	221,553	247, 137	296, 297	272,499	281,964	248, 186	242,984

Table 4. *IPPU sector. Information on updated greenhouse gas forecasts under the With Current Measures Scenario. GHG emissions (CO2-eq.)*

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2019**	**2025**	**2030**	**2035**
Sector								Emissions forecasts		
Industry/Industrial processes	**19, 405.85**	**8,904.59**	**12,703.25**	**16,098.74**	**16, 878.06**	**21,992.73**	**21,678.15**	**23,965.54**	**25, 441.93**	**26,739.72**
Processing of mineral raw materials	**3,876.59**	**826.90**	**1,262.89**	**3,879.49**	**3,893.21**	**7,779.11**	**6,778.39**	**8,195.75**	**8,844.08**	**9,295.22**
Chemical industry	**1,234.17**	**223.57**	**26.87**	**54.55**	**319.66**	**599.21**	**674.58**	**815.64**	**880.16**	**925.06**
Metallurgy	**14,292.73**	**7,848.76**	**11,198.59**	**11,570.48**	**11,782.77**	**12,489.60**	**13,064.47**	**13,730.89**	**14,431.30**	**15,167.44**
Use of solvents and non-energy products	**2.36**	**1.71**	**1.12**	**0.30**	**2.77**	**5.96**	**18.83**	**22.77**	**24.57**	**25.83**
Electronics manufacturing	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.00**	**0.00**	**0.00**
Emissions from fluorinated ODS substitutes	**NO**	**3.65**	**213.79**	**592.27**	**877.90**	**1,116.84**	**1,139.56**	**1,197.69**	**1,258.79**	**1,323.00**
Using other products	**NO, NE**	**NO, NE**	**NO, NE**	**1.65**	**1.73**	**2.01**	**2.32**	**2.80**	**3.03**	**3.18**
Other	**NO, NA**	**NO, NA**	**NO, NA**	**NO, NA**	**NO, NA**	**NO, NA**	**NO, NA**	**0.00**	**0.00**	**0.00**

Gas										
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	19, 373.50	8,888.78	12,477.17	15, 492.67	15, 323.99	20,128.28	19, 670.54	23,783.65	25, 665.09	26,974.27
CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	1.29	0.49	0.49	0.49	0.37	0.40	0.42	0.44	0.46	0.49
N_2O emissions, excluding N_2O emissions in the LULUCF sector	NO, NE, NA	NO, NE, NA	NO, NE, NA	NO, NE, NA	0.32	0.60	0.65	0.79	0.85	0.90
HFC, thousand tons CO2.eq.	NO, NA	3.65	213.79	592.27	877.90	1,116.84	1,139.56	1,377.85	1,486.84	1,562.69
PFC, thousand tons CO2-eq.	NA, NO	NA, NO	NA, NO	NA, NO	570.63	556.28	660.40	798.48	861.65	905.60
Indivisible combination of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF_6	NA, NO	NA, NO	NA, NO	1.65	1.73	2.01	2.32	2.80	3.03	3.18
NF_3	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Table 5. *IPPU sector. Information on updated greenhouse gas forecasts under the Without Measures Scenario*

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2019**	**2025**	**2030**	**2035**
Industry/Industrial processes	19, 405.85	8,904.59	1 2,703.25	16, 098.74	16, 878.06	21,992.73	22,278.15	26, 809.39	28, 882.41	30,825.10
Processing of mineral raw materials	3876.59	826.90	1,262.89	3,879.49	3,893.21	7,779.11	6,978.39	8,395.75	9,044.08	9,595.22
Chemical industry	1,234.17	223.57	26.87	54.55	319.66	599.21	674.58	815.64	880.16	925.06
Metallurgy	14,292.73	7,848.76	11,198.59	11,570.48	11,782.77	12,489.60	13,464.47	16,194.59	17,443.73	18,713.13
Use of solvents and non-energy products	2.36	1.71	1.12	0.30	2.77	5.96	18.83	22.77	24.57	25.83
Electronics manufacturing	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00
Emissions from fluorinated ODS substitutes	NO	3.65	213.79	592.27	877.90	1,116.84	1,139.56	1,377.85	1,486.84	1,562.69
Using other products	NO, NE	NO, NE	NO, NE	1.65	1.73	2.01	2.32	2.80	3.03	3.18
Other	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0.00	0.00	0.00
Gas										
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	19,373.50	8,888.78	12,477.17	15,492.67	15,323.99	20,128.28	20,270.54	24,383.65	26,265.09	28,074.27

CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	32.35	12.16	12.30	12.15	9.30	9.96	10.50	11.03	11.60	12.19
N_2O emissions, excluding N_2O emissions in the LULUCF sector	NO, NE, NA	NO, NE, NA	NO, NE, NA	NO, NE, NA	94.51	179.37	194.83	235.57	254.21	267.17
HFC, thousand tons, CO_2-eq.	NO, NA	3.65	213.79	592.27	877.90	1,116.84	1,139.56	1,377.85	1,486.84	1,562.69
PFC, thousand tons, CO2-eq.	NA, NO	NA, NO	NA, NO	NA, NO	570.63	556.28	660.40	798.48	861.65	905.60
Indivisible combination of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF_6	NA, NO	NA, NO	NA, NO	1.65	1.73	2.01	2.32	2.80	3.03	3.18
NF_3	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Table 6. *IPPU sector. Information on updated greenhouse gas forecasts under the With Additional Measures Scenario*

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2019**	**2025**	**2030**	**2035**
Industry/Industrial processes	19,406	8,905	12,703	16,099	16,878	21,993	21,678	25,009	26,782	27,675
Processing of mineral raw materials	3,877	827	1,263	3,879	3,893	7,779	6,778	7,996	**8,644**	**8,795**
Chemical industry	1,234	224	27	55	320	599	675	816	**880**	**925**
Metallurgy	14,293	7,849	11,199	11,570	11,783	12,490	13,064	14,795	**15,744**	**16,363**
Use of solvents and non-energy products	2	2	1	0	3	6	19	23	25	26
Electronics manufacturing	NO	NO	NO	NO	NO	NO	NO	0	0	0
Emissions from fluorinated ODS substitutes	NO	4	214	592	878	1,117	1,140	1,378	1,487	1,563
Using other products	NO, NE	NO, NE	NO, NE	2	2	2	2	3	3	3
Other	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	0	0	0
Gas										
CO2 emissions, excluding net CO2 emissions in the LULUCF sector	19,374	8,889	12,477	15,493	15,324	20,128	19,671	22,584	24,265	2,4924
CH_4 emissions, excluding CH_4 emissions in the LULUCF sector	32	12	12	12	9	10	10	11	12	12
N_2O emissions, excluding N_2O emissions in the LULUCF sector	NO, NE, NA	NO, NE, NA	NO, NE, NA	NO, NE, NA	95	179	195	236	254	267

HFC, thousand tons, CO2-eq.	NO, NA	4	214	592	878	1,117	1,140	1,378	1,487	1,563
PFC, thousand tons, CO2-eq.	NA, NO	NA, NO	NA, NO	NA, NO	571	556	660	798	862	906
Indivisible combination of HFCs and PFCs	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
SF_6	NA, NO	NA, NO	NA, NO	2	2	2	2	3	3	3
NF_3	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA

Table 7. *Progress towards achieving a certain quantitative target for reducing emissions across the economy: information on actions to prevent climate change and their impact*

No.	Actions to prevent climate change	*Purpose and/or activity covered*	*Implementation status*	*Implementation start year*	*Implementing entity or entities*
1	National Allocation Plan for 2018-2020, rules for trading greenhouse gas emissions quotas and ETS carbon units. Penalty for GHG emissions in excess of the established quota, unreliable data on the GHG inventory	Control of limited carbon dioxide emissions	Approved	2018	Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan. Zhasyl Damu JSC
2	State Program for Industrial and Innovative Development of the Republic of Kazakhstan (SPIID) 2020-2024	Industrial modernization	Draft	2019	AP
3	New Environmental Code		Draft resolution	2020	Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
4	Ban on the export of scrap metal, domestic recycling.	Reduced demand for fossil metal ore	Approved	2019	Kazakhstan's ME
5	Ban on the burial of scrap metals, glass (changes in the Environmental Code for the development of the circular economy) support for the turnover of glass and scrap metal	Reduction of primary glass and metal smelting volumes	Approved	2019	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
WAM					
6	Implementation of projects at the Zhezkazgan copper-smelting plant to improve air quality. Development and implementation of a gasification project.	Replacement of fuel oil with natural gas	Planned	2023	MEGNR RK, Akimat of Karaganda Oblast, Kazakhmys Smelting LLP
7	Modernization and reconstruction of workshops of Aktobe ferroalloy plant	Industrial modernization	Planned	2023	MEGNR RK, TNC Kazchrome JSC
8	Commissioning of gas-handling equipment and an automated monitoring system in the sintering and coal preparation shops and in the lime roasting shop of Arcelor Mittal Temirtau JSC in the Karaganda Oblast	Industrial modernization	Planned	2023	MEGNR RK, Akimat of Karaganda Oblast, Arcelor Mittal Temirtau JSC

9	Replacement of gas-cleaning plants at the Aksu Ferroalloy Plant of TNC Kazchrome JSC and Aluminum of Kazakhstan JSC	Industrial modernization	Planned	2023	MEGNR RK, TNC Kazchrome JSC Aluminum of Kazakhstan JSC
10	Circular economy, recycled glass containers, support for eco-vessels instead of glass. Glass collection station	Waste sorting	Planned	2023	Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
DDS					
11	Online monitoring of emissions in the chemical industry	Industrial modernization	Recommended	2030	KazAzot JSC
12	The use of green hydrogen to produce ammonia, ammonium nitrate (PtX)	Industrial modernization	Cutting-edge technologies	2030	KazAzot JSC
13	Production of green steel	Industrial modernization	Cutting-edge technologies	2030	MIID
14	Reducing the proportion of clinker in cement can reduce the corresponding GHG emissions by 30%. The use of carbon-cured concrete has the potential to reduce emissions from cement production by 48%.	Industrial modernization	Cutting-edge technologies	2030	MIID

Annex 2
(to section VI)

Table 1. *Evaluation results of the theoretical model relationship in the Views statistical package*

Dependent Variable: D(WATER_CONSUMPTION) D
Method: Least Squares
Date: 30/11/21 Time: 22:04
Sample: 2010 2019
Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IRRIGATED_LAND)	21.12457	10.41981	2.027347	0.0772
D(AVER_TEMP)	176.3225	1251.963	0.140837	0.8915

R-squared	0.266782	Mean dependent var	261.5000
Adjusted R-squared	0.175130	S.D. dependent var	827.5967
S.E. of regression	751.6427	Akaike info criterion	16.25926
Sum squared resid	4519734.	Schwarz criterion	16.31977
Log likelihood	-79.29628	Hannan-Quinn criter.	16.19287
Durbin-Watson stat	2.346948		

(WATER_CONSUMPTION) – annual absolute change in the volume of water consumption in agriculture, million cubic meters
D (AVER_TEMP) – the annual absolute change in the average air temperature, gr. Celsius
D (IRRIGATED_LAND) – annual percentage change in the area of irrigated land in agriculture, thousand hectares

Figure 1. *Actual and model dynamics of the annual absolute change in the volume of water consumption in agriculture, million cubic meters*

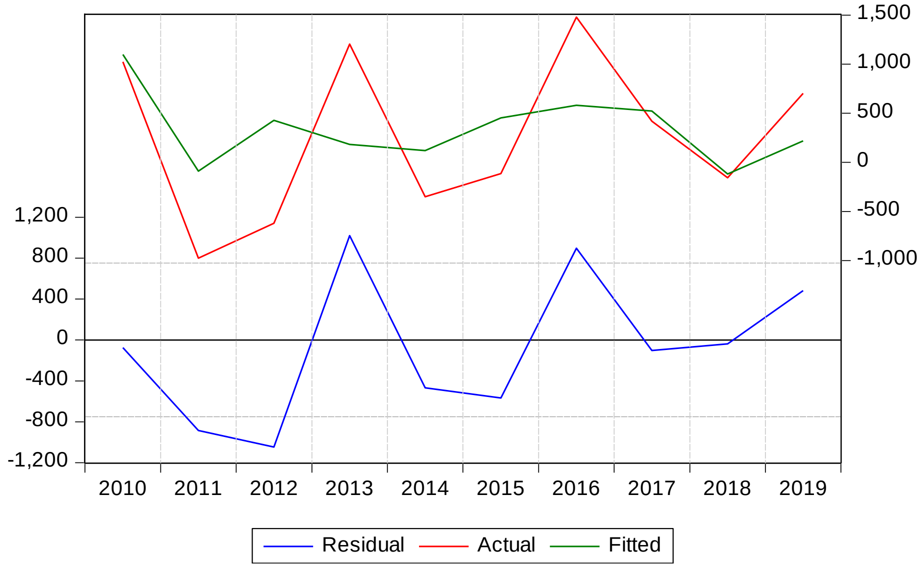


Table 2. *The results of calculations of the assessment of economic losses for the wheat yield sector by regions of Kazakhstan*

No.	Indicator	Akmola	Aktobe	WKO	Karaganda	Kostanay	Pavlodar	NKO
Base values								
1	Base value of the harvested area of crops, ha	3,428,221.6	400,694.3	238,749.1	576,832.8	3,468, 917.4	387,105.4	2,664,97.6
2	Base value of yield, metric quintal/ha	10.1	6.3	7.6	8.0	11.5	8.4	13.3
3	Base value of gross output, thousand tons	3, 475.5	254.2	181.0	462.7	3, 996.6	323.9	3, 550.2
Perfect economic match								
4	Yield value with a positive economic effect for NKO, metric quintal/ha	8.38	7.74	8.02	8.43	7.90	8.04	8.70
Forecast for 2030								
5	Forecast of yield reduction by 2030:	75 %	87 %	65 %	80 %	63 %	82 %	66 %
6	Forecast of harvested areas from the baseline for 2030, %	49.71 %	40.17 %	8.98 %	53.53 %	38.26 %	49.96 %	77.00 %
7	Forecast value of gross output in 2030, thousand tons	1, 190.44	30.17	15.28	93.71	1, 169.00	122.82	1, 485.57
8	Estimation of losses of spring wheat production in 2030, %	65.75 %	88.13 %	91.56 %	79.75 %	70.75 %	62.08 %	58.16 %
9	Average annual wheat prices in 2019, KZT/ton without VAT	63, 855.00	57, 382.00	54,118.00	56, 068.00	65, 046.00	55, 173.00	59,729.00
10	Estimation of losses of spring wheat production in 2030, KZT bn in 2019 prices	129.46	12.09	8.47	18.21	166.94	9.89	111.88
Forecast for 2050								
11	Forecast of yield reduction by 2050:	58 %	80 %	57 %	64 %	51 %	71 %	52 %
12	Forecast of harvested areas from the	14.48 %	37.64 %	7.19 %	16.59 %	10.46 %	34.04 %	29.27 %

No.	Indicator	Akmola	Aktobe	WKO	Karaganda	Kostanay	Pavlodar	NKO
	baseline for 2050, %							
13	Forecast value of gross output in 2050, thousand tons	364.05	23.27	12.39	19.00	418.58	91.87	481.36
14	Estimation of losses of spring wheat production in 2050, %	89.53 %	90.85 %	93.16 %	95.89 %	89.53 %	71.64 %	86.44 %
15	Average annual wheat prices in 2019, KZT/ton without VAT	63, 855.00	57, 382.00	54,118.0 0	56, 068.00	65, 046.00	55, 173.00	59, 729.00
15	Estimation of losses of spring wheat production in 2050, KZT bn in 2019 prices	176.27	12.46	8.62	21.90	211.24	11.41	166.29
Mock solution to address the doubling of harvesting cost								
17	Yield value with a positive economic effect for NKO, metric quintal/ha	4.69	4.08	4.24	4.16	4.02	4.01	4.42
Forecast for 2030								
18	Forecast of yield reduction by 2030:	75 %	87 %	65 %	80 %	63 %	82 %	66 %
19	Forecast of harvested areas from the baseline for 2030, %	97.74 %	77.20 %	63.78 %	97.78 %	85.11 %	91.11 %	99.79 %
20	Forecast value of gross output in 2030, thousand tons	2, 504.08	200.79	84.18	336.72	2, 471.64	252.78	2, 341.82
21	Estimation of losses of spring wheat production in 2030, %	27.95 %	21.02 %	53.49 %	27.23 %	38.16 %	21.96 %	34.04 %
22	Average annual wheat prices in 2019, KZT/ton without VAT	63, 855.00	57, 382.00	54,118.0 0	56, 068.00	65, 046.00	55, 173.00	59,729.00
23	Estimation of losses of spring wheat production in 2030, KZT bn in 2019 prices	55.03	2.88	4.95	6.22	90.03	3.50	65.48

No.	Indicator	Akmola	Aktobe	WKO	Karaganda	Kostanay	Pavlodar	NKO
Forecast for 2050								
24	Forecast of yield reduction by 2050:	58 %	80 %	57 %	64 %	51 %	71 %	52 %
25	Forecast of harvested areas from the baseline for 2050, %	87.31 %	72.85 %	51.92 %	92.33 %	73.25 %	89.86 %	97.66 %
26	Forecast value of gross output in 2050, thousand tons	1, 547.12	171.31	65.29	248.69	1 839.27	188.52	1 795.89
27	Estimation of losses of spring wheat production in 2050, %	55.48 %	32.62 %	63.93 %	46.26 %	53.98 %	41.80 %	49.41 %
28	Average annual wheat prices in 2019, KZT/ton without VAT	63, 855.00	57, 382.00	54, 118.00	56,068.00	65, 046.00	55, 173.00	59,729.00
29	Estimation of losses of spring wheat production in 2050, KZT bn in 2019 prices	109.25	4.47	5.92	10.57	127.37	6.66	95.06

Source: *compiled per S. S. Baisholanov's data, MNE RK SC's data, own calculations* **Table 3**. *Forecast calculation of economic losses (production growth) for the sunflower seed cultivation sector in three regions of the Republic of Kazakhstan*

	Indicator	EKO	Kostanay	Pavlodar
Base values				
	Base value of the harvested area of crops, ha	272,009.8	33,168.6	106,715.4
	The basic value of yield in the originally recorded weight, metric quintal/ha	7.2	5.4	3.7
	Baseline value of gross output in the originally recorded weight, thousand tons	195.2	17.8	39.4
Forecast for 2030				
	Yield forecast by 2030:	109 %	102 %	106 %
	The forecast value of gross output in 2030 in the originally recorded weight, thousand tons	212.78	18.19	41.79
	Estimation of sunflower production growth in 2030, %	9.00 %	2.00 %	6.00 %
	Average annual prices for sunflower seeds in 2019, KZT/ton without VAT	98,497.00	111,240.00	100,283.00
	The yield conversion factor in the recorded weight into the yield in the modified weight. times	0.90	0.89	0.88
	Estimation of sunflower production growth in 2030, KZT bn in 2019 prices	1.55	0.04	0.21
Forecast for 2050				
	Yield forecast by 2050:	104 %	100 %	105 %

	Indicator	EKO	Kostanay	Pavlodar
	Forecast value of gross output in 2050, thousand tons	203.02	17.83	41.39
	Estimation of sunflower production growth in 2030, %	-4.00 %	0.00 %	-5.00 %
	Average annual prices for sunflower seeds in 2019, KZT/ton without VAT	98 497.00	111,240.00	100,283.00
	The yield conversion factor in the recorded weight into the yield in the modified weight, times	0.90	0.89	0.88
	Estimation of sunflower production growth in 2030, KZT bn in 2019 prices	0.69	-	0.17

Source: *compiled per S. S. Baisholanov's data, MNE RK SC's data, own calculations*

Table 4. *Stocking capacity (N) and optimal stocking of pastures (H_o) during summer grazing of sheep in the conditions of the modern climate (MC) and the climate of 2030 according to the scenarios of RCP 4.5 and RCP 8.5*

MS	N, animal/ha			Ho, ha/animal		
	SK	RCP 4.5	RCP 8.5	SK	RCP 4.5	RCP 8.5
Almaty Oblast						
Auyl 4	2.0	1.9	1.9	0.49	0.53	0.53
Aidarly	1.0	1.0	0.9	1.00	1.05	1.06
Assy	13.4	10.9	10.7	0.07	0.09	0.09
Zhambyl Oblast						
Ulanbel	1.7	1.6	1.6	0.58	0.62	0.62
Moiynkum	1.8	1.7	1.7	0.54	0.58	0.58
Turkestan Oblast						
Tasty	1.1	1.0	1.0	0.89	1.01	1.01
Kyzylkum	0.5	0.4	0.4	1.94	2.26	2.26
Kyzylorda Oblast						
Zlikha	2.1	1.8	1.8	0.48	0.55	0.55
Karak	2.0	1.8	1.8	0.49	0.57	0.57
Mangystau Oblast						
Sam	0.9	0.8	0.8	1.09	1.27	1.27
Kyzan	0.7	0.6	0.6	1.40	1.56	1.56
Akkudyk	1.3	1.1	1.1	0.80	0.92	0.91
south of Aktobe Oblast						
Ayakkum	1.6	1.4	1.4	0.63	0.69	0.69
south of Karaganda Oblast						
Kyzyltau	3.4	3.2	3.2	0.29	0.31	0.32

Source: *compiled per S. S. Baisholanov's data.*

Table 5. *Stocking capacity (N) and optimal stocking of pastures (H_o) during summer grazing of sheep in modern climate (MC) conditions and the climate of 2050 according to the scenarios of RCP 4.5 and RCP 8.5*

MS	N, animal/ha			Ho, ha/animal		
	SK	RCP 4.5	RCP 8.5	SK	RCP 4.5	RCP 8.5
Almaty Oblast						
Auyl 4	2.0	1.8	1.7	0.49	0.56	0.58
Aidarly	1.0	0.9	0.9	1.00	1.11	1.17
Assy	13.4	9.0	7.8	0.07	0.11	0.13

Zhambyl Oblast						
Ulanbel	1.7	1.3	1.2	0.58	0.75	0.82
Moiynkum	1.8	1.4	1.3	0.54	0.71	0.77
Turkestan Oblast						
Tasty	1.1	0.9	0.9	0.89	1.11	1.17
Kyzylkum	0.5	0.4	0.4	1.94	2.26	2.43
Kyzylorda Oblast						
Zlikha	2.1	1.7	1.6	0.48	0.60	0.63
Karak	2.0	1.8	1.6	0.49	0.57	0.61
Mangystau Oblast						
Sam	0.9	0.8	0.7	1.09	1.27	1.36
Kyzan	0.7	0.6	0.6	1.40	1.65	1.78
Akkudyk	1.3	1.0	0.9	0.80	0.97	1.06
south of Aktobe Oblast						
Ayakkum	1.6	1.4	1.3	0.63	0.74	0.79
south of Karaganda Oblast						
Kyzyltau	3.4	3.0	2.9	0.29	0.33	0.35

Source: *compiled per S. S. Baisholanov's data.*

Table 6. *Calculation of the forecast of economic losses for the pasture yield sector in seven oblasts of Kazakhstan*

Indicator		Aktobe	Almaty	Zhambyl	Karaganda	Kyzylorda	Mangystau	Turkestan	Total	Source:
The norm of pasture area per 1 farm animal on restored and degraded lands, hectare	Restored	2.2	2.2	1.9	2.4	3.0	2.7	1.8		Order of the Minister of Agriculture of the Republic of Kazakhstan dated April 14, 2015, No. 3-3/332 'On approval of the maximum permissible load rate for the total area of pastures'
	Degraded	3.5	3.3	2.8	3.6	4.5	4.1	2.9		
	average	2.8	2.8	2.3	3.0	3.8	3.4	2.4		
Duration of the pasture period, days	min	200.0	192.8	215.6	194.1	238.3	275.7	209.4		
	max	210.0	208.9	236.1	214.1	258.3	295.7	232.5		
	average	205.0	200.8	225.8	204.1	248.3	285.7	220.9		
Average area of agricultural pastures by region for 2000-2016 (base period), thousand hectares		25, 363.4	14, 637.9	9, 419.2	35, 480.7	10, 537.3	12, 673.9	9, 026.4		CLM MA RK
The forecast of a decrease in stocking capacity per RCP 4.5, % of the current level	2030	87.5 %	92.1 %	94.3 %	94.1 %	87.9 %	86.4 %	85.5 %		Report by Baisholanov S. S., own calculations
	2050	87.5 %	82.4 %	77.1 %	88.2 %	85.5 %	83.8 %	80.9 %		
The forecast of a decrease in stocking capacity per RCP 8.5, % of the current level	2030	87.5 %	88.3 %	94.3 %	94.1 %	87.9 %	86.4 %	85.5 %		
	2050	81.3 %	77.7 %	71.4 %	85.3 %	78.1 %	77.6 %	80,9 %		
Average daily gain of SC, kg/animal		0.2	0.2	0.2	0.2	0.2	0.2	0.2		http://agro.tatarstan.ru/rus/file/pub/pub_39067.doc
Average annual prices of agricultural producers for 2019 (sheep cattle), KZT/ton		621,924	675,222	596,974	619,017	578,328	765,140	557,870		MNE RK SC

Indicator		Aktobe	Almaty	Zhambyl	Karaganda	Kyzylorda	Mangystau	Turkestan	Total	Source:
Base period	Potential number of SC on pastures, thousand animals	8, 921.8	5, 274.9	4, 051.3	11, 861.8	2, 797.5	3, 704.3	3, 790.6	40,402.2	Own calculations
	Potential weight gain of the herd on pastures during the pasture period (live weight), thousand tons	365.8	211.9	183.0	484.2	138.9	211.7	167.5	1, 763.0	
	Production potential in 2019 prices, KZT bn	227.5	143.1	109.2	299.8	80.4	162.0	93.4	1, 115.3	
Losses of potential products in 2019 prices with a forecast of a decrease in stocking capacity per RCP 4.5, %	2030	12.5 %	7.9 %	5.7 %	5.9 %	12.1 %	13.6 %	14.5 %	9.8 %	
	2050	12.5 %	17.6 %	22.9 %	11.8 %	14.5 %	16.2 %	19.1 %	15.2 %	
Losses of potential products in 2019 prices with a forecast of a decrease in stocking capacity per RCP 8.5, %	2030	12.5 %	11.7 %	5.7 %	5.9 %	12.1 %	13.6 %	14.5 %	10.3 %	
	2050	18.8 %	22.3 %	28.6 %	14.7 %	21.9 %	22.4 %	19.1 %	19.9 %	

Indicator		Aktobe	Almaty	Zhambyl	Karaganda	Kyzylorda	Mangystau	Turkestan	Total	Source:
Losses of potential products in 2019 prices with a forecast of a decrease in livestock consumption per RCP 4.5, KZT bn	2030	28.4	11.3	6.2	17.6	9.8	22.0	13.6	109.0	
	2050	28.4	25.2	25.0	35.3	11.7	26.2	17.8	169.6	
Losses of potential products in 2019 prices with a forecast of a decrease in stocking capacity for RCP 8.5, KZT bn	2030	28.4	16.8	6.2	17.6	9.8	22.0	13.6	114.4	
	2050	42.7	31.9	31.2	44.1	17.6	36.3	17.8	221.6	
The number of SC by region. thousand animals	for the base period from 2000 to 2016	941.7	2, 796.3	2, 017.5	916.1	645.2	437.1	3, 190.6		MNE RK SC
	at the end of 2019	1, 127.1	3, 511.8	2, 861.8	924.5	620.9	422.5	4, 291.2		
Utilization of pasture capacity, %	for the base period from 2000 to 2016	10.6 %	53.0 %	49.8 %	7.7 %	23.1 %	11.8 %	84.2 %	27.1 %	Own calculations
	at the end of 2019	12.6 %	66.6 %	70.6 %	7.8 %	22.2 %	11.4 %	113.2 %	34.1 %	

Source: *compiled per to S. S. Baisholanov's data, CLM MA RK's data, MNE RK SC's data, standards, own calculations*

Table 7. *Natural hydrometeorological phenomena and their characteristics*

No.	NHMP	NHMP characteristics and criteria
1	Wind, (including squalls and tornadoes)	The maximum speed (including gusts) is 30 m/s or more.

2	Heavy rain	Precipitation of 50 mm or more, and in mountainous and debris-flow vulnerable areas - 30 mm or more for 12 hours or less.
3	Large hail	The diameter of the hailstones is 20 mm or more.
4	Heavy snowfall	Precipitation of 20 mm or more and for 12 hours or less.
5	Heavy glaze	The diameter is 20 mm or more.
6	Complex deposits	The diameter is 35 mm or more.
7	Heavy snowstorms	For 12 hours or more with an average wind speed of 15 m/s or more.
8	Strong dust (sand) storms	For 12 hours or more with an average wind speed of 15 m/s or more.
9	Thick fogs	Visibility of 100 m or less for 6 hours or more.

Table 8. *Extreme meteorological phenomena in Kazakhstan in 2017-2021 and their ramifications*

Oblast, region	**Phenomenon (date)**	**Description and ramifications, extent of damage**	**Affected sectors**
Mountainous area in the south of Kazakhstan	An event with extreme precipitation (April 13, 2017)	The geographical extent was about 150 km^2. The precipitation was about 60 mm in 12 hours or 85% of the monthly norm.	
West of Kazakhstan	An event with extreme precipitation (June 22, 2017)	The geographical extent was about 150 km^2. The precipitation was about 52 mm in 3 hours, or 147% of the monthly norm.	
East of Kazakhstan, Barshatas village	Wind, storms (June 25, 2017)	The geographical extent of about 280 km^2. Average wind speed: 30 m/sec, wind gust: 40 m/sec. The maximum wind speed in July between 1966-2000 was 24 m/s with wind gusts up to 40 m/s. Roofs of buildings and structures were damaged.	Housing and Utilities Population
East of Kazakhstan, Seleznevka village	Wind, storms (July 28, 2017)	The geographical extent of about 280 km^2. Average wind speed: 20 m/sec, wind gust: 40 m/sec. The maximum wind speed in July between 1966-2000 was 24 m/s with wind gusts up to 40 m/s.	
Central part of Kazakhstan	Snowstorm (February 19, 2017)	Average wind speed: about 25 m/s, visibility: about 50 m (unprecedented). Between 1971-2000, the probability of a wind speed of more than 20 m/sec during a blizzard was 2.8%. Public services such as schools, airports, and roads were closed. There were more than 100 cars stuck in the snow drifts, over 300 people were evacuated.	Transport Population

Central part of Kazakhstan	Snowstorm (March 30, 2017)	Average wind speed: about 35 m/sec. Between 1971-2000, the probability of a wind speed of more than 20 m/sec occurring during a blizzard was 0.7%. Public services such as schools, airports, and roads were closed. Traffic restrictions were imposed on the oblast roads. There were more than 150 cars stuck in the snow drifts, over 400 people were evacuated from the roads.	Transport Population
South of Kazakhstan	Hail (May 17, 2017)	The geographical extent was about 150 km^2. The diameter of the hail was 20 mm. The phenomenon lasted for 20 minutes. There was damage to crops and fruit trees.	Agriculture
West of Kazakhstan	Wet snow build-up on electrical wires (March 3, 2017)	Diameter: 38 mm, weight: 40 g per 1 m of electrical wires (unprecedented). Between 1971-2000, the probability of a diameter of more than 30 mm occurring was 9.3%. Power outage.	Energy Population
South of Kazakhstan	Wet snow build-up on electrical wires (January 7, 2017)	Diameter: 50 mm, weight: 280 g per 1 m of electrical wires (unprecedented). Between 1971-2000, the probability of a diameter of more than 50 mm occurring was 1.9%. 10-day long power outage.	Energy Population
Esil River in the northern and central part of Kazakhstan	Floods (April 14-18, 2017)	To prevent casualties, about 3000 people were evacuated from settlements in flooded areas. More than 3,000 farm animals were evacuated to safe places. Preventive measures were taken, and over a million cubic meters of snow were removed from the settlements. 380 houses in 15 settlements and more than 5 thousand suburban areas were flooded. 10 houses were completely destroyed. 1050 m of the roadway were washed away, 11 pipe culverts were destroyed. Engineering protection of 61 settlements was carried out by erecting earth dumps, drainage ditches with a total length of more than 68 km. 950,000 cubic meters of water were pumped out.	Housing and Utilities Population
Nura River in the central part of Kazakhstan	Floods (April 14-25, 2017)	About 2500 people were evacuated from settlements in flooded areas to prevent a fatal outcome. 140 houses were flooded. About 7000 farm animals were evacuated to safe places. About 10 km of highways and 3 km of railways were washed away. More than 30 km of protective dams and ramparts were erected, about 30,870 thousand sandbags were put in place, more than 700 cubic meters of water were pumped out to drain meltwater and protect settlements.	Housing and Utilities Transport Population
Western and Southern Kazakhstan (47°10' N, 51°80' E)	Heat wave (July 1-31, 2018)	*An unprecedented event*. This heat wave was the most significant in Kazakhstan since 2010 and covered a wider region. In the first week of the month, the maximum daily air temperature rose above 40 ° C, at times even above 45 ° C. As a result, the average monthly temperatures in July 2018 were the highest at 13 stations in these regions. For example, a record anomaly (4.4° C) was registered in Atyrau for the entire period of observations since 1881, the previous record with an anomaly of 3.8 ° C occurred in 2010 and 2011.	Population

Southern and South-Eastern Kazakhstan (43°03' N, 78°38' E)	Cold wave (November 12-13, 2018)	*An exceptional event*. At many stations in this region, daytime temperatures were below the 10th percentile and even the 5th percentile. As a result, the average monthly temperatures at some stations were also below the 5th percentile. For example, in Zhalanash (43°03' N, 78°38'E), the average monthly temperature was even lower than the 1st percentile.	Population
Yesik town, Southern Kazakhstan (43°40' N, 77°50' E)	An event with extreme precipitation (November 24, 2018)	*An exceptional event*.	
South-Eastern Kazakhstan (46°48' N, 75°03' E)	An event with extreme precipitation (May 12, 2018)	*An unprecedented and exceptional event*. At some stations in this area, the daily precipitation amounted to 70-80% of the monthly norm. A new record of daily precipitation in November (115% of the monthly norm) was set at the Balkash station (46°48' N., 75°03' E). At the Tasaryk station (42°14' N, 70°09' E), the precipitation lasted for 9 hours and amounted to 61% of the monthly norm.	
Turkestan, Southern Kazakhstan (43°30' N, 68°30' E)	Drought (July 1-31, 2018)	An exceptional event. There was no precipitation during the month.	Agriculture
Aigoz River, Aigoz town, Eastern Kazakhstan (47°90' N, 80°50' E)	Floods (March 11, 2018)	*An exceptional event*. More than 100 houses were flooded.	Housing and Utilities Population
Yertis River, Semey city, Eastern Kazakhstan (50°40' N, 80°20' E)	Floods (March 29, 2018)	*A rare event*, 141 residential buildings and 596 country houses were flooded.	Housing and Utilities Population
Zholboldy village, Northern Kazakhstan (52°70' N, 74°90' E)	Wind, storms (January 11-12, 2018)	Power lines were damaged in several places. Several trees fell.	Energy Population

Mugodzhar village, Western Kazakhstan (48°60' N, 58°50' E)	Snowstorm (January 22-28, 2018)	Many trees were knocked down. The roofs of more than ten houses were demolished. Snow drifts on roads and railways.	Housing and Utilities Transport Population
Shuuldak village, Southern Kazakhstan (42°30' N, 70°40' E)	Snowfall (April 10, 2018)	*An exceptional event.*	
Shirik-Rabat, Southern Kazakhstan	Heat wave (January 6 – February 4, 2019)	*An unusual event.* On some days, the average daily air temperature at many stations in Southern Kazakhstan was higher than the norm by more than 10 °C. A new record of the average monthly air temperature was recorded at 2 MS.	Population
Kyzylorda, Southern Kazakhstan	Heat Wave (July 17 – July 21, 2019)	*An unprecedented event.* In Southern Kazakhstan, the daily maximum temperature exceeded 40 °C, sometimes even 45 °C. The average monthly temperatures hit an all-time record at 15 MS, and the most significant anomaly (3.9 °C) was noted at Kyzylorda MS, which was a new record since 1856, the previous extreme anomaly recorded was 3 °C (2018).	Population
Kishkenenkol village, North Kazakhstan Oblast	Cold wave (June 14 - June 19, 2019)	*An unprecedented event.* On some days, the average daily temperature was 7-9 °C below normal at many stations in Northern Kazakhstan. The daily minimum temperature was about 0 °C. The most significant anomaly of the average monthly temperature (minus 3.5 ° C) was registered at Kishkenenkol MS.	Population
Balkash, Karaganda Oblast	Extreme precipitation (May 3, 2018)	*An unprecedented event*. On May 3, 66 mm of precipitation was registered at Balkash MS within 5 hours with a monthly norm of 15 mm.	Transport Population
South-western Kazakhstan	Extreme precipitation (July 30, 2019)	*An unprecedented and exceptional event.* 53 mm precipitation was registered at Makhambet MS within 4 hours with a monthly norm of 21 mm, and 65 mm per day, i.e., 3 monthly norms.	Transport Population
Almaty city	Extreme precipitation (July 15, 2019)	*An unusual event.* 42-mm precipitation was registered within 12 hours with a monthly norm of 30 mm. It was the fourth extreme case over the last 20 years in Almaty. Heavy rain in mountainous and submontane areas were also registered near the city.	Transport Population
Yesik town, Almaty Oblast	Heavy snowfall (February 1, 2019)	*An unprecedented event.* For the first time in the last 20 years, 38-mm precipitation was registered at Yesik MS within 12 hours. This was a case when a monthly precipitation rate was registered in a day.	Transport Population

Yerementau district of Akmola Oblast	Snowmelt flood (March 27 – March 31, 2019)	*An unusual event.* A large amount of water entered the Seletinsky reservoir, as a result, there were increased water discharges. The Segiz -koz hydro-technical utility, intended for inundative irrigation, was destroyed, the roads leading to the villages of Kulykol and Karatal were flooded. The damage amounted to EUR 0.5 million.	Transport Population Agriculture
Karaganda Oblast	Snowmelt flood (March 29 – April 1, 2019)	*An unusual event.* As a result of intense snowmelt and the inflow of meltwater, water levels increased to 3 meters on Sarysu and Nura rivers. Roads leading to settlements and houses located in the lowlands were flooded.	Transport Population
North Kazakhstan Oblast	Snowmelt flood (April 16 – April 17, 2019)	*An unusual event.* The water level on Yesil river near the city of Petropavlovsk has exceeded a dangerous mark. As a result, 103 suburban areas, a bridge in the village of Novonikolskoye were flooded, water overflowed through 2 sections of the M-51 Chelyabinsk–Novosibirsk (528 and 529 km) highway of republican significance, a section of the Yekaterinburg – Almaty (795-856 km) highway of republican significance was washed away.	Transport Population
Almaty Oblast	Mudslide (April 16, 2019)	*An unusual event.* Due to significant precipitation and waterlogging of the slopes of the Kyzylzhar river erosion cut, a mudslide with a flow rate of up to 3.0 m^3/s was registered in Aksai River basin. A section of the road leading to Ayan children's summer camp was silted up with mudflow mass and was clogged up with boulder stones up to 0.6 m in diameter.	Transport Population
Akmola Oblast	Snowmelt flood (April 16-21, 2020)	The bulk road between the village of Bestogai and the village of Baysary was flooded, but there was no threat of flooding for the village.	Transportation
North Kazakhstan Oblast	Snowmelt flood (April 9, 2020)	2,300 country houses were flooded (according to the Ministry of Emergency Situations). The Chelyabinsk – Novosibirsk highway of international importance (528 km) was flooded, on April 17, there was a water outlet on the road of 1st Zarechnaya Street, Zarechny village.	Transportation
Turkestan Oblast	Flood (May 1-5, 2020)	Economic losses of more than USD 10 million. 22,000 people were evacuated. As a result of the dam breach in Sardobinsky reservoir in Uzbekistan, 10 villages in the south of the Turkestan Oblast in Kazakhstan were flooded.	Housing and Utilities Population
Turkestan Oblast	Landslide (April 14, 2020)	A landslide occurred 500-600 meters from the settlement of Zhana-Zhol.	Population
Almaty Oblast	Landslide (April 19, 2020)	Tau-kuni educational and health complex partially collapsed.	Housing and Utilities

Mangystau Oblast	Extreme precipitation (August 5-6, 2020)	On August 5-6, 2020, a very heavy rain with a thunderstorm was registered in Mangystau Oblast. As a result, more than 7 monthly precipitation norms were registered. In Fort-Shevchenko on August 5, 23-mm precipitation was recorded with the monthly norm of 7 mm. In Aktau on August 06, 66-mm precipitation was registered within 6 hours with a norm of 6 mm, which is 11 times more than the monthly norm.	
Western, Central, South-Western, Southern Kazakhstan	Heat wave (July 1-10, 2021)	At the beginning of July, a strong heat wave, with the daytime air temperature reaching up to + 35 ... + 47 degrees, led to new temperature records. For example, on July 7, the highest air temperature of + 46.5 degrees was recorded at the Kyzylorda MS (Kyzylorda Oblast), thereby breaking the record of 1975, when the air temperature reached + 46 degrees on July 20.	
Central Kazakhstan	Forest fire (September 18-19, 2021)	Karaganda region (Central Oblast). Fires covered more than 3,000 hectares, one person was killed, 2 more people suffered burns. In 2021, there were severe wildfires registered in this region: at the end of July (more than 4,000 hectares) and at the end of August (about 1,500 hectares). 1 person died, 2 were injured.	Population
Northern Kazakhstan	Snowfall (November 24-25, 2021)	On November 24-25, monthly precipitation level (29 mm) was registered in the capital of Kazakhstan (Astana). Snow drifts paralyzed traffic in the city. The historical record of daily precipitation was registered in November 1915 (44 mm).	Transport Population
Northwest, Northern, Central, Southern, South-Eastern, Eastern Kazakhstan	Cold wave (January 1-11, 2021)	In the central, eastern, and northeastern parts of the country, daily temperature anomalies amounted to 21-26° C (the temperature dropped to minus 36-44° C). The lowest air temperature was recorded on January 3 at the Semyarka station (minus 43.8° C). In the south-eastern and north-western of the country, the air temperature dropped below minus 20° C, which is 15-18 ° C below the daily norm. The lowest air temperature was recorded on January 5 at the Lepsy station (minus 36.3 ° C). Similar cold waves were registered in 2018 and 2012.	
Atyrau Oblast, Western Kazakhstan	Floods (March 26, 2021)	*An unprecedented event*. The flood demolished 2 bridges in the village of Sagiz due to a drastic rise in the water level.	Transportation
Southern, South-Eastern, Eastern Kazakhstan	Heat wave (February 1-20, 2021)	The prolonged heat affected a vast area in the south and southeast. The daily temperature exceeded the norm by 10-14° C in the south, and by 14-18° C in the east. Records of the maximum daily temperature have been updated at many MS. For example, at Shymkent MS on February 18, the temperature was + 24.7 °C (the previous record was + 11.4 °C in 2012), at Ridder MS on February 19, the temperature reached + 12.3 ° C (the 1980 record was updated), which was + 5.0 °C). As a result, in these areas, the anomalies of the average	

		monthly temperature were higher than normal by 4-6° C, at some stations the average monthly temperature reached record values.	
Almaty Oblast, Southern Kazakhstan	Hail (July 10, 2021)	Hail over 20 mm in size, sometimes accompanied by strong winds, was registered in several cities of the southern region (for example, in the towns of Ushtogan and Kapshagai).	
Eastern, Southern and South-Eastern Kazakhstan	Heat Wave (July 1 – August 10, 2021)	46 weather stations recorded the most significant and prolonged heat wave, which had record values. The highest air temperature was recorded on July 7 at Kyzylorda station at + 46.5 ° C, thereby beating the record on June 20, 1975 (+ 46.0 ° C).	
Vast territories in Western, Northwestern, Northern, Central, and Southern Kazakhstan	Drought (April 1 – August 31, 2021)	The prerequisites for the spring-summer drought occurred due to the accumulated precipitation deficit in the preceding autumn-winter period. The situation was aggravated by the absence or insignificant amount of precipitation in many regions from April to August. Precipitation deficit was combined with high temperatures in these months (average monthly temperatures exceeded the norm by 3-6° C) and low humidity (less than 30-40%). In many areas, the air drought has turned into a soil drought. Sufficient vegetation cover was not formed on wide pastures, which led to loss of cattle.	Agriculture
Northern, Central, Eastern Kazakhstan	Heat wave (May 21-27, 2021)	In May, several strong heat waves were registered throughout Kazakhstan. Daytime air temperatures rose to + 35-38° C, exceeding the records of 2020. On May 24, the air temperature at Astana MS of + 34.2 °C beat the 2020 record (+ 33.9 °C). On May 25, at Petropavlovsk MS, the air temperature reached + 36.5 ° C, which is 1.7 °C higher than the previous daily maximum registered in May 2020. On May 26, at Ekibastuz MS, the air temperature reached + 38 ° C, thereby beating the 2020 record (+ 36.7° C). On May 26, the air temperature at Semey station rose to + 36.2° C, which became a new record for the entire period of meteorological observations. In the northern half of Kazakhstan, the average monthly temperature anomalies exceeded 4-6 °C. Record values of the average monthly temperature were recorded at more than 90 MS. As a result, the average air temperature in Kazakhstan also reached a record-high level, exceeding the norm by 3.98° C (the previous record was in 2020).	

Western, South-Western, Southern Kazakhstan	Heat wave (August 1-23, 2021)	Prolonged heat was observed during this period; daytime air temperatures rose to + 40-46 ° C. The highest air temperature was registered on August 8 at Akkuduk MS and reached + 46 °C. Such a prolonged heat wave previously occurred in 2016. The average monthly air temperature in August in the western and southern areas was 3-6 °C above the climatic norm for these areas. Record values of the average monthly temperature were registered at 30 MS. As a result, the average air temperature in Kazakhstan also reached a record-high level, exceeding the norm by 2.21 ° C (the previous record was registered in 1998).	
Almaty Oblast, Southern Kazakhstan	Landslide (May 29, 2021)	Heavy rain triggered a mudflow in the lower part of Charyn Canyon.	
Zhambyl Oblast, Southern Kazakhstan	Landslide (August 16, 2021)	As a result of heavy rainfall at the confluence of Aspara and Shu rivers, a powerful stream of water destroyed a section of the Merke – Shu–Burylbaytal highway.	Transportation

Projected impacts of climate change on tourism

Table 9. *Projected impacts of climate change on beach tourism*

The main factors affecting beach tourism: ***Impactful climate-related and environmental factor(s)***	**Climate forecasts**
Duration of the tourist season [a]: *1. Temperature: seasonal temperatures* *a. Summer*	1. An increase in average annual temperatures and average seasonal temperatures may lead to a longer duration of the summer season due to temperature increase in summer *(all scenarios)*, as well as in spring and autumn *(all scenarios)*. Thus, the summer season can be opened earlier (in spring) and closed later (in autumn), although the duration of the tourist season depends on other factors unrelated to the environment. The average temperature in winter is also increasing, which leads to a likely reduction in the winter tourism season. The average temperature increases with more intense emission scenarios and with time [5,7]. a. ***Summer.*** General increase in average summer temperatures *(all scenarios).*

b. *Spring* *c.* *Autumn*	**By 2030**, the average summer temperature is likely to rise by at least 2 °C throughout Kazakhstan *(scenarios A1B, A2, and B1, except for the northernmost part of Kazakhstan)*. **By 2050**, the average summer temperature will increase by at least 3 °C throughout Kazakhstan *(scenarios A1B and A2)* and 2-2.5 °C *(scenario B1)*. **By 2085,** most of Kazakhstan will likely witness an increase in the summer average temperature of at least 4.5 °C. Across Pavlodar Oblast and East Kazakhstan Oblast the increase will be 5 °C *(scenario A1B)* or 5.5 °C across South Kazakhstan, Almaty, Zhambyl, Kyzylorda and Aktobe Oblasts *(scenario A2)*. According to scenario B1, the temperature is likely to increase by 3 °C across Kazakhstan by 2085.[5] b. ***Spring***. General increase in average temperature in spring *(all scenarios)*. **By 2030**, the average spring temperature in most of Kazakhstan is projected to be 2 °C higher, along the Caspian Sea coast the increase is projected to be 1.5 °C *(all scenarios)*. By 2050, the average spring temperature is likely to increase by at least 2.5 °C *(scenario A2)*, in most of Kazakhstan *(scenario A1B)* by 3 °C and at least 2 °C *(scenario B1)*. **By 2085, the temperature increase is likely to reach 4 °C for most of eastern, south-eastern and south-western Kazakhstan, 4.5 °C for the central, northern and western parts of Kazakhstan, and 5 °C for the northernmost part of the country and parts of Aktobe, Karaganda** and Kostanay Oblasts*(scenario A1B)*; with an increase in latitudinal belts, the forecast is 5.5 °C in the northern part of Kazakhstan, 5 °C in the central part and 4.5 °C in the southern belt *(scenario A1B)*. According to scenario B1, by 2085, the temperature is likely to increase by 3.5 °C for the north of Kazakhstan, by 2.5 °C for the southern regions and by 3 °C for the central belt. In all scenarios, especially in high-emission scenarios, temperatures are likely to increase in spring and, accordingly, an earlier opening of the summer season is expected and, as a result *(in various scenarios)*, an increase in the duration of the summer beach season is expected c. ***Autumn***. Overall increase in average temperature in autumn *(all scenarios)*. **By 2030**, autumn temperatures in most of Kazakhstan will increase by 2 °C *(all scenarios)*; the increase along the coast of the Caspian Sea is expected to be 1.5 °C. **By 2050**, the average autumn temperature will increase by 3 °C, while the temperature in the northernmost part will increase by 3.5 °C, the southwestern part - by 2.5 °C *(scenario A1B)*; the temperature will increase by 2.5 °C in most of Kazakhstan with a belt from north to west along the northern border of Kazakhstan, where increase is predicted to reach 3 °C *(scenario A2)* and 2-2.5 °C *(scenario B1)*. By 2085, in the central and southern regions of Kazakhstan, the average temperature will increase by 4 °C, in the north and east by 4.5 °C; the temperature in the west and southwest and along the coast of the Caspian Sea is projected to increase by 3.5 °C *(scenario A1B)*; 5 °C increase is expected in the north and east of Kazakhstan, 4.5 °C - in central and southern Kazakhstan, and 4 °C - in the southwest and along the coast of the Caspian Sea *(scenario A2)*; or will increase by 2.5 °C in most of Kazakhstan and by 3 °C in the north and in some eastern parts *(scenario B1)*.

	In all scenarios, especially in high-emission scenarios, an increase in the autumn season temperature is likely to allow the summer season to finish later. In areas with intense autumn warming *(various scenarios),* there is likely to be an increase in the duration of the summer beach season.
Non-seasonal and extreme weather and climatic phenomena (unusual climatic/weather phenomena; extreme events) [a,b,c,d]: *1. Off-season events* *a. Summer* *2. Extreme events* *a. Abnormal heat in summer* *b. Storms, blizzards, and strong winds* *c. Heavy rain and hail* *d. Dusty whirlwinds* *e. Floods (spring)*	*1. Off-season phenomena* - an increase in global temperatures and an unstable climate lead to a complex set of impacts, including an increase in the frequency and intensity of extreme events. *2. Summer:* off-season weather and climatic phenomena in summer include, for example, storms, heavy rains, hail, etc. It is assumed that their number will increase in the future *(all scenarios)* with an increase in the number of phenomena for higher emission scenarios. 3. *Extreme events.* Global forecasts indicate an increase in the number of off-season and extreme weather and climate events. An increase in the average temperature means that extreme events will occur more often, and more frequent extreme and intense events may also occur. **By 2050**, according to forecasts, the average annual temperature growth rate in Central Asia will be 2.9–5.5°C (WOM scenario) or 1.9–3.3 °C (low-emission scenario) relative to 1961-1990. **By 2080**, the temperature is expected to increase to 4-7.2 °C (WOM scenario) or to 2.9–4 °C (low-emission scenario) relative to 1961-1990. In Central Asia, an increase in average, maximum and minimum temperatures is likely to occur in all seasons. *a.* ***Abnormal heat in summer***. In Central Asia and Kazakhstan, there are trends of increasing frequency and intensity of heat wave events, it is expected that these trends will continue in the future *(all scenarios)*. In Kazakhstan, **by 2030**, August and September are likely to be the months with the highest average temperature increase per year by 1.8–2.1°C *(scenarios A1B, A2, B1)*. **By 2050**, the fastest rates of temperature increase in Kazakhstan are expected in summer (and winter) at the level of 2.1–3.2 °C *(scenarios A1B, A2, B1)*. Higher emission scenarios correspond to higher temperatures and probably more frequent and severe heat wave events. In Kazakhstan, there will be a particularly strong impact of temperature changes in the summer months. Beach resorts can benefit from an increase in temperature, as more tourists will plan a vacation there or based on information about high temperatures, make spontaneous decisions about temporary accommodation near the beach. *b. Storms, blizzards, and strong winds.* It is assumed that strong winds and blizzards will become more common in the future *(all scenarios)*, while the risk of severe snowstorms will be increased in the northern regions of Kazakhstan, although this should be studied further. A strong wind with a speed of 30 m/s or more is also likely in steppe areas, which can damage infrastructure. These phenomena cause damage to the infrastructure and lead to site closures for the duration of certain extreme events as well as the need for damage compensation. [5] *c. Heavy snowfall, rain, and hail.* It is expected that future levels of precipitation (rain, snow) and strong winds with hail *(all scenarios)* will increase, which will lead to damage to infrastructure, site closures as the need for damage compensation. *d. Dusty whirlwinds.* The number of days with dust storms (because of increased aridity and rising temperatures combined with the

	ramifications of the Aral Sea disaster) has increased in the Aral Sea region and is expected to continue to increase as climate change progresses, which may create a problem for vacationers in this region, especially on Lake Kamystybas. *e. Floods (spring).* Spring floods will increase in the future in terms of severity *(all scenarios)*, especially in mountainous and foothill areas [5]. However, they may differ for watersheds based on the melting of glaciers (an increase in the short- to medium-term and a decrease in the medium- and long-term periods) and the forecast of precipitation (in many areas, a significant increase in precipitation is likely, *all scenarios*). Spring floods in steppe areas after winter with a high probability of precipitation will increasingly appear in the future with the forecast of high levels of winter precipitation. Floods can cause both flash floods and landslides. Although this may not affect the tourist seasons, it may have an impact on tourism infrastructure during the off-season and may lead to damage and associated costs.
Water availability [b]: *1. Water scarcity (due to increasing aridity, increased demand, and management issues)*	It is likely that scenarios with higher emissions will correspond to greater water scarcity. *Water scarcity:* aridity is likely to increase significantly by 2050 and 2100 *(all SRES climate scenarios)* in Central Asia, and especially in central and western Kazakhstan. Shrinking of glaciers in the medium and long term will also contribute to a decrease in the volume of water resources in the region, in the short term (until 2030), glacier melting may increase. An increase in summer droughts in Pavlodar Oblast and South Kazakhstan Oblast is already predicted by 2030 *(scenarios A1B, A2)*, which may create problems for popular beach holiday destinations in these areas, in particular in Bayanaul lake and Shardara reservoir. Management of some water resources and flows in rivers and reservoirs also depends on neighboring states: China's plans to withdraw and develop industry and agriculture in the Western Province may lead to a decrease in the water level of Balkash lake to the four lakes and a change the river delta (may also lead to desertification in this area)[5]. Thus, water scarcity can make beach tourism and lake tourism less attractive due to the depressed state of the environment.

[a] Impacts the number and duration of tourist trips during the season and/or contributes to a gradual change in the period of the tourist season
[b] May lead to cancellation/closure or disruption of tourist activities
[c] May damage the infrastructure /access
[d] May lead to the loss of tourist sites/reasons to visit

Table 10. *Projected impacts of climate change on ski tourism*

The main climatic factors affecting ski tourism:	**Forecasts**
Duration of the tourist season (winter)[a]: *1. Temperature: seasonal temperatures* *a. Winter* *b. Spring* *c. Autumn* *2. Precipitation: Seasonal snowfall (autumn, winter, spring) (see next section)*	1. *Seasonal temperatures.* An increase in seasonal average temperatures is likely to play a role in shortening the duration of the winter ski season, as the number of days with temperatures supporting snowfall and the surface snow is generally decreasing. a. ***Winter*** – a rapid increase in average winter temperature *(all scenarios).* **By 2030**, the temperature increase in most of Kazakhstan is expected by 2 °C, including the mountainous regions of Altai and Tien Shan *(all scenarios)*, increase by 2.5 °C is expected in various parts of northern Kazakhstan *(scenario B1)* and northeast Kazakhstan *(scenarios A1B and A2; A1B - demonstrate large areas exposed to higher temperatures)*. **By 2050**, in most oblasts of Kazakhstan in the northern and central latitudes, the average temperature will increase by 3.5 °C, in the southeastern (Northeastern Tien Shan) and eastern (Altai Mountains) borders of Kazakhstan - by 3 °C, and in southern Kazakhstan (Western Tien Shan), Kyzylorda and Mangystau Oblasts*(scenario A1B)* - by 2.5 °C; temperature in central latitudes (including the Northeastern Tien Shan and the Altai Mountains) is expected to rise by 3 °C, in South Kazakhstan (Western Tien Shan) and Kyzylorda Oblasts - by 2.5 °C *(scenario A2)*; and in most of Kazakhstan, temperatures are expected to rise by 2.5 °C, with an increase by 2 °C in areas near the Altai Mountains, Western Tien Shan and parts of the Northeastern Tien Shan *(scenario B1)*. **By 2085,** the northern latitudinal range of Kazakhstan will experience warming at the level of 5.5–6 °C, an increase of 4-4.5 °C is expected in the central latitudes (including the Altai Mountains), an increase of 4-4.5°C is expected in Almaty Oblast, 4° C in most of the Zhambyl Oblast (Northeastern Tien Shan) and an increase of 3-4 °C is expected in South Kazakhstan Oblast (including Western Tien Shan) *(scenario A1B).* According to the *A2 scenario*, forecasts for the northern latitude of Kazakhstan are 6-6.5 °C, 5-5.5 °C - for the central latitude (4.5–5 °C for the Altai Mountains), 4.5–5 °C - for Almaty Oblast, 4.5 °C - for the southeastern border of the Northeastern Tien Shan and 3.5–4.5 °C - for South Kazakhstan Oblast (Western Tien Shan). *Scenario B1* for **2085** – the highest increase (4 °C) occurs in the north of Kazakhstan in the area of the Tien Shan and Altai Mountains –2–3.5 °C. Although temperatures will still support snowfall and snow on the surface in many places, forecasts with an increase in average winter temperatures mean that winter will be warmer, with fewer cold and very cold days and this may be one of the factors shortening the winter ski season. b. ***Spring*** – an increase in average spring temperature *(all scenarios).* **By 2030**, the average temperature in most of Kazakhstan is projected to be 2 °C higher (*all scenarios*), 1.5 °C higher - in the Northeastern Tien Shan *(scenario A1B)* and along the line of the Tien Shan and Altai Mountains *(scenario B1)*. **By 2050**, the temperature in most of Kazakhstan will increase by 2.5 °C, including the mountainous areas of the Tien Shan and Altai *(scenario A2)*; a

	3 °C increase is expected for most of Kazakhstan, including the Altai Mountains, in the northeastern part of the Tien Shan - by 2.5 °C *(scenario A1B)*; and by 2 °C *(in scenario B1)*. **By 2085, the temperature increase will be up to 4 °C for most of eastern, southeastern and southwestern Kazakhstan, including the Tien Shan and the Altai Mountains, 4.5 °C - for the central, northern and western parts of Kazakhstan and 5 °C - for the northernmost part and parts of Aktobe, Karaganda** and Kostanay Oblasts*(scenario A1B)*; with an increase in latitudinal belts, the forecast is 5.5 °C in the northern part of Kazakhstan, 5 °C - in the central part and 4.5 °C - in the southern belt, including the Tien Shan (as well as the Altai Mountains) *(scenario A1B)*. Forecasts B1 for **2085** show an increase for the very north of Kazakhstan by 3.5 °C, for the southern regions - by 2.5 °C and for the central strip - by 3 °C, with an increase in temperature of 2.5–3 ° C for the Tien Shan and Altai Mountains [5]. An increase in spring temperature is likely to contribute to the shortening of the winter snow season, since a faster increase in temperature in spring accelerates snow melting and is an unfavorable condition for snowfall and surface snow, and thus concludes the winter ski season. c. ***Autumn.*** The overall increase in average temperature *(all scenarios).* **By 2030**, autumn temperatures in most of Kazakhstan will be 2 °C higher, including in the Tien Shan and Altai Mountains *(scenarios A1B and A2)*; and 1.5 °C warmer in most of Kazakhstan, including the Tien Shan and Altai Mountains *(scenario B1)*. **By 2050**, it will increase by 3 °C, including the mountainous areas of the Tien Shan and Altai Mountains, while the northernmost part will increase by 3.5 °C, and the southwestern part - by 2.5 °C *(scenario A1B)*; in most of Kazakhstan - by 2.5 °C, including the Tien Shan region, with a belt from north to west along the northern border of Kazakhstan, where warming to 3 °C is predicted, and by 2.5–3 °C in the Alatau mountains – *(scenario A2)*; by 2 °C including the Tien Shan and Altai *(scenario B1)*. **By 2085**, in the central and southern parts of Kazakhstan, the average autumn temperature will increase by 4 °C (including along the Tien Shan), by 4.5 °C - in the north and east (including the Altai Mountains), and by 3.5°C in the west and southwest *(scenario A1B)*; by 5 °C - in the north and east of Kazakhstan (including the Altai Mountains and the North-Eastern Tien Shan), by 4.5 °C - in Central and Southern Kazakhstan (including the Western Tien Shan) and by 4 °C - in Western and South-Western Kazakhstan *(scenario A2)*; or by 2.5°C in most of Kazakhstan, with warming up to 3°C in the north and some parts of the east *(scenario B1)*. Under all scenarios, but especially for the higher emissions scenarios, a warmer autumn season is likely to help delay the opening of the winter ski season as favorable conditions for snowfall and ground snow become less common. 2. *Seasonal precipitation (snowfall).*
Snowfall [a,b,c]: *1. Precipitation: Seasonal snowfall (autumn, winter, spring)*	*Seasonal precipitation (snowfall).* Despite a noticeable increase in the average precipitation in some areas, there will be an increase in precipitation by approximately several millimeters more often during the season. However, an increase in extreme events means that in one particular case, much more precipitation (snow) may occur which may prolong the season, especially in cases with snow retention. *a.* ***Winter precipitation*** – an increase in the amount of precipitation in winter, especially in the mountainous regions of Eastern, Northern and Central Kazakhstan *(all scenarios)*, an increase in the future *(all scenarios)*.

By 2030, according to forecasts of winter precipitation in the Altai Mountains, their amount will increase by 21%, and by 8-21% in the Tien Shan Mountains *(scenarios A1B, B1)*; by 29% in the Altai Mountains, by 8-25% in the western and north-central part of the Tien Shan and 38% in the North-Eastern Tien Shan *(scenario A2)*.

By 2050, precipitation will increase up to 38% in the Altai Mountains and from 8% (Western Tien Shan) to 38% (Northeastern Tien Shan) in the Tien Shan Mountains *(scenario A1B)*; up to 29% in the Altai Mountains and from 17% (Western Tien Shan) to 29% (Northeastern Tien Shan) in the Tien Shan Mountains *(scenario A2)*; up to 21% in the Altai Mountains and from 13% (Western Tien Shan) to 21% (Northeastern Tien Shan) in the Tien Shan Mountains *(scenario B1)*.

By 2085, precipitation will increase by 42-46% in the Altai Mountains and from 17% (Western Tien Shan) to 50% (Northeastern Tien Shan) in the Tien Shan Mountains *(A1B scenario)*; by 50% in the Altai Mountains and by 8-50% (Western Tien Shan, North-Eastern Tien Shan) in the Tien Shan Mountains *(scenario A2)*; by 42% in the Altai Mountains and by 4-33% (Western Tien Shan, Northeastern Tien Shan) in the Tien Shan Mountains *(scenario B1)*[5].

In the near future, an increase in precipitation in the form of snow, especially in the case of heavy snowfalls in winter at low temperatures, is likely to support the winter snow season and may serve to lengthen the season, since large amounts of snow lie on the ground for long periods of time exceeding the initial snow period (and, for example, remain for a long time in spring). However, in the medium and long term, this potential benefit should be balanced against noticeably increased temperatures, especially in the second half of the century *(especially under high-emission scenarios)*.

b. ***Autumn precipitation*** – a moderate and unstable increase in precipitation is predicted in the Altai and Tien Shan mountains, while precipitation patterns remain somewhat unclear.

By 2085, a moderate increase of about 8% is predicted in these mountains *(scenario A1B,)*; changes of 4%-13% *(scenario A2)*; and an increase of 4-17% *(scenario B1)*[5]. An increase in autumn precipitation could contribute to an increase in autumn snowfall.

In the near future and in the short term, especially if snow covers are formed in large volumes at the beginning of the snow season, this will benefit ski tourism *(all scenarios, in particular, high-emission scenarios (A1B, A2, RCP6.0, RCP8.5), before the temperature rises enormously)*. In the medium and long term, any increase in precipitation may be accompanied by an increase in temperature (resulting in precipitation falling in the form of rain rather than snow, or rapid snow melting) *(high-emission scenarios (A1B, A2, RCP6.0, RCP8.5)*. In general, an increase in precipitation would be insignificant, and the trends are not clear.

c. ***Spring precipitation*** – an increase in the average amount of spring precipitation in the east of Kazakhstan (near the Altai Mountains) and a decrease in the south of Kazakhstan (western part of the Tien Shan).

By 2085, precipitation is likely to increase by 25-29% in the Altai Mountains and by 4% in the western part of the Tien Shan *(A1B scenario)*; by 21-25% in the Altai Mountains and by 13% in the western part of the Tien Shan *(A2 scenario)*; by 17-21% in the Altai Mountains and by 8% in the Western Tien Shan *(scenario B1)*.

	In the short term, an increase in spring precipitation may contribute to an increase in spring snowfall in the Altai Mountains and the northeastern and central regions of the Tien Shan *(all climatic scenarios, especially high-emission scenarios (A1B, A2, RCP6.0, RCP8.5), to a sharp warming of temperature)*; while a decrease in precipitation in the west of the Tien Shan contributes to the reduction in snowfall and may lead to a reduced ski season *(all climatic scenarios associated with an increase in the future)*. However, in reality, changes in precipitation are insignificant.
Non-seasonal and extreme weather and climatic phenomena [a,b,c,d]: 1. *Off-season events* a. *W inter* 2. *Extreme events* a. *Storms, blizzards, and strong winds* b. *Heavy rain, snow, and hail* c. *Winter thaws* d. *Floods (spring)* e. *Avalanches* f. *Glacial Lake Outbursts (GLOs)*	1. *Off-season phenomena* - an increase in global temperatures and an unstable climate lead to a complex set of impacts, including an increase in the frequency and intensity of extreme events. Global forecasts indicate an increase in the number of off-season and extreme weather and climate events. a. *Winter.* Off-season weather and climatic phenomena in winter include, for example, storms, snow drifts, etc. It is expected to increase their number in the future *(all scenarios)*, especially for higher emission scenarios. 2. *Extreme events:* Global forecasts indicate an increase in the number of non-seasonal and extreme weather and climate events. Studies show that in all Central Asian countries, the average and seasonal temperature, as well as the number and intensity of extreme events, will constantly increase. **By 2050**, according to forecasts in Central Asia, the average annual temperature growth rate will be 2.9–5.5 °C *(WOM scenario)* or 1.9–3.3 °*C (low-emission scenario)* relative to 1961-1990. **By 2080**, it is expected to increase to 4-7.2 °C *(WOM scenario)* to 2.9–4 °*C (low-emission scenario)* relative to 1961-1990. In Central Asia, the average, maximum and minimum temperatures rise in all seasons. a. *Storms, blizzards, and strong winds:* it is assumed that strong winds, blizzards will become more common in the future in the mountainous regions of Kazakhstan, although this should be further investigated. Strong winds with a speed of 30 m/s and more, capable of damaging infrastructure [5] of steppe territories, may have ramifications for small cross-country ski facilities. b. *Heavy rain, snow, and hail:* it is expected that the intensity of precipitation (rain, snow, and hail) will increase in the future, showers and heavy snowfalls will be more frequent in the mountainous regions of Kazakhstan and in the snowfields of the northeastern part of Tien Shan. Extreme showers and hail are most likely to be observed in winter in areas where an increase in precipitation is predicted, since this factor, combined with higher temperatures, supports extreme precipitation. This may damage infrastructure and lead to site closures for the duration of such events and for the period necessary to compensate for the damage. Snowfalls, as a rule, will be perceived positively, since heavy snowfalls will help to prolong the ski season, although infrastructure facilities may have to be closed during days of snow blockages for safety reasons. However, snow blockages can contribute to the risk of avalanche. c. *Thaws in winter, spring, and autumn:* there are trends of increasing frequency and intensity of thaw cases in Central Asia and Kazakhstan, it is expected that these trends will continue in the future. In Central Asia, the average winter temperature will increase by 1.6–4.9 °C, autumn temperatures – by 3.1–4 °C and spring temperatures – by 2.9–4 °C by 2050 relative to 1961-1990. *(All low and high emission scenarios)* [7]. Thaws are extreme phenomena that increase in frequency, and intensity with along with average temperature *(scenarios A1B, A2, B1* [5]).

	By 2030, the fastest warming rates in Kazakhstan will occur in winter (and in August and September, see above), warming by 1.8–2 ° C *(scenarios A1B, A2, B1)*. According to forecasts, **by 2050**, the winter months will experience the fastest temperature growth rates in Kazakhstan: 2.6–2.9 °C in January and February *(scenario A1B)*; 2.5–3.3 °C *(A2)*, and 2.1–2.3 °C *(B1)*[5]. Thus, the winter months are likely to suffer from more extreme events, including thaws, faster than other seasons in Kazakhstan, especially in areas with warmer winters (see temperature above). Thaws create unfavorable conditions for ski tourism, since precipitation falling in the form of rain, not snow, damages the snow cover, especially in autumn and spring, when temperatures are generally higher. This can shorten the ski season. d. ***Flood (spring):*** spring floods will increase in the future (in terms of the degree of intensity and number of phenomena) *(all scenarios)*, especially in mountainous and foothill areas, depending on watersheds based on glacier melting (an increase in the short- to medium-term, and then a decrease in the medium- and long-term periods) and precipitation forecasts (a significant increase in precipitation is predicted in many areas, *all scenarios*). Floods can also cause flash floods and landslides. Although this may not directly affect the tourist season, it may affect tourist infrastructure during the off-season, which may lead to damage and additional business costs. However, in the medium and long term, the peak of river flow and "spring thaw" is likely to shift from late spring/early summer to late winter/early spring due to the flow from glaciers and the reduction of permanent snow cover. This can have a direct impact on ski areas during the season: "spring thaw" (although reduced) can lead to floods and site closures due to damage to infrastructure and snow cover, harming ski tourism. e. *Avalanches.* An increase in temperature leads to an increase in the risk of avalanches. Based on precipitation and temperature forecast data, avalanches are likely to be more frequent and intense in mountainous areas of Kazakhstan, where heavy snowfalls, rains and temperature increases are observed; this is in line with forecasts for other areas of Tien Shan of Kyrgyzstan. Avalanches are dangerous phenomena that can cause casualties and damage or destroy infrastructure. f. *Glacial Lake Outbursts (GLOs).* More frequent GLOs are predicted in Kazakhstan as a result of an increase in glacial flow and rapid filling of glacial lakes. This, in turn, can lead to mudslides and avalanches in mountainous areas. During or outside the winter season, they can cause casualties and completely destroy infrastructure, forests, and anything in their path.

[a] Affects the number and duration of tourist trips during the season and/or contributes to a gradual change in the period of the tourist season

[b] May lead to cancellation/closure or disruption of tourist activities

[c] May damage the infrastructure /access

[d] May lead to the loss of tourist sites/reasons to visit

Table 11. *Projected impacts of climate change on wellness tourism*

The main factors affecting wellness tourism:	**Forecasts**
Non-seasonal and extreme weather and climatic phenomena [a,b,c,d]: *1. Extreme events* *a. Storms, blizzards, and strong winds* *b. Heavy rain and hail* c. *Floods (spring)*	1. *Extreme events.* Global forecasts indicate an increase in the number of off-season and extreme weather and climate phenomena [2]. Studies show that the average and seasonal temperature will constantly increase in all Central Asian countries. An increase in the average temperature means that more extreme and intense phenomena will occur. **By 2050**, according to forecasts, the average annual temperature growth rate in Central Asia will be 2.9–5.5 °C *(WOM scenario)* or 1.9–3.3 °*C (low-emission scenario)*, compared with the period 1961-1990. **By 2080**, it is expected to increase to 4-7.2 °C *(WOM scenario)* to 2.9–4 °*C (low-emission scenario),* compared with the period 1961-1990. *a. Storms, blizzards, and strong winds:* it is assumed that in the future they will become more frequent in the mountainous regions of Kazakhstan, although this should be further investigated. Strong winds with a speed of 30 m/s and more, capable of destroying infrastructure, are also predicted in steppe territories and may have ramifications for sanatoriums in these areas, especially for the Sosnovy Bor sanatorium, Okzhetpes recreational compound, Sayaly sanatorium, Moildy sanatorium and Zhosaly sanatorium. *b. Heavy rain, snow, and hail: an* increase in phenomena is expected *in all scenarios* [5]. Extreme rains and hail are more likely to occur in winter in areas where an increase in precipitation is predicted, since this factor, combined with an increase in temperature, leads to the formation of more extreme precipitation events in winter *(under all scenarios)*. This may cause damage to the infrastructure and lead to the closure of the facility for the duration of such an event and the period necessary for damage compensation. *c. Flood (spring):* in the future, the number and intensity of spring floods will increase (i.e., more frequent and severe floods) *(all scenarios)*, especially in foothill and mountain regions, possibly with ramifications for sanatoriums in these areas, especially for Rakhmanovskie Klyuchi, Kazakhstan sanatorium and Merke sanatorium[5]. However, for watersheds based on glacier melting (an increase in the short- to medium term, and then a decrease in the medium- and long-term periods) and precipitation forecasts, a significant increase in precipitation is predicted in many areas in the future *(all scenarios).* Floods can also cause flash floods and landslides. Spring floods in steppe areas after a winter with a high degree of precipitation are also likely to occur more often in the future, when forecasts of winter precipitation levels are high. Floods can also cause flash floods and landslides. This can lead to damage to wellness resorts and access to infrastructure, which will entail losses and costs.

[a] Affects the number and duration of tourist trips during the season and/or contributes to a gradual change in the period of the tourist season
[b] May lead to cancellation/closure or disruption of tourist activities
[c] May damage the infrastructure /access
[d] May lead to the loss of tourist sites/reasons to visit

Table 12. *Projected impacts of climate change on MICE and business tourism*

The main factors affecting MICE and business tourism	Forecasts
Non-seasonal and extreme weather and climatic phenomena [a,b,c,d]: *1. Extreme events* *a. Storms, blizzards, and strong winds* *b. Heavy rain and hail*	1. *Extreme events:* Global forecasts indicate an increase in the number of non-seasonal and extreme weather and climate events. Studies show that in all countries of Central Asia, the average and seasonal temperature will constantly increase, the number and intensity of extreme events will increase. **By 2050**, the average annual temperature growth rate in Central Asia will be 2.9–5.5 °C *(WOM scenario)* or 1.9–3.3 °*C (low-emission scenario)* relative to 1961-1990. **By 2080**, it is expected to increase to 4-7.2 °C *(WOM scenario)* to 2.9–4 °*C (low-emission scenario)* relative to 1961-1990. *a. Storms, blizzards, and strong winds.* It is expected that strong winds and blizzards will become more common in the mountainous regions of Kazakhstan in the future (additional research is needed), which will have significant ramifications for Almaty Oblast. Strong winds of 30 m/s or more, capable of damaging infrastructure, are also predicted for steppe territories, which may have consequences for Astana. *b. Heavy rain, snow, and hail.* It is expected that in the future the number of these phenomena will increase *in all scenarios*. Extreme rains and hail are more likely to occur in winter in areas where the probability of increased precipitation increases, and with an increase in the probability of an increase in temperatures, the probability of the number of extreme precipitation events in winter increases *(all scenarios)*. This may cause damage to the infrastructure and lead to the closure of the facility during such an event, and then during the period necessary for damage compensation.

[a] Affects the number and duration of tourist trips during the season and/or contributes to a gradual change in the period of the tourist season

[b] May lead to cancellation/closure or disruption of tourist activities

[c] May damage the infrastructure /access

[d] May lead to the loss of tourist sites/reasons to visit

Table 13. *Projected impacts of climate change on ecotourism*

The main factors affecting ecotourism: ***Impactful climate-related and environmental factor(s)***	**Forecasts**
Duration of tourist seasons [a]: 1. *Temperature: seasonal temperatures* *a. Summer* *b. Spring* *c. Autumn*	1. An increase in average annual and seasonal temperatures may lead to an increase in the duration of the ecotourism season (usually considered the period from May to September), but due to an increase in summer temperatures *(all scenarios)*, as well as higher spring and autumn temperatures *(all scenarios)*, the duration of the season increases due to an earlier opening (for example, in early spring) and later closing (for example, in late autumn). a. ***Summer***. An increase in the average temperature in the summer *(all scenarios).* **By 2030**, the average temperature is likely to rise by at least 2 °C throughout Kazakhstan *(scenarios A1B, A2, and B1, except for the northernmost part of Kazakhstan)*. **By 2050**, the average temperature is likely to rise by at least 3 °C across Kazakhstan *(scenarios A1B and A2)* and 2-2.5 °C *(scenario B1)*. **By 2085, the average temperature in summer is expected to increase by at least 4.5 °C in most of the territory of Kazakhstan, with an increase of 5 °C in most of the Pavlodar region** (scenario A1B), *or an increase of 5 °C in large areas of East Kazakhstan, South Kazakhstan, Almaty*, Zhambyl, Kyzylorda and Aktobe Oblasts, subject to an increase of 5.5 °C *(scenario A2)*. *Scenario B1* shows an increase of 3°C for most of Kazakhstan by **2085.** [5]. b. ***Spring***. A general increase in the average temperature in spring *(all scenarios)*. **By 2030**, the average temperature in most of Kazakhstan is projected to be 2 °C higher *(all scenarios)*, 1.5 °C higher in the Northeastern Tien Shan *(scenario A1B)* and along the line of the Tien Shan and Altai Mountains *(scenario B1)*. **By 2050**, the average spring temperature in most of Kazakhstan will increase by 2.5 °C, including in the mountainous areas of the Tien Shan and Altai *(scenario A2)*; by 3 °C is expected in most of Kazakhstan, including the Altai Mountains, by 2-2.5°C in the northeastern part of the Tien Shan *(scenario A1B) (scenarios B1)*. **By 2085, the** temperature increase will amount up to 4 °C in most of Eastern, Southeastern and Southwestern Kazakhstan, including the Tien Shan and Altai Mountains, up to 4.5 °C in the central, northern and western parts of Kazakhstan, and up to 5 ° C in the north of the country and Aktobe, Karaganda and Kostanay Oblasts*(scenario A1B)*; with an increase in latitudinal belts, the forecast is 5.5 °C in the northern part of Kazakhstan, 5 °C for the central part and 4.5 °C for the southern belt, including the Tien Shan (as well as the Altai Mountains) *(scenario A1B)*. *Forecasts B1* for **2085** show an increase of 3.5 °C for the very north of Kazakhstan, 2.5 °C for the southern regions and 3 °C for the central belt, while the Tien Shan and Altai Mountains expect an increase of 2.5–3 ° C [5]. Rising temperatures in spring are likely to increase the duration of the

	ecotourism season, as higher temperatures start earlier after a cold winter. c. ***Autumn.*** An increase in average autumn temperature *(all scenarios)*. **By 2030**, autumn temperatures in most of Kazakhstan will be 2 °C higher, including the Tien Shan and Altai Mountains *(scenarios A1B and A2)*; and 1.5 °C higher in most of Kazakhstan, including the Tien Shan and Altai Mountains *(scenario B1)*. **By 2050**, the average temperature in autumn will increase by 3 °C, including the mountainous areas of the Tien Shan and Altai Mountains, while the northernmost part will increase by 3.5 °C, and the southwestern part by 2.5 °C *(scenario A1B)*; by 2.5 °C in most of Kazakhstan, including the Tien region-Shan, with a belt from north to west along the northern border of Kazakhstan, where an increase to 3 °C is predicted and in the Alatau mountains – by 2.5–3 °C *(scenario A2)*; and by 2 °C, including Tien Shan and Altai *(scenario B1)*. **By 2085, in** the central and southern parts of Kazakhstan, the average autumn temperature will increase by 4 °C (including the Tien Shan), 4.5 °C in the north and east (including the Altai Mountains) and 3.5 °C in the west and southwest *(scenario A1B)*; 5 °C in the north and East of Kazakhstan (including the Altai Mountains and Northeastern Tien Shan), 4.5 °C in central and southern Kazakhstan (including Western Tien Shan) and 4 °C in western and southwestern Kazakhstan *(scenario A2)*; or 2.5 °C in most of Kazakhstan with an increase to 3 °C in the north and some areas of the east *(scenario B1)*[5]. *According to all scenarios*, especially higher emissions scenarios, an increase in autumn temperatures is likely to contribute to a longer ecotourism season since higher temperatures will persist steadily until the cold winter.
Off-season and extreme weather and climatic phenomena [a, b, c, d]: *1. Off-season events* *a. Summer* *b. Spring* *c. Autumn* *2. Extreme events* *a. Abnormal heat in*	1. *Off-season phenomena.* Rising global temperatures and unstable climate lead to a complex set of impacts, including an increase in the frequency and intensity of extreme events. Global forecasts indicate an increase in the number of off-season and extreme weather and climate events. *a.* ***Summer***. Off-season weather and climate events in summer include, for example, off-season storms, rains, off-season hail, etc. It is assumed that their number and intensity will increase in the future *(all scenarios)* for higher emission scenarios. *b.* ***Spring.*** Off-season weather and climatic phenomena in spring include, for example, off-season storms, snow blockages, hail, etc. It is assumed that their number and intensity will increase in the future *(all scenarios)* at higher emission levels. *c.* ***Autumn.*** Off-season weather and climatic events in autumn include, for example, early snow blockages, off-season storms, hail, rains, etc. It is assumed that their number will increase in the future *(within all scenarios)* with an increase in the number of phenomena for higher emission scenarios. 2. ***Extreme events.*** Global forecasts indicate an increase in the number of off-season and extreme weather and climate events. Studies show that in all Central Asian countries, the average and seasonal temperature will constantly increase. An increase in average temperature means that more extreme events will occur, as well as climate warming; more frequent, extreme, and severe events may occur. **By 2050**, according to forecasts, the average annual temperature growth rate in Central Asia will be 2.9–5.5 °C *(WOM scenario)* or 1.9–3.3 °*C*

summer *b. Drought* *c. Storms, blizzards, and strong winds* *d. Heavy rain and hail* *e. Dust storms and sandstorms* *f. Floods (spring)* *g. Glacial Lake Outbursts (GLOs)*	*(low-emission scenario) relative* to 1961-1990. **By 2080**, it is expected to increase by 4-7.2 °C *(WOM scenario)* to 2.9–4 °*C (low-emission scenario)* relative to 1961-1990. In Central Asia, the average, maximum and minimum temperatures are expected to rise in all seasons [7]. *a.* *Abnormal heat in summer:* in Central Asia and Kazakhstan, there are trends associated with an increase in the frequency and intensity of cases of abnormal heat. Such trends will continue in the future *(all scenarios)*. The average maximum temperature in summer (daytime) is projected to increase by an average of 3.4–7.4 °C *(low and high emission scenarios)* in Central Asia **by 2050** relative to 1961-1990.[7] In Kazakhstan, **by 2030**, August and September are expected to be the months with the highest average annual increase of 1.8–2.1 °C *(scenarios A1B, A2, B1)*[4]. **By 2050**, the fastest rates of increase in Kazakhstan in summer (and winter) are expected at 2.1–3.2 °C *(scenarios A1B, A2, B1).* The higher the average annual (and seasonal) temperature, the more extreme is the nature of some phenomena, such as abnormal heat. Thus, higher emission scenarios correspond to hotter weather and the likelihood of more frequent and extreme cases of abnormal heat, in connection with which Kazakhstan will see a particularly strong impact in the summer months, especially in areas with hot summers. Severe cases of abnormal heat can have a dual effect on tourism: on the one hand, due to high temperatures, tourists can cancel trips to rest in hot areas outdoors, or, on the contrary, tourists will take the opportunity to avoid the heat in urban areas and go on vacation, for example, on weekends. It should be noted that most foreign ecotourists plan their holidays in advance and do not cancel trips regardless of the weather. *b.* *Drought.* The drought is expected to intensify in Central Asia and Kazakhstan in the future,[7] especially in areas with expected lower precipitation. *c.* *Storms, blizzards, and strong winds.* It is assumed that strong winds, blizzards, and snowstorms will become more common, although this should be further investigated [5]. Strong winds with a speed of 30 m/s or more, capable of damaging infrastructure, are also predicted for steppe territories, which may have consequences for eco-sites in these areas, in particular, in Korgalzhyn, Karkaraly, Shabanbai Bi, Balkashino and Kokshetau. These phenomena can cause damage to the infrastructure and lead to site closures during such an event, as well as for the period necessary for damage compensation. *d.* *Heavy rain, snow, and hail.* It is expected that the amount of precipitation (rain, snow) and hailstorms will increase under *all scenarios*. Extreme rains and hail are most likely to occur in winter in areas where precipitation is predicted to increase, since this factor, combined with high temperatures, leads to extreme precipitation, which has consequences for the eco-sites located in these areas, in particular, Altyn-Emel, Talgar, Sata and Dzungarian Alatau (as well as other eco-sites in Altai and Tien Shan mountains). Although no damage may occur directly during the tourist season, damage caused to the infrastructure during the off-season may lead to the need for repairs and interfere with tourist activities in the next season. *e.* *Dust storms and sandstorms.* The number of days with dust storms (because of increased aridity and hotter summers combined with the consequences of the Aral Sea disaster) has increased in the Aral Sea region [5] and is expected to increase with ongoing climate change. Dust

	storms and sandstorms are also expected to intensify in other regions. This may reduce the number of vacationers in the affected regions. *f.* *Floods (spring)*. It is predicted that spring floods will become more frequent and severe *(under all scenarios)*, especially in mountainous and foothill areas [5], which may have consequences for ecotourism in these areas, in particular, for the Ridder, Katon-Karagai, Dzungarian Alatau, Saty, Altyn-Emel, Talgar, Zhabagly, Tulkubas, Ugam eco-sites. However, the forecast may differ for watersheds based on glacier melting (predicted increase in the short- to medium term, and then decrease in the medium- and long-term periods) and precipitation forecasts (in many areas, a significant increase in precipitation is predicted in the future, *in all scenarios*, in particular, for the north and east of Kazakhstan, including the north-eastern Tien Shan and Altai, *according to all scenarios*). Extreme spring floods can also occur in steppe areas with more significant precipitation which may affect ecotourism in these areas, in particular, in Kokshetau, Balkashino, Korgalzhyn, Karkaraly and Shabanbai Bi. Floods can also cause flash floods and landslides. Although extreme spring floods are likely to occur at the beginning of the season or before the opening of the season, they can damage tourist infrastructure which will lead to damage and additional costs, as well as make it difficult to start the season. However, in the medium and long term, peak river flow and "spring thaw" are likely to shift from late spring/early summer to late winter/early spring due to flow from glaciers and a reduction in permanent snow cover [5]. Again, although this will happen in the off-season, the damage caused to the tourism and access infrastructure can be significant, requiring time to repair/rebuild, which undermines ecotourism. *g.* *Glacial Lake Outbursts (GLOs).* More frequent GLOs are predicted in Kazakhstan as a result of an increase in glacial flow and rapid filling of glacial lakes. This, in turn, can lead to mudslides and avalanches in mountainous areas. Cases of GLO during or outside the ecotourism season can cause casualties and completely destroy infrastructure, forests, and anything in its path. National parks and areas that will be closed due to GLO risks will lose revenue from ecotourism, which will affect all ecotourism activities.
Loss of biological diversity and ecosystem change (for example, loss of species at the local or regional level, changes in the distribution of species, changes in ecosystem characteristics) [a, d]: *1. Changes in bioclimatic zones* *2. Change*	1. *Changes in bioclimatic zones*. It is assumed that an increase in temperature will lead to the displacement of bioclimatic zones and long-term shifts and changes that radically undermine the landscape or ecosystem. According to forecasts, Kazakhstan will experience rapid and significant changes in bioclimatic zones **by 2050** *(all scenarios)*. **In 2000**, most of Northern Kazakhstan was classified as "cool and dry", and some mountainous areas (the Altai Mountains, Dzungarian Alatau, Northeastern Tien Shan) were classified as "cold and humid" and "extremely cold and humid". The central and southern parts of Kazakhstan are mainly described to be "cool and arid", and the upper part of southern Kazakhstan is included in the "moderately warm and moderately humid" zone. **By 2050**, according to forecasts, the "moderately warm and moderately humid" zone will expand to the northwest and east and will also capture the southwestern corner of Kazakhstan *(scenario RCP 4.5)* and will significantly expand further to the north, west and east of the central part of Kazakhstan, as well as to the north covering the Caspian coastline. At the same time, the central part of the south will switch to a "moderately warm and arid" climate *(scenario RCP 8.5)*. The "cool and arid" belt of Northern Kazakhstan is projected to shrink to a narrow line running in a southeasterly direction from the northern part of the center towards the Altai Mountains *(RCP 4.5 and 8.5)*. **By 2050**, a slight reduction in "extremely cold and humid" zones in mountainous and foothill areas in the east and southeast is expected *(RCP 4.5 and 8.5)*. Ecosystems (see point 2) currently located on the edges of various zones are likely to be affected by the rapid pace of these changes, which may affect ecotourism in these areas, in particular, in Kokshetau, Balkashino, Korgalzhyn, Karkaraly and

in distribution of ecosystems, species, and loss of biological diversity *3. Change in timing of natural phenomena*	Shabanbai Bi. These shifts can lead to changes in the characteristics of natural objects and ecosystems visited by eco-tourists: sites can change and look different, and their natural beauty may be preserved or damaged as a result of changes, they may even lose their special value. Changes in bioclimatic zones are also likely to be accompanied by reducing biodiversity. Thus, a change in bioclimatic zones can, at least, modify ecotourism, and, at most, cause damage to it. 2. *Shifting ecosystems, changing species ranges and loss of biological diversity.* *a. Ecosystem shift.* As indicated above (paragraph 1), the shift of ecosystems will be caused by changes in temperature changes and bioclimatic zones *(all scenarios)*, with higher emission scenarios leading to faster and more radical changes. Studies on the changes in the Altai Mountains caused by climatic consequences indicate drastic changes, as alpine meadows are replaced by steppe and forests, and mountain tundra are replaced by alpine and alpine meadows. Similar changes are likely to occur in other mountain ecosystems, while ecological zones usually move upwards, which impacts eco-sites in mountainous and foothill areas, such as Ridder, Katon-Karagai, Dzungarian Alatau, Saty, Talgar, Altyn-Emel, Zhabagly, Tulkubas, Ugam. Changes in the ecosystem zone are also likely to be accompanied by reducing biodiversity. The shifts are likely to lead to degradation and changes in ecosystems, as a result at least part of their natural beauty and value may be lost. *b. Shifting ranges of species and loss of biological diversity.* As in the case of shifting ecosystems, changing natural conditions in specific areas leads to shifts in the distribution ranges of flora and fauna. Studies show that the global average shift towards the poles (or upwards) of land species communities is about 6.1 km over ten years. Some species, such as mobile animals, will be able to adapt to changes, leaving the former range in order to find more suitable habitats (if any), but others, especially slow-growing plants, will not be able to keep up with the pace of change and will suffer, may be exterminated, or will have to compete with invasive species moving to their territory from other places. The impact of climate change will also affect migratory species. *c. Change in the timing of natural phenomena*. Temperature is a key factor for the natural life cycle of many species of flora and fauna, and an increase in global temperatures will significantly affect the shift in the timing of natural phenomena. Studies have shown a trend towards early spring and summer events, including the breeding of frogs, nesting of birds, emerging leaves, and flowering of trees, as well as the arrival of migrating birds and butterflies. Anecdotal evidence suggests that trees bloom earlier in the mountainous regions of southern Kazakhstan. These changes can have a serious impact for the health and sustainability of local ecosystems. Changes in the timing of natural phenomena can easily disrupt ecotourism plans, especially during the period when ecotourism operators learn about what is happening and adapt their calendars.
Risk tick infestation [a, b, d]: 1. Disease-carrying tick infestation	1. *Disease-carrying tick infestation.* In Kazakhstan, *ixodid* ticks are carriers of the tick-borne encephalitis virus. Environmental changes impact changes in natural habitats of animals, including ticks, and *ixodid* ticks, as it turned out, move north in response to climate change, which can lead to disruption of the ecotourism season.

[a] Affects the number and duration of tourist trips during the season and/or contributes to a gradual change in the period of the tourist season

[b] May lead to cancellation/closure or disruption of tourist activities

[c] May damage the infrastructure /access

[d] May lead to the loss of tourist sites/reasons to visit

Figure 2. *Probable change in the average air temperature and precipitation in the* ***winter*** *season under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

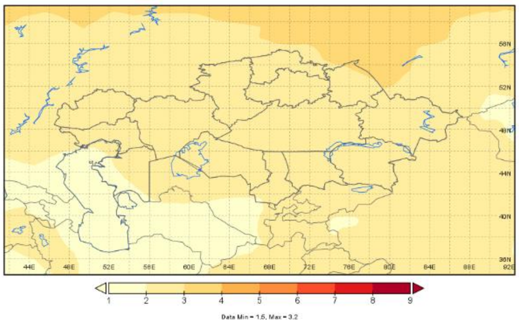
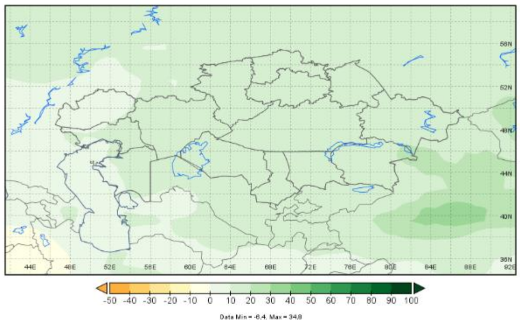
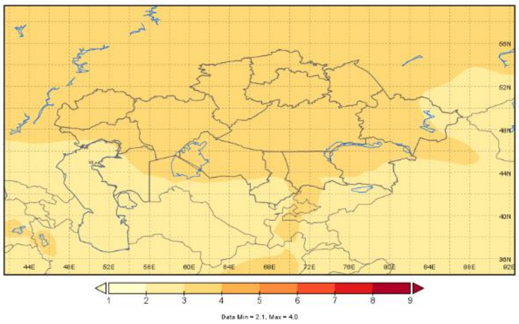
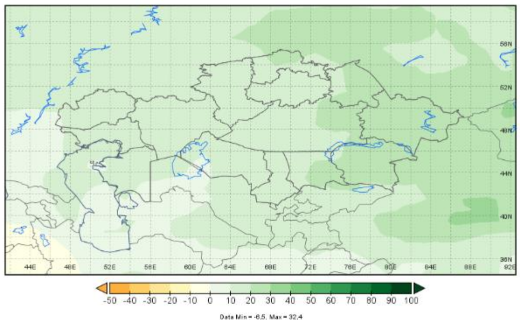
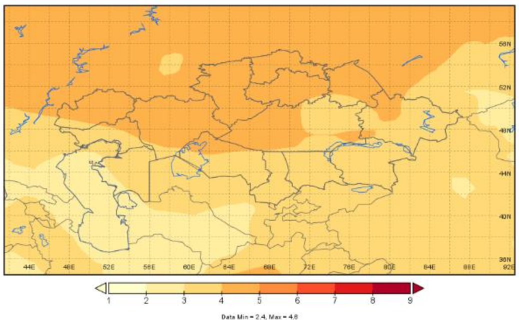
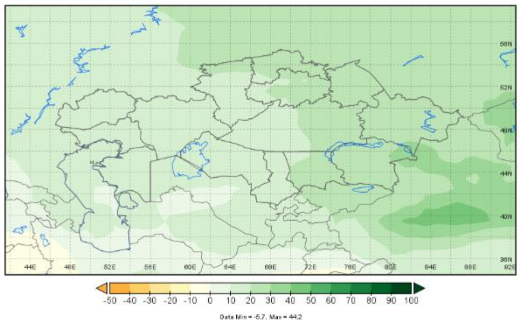
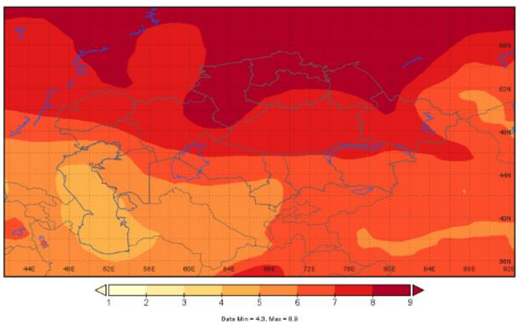
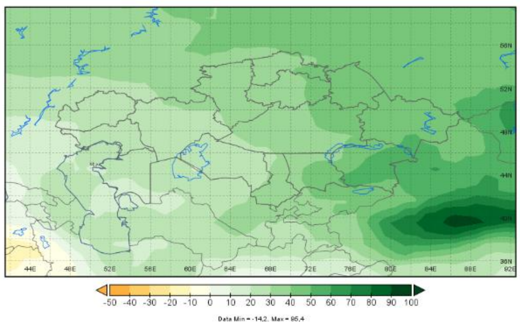
Changes in air temperature (°C) and precipitation (%)		
	Temperature	Precipitation
2041-2060		
SSP2-4.5		
SSP5-8.5		
2081-2100		
SSP2-4.5		
SSP5-8.5		

Figure 3. *Probable change in the average air temperature and precipitation in the* ***spring*** *season under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

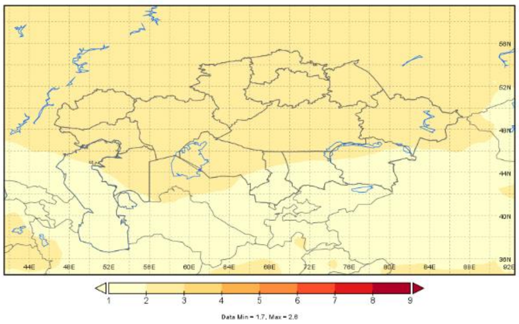
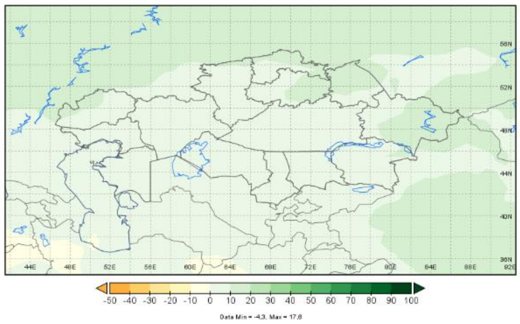
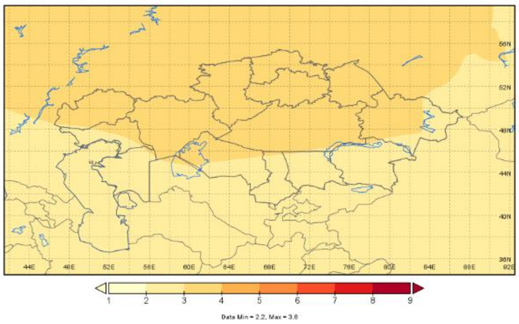
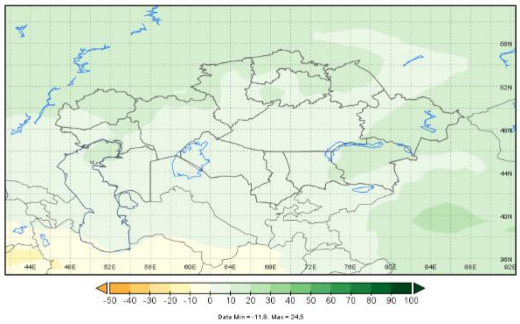
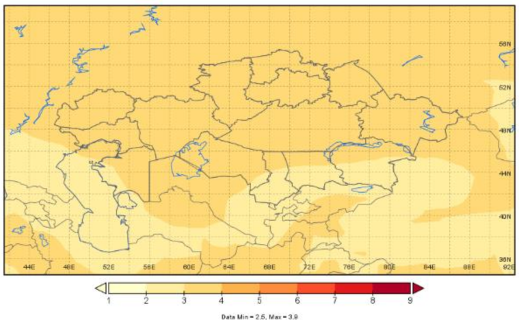
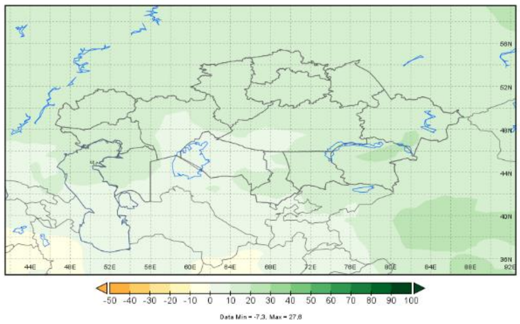
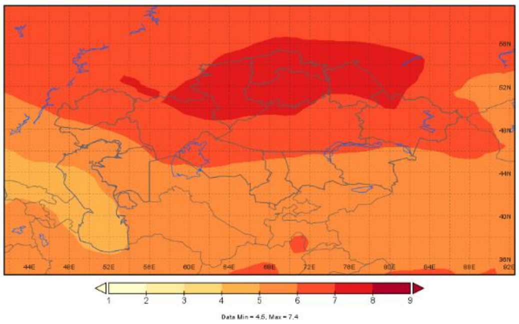
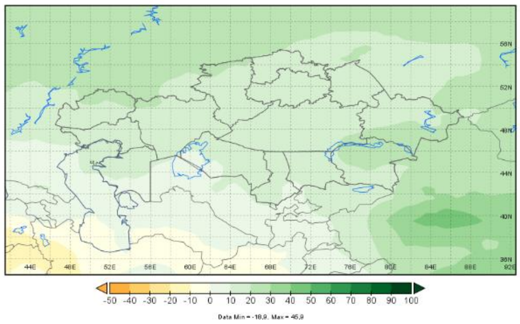
Changes in air temperature (°C) and precipitation (%)		
	Temperature	Precipitation
2041-2060		
SSP2-4.5		
SSP5-8.5		
2081-2100		
SSP2-4.5		
SSP5-8.5		

Figure 4. *Probable change in the average air temperature and precipitation in the* ***summer*** *season under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

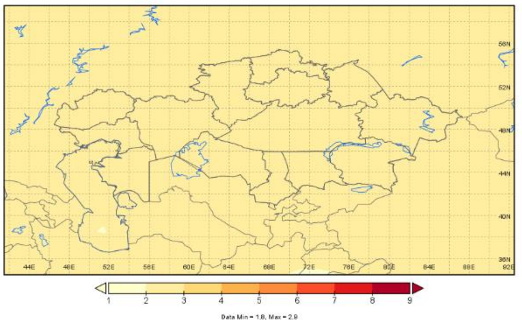
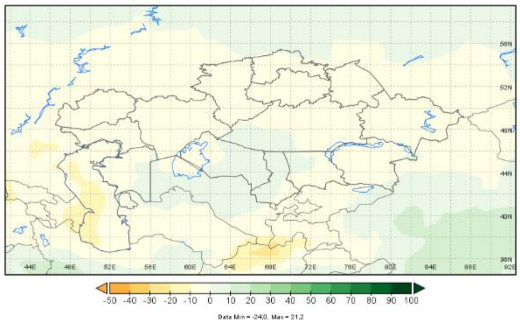
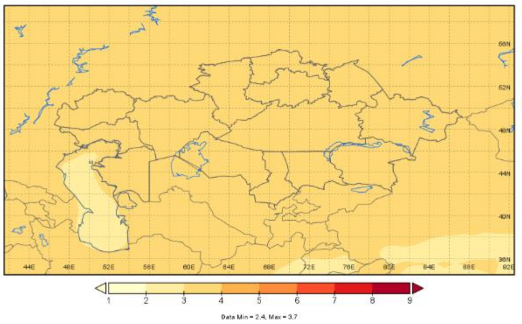
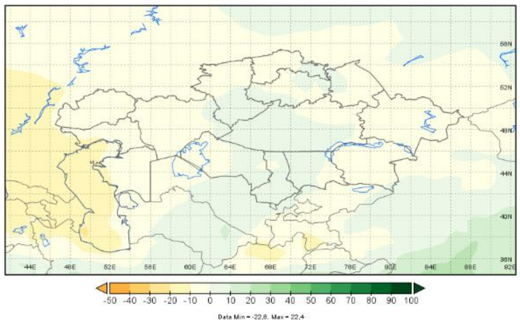
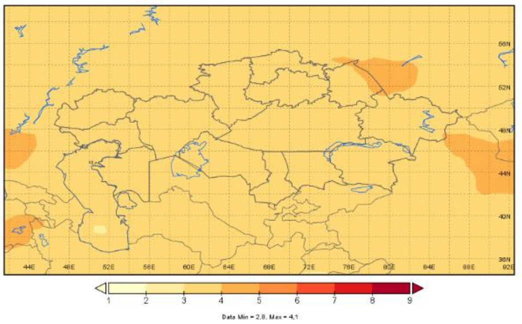
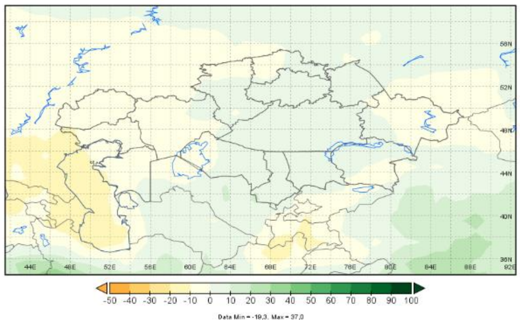
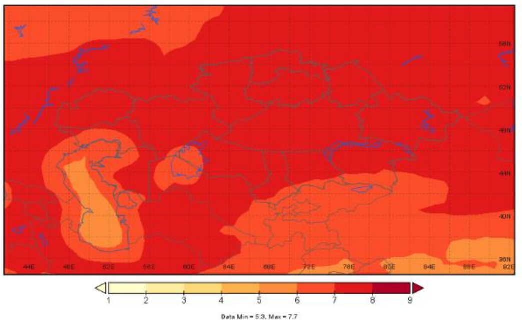
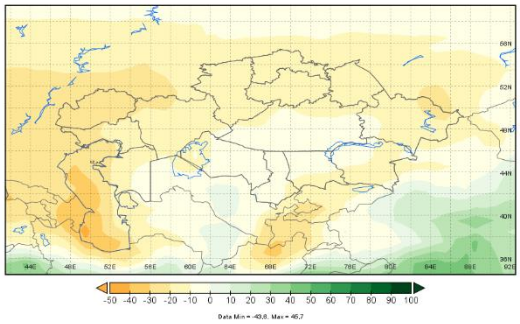
Changes in air temperature (°C) and precipitation (%)		
	Temperature	Precipitation
2041-2060		
SSP2-4.5		
SSP5-8.5		
2081-2100		
SSP2-4.5		
SSP5-8.5		

Figure 5. *Probable change in the average air temperature and precipitation in the* ***autumn*** *season under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

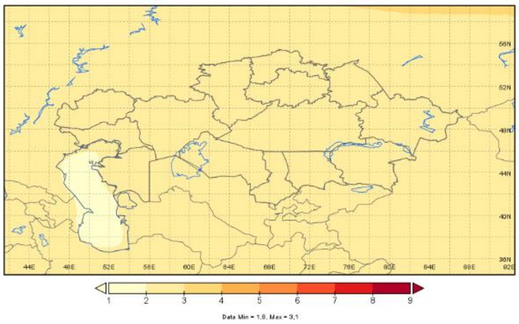
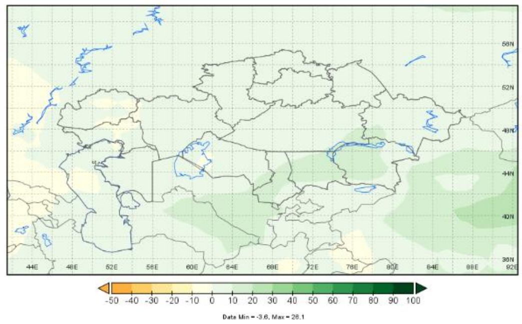
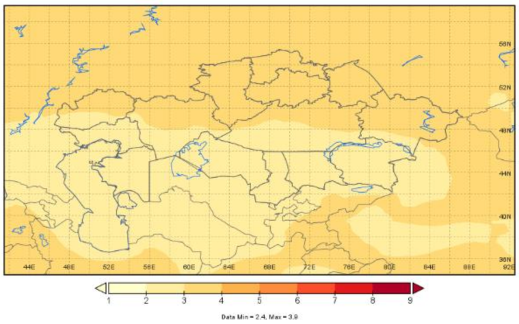
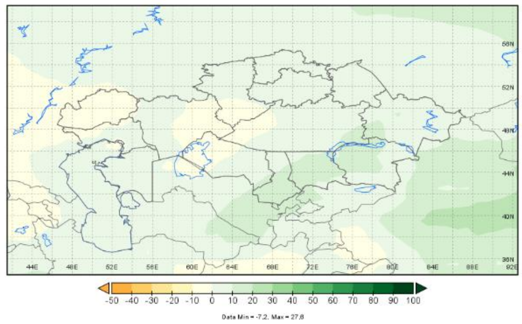
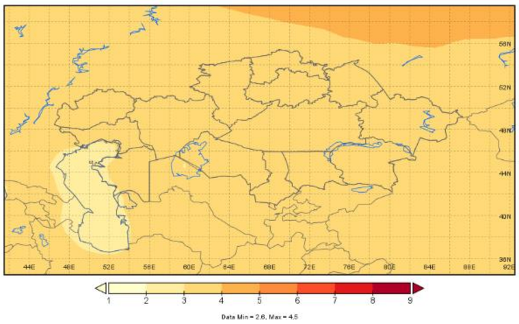
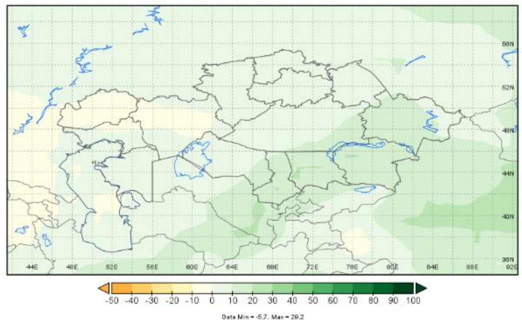
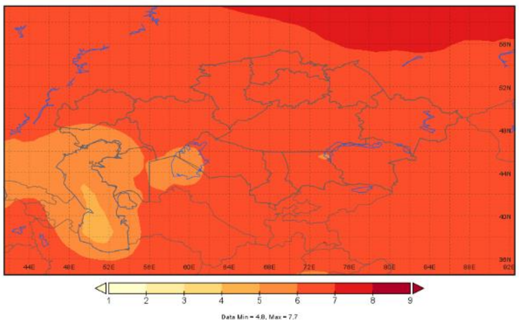
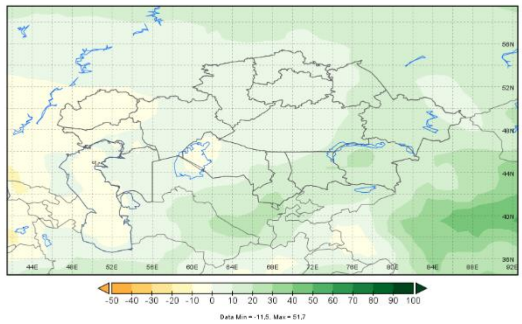
Changes in air temperature (°C) and precipitation (%)		
	Temperature	Precipitation
2041-2060		
SSP2-4.5		
SSP5-8.5		
2081-2100		
SSP2-4.5		
SSP5-8.5		

Figure 6. *Probable change in the number of days with temperatures above 40 ℃ (SU40 index, days) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

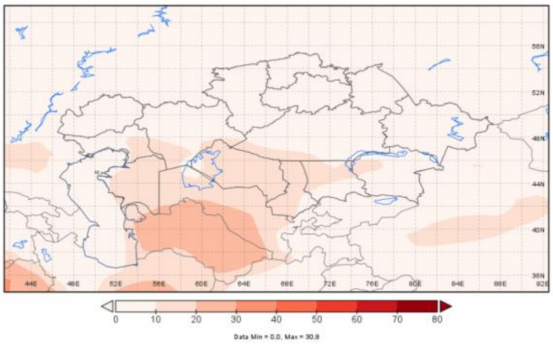
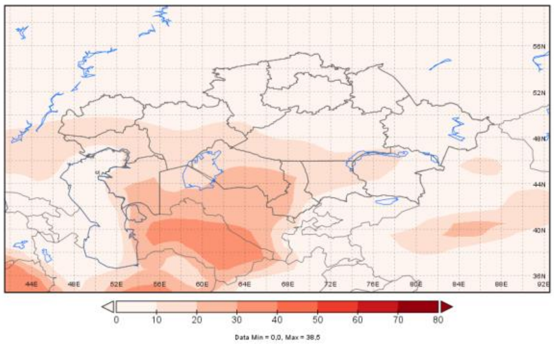
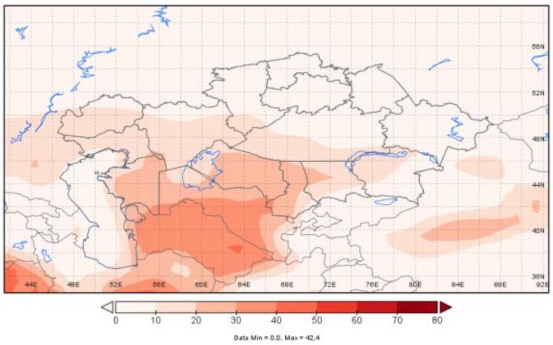
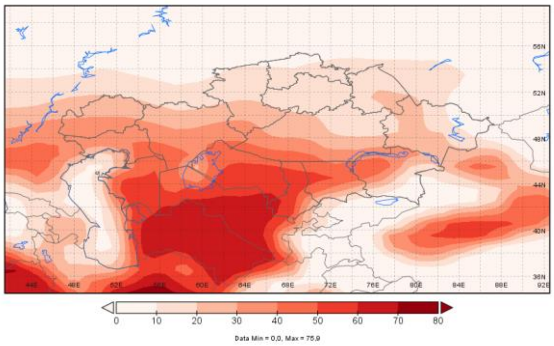
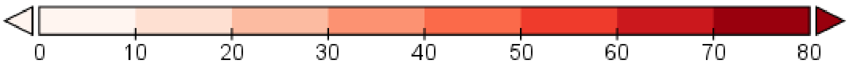
SSP2-4.5	SSP5-8.5
2041-2060	
	
2081-2100	
	
	

Figure 7. *Probable change in the values of absolute maxima of air temperature (index TXx, ℃) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

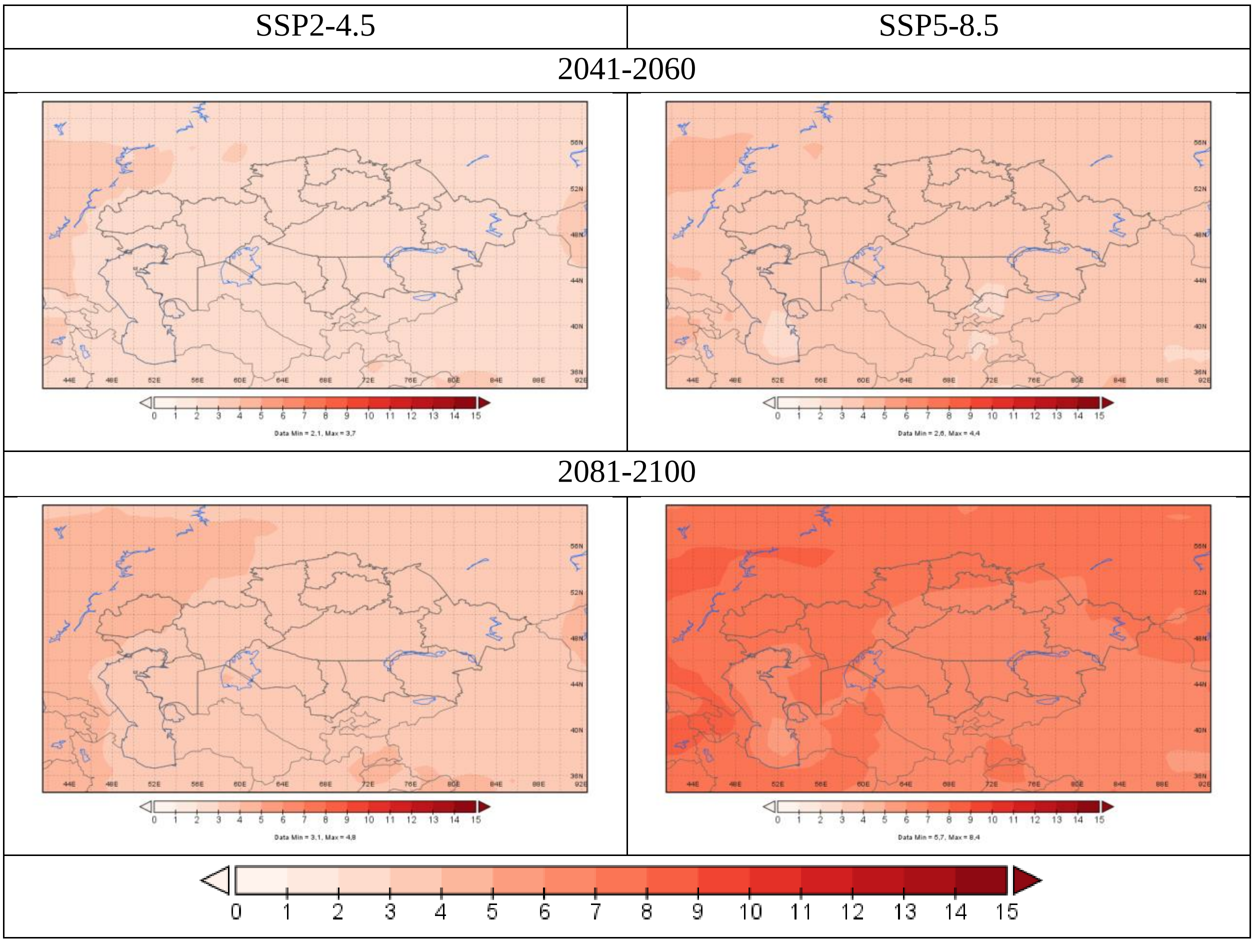


Figure 8. The probable change in the values of absolute minima of air temperature (TNn index, °C) under the SSP2 4.5 and SSP5 8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.

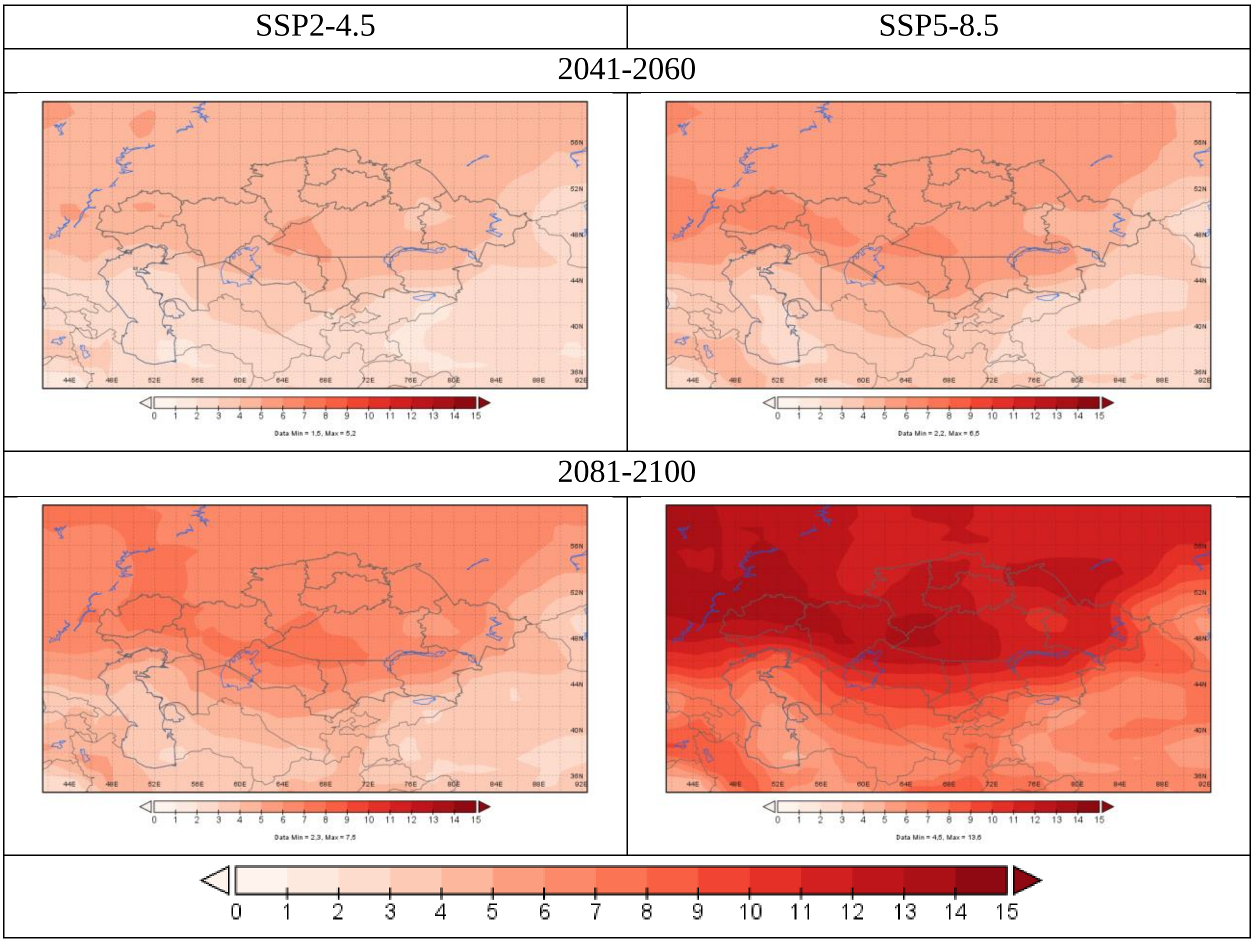


Figure 9. *Probable change in the need for indoor air conditioning (CDDcold index, degree-days) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

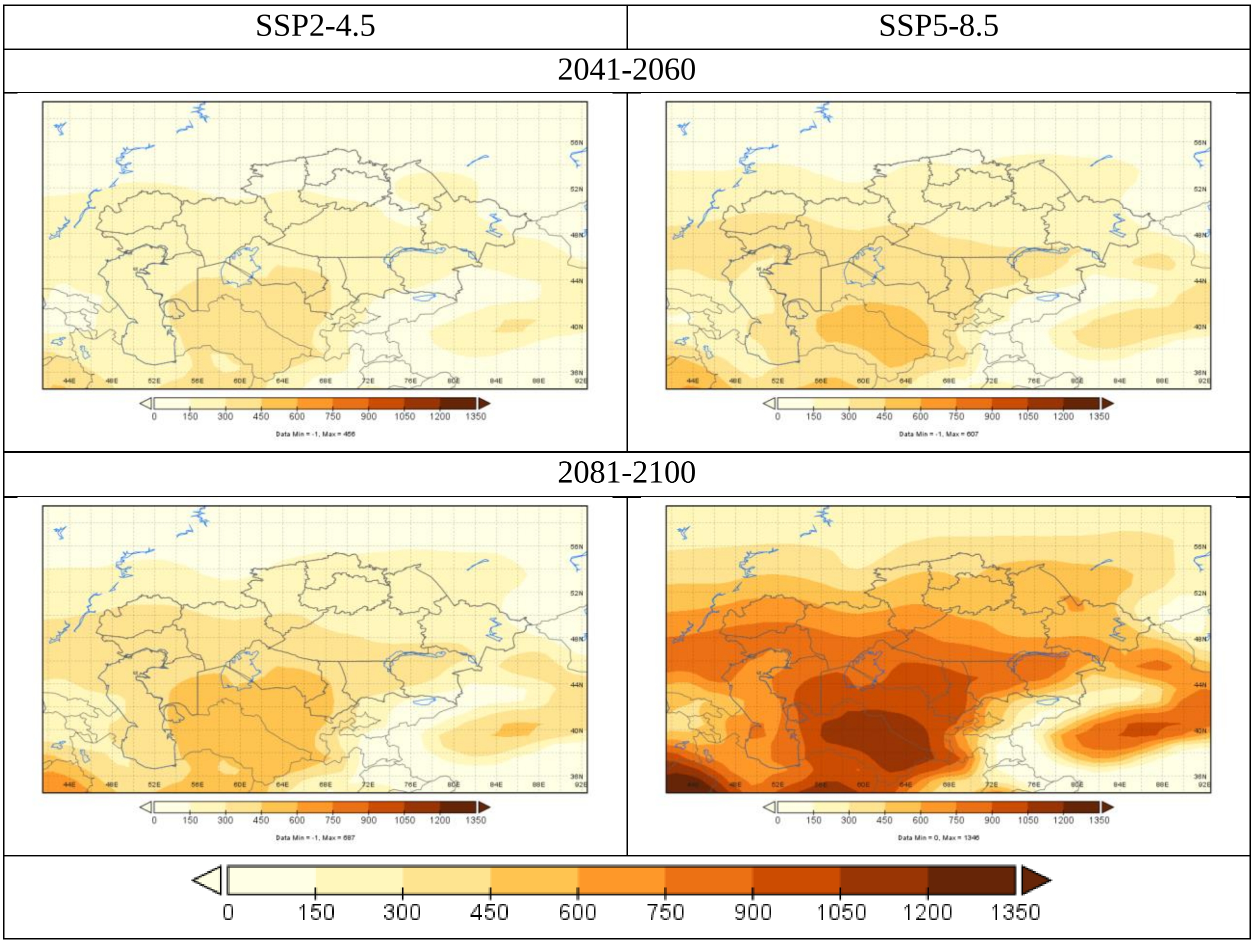


Figure 10. *The probable change in the number of days with frost, when the daily minimum temperature drops below 0 ℃ (index FD0, days) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

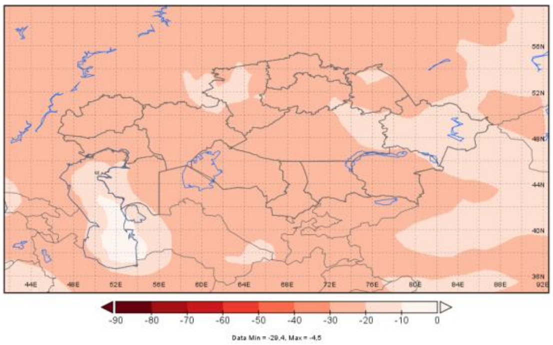
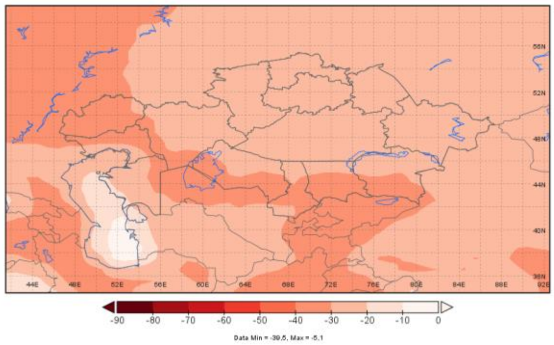
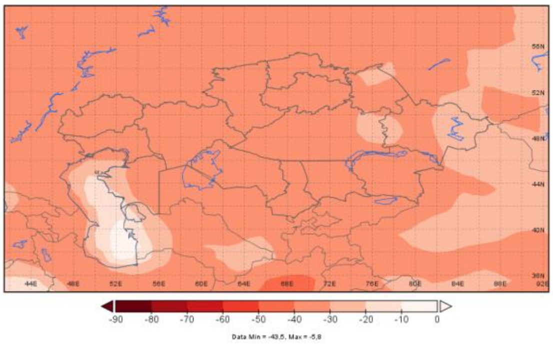
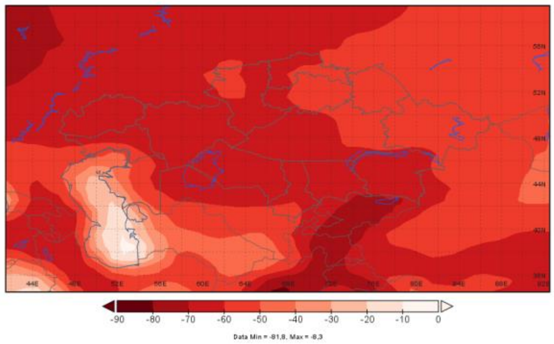
<table>
<tr><td>SSP2-4.5</td><td>SSP5-8.5</td></tr>
<tr><td colspan="2">2041-2060</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">2081-2100</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">
</td></tr>
</table>

Figure 11. *The probable change in the need for indoor heating (HDDheat index, degree-days) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

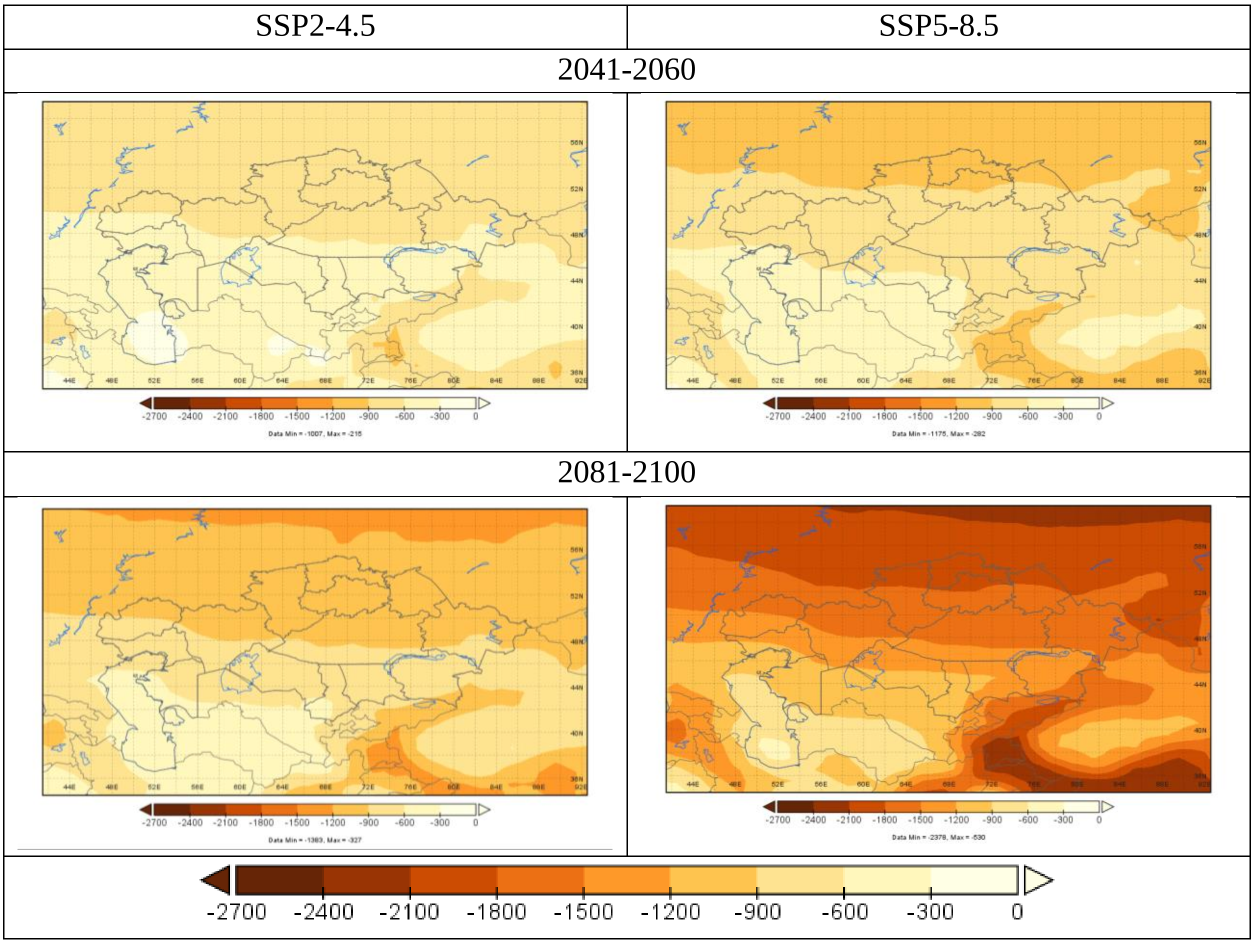
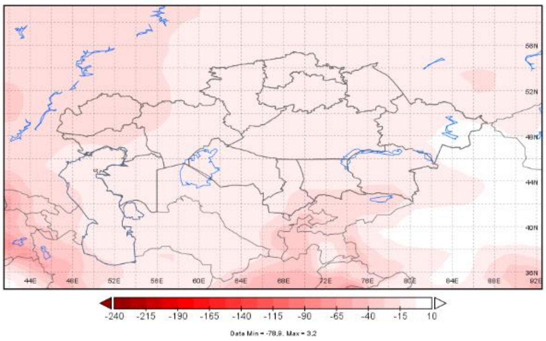
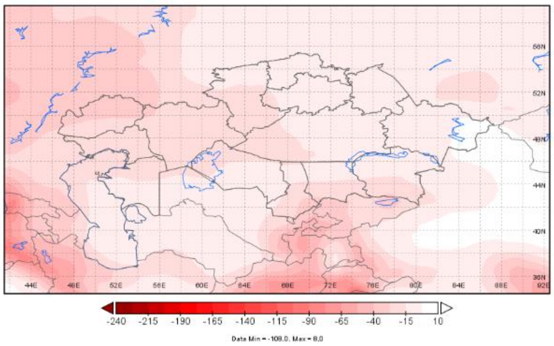
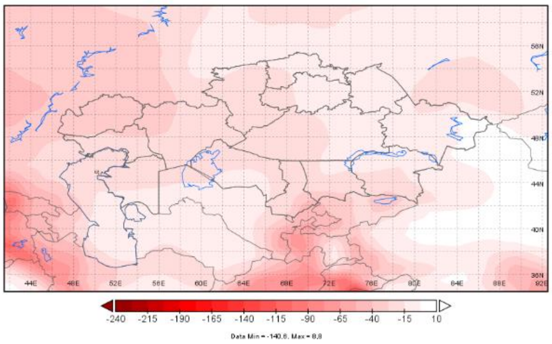
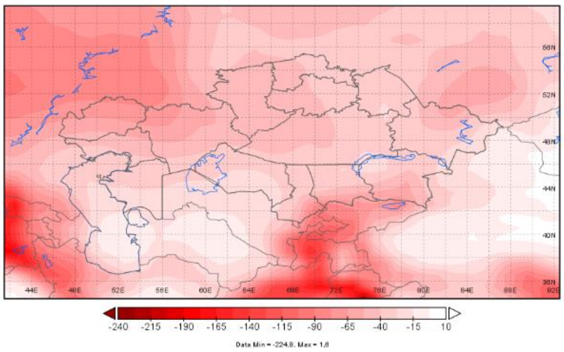


Figure 12. *The probable change in the amount of precipitation falling in the form of snow (in mm) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

SSP2-4.5	SSP5-8.5
2041-2060	
	
2081-2100	
	

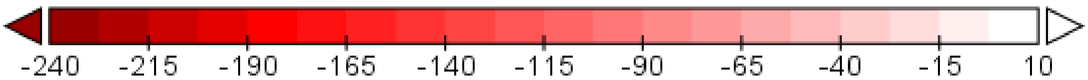


Figure 13. *The probable change in the daily maximum precipitation (index R ×1day, in %) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

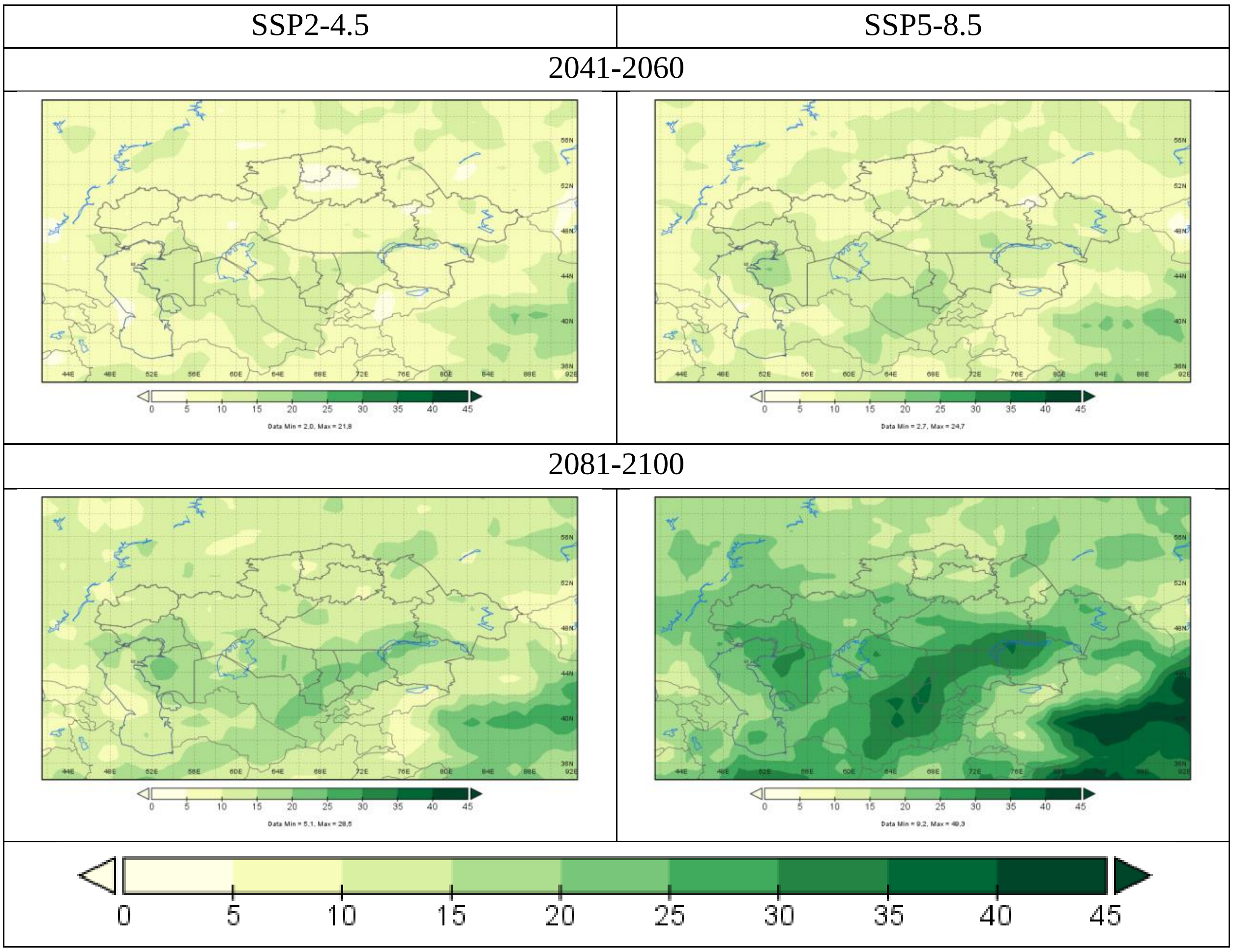
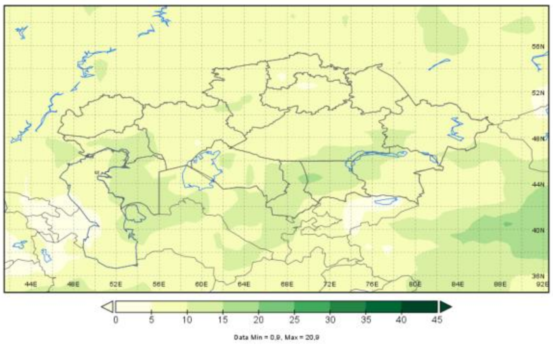
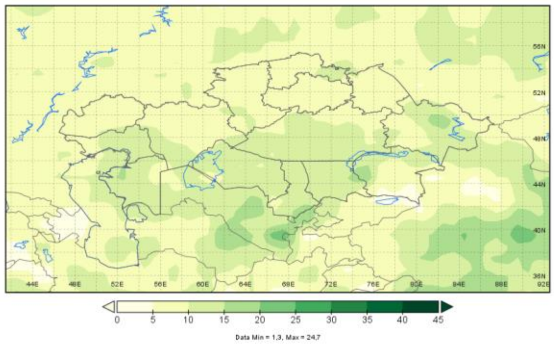
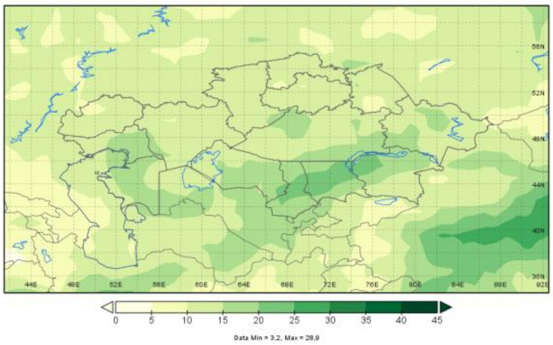
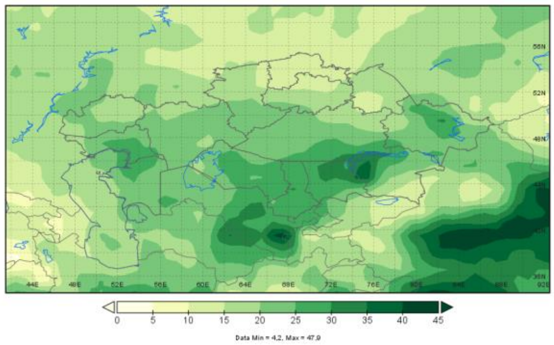


Figure 14. *The probable change in the maximum amount of precipitation for consecutive 5 days (R ×5day index, in %) under the SSP2 -4.5 and SSP5 -8.5 scenarios of change in GHG concentration. The changes are calculated relative to the period between 1986-2005.*

<table>
<tr><td>SSP2-4.5</td><td>SSP5-8.5</td></tr>
<tr><td colspan="2">2041-2060</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">2081-2100</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">
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</table>

Annex 3

Table 1. *Probable changes in annual and seasonal air temperature on the territory of Kazakhstan in the 2030s, 2050s, 2070s and 2090s relative to the base period of 1980-1999 for two scenarios for the Ile-Balkash basin*

Scenario	Season				Year
	winter	spring	summer	autumn	
	2020-2039				
RCP 4.5	1.7	1.6	1.8	1.6	1.7
RCP 8.5	2.0	1.9	1.9	1.8	1.9
	2040-2059				
RCP 4.5	2.4	2.6	2.6	2.2	2.4
RCP 8.5	3.0	3.1	3.2	2.9	3.1
	2060-2079				
RCP 4.5	3.2	3.0	3.1	2.6	3.0
RCP 8.5	4.8	4.4	4.8	4.3	4.6
	2080-2099				
RCP 4.5	3.5	3.3	3.2	2.9	3.2
RCP 8.5	6.4	5.8	6.1	5.6	6.0

Table 2. *Probable changes in annual and seasonal precipitation (%) on the territory of Kazakhstan in the 2030s, 2050s, 2070s, and 2090s relative to the base period of 1980-1999 for two scenarios for the Ile-Balkash basin*

Scenario	Season				Year
	winter	spring	summer	autumn	
	2020-2039				
RCP 4.5	12.5±5.75	9.59±7.96	6.96±12.11	5.81±7.21	8.37±21.69
RCP 8.5	9.47	6.04	4.40	0.76	4.94
	2040-2059				
RCP 4.5	15.81	10.82	5.33	7.53	9.26
RCP 8.5	14.28	9.77	-0.43	2.76	5.98
	2060-2079				
RCP 4.5	20.91	16.58	8.51	7.71	12.7
RCP 8.5	22.06	13.54	-1.88	2.75	8.2
	2080-2099				
RCP 4.5	21.85	17.91	7.99	7.50	13.21
RCP 8.5	32.68	17.69	-2.07	4.76	11.77

Table 3. *Probable changes in the annual and seasonal air temperature on the IBB (Ile-Balkash basin) territory under the RCP 4.5 and RCP 8.5 scenarios of change in GHG concentration for the Ile-Balkash basin*

Scenario	Season				Year
	winter	spring	summer	autumn	
	2020-2039				
RCP 4.5	1.7	1.5	1.7	1.7	1.7

RCP 8.5	1.8	1.7	1.9	1.8	1.8
	2040-2059				
RCP 4.5	2.3	2.3	2.7	2.4	2.4
RCP 8.5	2.0	2.0	3.9	2.0	2.5
	2060-2079				
RCP 4.5	3.3	2.9	3.6	3.2	3.2
RCP 8.5	4.5	3.4	4.6	4.3	4.2
	2080-2099				
RCP 4.5	3.5	2.8	3.4	3.0	3.2
RCP 8.5	5.2	5.2	6.3	5.6	5.6

Table 4. *Probable changes in annual and seasonal precipitation amounts (%) on the territory of the basin under the RCP 4.5 and RCP 8.5 scenarios of change in GHG concentration for the Ile-Balkash basin*

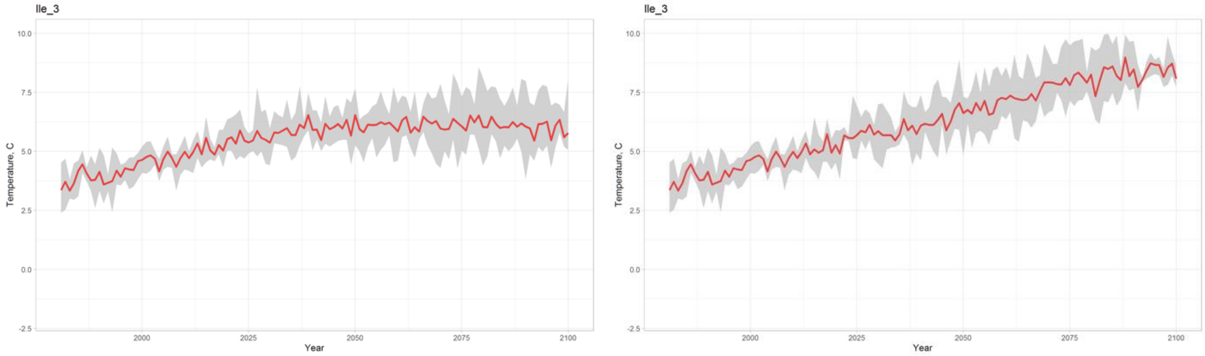
Scenario	Season				Year
	winter	spring	summer	autumn	
	2020-2039				
RCP 4.5	13	11	8	9	10
RCP 8.5	15	11	7	8	10
	2040-2059				
RCP 4.5	21	14	9	10	14
RCP 8.5	22	15	-2	9	11
	2060-2079				
RCP 4.5	33	17	10	13	16
RCP 8.5	33	17	-2	8	14
	2080-2099				
RCP 4.5	36	21	8	11	19
RCP 8.5	43	24	-3	9	18

Table 5. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for ssp 126 and ssp 370 scenarios of the Balkash-Alakol basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370
The average increase is from 1.2 to 3-4^0 C, depending on the model and period.	A more rapid increase in temperature to 5-6 ^{0} C.	Changes from small negative values to +15-20% depending on the period and station. Seasonal precipitation: the increase is mainly in the winter and spring months; some summer periods do not change or have negative values.		No changes in flow have been detected, an increase of 1% is expected by the end of the century.	Unchanged in 2016-2045, 3% - 2036-2065 and 6% - 2071-2100.

* To calculate the change in average annual water consumption, the following rivers were selected: Ile River (Dobyn village), Sharyn River (Sarytogai tract). The flow change in three selected climatic periods was compared to the base period (1981-2010).

Figure 1. *Average annual temperature change until the end of the century based on 5 climate models for ssp126 (a) and ssp370 (b) scenarios of the Balkash-Alakol basin*



a) ssp126 scenario *b) ssp370 scenario*

The increase in flow by the end of the century (Figure 2.3) can be explained by the possible degradation of glaciers.

Figure 2. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 126 scenario of the Balkash-Alakol Basin*

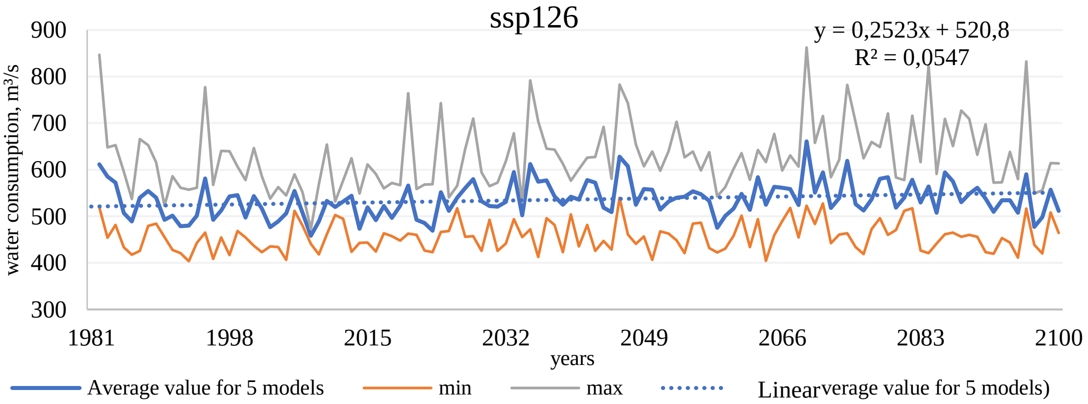


Figure 3. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 370 scenario of the Balkash-Alakol Basin*

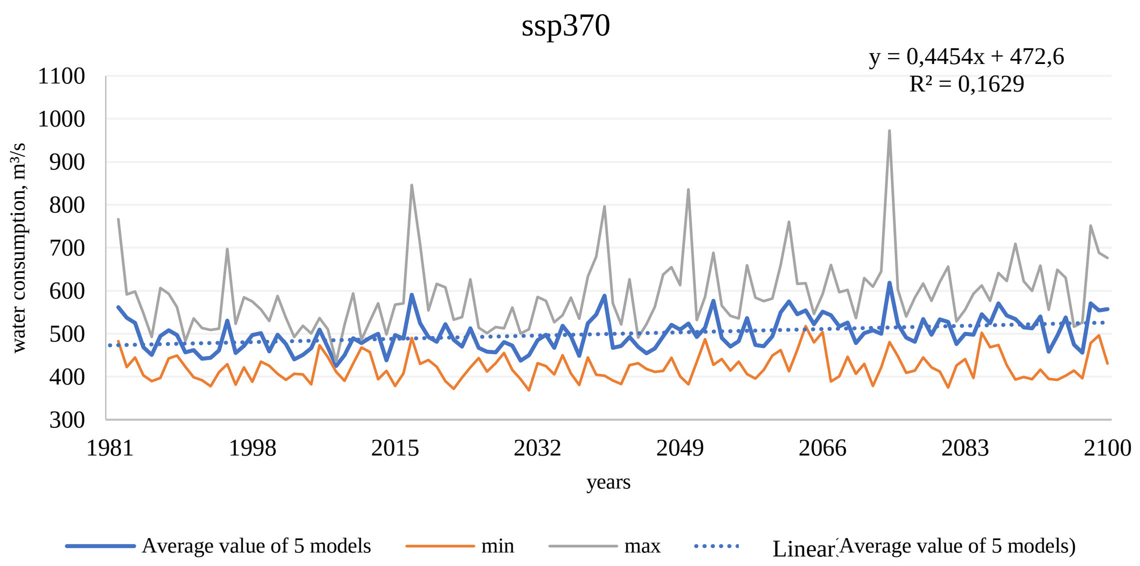
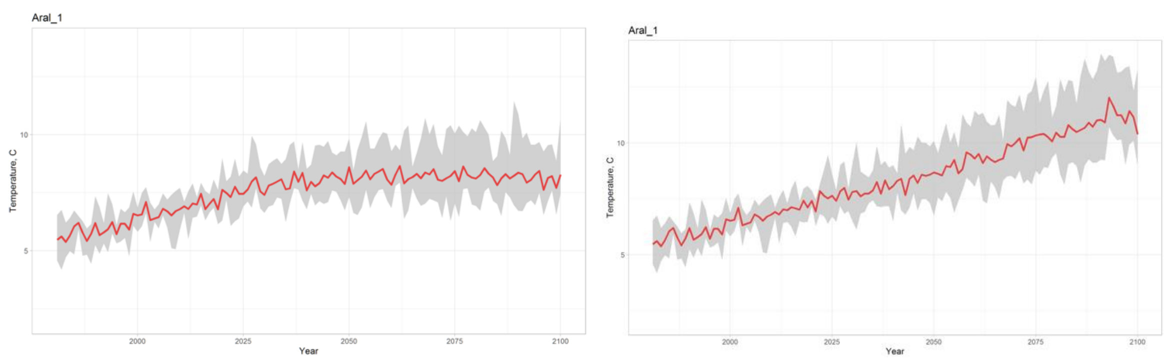


Table 6. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Aral-Syrdarya Basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370
The temperature rises in all months for both scenarios and future periods.		A slight decrease in precipitation from July to October for some periods, there is a slight increase in the remaining months, which can reach 20% in the winter months. The level of uncertainty of models is increasing till the end of the century.		For all periods, an increase in flow by 10% (2016-2045), for other periods, a decrease in flow: by 3% in 2036-2065 and 15% in 2071-2100.	The following changes in the flow: 2016-2045 – 6% increase, 2036-2065 - 1% and 2071-2100 - 12% decrease.

*A tributary of the Syrdarya River, the Arys River, was selected to identify changes in average annual water consumption. The flow change in three selected climatic periods was compared to the base period.

Figure 4. *Average annual temperature change until the end of the century based on 5 climate models for ssp 126 (a) and ssp 370 (b) scenarios of the Aral-Syrdarya Basin*



a) ssp 126 scenario b) *ssp 370 scenario*

Figures 5, 6 show annual fluctuations in flow associated with the melting of glaciers which leads to an increased flow in the first period and depletion of glaciers in the second and third periods and, accordingly, results in flow decrease.

Figure 5. *Change in average annual water consumption by the end of the century based on 5 climate models for the SSP126 scenario for the Aral-Syrdarya Basin*

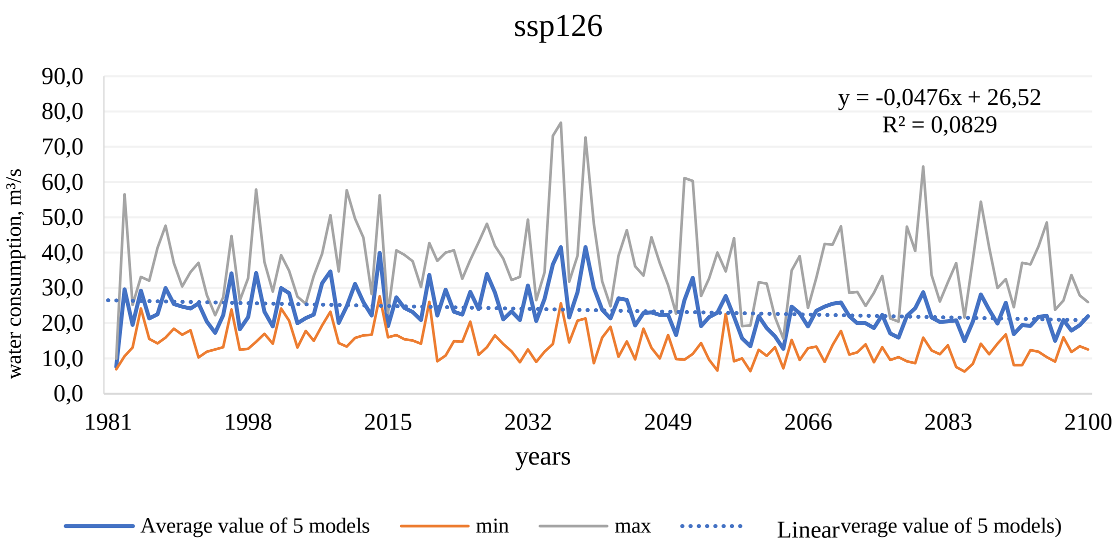


Figure 6. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 370 scenario of the Aral-Syrdarya Basin*

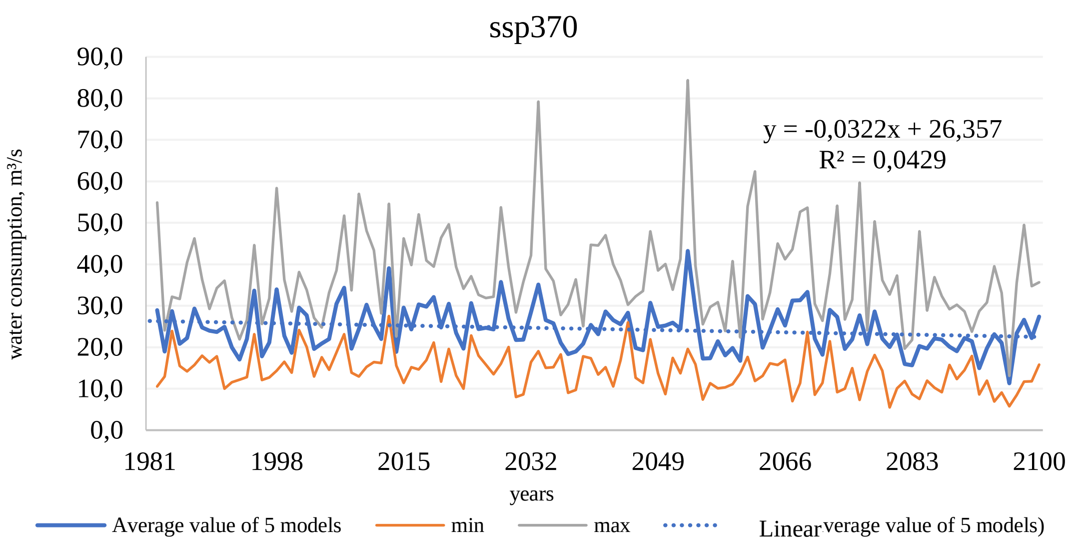


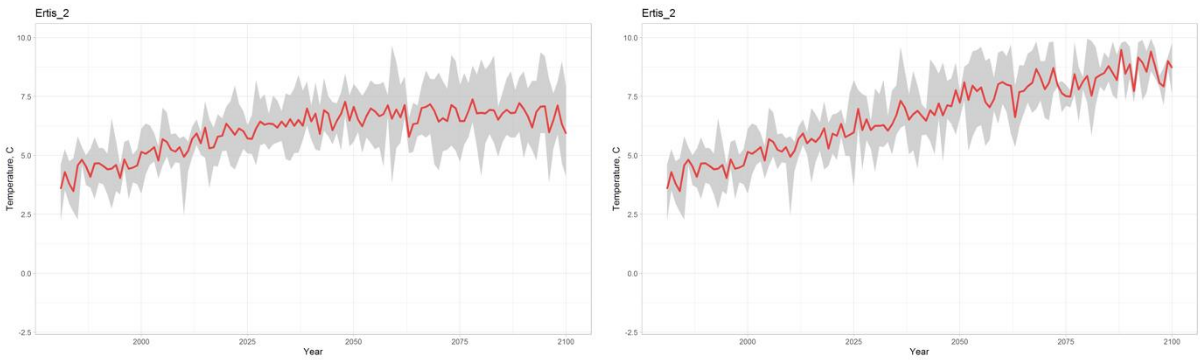
Table 7. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Yertis basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370

Temperature increase from 1.2 to 2.2 ^{0} C	Increase to 5.5 ^{0} C. Seasonal dynamics - temperature increase for all months.	Annual precipitation for most future periods and scenarios has a slight positive trend.	Flow changes averaged an increase of 7% in 2016-2045, as well as a decrease of 3% in 2036-2065 and 4% in 2071-2100.	An increase in flow of 6% in 2016-2045, as well as a reduction of 5% in 2036-2065 and 6% in 2071-2100.

*To identify changes in the average annual water consumption in the Yertis basin, the following rivers were selected: the Yertis River (Boran village), the Buktyrma River (Lesnaya village), the Oba River (Shemonaiha village), and the Ulbi River (Ulbi Transshipment village). The flow change in three selected climatic periods was compared with changes in the base period.

Figure 7. *The change in the average annual temperature until the end of the century based on 5 climate models for ssp 126 (a) and ssp 370 (b) scenarios of the Yertis basin.*



a) ssp126 scenario *b) ssp370 scenario*

The graphs below (Fig.8, 9) show annual fluctuations in flow which are also associated with the melting of glaciers and their subsequent degradation.

Figure 8. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 126 scenario of the Yertis Basin*

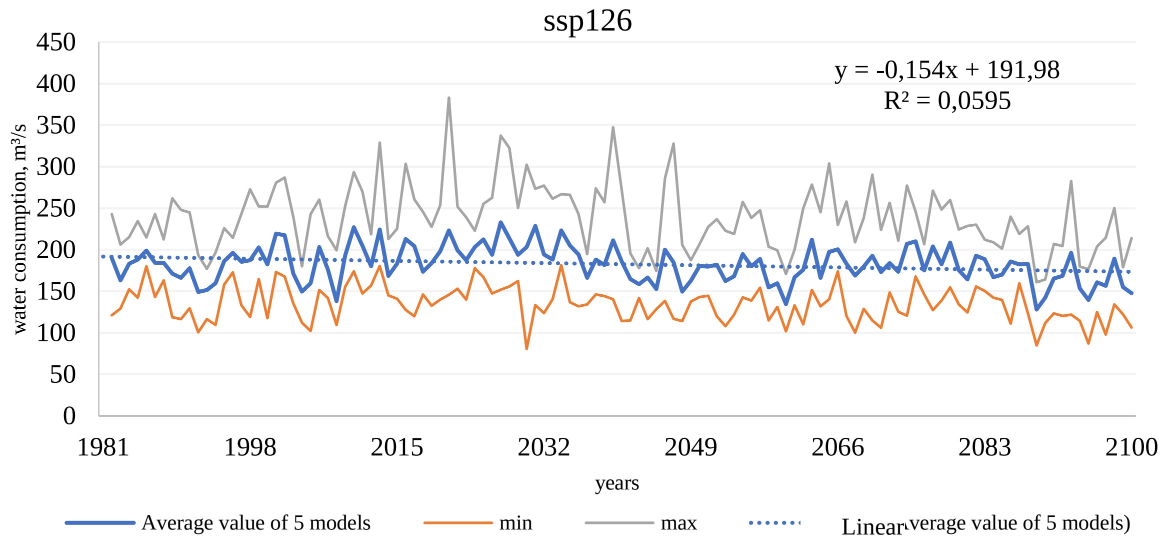


Figure 9. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 370 scenario of the Yertis Basin*)

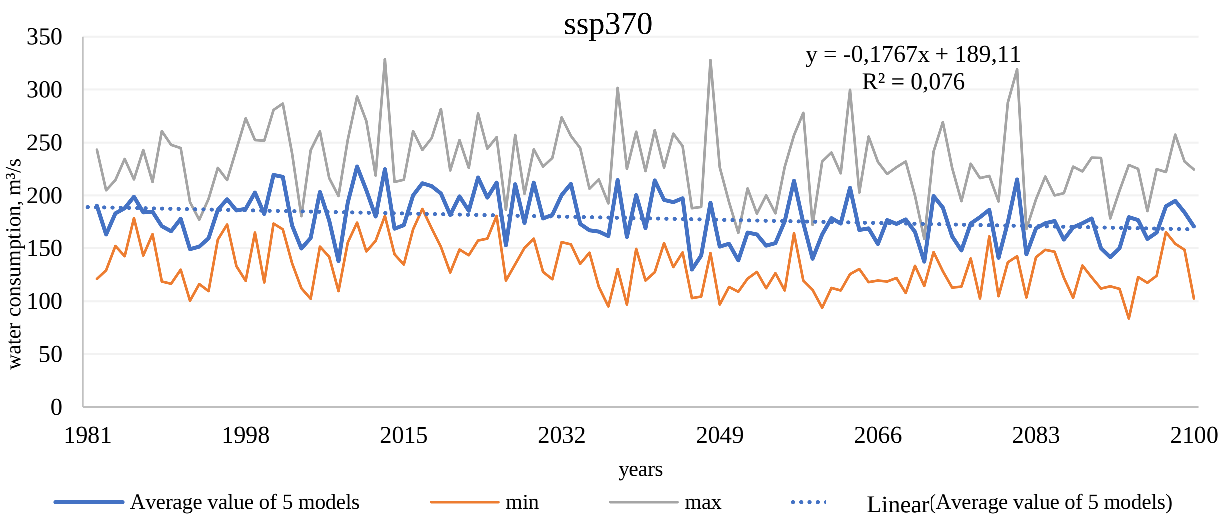
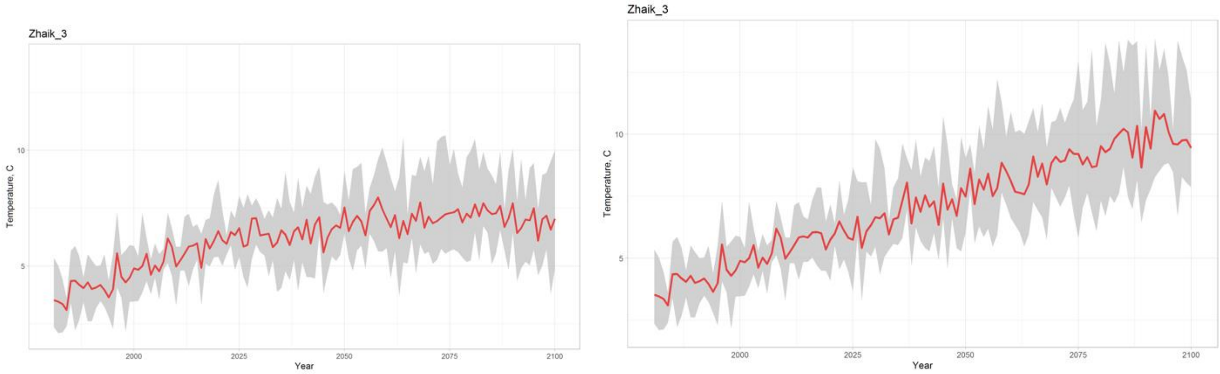


Table 8. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Zhaik-Caspian Basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370
Increase on average from 1.2 to 3-4 ^{0} C, depending on the model, until the end of the century.	A more rapid increase to 6 ^{0} C.	Intra-annual precipitation has minor or negative changes from April to October, in some periods to November. There is an increase in precipitation in the remaining months.		The change in flow is decreasing for all periods. In 2016-2045 - by 5%, by 10% in 2036-2065 and by 8% in 2071-2100.	Changes in flow by 6% in 2016-2045, 8% in 2036-2065 and 12% in 2071-2100.

*To identify changes in the average annual water consumption of the basin in question, the Zhaiyk river was selected (Yanvartsevo village).

Figure 10. *Average annual temperature change until the end of the century based on 5 climate models for SSP126 (a) and ssp370 (b) scenarios of the Zhaik-Caspian basin*



a) ssp126 scenario *b) ssp370 scenario*

The graphs (Fig. 11, 12) show annual fluctuations in flow. Intra-annual precipitation decreases in the autumn period result in a shortage of soil moisture. Thus, during snowmelt, most of the water supply from snow goes into the soil, which in turn leads to a decrease in flow. An increase in temperature and intense evaporation also affect the reduction of flow in the basin.

Figure 11. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp126 scenario of the Zhaiyk-Caspian Basin.*

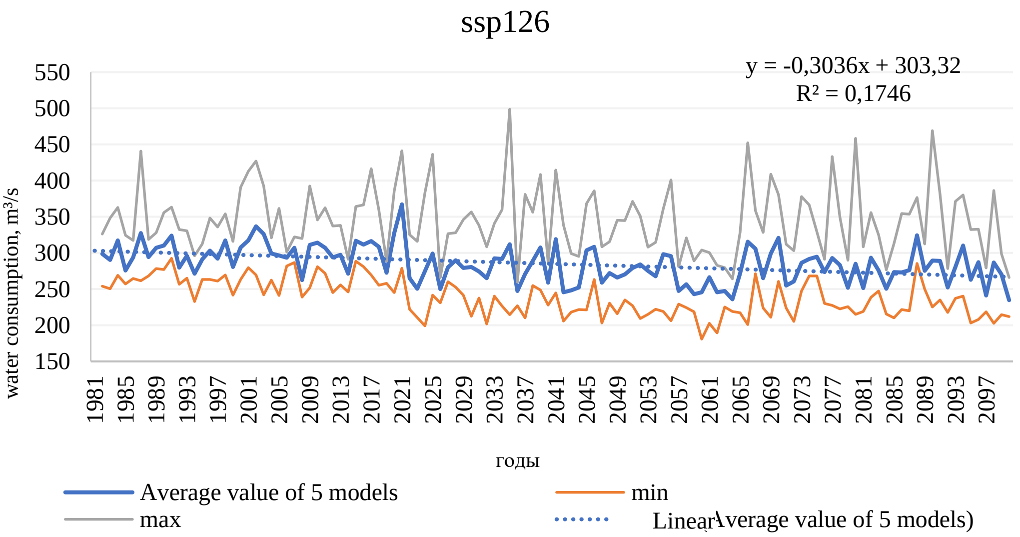


Figure 12. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp370 scenario of the Zhaiyk-Caspian basin*

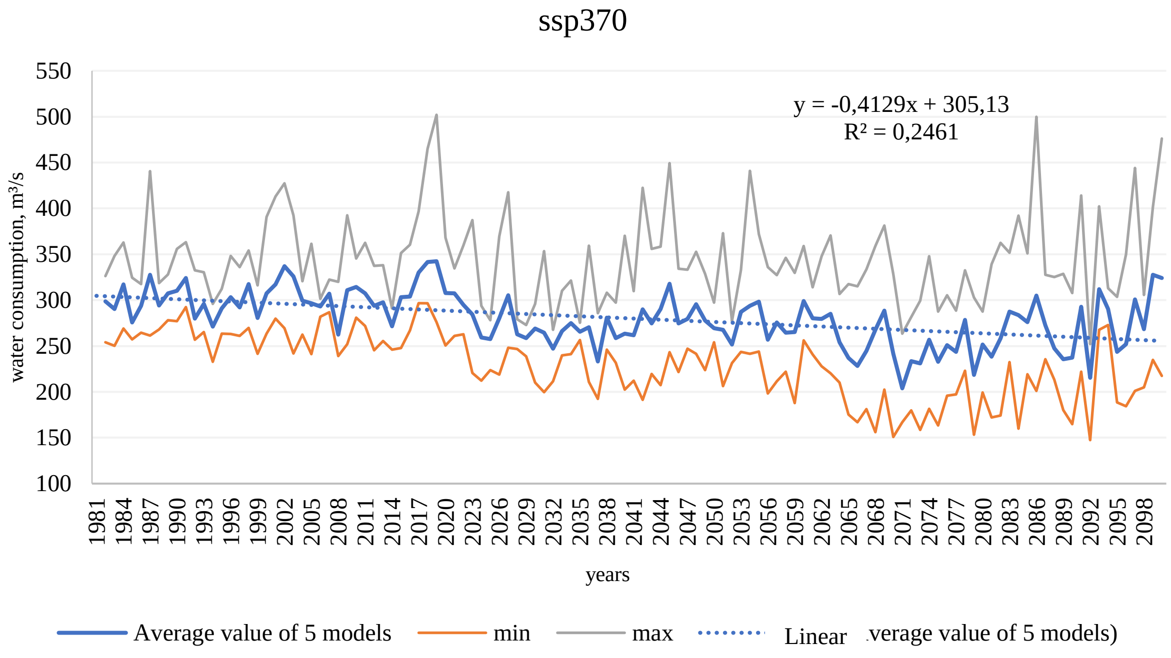
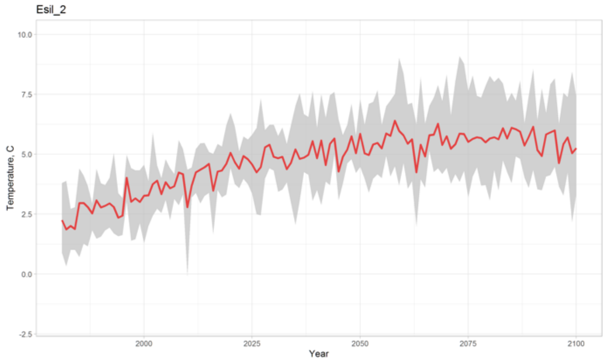


Table 9. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Esil Basin*

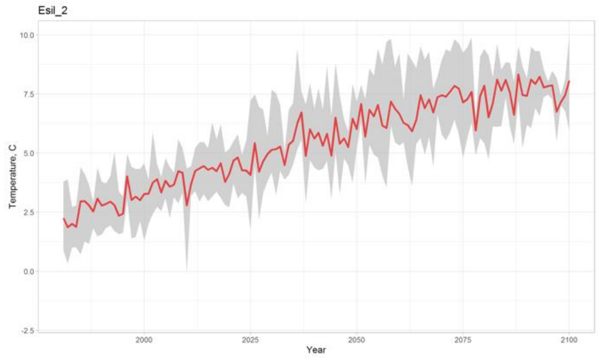
Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370
The average annual temperature increases for both scenarios in all future periods. For ssp 370 scenarios, the temperature rises more rapidly. The intra-annual dynamics is represented by an increase in temperature for all months for both scenarios.		Annual precipitation (ssp 126) is practically unchanged for four out of five models, only one model shows an increase of up to 25% for all future periods. Similar results for this model can be traced for most of the studied objects.		In 2016-2045, 2036-2065 and 2071-2100, there is a flow decrease by 8.5%, 18.5% and 19% respectively.	The following changes in flow: 2016-2045 - 14.5%, 2036-2065 - 12.5% and 2071-2100 - 1.9% (decrease).

*To identify changes in average annual water consumption, the following rivers of the Esil basin were selected: Yesil (Turgen village), Kalkutan (Kalkutan village) and Zhabai (Atbasar town). The flow change in three selected climatic periods was compared with the base period (1981-2010).

Figure 13. *Change in the average annual temperature until the end of the century based on 5 climate models for ssp 126 (a) and ssp 370 (b) scenarios of the Esil Basin*



a) ssp 126 scenario



b) ssp 370 scenario

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The graphs (Fig. 14, 15) show annual fluctuations in flow which can be attributed to the invariance of precipitation with a significant increase in temperature and intense evaporation in this region.

Figure 14. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp126 scenario of the Esil Basin*

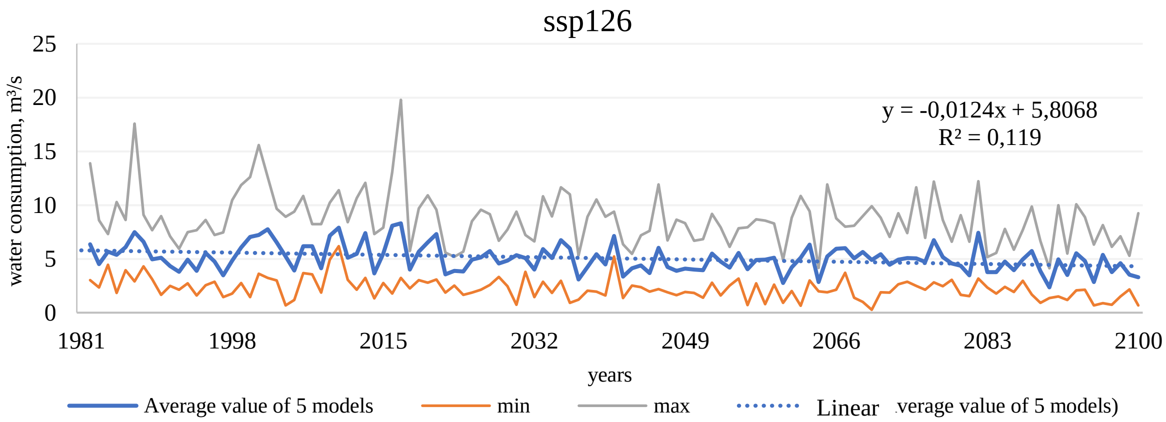
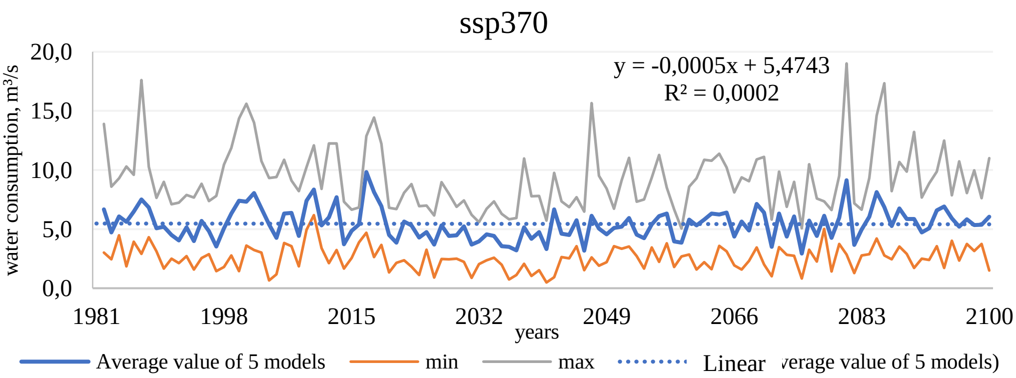


Figure 15. *The change in average annual water consumption until the end of the century based on 5 climate models for the ssp 370 scenario of the Esil Basin.*



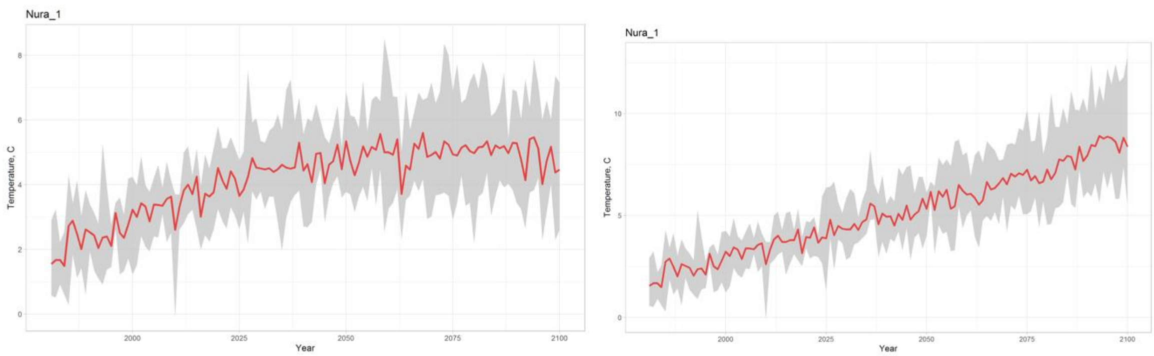
b)

Table 10. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Nur-Sarysu basin*

<table>
<tr><td colspan="2">Average annual temperature</td><td colspan="2">Precipitation</td><td colspan="2">Average annual water consumption*</td></tr>
<tr><td colspan="6">Scenarios</td></tr>
<tr><td>ssp 126</td><td>ssp 370</td><td>ssp 126</td><td>ssp 370</td><td>ssp 126</td><td>ssp 370</td></tr>
<tr><td colspan="2">The average annual temperature increases for both scenarios in all future periods.</td><td colspan="2" rowspan="2">Annual precipitation is characterized by a slight increase for most scenarios and future periods by an average of 10-14%.</td><td rowspan="2">In 2016-2045, there is an increase in flow by 2.2%, but a decrease in 2036-2065 by 1.7% and 2071-2100 by 3.5 %</td><td rowspan="2">No change in flow was detected for 2016-2045. Flow is expected to decrease by 5% in 2036-2065 and by 8 % in 2071-2100.</td></tr>
<tr><td>Temperature increase is slowing in the middle of the century due to the expected reduction of greenhouse gases.</td><td>The temperature rises more rapidly.</td></tr>
</table>

* To identify changes in average annual water consumption, the following rivers of the basin were selected: the Nura River (Balykty railway station), the Sarysu River (Kyzylzhar junction). The flow change in three selected climatic periods was compared with the base period (1981-2010).

Figure 16. *Average annual temperature change until the end of the century based on 5 climate models for the ssp 126 (a) and ssp 370 (b) scenarios.*



a) ssp 126 scenario *b) ssp 370 scenario*

Figure 17. *The change in average annual water consumption until the end of the century based on 5 climate models for the ssp 126 scenario of the Nur-Sarysu basin.*

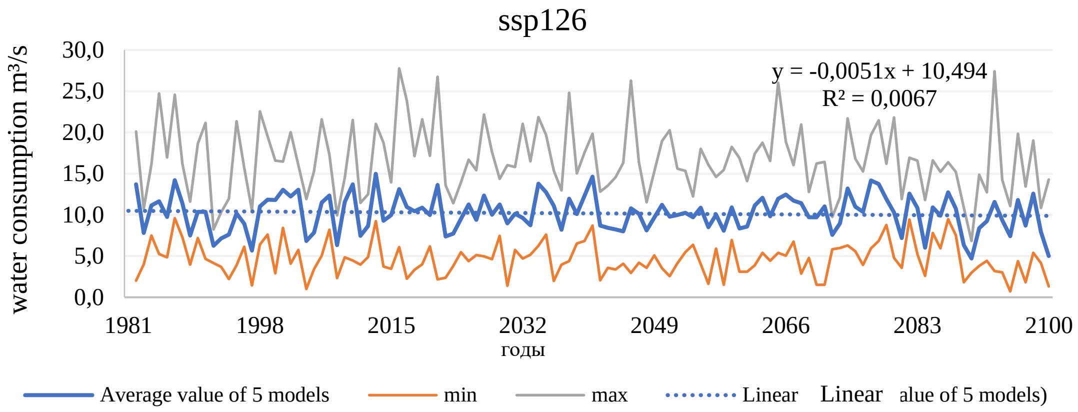
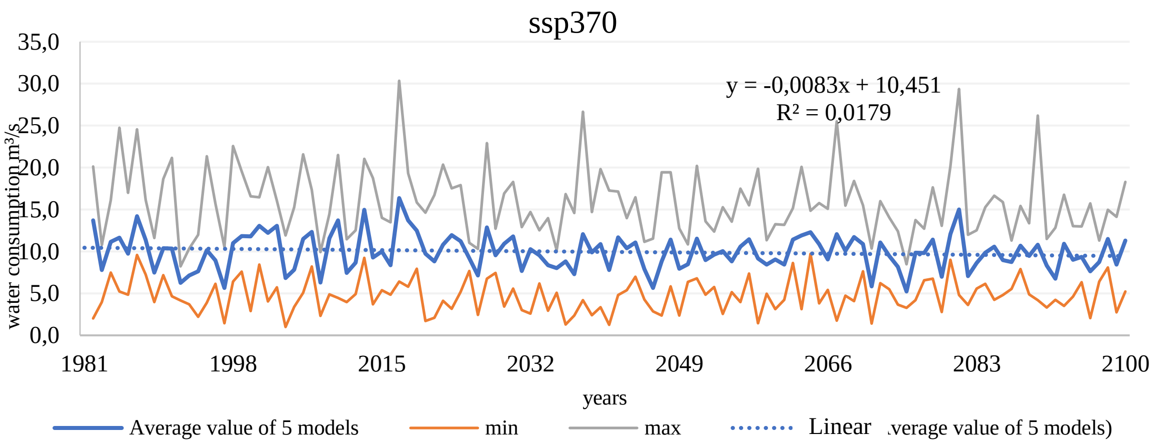


Figure 18. *Change in average annual water consumption until the end of the century based on 5 climate models for the ssp 370 scenario of the Nur-Sarysu basin.*



Such fluctuations in the flow may be associated with a more rapid increase in temperature and more intense evaporation, respectively (Fig. 23).

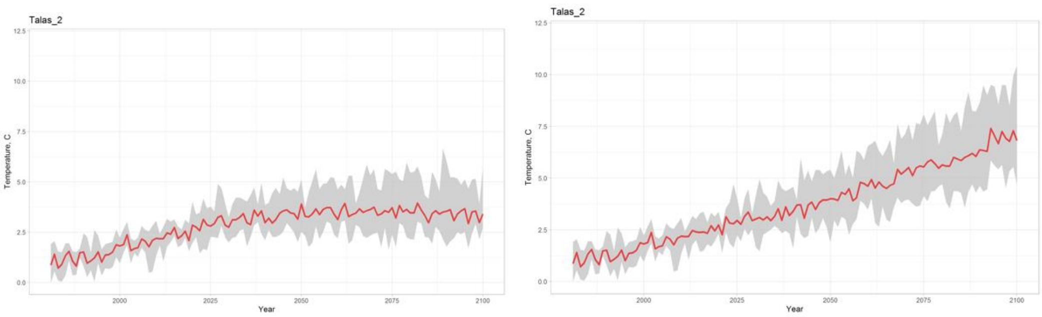
Table 11. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Shu-Talas basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370

The average annual temperature rises similarly with the rest of the objects of study. For ssp 370 scenarios, the temperature rises more rapidly. For both scenarios and all time periods, the temperature increases throughout the year.	Precipitation, both average annual and seasonal, has a similar dynamic of changes. In some periods there is a decrease in precipitation in the summer.	In 2016-2045 and 2036-2065, there is an expected increase in flow by 8%, in 2071-2100, there is a decrease by 13%.	In 2016-2045 there is flow increase of 9%, in 2036-2065, there is a decrease of 6%, and in 2071-2100 there is an increase of 7%.

* To identify changes in average annual water consumption, the following rivers of the Shu-Talas VKHB were selected: the Merke River (Ulbutui wintering) and the Teris River (Nurlykent village). The flow change in three selected climatic periods was compared with the base period.

Figure 19. *Average annual temperature change until the end of the century based on 5 climate models for the ssp 126 (a) and ssp 370 (b) scenarios of the Shu-Talas basin*



a) ssp126 scenario *b) ssp370 scenario*

The graphs (Fig. 20, 21) show annual fluctuations in flow. This trend may be associated with changes in the melting of glaciers: degradation and subsequent depletion.

Figure 20. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp126 scenario of the Shu-Talas basin*

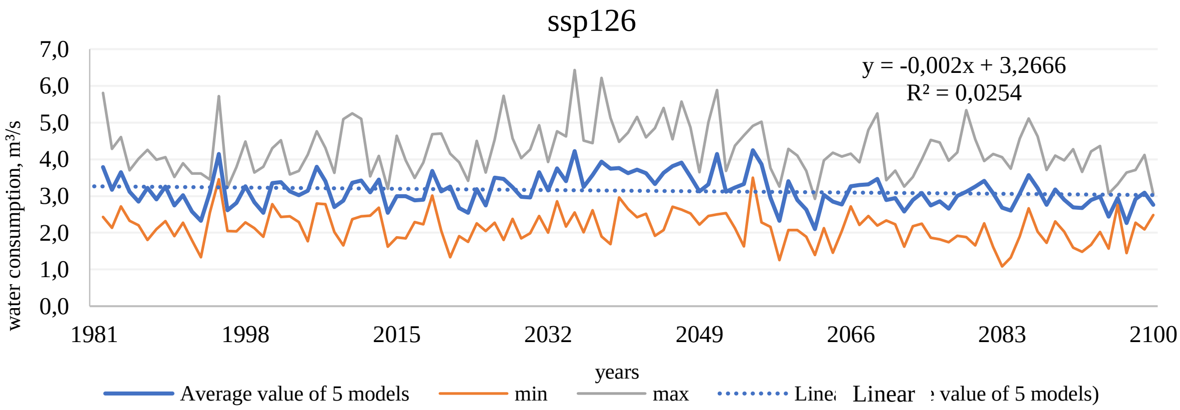
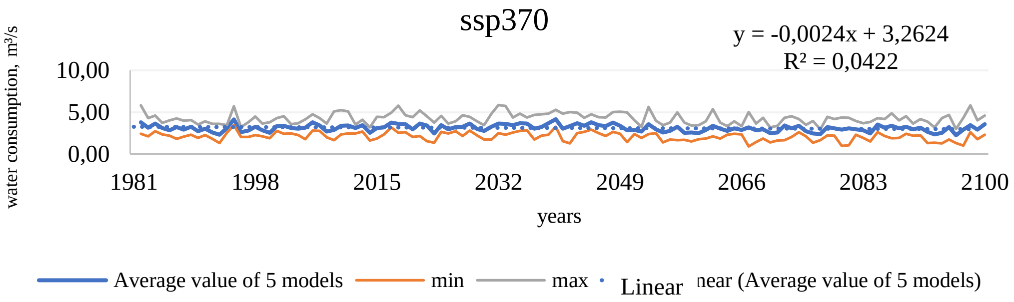


Figure 21. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp370 scenario of the Shu-Talas Basin*



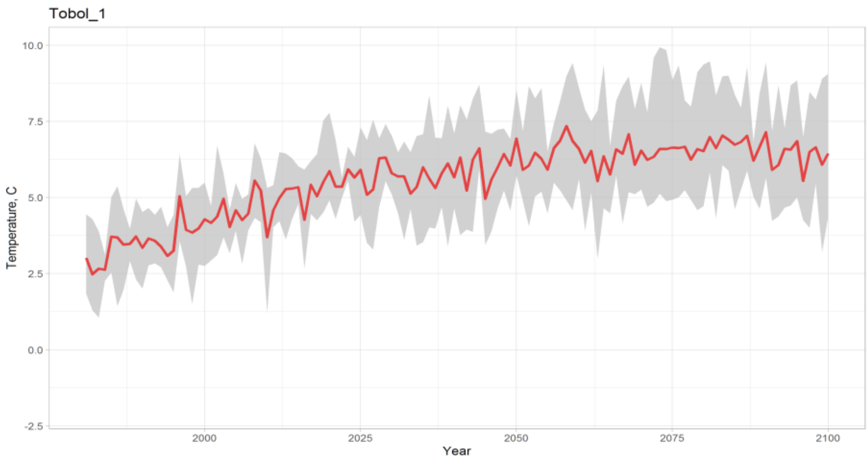
b)

Table 12. *Changes in average annual temperatures, precipitation, average annual water consumption until the end of the century for the ssp 126 and ssp 370 scenarios of the Tobol-Torgai basin*

Average annual temperature		Precipitation		Average annual water consumption*	
Scenarios					
ssp 126	ssp 370	ssp 126	ssp 370	ssp 126	ssp 370
The average annual temperature rises for both scenarios and can reach an average of about 2.2 ^{0} C for ssp 126 and up to 5.6 ^{0} C for ssp 370. Seasonal dynamics are represented by an increase in temperature for all months.		Annual precipitation for most future periods and scenarios has a slightly positive trend. Seasonal dynamics of precipitation indicate an increase in winter, spring, and autumn periods.		Changes in flow to decrease by 6% in 2016-2045, by 11% in 2036-2065 and by 12% in 2071-2100,	Changes in flow to decrease by 7% in 2016-2045, 12% in 2036-2065 and 17% in 2071-2100.

*To identify changes in average annual water consumption, the following rivers of the basin were selected: the Tobyl river (Grishenka village) river and the Torgai river (Tusum sands). The flow in three selected climatic periods was compared with the base period (1981-2010).

Figure 23. *Average annual temperature change until the end of the century based on 5 climate models for ssp126 (a) and ssp370 (b) scenarios of the Tobol-Torgai basin*



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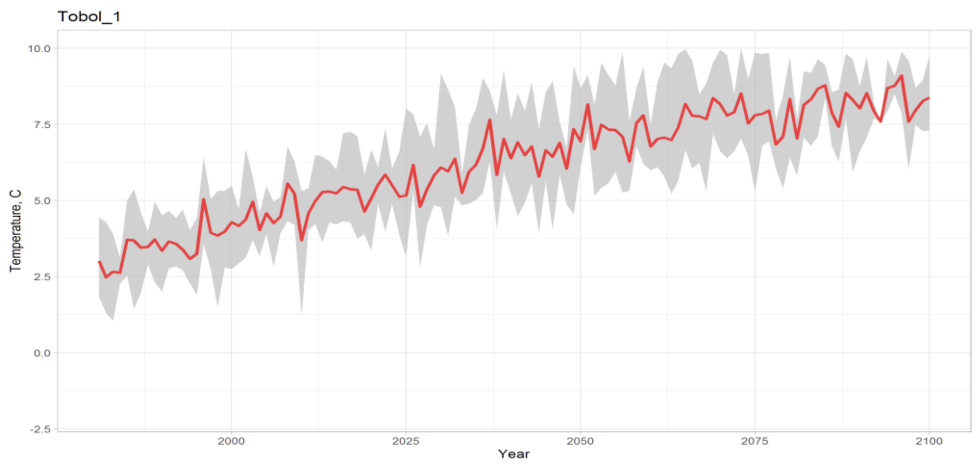

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Figure 24. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp126 scenario of the Tobol-Torgai Basin*

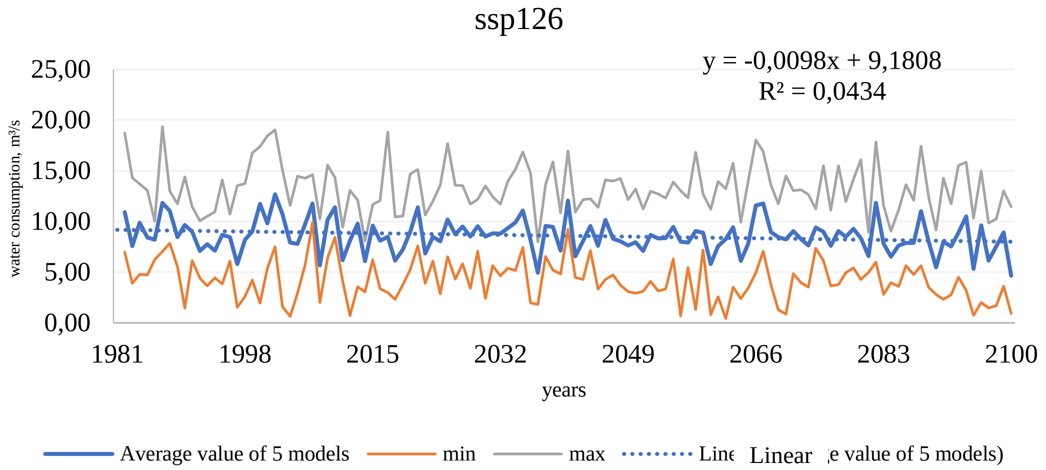
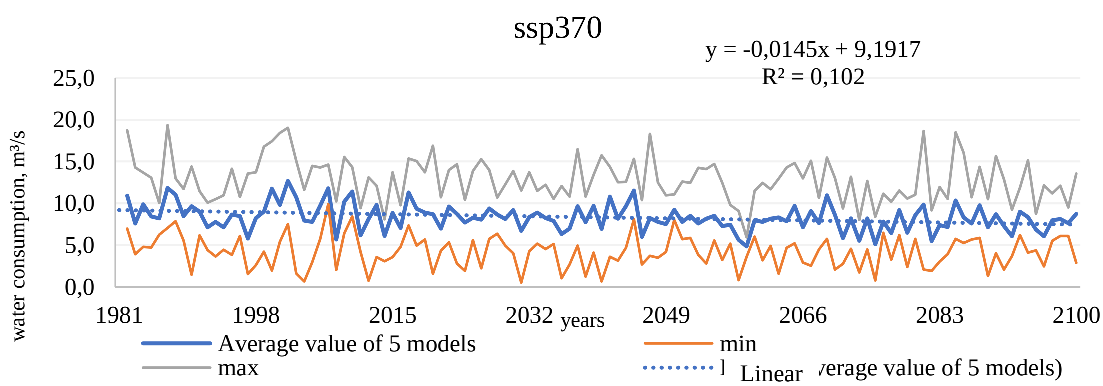


Figure 25. *Change in average annual water consumption by the end of the century based on 5 climate models for the ssp 370 (b) scenario of the Tobol-Torgai Basin*



The graphs (Fig. 23, 24) show annual fluctuations in the flow which is associated with a rapid increase in temperature and intense evaporation.