Analytical report
“Study of climate change, land degradation and water nexus in the Aral Sea regions”
prepared as part of the Global Initiative “Biodiversity and Ecosystem Services Network” (BES-Net)

Executor:

Public Fund
“Executive Directorate of the International Fund for Aral Sea Saving in the Republic of Kazakhstan”

December 22, 2023

Table of contents

INTRODUCTION

Over the past half century, the volume of the Aral Sea has decreased by almost 10 times, and the world's fourth largest sea has been divided into several relatively independent reservoirs. Using modern remote sensing technologies, such water bodies could be observed in 2022 as the Northern Aral Sea with a volume of about 18.7 km3, salinity 10-14 g/l; the Western Aral Sea with a volume of 42.5 km3, salinity 170 g/l; and Lake Tushchibas with a volume of 1.7 km, salinity 90 g/l.[1][2]

Due to global climatic phenomena, the influence of arid and low-water periods has led to further regression of the water bodies of the Aral Sea, which determines an increase in the concentration of fine salt during salt and dust storms.

More than 5.4 million hectares (54 thousand km^2) have turned into a salt desert, a source of salt aerosols into the Earth's atmosphere, while the Kazakh part is about 2.0 million hectares (20 thousand km^2).[3]

Billions of tons of toxic salts have accumulated in the Aral Sea, which got here along with the water after washing the fields. According to experts, there are about 107-114 billion tons of salt on the drained bottom of the Aral Sea (ODAM). This circumstance, as well as the death of almost all spawning grounds, led to a catastrophic reduction in the fish population, numbering about 34 species, of which more than 20 were of commercial importance. This dealt a devastating blow to the local fishing industry, which once employed about 60,000 people.

Every year, up to 80 million tons of toxic salts rise from the dried-up bottom of the Aral Sea.[4] [5] [6] They are carried by dust storms over many thousands of kilometers - from Western Europe to the peaks of the Tien Shan and the Himalayas, negatively affecting the health of people and ecosystems in all our countries. Hundreds of thousands of people are breathing poisonous air. Salt dust covers the high-altitude glaciers that give rise to many rivers with an impenetrable film. This has a detrimental effect on the quality of water, which eventually finds its way into water supplies and wells even thousands of kilometers away from the source, not to mention the residents of coastal areas, who often have diseases of the eyes, lungs, digestion and genitourinary system, blood and hematopoietic organs, and others.

The changes in microclimate and temperature that have occurred since 1960 in the territory surrounding the Aral Sea are so large that they cannot be attributed solely to the general atmospheric processes characteristic of the region. The impact of the Aral Sea retreat on the thermal regime and climatic changes is recognized, although it is limited to a 30-50 km wide strip of land around the water area of the former sea, this is confirmed by modeling performed by the Kazakh Scientific Research Hydrometeorological Institute (KazNIGMI).

According to KazNIGMI, the first strip of the territory – 20-30 km from the drained bottom of the Aral Sea – receives an average of 140-150 tons/km^2 of dust and salt aerosol, which corresponds to 3-

---

[1] Aral-Syrdarya Basin Inspectorate for Regulation of Water Resources Use and Protection of the Water Resources Committee of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan

[2] http://aral.uz/wp/

[3] https://kazaral.org/2021/02/05/

[4] https://kazaral.org/aral-zabota-obshhaya/

[5] https://kazaral.org/aral-zabota-obshhaya/

[6] https://yuz.uz/ru/news/ejegodno-plne-buri-arala-vnosyat-do-75-mln-tonn-peska-i-soli-na-territoriyu-uzbekistana-i-drugix-stran-tsa

15 tons/km^2 of salt. At a distance of 65 km, 25 tons/km^2 settle, at 120 km – about 5 tons/ km^2. The effect of dust and salt aerosol is mainly limited to a band of 30-50 km around the ODAM, although some particles can be transported for thousands of kilometers (the RRSSAM project, 1996).

Currently, there is still a pattern of extensive environmental management. For example, in order to obtain high yields of cotton, rice and other agricultural crops, large amounts of mineral fertilizers and pesticides are introduced into the soil, some of which do not even decompose in nature and therefore pose an even greater danger to humans. All this complex of pesticides and herbicides from fields with water gets into the Syrdarya, and therefore into the Aral Sea, seeping into groundwater and groundwater, which are used for drinking and household needs. This issue is especially relevant for the Kyzylorda region, located in the lowest part of the Syrdarya River, and therefore the most affected by this factor.

The main factor limiting the species diversity and resource importance of plant complexes is the contamination of water and soils with various pollutants (pesticides, herbicides, etc.).

Violation of the qualitative composition of soils and water proportionally increases the consumption of irrigation water, significantly exceeding scientifically justified standards. According to forecasts, if the current trend of salinization of water bodies and soils continues, most of the agricultural land in the Syrdarya river basin (probably the situation is similar in the Amudarya river basin) will become unsuitable for irrigated agriculture within several decades. The level of salt pollution in rivers will also be unsuitable for drinking water supply. This type of river pollution can cause irreparable damage to the ecological and socio-economic development of the Kyzylorda region.

In accordance with the Unified System of Classification of water quality in the water bodies of the Republic of Kazakhstan, the Syrdarya River belongs to Class IV.: the village of Kokbulak (10.5 km to the north, northwest (hereinafter referred to as the CCC) from the post): Water quality belongs to the 4th class: suspended solids – 125.62 mg/dm^3, magnesium – 42.79 mg/dm^3, sulfates – 510.25 mg/dm^3, phenols – 0.0015 mg/dm^3. The concentration of magnesium and phenols does not exceed the background class, the concentration of sulfates and suspended solids exceeds the background class.[7]

In 2021, in the Kyzylorda region, FAO specialists carried out work on mapping soil salinity. According to the data obtained, almost 85% (20.3 million hectares) of the total agricultural land area (22.6 million hectares) is currently saline in the region.[8] This situation requires immediate action to apply new technologies that regulate the pace and degree of salinization of the territory. Inefficient farming causes soil erosion, salt pollution, overgrazing, and increasing desertification. Pastures make up 46.7% of the region's territory. Currently, more than 80% of pastures are degraded mainly due to soil salinization, groundwater mineralization and the irrational use of natural resources.

In addition to soil salinization, there is an increasing pattern of land degradation around populated areas due to non-compliance with livestock grazing rules. For the same reason, there is a large-scale consumption of saxaul by livestock, planted for the "green belt" around populated areas.

Due to the drying up of the Aral Sea, coastal countries are carrying out work to combat salt and dust transfer, to consolidate moving sands, and to localize the negative impact of this phenomenon on the environment. In order to consolidate the sands on the exposed seabed, several thousand hectares of saxaul and other unpretentious plants are planted here annually, which easily tolerate the conditions of a semi-desert and desert climate. As a result, forests today in the Kazakh part of the drained bottom

[7] https://www.kazhydromet.kz/uploads/files/39/file/600aabe6ad292byulleten-tg-perenos-2020-god-rus-iyaf.pdf

[8] https://eldala.kz

of the Aral Sea (ODAM) have been created on almost 337 thousand hectares, including through self-reproduction.

In 2021-2030, it is planned to carry out reforestation of plants on an area of 1.1 million hectares in the Kazakh part of ODAM.[9] It is expected that in the near future, the Green Aral Sea will make a huge contribution to the global process of achieving carbon neutrality. After all, one saxaul holds up to 4 tons of sand, 1 ha of saxaul at the age of four absorbs 1158.2 kg of carbon dioxide per year and releases 835.4 kg of oxygen, the shrubby plant cherkez (Richter's solyanka) per 1 ha absorbs 1547.8 kg of carbon dioxide and releases 1116.4 kg of oxygen.[10] Accordingly, 1.1 million hectares will consume about 1.3 million tons of carbon dioxide.

At the same time, it is necessary to regulate the water regime in the shallow channels of the Greater Aral Sea with an area of about 2 thousand km^2, [11]since with high water content, saxaul dies and germination of more moisture-loving plants, for example, tamarix, is observed. In the following dry years, the tamarisk dies. Therefore, it is necessary to provide for the regulation of water resources in the shallow channels of the drained bottom of the Aral Sea, to consider the possibilities of exploiting groundwater using abandoned wells and developing new groundwater wells.

The shortage of water resources and a decrease in the quality of drinking water, land degradation, climate change, an increase in the incidence of diseases among the population, primarily children, and a complex set of related socio-economic and demographic problems are the harsh realities faced by residents of the Aral Sea region.

Accordingly, the low level of "NEXUS: water, energy, food, environment" interaction between the main sectors of the economy in the Aral Sea basin and the environment creates a regressive trajectory of the chain of impact of the social and economic development of the region. All this, of course, is reflected in the main indicators of the Human Development Index, the degree of employment of the population, environmental and economic migration and the general welfare of the population.

[9] Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, Akimat of Kyzylorda region

[10] https://www.gazeta.uz/ru/2021/04/30/aral-sea-region/

[11] http://kazaral.org/kartograficheskie-materialy/

KYZYLORDA REGION IN MODERN CONDITIONS OF CLIMATE CHANGE

Briefly about the current climatic conditions. The sharply continental climate of the Kyzylorda region is due to the location of the region inside the Eurasian continent far from the oceans, the peculiarities of atmospheric circulation, the nature of the underlying surface, and other factors. Summers in the region are long, hot and dry, with lots of sunny days. Winter is cold, short, with little snow, and strong winds.

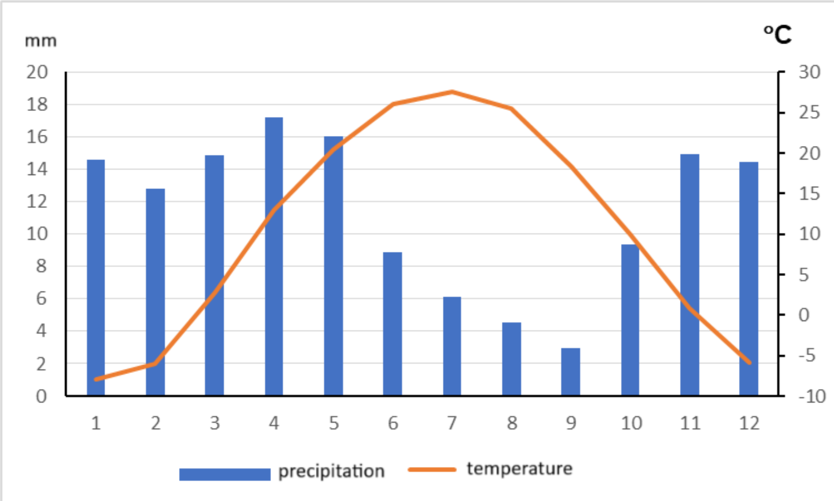


Figure 1. Average monthly precipitation rates (mm) and air temperature (°C) for the territory of the Kyzylorda region, calculated based on data for the period -1991-2020. (Source: Dolgikh S., 2023)

The continentality of the climate is manifested in large fluctuations of meteorological elements, in their daily, monthly and annual course. The average temperature in July is in the range of -26-29 °C. The absolute maximum temperature in the majority of the region is 43 -47 °C, the absolute minimum is 7 -9 °C.[12]

Winters are short, with frequent thaws, and mild. The coldest month is January, with an average temperature ranging from +2.0 °C to minus 10.0 °C in the lowlands.

In winter, the difference in temperatures between the south and north of the region is more noticeable, for example, the average temperature in January drops from minus 4 in the southern areas to minus 12C and below in the northern part of the Aral Sea region. The openness to the north allows cold air masses to penetrate unhindered into the territory of the region and cause sharp cold spells, especially in winter. The absolute minimum air temperature reaches minus 35 -41 °C.

The first snowfalls in the flat part of the region occur in October, but the first snow cover is extremely unstable. Due to frequent thaws and low power, it is almost completely gone.

As indicators of the thermal resources of the territory in relation to crop production, the following are used:

– dates of steady temperature transition after 5, 10, 15 °C;

– the duration of the growing season with an air temperature above 5, 10, 15 ° C;

– the sum of the daily temperatures for the period with an air temperature above 5, 10, 15 °C.

For most plants, their growth and development begins after a steady temperature transition in 5C, for heat–loving crops - in 15C

[12] https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana

The Kyzylorda region is characterized by a long growing season (temperatures over +5°C), which averages less than 210 days in the north of the Aral region and increases to more than 240 days in the south. In warm years, the duration of the growing season can be 230-260 days, and in cold years it can be reduced to 175-200 days.

In spring, a steady increase in temperature to 5C and above occurs in mid-March in the south and at the end of March in the north of the region. In autumn, the return trip falls at the end of October in the south and the first decade of November in the north. The early and late dates of the average daily temperature transition after 5°C may differ from the average by 12-15 days, depending on the weather conditions in a particular year.-

The sum of average daily temperatures for the period with temperatures above 5C in the north of the region is about 4100C, in the south - about 4300C.

The region is located in the desert zone. Aridity is one of the distinctive features of the region's climate. There is very little precipitation. The annual precipitation does not exceed 100-180 mm and is distributed unevenly over the seasons of the year: about 60-65% of all precipitation falls in the winter-spring period. According to all meteorological stations, there may be no precipitation at all in all months of the year. The absolute maximum daily precipitation in the region is in the range of 40-80 mm, so precipitation per day can be two or more times the monthly norm.- In some months, monthly precipitation amounts can exceed the norm by dozens of times. These data characterize the high heterogeneity of precipitation over time.

Table 1. Characteristics of the precipitation regime according to the Aral Tenisi Meteorological Station (Source: kazhydromet.kz)

Month	Norm, mm	Monthly minimum, mm	Monthly maximum, mm	Daily maximum, mm
January	11.2	0.0 (1906)	37 (1925)	19 (1910)
February	13.2	0.0 (1931)	62 (2017)	25 (1919)
March	15.6	0.0 (1996)	46 (1952)	29 (1929)
April	14.3	0.0 (1917)	92 (1980)	38 (1980)
May	14.1	0.0 (1916)	60 (1981)	34 (2012)
June	12.2	0.0 (1920)	101 (2003)	45 (2003)
July	8.3	0.0 (1914)	82 (1957)	44 (1957)
August	6.4	0.0 (1913)	53 (1949)	40 (1970)
September	4.1	0.0 (1909)	32 (1907)	26 (1907)
October	13.9	0.0 (1905)	80 (1980)	39 (1980)
November	13.8	0.0 (1905)	53 (1963)	27 (1961)
December	12.8	0.0 (1905)	34 (1979)	23 (1947)
Year		52 (1909)	287 (1980)	45 (2003)

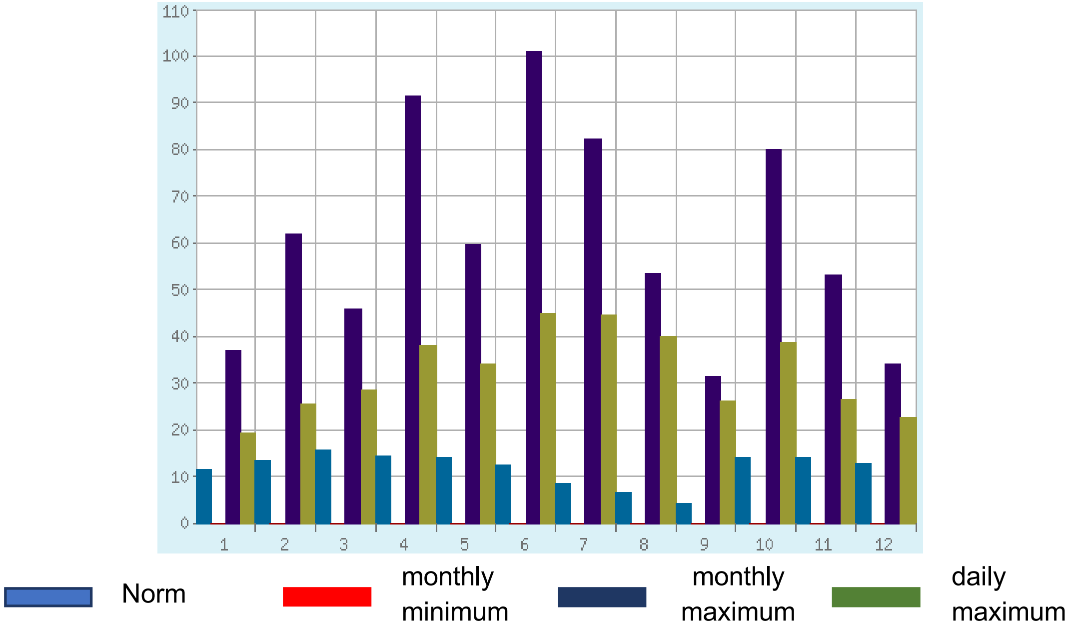


Figure 2. Precipitation regime characteristics according to the Aral Tenisi Meteorological Station (mm) (Source: kazhydromet.kz)

However, high temperatures, instability in precipitation, increased wind, and significant evaporation contribute to the occurrence of early spring droughts. Precipitation is less than 10 mm in summer, and in some years there may be no precipitation throughout the month. Daily rainfall of less than 5 mm is inefficient for agriculture.

The concept of "drought" does not apply to desert areas, which include almost the entire Kyzylorda region. The extremely low rainfall makes it possible to farm only with irrigation. In order to assess the aridity of the climate in such regions, Selyaninov's hydrothermal coefficient (HTC) is used whereby the climate is characterized as “severely arid” (HTC less than 0.40) throughout the region. Also moisture availability of vegetation period in the conditions of Kazakhstan is well enough characterized by the coefficient of wetting “K”, according to this indicator, in modern climatic conditions the territory of Kazakhstan is divided into 6 zones: from dry to well-wet, and the territory of Kyzylorda region is in the spirit zones - dry in the south (K=0.2-0.4) and very dry zone (K=0.2-0.4).

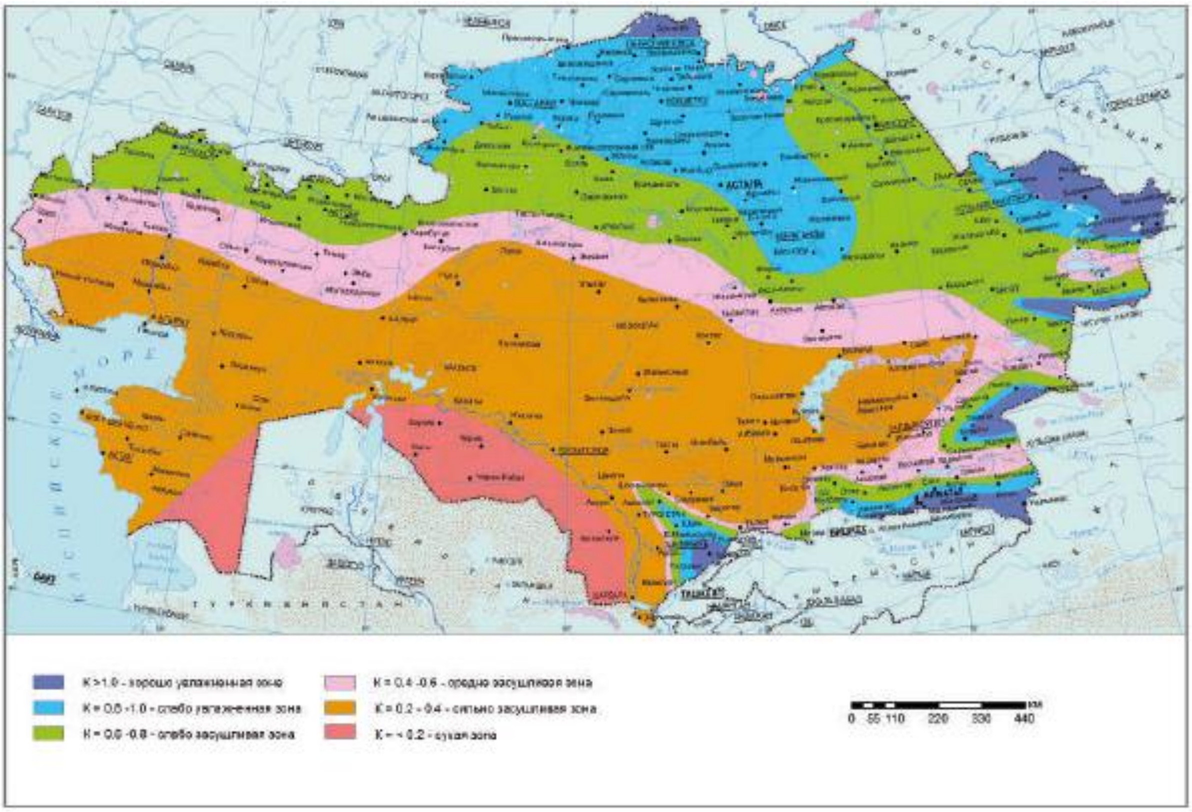


Figure 3. Distribution of the humidification coefficient "K" over the territory of Kazakhstan (Source: S. Baisholanov[13])

The entire territory of the region is characterized by frequent and strong winds, mainly from the northeast. The average annual speed ranges from less than 2 m/s in the southern part of the region to more than 4.0 m/s in the northern part. Strong winds in winter at low temperatures blow away insignificant snow cover from elevated parts of the relief, which causes deep freezing and cracking of the upper layers of the soil. Dust storms are observed in the summer.

The drained bottom of the Aral Sea is a hotspot for the development of sand and salt storms in Central Asia. The most frequent dust storms occur in the western part of the Kyzylorda region (from 10 to 60 days), in the rest of the territory – less than 20 days. In particularly windy years, the frequency of dust storms was 33 to 109 days.- According to the Atlas of Natural and Man-Made Hazards and Risks of Emergency Situations (2010), the [14]level of risk of dust storms in the Aral Sea region is assessed as "high".

The region is characterized by frequent dry winds that occur at wind speeds of more than 5 m/s, characterized by high air temperature (more than 25°C) and low humidity (less than 30%). The annual number of dry days increases from north to south from 125 to 175 days.

Current and expected climate change. Currently, global warming is an indisputable fact, as an increase in surface temperature is observed almost all over the world. According to the World Meteorological Organization, the years from 2015 to 2022 were the eight warmest in the 173-year history of instrumental observations. 2022 was the fifth or sixth warmest year on record.[15] In 2021, the Intergovernmental Panel on Climate Change (IPCC), based on the most up-to-date physical understanding of the climate system and climate change, combining the latest

---

[13] Baisholanov S.S. Vulnerability and adaptation of agriculture in the Republic of Kazakhstan to climate change. Astana, 2017. – 128 pages.

[14] https://ingeo.kz/?page_id=2340 , https://cesdrr.org/разработки-мчс-рк

[15] https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate

achievements in climate science and numerous observational evidence, as well as modeling of global and regional climate, prepared the Physical Scientific Basis of a new, sixth report, which provides all new evidence of climate change.[16] Each of the last four decades has been consistently warmer than any previous decade, according to a new report.

According to the results of research by Kazakhstani climatologists, the [17]rate of climate change in Kazakhstan is outpacing global climate change, and the rate of temperature increase in the Kyzylorda region is even higher. Thus, in 1976-2022, the change in the average annual global temperature is 0.19 ° C for every 10 years, in Kazakhstan the temperature rises by 0.33C / 10 years, in the Kyzylorda region – by 0.44 / 10 years.-[18]

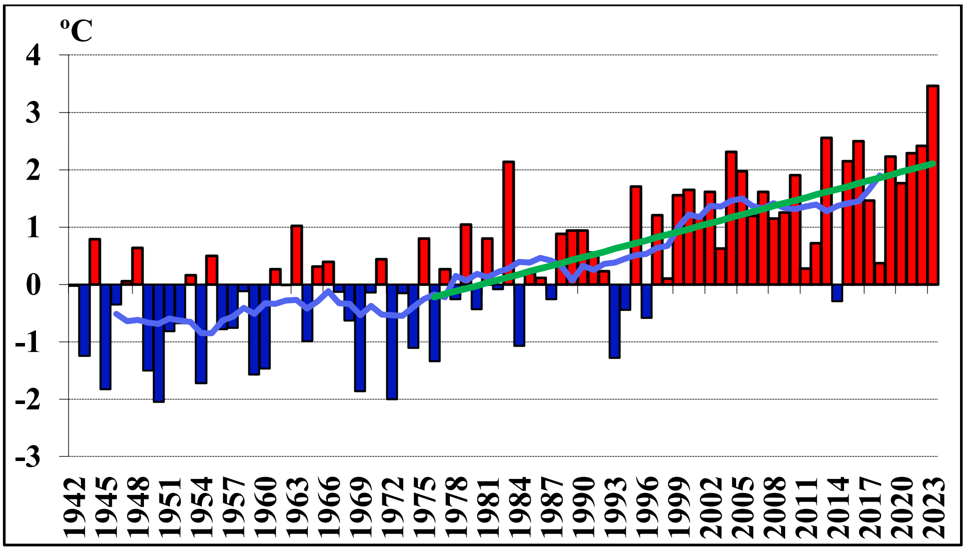


Figure 4. Anomalies of the average annual air temperature relative to the norm for the period 1961-1990, averaged over the Kyzylorda region. The linear trend for the period 1976-2023 is highlighted in green. The smoothed curve is obtained by an 11-year moving average. (Source: RSE Kazhydromet)

There is also a widespread and significant increase in seasonal surface air temperatures in the Kyzylorda region. The greatest temperature increase occurs in spring – by 0.87°C / 10 years; in summer and winter – by 0.33 and 0.34°C / 10 years, respectively; the lowest rate of temperature increase – by 0.20°C / 10 years, is observed in autumn.

As for the amount of precipitation, there is an alternation of short-term in relatively wet and dry periods in annual and seasonal precipitation amounts.

[16] https://www.ipcc.ch/report/ar6/wg1/

[17] https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana

[18] http://seakc.meteoinfo.ru/images/seakc/monitoring/cis-climate-2022.pdf

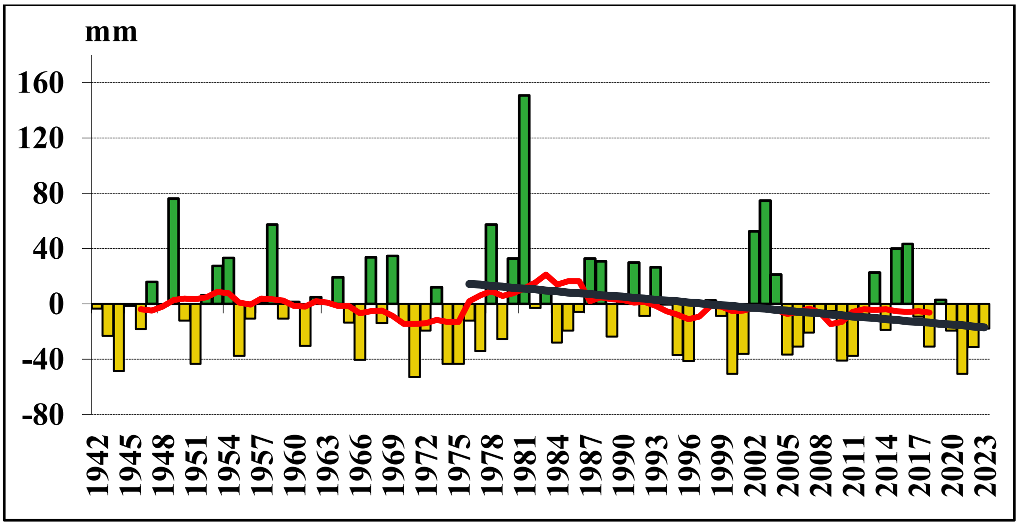


Figure 5. Annual precipitation anomalies (%) for the period 1941-2021, averaged over the territory of the Kyzylorda region (positive anomalies are highlighted in green, negative ones in yellow) relative to the norm for 1961-1990. The linear trend for the period 1976-2021 is highlighted in black. The smoothed curve is obtained by an 11--year moving average (red line). (Source: RSE Kazhydromet)

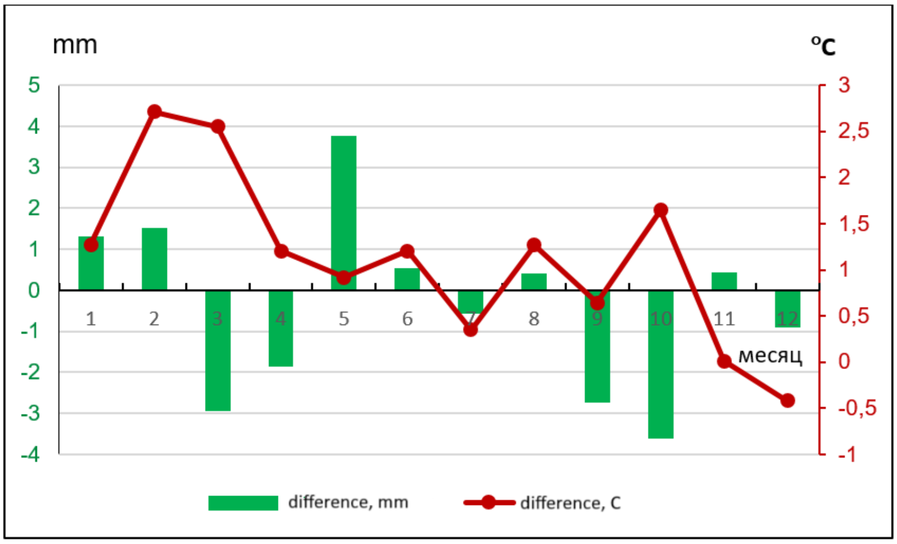


Figure 6. The difference between the average long-term monthly precipitation (mm) and the average monthly air temperature (C) for 1991-2020 and for 1961-1990, on average, in the territory of the Kyzylorda region (Source: Dolgikh S., 2023)

When assessing thermal resources, moisture resources, and dangerous hydrometeorological phenomena, it is very important to take into account that not only the average air temperature and precipitation levels are changing, but also other important characteristics of these basic climate elements are changing, including the frequency and intensity of extremes. Thus, climate change can affect almost all spheres of human activity, physical and chemical processes in the biosphere.

A correct assessment of such impacts of climate change should have a pronounced regional and even local character, since both climate change and vulnerability of systems, as well as adaptation opportunities, significantly depend on the physical, geographical, economic and demographic characteristics of regions that have their own specifics in this regard.

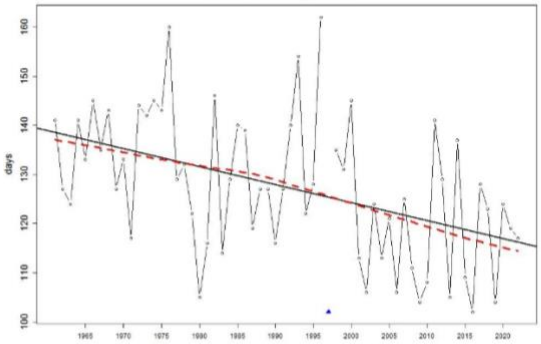
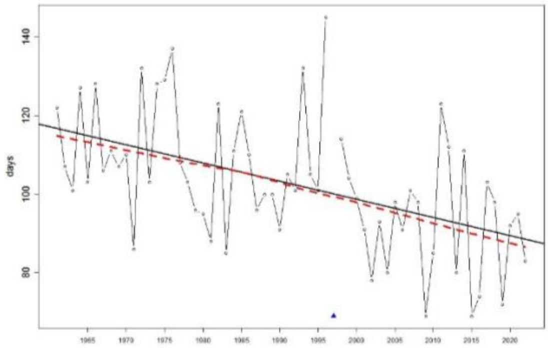
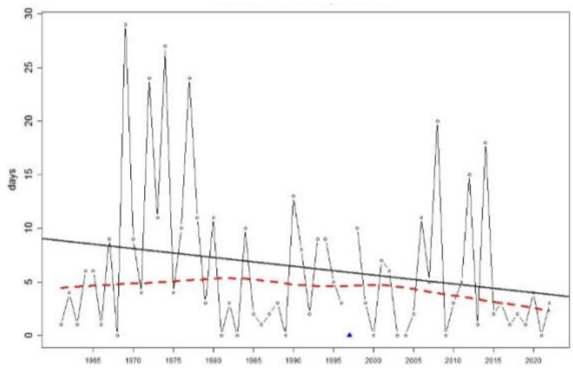
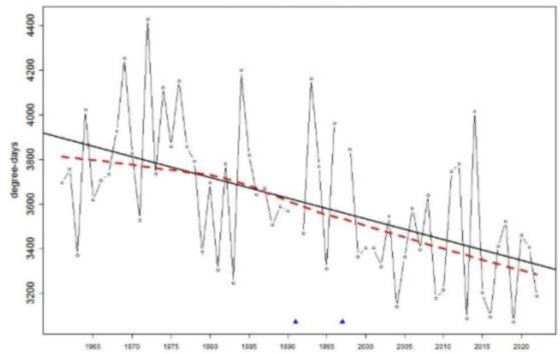
The number of days with a daily minimum temperature of <0 ºC (days)	The number of days with a daily minimum temperature of <-2 ºC (days)
	
The number of days with a daily minimum temperature of <-20 ºC (days)	Temperature difference between indoor and outdoor areas during the cold season (degree-days)
	

Figure 7. Changes in some characteristics of the temperature regime during the cold season according to the Shieli meteorological station (Source: Dolgikh S., 2023)

Climate change indices recommended by the World Meteorological Organization (WMO) were used to assess changes in the characteristics of temperature and precipitation regimes, which are important for various sectors of the economy and ecosystems. The initial data for calculating the indices are the daily maximum and minimum temperatures of surface air and the daily amount of precipitation. Thus, the indices allow us to assess many important aspects of climate change, such as changes in the intensity, frequency and duration of climatic extremes. The calculations were performed using the ClimPact2 software package[19] also developed as part of the WMO Climate Program.

The results of the assessment of changes in the most significant climate indices according to data from several meteorological stations in the Kyzylorda region are given in the Appendix, which also indicates which areas of economic or social activity these changes may or are already affecting.

Over the past decades, the following temperature changes have been recorded during the cold season, on average for every 10 years of the period 1961-2022:

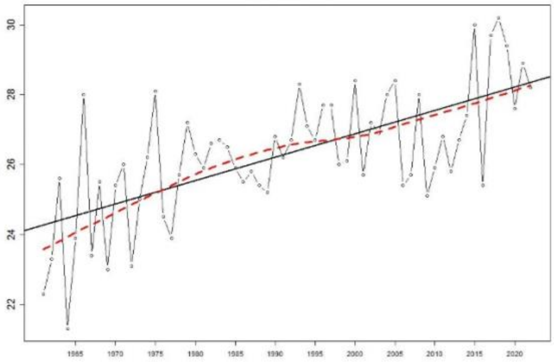
- On average, the number of days per year with frosts and severe frosts decreases by 2-5 days, when the daily minimum temperature drops below 0°C and below -2°C, respectively.
- On average, the number of days per year with hard frosts, when the daily minimum temperature is below -20 ºC is reduced by 1-2 days.
- The sum of the difference between the average daily temperature outside and the desired indoor temperature (in this case 20 ºC), which must be compensated for by heating the premises, is reduced by 90-129 degree days.

[19] https://climpact-sci.org/get-started/ , https://github.com/ARCCSS-extremes/climpact2

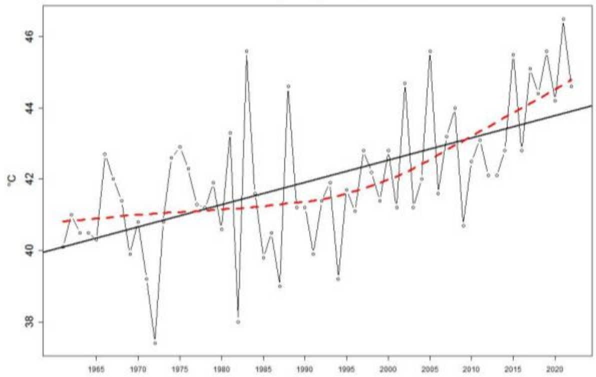
The warm season temperature characteristics experienced the following changes, averaged over each 10-year period 1961-2022:

- According to data of most stations, the maximum of night temperatures and the values of the absolute annual maximum of air temperature increased by 0.2-0.7 ºC.
- The number of so-called "tropical" nights (by 1-7 nights), when the daily minimum temperature does not fall below 20 ºC, increased. This climatic index is proposed by the World Health Organization, as it is believed that the human body does not recover from the heat of the day at night temperatures above 20 ºC.
- The duration of the growing season - the annual number of days with average daily air temperature > 5C - increases by 2-4 days.
- On average, the sum of temperatures during the active vegetation period - with average daily air temperature > 10C - increases by 48-114 degree days.
- The recurrence of extremely hot days with temperatures above 35C increases by 2-6 days every 10 years.
- The recurrence of heat waves increases (at least 6 consecutive days with temperatures less than 10%), the total duration of heat waves increases by 2-4 days, and the maximum duration of the heat wave increases by about a day.
- At the same time, the peak temperature of the hottest heat wave increases by 0.5-1.1ºC.
- The sum of the difference between the average daily temperature outside and the desired indoor temperature (in this case 23ºC) increases by 16-55 degree days, which must be compensated for by cooling the premises.

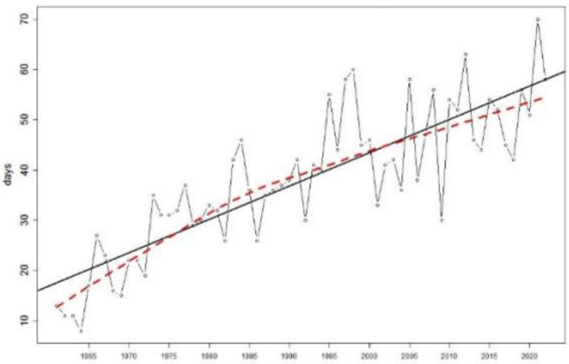
Maximum nighttime temperatures (ºC)



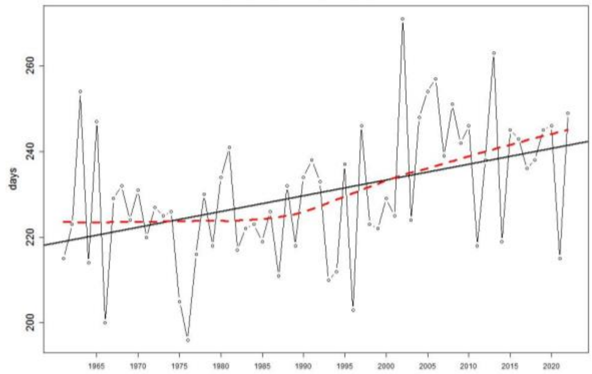
Absolute annual maximum temperature (ºC)



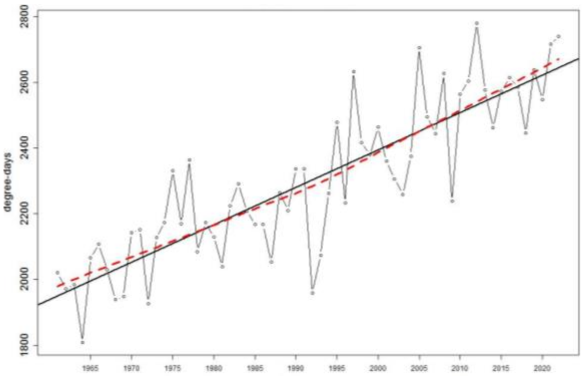
Number of “tropical” nights (days)



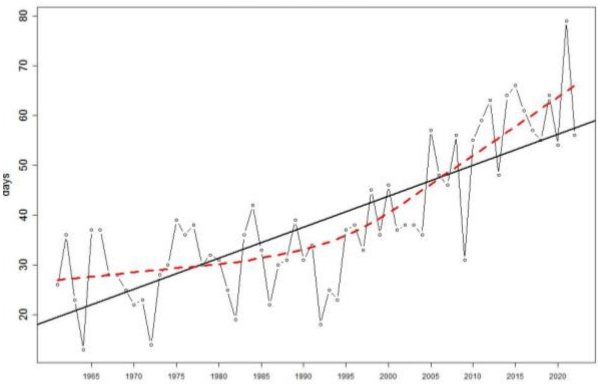
Duration of the vegetation period (T≥5 ºC, days)



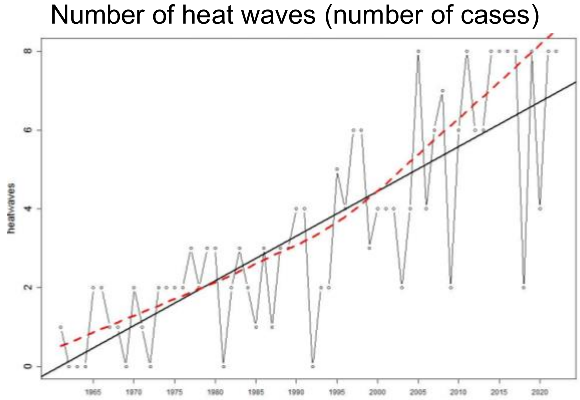
Sum of temperatures during the active vegetation period (T≥10ºC, degree days)



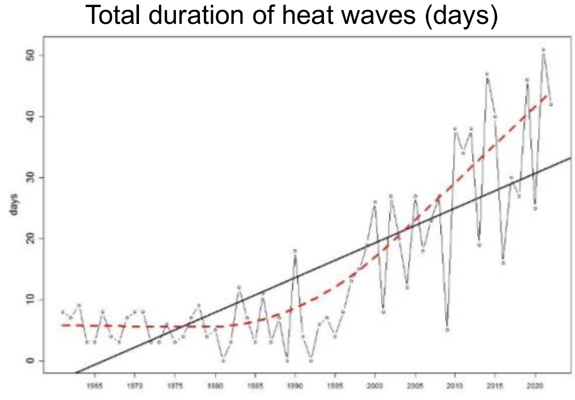
Number of extremely hot days (T≥35ºC, days)



Number of heat waves (number of cases)



Total duration of heat waves (days)



Peak temperature of the hottest heat wave (ºC)

Temperature difference between indoor (23ºC) and outdoor temperatures in warm season (degree days)

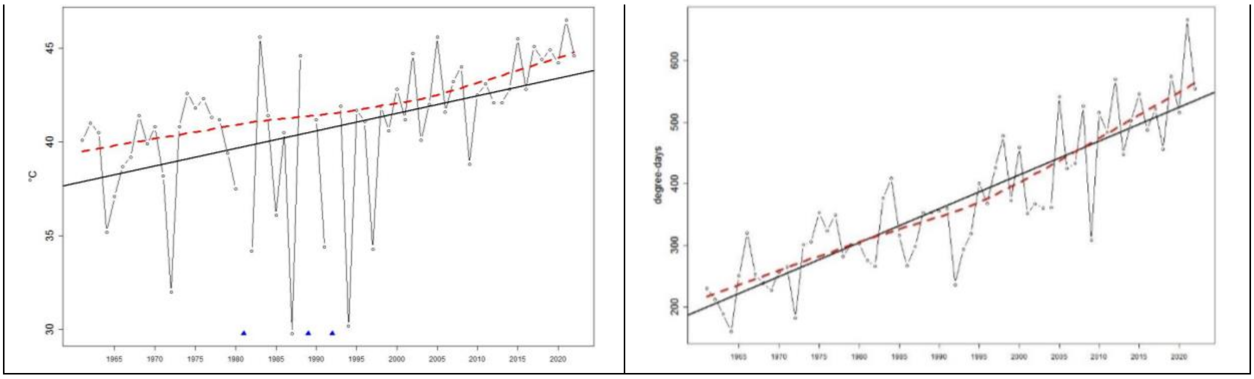


Figure 8. Change in some characteristics of the temperature regime in the warm period of the year according to the meteorological station in Kyzylorda (Source: Dolgikh S., 2023)

In contrast to the temperature regime, the precipitation regime has not changed practically for the last decades. But practically on the whole territory of Kyzylorda region there is a tendency to decrease the monthly amount of precipitation, so far, mostly weak, statistically not significant. There are also no stable trends in precipitation regime indices, which could affect changes in the moisture conditions of the region, such as:

- maximum daily precipitation;
- maximum precipitation for five consecutive days with precipitation;
- average daily precipitation intensity.

But it is always necessary to take into account the heterogeneity of precipitation in time, as can be seen in the figure below on the example according to the meteorological station of the city of Kyzylorda.

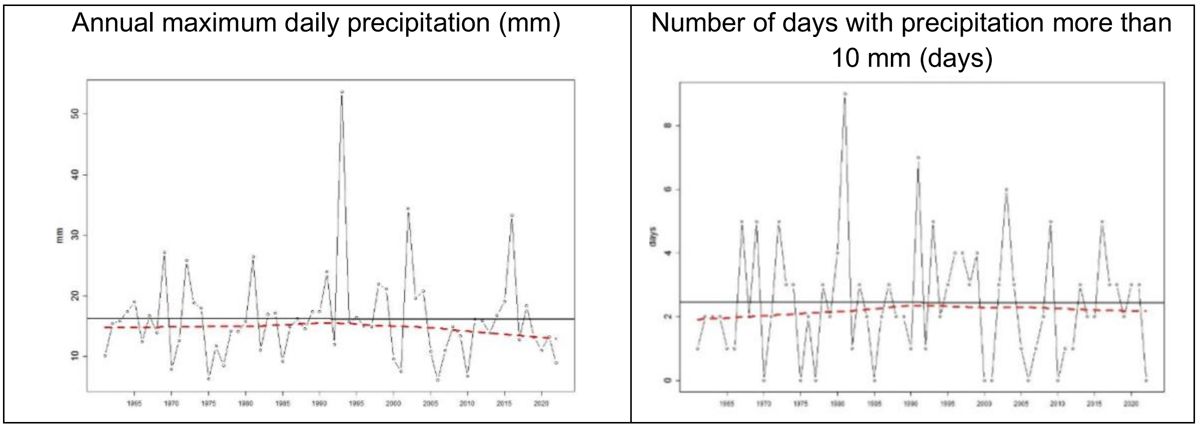


Figure 9. Change in some characteristics of precipitation regime according to the data of meteorological station in Kyzylorda city (Source: Dolgikh S., 2023)

The Sixth Assessment Report (AR6, 2021[20]) of the Intergovernmental Panel on Climate Change (IPCC: the Intergovernmental Panel on Climate Change) estimates that even if anthropogenic greenhouse gas emissions were to be drastically reduced now, global warming would continue due to the inertia of the Earth's climate system. The effects of climate change in the future may have both negative and positive consequences.[21] Given that the existing infrastructure has been built generally under the climatic conditions of past decades, climate change is mainly responsible for negative impacts, especially in arid regions, and often very significant ones. This is primarily due to an increase in the probability and intensity of heat waves and to changes in hydrological processes. In order to avoid the dangerous effects of climate

[20] https://www.ipcc.ch/report/ar6/wg1/

[21] https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

change, we need to act on two fronts: to reduce the impact on the climate system by reducing greenhouse gas emissions into the atmosphere, and to adapt to the changes already observed and expected. In order to adapt effectively, minimizing damage and taking full advantage of the benefits of climate change and its impacts on economic sectors, people and natural landscapes, estimates of likely climate change up to several decades in the future are needed.

In 1995, the CMIP project was launched under the auspices of the World Meteorological Organization's Working Group on Coupled Modeling (WGCM) (Coupled Model Intercomparison Project[22]). The goal of the CMIP project is to better understand past, present, and future climate changes resulting from natural variability or in response to changes in radiative forcing in the context of several models. This understanding includes evaluating the performance of models in experiments for the historical period and quantifying the causes of future climate change. An important goal of the CMIP project is to make the multi-model output publicly available in a standardized format. The first series of generic experiments involved comparing the response of the models to an idealized forcing - a constant rate of 1% CO_2 increase per year cumulatively. Subsequently, a series of CMIP experiments were developed. These now also include integration with estimates of changes in historical radiative forcing as well as estimates of future changes.

In order to develop climate projections for the territory of Kyzylorda region, the Internet platform of the Interactive Atlas[23] to the IPCC First Working Group (WGI) report "Climate Change 2021: Physical Science Basis" was used[24]. This platform, through the benefits of interactivity, provides a flexible and enhanced exploration of some of the key IPCC products underlying the assessment of various characteristics of likely climate change, including extreme event indices and climate forcing factors. On this web-based platform, the results of new and improved versions of the global climate models,[25] that participated in CMIP Phase 66 are computed.[26]

---

[22] https://www.wcrp-climate.org/wgcm-cmip

[23] *Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. 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, 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. In Press. Interactive Atlas available from Available from* http://interactive-atlas.ipcc.ch/

[24] https://www.ipcc.ch/report/ar6/wg1/

[25] IPCC, 2021: Annex II: Models [Gutiérrez, J M., A.-M. Tréguier (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, 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. 2087–2138, doi:10.1017/9781009157896.016.

[26] https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6

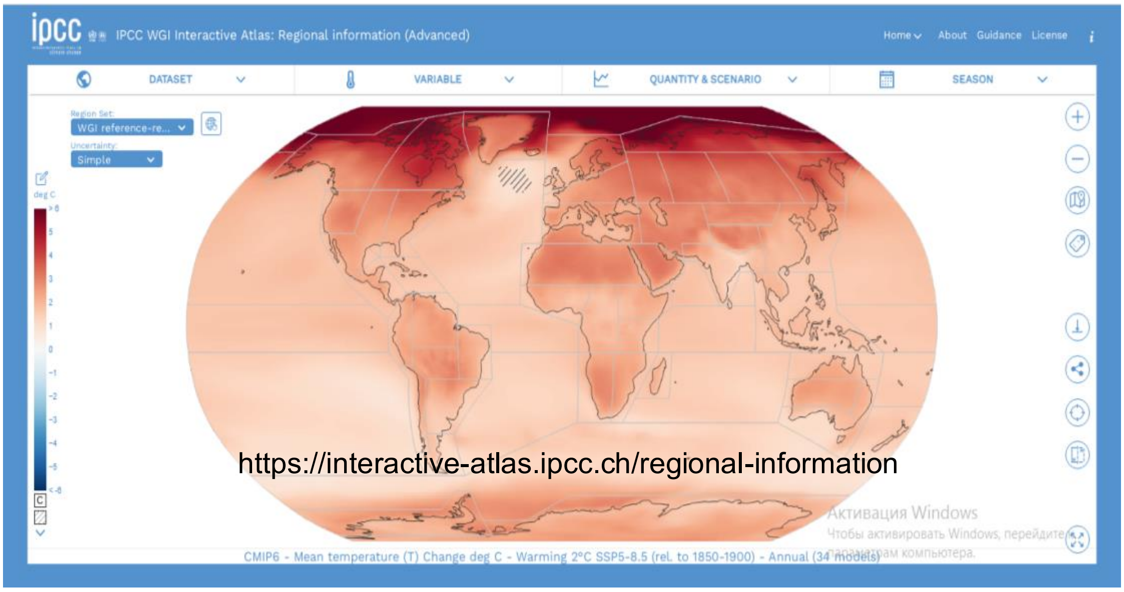


Figure 10. Interactive atlas on global climate change

Two scenarios were chosen to describe regional climate change - SSP2-4.5 and SSP5-8.5, which are a combination of projected socioeconomic pathways of global change (Shared Socioeconomic Pathways[27]) and representative pathways of greenhouse gas concentrations in the atmosphere (Representative Concentration Pathways). The characteristics of these scenarios are incorporated into global climate models as externalities to the climate system. These two scenarios are the focus of most studies of likely climate change.

Scenario SSP5-8.5 (extreme) reflects a pathway with high CO_2 emissions without climate mitigation, assuming that annual global emissions continue to rise throughout the 21st century. Scenario SSP2-4.5 (moderate) assumes systematic global action to reduce greenhouse gas emissions during the 21st century sufficient to stabilize their concentrations by about 2100.

Thus, according to the two scenarios some range of probable changes in a number of climatic characteristics on the territory of Kyzylorda region for the period up to 2100 is obtained:

- change in average monthly, seasonal and annual air temperature;
- change in monthly, seasonal and annual precipitation amount.

The range of increase of average annual and seasonal temperatures on the territory of Kyzylorda region by 2050 is 2.2-3.3ºC, by 2090 - increase by 3.2-3.8ºC according to the scenario SSP2-4.5, and much more significant increase - by 6.1-7.1ºC according to the extreme scenario SSP5-8.5.

[27] IPCC, 2021: Annex VII: Glossary [Matthews, J.B.R., V. Möller, R. van Diemen, J.S. 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, 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. 2215–2256, doi:10.1017/9781009157896.022.

Table 2. Expected air temperature increase (ºC) on average in Kyzylorda region according to scenarios SSP2-4.5 and SSP5-8.5 relative to the period 1986-2005.

Scenario	Year	Winter	Spring	Summer	Autumn
by 2050					
SSP2-4.5	2.4	2.5	2.5	2.5	2.2
SSP5-8.5	3.0	3.2	3.0	3.3	2.9
by 2090					
SSP2-4.5	3.5	3.8	3.3	3.7	3.2
SSP5-8.5	6.5	6.7	6.1	7.1	6.1

By the end of the current century, annual precipitation is expected to increase by 5.3-6.2% by mid-century and by 8.0-10.2% by 2090 relative to the period 1986-2005. Until the middle of the century, the largest increase in precipitation is expected in the winter period - by 12-13%, in the other seasons - by 1.4-5.3%. By the end of the century, the largest increase in precipitation shifts to the spring period, by 13.8-26.1%. During the summer and fall periods, a decrease in precipitation of about 6% is expected under the extreme scenario of SSP5-8.5, combined with a maximum increase in temperature. Taking into account that under current climatic conditions the Region receives very little precipitation (not more than 100 mm in most parts of the territory), an increase in annual amounts by 5-10% will not have a positive effect on the moisture conditions in the Region, and the combination of a significant increase in temperature and a decrease in precipitation amounts in the summer and autumn period may lead to their deterioration.

Table 3. Expected change in precipitation (in %) on average for Kyzylorda region under scenarios SSP2-4.5 (moderate) and SSP5-8.5 (extreme) relative to the period 1986-2005 (Source: Dolgikh S., 2023).

Scenario	Year	Winter	Spring	Summer	Autumn
by 2050					
SSP2-4.5	5.3	13.0	3.2	1.4	3.7
SSP5-8.5	6.2	12.1	5.3	5.3	2.1
by 2090					
SSP2-4.5	8.0	9.6	13.8	2.5	6.0
SSP5-8.5	10.2	26.1	26.1	-5.7	-5.7

There were also changes in other characteristics of the temperature and precipitation regime (in climatic indices) of interest for the economic sectors and population. The changes in the surface air temperature regime are associated with its increase:

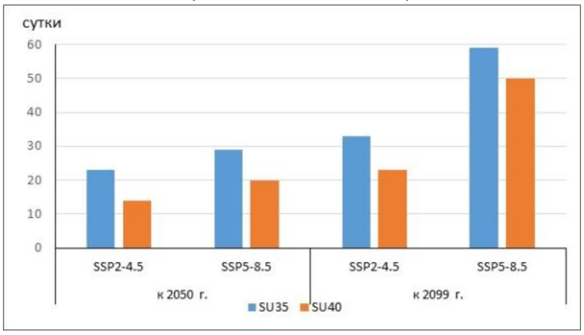
– The number of extremely hot days with temperatures above 35 and 40ºC could increase by 14-23 days by 2050 and by 23-33 days by 2090 under the moderate climate scenario. Under the extreme scenario, the number of such days could increase much more dramatically by the end of the century.

– Absolute annual maximums are expected to increase by 2-3ºC by 2050 and by 4-7ºC by the end of the century. The minimum temperature is expected to increase more significantly, by 4-6 and 6-11ºC.

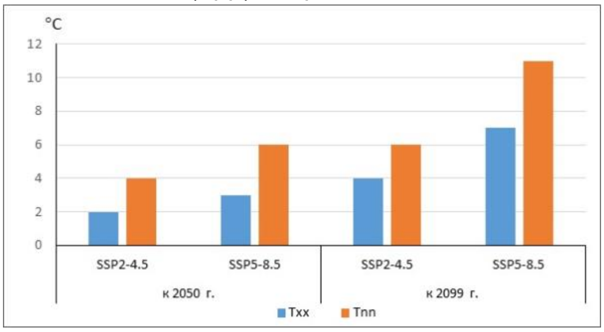
– At the same time, the number of days when the daily minimum temperature drops below 0ºC is expected to decrease by 23-30 days by 2050 and by 35-67 days by the end of the century.

– Such changes in the temperature regime lead to an increase in the temperature difference between outdoor and indoor comfort temperatures in the warm period of the year - by 291-384 degree-days on average by 2050 and by 444-898 degree-days by the end of the century. At the same time, the temperature difference between the temperature outside and comfortable indoor temperature in the cold period of the year is expected to decrease by 496-635 degree days on average by 2050 and by 725-1214 degree days by the end of the century. This leads to a decrease in the period of space heating. Moreover, due to a faster increase in minimum daily temperatures compared to the growth rate of maximum daily temperatures, the heating period will be reduced faster than the increase in the air conditioning period.

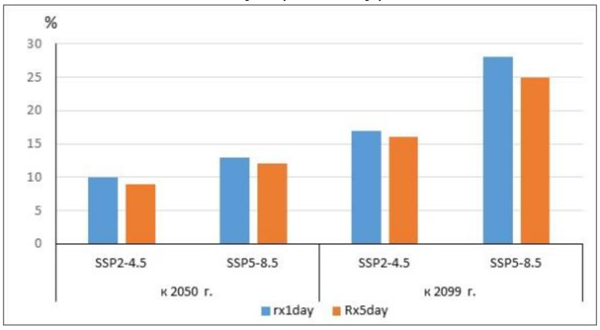
Number of extremely hot days (T≥35 ºC, T≥40 ºC)



Absolute annual maximum (Txx) and minimum (Tpp) temperatures



Amount of precipitation per day (rx1day) and 5 days (Rx5day)



Indoor/outdoor temperature difference between cooling (cddcold) and heating of rooms (hddheat)

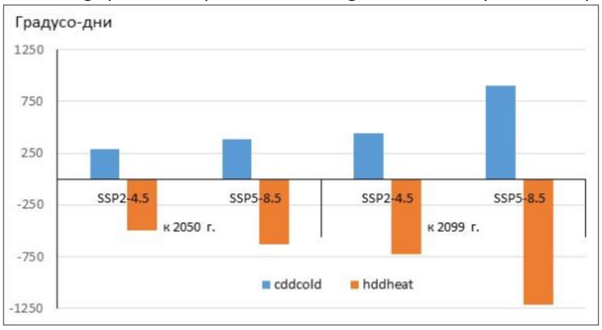


Figure 11. Probable change of climatic indices of air temperature and precipitation regimes on average in Kyzylorda region by 2050 and by 2090 according to scenarios SSP2-4.5 (moderate) and SSP5-8.5 (extreme). (Source: Dolgikh S., 2023)

Changes in the precipitation regime are not as unidirectional as in the temperature regime. For example, the annual maximum daily precipitation sum is expected to increase by 10-13% by 2050 and by 17-28% by the end of the century. The sum of precipitation over 5 consecutive days with precipitation could increase (Rx5day, in %) by 9-12% by 2050 and by 16-25% by the end of the century. Under current climate conditions, these characteristics of the precipitation regime have not changed much. At the same time, the duration of periods without precipitation is likely to increase slightly, by about 2 days by 2050 and by 7 days by the end of the century. Due to the reduction of the period with negative temperatures, annual precipitation in the form of snow will decrease - by 11-15 mm by 2050 and by 15-29 mm by the end of the century.

The main conclusion about likely climate change is that the increase in surface air temperature through 2050 and 2090 indicates a further significant increase in the region's thermal resources in all seasons of the year. Winters will be warmer and wetter. In contrast, many of the warmer months of the year will be drier.

Potential impacts of climate change. All obtained estimates of indicators of the current climate and its changes can either directly characterize heat or moisture resources, or can be used in sectoral models (hydrological, agrometeorological, etc.) to assess the impacts of climate change.

Impact on water management. Since water resources on the territory of Kazakhstan are very limited already under current climatic conditions, the nature of expected climate change - a significant increase in surface air temperature with a slight increase in annual precipitation - can exacerbate the problem of water resources shortage. The task of assessing the impacts of climate change on river flow and water resources is quite complex for many reasons, but very important from the point of view of ensuring sustainable development of any region.

According to the studies conducted during the preparation of the 7th National Communication of the Republic of Kazakhstan to the UN Framework Convention on Climate Change,[28] by the middle of the 21st century there may be an increase in river runoff in the Aral-Syrdarya water basin due to the process of water release by glacial systems in the runoff formation zone. By the end of the century, the runoff is likely to decrease by 13.7% on average due to the depletion of these glaciers.

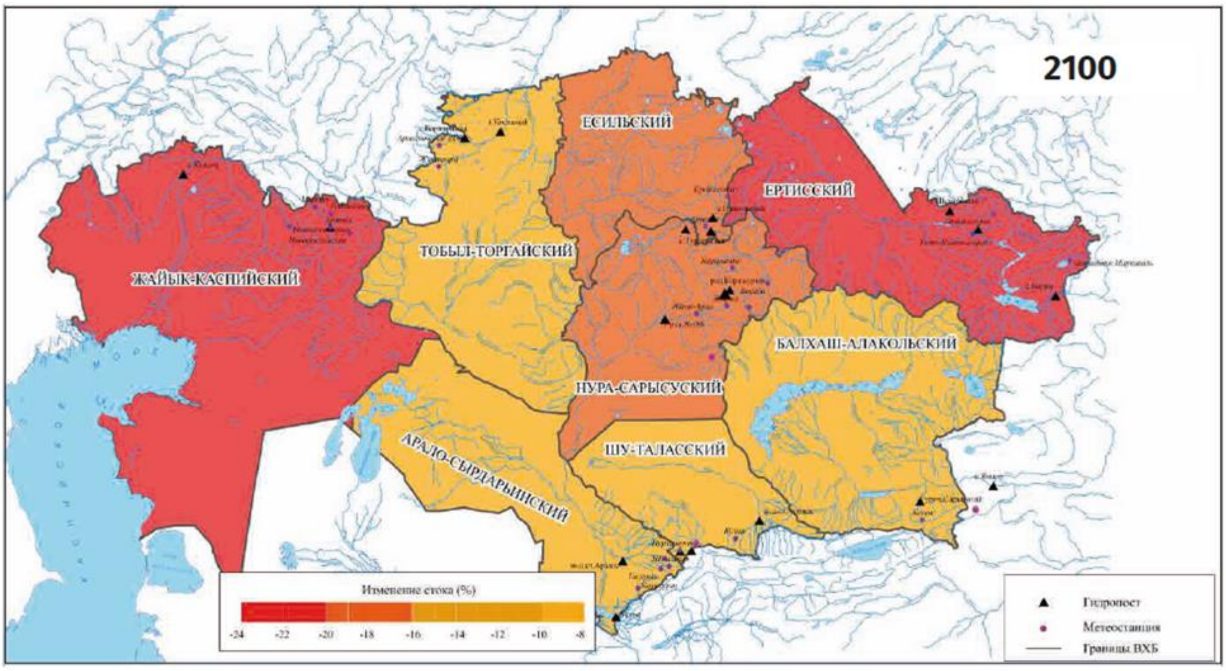


Figure 12. Assessment of the likely change in water resources of eight main water basins of the Republic of Kazakhstan under the RTC4.5 climate change scenario by 2050 (Source: 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change. Astana, 2017 - 304 pp.)

In preparation of the next 8th National Communication[29] based on modeling of changes in average annual water discharge of the Arys tributary of the Syrdarya River under the “moderate”

[28] 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.

[29] Babagalieva Z. Forecast of climate change impact on water flow changes in water management basins of the Republic of Kazakhstan for the period up to 2100 within the framework of the project on development of the Eighth National Communication of the Republic of Kazakhstan to UNFCCC and preparation of biennial reports. Nur Sultan. – 2021, 34 p. (https://www.undp.org/ru/kazakhstan/publications/прогноз-воздействия-изменения-климата-на-изменение-стока-воды-водохозяйственных-бассейнов-республики-казахстан-на-период-до 2100г.)

scenario SSP3-7.0, an increase in flow by 1% by 2050 and a decrease in flow by 12% by the end of the century were also identified.

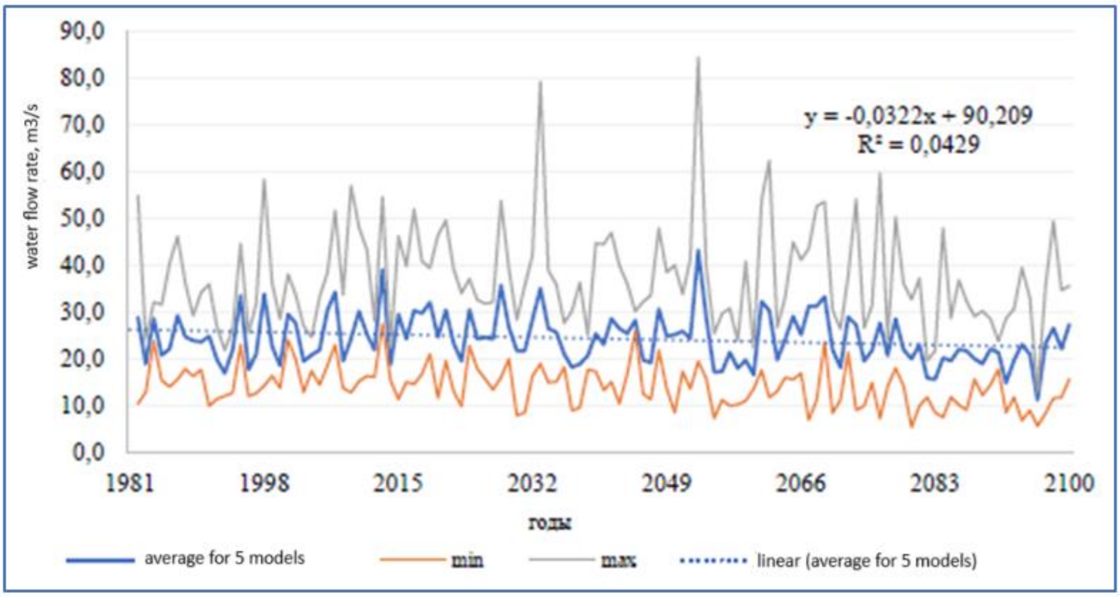


Figure 13. Change in mean annual water discharge up to the end of the century based on the results of five climate models for the "moderate" scenario SSP3-7.0 for the Aral-Syrdarya water basin (Source: Babagalieva Z. Forecast of climate change impact on water flow changes in water basins of the Republic of Kazakhstan for the period up to 2100 within the framework of the project on development of the Eighth National Communication of the Republic of Kazakhstan to the UNFCCC and preparation of biennial reports. Nur-Sultan. - 2021, 34 pp. (https://www.undp.org/ru/kazakhstan/publications/прогноз-воздействия-изменения-климата-на-изменение-стока-воды-водохозяйственных-бассейнов-республики-казахстан-на-период-до 2100г.))

Due to the increase in the average annual winter air temperature, the number and duration of thaws increases and the depth of ground freezing decreases. Because of this, melt water goes into the soil and does not fill rivers. Warm spring causes water to evaporate instead of entering rivers and reservoirs, changing the river regime.

Impact on agriculture. Under conditions of further climate warming until 2050 in Kazakhstan, moisture availability during the growing season will gradually deteriorate.[30] This is due to an increase in evapotranspiration due to an increase in air temperature. The expected climate change will lead to a northward shift of thermal zones and moisture availability zones. Compared to the current distribution of the K factor in 2050, the K factor isolines have some shift to the north. As a result, the zone of "Optimal and stable moisture availability" (K=1.0-1.2) will completely disappear in the north of North Kazakhstan region, and in the area of Kokshetau upland will significantly decrease in size. The northern boundary of the severely arid zone with a moisture coefficient K less than 0.4 will also shift to the north, i.e. by 2050 conditions in this zone will become even more arid.

[30] 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.

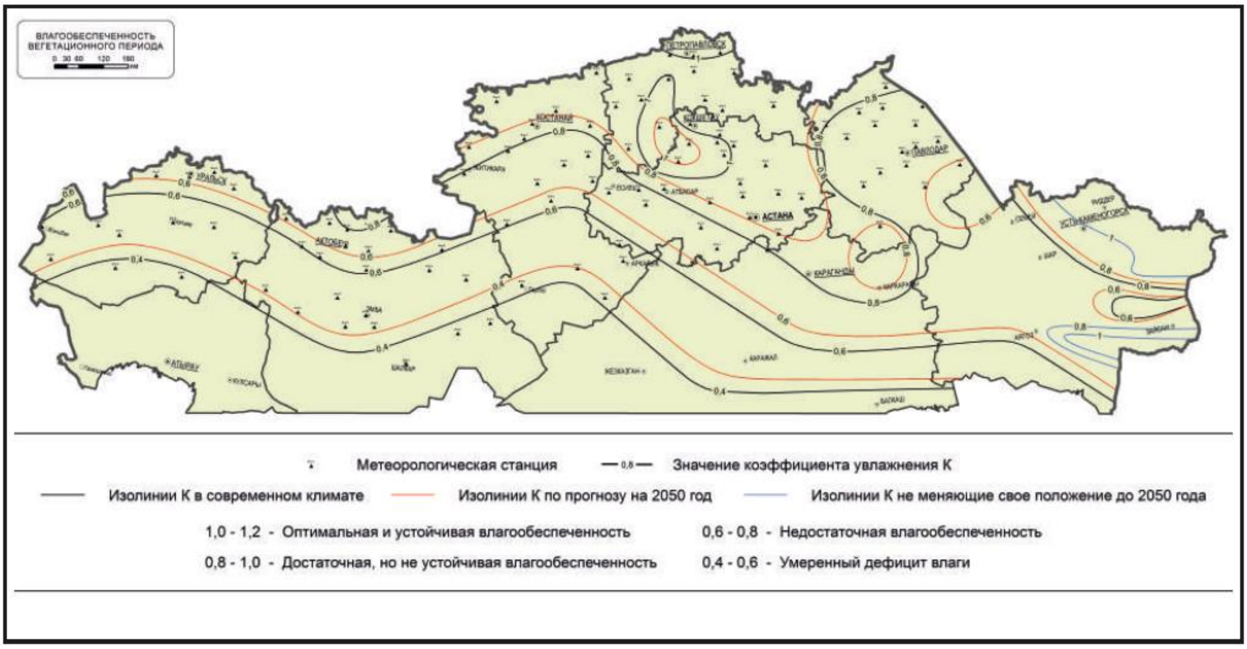


Figure 14. Forecast of moisture availability of the growing season in the northern half of Kazakhstan under 2050 climate conditions (Source: S.S. Baisholanov, 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.)

In the livestock sector of Kazakhstan, mainly due to the unfavorable impact of weather conditions, death of farm animals occurs. This may be due to severe frosts, heavy snowstorms, high snow cover, ice layer in the snow cover, return of cold weather after sheep shearing, heavy rains and hailstorms, severe heat and drought, etc. Besides, the terms of such important activities as grazing, calving, ferrying, insemination, shearing and buying of sheep are closely connected with climatic and weather conditions of the area.

A complex zooclimatic indicator of the cold period is the number of non-grazing days (NGD) for November-March, which depends on the characteristics of snow cover (height and density), air temperature, and wind velocity.

Reduction of days with temperatures below 0ºC leads to reduction of days with precipitation in the form of snow and to reduction of snow cover duration. On the one hand, this leads to a decrease in moisture accumulation in soils, which negatively affects spring moisture availability of pasture vegetation. On the other hand, the number of non-grazing days in the cold period of the year is reduced. If under current conditions the number of such days on the territory of the region from less than 2 in the south to 16 in the north, and in some severe winters they can be from 15 to 40 days[31], then under expected climate change by 2050 their number will be reduced: in the north of Kyzylorda region in Priaralie Karakum - by 3-4 days; in the southern sandy pastures of the region the number of non-grazing days will be reduced by 2 days.

[31] Baisholanov S.S. Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. Astana, 2017 - 128 pp.

Figure 15. Average number of non-grazing days per cold period of the year in the plain territory of southern Kazakhstan under current climatic conditions 1981-2015 (Source: 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.).

Table 4. Change in the number of non-grazing days (NGD) for sheep in Kyzylorda region by 2050 (in days from current conditions) under climate change scenarios RTC4.5 and RTC8.5. (Source: 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change. Astana, 2017 - 304 pp.)

Region	NGD in the current climate	Change in NGD by 2050	
		PTK4.5	PTK8.5
Aral Sea Karakum	14	-4	-5
Kyzylkum Sands	4	-2	-2

Spring shearing of sheep is carried out in the period of cessation of cold weather and onset of warm weather. It was established that for the southern half of Kazakhstan shearing of sheep should start after the date on which the sum of positive average daily air temperatures of 550°C is accumulated[32]. Premature shearing leads to poor quality wool, increased probability of disease and death of sheared sheep due to cold weather conditions. Under the current climate, spring shearing of sheep in the Kyzylkum sands is on average on May 1, in the Aral Karakum - on May 10. By 2050, shearing dates may slightly shift to earlier dates - by 2-4 days.

[32] Kozhakhmetov P.J. Meteorological conditions and method of forecasting of the beginning of spring shearing of sheep // KazNIGMI. KazNIGMI. 1990. Issue. 108. p.117-119.

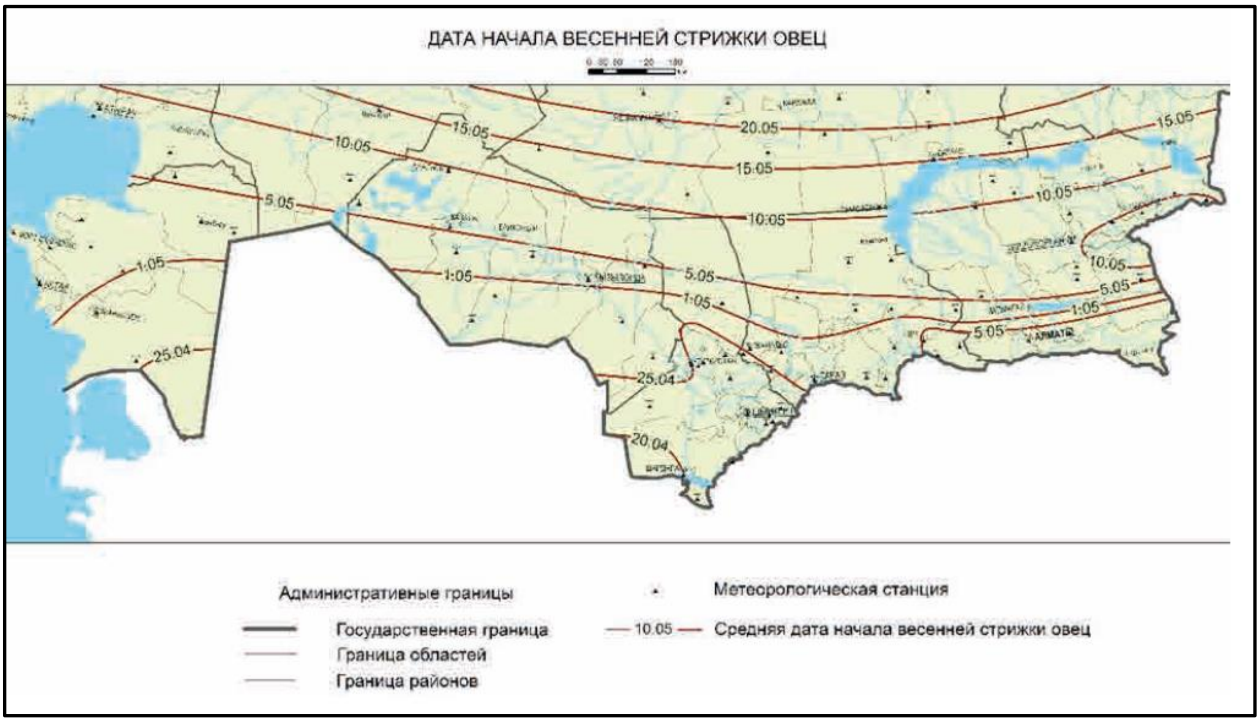


Figure 16. Average date of sheep shearing on the plain territory of southern Kazakhstan under current climatic conditions 1981-2015 (Source: 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.)

In the warm season, the limiting factor for sheep grazing is the duration of the sustained hot period (SHP). Hot weather, characteristic at this time of the year in Kyzylorda region, depresses animals and leads to a decrease in their weight. In modern climatic conditions from the south to the north of Kyzylorda region for coarse-wool sheep the duration of the SST decreases from 70 to 40 days. Under the expected climate change by 2050, their number may increase: for fine-fleece sheep - by 13-15 days in the Aral Karakum and 15-17 days - in the Kyzylkum sands; for coarse-wool sheep - by 7-8 days in the Aral Karakum and 10-11 days - in the Kyzylkum sands.

With the onset of a stable hot period, animals should be moved to more favorable pastures, i.e. to more northern areas and mountain pastures. The average multiyear date of the beginning of SHP, and hence the date of ferrying, in Kyzylorda region for fine-fleece and coarse-wooled sheep breeds falls in Kyzylkum for the period from May 15 to 20 (June 5-10), in Karakum sands - on June 1 (June 20). By 2050, the ferrying dates may shift to earlier dates by about 7 days.

Important characteristics of pasture lands, depending on weather conditions, are yield and livestock capacity of pastures (number of animals (heads) per 1 ha of area that can be fed during one month or during the whole pasture period), as well as optimal load on pastures. In well-moisturized years, pasture yields are much higher than in dry years.

Future modeled air and precipitation temperatures were used to project pasture plant yields under climate conditions through 2050[33]. The increase in air temperature in mid-summer under conditions of high moisture deficit will lead to earlier burnout of pasture plants and lengthening of their summer dormancy. Pasture yields are expected to decrease according to data from the Karak and Zlich meteorological stations and by 2050 will be 76-84% of the current level (4.2-4.3 c/ha).

[33] 8th National Communication and 5th Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2022 - 514 pp.

The expected decrease in pasture productivity will naturally lead to changes in livestock capacity and optimal pasture load. Based on expected pasture yields by 2050, a significant decrease in livestock intensity and an increase in optimal pasture load is projected, which implies an increase in the area of pasture required for grazing a flock of sheep. Livestock intensity will be 1.6-1.8 heads per 1 ha against 2.0-2.1 heads per 1 ha. The optimal load will increase from 0.48-0.49 ha/head to 0.57-0.63 ha/head.

Calculation of economic losses under the forecast of livestock intensity reduction under scenarios RTC4.5 and RTC8.5 for Kyzylorda region, performed by LLP "Kazakh Research Institute of Agro-Industrial Complex Economy and Rural Development"[34] showed that by 2050, they may amount to 14.5-21.9% in 2019 prices.

With the expected increase in air temperature, net irrigation rates will exceed their current values by 2050. At the same time, the value of net irrigation rate growth increases with the growth of crop heat demand, i.e. the greatest growth of irrigation rate is observed for crops with longer growing season. This will require the use of more water in irrigated agriculture than at present. The expected growth of crop net irrigation rate in the southern regions of Kazakhstan indicates the vulnerability of irrigated agriculture to climate change.

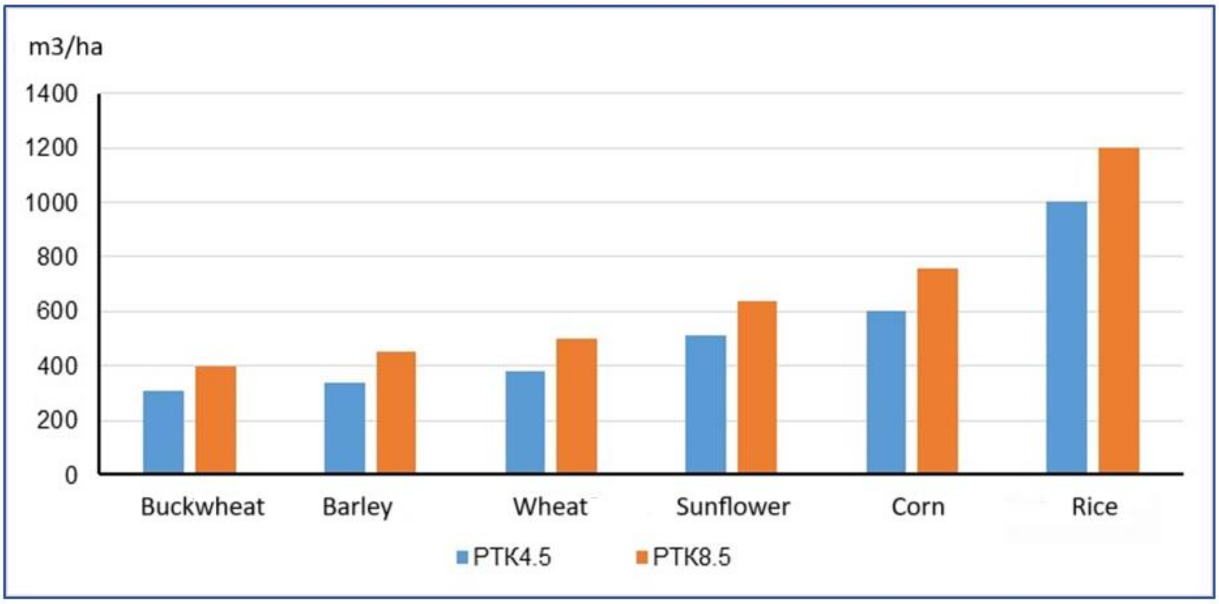


Figure 17. Change in the Kyzylorda region average net irrigation rate of the region's crops by 2050 under RTC4.5 and RTC8.5 scenarios relative to current rates, m3/ha (Source: 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change. Astana, 2017 - 304 pp.)

In summarizing the results of studies on the impact of climate change on agriculture, potential negative and positive impacts of climate change can be distinguished.[35]

Positive consequences:

- lengthening of the growing season
- increase in heat resources during the growing season
- удлинение беззаморозкового периода

[34] Development of cost norms per unit of the main types of agricultural products of crop and livestock // Kazakh Research Institute of Agroindustrial Complex Economy and Rural Development LLP - Almaty, 2009. - p.332.

[35] III-VI National Communication of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. - Astana, 2013. - p.274

- increase in air temperature during the cold period of the year
- early start of spring vegetation growth
- increase in atmospheric CO_2 content necessary for photosynthesis

Negative consequences:

- increase in the number of days with high air temperature
- decrease in moisture availability during the growing season
- shift of moisture zones to the north
- increase in the share of heavy precipitation
- increase in the number of hail events
- increase in the frequency of anomalously cold winters and hot years
- increase in inter-annual and intra-seasonal variability of weather regime
- early burnout of natural vegetation
- increased aridity of the climate and increased recurrence of drought
- shortening of the period with snow cover
- development of infectious diseases, pests and weeds
- shifts in the timing of phenological events in plants, boundaries of vegetation zones

In the case of livestock production in South Kazakhstan we can expect:

- mitigation of weather conditions for winter housing of farm animals by 30-40% (positive effect)
- earlier onset of spring shearing of sheep - by 3-5 days
- increasing the duration of the period with stable hot weather for sheep by 15-25% (negative effect)
- earlier onset of sheep moving to summer pastures by 7-8 days.

Impact on public health. The following ratio determining the degree of influence of various factors on human health is generally accepted: 50% - lifestyle, 20% - environmental situation (climatic conditions can also be included), 20% - hereditary factors and 10% - the state of the health care system.

The list of climate change impacts that can affect the health of the population has been researched in some detail[36] and is presented in various reports and methodologies of different international organizations[37] for assessing the health impacts of climate change.

In 2010-2012, the Ministry of Health of Kazakhstan supported by the World Health Organization (WHO) and the Ministry of Environment, Nature Protection and Nuclear Safety of the Federal Republic of Germany conducted the first large-scale study on “Impacts, vulnerability and assessment of adaptive capacity of the health care system of the Republic of Kazakhstan to climate change”.[38]

The main impacts of climate change in Kazakhstan were identified as adverse weather events, changes in air quality, flood and mudflow hazards, heat waves (and consequent drought and fires), lack of safe drinking water.

---

[36] https://gfcs.wmo.int/sites/default/files/Fact_Sheets/Health/GFCS_healthflyer_ru.pdf

[37] 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://documents1.worldbank.org/curated/en/552631515568426482/pdf/122328-WP-PUBLICWorldBankClimateChangeandHealthDiagnosticMethodologyJan.pdf

[38] Impacts, vulnerability and assessment of adaptive capacity of the health care system of the Republic of Kazakhstan to climate change. Astana. - 2012. - 49 p.

Figure 18. Direct and indirect health impacts of climate change (Source: Impacts, vulnerability and assessment of adaptive capacity of the health system of the Republic of Kazakhstan to climate change. Astana. - 2012. - 49 p.)

Research on the impact of climate change on public health was continued with the support of UNDP as part of the preparation of the 8th National Communication of the RK on Climate Change.[39] According to climate change scenarios, Kazakhstan may experience a change in geographical zones, an increase in arid zones, a shortage of water resources, deterioration of conditions for agriculture, possible changes in seasonality and areas of spread of some infectious diseases, an increase in extreme weather events, an increase in air, water and food pollution. The health effects of climate change can be both favorable and negative.

Scientific studies confirm an increase in both direct and indirect impacts of climate change on human health and the health system. Negative health impacts of climate change may include worsening of infectious diseases, cardiovascular diseases, respiratory diseases, injuries and mental health issues.

When selecting nosologies for study, the relevance of the problem for the current health care system of Kazakhstan was taken into account. The following diseases and conditions potentially affected by climate change are represented in the Republic:

1) injuries, poisonings, accidents;
2) diseases of the circulatory system: arterial hypertension, myocardial infarction, strokes;
3) diseases of the respiratory system: bronchitis, bronchial asthma, allergic reactions;
4) infectious diseases: cholera, dysentery, acute intestinal infections, tick-borne encephalitis, malaria;
5) mental disorders: exacerbation of existing mental illnesses, depression, anxiety-depressive disorders, post-traumatic stress disorder.

[39] 8th National Communication and 5th Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2022 - 514 p.

Weather conditions affect air quality through the transport and/or formation of pollutants (or their precursors). They can also affect both biogenic emissions of atmospheric pollutants (e.g. pollen production) and anthropogenic emissions (e.g. caused by increased energy demand).

An increase in the number of days with abnormally high temperatures and periods of stable, prolonged hot weather causes an increase in morbidity and mortality from cardiovascular diseases. Such days are also associated with an exacerbation of existing cardiovascular diseases such as angina pectoris, chest pain, headache, dizziness, nausea, fatigue etc. The incidence of diseases of the circulatory system in Kyzylorda region exceeds the average republican indicators. The most at-risk groups include young children, people of retirement age, as well as people whose occupations involve being outdoors and people with low incomes. In addition, even in healthy people, prolonged and intense heat can lead to significant health problems with heat stroke, sunstroke, muscle cramps, and vasospasms.

Respiratory diseases - this is one of the most common reasons with which people turn to the doctor. This group of diseases includes quite a large number of different pathologies with different clinical picture and causes of occurrence. Various environmental factors (including pollutants), bacteria, viruses, fungi, various allergens, including plant pollen, the content of which in the atmosphere may significantly increase due to the lengthening of the growing season, can be the cause of respiratory diseases.

Many infectious diseases are sensitive to either temperature or precipitation and in many places are characterized by marked seasonal variations. The incidence of many intestinal infectious diseases peaks during the hottest months of the year. Climate change can have a very large impact on water resources and their sanitation where there has been a reduction in water supply and water availability. Episodes of drought can cause increased concentrations of pathogens in reservoirs that store water. In addition, water shortages may necessitate the use of inferior quality freshwater sources. The frequency and extent of drinking water contamination can be affected by rainfall and especially heavy downpours. Increased rainfall can cause flooding and inundation of sewage systems. All these factors can lead to an increase in the incidence of intestinal infections.

Natural disasters, such as floods or heavy rains, increase the risk of deteriorating sanitation conditions for people exposed to natural hazards. This situation may lead to increased incidence of infectious diseases with fecal-oral transmission: cholera, hepatitis A, amebic and bacterial dysentery. Climate change can affect the growth, survival, resistance, transmission or virulence of pathogens. Hepatitis A outbreaks may occur after floods or prolonged rainfall, particularly where water supplies are partially or completely destroyed.

The following trends were identified during the assessment of climate-influenced diseases:

1. Exceeding the rates of mortality from accidents, injuries and poisoning in rural areas, similar to the rates among urban residents.
2. Increase in morbidity rates for diseases of the circulatory system in general.
3. Increase in morbidity rates of arterial hypertension.
4. Increase in morbidity rates of acute myocardial infarction.
5. Increase in the incidence of strokes.
6. Excess of mortality rates from respiratory diseases in rural areas, similar to mortality rates from this pathology among urban residents.
7. Increase in morbidity rates of bronchial asthma.
8. Prevalence of women living in urban areas among the total number of people suffering from bronchial asthma.
9. Decrease in the incidence of bacterial dysentery and acute intestinal infections.
10. Decrease in the incidence of mental disorders.

Thus, at the moment we can see an increase in the incidence of diseases, the occurrence and exacerbation of which may be associated with climate change, but it is difficult to confirm this link, since the development of diseases may also be influenced by living in an environmentally unfavorable area, bad habits, heredity, ignoring existing screening medical programs, remoteness from medical organizations or, conversely, improving the quality and accessibility of medical care, which can increase the detection of diseases. Thus, a certain trend can be seen at present, but climate change cannot be considered the sole cause of these changes, so the conclusions drawn are probabilistic and require further study and confirmation.

KEY FINDINGS

- Climate is a strategic natural resource, on a par with mineral, land, forest, water and other resources.
- Now the climate familiar to us is changing rapidly: the last 5 years and the last 10 years have become the warmest in the history of observations.
- The climate of Kazakhstan and Kyzylorda region is warming at a more accelerated rate than the average for the globe.
- Global and regional climate projections suggest a continued warming trend in the future.
- Climate changes are and will be heterogeneous across the territory and seasons of the year.
- Climate change affects all spheres of human activity and ecosystems, adaptation is already necessary.

MAIN RECOMMENDATIONS TO IMPROVE HYDROMETEOROLOGICAL SERVICES

- Identify priority needs for expanding the network of agrometeorological and hydrological observations in Kyzylorda region. For example, it is necessary to establish hydrological measurements at most large hydraulic structures.
- Improve agrometeorological, hydrological and meteorological forecasts.
- Improve the availability of hydrometeorological forecasts and, in general, hydrometeorological information to consumers at the region, district and local levels.
- Improve the interaction of the hydrometeorological service with end users - feedback to improve the quality of use of hydrometeorological information, on the one hand, and to increase the level of consumer satisfaction with a variety of hydrometeorological products on the part of the hydrometeorological service.
- Establishment of a sectoral hydrometeorological institute (similar to the previously existing Kazakh Research Hydrometeorological Institute - KazNIGMI) to improve, in particular, hydrometeorological forecasting products of various advance (from day to season) and development of climate projections for decades ahead.
- Conduct climate change vulnerability assessments and take them into account in sectoral and territorial development plans, as provided for in Chapter 22 “State Management in the Sphere of Adaptation to Climate Change” of the Environmental Code of the Republic of Kazakhstan (dated January 2, 2021, No. 400-VI of the Law on Climate Change).[40]

[40] http://adilet.zan.kz/rus/docs/K2100000400

Table 5. Rate of change in climate index values between 1961 and 2022 (linear trend coefficient expressed in 10-year change) (Source: Dolgikh S., 2023).

Statistically significant changes in indices at the 0.05 level of statistical significance are highlighted in bold font

Definition and designation index	**Meteorological station**							**Sector concerned**
	Aral Tenisi	Kazaly	Karak	Kyzylorda	Zlikha	Zhosaly	Shieli	
Number of days in a year with frost when the daily minimum temperature is <0 ºC (FD0, day)	-1,9	-2,0	-3,0	-4,4	-1,3	-2,7	-3,7	- health care - agriculture - transportation (ice) - energy sector
Number of days per year with hard frosts, when the daily minimum temperature < -2 ºC (tnltm2, day)	-1,7	-2,1	-2,7	-4,0	-1,6	-2,3	-4,6	- agriculture - transportation (ice) - water resources - utilities - power industry
Number of days per year with hard frost, daily minimum temperature < -20 ºC (tnltm20, day)	-2,2	1,5	-1,5	-1,5	-1,4	-1,7	-0,8	- health care - animal husbandry - transportation - social sphere - energy sector - emergency situation - public utilities
Absolute annual maximum temperature (txx, ºC)	0,7	0,2	0,4	0,6	0,2	0,5	0,5	- health care - emergency situation - agriculture - energy sector - utilities - transportation infrastructure - tourism
maximum of daily minimums (TNx, ºC)	0,3	0,1	0,3	0,7	0	0,2	0,6	- health care
Number of “tropical” nights with daily minimum temperature > 20 ºC (tr, day)	2,8	1,9	4,2	6,6	0,8	2,8	4,2	- healthcare (no nighttime chill) - agriculture

Definition and designation index	Meteorological station							Sector concerned
	Aral Tenisi	Kazaly	Karak	Kyzylorda	Zlikha	Zhosaly	Shieli	
Growing season length - annual number of days with average daily air temperature > 5ºC (GSL, days)	2,4	2,5	3,4	3,7	2,6	3,2	3,1	- agriculture - public services (landscaping) - agriculture - water management - utilities (landscaping)
Sum of temperatures during the active growing season - with average daily air temperature > 10ºC (gddgrow10, degree days)	84,6	47,6	81,4	113,8	50,4	66,1	93,4	
Daily amplitude of air temperature (dtr, ºC)	0,2	0	0	0	0,3	0,1	-0,1	- health care - agriculture
Annual number of days with daily maximum temperature > 35ºC (SU35, days)	5,7	2,0	3,8	6,2	3,9	4,2	5,3	- health care - emergency situation - energy sector - agriculture - transportation infrastructure - tourism
Maximum duration of heat wave in warm period (HWD, day)	0,8	0,5	0,7	1,1	0,7	0,6	0,8	- health care - emergency situation - energy sector - agriculture/ - water management - transportation infrastructure
Peak daily value in the hottest heat wave in the warm period (Tx90.HWA, °C)	1,1	0,6	0,6	0,9	0,5	0,7	0,8	
Number of heat waves during the warm season (HWN-Tx90, number of cases)	0,8	0,3	0,5	1,0	0,5	0,6	0,8	
Total duration of heat waves in the warm period (HWF-Tx90, days)	4,4	1,8	3,0	5,7	2,8	3,7	3,8	
Sum of the difference between the average daily temperature outside and the desired indoor temperature (in this case 20 ºC) to be compensated by space heating (hddheat20, degree days)	-104	-90	-106	-129	-98	-100	-93	- health care - energy sector - household expenditures for heating

Definition and designation index	Meteorological station							Sector concerned
	Aral Tenisi	Kazaly	Karak	Kyzylorda	Zlikha	Zhosaly	Shieli	
Sum of the difference between the average daily outdoor temperature and the desired indoor temperature (in this case 23ºC) to be compensated for by cooling the premises (cddcold23, degree days)	38,2	16,5	35,8	54,9	16,4	29,5	41,2	- health care - energy sector - household spending on electricity
Annual precipitation (prcptot, mm)	0,1	0	-5,1	1,7	-2,8	1,6	3,1	- agriculture - water industry - health care - public utilities - emergency situation - tourism
Annual maximum daily precipitation (rx1day, mm)	-0,4	-0,4	-0,2	0	-0,8	-0,7	-0,3	- agriculture - water management - emergency situation - utilities
Maximum precipitation for 5 consecutive days with precipitation (Rx5day, mm)	-0,54	-0,01	-0,69	-0,08	-2,1	-0,79	-1,78	
Annual average daily precipitation intensity (sdii, mm/day)	0,1	0,1	0	0	-0,1	0	0	

Table 6. Expected changes in climatic indices of air temperature and precipitation regimes on average in Kyzylorda region by 2050 and by 2099 under scenarios SSP2-4.5 (moderate) and SSP5-8.5 (extreme) (Source: Dolgikh S. 2023)

Definition and designation of index	by 2050		by 2099		Industries concerned
	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	
Sum of the difference between the average daily outdoor temperature and the desired indoor temperature to be compensated for by cooling the premises (cddcold, degree days)	291	384	444	898	- health care - energy sector - household spending on electricity
Sum of the difference between the average daily temperature outside and the desired indoor temperature (in this case 20ºC) to be compensated by space heating (hddheat20, degree days)	-496	-635	-725	-1214	- health care - energy sector - household expenditures for heating
Annual number of days with daily maximum temperature > 35ºC (SU35, days)	23	29	33	59	- health care - emergency situation - energy sector - agriculture - transportation / transport infrastructure - utilities
Annual number of days with daily maximum temperature > 40ºC (SU40, days)	14	20	23	50	
Annual absolute maximum temperature (Txx, ºC)	2	3	4	7	
Annual absolute minimum temperature (Tnn, ºC)	4	6	6	11	
Number of days in a year with frost when the daily minimum temperature is <0 ºC (FD0, day)	-23	-30	-35	-64	
Annual maximum daily precipitation (rx1day, in %)	10	13	17	28	- agriculture - water industry - emergency situation - public utilities
Maximum precipitation for 5 consecutive days with precipitation (Rx5day, in %)	9	12	16	25	
Annual total annual solid precipitation (snow, mm)	-11	-15	-15	-29	
Maximum annual sequence of days without precipitation (CDD, days)	0.5	1.7	1.7	7.5	

WATER RESOURCES IN THE KAZAKH PART OF THE ARAL SEA BASIN

Water resources of the Syrdarya River amount to 37.4 cubic km (38.4 cubic km according to the Compendium). In the collection of average annual data are determined on the basis of analysis of hydrological series for 1974-1991. The length of the river is 2212 km (according to other data, 2137), from the source of the Naryn - 3019 km. The main volume of its flow is formed in the upper part of the basin on the territory of the Kyrgyz Republic in the basins of the Naryn and Karadarya rivers.

Figure 19. Syrdarya River Basin (Source: Scientific Research Center of the Interstate Commission for Water Coordination)

The Naryn River is the largest tributary with an average perennial flow of 14.6 cubic kilometers (10.6 - 19 cubic kilometers)[41] and an average annual discharge of 500 m3/sec. The average annual discharge of the Karadarya River[42] is 120 m3 /sec.

These two rivers join on the territory of Uzbekistan and form the Syrdarya River. Then it flows through the territories of Uzbekistan, Tajikistan and Uzbekistan again, and only then enters Kazakhstan. The average annual flow rate of the Syrdarya River after the inflow of the Chirchik tributary is 724 m3/sec.

The tributaries of the Syrdarya River in the Fergana Valley are intercepted and redistributed by the Big Fergana, South Fergana, North Fergana and Namangan canals and do not give their water to the Syrdarya River during the growing season. The runoff of many small tributaries of the Syrdarya is used for irrigation and does not reach the Syrdarya.

The Angren (Ahangaran), Chirchik and Keles rivers flow into the Syrdarya in its middle reaches (from the Farkhad Mountains to Shardara).

[41] Alamanov S. Transboundary water resources of Kyrgyzstan. 2015

[42] Water resources of the Kyrgyz Republic. 2012. Materials from www.eco.kg.

Figure 20. Chirchik and Ahangaran river basins (Source: Scientific Research Center of the Interstate Commission for Water Coordination)

Ahangaran is a river in Uzbekistan, a right tributary of the Syrdarya, with an average annual flow of 0.72 km3. It originates under the Boshravat Pass (other name - Jirdan) at the confluence of the Aktashsay and Urtalyksay, flowing from the southern slopes of the Chatkal Range. The length of the river together with Aktashsay is 236 km, and the basin area is 7710 km². The average water discharge is 22.8 m³/sec.

The Chirchik River is formed at the confluence of the Chatkal and Pskem rivers. The length of the Chirchik River is 155 km and the basin area is 14.9 thousand km². The river has several tributaries, all of which come to the upper part of its valley, fringed by mountains.

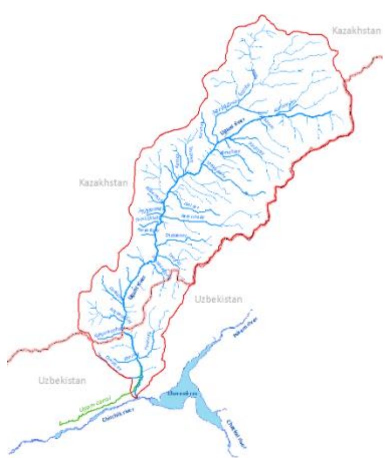


Figure 21. Ugam River Basin (Source: Scientific Research Center of the Interstate Commission for Water Coordination)

The largest of them are the transboundary Ugam and Aksakatasai. The average annual discharge of the Chirchik River at the exit from the mountains is 224 m^3/s. The average annual flow of the Chatkal

River is 100 m^3/s. Average annual discharge of the Pskem River - 82.2 m^3/s, including the Maidantal River - 15.0 m^3/s, Oigaying River - 27.9 m^3/s[43]. The average annual discharge of the Ugam River is 20.9 m^3/s and the Aksakatasai River is 6.14 m^3/s.

Within the Republic of Kazakhstan, the main tributaries of the Syrdarya River are the Keles, Arys and Bogen Rivers. Each of these rivers has a developed river system with large and small tributaries.

The Keles River originates on the Korzhyntau and Kazygurt mountain ranges. It is formed from the confluence of the rivers Zhuzumsai and Zhegerensai. The length of the river is 241 km and the basin area is 3310 km². Feeding is mixed, predominantly snow, also rain. The water flow rate at the outlet to the plain (in Gorny settlement) is 5.72 m³/s, at the mouth - 6.5 m³/s.

Further downstream, the Syrdarya flows along the eastern and northern margins of the Kyzylkum sands; the river channel here is winding and unstable, and floods are not uncommon in the winter-spring period.

Figure 22. Arys River Basin (Source: Google)

The Arys River is a major tributary. The Arys is a river in the south of Kazakhstan, a right tributary of the Syrdarya. The length of the river is 378 km and the basin area is 14,900 km². It flows through the territory of Turkestan and Zhambyl regions. The river originates near Aksu-Dzhabaglin reserve from springs on the Talas Alatau ridge and Karatau mountain systems. The main tributaries are Badam, Aksu and Boraldai. The Arys falls into the Syrdarya River near the Talapty aul. Its character is mountainous in the upper reaches, and in the lower reaches it changes to plain. It belongs to the rivers of snow and rain feeding. The average water discharge at Arys is 46.6 m³/sec. The highest flow is in April, the lowest is in August[44].

The Bogen River is formed at the confluence of the Kattabogen and Balabogen rivers and, before reaching the Syrdarya River, flows into the small Kumkol Lake. The river is fed by snow and

[43] Chirchik (river) - Wikipedia
[44] Arys (river) - Wikipedia

groundwater. Its length is 164 km and its catchment area is 4680 km2. The main tributaries are the Shayan and Sasyk rivers. In the middle part of the Bogen River the Bogen Reservoir was built[45]

At its mouth, the Syrdarya forms a delta (near the town of Kazalinsk) with numerous channels, lakes and swamps.[46]

Regulation and use of river water resources. After the disintegration of the Soviet Union, the Syrdarya and Amudarya rivers moved from the category of internal to the category of transboundary rivers. Large water management and hydropower facilities, such as reservoirs with hydroelectric power plants, large hydro-technical nodes of water intake and distribution, in accordance with their territorial location were transferred into the ownership of the newly formed Aral Sea basin states.

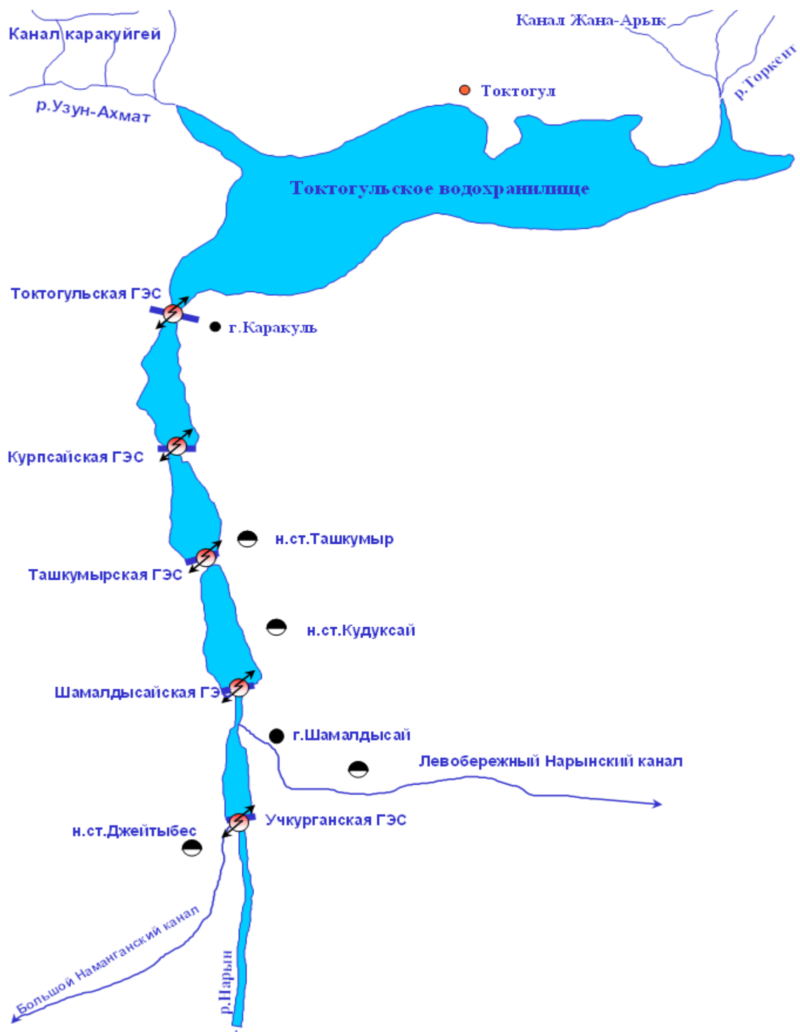


Figure 23. Nizhne-Naryn HPP Cascade (Source: Scientific Research Center of the Interstate Commission for Water Coordination)

---

[45] Surface Water Resources of the USSR, Volume 14. Central Asia. Vol. 1, Syrdarya River Basin. L., Gidrometeoizdat, 1969. 439 pp.

[46] Syrdarya River Water Resources Handbook.
Wikipedia material.

At the same time, problems have arisen in the management of water management facilities located on the border lines between the states. For example, in the Syrdarya river basin, the Farkhad hydrosystem is located on the territory of Tajikistan, while the HPP is located on the territory of Uzbekistan; the Andijan HPP belongs to Uzbekistan, but its reservoir is located on the territory of Kyrgyzstan.

In addition, water supply to South Kazakhstan depends on the operation of the Toktogul (Kyrgyzstan), Kayrakkum (Tajikistan), Charvak (Uzbekistan) reservoirs, as well as interstate canals passing through Uzbekistan.

The collapse of the Union of Soviet Socialist Republics (1991) led to the destruction of economic-economic and interdepartmental ties between the former union republics, to a widespread decline in production, reduction of production and centralized mutual supply of fuel resources, including coal production in Kyrgyzstan itself.

Centralized supplies of fuel resources began to decrease already in the perestroika years, which sharply reduced electricity generation at thermal power plants in Kyrgyzstan and forced the republic to rely more on hydroelectric power plants of the Lower Naryn cascade, especially in winter, which fundamentally changed the situation with water supply to consumers in the Syrdarya river basin. The first signs of changes in the regime of the Toktogul reservoir appeared already in 1988. Kyrgyzstan increased winter power generation at the Toktogul HPP for domestic consumption by making releases from the reservoir (up to 3.9 cubic kilometers in the non-vegetation period of 1989/90 water year). In the non-vegetation years 1990/91 and 1991/92, the increased releases were repeated and, respectively, 4.9 and 5.1 cubic kilometers of water were released from the Toktogul Reservoir.

In the following years Toktogul HPP started to produce maximum power in winter period. During this period, 6.0 - 8.5 km3 of water was released from the reservoir, and vegetation releases were reduced to 4.5 - 6.5 km3 to accumulate water in the reservoir. These changes took place in the following years, but they insignificantly affected water reserves in the Toktogul reservoir, as they occurred between two peaks of high water years - 1987/88 and 1993/94.

Thus, after the collapse of the Soviet Union, the established practice of using reservoirs as a single water management complex in the basin was broken. The operation regime of the Toktogul reservoir as a property object of the Kyrgyz Republic was not coordinated with the regime of other water management objects of the Central Asian republics. It had a separate regime focused on generation of cheap electric power - both for domestic needs and for export, and, as a consequence, there was an annual increased release of water from the reservoir in the winter period.

Under these conditions, in order to maintain stability in interstate water relations, conflict-free and coordinated water resources management in the Aral Sea basin, in October 1991, in Tashkent, the leaders of water management sectors of the above-mentioned states agreed to develop a regional water resources management mechanism to replace the centralized coordination and control system of the Soviet period.

On this basis, on February 18, 1992 in Alma-Ata, ministers of water management state bodies in the Aral Sea basin signed the first interstate document in the field of water relations - Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on cooperation in the field of joint management of interstate water resources use and protection. By this agreement, the parties agreed to establish the Interstate Commission for Water Coordination (ICWC) with the following executive bodies: Basin Water Management Organization “Amudarya” and Basin Water Management Organization “Syrdarya”, Scientific-Information Center (SIC) and Secretariat.

The parties noted in the preamble that they respect the established structure and principles of allocation, existing normative documents on water resources allocation of interstate water sources. This agreement was approved in the same year within three months from the date of signing by all governments of the Parties.

Subsequently, on March 26, 1993, at the meeting in Kzyl-Orda, the Heads of State once again emphasized interstate water relations and approved this Agreement. Here they also signed the Agreement on joint actions to solve the Aral Sea and Aral Sea region problem, ecological rehabilitation and provision of socio-economic development of the Aral Sea region, thus consolidating the vision of common tasks of the region and defining the structure of interstate bodies authorized to implement the tasks set by this Agreement.

On January 11, 1994 in Nukus city the decision of the Heads of Central Asian states on approval of the “Program of concrete actions on improvement of ecological situation in the Aral Sea basin for the next 3-5 years taking into account socio-economic development of the region” as well as on approval of the main provisions of the Concept on solving the problems of the Aral Sea, Aral Sea region and Aral Sea basin taking into account the social and economic development of the region was adopted.

Within the framework of the UN International Conference on Sustainable Development of the Aral Sea Basin States, held on September 20, 1995 in the city of Nukus, the Heads of the Central Asian states signed the “Nukus Declaration of the Central Asian states and international organizations on the problems of sustainable development of the Aral Sea Basin”.

In it, the heads of the Central Asian states confirmed that they recognize the previously signed and existing agreements, treaties and other normative acts regulating relations between them on water resources in the Aral Sea basin and accept them to be steadily implemented. The Declaration also contains an appeal to the international community, to the governments of states and peoples all over the world to help in joint efforts of the Central Asian states in solving the problems of sustainable development and improving the ecological situation in the region.

Thus, thanks to the political will and foresight of the leaders of the Central Asian states, the basis has been laid for a mutually agreed and conflict-free solution to the problems of joint management and use of water resources in the Aral Sea basin.

Time, political and economic situation always make their adjustments. It so happened that, relying on all-regional interstate agreements and normative acts, the states of the region started to solve interstate water relations in the river basins of strategic and operational character on bilateral and multilateral basis.

In the Syrdarya river basin, since 1995, the water-consuming states have started to conclude interstate protocols and agreements between themselves, which established the amounts of compensatory fuel and energy supplies and the amounts of vegetation releases from the Toktogul reservoir to cover the needs of irrigated agriculture in the middle and lower reaches. Under these arrangements, Uzbekistan and Kazakhstan receive electricity from Kyrgyzstan in summer, generated by agreed regimes of water releases from the Toktogul reservoir, and in winter they transfer electricity to Kyrgyzstan, and return part of it, respectively, by supplying gas and coal. Prior to 1998, these agreements did not stipulate the size of winter releases.

Such agreements were ad hoc and did not allow to solve the problem in a complex. Besides, the 1990s were generally high-water years, and the acuteness of the problem was mitigated each time.

Meanwhile, high water levels simultaneously aggravated the situation during the non-growing season. Increased winter releases from the Toktogul reservoir and high natural water content of these years contributed to rapid filling of downstream channel reservoirs, and under the limited capacity of the river downstream of Kzyl-Orda and ice age led to the release of large volumes of water into the

Arnasay depression with known negative consequences associated with flooding and waterlogging of vast territories.

As a result of intensive work by experts from the basin countries, with the assistance of USAID and the Central Asian Economic Community (CAEC), a draft of such an agreement, which laid down the basic principles of compensatory mutual deliveries of fuel and energy between the basin states, was worked out in 1997. The draft of this agreement on the use of water and energy resources of the Syrdarya River basin with minor amendments was signed on March 17, 1998 by the first heads of governments of Kazakhstan, Kyrgyzstan and Uzbekistan. Later, in 1999, Tajikistan joined it as well. In this Agreement, unlike the Agreement of February 18, 1992, some mechanisms for solving water allocation problems between the countries of the basin were established.

In January 2000, the Government of the Republic of Uzbekistan and the Government of the Republic of Tajikistan signed a bilateral agreement on cooperation in the field of rational use of water and energy resources. It created conditions for accumulation of water in the Kayrakkum (nowadays - Bakhri Tojik, translated as Tajik Sea) reservoir, for realization of fixed releases from it and mutual power flows to the energy systems of the parties. The CAEC states signed an agreement on cooperation in the field of hydrometeorology, as well as a regional agreement on parallel operation of energy systems of the Central Asian states.

All these agreements, one way or another, are aimed at solving water resources management issues in the Aral Sea basin. The level and content of the agreements correspond to the realities of the time of their conclusion and, at the same time, the basic principles laid down in them do not contradict international water law and world practice.

At the same time, it should be recognized that the states of the region did not fully fulfill their obligations under all these agreements, which will be discussed below. However, despite the difficulties of the transition period to market relations, different levels of socio-economic development related to the chosen models of economic development, they did their best to solve the problems of interstate water relations at the negotiating table and fulfill their obligations under the interstate agreements.

The Agreement dated March 17, 1998 on the use of water and energy resources in the Syrdarya River Basin was the first step in this direction. It was based on the mentioned previous agreement and took into account three-year experience of annual protocols between water, energy and other sectors of economy of the Syrdarya river basin countries and annual intergovernmental agreements on the basis of these protocols.

This agreement defines the basic principles of mutual water and fuel and energy resources transfers between the countries of the basin. At the same time, this agreement turned out to be a framework agreement. It does not contain responsibility and obligations of the states for mutual deliveries in years of different water availability. There are no articles stipulating which state bodies of the parties are responsible for fulfillment of obligations, sources of financing, etc.

Naturally, under these conditions, fulfillment of obligations on mutual deliveries leaves much to be desired. Although annual protocols and agreements stipulate the same volumes of mutual deliveries, their fulfillment strongly depends on the water content of the year and, probably, on subjective factors. Already in the year of signing the agreement, in 1998, due to the high water content of the year, Kazakhstan delivered only 150.4 thousand tons of coal instead of 566.7 thousand tons and received 150 million kWh of electricity instead of 250 million kWh under the obligation. Uzbekistan also took in only 74.9 million kWh that year instead of 200 million kWh. In 1999, Kazakhstan overfulfilled its coal obligations, but Uzbekistan underdelivered gas by 169 million cubic meters. In the low-water year of

2000, Uzbekistan overfulfilled its gas obligations, but Kazakhstan underdelivered coal by 31,400 tons, etc.[47]

The main reasons for the unsustainable fulfillment of obligations by the Syrdarya River Basin States are as follows:

- private ownership of fuel and energy facilities in some countries and state ownership in others in the Aral Sea basin;
- inconsistency and non-transparency of tariff policy between the states of the region in the mutual supply and transportation of electricity and energy carriers; different rates and models of socio-economic development of the countries of the basin, and, accordingly, different conditions of transition to market relations, especially in the agricultural and energy sectors of the economies of the states;
- uncertainty of the legal status of interstate water and energy management bodies;
- lack of clear delineation of functions and responsibilities between interstate water executive bodies, national water authorities and local authorities in the field of joint management of transboundary water bodies;
- incomplete transfer of their water management facilities of regional importance to interstate water management bodies by the states of the region, except Uzbekistan, and, as a consequence, staffing of management personnel of interstate bodies with specialists from only one state;
- lack of agreements on information exchange in the field of joint water resources management of transboundary water sources and, as a consequence, lack of information on water withdrawals from interstate canals, especially from the trunk of transboundary rivers;
- uncertainty of downstream states and water users in receiving agreed water volumes in due time, and others.

It is known that the elimination of these and other reasons that affect the fulfillment by the states of the region of their obligations under the agreements signed by them requires some time, as it is related to political and socio-economic conditions, as well as to the development of the environmental situation within each state. First of all, each state in the region must have a clear understanding of the benefits and losses in fulfilling their obligations, both economically and, importantly, socially. So far, no basin state has carried out such calculations.

Naturally, making such calculations is a very complicated matter, since the calculations will cover not only water and energy sectors of the states' economies. In order to defend their interests in the sphere of water and energy resources use, the states can link these issues with other directions of interstate relations. Meanwhile, a clear understanding of benefits and losses is one of the real possible ways to bring positions closer and establish cooperation between the states on joint management of water and energy resources in the Aral Sea basin.

[47] Kenshimov A.K. Interstate water allocation in the Aral Sea basin. Final Report of Royal Gasconning Company, Appendix to the Report, 2003.

Table 7. Volumes of mutual deliveries of water and fuel and energy resources under Intergovernmental Agreements for 1995-2001 (Kyrgyzenergo JSC - A. Zyryanov) (Kenshimov A. 2023)

Indicators ↓	Years → Dimensionality		1995		1996		1997		1998		1999		2000		2001	
Volume of Toktogul reservoir	bln m³	01.01	17,7		13,9		13,0		10,2		13,5		14,5		11,9	
		01.04	14,2		10,4		9,8		7,3		10,4		11,0		8,7	
		01.10	15,6		15,2		11,8		15,1		16,3		13,7		12,1	
Volume of water releases from the Toktogul reservoir	bln m³	plan	6,5		6,5		6,5		6,5		6,5		6,5		5,9	
		fact	6,3		6,2		6,1		3,7		5,06		6,5		5,9	
Electricity exports to Kazakhstan and Uzbekistan	mln kWh		Kaz.	Uzb.	Kaz.	Uzb.	Kaz.	Uzb.	Kaz.	Uzb.	Kaz.	Uzb.	Kaz.	Uzb.	Kaz.	Uzb.
		plan	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	580	1905	1100	1100
		fact	782	928	995	1077	709,5	1615	468,6	489	585,3	970	673,2	1925,6	912,4	1038,1
Volumes of supplies to the Kyrgyz Republic																
Natural gas	mln m³	plan	-	200	-	500	-	630	-	772	-	500	-	422	-	700
		fact	-	200	-	476	-	632	-	748	-	331	-	430,6	-	594,9
Karaganda coal	thousand tons	plan	985	-	600	-	-	-	566,7	-	566,7	-	362,5	-	618	-
		fact	450	-	202	-	-	-	150,4	-	572	-	331,1	-	466,5	-
Furnace fuel oil	thousand tons	plan	-	-	-	-	-	-	-	20	-	-	-	55	20	20
		fact	-	-	-	-	-	-	-	23,8	-	-	-	27,9	9,8	16,5
Electricity	mln kWh	plan	-	-	-	635	0	400	250	200	-	-	-	0	-	-
		fact	-	415	-	635	11,4	433,5	150	74,9	-	-	-	195	-	-
Diesel and motor fuel	thousand tons	plan	-	-	-	-	-	-	-	-	-	-	-	-	-	23
		fact	-	-	-	-	-	-	-	-	-	-	-	-	-	15,4
Transf. oil	tons	plan	-	-	-	-	-	-	-	-	-	-	-	-	-	540
		fact	-	-	-	-	-	-	-	-	-	-	-	-	-	425
Turbine oil	tons	plan	-	-	-	-	-	-	-	-	-	-	-	-	-	240
		fact	-	-	-	-	-	-	-	-	-	-	-	-	-	222

As mentioned above, since 2001, Uzbekistan, in parallel with the multilateral Agreement, started practicing bilateral agreements with Tajikistan and then with Kyrgyzstan. Subsequently, starting from 2004, Uzbekistan completely withdrew from the 1998 Agreement. Since the 1998 Agreement ceased to be in force, the other countries of the Syr Darya River Basin also began to practice bilateral agreements with each other, which did not meet the interests of Kazakhstan as a downstream state.

Despite the fact that significant volumes of water were diverted to the Arnasay depression, it was also necessary to discharge unusually high discharges for winter time down the riverbed. At the same time, in order to prevent water from reaching the ice surface and dam failures, especially in the Kzyl-Orda-Terenozek section, large water flows were diverted to irrigation systems located upstream of Kzyl-Orda. As a result, repair and rehabilitation works were not carried out on these systems in those years. In addition, increased winter discharges contributed to waterlogging of significant coastal areas and, as a consequence, hindered the timely conduct of spring field works.

Despite the fact that Uzbekistan has ratified both International Conventions: "Convention on the Protection and Use of Transboundary Watercourses and International Lakes" (Helsinki, 1992) and "Convention on the Law of the Non-navigational Uses of International Watercourses" (New York, 1997), it has started to build new water management facilities in violation of previous agreements between the Aral Sea basin countries.

By the end of 2003, Uzbekistan blocked the Arnasai catastrophic release from the Shardara reservoir by constructing the 997 million cubic meters Arnasai reservoir. Against the background of high water levels during the non-growing season of 2003-2004, this reservoir almost caused the dam failure of the Shardara reservoir. Due to the blocking of the Arnasay catastrophic release channel, Kazakhstan was unable to release from Shardara. As a result, by the beginning of January 2004, over 5.2 billion cubic meters of water had accumulated in the reservoir. The situation was saved by the fact that one of the inter-island dams of the Arnasay reservoir was not brought up to the design level, and it broke through.

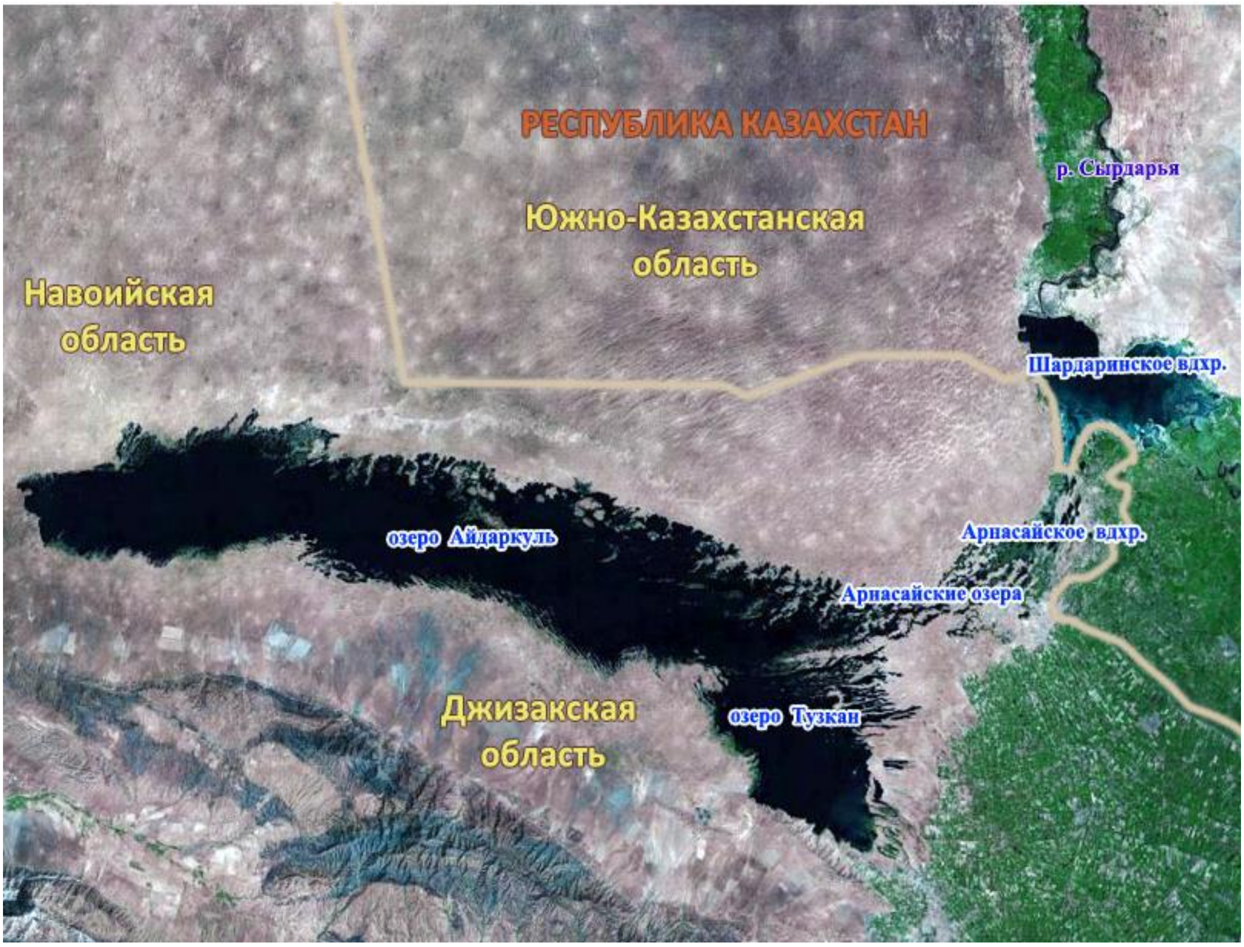


Figure 24. Arnasay-Aydarkol lake system (Arnasay reservoir is located between Shardara reservoir and Arnasay lakes) (Source: Google maps)

Figure 25. Central Fergana Bulk Reservoir (Source: Google maps)

Figure 26. Sardbin Bulk Reservoir (Source: Google maps)

In violation of the 1992 Agreement and the above-mentioned Conventions, Uzbekistan continues to build reservoirs in the Fergana Valley and the Golodnaya Steppe, the largest of which are: Rezaksai (660 million cubic meters), Central Fergana (350 million cubic meters) and Sardobinsk (922 million cubic meters, after the accident - 600 million cubic meters).

The Karaman reservoir with a volume of 500 million cubic meters is planned, and a part of the Chirchik River flow is to be transferred to the left bank of the Syrdarya River in the Golodnaya Steppe. 55 cubic meters per second structure has been built to discharge water from the Dustlik canal into the Central Golodnostepa collector to maintain the level of the Aidarkol lake system.

Aidarkol is a large drainless lake in the north-eastern part of Uzbekistan, it is an artificial reservoir in the Arnasay lake system. Currently, the lake is part of the Arnasay-Aidarkol lake system. It was formed as a result of the discharge of collector-drainage runoff of the Golodnaya Steppe, as well as part of flood waters of the Shardara reservoir. A lake was formed in the natural Arnasay depression in the following years. Water flooded the Prituzkan lowland and raised the level in Lake Tuzkan. The basin with Aidar solonchaks also began to fill with water.

In 1969, during a catastrophic flood in the Syrdarya river basin, the Arnasay depression was used as an accumulator. The total discharge from the Shardara reservoir amounted to 21.8 km3 of water. The Arnasay lake system appeared. At the same time, the level of Tuzkan Lake rose by 10 m, and in Aydar solonchak - by 22 m in relation to the lowest bottom elevations.

As a result of water release into the Aydar solonchak, the water level in the Upper Arnasay lakes decreased by 2-3 m. According to N.E. Gorelkin and A.M. Nikitin (1976), a lake system 155 km long, with the greatest width of 33 km, volume up to 20 km3 and water surface area of 2300 km2 was formed.

The Arnasay lake system has an intra-annual regime of changing phases of winter-spring filling, summer fall and fall-winter equilibrium. In 2005 there was 44.3 km3 of water in Aidarkul. Today, the lake has an area of about 3000 km2. It is almost 250 km long and up to 15 km wide. The mineralization of water in Aidarkul is only 2 grams per liter.

Many species of fish have been introduced into the lake, including carp, pike-perch, bream, catfish, catfish, jherekh, chekhon, and snakehead - now these fish serve as the basis for fisheries. The lake system produces between 760 and 2,000 tons of fish per year (based on 1994-

2001 statistics). In addition, this lake system was included in the list of Ramsar wetlands at the suggestion of Uzbekistan.

At the same time, it should be noted that after construction of the Arnasai reservoir on the Arnasai spillway by Uzbekistan and implementation in Kazakhstan of the World Bank project “Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea” (RRSSAM-1), as well as construction of the Koksarai counter-regulator, water was not discharged into the Arnasai-Aydarkol lake system. This led to a gradual decline in the lake level and increased water salinity. In this regard, Uzbekistan constantly raises the issue of resumption by Kazakhstan of annual water discharge to Arnasai from the Shardara reservoir in the amount of 1.5 billion cubic meters.

The closure of the Arnasay catastrophic release by Uzbekistan led to big problems related to regulation of the volume of the Shardara reservoir against the background of winter power generation in the Toktogul HPP in order to cover the energy needs of Kyrgyzstan.

At the same time, Kazakhstan faced the need to implement winter increased releases from the Shardara reservoir, flooding floodplain lands and in some places the lands of the first terraces of the Syrdarya river lower reaches, which were developed in the Soviet and post-Soviet periods taking into account low water discharges according to the Syrdarya SCIWR 1982.

Water resources of the Kazakhstan part of the Syrdarya River and their use

At present, 18 reservoirs, large and small, with a total usable capacity of 4.82 km3 are functioning in the Syrdarya basin on the territory of Kazakhstan.

The largest reservoir is the Shardara reservoir on the Syrdarya River with a designed usable capacity of 4230 million m3. The Shardara reservoir is used for irrigation and power generation. Small reservoirs with a usable capacity from 0.3 to 365 million m3 are used mainly for irrigation.

The territory located downstream of the Shardara reservoir is in the runoff dispersion zone. The only tributary flowing into the Syrdarya River in this area is the Arys River. Small rivers of the south-western slope of the Karatau Range practically do not bring their waters to the Syrdarya River.

Water resources of the Syrdarya river basin within the RK are composed of inflow to the Shardara reservoir, including residual flow of the Keles and Kurykkeles tributaries; flow of rivers and small watercourses (Arys river and others) formed in the territory of Turkestan and Kyzylorda regions.

The hydrological regime of the Syrdarya river basin rivers before 1961 can be considered as conditionally natural, which since 1961 has been strongly distorted by economic activity. Water resources of the Syrdarya River under conditionally natural conditions were: in the runoff formation zone - 37.1 km3, in the sites (Lower reach) of the Shardara reservoir - 22 km3, near Kazalinsk - 15.0 km3. As a result of long-term development of the river flow and its tributaries, the decrease of domestic flow in different periods of water management development of the territory in comparison with conditionally natural flow was from 5.5 km3 to 11.5 km3 in these sites, respectively.[48]

The main parameters of average long-term annual runoff of the largest rivers forming on the territory of Turkestan and Kyzylorda regions are given in Table 9. Also Kazgiprovodkhoz Institute determined the distribution of water resources by water management sites (without taking into account transit flow). Calculations determined that the flow formed on the territory of Kazakhstan is 4.7 km3, the inflow from outside Kazakhstan is 14.96 km3. Total water resources - 19.66 km3.

[48] Scheme of integrated use and protection of water resources in the Syrdarya river basin. Volume 1, Book 1, Summary note. Production Cooperative “Kazgiprovodkhoz Institute”, 2008.

Table 8. Annual runoff parameters of the main rivers in the Syrdarya River basin (under natural conditions) (Source: Water Resources Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan)

Расчетные створы	Среднемноголетние параметры				Расчетные объемы стока, км³		
	Q, м³/с	W, км³	C_v	C_s	50%	75%	95%
р. Арысь – клх Юсансай	44,2	1,395	0,19	1,25	1,341	1,196	1,070
р. Арысь – ж.-д. ст. Арысь	69,8	2,203	0,26	0,87	2,124	1,767	1,427
р. Аксу – с. Подгорное	10,1	0,319	0,26	0,51	0,314	0,262	0,199
р. Боролдай – с. Чубаровка	106	0,335	0,52	0,78	0,290	0,219	0,172
р. Бадам – аул Маятас	3,97	0,125	0,51	1,02	0,115	0,079	0,062
р. Сайрам – с. Тасарык	8,26	0,261	0,24	0,48	0,255	0,215	0,197
р. Балдыбрек – с. Сахаровка	3,16	0,100	0,31	0,61	0,097	0,078	0,056
р. Бугунь – Красный Мост	5,00	0,158	0,40	0,70	0,150	0,112	0,068

Table 9. Surface water resources of the Syrdarya River basin brought to present-day conditions, km3 (Source: Water Resources Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan)

NN п/п	Индекс водо-хозяйст-венного уча-	Основные водо-токи, каналы	Приток речных вод в РК			Сток, формирующийся в РК			Итого		
			Ср.	75%	95%	Ср.	75%	95%	Ср.	75%	95%
1	05-02-04-1	Канал Достык				0	0	0	0	0	0
2	05-02-04-2	Реки Угам, Майдан-тал				1,16	0,996	0,807	1,16	0,996	0,807
		Река Келес				0,18	0,124	0,077	0,18	0,124	0,077
		Итого по участку				1,34	1,12	0,884	1,34	1,12	0,884
3	05-02-04-3	Бассейн р. Арысь				2,45	2,00	1,75	2,45	2,00	1,75
		Бассейн р. Бугунь				0,27	0,19	0,13	0,27	0,19	0,13
		Реки юго-западного склона хр. Каратау у границы зоны фор-мирования				0,47	0,29	0,19	0,47	0,29	0,19
		Итого по участку				3,19	2,48	2,07	3,19	2,48	2,07
4	05-02-05-1	Река Сырдарья, приток к Шардарин-скому водохранили-щу*	14,96	11,48	8,42				14,96	11,48	8,42
5	05-02-05-2	Реки юго-западного склона хр. Каратау у границы зоны фор-мирования				0,17	0,12	0,08	0,17	0,12	0,08
6	05-02-05-3		0	0	0	0	0	0	0	0	0
Всего по Зоне Проекта			14,96	11,48	8,42	4,70	3,72	3,03	19,66	15,20	11,45

*без стока рек Угам, Майдантал, Келес

As it was mentioned above, due to transition to energy mode of Toktogul reservoir operation winter inflow to Kazakhstan increased, which accordingly led to increased water releases from Shardara reservoir and flooding of settlements, breach of barrier dams and a number of other negative consequences for the lower reaches of the reservoirs.

This is due to the fact that natural parameters of the Syrdarya river channel downstream of the Shardara reservoir, developed during the period of Soviet development of its water resources, do not allow to pass increased water discharges. Maximum possible water releases to the downstream of the Shardara reservoir are limited by the following values: during the period with ice phenomena (XII-15.III) - 700 (600) m3/s; during the period without ice phenomena (16.IV-

IX) - 1800 (1500) m3/s; during the off-season period (X-XI, 16.III-15.IV) - 1500 m3/s. In especially extreme years with probability P = 0.1% (once in 1000 years) winter releases from the Shardara reservoir can be increased up to 800 m3/s. Down the river, these discharges are transformed: at the maximum winter discharge at the Shardara reservoir site of 800 m3/s (taking into account the inflow of the Arys River) at the Tasboget and Kazalinsk sites, the maximum water discharges are 750 m3/s and 650 m3/s, respectively.

	
Shooting date: April 8, 2024	Shooting date: September 15, 2024

Figure 27. Koksarai counter-regulator (Source: KC Santinel)

The current situation on water flow through the river trunk and uncoordinated actions of the basin countries on the use of water resources of the Syrdarya River and limitation of the Arnasay catastrophic discharge forced Kazakhstan to construct the Koksarai counter-regulator (fill reservoir, commissioned in 2010), which is located on the territory of rural districts Akdala and Zadarya of Arys district, Turkestan region, 160 kilometers downstream of the Shardara reservoir, south of the village of Koksarai. Its design volume - 3 billion m3, water area - 467.5 km2, flow rate of the channel concrete dam - 1800 m3/s, the capacity of the supply channel 16 km long - 500 m3/s. The reservoir dam is 44.7 km long, with an average height of 7.7 m, and a 10.2 km long diversion channel with a capacity of 500 m3/s.

On the basis of the Basic Provision of the Concept of Aral Sea Crisis Exit and the “Program of concrete actions on improvement of ecological situation in the Aral Sea basin and Priaralie for the next 3-5 years taking into account socio-economic development of the region” (PBAM-1) approved by the heads of Central Asian states in Nukus on January 11, 1994, Kazakhstan since 1998 started implementation of the project “Regulation of the Syrdarya river channel and preservation of the Northern part of the Aral Sea” (RRSSAM-1).

“In 1998-1999 the Feasibility Study (FS) of the 1st phase of the project was developed by the Production Cooperative “Kazgiprovodkhoz Institute” together with the Association of Consulting Engineers Salzgitter (Germany) and Sogreah Ingenierie (France). The sources of financing were grants of Japanese government TF 025236 for the amount of 650 thousand US dollars and TF 027108 for the amount of 898,8 thousand US dollars.

2000-2002 detailed design and tender documents for the main structures of the project (CAM dam, Aklak hydroscheme, Aitek complex, protective dams and straightening of the Syrdarya river channel) were developed by the Production Cooperative “Kazgiprovodkhoz Institute” together with the Association of Consulting Engineers Salzgitter (Germany) and Sogreah

Ingenierie (France). Source of financing: PPF pre-loan advance #P371-0KZ of the World Bank in the amount of US$1.8 million".[49]

The project was launched in November 2002 with a loan from the World Bank in the amount of US$64.5 million and co-financing from the Republican Budget in the amount of US$21.29 million. The total cost of the project amounted to US$85.79 million.

Key objectives were defined as:

- ensuring the passage of increased water flows through the Syr Darya river channel by constructing new regulating hydraulic structures and reconstructing existing hydrosystems;
- preservation of the northern part of the Aral Sea as a geographical climate-forming object;
- supporting and increasing agricultural (including livestock) and fishery production in the Kazakh part of the Syrdarya River basin;
- improvement of ecological conditions and environment in the delta and around the Northern Aral Sea, which will have an impact on improving public and animal health, as well as on the restoration of biodiversity;
- construction and reconstruction of existing protective dams.

In order to achieve the set objectives, the following were constructed:

- North Aral Sea dam (Kokaral dam)
- Aitek complex
- protective dams on the Syrdarya River
- straightening of the river channel in the area of Aksu village

and repair and rehabilitation works were carried out on existing hydraulic structures:

- Kazaly hydroscheme
- Kyzylorda hydroscheme
- Shardara and Arnasay dams.

As a result of the RRSSAM-1 project implementation, the following was achieved:[50]

1. The Syrdarya River throughput capacity increased from 350 to 700 m3/s.
2. Preservation of the northern part of the Aral Sea as a geographical and climate-forming object:
    - the dried seabed was covered with a water mirror with an area of 870 square kilometers (from 2,414 square kilometers to 3,288 square kilometers);
    - the volume of water in the sea increased by 11.5 km3 (from 15.6 km3 to 27.1 km3);
    - water salinity decreased from 23 to 17 g/l.
3. Improved water supply to irrigation and lake systems.
4. Safe operation of the Shardara dam and stabilization of the Shardara HPP operation mode (increased power generation in winter time).
5. Improvement of ecological and socio-economic situation of the region and population of Aral Sea region:
    - development of local fish species has increased and favorable conditions for sturgeon breeding have been created;

[49] Project "Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea. Issue 1. Production cooperative "Kazgiprovodkhoz Institute". Almaty 2017.

[50] Project "Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea. Edition 1. Production cooperative "Kazgiprovodkhoz Institute". Almaty 2017.

- the volume of fish catch increased from 0.4 to 6.0 thousand tons and in the future it is expected to increase to 11.0 thousand tons.

6. Reliability of existing structures on the river, increased their service life, improved operational characteristics of hydroelectric facilities.
7. Biodiversity of the Kazakh part of the Aral Sea region restored.

In the Aral-Syrdarya water basin 1/3 of the irrigated land fund of the Republic of Kazakhstan is located, and the socio-economic situation and ecological situation of the region and food security of the republic as a whole depend on how effectively it is used. Due to high heat availability, the lands of the Aral-Syrdarya water basin have the highest productivity potential in the republic, and under favorable reclamation regime on these lands it is possible to obtain very high and sustainable yields of various agricultural crops.

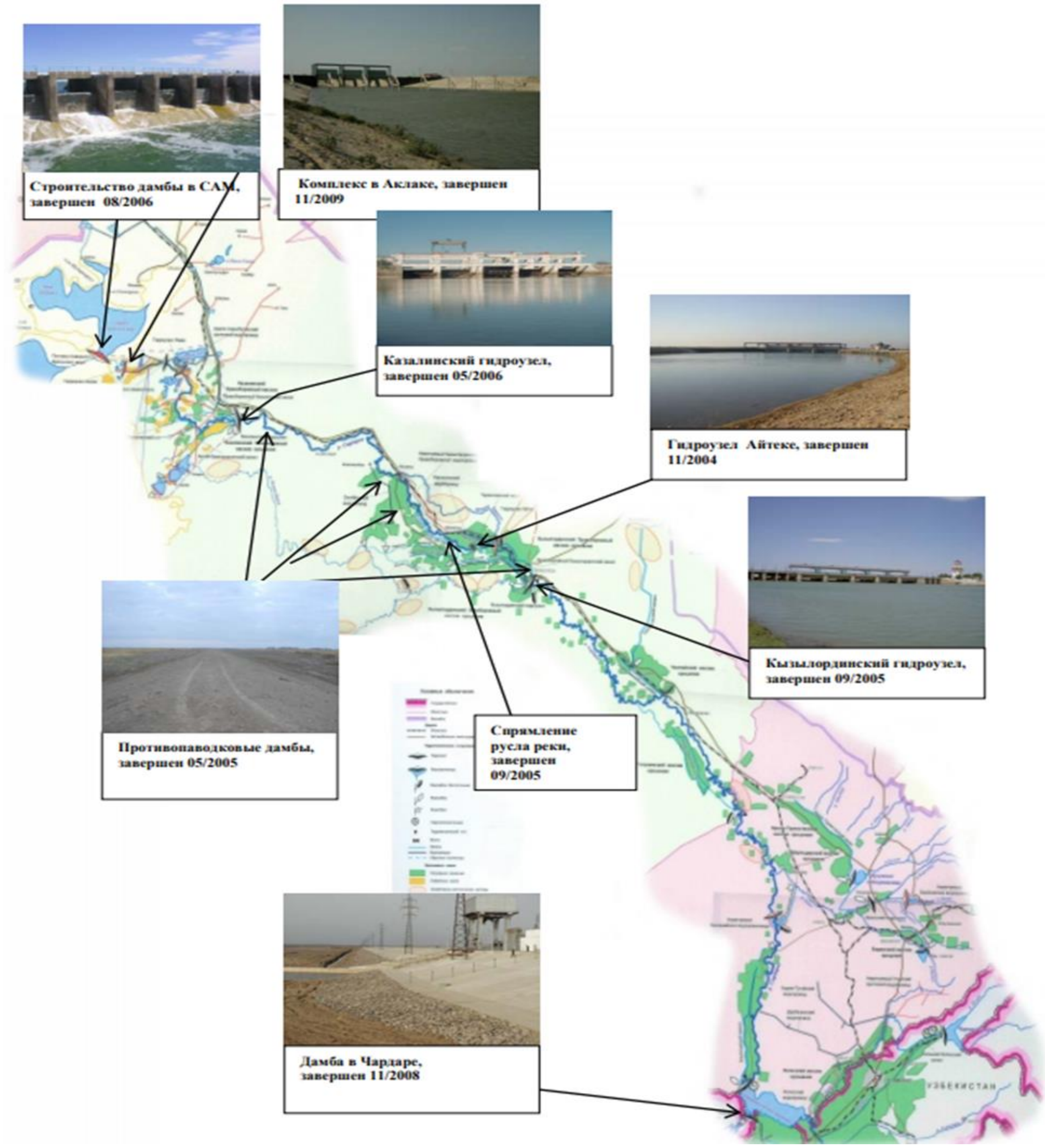


Figure 28. Location scheme of RRSSAM-1 facilities (Source: Kazgiprovodkhoz)

According to the state accounting data, in total in the Kazakhstan part of the Syrdarya river basin at the base level of 1990 there were 768.68 thousand hectares of irrigated areas, of which in Turkestan region - 482.65 thousand hectares and in Kyzylorda region - 286.03 thousand hectares. At the present level there are respectively: 667 thousand ha, 472 thousand ha and 195 thousand ha. The main reasons for reduction of irrigated lands by more than 100 thousand ha are deterioration of land reclamation state and condition of irrigation and collector-drainage network, which is caused by reduction of potential of water management organizations and institutions.

Table 10. Dynamics of changes in the main parameters of the Northern Aral Sea (NAS) (Source: Water Resources Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan)

Основные параметры	Unit of measurement	Changes in parameters		
		Prior to project implementation	After the project implementation	Increase or decrease (+/-)
Water level mark	m BS	38	42	+4
Water surface area	sq. km	2 414	3 288	+874
Water volume	cubic km	15,6	27,1	+11,5
Water mineralization	g/l	23	12	-11
Commercial fishing	thous. tons	0,4	6,0	+3,6
Distance from the water's edge to Aralsk city	km	75	22	-53

To transport water from irrigation sources to the points of water allocation to farms to irrigated lands in Turkestan and Kyzylorda regions, there is a sufficiently developed irrigation network of main and inter-farm canals and distributors of the 1st order, which are on the balance sheet of state operational organizations. The main part of engineering irrigation systems and structures is up to 50 years old, and a number of canals and hydraulic structures have been in operation for more than 60 years.

The main and inter-farm network is represented by earthen canals with a total length of about 2.9 thousand km. In general, the engineering condition of this network can be considered quite good, although in recent years it has deteriorated significantly: siltation, overgrowing, destruction of the network, deterioration of hydromechanical equipment, and cessation of repair works are noted. The system is poorly equipped with means of water accounting, communication, transportation communications, and a number of large structures and canals require serious rehabilitation works. The system has efficiency within 0.8, and water losses in general amount to about 1.5 km3.[51]

According to Kazgiprovodkhoz Institute, on-farm irrigation network also consists exclusively of earthen canals. The efficiency of the system does not exceed 0.73, i.e. water losses are up to 25%, and in some areas - up to 30-35%. In many cases, canals and structures are deformed and half-destroyed. Reinforcement of the network with water-regulating structures, especially small ones (in the field), is insufficient, the level of their maintenance and upkeep is low, and their technical condition in most cases does not meet modern requirements. All this leads to large unproductive water consumption and losses of agricultural products.

[51] Scheme of integrated use and protection of water resources in the Syrdarya river basin. Volume 1, Book 1, Summary note. Production cooperative “Kazgiprovodkhoz Institute”. 2008

According to the applied technologies, the predominant method of crop irrigation is surface irrigation with traditional furrow irrigation and flooding of checks. Sprinkling and other water-saving technologies have not been applied here yet. Under insufficient planning of fields, the applied irrigation methods do not contribute to economical water use in the field, losses here make 15-20% and more. In general, irrigation systems have efficiency of 0.6-0.63, and taking into account water losses in the field - 0.5-0.55, i.e. the total volume of water losses during its transportation from the source to the plant reaches up to 50%.

Irrigated lands of Turkestan region are mainly concentrated on large irrigation massifs, which were equipped with engineering irrigation and drainage systems more than a quarter of a century ago. These include: the former Golodnostep irrigation array, Kyzylkum, Arys-Turkestan, Keles and smaller irrigated areas (outside the massive lands). Irrigated areas are used mainly for sowing cotton, fodder and vegetable crops. Among the total area under regular irrigation (base year 1990), 46% was occupied by cotton crop rotations, 30% by fodder crop rotations, 8% by rice crop rotations (Kyzylkum massif of the 1st stage), and the remaining area was used for vegetables, orchards and vineyards. At the present level in the Syrdarya river basin, irrigated lands are developed as follows: cotton - 44%, fodder - 31%, cereals - 4% and other crops. Crop rotations are not always observed.

Irrigated lands of Kyzylorda region are also located on large massifs, such as Zhanakorgan-Shieli, Right-bank and Left-bank Kyzylorda, Kazalinskiy. For the whole period of operation irrigation systems of the region not only were not updated, but also functioned without proper maintenance and repair, which justifies the high degree of their physical deterioration and, as a consequence, low reclamation efficiency.

In the base year of 1990, 286.03 thousand ha were registered in the region, but 258.39 thousand ha were actually irrigated. Among the irrigated lands available at that time, 147.4 thousand ha were covered by engineering systems. However, the engineering systems commissioned 40-50 years ago do not meet the current technical status of irrigation systems and cannot provide optimal conditions for growing crops.

There are 1143.5 thousand hectares of lands potentially suitable for irrigation in the region. But the lack of irrigation water hinders the increase of irrigated areas. Practically the only water source in Kyzylorda region - the Syrdarya River - has exhausted its water resources, and its flow is fully distributed among water users in the basin.

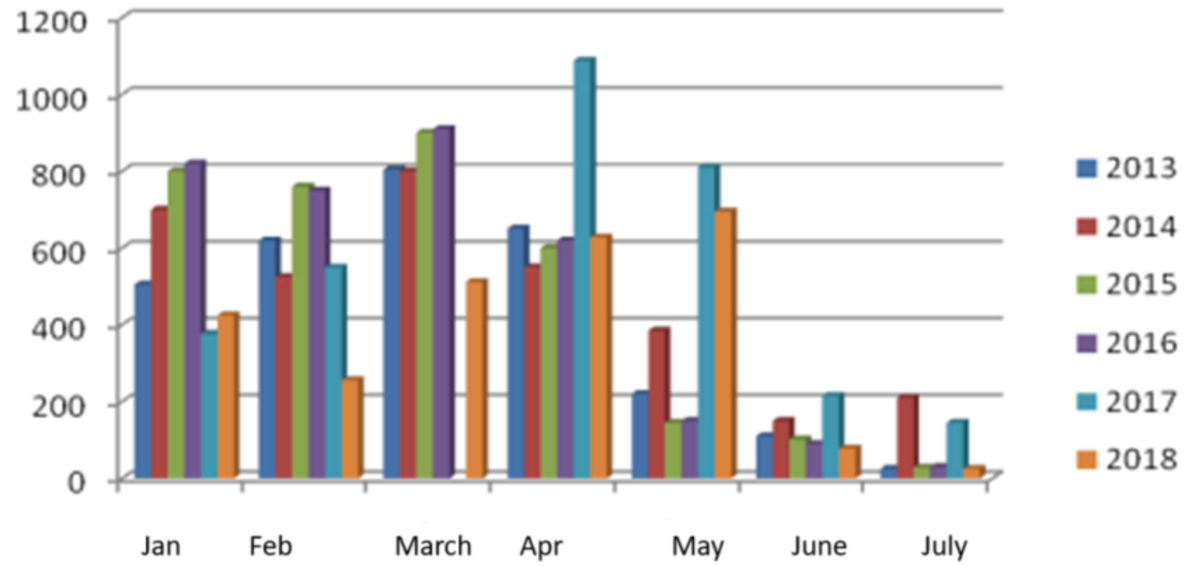
Return water is formed at the expense of collector-drainage and discharge water from irrigation, as well as domestic and industrial water of cities and working settlements, centrally supplied to water receivers. The volume of collector-drainage and waste water discharged into water bodies in Kyzylorda region is about 350 million m3.

Collector-drainage and return waters in the basin are characterized by high salinity - from 1.5 to 3.0 g/l during vegetation period and up to 5.0-12.0 g/l in autumn-winter period. Waters with dry residue up to 2.5-2.8 g/l are referred to sulfate waters, over - to chloride-sulfate waters. All of them are heavily polluted with nutrients, pesticides, organic compounds. Practically all collector-drainage waters do not meet the requirements of fishery and domestic water use in terms of salt content, pesticides and other pollutants. When used for irrigation, they are subject to dilution with river water.

Mass removal of pollutants from the residential area of Kyzylorda city to the river is 179,624 tons/year, of which soluble salts of major ions account for 99.45% (178,631 tons/year). Nitrogenous nutrients, organic pollutants and synthetic surfactants account for the remaining volume. The cities of the basin are not provided with storm water collectors and pumping stations, and thus are not adapted to wastewater treatment and protection of water bodies from pollution.

According to Kyzylorda Center “Kazgidromet”, after 2006, the maximum flow of the Syrdarya River was recorded in 2010 and amounted to 9198 million m3, and already in 2011 -

only 4639 million m3, which is due to fluctuations in water availability of the river, as well as with the growth of water withdrawals for rice irrigation. In subsequent years, the river flow in Kyzylorda region was in the range of 4000-5200 million cubic meters, again due to water availability in the corresponding years. A noticeable decrease in the river flow after 2018 is due to the onset of a series of low-water years in the Syrdarya river basin.



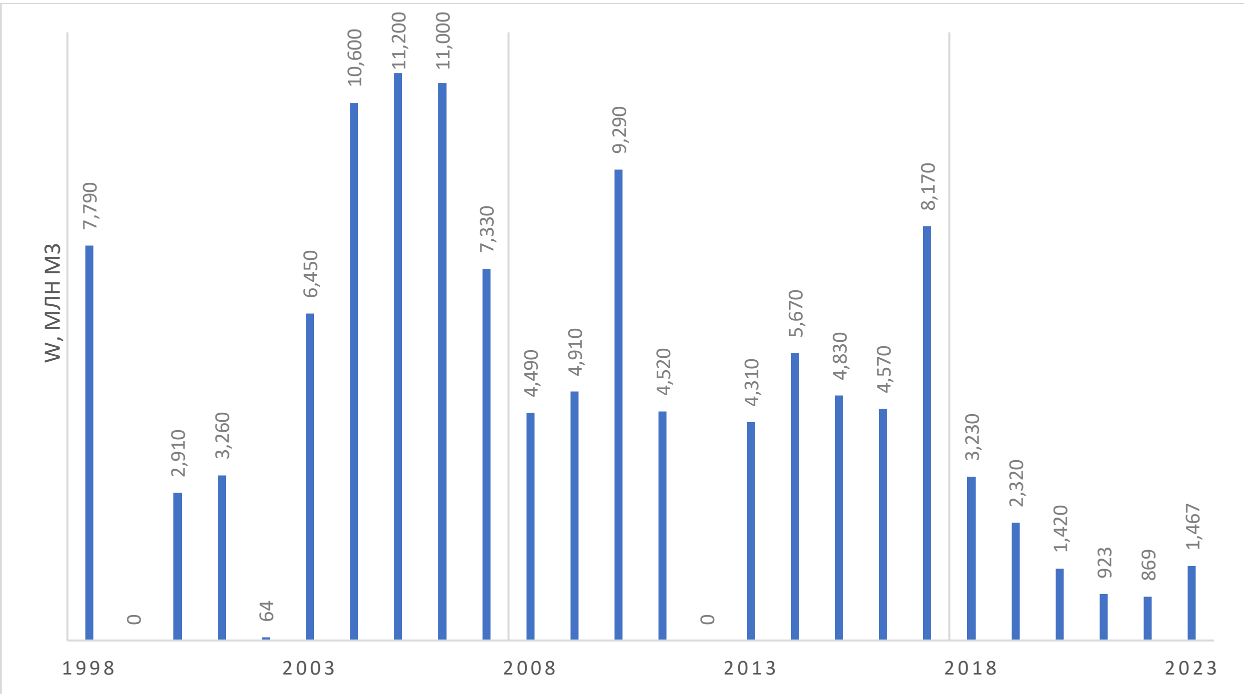


Figure 29. Dynamics of average monthly and annual runoff (mln m3) according to the data of the Karteren gauging station for 2013-2018 (Source: kazhydromet.kz)

The main consumers in agricultural water supply are rural population, livestock breeding, enterprises for primary processing of agricultural products, household plots of the population for personal subsidiary farms.

At present, 97% of the population in Kyzylorda region has been covered by centralized water supply. However, in rural settlements water supply is carried out according to the schedule, i.e. with interruptions. Water quality practically corresponds to the requirements of SanPiN, but there are cases of exceedances in some indications during summer periods, when the water level of the Syrdarya River decreases. In fact, not all the population of the settlements receives water from water pipelines, as the intra-settlement networks are insufficiently developed or in most cases are in poor technical condition. This is mainly 50-80% of the total population of the settlements. As a rule, water supply to the population is carried out through a network of standpipes.

In general, it should be noted that there are problems in ensuring the quality of drinking water and wastewater disposal. In all district centers of the region there is no central sewerage system, the population uses septic tanks to dispose of wastewater, worsening the sanitary and epidemiological situation of the environment, causing various risks in medical and environmental terms.

The lower figure clearly shows the influence of water withdrawals during the irrigation season on river flow downstream of Tasboget gauging station compared to the data of Kokbulak gauging station. Data of Kazaly and Karateren gauging stations for June-August show increased water withdrawal from the river to fill deltaic lake systems.

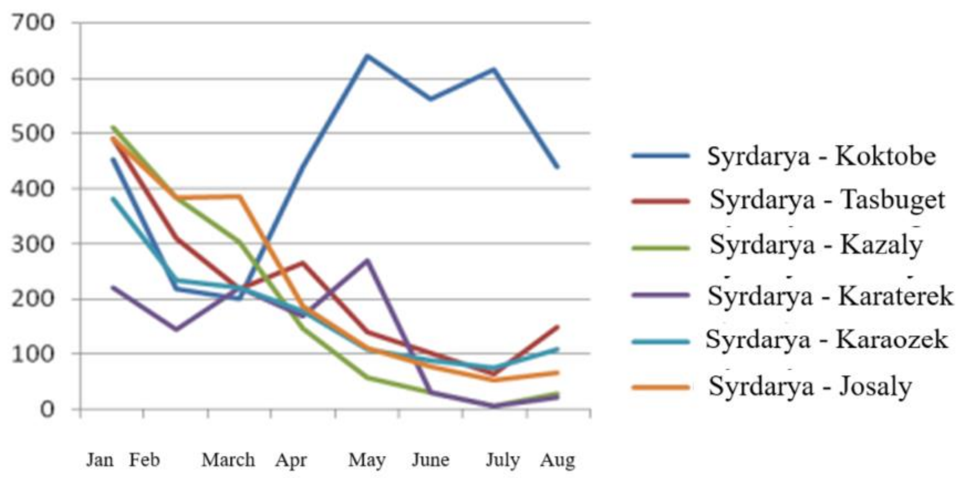


Figure 30. Dynamics of average monthly river discharge (m3/s) by gauging stations in Kyzylorda region for 2018 (Source: kazhydromet.kz)

Until mid-1960, the Aral Sea and the Syrdarya Priaralie were economically rich and ecologically clean areas. The sea and the Syrdarya delta represented a single balanced ecological system.

Tentatively, since 1961, the Aral Sea regime has been affected by the increasing involvement of river water resources in economic use in the Amudarya and Syrdarya basins. Irretrievable withdrawal of river flows to meet the demands of the growing population, for irrigation and other economic sectors without taking into account the needs of the environment has led to an imbalance in the water and salt balance and, consequently, to a reduction in water inflow to the Aral Sea.

River water inflow to the sea decreased over this period to an average of 30.0 km3/year in 1965, and for 1971-1980 it averaged only 16.7 km3/year on average, or 30% of the annual average, for 1980-1999 - from 3.5 to 7.6 km3/year, or 6-13% of the annual average. In some low-water years, the Amudarya and Syrdarya runoff practically did not reach the sea.[52]

---

[52] Aral Sea and Aral Sea region. Scientific-Information Center of the Interstate Commission for Water Coordination supported by UNESCO. "Complex Print", Tashkent, 2020

PC Kazgiprovodkhoz Institute, analyzing the state of water resources in the Kazakhstan part of the Syrdarya river basin, proposes to solve the following problems:

- establishing a system of environmental legislation regulating water and environmental protection and nature use management;
- improvement of the system of state control, environmental expertise and standardization;
- introduction of a unified monitoring system;
- creation of economic mechanism for water use and environmental protection;
- planning of environmental protection measures, development of programs and schemes for sustainable water use and environmental protection;
- ensuring advanced development of scientific research on the most important problems of sustainable water use and environmental safety, including fundamental research;
- assessing the state of the natural environment quality, ecological zoning and special mapping of the basin territory;
- development of the system of environmental education and upbringing;
- development of international cooperation programs and, in particular, with Kyrgyzstan, Uzbekistan, and Tajikistan on water use, environmental protection, and protection from natural disasters.

The drying up of the Aral Sea has caused a number of negative processes in the Aral Sea region, including in the delta of the Syrdarya River. It has led to the exposure of huge areas of the former sea bed, degradation of lake systems and reduction of biodiversity and, in general, to an ecological catastrophe on a global scale.

The Aral Sea, formerly the fourth largest inland sea, has become a body of water with a water mineralization of more than 60 g/l (130 g/l according to the latest data). The land around the sea has been subjected to desertification and has become a source of dust storms for the region, where up to 3 million people used to live. The drying up of the Aral Sea has left the once majestic sea with two large lakes, the western one being bitterly saline.

After the separation of the Small Sea from the Large Sea, the situation in the northern and southern parts of the former sea began to develop under different scenarios. In 2006, Kazakhstan built a dam in the northern part, in the Berg Strait area, with a spillway-retaining structure with a capacity of up to 600 cubic meters/second, designed for a level rise at 42-43m BS. At the same time, it became possible to accumulate water in the volume of up to 27 cubic kilometers.

At the same time, the volume and level of the Small Sea depend entirely on inflow, and in years of different water availability can fluctuate significantly, which occurred in the extremely low-water years 2018-2022. By the end of 2022, according to the Aral-Syrdarya Basin Inspection, the volume of water in the Small Aral Sea decreased from 27 billion cubic meters to 18.72 billion cubic meters and the water level from 42.13m to 40.42m BS.

According to the latest data, from December 2022 to today the water level in the sea has risen to 40.90 m BS, or 48 cm, and the volume of collected water amounted to 19.7 billion cubic meters. At the same time, if last year the volume of water flowed into the Aral Sea was 816 million cubic meters, then for two months of this year 803 million cubic meters have already been received.[53]

2008-2010 under the financial support of NATO Department “Science for Peace”, under the leadership of Kipshakbaev N.K. and Dukhovny V.A., scientists and specialists of research and design institutes, Scientific Research Center of the Interstate Commission for Water Coordination

[53] Kazakhstan Today. 04.03.2023

conducted research to develop a set of measures to restore the ecological system in the delta of the river. Syrdarya and Northern part of the Aral Sea.[54]

The authors of the work conducted comprehensive studies, identified the causes and consequences of the Aral Sea desiccation and proposed a number of specific measures to restore the ecosystem of the Syrdarya delta and the northern part of the Aral Sea.

The authors noted that in the late 80s of the last century and during the years of independence, the water infrastructure of irrigated massifs was severely worn out due to lack of funds for current and capital repairs, as well as due to the decline in its level of operation.

[54] Kipshakbaev N. Yup de Schutter. Dukhovny V. et al. Restoration of ecological system in the Syrdarya delta and northern part of the Aral Sea. Almaty. Ed. “Evero”. 2010

Table 11. Aral Sea characteristics
(Sources: Aral-Syrdarya Basin Authority and Scientific-Information Center of the Interstate Commission for Water Coordination)

Years	Volume (km^3)			Area (km^2)			Water inflow (mln m^3)			Water level (m BS)		Salinity (g/l)	
	General	Big Sea	Small Sea	General	Big Sea	Small Sea	General	Big Sea	Small Sea	Big Sea	Small Sea	Big Sea	Small Sea
2000	158,79	139,53	19,26			2899	3800	3865	65	33,50	39,80	57	17
2001	164,86	149,13	17,97			2919	3563	3293	270	32,40	39,20	60	18,6
2002	129,28	110,84	18,44			2882	8641	9151	510	32,00	39,30	No data	15,1
2003	117,00	97,23	19,77			3091	9764	6914	2850	31,50	40,00	No data	10,7
2004	114,85	93,46	21,39			2884	12956	10106	2850	31,09	40,80	No data	12,4
2005	112,31	89,79	22,52			2940	9888	5570	4318	30,70	41,00	No data	10,3
2006	105,36	81,35	24,01			3180	6759	2277	4482	30,40	41,80	No data	8,9
2007	99,84	73,51	26,33			3240	6619	3016	3603	29,30	42,50	No data	6,3
2008	88,50	63,22	25,28			3169	3690	2521	1169	28,70	42,50	No data	12,1
2009	85,08	58,81	26,27			3235	4108	315	3793	28,00	42,50	No data	12,9
2010	90,15	62,80	27,35	9840	6500	3340	9198	5057	4141	27,80	43,00	No data	11
2011	82,50	56,68	25,82	9697	6500	3197	4636	3462	1174	28,00	42,50	No data	10
2012	77,61	51,91	25,70	9744	6500	3244	4588	2005	2583	27,00	42,70	No data	10
2013	76,11	51,68	24,43	9740	6500	3240	4106	2424	1682	27,00	43,00	No data	10
2014	73,26	48,42	24,84	9792	6500	3292	5134	2570	2564	26,00	43,00	No data	10
2015	80,17	54,56	25,61	9746	6500	3246	5538	2448	3090	27,10	41,90	No data	10
2016	74,51	49,09	25,42	9745	6500	3245	5149	2830	2319	26,50	41,80	No data	10
2017	71,20	47,06	24,14	9833	6500	3259	9208	6662	1956	25,00	42,10	No data	17
2018	70,62	44,17	26,45	9720	6500	3220	4351	3323	1028	24,90	41,70	No data	17
2019			25,04	9746	6500	3206	3697	828	2869		41,90	No data	15
2020			23,60	9844	6500	3144	1198	881	317		42,16	No data	17
2021			20,10	9638	6500	3138	1194	183	1011		41,17	No data	17
1.12. 2022			**18,72**	9445	6500	**2945**	633	0	**633**		**40,42**	No data	**17**

Meanwhile, the lake systems and wetlands of the Syrdarya delta are the basis for sustainable existence of aquatic and aquatic ecosystems of the Kazakhstan Priaralie, the basis for fishery and fodder production, and a necessary condition for the livelihood of the population of Kazaly and Aralsk districts of Kyzylorda region.

The water management structure of the Syrdarya delta is divided into six lake systems: Aksai, Kuvandarya, Kamystybas and Akshatau (delta); Primorskaya Right-Bank and Left-Bank (littoral). Each of the lake systems is a set of individual lakes and marshes connected by a complex network of natural channels and artificial channels.

In general, there are 53 priority water bodies in the lake systems of the delta, including 27 lakes and 26 bogs of economic and ecological importance. The water management infrastructure of the delta includes 54 natural and artificial watercourses of various lengths, as well as 55 hydrotechnical water regulating structures.

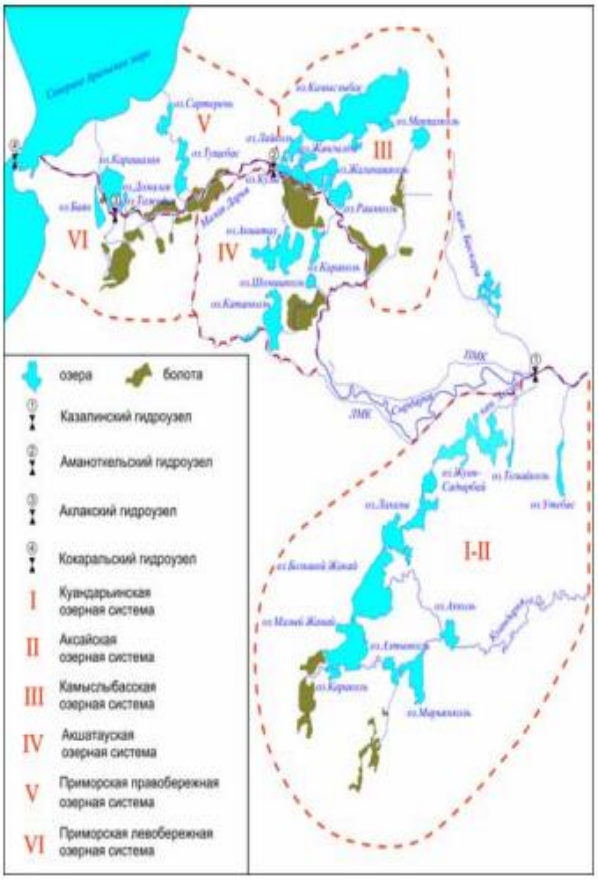


Figure 31. Lake systems of the Syrdarya delta (Source: kazaral.org)

In order to improve the situation in the river delta and create here a managed lake-delta ecological system, the authors propose to implement a number of complex measures:

- create a management system for the lake-delta complex;
- reconstruct and replace existing hydraulic structures on the river with new, more capitalized ones, satisfying the passage of flood discharges and providing command during the low-water period;
- reorganize the system of water regulation and supply to lake systems, hayfields, wetlands and other ecosystems of the delta by constructing new canals and reconstructing existing ones with appropriate water regulating structures;
- restore fish productivity of delta lakes by increasing their water availability, flowability, and special fishery measures;

- water the near-delta part of the dried seabed in order to reduce salt and dust transfer by creating shallow estuaries overgrown with reeds, fish-breeding lakes and other wetlands on the basis of irrigated land discharge water;
- carry out phytomelioration of the dried seabed in order to fix it and suppress deflation;
- improve the social conditions of the population living here, construct additional socio-economic, cultural and domestic infrastructure facilities.

Water requirements in the river delta after the planned measures will be about 2.0 km3 per year with guaranteed supply regardless of the water availability of the year.

The Executive Directorate of the International Fund for Saving the Aral Sea in the Republic of Kazakhstan also makes a great contribution to the improvement of the ecological situation and rational use of water resources in the Aral Sea.

The USAID Aral Sea Drainage Ecosystem Restoration Project supports the efforts of the Government of Kazakhstan to restore the Aral Sea ecosystem and the well-being of its population. Using innovative approaches, the Project contributes to improving the environmental conditions and socioeconomic stability of the region. An additional benefit of the created “oasis” will be increased carbon sequestration by plants and soil to mitigate the effects of climate change.

On June 26, 2022, within the framework of the USAID Project for Ecosystem Restoration on the dried Aral Sea bed by the IFAS Executive Directorate in Kazakhstan, the first cycle of irrigation of 62500 saxaul seedlings on the territory of the “oasis” in the northern part of the dried Aral Sea bed started.

Currently, the preliminary process of preparation of the large-scale World Bank project “Regional Development and Rehabilitation of the Northern Aral Sea in Kazakhstan” is being finalized, which envisages implementation of projects in the following areas:

1. Improvement of water infrastructure and hydrological regime in the Northern Aral Sea-Syrdarya basin, creation of solid foundations for both ecological restoration and economic and social development in the region *(including Increase of capacity and decrease of salinity level in NAS; Stabilization of lowland wetlands of NAS and creation of useful environmental properties; Restoration of Kamyshlybash and Akshautau systems of lakes in the lower reaches of the Syrdarya River).*

2. Supporting sustainable economic, social and environmental activities in Kyzylorda region through a range of catalytic investments *(including Fisheries Development; Tourism Development; Green Belt Creation; Crop Production Development; Livestock Production Development).*

3. Improved information database and integrated water resources management, regional planning and project management *(including Supporting data for decision-making; Multi-stakeholder planning - public participation; Project management, monitoring and evaluation).*

It is expected that the implementation of the World Bank project “Regional Development and Rehabilitation of the Northern Part of the Aral Sea in Kazakhstan” will increase the productivity of water and land resources, improve the management of natural resources of the region under consideration. At the same time, qualitative transformation of the environment, development of biodiversity of the region will give another multiplier effect in the development of human capital in the region under consideration.

CONCLUSIONS

Taking into account further development of the agro-industrial complex, further increase of competition for water should be expected, which will require new mechanisms and instruments of cooperation in transboundary river basins, based, first of all, on deep economic integration of the countries of the region.

The economic potential of the region can be increased by an order of magnitude higher, including through the creation of regional, international clusters in various economic sectors and joint promotion of export products to non-CIS markets.

In order to increase water availability in the Aral Sea region, a comprehensive reconstruction and modernization of irrigation systems is necessary, where the effective operation of collector-drainage systems will allow to reuse up to 2 km^3 of discharge water, while in Central Asia this indicator is about 30 km^3.

Under efficient operation of sewage and treatment facilities in the Aral-Syrdarya water management area, it will be possible to return more than 200 million cubic meters/year (equal to one medium-sized reservoir) to natural ecosystems, and more than 4 km^3 will be used in the Aral Sea basin. At present, these volumes are simply turned into vaporizers of harmful substances.

In addition, special attention should be paid to the quality of surface water, as most of the sewage and treatment water is discharged into storage lagoons or into open sources without full-fledged treatment.

Restoration of urban arychnic systems will reduce the load on drinking water supply systems in summer, increase the number of green areas and significantly improve the ecology and microclimate in settlements, which will certainly have a positive impact on the health of the population.

In recent years, large-scale reforestation works have been carried out on the dried bed of the Aral Sea.

However, in addition to planting saxaul on the dried Aral Sea bed, it is necessary to carry out afforestation in water protection zones of water bodies (rivers, lakes, ponds, canals, streams).

Presence of forests in water protection zones will favorably contribute to:

- increasing water availability up to 20% (by accumulating winter precipitation);
- optimization of runoff regulation (by reducing peak floods and floods);
- improving water quality in water bodies (by purifying water from harmful chemicals and toxic impurities);
- development of biodiversity of river ecosystems affecting the increase of fish resources.

In the future, forest areas on the dried Aral Sea bed and water protection zones, as well as cultural pastures can be applied within the framework of the carbon offsets mechanism as measures for adaptation and mitigation of global climate change processes.

In addition to the above mentioned mechanisms to reduce pressure on water resources in the region, full implementation of national projects and regional programs is also necessary.[55] [56]

All this will also contribute to ensuring the principles of Land Degradation Neutrality (LDN), development of social protection system for marginalized communities in the Aral Sea regions by creating jobs, generating alternative incomes, reducing land abandonment and water connectivity.

[55] https://akorda.kz/ru/ob-utverzhdenii-perechnya-nacionalnyh-proektov-1391918

[56] https://www.gov.kz/memleket/entities/kyzylorda/documents/details/120558?lang=ru

AGRICULTURE OF KYZYLORDA REGION

Climate is one of the most important factors of nature and its importance for agricultural production is very high. The components of climate - moisture, heat, light - are among the necessary components that ensure the normal development of agrocenoses. These elements are assimilated by the plant community in the process of organic matter accumulation. Therefore, we consider them as natural and climatic resources of agriculture, which should be used effectively.

Climate change is a problem that affects all aspects of life on our planet. Its impacts can be of different nature: physical (precipitation, river water content), biological (distribution and development of ecosystems), economic (profitability of production), social (health).

Meteorological and climatic factors are of great importance for food production and hydropower. They determine the volume of river flows, the intensity of floods and droughts, and the seasonal dynamics of energy and water use. With further increases in temperature in the second half of the century, shrinking glaciers and changes in snow cover regimes (e.g., early snowmelt), the pattern of hydrological processes in mountain areas will change significantly, which could lead to reduced flows at a time when they are critical for food production.

Agricultural production will suffer from land degradation caused by climate change as well as reduced access to water resources. Rising temperatures could damage many crop species, especially if exacerbated by water shortages for irrigation. As a result, there is a high probability of a significant decrease in agricultural production. At the same time, against the background of these processes, the demand for resources and energy is projected to increase as a result of demographic and economic growth.

Natural and climatic conditions of the Aral-Syrdarya basin. The climate of the Aral Sea basin is characterized by sharp continentality and extreme aridity. Summers are dry and hot, with dust storms and dry windstorms, while winters are snowy, with constant alternation of frosts and thaws. The distribution of precipitation by seasons of the year is very uneven. Abundance of solar energy and significant duration of the warm period of the year, extreme aridity of the plain part of the basin are characteristic features of the climate for Kyzylorda region.

Low cloudiness causes a high inflow of radiation. The annual duration of sunshine reaches 3000 hours. The territory of the region under consideration, especially from the north and south, is accessible to the intrusion of both cold and warm air masses, which causes sharp fluctuations in air temperature. For example, the annual amplitude of temperature fluctuations at the Aral Sea station reaches 39C. Daily amplitudes vary in the range of 6...15C, absolute minimum air temperature is minus 33...38C, absolute maximum is 41...44C.

The Aral-Syrdarya basin belongs to the areas of insufficient moisture. For example, in the area of Aralsk city the average annual precipitation is 125 mm, with the greatest amount of precipitation falling in spring and fall. On the periphery of the Aral Sea region, the amount of precipitation varies from 150 to 300 mm per year. In the coastal zone, the moisture regime is greatly influenced by the evaporating surface of the Aral Sea. At the same time, relative humidity indicators here do not exceed 26...65%.

Under arid climate conditions, the main indicator of heat and moisture availability during the growing season is moisture availability, which is limiting for the conditions under consideration.

The hydrothermal coefficient (HTC) of Selyaninov, which varies within 0.1...0.3 (very dry zone) according to the moisture conditions of the basin area, is taken as an indicator of moisture availability. The heat availability index is expressed by the sum of temperatures for the growing season, i.e. for the period with air temperature above 10C. This sum within the boundaries of the Kazakhstan part of the basin area varies from 3275C (Kyzylorda) to 4000...4200C (Shardara, Zhetysai). Humidification coefficient for the considered agroclimatic zone varies within the limits of 0.1...0.2.

Table 12. Agroclimatic characteristics of the Syrdarya basin in its middle and lower reaches (Source: kazhydromet.kz)

Name of weather stations	HTC	Radiation balance, kcal/cm^2	Total precipitation per year, mm	Sum of temperatures above 10C	Duration of the period with air temperature 10C	Evaporability, mm
Zhetysai	0,25	43,2	306	4200	230	1345
Shardara	1,20	48,2	197	4000	220	1440
Koktyube	0,18	48,8	178	3800	210	1330
Shieli	1,15	45,3	117	3700	200	1210
Kyzylorda	0,12	43,4	159	3275	190	1090
Kazalinsk	0,10	42,8	126	3620	170	1060
Aral Sea	0,10	41,4	142	3450	150	975

The value of evaporation from the water surface averaged for each observation post for a multi-year period: for the northern plain part of the basin (Kazalinsk) it varies from 975 to 1060 mm, for the southern part (Shardara) - from 1210 to 1440 mm. The highest average monthly values of evapotranspiration are observed here in the spring-summer period - July-August (280...350 mm).

Kyzylorda region is located in the belt of Asian deserts. Two main groups of soils can be distinguished here: desert gray-brown, takyr soils of plains, the area of distribution of which is the left bank of the Syrdarya River and a belt of sierozems of low foothills of the floodplain part of the right bank of the Syrdarya River.

Soil cover of Kyzylorda region is characterized by significant diversity, but it is clearly divided into two large areas: moistened (hydromorphic) soils of agricultural strip and the area of dried (subaerial) soils of desert part with traces of ancient irrigation.

Analysis of soil morphology within the boundaries of irrigation contours has shown that a significant part of irrigated lands of Kyzylorda region is occupied by meadow-marsh soils (169.4 thousand ha) and to a much lesser extent - by other types of soils.

Based on the conditions of irrigation and reclamation measures necessary for the development of one or another type of soils, the land fund of the region is divided into four categories [6, 8]:

- first category lands are suitable for irrigation without complex reclamation under application of usual agro-techniques developed for cultivated crops. They include all varieties of alluvial-meadow soils, meadow-marsh and bog soils;
- second category lands are suitable for irrigation under condition of application of medium complexity of agrotechnical reclamation (leaching, leveling, crusting control, application of increased doses of fertilizers). It includes all varieties of takyr-like soils, except solonetz soils, as well as meadow-marsh and bog soils of sandy loamy and sandy granulometric composition;
- third category lands are suitable for irrigation under application of complex agrotechnical reclamations. They include takyr-like solontsy-solonchak soils, takyrs, all types of solonchaks;
- fourth category lands are unsuitable for irrigation. They include sandy soils of hilly-ridge sands, brown and gray-brown soils.

The vegetation cover of the basin is quite diverse. In its northern part, desert vegetation prevails - wormwood and saltwort. In the river valley, on sandy and sandy loam soils, the most representative species is ephemeral ebelek vegetation.

Hydrogeological conditions of a particular part of the territory, along with structural-geological and geomorphological features, are determined by climate, which obeys the law of vertical zonality and largely depends on the position of the area in the basin system.

The hydrogeological conditions are significantly influenced by economic activities related to river flow regulation, irrigation development, etc. The most significant regional impact is the impact of irrigation. The most significant in regional terms is the impact of irrigation. For example, in recent years the areas with shallow groundwater table in irrigated lands of the basin have significantly increased.

In the lower reaches of the basin, close depth of groundwater occurrence, insignificant amount of precipitation (100...150 mm) and large evaporation value determine formation of groundwater with diverse mineralization and chemical composition. Water with mineralization (1...3 g/l), sodium hydrocarbonate-sulphate composition prevails here.

Reclamation systems were built more than forty years ago. Their technical condition is currently below the required level, which negatively affects the level-salt regime of groundwater, contributing to its rise, evaporation and intensive secondary salinization of soils.

This region is one of the main areas of irrigated agriculture in Kazakhstan. Water from the Syr Darya and a number of other rivers in the basin is used for irrigation of lands, which is taken from water sources by means of a whole system of irrigation canals and delivered to irrigated fields.

In Kazakhstan, the water sector is an important link of productive forces designed to ensure normal functioning of the economy, satisfaction of social, cultural and other needs of the society. At present, the solution of these tasks takes place under the conditions of emergence of regions, where general deterioration of economic and socio-ecological situation is observed. The threat of water resources depletion in the zones of intensive irrigation is also growing.

One of such regions of the republic is Kyzylorda region. The largest river in the region is Syrdarya (total length of 2219 km, within Kazakhstan - 1400 km), the length of which in the region is 1281 km. The territory of the region as of January 1, 2022 is 226 thousand square kilometers. The population of the Region as of January 1, 2022 was 827.9 thousand people. There are 7 rural districts and 4 small towns, 2 settlements, 142 aul districts and 2 settlement districts, 230 rural settlements in the region. The urban population is 372.1 thousand people (44.9%), rural population - 455.8 thousand people (55.1%).

Table 13. Dynamics of labor resources of Kyzylorda region (thousand people)
(Source: Bureau of National Statistics)

s/i	Indicators	2017	2018	2019	2020	2021
1	Total labor resources	347,4	349,7	349,1	346,3	347,1
	- in % of total population	66,9	67,0	66,2	64,5	64,5
2	Employed in economy	330,6	332,9	332,3	329,4	330,1
	- in % of total labor resources	95,2	95,2	95,2	95,1	95,1
3	- Unemployed	16,8	16,8	16,8	16,5	17,0
	- in % of total labor resources	4,8	4,8	4,8	4,9	4,9
4	- Men	8,7	8,9	9,0	9,2	9,1
5	- Women	8,2	7,9	7,8	7,7	7,9
6	- Persons not in the labor force	172,0	172,3	178,5	187,6	190,7
	- in % of total labor resources	33,1	33,0	33,8	35,1	35,5
7	Employed in agriculture	30,3	28,1	27,2	28,5	29,4
	- in % of total labor resources	8,7	8,0	7,8	8,2	8,5

As evidenced by the above data, the number of labor resources for the analyzed period decreased by 2.4%, the number of employed in the economy from the total number of labor resources amounted to 95.1%. The number of unemployed for the analyzed period has slightly increased - from 16.8% to 17%. The number of unemployed among the male population increased from 8.7% to 9.1%, while the number of unemployed among the female population decreased slightly from 8.2% to 7.9%.

The number of those employed in agricultural production is only 8.7-8.5% and tends to decrease, although the rural population in the region is 55.1%.

Limited employment spheres in rural areas, lack of a developed housing market, low territorial and socio-professional mobility of the rural population, poor social protection of the unemployed and other negative factors hamper the process of optimizing the level and structure of employment in agricultural production. As a result, the qualitative composition of agricultural personnel is also deteriorating. Graduates of universities and technical schools leave the village, so the age structure of specialists becomes unfavorable. The share of highly qualified mechanizers is decreasing. It is also very concerning that the number of children who do not attend school for various reasons is increasing in rural areas.

Table 14. Dynamics of social and economic development
(Source: Office for National Statistics)

s/i	Indicators	2017	2018	2019	2020	2021
1	Total population in the region, thousand people.	783,2	794,3	803,5	814,6	827,9
2	Employed population in the agro-industrial complex, thousand people.	30,3	28,1	27,2	28,5	29,4
3	Crop area, thousand hectares	180,8	178,9	183,1	184,3	188,6
4	Number of agricultural holdings: - agricultural enterprises - farms - household farms	590 5350 83092	602 6644 84649	587 8558 86050	584 11422 87004	552 12613 87674
5	Average monthly nominal salary of one employee, KZT	124107	130 391	152 085	178174	212777
6	Average monthly nominal salary of one employee in agro-industrial complex, KZT	82 011	82 141	90 429	98 430	112219
7	Gross output of agricultural products (services), KZT, mln	88673,9	103923,7	128562,1	143554,0	170840,0
8	Crop production, KZT, mln	53789,5	62 394,8	80 457,7	89 524,2	108578,3
9	Livestock products, KZT, mln	33299,9	39 561,0	45 705,8	52 888,5	60 882,3
10	Level of agricultural production profitability: - for RK as a whole, % - in the region, % including Crop production: - for the Republic of Kazakhstan as a whole, % - in the region, % Livestock breeding: - for the Republic of Kazakhstan as a whole, % - for the region, %	 31,6 9,7 39,7 11,8 17,0 -7,8	 36,7 4,4 37,3 5,6 19,7 0,1	 34,2 12,8 41,5 14,9 22,0 -11,1	 30,0 25,4 50,1 28,1 21,1 30,3	 37,8 26,7 51,0 30,4 17,2 7,9

The number of population in the region for the period under review increased by 5.7%, at the same time the number of people employed in the agro-industrial complex decreased by 0.9 thousand people, decreasing in some years to 3.1 thousand people (2019). The number of peasant farms is growing (2.4 times), as well as the number of households - by 4,582. The indicators of the social situation in the region show an improvement in some parameters of the living standards of the population. The average monthly nominal wage of one worker increased 1.7 times, and in the agro-industrial complex - 1.4 times. At the same time, the wages of agricultural workers are still 44-47% lower than in the economy as a whole.

The gross output of agricultural products (services) almost doubled, including crop production - more than twice, livestock production - 1.8 times. However, the increase in agricultural output in monetary terms is apparently associated with the growth of prices for agricultural products.

The level of profitability of agricultural production in the region is 3-5 times lower than in the Republic of Kazakhstan, but in the last two years there is a significant increase in this indicator and the gap with the same indicator in the Republic of Kazakhstan amounted to 0.7-0.8 times.

A similar picture can be traced in crop production, where the level of profitability for this period increased almost threefold - 11.8% to 30.4%, but still remains below the national average.

In livestock farming the picture is unsightly - the level of profitability is low, and in some years negative values of this indicator are observed (2017 and 2019).

At present, the social composition of the low-income population has significantly expanded. The reason for such social changes is primarily due to the loss of work by several members of the household, the decline in the real wage level.

Low population growth rates and the outflow of rural population to the city, as a rule, reduce labor resources in rural areas and create difficulties in providing labor force, and this at a given level of technical equipment of labor constrains economic growth. With full and rational use of available labor resources further increase in production is possible only at the expense of labor productivity.

The age structure of the population also largely reflects the low degree of development of their economy. The high specific weight of dependents, being the main characteristic of rural areas, will further restrain the development of productive forces, as significant resources of the region are withdrawn from economic turnover and used for the maintenance of this category of population, as a consequence, the economic situation of the region will deteriorate even more.

In Kyzylorda region significant production and natural resources are utilized. The total area of agricultural land within the administrative boundaries of the region is 3056.8 thousand hectares, of which 174.5 thousand hectares are irrigated. Arable lands in the total structure of agricultural lands make up 5.4%, irrigated lands - 74.4%. The area of fallow lands is 1.4% and 19.1% of irrigated lands, respectively.

In the total area of agricultural land the largest share is occupied by pastures - 70.6%, hayfields occupy 2.2%.

The distribution of arable land areas by forms of ownership and management is as follows: peasant farms - 53.9%, agricultural enterprises - 35.7%, household farms - 10.4%.

Table 15. Sown area of agricultural crops by form of ownership, thousand hectares

Forms of ownership	2017	2018	2019	2020	2021
All categories of farms	180,7	178,9	183,1	184,3	188,6
Agricultural enterprises	68,7	76,7	68,9	69,4	67,4
Individual entrepreneurs and peasant or private farms	94,2	83,8	96,1	96,2	101,5
Households of population	17,9	18,4	18,0	18,8	19,6

Source: Statistical collection “Agriculture of Kyzylorda region 2017-2021”.

Productivity and efficiency of irrigated land use depends on a greater extent on the composition and structure of cultivated crops. The projected cropping pattern on irrigated lands should be oriented towards ensuring food security and solving socio-economic problems of the country. Irrigated lands should be saturated with highly profitable crops, demanded in the market, cultivation of which is associated with the lowest degree of economic risk of intensive land use.

At the same time, soil fertility, precipitation, its distribution by seasons of the year, the amount of irrigation water by seasons in the regions of irrigated agriculture, temperature regime, biological characteristics of crops, their adaptation to specific soil and climatic conditions should be taken into account, since there is a close relationship between these factors and yields, as well as the quality of products.

The volume of crop production and the efficiency of agricultural production as a whole depends on the area and structure of crops.

Table 16. Area by crops for all categories of farms, thousand ha

s/i	Area by crops, thousand hectares	2017	2018	2019	2020	2021
1	Cereals (including rice) and legumes	97,5	95,3	97,5	100,1	97,1
2	Wheat	5,1	5,7	7,9	8,7	11,5
3	Corn	0,7	0,8	0,6	0,6	0,6
4	Millet	0,4	0,6	0,5	0,5	0,4
5	Rice, unhusked	90,9	87,5	87,9	89,7	84,1
6	Potatoes	4,2	4,3	4,0	3,8	3,8
7	Sunflower	0,5	0,1	0,1	0,1	0,1

8	Open ground vegetables	5,0	5,2	5,7	5,6	6,0
9	Gourds	7,3	7,8	7,8	8,1	8,5
10	Fodder	59,9	57,8	60,2	61,0	66,4
11	Vineyards, ha	65,6	61,4	63,3	64,1	63,1
12	Seed and stone plantations, ha	425,8	427,3	447,1	471,6	560,2
13	Berries, ha	4,4	4,3	4,1	4,3	4,7

Source: Statistical compendium “Agriculture of Kyzylorda region, 2017-2021”.

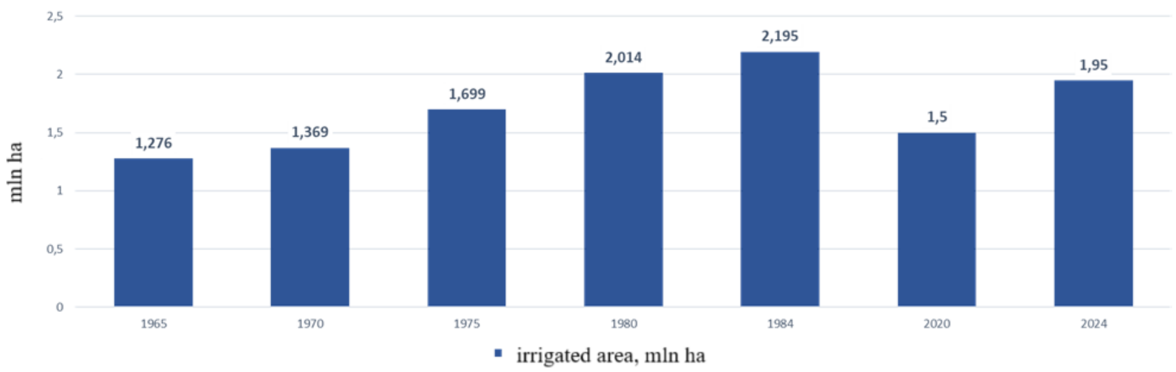
In the structure of agricultural crops for the analyzed period, the largest specific weight is occupied by rice crops 46.2%. During this period, the crops of this crop decreased from 90.9 thousand hectares to 84.1 thousand hectares.

The main direction of economic activity in the region is cultivation and processing of rice. As it is known, rice is one of the highly productive crops among cereals, its average yield is about 42 c/ha. Rice production is also of great importance in ensuring food security of the republic. The average annual consumption of rice by the population in the republic is 8.8-10 kg per person. In some countries the average per capita consumption of rice reaches 160 kg per year (Japan). The volume of rice production in the region exceeds 20 times its own needs, calculated according to scientifically substantiated norms, to provide the population with rice. Therefore, there are real opportunities for rice production for export in the region**.**

Table 17. Dynamics of irrigated agriculture development in Kyzylorda region

Irrigated area by years (thousand ha)						
1910	1925	1935	1956	1966	1969	1970
60,0	40,0	63,1	84,7	94,1	121,5	140,0
Dynamics of areas under rice (thousand hectares)						
1906	1928	1937	1950	1963	1969	1970
0,75	3,5	16,4	22,99	25,95	57,38	63,0

Source: Water Management in Kazakhstan. Under general editorship of S.M. Sarsembayev. Alma-Ata, “Kainar”, 1971.



s/i	Water management basins	2020			2021			2022			2023		
		Watered lands, th.ha	Water intake, mln m3	Specific consumption, thousand m3/ha	Watered lands, th.ha	Water intake, mln m3	Specific consumption, thousand m3/ha	Watered lands, th.ha	Water intake, mln m3	Specific consumption, thousand m3/ha	Watered lands, th.ha	Water intake, mln m3	Specific consumption, thousand m3/ha
1	Aral-Syrdarya	642	7 456	11,6	536	6 920	12,9	590	6 781	11,5	694	7126	10,2
2	Balkhash-Alakolsky	456	3 401	7,5	453	3 310	7,3	312	3 347	10,7	291	3229	11,1
3	Ertysky	49	165	3,4	48	158	3,3	52	174	3,3	63	187	2,96
4	Yesilsky	6	10	1,8	9	14	1,5	8	5	0,6	12	11	0,92
5	Zhaiyk-Caspian	12	46	3,9	12	48	4,1	15	47	3,2	13	48	3,69
6	Nura-Sarysu	24	74	3,1	9	74	7,9	20	74	3,7	25	92	3,68
7	Tobol-Torgay	6	13	2,2	7	13	2	8	20	2,3	8	210	2,63
8	Shu-Talas	84	936	11,2	104	936	9	139	1 040	7,5	122	1002	8,21
	Total:	1277	12 101	9,5	1 177	12 101	10,3	1 144	11489	10	1228	11905	9,69

Availability of irrigated lands in Kazakhstan for the period of 1965-2024.

As can be seen from the above table and analysis of the chapter "Water resources in the Kazakhstan part of the Aral Sea basin", it should be stated that the most optimal share of the leading crop - rice - in the crop rotation structure of Kyzylorda region is about 30%.

Rice crops are located in 118 countries on 145 million hectares with annual grain production of about 600 million tons. At present, among the rice producers are such countries as China producing 125000 thousand tons, Iran - 2200 thousand tons, Russia - 306 thousand tons, Afghanistan - 300 thousand tons, Uzbekistan - 118 thousand tons, Ukraine - 50 thousand tons. At the same time, rice producing countries are experiencing a deficit in this product: Russia - 223 thousand tons, Ukraine - 75 thousand tons, Uzbekistan - 25 thousand tons, Azerbaijan - 5 thousand tons, Iran - 86 thousand tons. China lacks 20 million tons of rice, while the world export of this crop is only 26 million tons. The above figures also indicate the great potential for rice production in the country for export, as the demand for this product in the world market is significant.

The volume of rice production in Kazakhstan, taking into account favorable climatic and geographical conditions, can be increased to 400-500 thousand tons or to 240-300 thousand tons after processing, 90% of which can be produced in Kyzylorda region.

At the same time, there is a tendency to reduce the volume of exports of Kazakhstani rice and decrease its competitiveness even in traditional markets. The main reason is its high production cost and low quality, which does not meet world standards. This is due to a number of objective and subjective reasons - resource-intensive technologies of rice cultivation, poor material and technical equipment of farms, unsatisfactory technical condition of irrigation systems and, as a consequence, poor reclamation condition of lands, insufficient use of mineral and organic fertilizers due to their high cost and financial insolvency of farms for its purchase, cultivation of varieties that do not meet modern market requirements.

The same picture can be traced in the sphere of further processing of rice. Most rice processing enterprises use outdated resource-intensive technologies due to the lack of modern technological lines, the purchase of which is associated with significant financial costs.

The second place is occupied by fodder crops, the share of which amounted to 36.5%. It is necessary to note the increase in the area occupied by fodder crops - from 59.9 thousand hectares to 66.4 thousand hectares, or by 6.5 thousand hectares.

Increase in areas of fodder crops, represented mainly by crops of perennial grasses, which are good precursors in rice crop rotation, has a positive impact on soil fertility on irrigated lands. In addition, the increase in sown areas of fodder crops also positively affects the provision of fodder for livestock production and, ultimately, the profitability of livestock production.

The resulting indicator of agricultural production of crop production is the yield of agricultural crops.

Table 18. Crop yields for all categories of farms, c/ha

s/i	**Area by crops, thousand hectares**	**2017**	**2018**	**2019**	**2020**	**2021**
1	Cereals (including rice) and legumes	45,9	46,5	53,2	52,1	47,7
2	Wheat	15,1	16,8	16,3	15,4	9,2
3	Corn	27,9	40,3	35,0	-	39,4
4	Millet	21,8	23,8	23,6	23,4	22,6
5	Rice, unhusked	48,1	48,9	57,1	56,2	53,4

6	Potatoes	142,7	142,8	141,9	143,7	144,5
7	Sunflower	6,8	12,8	11,8	11,7	10,9
8	Open ground vegetables	165,2	170,2	170,8	172,1	173,2
9	Gourds	188,4	186,1	191,1	191,9	194,6
10	Vineyards	54,2	52,9	48,4	48,8	49,0
12	Seed and stone plantations	41,4	43,0	39,0	36,6	37,7
13	Berry and other fruit trees	91,8	95,1	95,7	93,4	92,7

Source: Statistical collection “Agriculture of Kyzylorda region 2017-2021”.

Grain yields in general for the period from 2017 to 2021 increased from 45.9 to 47.7 c/ha (in 2019 - 53.2 c/ha), or by 10.4%. Rice yields in the region as a whole increased from 48.1 to 53.4 c/ha, or by 11.1%. The yield of vegetable and melon crops also increased on average by 10.4%.

In agricultural production in the region, the development of livestock breeding is of great importance.

The number of sheep and goats for the period from 2000 to 2021 increased more than twice, horses - more than three times, camels - more than 2.5 times. During the same period there is a decrease in the number of pigs - 1.4 times.

Table 19. Number of livestock and poultry at the end of the year, thousand heads

Years	Cattle	Sheep and goats	Pigs	Horses	Camels	Poultry
2000	159,9	540,3	3,6	46,3	19,37	367,8
2005	216,1	679,3	3,6	51,2	23,69	418,9
2010	247,3	761,8	3,3	66,4	32,42	225,8
2015	268,9	570,4	2,7	97,4	37,38	86,5
2020	342,4	698,6	1,6	164,6	51,56	124,5
2021	360,7	716,2	1,2	189,6	54,07	125,8

Source: Statistical collection “Agriculture of Kyzylorda region 2017-2021”.

Water management activities on irrigated lands of the region. Successful development of the region's economy largely depends on the efficiency of functioning of all spheres of the agro-industrial complex, including irrigated agriculture.

In the region the development of crop production in general is based on irrigated farming, there are no rainfed lands.

Irrigated lands of Kyzylorda region are represented by irrigation systems located in the lower reaches of the Syrdarya River, which is the main source of irrigation in the region. The following irrigation massifs are located within the boundaries of the region: Togusken (29060 ha), Zhanakurgan-Shieli (33815 ha), Kyzylorda (103280 ha) and Kazalinsk (26 435 ha).

Table 20. Information on the use of irrigated lands in the region
(Source: Bureau of National Statistics)

					Reasons:

s/i	Regions	Availability of irrigated lands	Including engineers trained	Total unused irrigated lands	Salinization	Flooding	No management	Irrigation system malfunctions	Malfunctions in the drainage network	Other
1	2	3	4	5	6	7	8	9	10	11
1	Zhanakorgan	34465	28282	1908	354	278	397	-	-	879
2	Shielisky	31118	25801	7037	54	-	2457	-	-	4526
3	Syrdarya	45584	39917	12059	-	265	416	-	241	11137
4	Kyzylorda	10418	7907	2417	110	-	445	742	56	1064
5	Zhalagashsky	40821	32595	10415	175	164	276	321	-	9 479
6	Karmaksha	26017	23050	5273	912	-	1536	-	-	2825
7	Kazalinskiy	27322	19119	8338	-	-	-	-	-	8338
8	Aralsky	3078	2290	2680	-	-	92	-	-	2588
Total for the region:		218823	178961	50127	1605	707	5619	1063	297	40836

Annually, 25 to 30% of the total area of irrigated land in the region is not used. The reasons for non-utilization are as follows:

1. Close occurrence of highly mineralized groundwater level due to the drained area, when the existing collector-discharge network as a result of its unsatisfactory condition does not provide creation of optimal water-air-salt regime in soils of aeration zone, as well as malfunction of irrigation systems leads to soil salinization. Such sites were identified (3.2%).
2. Flooding by filtration water from main canals, as well as water infiltration from under rice paddies leads to the fact that low-lying areas of irrigated lands are subjected to waterlogging. The total area of waterlogged lands is about 1.4%.
3. Presence of non-command water horizons in irrigators as a result of dam shrinkage - 11.2%.
4. Due to malfunction of irrigation systems - 2.1%.
5. Due to collector-drainage network malfunction - 0.6%.
6. For other reasons (81.5%)

Technical condition of irrigation systems. The level of technical condition of irrigation systems determines the reliability of their operation and significantly affects the efficiency of agricultural production on irrigated lands.

One of the most important indicators of the technical condition of irrigation systems is the efficiency factor, which characterizes how efficiently water resources of the basin are used. The efficiency factor of the inter-farm part of irrigation systems in Kyzylorda region amounted to about 0.8. According to annual reports of water management organizations, the efficiency factor for irrigation systems was: for Kyzylorda region - 0.50-0.60, and in 1990 similar indicators were at the level of 0.76, which indicates the deterioration of the situation with the use of irrigation water in the inter-farm and on-farm parts of irrigation systems in the basin.

An important indicator of the technical condition of the basin's irrigation systems is the degree of their wear and tear. For example, for the state irrigation systems of Kyzylorda region - 72%.

The technical condition of irrigation systems was aggravated by the change of management forms. If before 1992, the water sector of the economy was maintained at the expense of the republican budget, which provided for financing of reconstruction works, then recently, due to the lack of state support and weak economic situation of agricultural producers and water consumers, repair and rehabilitation works of hydrosystems, canals, collectors and other water management facilities are carried out in insufficient volume. As a result, they are in unsatisfactory condition and out of order. Irrigation systems of the planned zone are poorly equipped with collector-drainage and catchment-discharge network, the specific length of which is only 9.8 and 3.9 r.m/ha, while the norm is 27 and 32 r.m/ha, respectively.

The irrigation and collector-drainage network is poorly equipped with necessary hydraulic structures, which determines the conditions of their unsatisfactory operation.

Field survey of irrigation systems and analysis of their technical condition showed the following:

- a significant part of main, inter-farm and on-farm canals run in the earthen channel, and only a small part has impervious cover;

- deformation and collapse of slopes is observed everywhere along main and inter-farm canals due to the presence of curvilinear sections, as a result of which flow failure and bank scour occurs;

- presence of a large number of water allotments in farms under imperfect water accounting complicates operational water allocation;

- imperfect water-metering is caused by inadequate equipment of gauging stations, non-compliance with the requirements set for them during their construction, and their unsatisfactory maintenance during operation;

The on-farm irrigation network is mainly represented by the 1st and 2nd order distributors made in the earthen channel. Its technical condition requires reconstruction measures. With the emergence of different forms of ownership and management on irrigated lands, the operation of the systems has recently become much more complicated. This situation has led to the fact that the on-farm network is rapidly deteriorating and falling into disrepair. Earthen canals are subjected to the greatest deterioration due to channel deformation, scouring, siltation and overgrowing. The condition of these canals is unsatisfactory in most cases. Lined canals need sealing of damages, joints, replacement of separate elements, cleaning from sediments, etc.

The technical condition of structures on the on-farm network is somewhat better, but even here there is destruction of concrete elements, warping of metal frames, etc. The structures are also in need of reconstruction, capital and current repairs.

Water-metering on the on-farm irrigation network due to insufficient number of gauging stations is extremely unsatisfactory. Water-measuring posts are arranged only at the points of water allocation - at the head of economic distributors.

Analysis of the technical condition of the collector-drainage network allowed to note the following:

- intensive fouling of collector slopes is observed;

- cofferdams are built on collectors, which form drainage water storage basins for their reuse. This reduces the efficiency of the collector network;

- lack of operational roads along collectors and discharges complicates their operation;

- part of collectors are silted up, slope collapse is observed on them, as a result of which the depth of collectors decreases and drainage capacity is reduced to a minimum.

All these deficiencies and shortcomings in irrigation systems lead to significant losses of the scarce resource - water, complicate normal operation of the whole complex of irrigation structures on the system and create considerable difficulties in water distribution and management of water management systems, and ultimately lead to a decrease in the efficiency of water use on irrigated lands.

Along with reduction of technical level of irrigation systems in the considered zone, reclamation state of irrigated lands is deteriorating, which is also one of the reasons of their productivity reduction.

The low technical level of irrigation systems is the main reason why the productivity of irrigated lands in the region is not everywhere at the level of relevant requirements. This situation requires revision of the existing water management practice, at that, priority should be given to reconstruction and technical re-equipment of irrigation canals and structures on them, which will significantly contribute to rational use of water resources.

Composition of works on rehabilitation and reconstruction of irrigated lands in general includes:

a) reconstruction of irrigation systems, KDS and GTS;

b) introduction of mechanized irrigation and micro-irrigation: surface irrigation, sprinkling, drip irrigation;

c) improvement of reclamation condition of irrigated lands: capital leaching, chemical reclamation.

Reclamation condition of irrigated lands. The area of irrigated lands subject to salinization in Kyzylorda region was 218823 ha, among them there are no non-saline lands, slightly saline - 34%, moderately saline - 39% and strongly and very strongly saline - 27%.

In the distribution of areas with different degree of groundwater salinity there is a certain zonality - its increase with removal from the Syrdarya river. Low-saline and low-saline waters with mineralization less than 3.0 g/l have limited development and are confined to incremental type of regime, and groundwater with mineralization from 5.0 to 10.0 and more g/l is spread on the rest of the area.

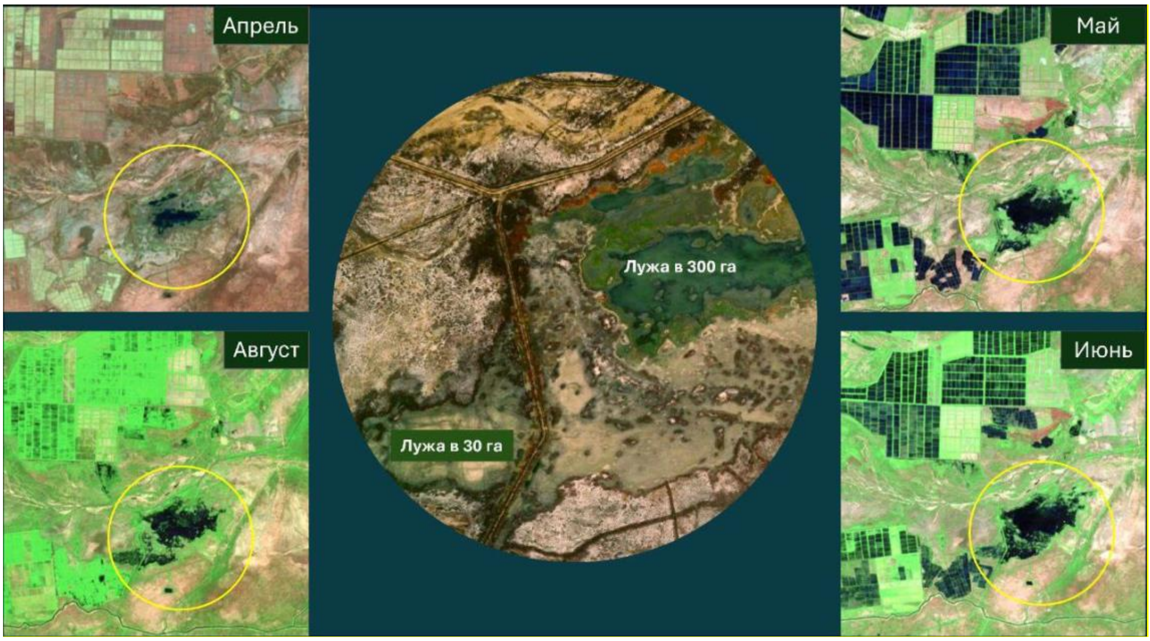
According to chemical composition sulfate-chloride sodium with different cation composition prevail.

In Kyzylorda region, according to V.M. Borovsky, on the flooded part of the Syrdarya river delta alluvial-meadow, meadow-marsh and solonchaks are predominantly distributed, in the non-flooded part - alluvial-meadow, takyr, takyr and residual solonchaks.

According to the qualitative composition of salts, the Syrdarya delta is defined as a region of sulfate-chloride salt accumulation.

One of the main reasons for deterioration of reclamation condition of irrigated lands is unsatisfactory condition of irrigation systems, which everywhere have deformations of slopes as a result of their collapse and siltation.

Most of the irrigation systems in the region under consideration were built long ago - 40-50 and more years ago. For example, the Baskara system in Kyzylorda region was built in 1928, and the Kazaly Right Bank system - in 1946. A significant part of irrigation systems was built before 1970 and require reconstruction. All this negatively affects the dynamics of groundwater regime, contributing to its rise, evaporation and subsequent secondary salinization of soils.



Water losses through irrigation canals as a result of breach of their integrity

Data on the irrigated lands salinization degree are given within the boundaries of corresponding irrigation areas. In Kyzylorda region, non-saline lands amount to 66.6 thousand ha. Weakly saline, moderately saline and strongly saline - 17.85, 20.57 and 181.01 thousand hectares respectively. From the given data it is seen that the increase in the area of highly saline lands in Kyzylorda region occurs at the expense of reducing the area of non-saline lands.

Groundwater of the irrigated area is formed by irrigation water, partly by atmospheric precipitation and underground inflow. Dynamics of groundwater level and its salt regime should be considered in the aspect of their possible influence on soil formation process development and prevention of secondary soil salinization phenomena.

Table 21. Distribution of irrigated lands in the Syrdarya basin by degree of soil salinization in 0-100 cm layer, thousand ha

Irrigation array	Irrigated area under control, thousand ha	Degree of soil salinization in 100 cm layer, thousand ha			
		unsalinated	slightly saline	medium saline	highly saline
Toguskensky	31,84	10,94	4,53	0,34	16,03
Zhanakorgano-Shieli	45,46	12,13	4,76	8,74	19,83
Kyzylorda Left Bank	88,45	12,26	1,70	1,35	73,14
Kyzylorda Right Bank	26,43	3,66	0,51	0,40	21,86
Kazalinskiy Left Bank	20,64	6,85	1,39	2,12	10,28
Kazalinskiy Right Bank	16,44	2,60	1,10	1,69	11,05
Extramassive	56,77	18,16	3,86	5,93	28,82
Average for Kyzylorda region	286,03	66,60	17,85	20,57	181,01

Source: Cadastre of reclamation state of irrigated lands of Kyzylorda region, Kyzylorda

Criteria for assessment of reclamation condition of irrigated lands in the Syrdarya basin are accepted by depth of groundwater table and degree of soil salinization (in 100 cm layer). The condition is considered good when groundwater table is more than 3.0 m and soils are not saline; satisfactory - when groundwater table is 2-3 m and soils are slightly and moderately saline; unsatisfactory - when groundwater table is less than 2.0 m and soils are highly saline.

Table 22. Assessment of reclamation condition of irrigated lands in Kyzylorda region on groundwater table (GWT) and salinity (2022)

Indicators	Farmland area by GWT and soil salinity	
	thousand ha	%
Good	71,6	32,9
Satisfactory	77,4	35,6
Unsatisfactory,	68,6	31,5
including GWT	15,3	22,3
due to salinization	42,7	62,2
by depth of GWT and salinization	10,6	15,5

Source: Cadastre of reclamation state of irrigated lands of Kyzylorda region, Kyzylorda

In order to assess the reclamation condition of lands in the republic, "Rules of state maintenance of monitoring and assessment of reclamation condition of irrigated lands in the Republic of Kazakhstan and information data bank on reclamation condition of agricultural lands" No. 330 dated July 25, 2016 were adopted.

On main and inter-farm canals in the non-irrigation zone in order to reduce water losses, it is necessary to increase the length of lining sections. It is necessary to solve the problem of normal water drainage through KDS everywhere, to restore its profile, to equip it with means of mechanical water pumping. It is assumed that implementation of the planned set of reconstruction works will allow increasing the efficiency of irrigation systems up to the following values:

- for the basin as a whole - up to 0.75;
- for inter-farm systems - 0.85;
- for on-farm systems - 0.80.

Significant scope of works on reconstruction of irrigation systems in the Syrdarya basin is conditioned by the fact that almost all irrigation systems here have a target purpose and accordingly irrigation and collector-drainage networks were constructed in 1970...1980 taking into account the appropriate purpose of this massif: Togusken, Zhanakorgan-Shieli, Kzylorda (left-bank and right-bank) and Kazalinsk (left-bank and right-bank) were intended for rice cultivation.

The scope of works on reconstruction of irrigation systems on irrigation massifs of the planned zone, as well as organizational and technical measures on reduction of specific water consumption for irrigation purposes are given below.

Table 23. Necessary measures to improve irrigation infrastructure in the Syrdarya basin (2022)

s/i	Reconstruction activities	m.u.	Kyzylordinsky
1.	Comprehensive reconstruction	thousand ha	168,5
	- engineering non-rice systems	thousand ha	62,6
	- obsolete engineering non rice systems	thousand ha	13,2
	- rice systems to be converted into non-rice systems	thousand ha	30,8
	- obsolete engineering rice systems	thousand ha	61,9
	- transfer of particularly disadvantaged irrigated areas	thousand ha	12,9
2.	Partial reconstruction		
	- reconstruction and impervious lining of main canals	km	-
	- reconstruction and rearrangement of main collectors	km	787,0 93
	- reconstruction and expansion of collector-drainage and waste water reuse systems	thousand ha	30,0
	- redevelopment of lands prone to salinization for irrigation through furrows in horizontally planned checks	thousand ha	-
3.	Development of regular irrigation using KDS, wastewater and groundwater	thousand ha	14,1
4.	Capital leaching of lands	thousand ha	21,3
5.	Measures to protect from waterlogging and salinization of lands outside irrigated areas	thousand ha	95,0
	- redevelopment of lands prone to salinization for irrigation through furrows in horizontally planned checks	thousand ha	-

Source: Kyzylordavodkhoz data

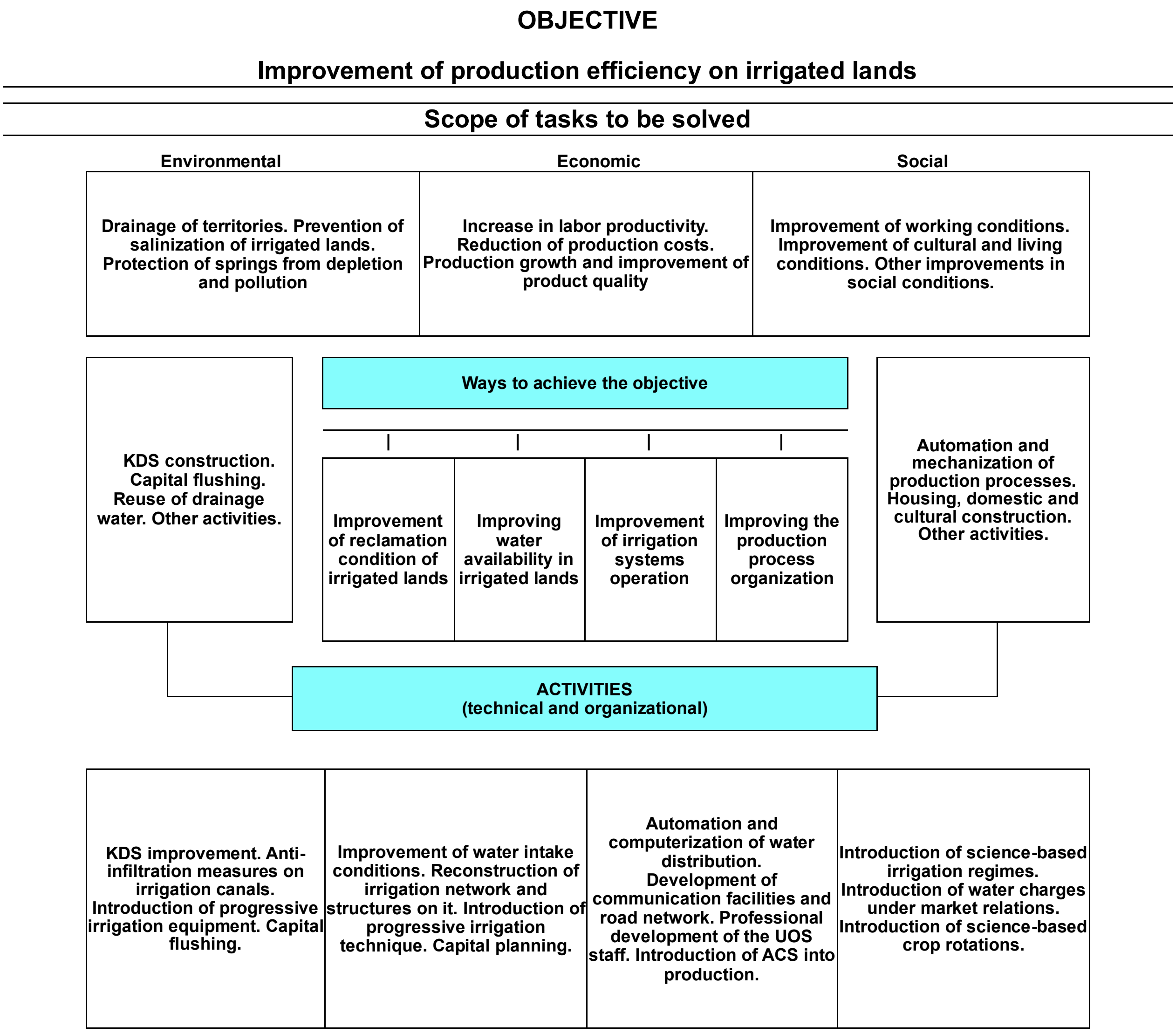


Figure 32. Block diagram of the structure of measures under conditions of irrigation systems reconstruction in Kyzylorda region (Source: Mirsaitov R. 2023)

The Aral Sea is short of 41% of water in 2024.

At the 87th meeting of the Interstate Commission for Water Coordination (ICWC) held in Ashgabat on November 6 this year, water withdrawal limits for the non-vegetation period of 2024-2025 were approved.

Tajikistan will receive almost 3.3 billion cubic meters.

From October 1, 2024 to April 1, 2025, 2.941 billion m3 of water from the Amudarya River was allocated for Tajikistan's needs. Under the allocation approved for the countries of the region, Tajikistan will also receive 365 million m3 from the Syrdarya River.

The total volume of water withdrawal from the Amudarya will be 15.791 billion m3, including::

- Turkmenistan received 6.5 billion m3;
- Uzbekistan - 5.98 billion m3.

From the Syrdarya, the total allocation will be 4.247 billion m3:

- Kazakhstan received 488 million m3;
- Kyrgyzstan - 47 million m3;
- Uzbekistan - 3.347 billion m3.

Water allocation takes into account the countries' needs in agriculture, industry and provision of drinking water to the population.

Results of water resources utilization

According to the results of the growing season 2024, Tajikistan became one of the leaders in the effective use of water withdrawal limits in the Amudarya and Syrdarya basins. The republic used 90.6% of the total limit of 6 billion 326.3 million m3.

In the Amudarya river basin as a whole, the approved water withdrawal limits were used by 85.3%. Actually, 33 billion 829.1 million m3 of the planned 39 billion 701.6 million m3 was used.

For comparison: Turkmenistan used 13 billion 959.9 million m3, which is 90.1% of the limit; Uzbekistan - 13 billion 542.9 million m3, which corresponds to 78.6% of the limit.

The Aral Sea was short of 41% of water.

According to the decision, 1.672 billion m3 of water is expected to be delivered to the Aral Sea and Aral Sea region (Priaraliye) in 2025. This is more than 30% higher than the actual volume of supply in the last non-growing season, when 1.273 billion m3 of water was delivered instead of the planned 2.1 billion m3, i.e. only 59% of this volume was actually delivered.

This once again emphasizes the need to strengthen coordination of the countries in the region to prevent further drying up of the Aral Sea.

Nurek reservoir: forecast for the non-growing season 2024-2025

The meeting also approved the forecast operation mode of the Nurek reservoir for the non-growing season.

At the beginning of the period, the volume of water in the reservoir will be 10.568 billion m3. Inflow is expected at the level of 3.696 billion m3, and release - 7.772 billion m3.

By the end of the period, the water volume will decrease to 6.151 billion m3, which corresponds to drawdown (lowering of the water level in the reservoir during the period of time when water discharge from the reservoir exceeds inflow) by 4.417 billion m3.

For the Nurek reservoir in 2024, the inflow during the growing season exceeded the forecasts and amounted to 16.388 billion m3 (109% of the expected), while the release amounted to 12.634 billion m3 (114.9% of the planned). This high level of water availability allowed accumulating necessary water reserves to supply water users in the lower reaches of the river.

CONCLUSIONS

Irrational use of water for irrigation of cotton and rice leads to depletion of the Syrdarya River, threatening agriculture and ecosystems of the region. Worn-out reclamation systems (we lose up to 50 percent of water on earthen canals only during its transportation from the river to the irrigation point) and lack of coordinated actions only aggravate the water crisis.

It should be noted that throughout the Syrdarya River numerous dams prevent spawning and food migrations of fish, thus disrupting their reproduction and breaking the unified ecosystem of the river into separate, poorly connected populations.

Accordingly, it is necessary to carry out scientific and applied works on introduction of modern fish passage and fish protection structures into the water management complex on the basis of positive international experience. As an example, it is possible to cite works on restoration of historical migration routes of salmon in the USA and Canada, revival of eel migration in Spain and France.

About 12 thousand tons of fish products are produced in the Aral-Syrdarya water management area, 14 fish processing plants are operating. At the same time, while in Kyzylorda region more than 8 thousand tons of fish are fished, Turkestan region is the leader in the field of aquaculture development in the republic and produces about 4 thousand tons of fish products. Therefore, the region has all possibilities to increase more than twice the production and export of fish products.[57]

The positive experience of Germany and Poland in organizing the International Park in the lower valley of the Oder River deserves attention. In addition to favorable development of biodiversity and improvement of ecology, the International Park has gained fame as a place for tourism, where already in the first years of opening it brought income of about €1.5 million. Therefore, the development of tourism in the region has great potential - it is ecotourism, where

[57] https://www.gov.kz/memleket/entities/ecogeo/press/news/details/141320?lang=ru

many tourists from developed countries of the EU, USA, PRC wish to visit historical cities of Central Asia and the dried bottom of the Aral Sea together.

In recent years, the degradation of land around rural settlements due to non-compliance with the rules of grazing of livestock is increasingly observed. For the same reason there is a large-scale eating of saxaul and other plantings planted for "green belt" around settlements by livestock.

In this regard, it is proposed to intensify work on phytomelioration and domestication of pastures, restoration of remote pasture rotation and their watering, and it is necessary to revitalize the livestock cluster.

In 2020 in the world ranking on export of mutton or goat meat (fresh, chilled or frozen) Kazakhstan took the 26th place with gross value of production about $6 million. Having available land resources, Kazakhstan may well claim to become one of the five world leaders in mutton exports.

In turn, the consumption of beef in the world today is about 67 million tons per year, by 2030 is projected to grow to 105 million tons/year. Today, the world leaders in beef exports are already using all their resources at full capacity, so Kazakhstan has the potential and resources to occupy a worthy niche in this market.

In Kazakhstan in the middle of the last century the number of camels amounted to 1200 thousand individuals, in 2022 - 241.5 thousand individuals, in Kyzylorda region in 2022 the number of "ships of the desert" amounted to 61.5 thousand individuals. Accordingly, under the conditions of global climate change, increasing drought, reduction of surface transboundary runoff, the traditional industry - camel breeding will be an effective mechanism to adapt to modern challenges.

Cotton and rice yields in the Aral-Syrdarya water basin indicate systemic problems in agro-technology (fertilizers, seed production, crop rotation), which certainly increases the pressure on water resources.

Cotton yield is about 2.5 tons/ha, while the average yield in the countries leading in this industry is 9 tons/ha.

Reference: World leaders in raw cotton production: RU - 3.4 t/ha; India - 5.2 t/ha; Pakistan - 5.2 t/ha; USA - 8.7 t/ha; PRC - 13.1 t/ha.

The rice yield is about 5 tons/ha, where the average yield in countries with developed rice industry is 8.5 tons/ha.

Reference: In Egypt under the same climatic conditions, about 9.7 t/ha of rice is obtained, where in recent years rice export has been suspended due to water shortage and construction of a large dam "Ethiopian Renaissance". In the USA, the rice yield is 7.8 t/ha, in Krasnodar Krai of the Russian Federation - 7-8 t/ha, in Australia - 9 t/ha.

At the same time, irrigation water costs are an order of magnitude lower in these countries than in Kazakhstan.

Meanwhile, in the middle of the last century, record rice yields of 14 to 17 tons/ha were obtained in Kyzylorda region, where the average yield was about 10 tons/ha.

Reference: in 1945 Kim Man Sin harvested 14.4 tons/ha (world record), in 1948 Choi Gi Hwa harvested 9.5 tons/ha, in 1949 Ybyrai Zhakhayev harvested 17.1 tons/ha (world record), in 1962-1967 the team of Y. Zhakhayev harvested 8-9 tons/ha of rice.

IMPACT OF ANTHROPOGENIC FACTORS AND CLIMATE CHANGE ON THE HEALTH OF THE POPULATION OF THE ARAL SEA REGION

The consequences of climate change and growing water scarcity are a global problem. This problem has a special impact on vulnerable population groups - elderly people, children, pregnant women. Rapid development of anthropogenic impact on the environment, urbanization and intensive population growth require urgent measures.

The conclusions of studies of climatic conditions in 2022 indicate that by 2030 and with a forecast to 2050, a decrease in moisture availability and increased aridity of the growing season in the Aral Sea area is expected. Further increase of average annual air temperature by 2030 by 1.7 degrees and by 2050 - 2.5 degrees is forecasted. Consequently, in the Aral Sea basin we can expect aggravation of further anthropogenic load on water resources and natural environment, which is expected to negatively affect the health of the population.

Moreover, the issue of preserving the small Aral Sea is acute. Over the past 12 years, the volume of water in the Aral Sea has decreased by 35%, i.e. by 9 billion cubic meters. The Syrdarya River has practically turned into a fully regulated watercourse transporting polluted water, which is 93% dependent on the water policy of riparian countries. Water releases to the Aral Sea, especially during the growing season, despite the signed international agreements on water allocation, are currently carried out on a residual principle.

Therefore, cardinal measures are needed to solve the issues of Syrdarya river and Northern Aral Sea conservation, in accordance with generally accepted international conventions and especially under climate change conditions, we consider it necessary to pay special attention to the qualitative composition of water resources and preservation of the regime of water bodies close to the conditionally natural regime.

The problems of the Aral Sea for the last decades are the most severe of Kazakhstan's ecological problems, in the solution of which not only Kazakhstan but also many other countries of the world take part.

Since the first days of independence, the Republic of Kazakhstan has been active at the international and national level. For example, the Law of the Republic of Kazakhstan from June 30, 1992 № 1468-XII "On social protection of citizens affected by the ecological disaster in the Aral Sea region" provides for measures aimed at the development of human and natural potential, defined the status and social protection of citizens affected in the zone of ecological disaster. This Law of the RK requires further improvement, adapted to modern conditions of development of economic sectors of the region, social and economic situation, reduction of water resources, increase of drought and climate change.

It should be noted that the Republic of Kazakhstan is taking a number of initiatives and measures to strengthen the health care system. The infrastructure is being improved, medical specialists are continuously improving their capacity. At the same time, the health indicators of the population of the Aral Sea region do not show any improvement. Negative dynamics of demographic indicators should be noted. The birth rate in the Aral Sea region over the last five years has decreased by 13.6%, natural population growth - by 12.4%.[58]

The general morbidity of the population has more than tripled over the last 30 years. The level of respiratory diseases has increased almost as much, the level of congenital anomalies has increased 10-fold.[59]

The health index of pregnant women living in the region is 1.6 times lower than the republican values. In the last five years alone, extragenital pathology was the direct cause of 80%

[58] Speech by Akmaral Alnazarova, Deputy of the Senate of the Parliament of the Republic of Kazakhstan, at the third meeting of the Commission on Cooperation between the Senate of the Parliament of the Republic of Kazakhstan and the Senate of the Oliy Majlis of the Republic of Uzbekistan, November 5, 2022, Samarkand.

[59] Speech by Aizhan Yesmagambetova, Vice-Minister of Health - Chief State Sanitary Doctor of the Republic of Kazakhstan, at the International Scientific and Practical Conference "Environment and Health of the Aral Sea Region Population", October 20, 2022, Kyzylorda

of maternal mortality (20 out of 25 cases). The specific weight of anemia of pregnant women is 1.7 times higher than the republican value, hypertensive conditions of pregnant women are 1.8 times higher. The infant mortality rate is traditionally higher than the republican indicator and has no tendency to decrease. Preliminary analysis of blood of local residents showed that pesticide load on the population, especially on children, is higher than the body burden measured in children in Europe.

KazAcademy of Nutrition and UNICEF noted low bioavailability of iron in the diet in the Aral Sea region. This is due to the predominance of flour and bakery products, which contain large amounts of phytates that bind iron into a compound that is difficult to absorb (Dr. Momoko Chiba, 2004).

As a result, there is a correlation between low iron bioavailability and anemia in this area.

In Kyzylorda region, the Health Index of conscripts leaves much to be desired. For example, in 2015, almost every second conscript was unfit for military service. Many suffer from diseases of the gastrointestinal tract, liver, kidney, high blood pressure, spine, vision and skin diseases.

The health situation in Uzbekistan is similar. Karakalpakstan has one of the highest maternal, infant and child mortality rates in Uzbekistan. The trends in the prevalence of circulatory diseases among children under the age of five are also a cause for concern.

Despite the positive dynamics of a number of key medical and demographic indicators, there are many problematic issues in the region's healthcare sector that need to be addressed both by the management of polyclinics and hospitals and by local executive bodies. This concerns the organization of medical care in the field of maternal and child health care, insufficiently effective work of primary health care (PHC), low detection of diseases during preventive examinations, and technical equipment of medical facilities.

In the region, the number of deaths from acute myocardial infarction increased by 1.4% compared to the same period of 2022, the mortality rate from malignant neoplasms in 2022 amounted to 48.3 per 100,000 population, with a decrease of 12.5%; there is an increase in mortality from injuries, poisoning and accidents compared to the same period of 2021 by 13.3% and 21.0%.

In Kyzylorda region there are 164,467 people on dispensary registration for all diseases, including 72,128 patients receiving treatment for three diseases (arterial hypertension, diabetes mellitus, chronic heart failure). At the same time, two thirds of the patients participate in the disease management program, indicating low activity of the work carried out by general physicians. In addition, the effectiveness of screening tests is low.

In the region under consideration, when providing specialized care to patients with heart disease, the share of those who sought medical help within 60 minutes from the onset of symptoms in the region amounted to 35.85%, which is twice lower than the national average. The same unsatisfactory situation in the provision of medical care for stroke: there is a low proportion of systemic thrombolysis in patients with ischemic stroke, and only 70% of stroke patients are registered at their place of residence.

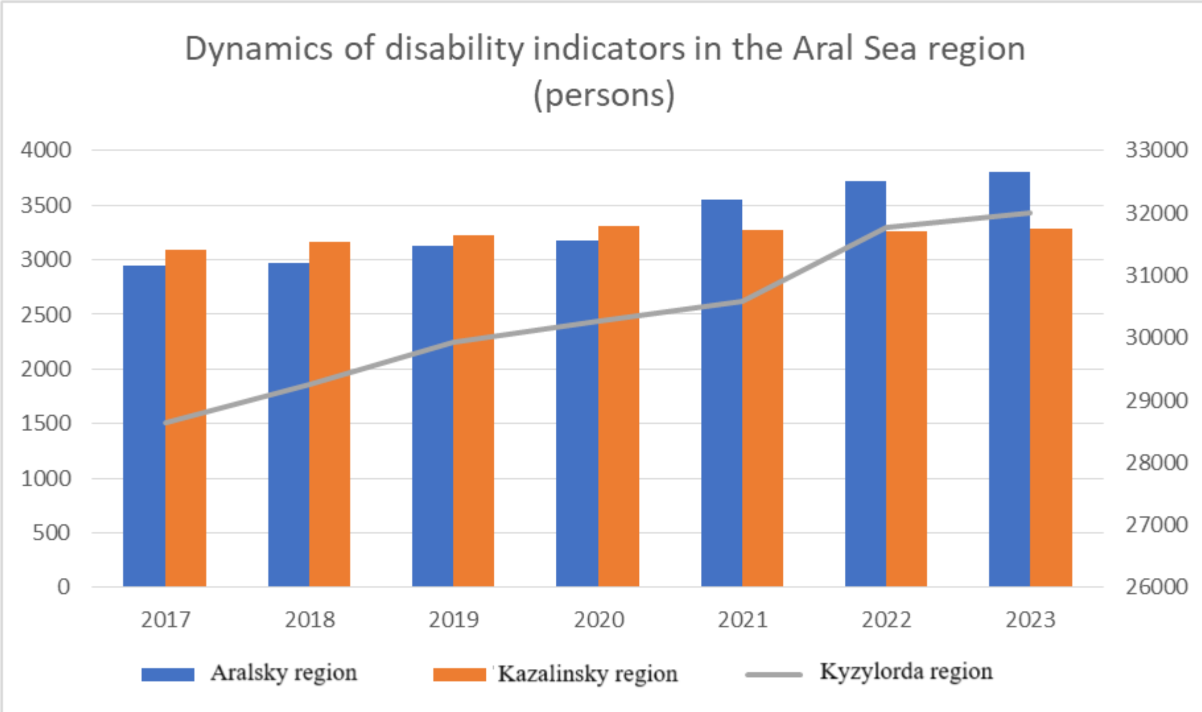


Figure 33. Impact of environmental aspects on the health of the population of Priaralie (Source: Myrzakhmetov K. 2023) (On ordinates: left - number of patients at the district level, right - number of patients at the regional level)

Kyzylorda region has problems in terms of organization of medical care for cancer patients. Among the main problems in the organization of medical care are the absence of the Regional Oncology Center of its own building, the lack of linear gas pedal, outdated equipment for radiation therapy, as a consequence - low coverage of radiation treatment of primary cancer patients - 27.4%, shortage of personnel of narrow specialists in head and neck tumors, specialists in tumors of the musculoskeletal system, pathomorphologists, neurosurgeons, hematologists.

According to the data of the Medical and Pharmaceutical Control Committee of the Ministry of Health, last year the Department received 303 appeals, including 272 appeals. Inspections were carried out on 80 appeals, including 31 (76%) justified and 30 partially justified. The bulk of appeals are about poor-quality treatment and incomplete examination - 92.5%, followed by refusals of hospitalization - 1.23%, other complaints - 6.2%.[60]

Regional health systems face acute challenges in the form of high morbidity, disability and mortality of the local population. In 2020, at the request of the Senate of the Parliament of the Republic of Kazakhstan, the WHO Country Office conducted a rapid review of the ecological state of the Aral Sea region environment and public health. In continuation of this work, an international scientific-practical conference “Environment and health of the population of the Aral Sea region” was organized in Kyzylorda on October 20 of the current year. For the last time similar international scientific-practical conference on the problems of health of the population of the Aral Sea region was held on September 8, 2004 in Kyzylorda.

Based on the results of the short-term expert studies conducted, it should be stated that scientific research plays a significant role in providing evidence of direct or measurable effects of environmental parameters on human health. Therefore, it is necessary to increase research capacity to assess environmental factors affecting public health.

---

[60] Speech by Vice-Minister of Health of RK, Vyacheslav Dudnik, at the meeting with the Minister of Health of RK, Azhan Giniyat, with heads of healthcare organizations of Kyzylorda region, February 21, 2023, Astana-Kyzylorda. (online).

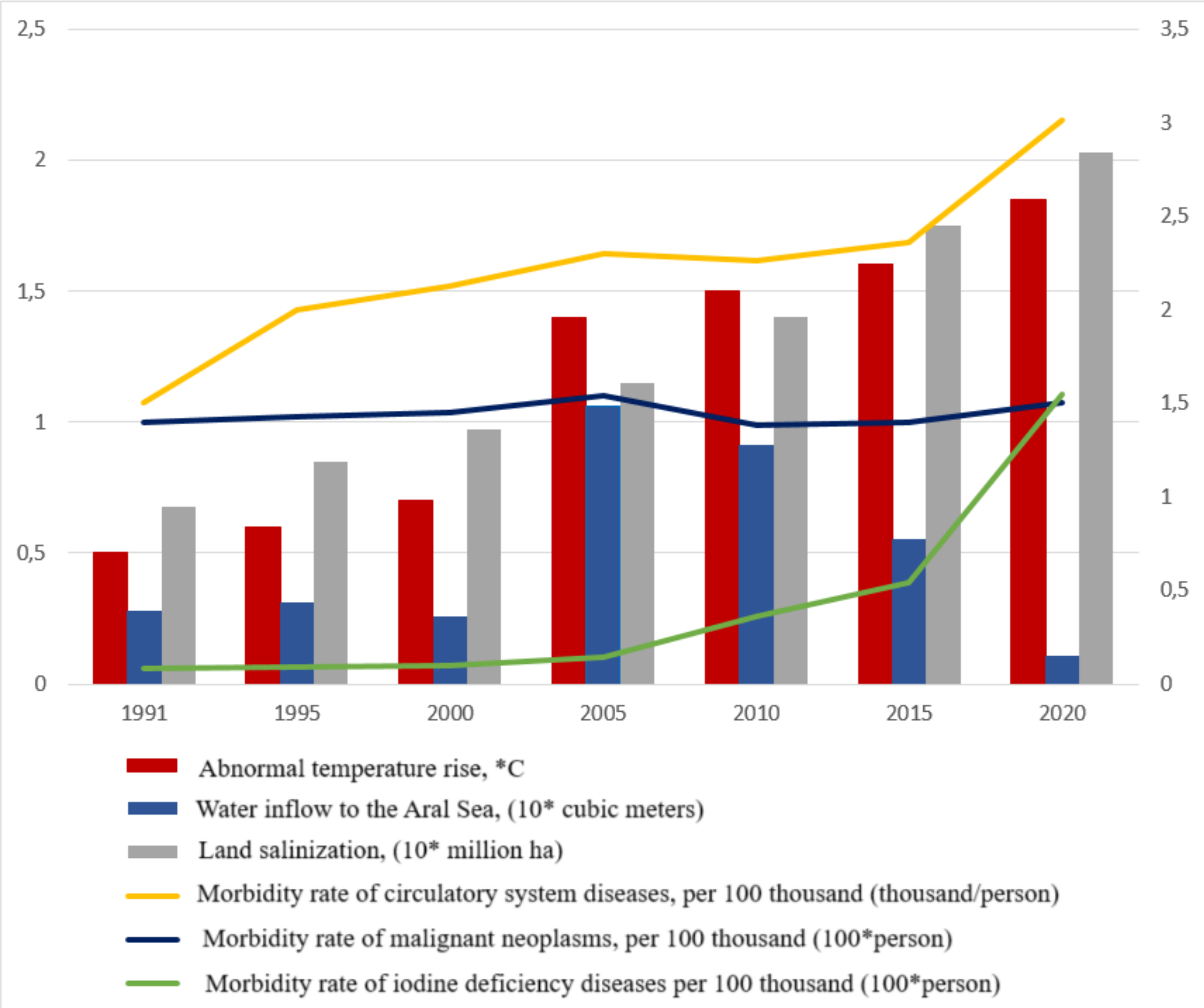


Figure 34. Impact of climate change on human security in Kyzylorda region (Source: Narbaev M. 2023) (On ordinates: synthesized absolute values characterizing the dynamics of the depth of intersectoral interaction in the context of climate change)

The dynamic growth of abnormal temperatures in the region predetermines the increase of water consumption norms in the main sectors of the economy, limiting the natural needs of natural ecosystems.

The observed growth of land salinization indicators indicates systemic shortcomings in the field of land and water resources management. All this, of course, affects the health of the population.

It should be noted that the dynamics of circulatory system diseases and iodine deficiency can be mitigated to a certain extent if a balanced diet and clean drinking water are consumed.

The stable trend in the incidence of malignant neoplasms indicates deeper complex ecological and social aspects in the region.

It should be noted that there is a negative trend in the number of hospital organizations: in 1991 - 84; in 1995 - 75; in 2000 - 55; in 2005 - 67; in 2010 - 67. - 55; in 2005 - 67; in 2010 - 61; in 2015 - 50; in 2020 - 34.

CONCLUSIONS

1. Determine the epidemiology of morbidity of the population in the Aral Sea region.

2. Conduct scientific research on the main environmental threats to public health to identify the mechanisms of their impact on health. Based on the results of the studies, identify measures to mitigate, prevent and monitor them.

3. Develop measures to adapt health systems to climate change through the development of national plans and health-oriented health strategies and responses.

4. Develop and implement environmental health early warning and rapid response systems.

5. Develop a program for raising public awareness of environmental health threats and training in rapid response.

6. Introduce a system of integrated monitoring of the Aral Sea and Aral Sea region, including tracking of the situation on the dried seabed, as well as residual water bodies of the Aral Sea and the Syrdarya river delta.

7. Prepare a program to ensure regional health security in the context of environmental and climate crisis. The program will be supported by the World Health Organization (WHO) Regional Office for Europe through the WHO European Office for Environment and Health Protection (EOEHP), Bonn (Germany) and the WHO European Office for Health Preparedness and Emergency Response, Istanbul (Turkey).

8. KR Health Department together with Akimat to work out issues of providing sanitary vehicles and medical equipment, using the capabilities of the local automotive industry.

Table 24. Morbidity rate of heart and circulatory diseases for 12 months. 2021-2022 (persons) (Source Myrzakhmetov K. 2023)

Area	Circulatory system diseases				including																			
					Ischemic heart disease				Acute myocardial infarction				Acute cerebral circulatory collapse				Atrial fibrillation and flutter				Diseases characterized by high blood pressure			
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
	abs.	abs.	ind.	ind.	abs.	abs.	ind.	ind.	abs.	abs.	ind.	ind.	abs.	abs.	ind.	ind.	abs.	abs.	ind.	ind.	abs.	abs.	ind.	ind.
Region	22764	23787	2830,9	2937,5	2262	2468	281,3	304,8	318	312	39,5	38,5	1455	1472	180,9	181,8	232	234	28,9	28,9	8403	8260	1045,0	1020,0
Kyzylorda city	12568	13687	3163,2	3367,7	1300	1404	327,2	345,5	157	151	39,5	37,2	722	753	181,7	185,3	147	138	37,0	34,0	3980	3769	1001,7	927,4
Aral	*1150*	*1363*	*1629,5*	*1880,8*	*160*	*210*	*226,7*	*289,8*	*26*	*19*	*36,8*	*26,2*	*153*	*171*	*216,8*	*236,0*	*9*	*32*	*12,8*	*44,2*	*624*	*616*	*884,2*	*850,0*
UVA Aral	100	0	4255,3	0,0	11	0	4,7	0,0	3	0	1,3	0,0	0	0	0,0	0,0	0	0	0,0	0,0	46	0	19,6	0,0
Kazaly	*1116*	*1247*	*2006,4*	*2266,7*	*82*	*117*	*31,0*	*212,7*	*13*	*19*	*23,4*	*34,5*	*80*	*65*	*143,8*	*118,1*	*14*	*17*	*25,2*	*30,9*	*358*	*524*	*643,6*	*952,5*
Kazaly ZDB LLP	364	364	1687,6	1664,3	40	73	185,5	333,8	21	8	97,4	36,6	40	28	185,5	128,0	0	0	0,0	0,0	240	218	1112,7	996,8
Karmakshy	857	816	2601,3	2523,7	98	99	297,5	306,2	14	23	42,5	71,1	70	68	212,5	210,3	1	0	3,0	0,0	447	414	1356,8	1280,4
Zhalagash	880	1013	2641,1	3090,7	82	80	246,1	244,1	12	14	36,0	42,7	59	58	177,1	177,0	24	28	72,0	85,4	109	153	327,1	466,8
Syrdariya	774	676	2158,7	1925,4	19	22	53,0	62,7	12	16	33,5	45,6	64	69	178,5	196,5	11	7	30,7	19,9	71	75	198,0	213,6
Shieli	2845	2558	3621,3	3273,2	238	236	302,9	302,0	44	43	56,0	55,0	151	120	192,2	153,5	26	12	33,1	15,4	1334	1276	1698,0	1632,7
Zhanakorgan	2110	2063	2776,1	2727,6	232	227	305,2	300,1	16	19	21,1	25,1	116	140	152,6	185,1	0	0	0,0	0,0	1194	1215	1570,9	1606,4

SWOT-ANALYSIS OF INDUSTRIES IN KYZYLORDA REGION

One of the tools for strategic planning of water sector development in the Kazakhstan part of the Aral Sea basin is SWOT-analysis. This methodology involves dividing the factors affecting the object of study into four categories: Strengths, Weaknesses, Opportunities and Threats. Strengths and Weaknesses are factors of the internal environment of the object under study, these indicators to a certain extent the object is able to independently manage. In turn, opportunities and threats are factors of the external environment, which in most cases are a consequence of external processes.

Materials of the Regional Development Program of Kyzylorda region, National Projects of the Republic and other materials were used in the preparation of this Chapter.

SWOT-analysis of the regional environment

Strengths	**Weaknesses**
1. Stable environmental situation in the context of growing industrial production. 2. Carrying out works to ensure forest conservation and increase the areas covered by forests. 3. Carrying out water management works to improve water availability in the region	1. Ecological problems of the Aral Sea region. 2. Mineralization and water pollution in the Syrdarya river. 3. Deterioration of ecological situation and quality of life due to the lack of modern facilities for processing industrial wastes. 4. Threat of Baikonur complex, the volume of emissions of pollutants into the atmosphere by enterprises and vehicles. 5. Underdeveloped system of collection, including separate collection of solid domestic waste. 6. Low volume of waste recycling and utilization.
Opportunities	**Threats**
1. Mitigation of negative environmental impact and improvement of socio-economic situation in the Aral Sea area through implementation of the large-scale World Bank project “Regional Development and Rehabilitation of the Northern Aral Sea in Kazakhstan”. 2. Increasing the share of recycled solid domestic waste after the launch of the Kyzylorda Solid Waste Treatment Plant. 3. Expansion of forest-seed and nursery farming.	1. Deterioration of the environmental situation due to the intensification of existing environmental problems and increase of emissions into the atmosphere and groundwater pollution. 2. Pollution and mineralization of water in the Syrdarya river and, as a consequence, degradation of biodiversity of natural ecosystems. 3. Continuing tendency of accumulation of ownerless, industrial, toxic and domestic wastes, as well as lack of recycling and utilization technologies.

SWOT analysis of land resources in the region

Strengths	Weaknesses
1. Availability of vacant land. 2. Increase in the use of agricultural land by agro-formations.	1. Irrational use of agricultural land. 2. Shortage of qualified specialists. 3. Low efficiency of land potential utilization.
Opportunities	**Threats**
1. Rational use of land. 2. Use of fertilizers to improve the efficiency of land use. 3. Training of qualified personnel. 4. Improving the efficiency of agricultural production.	1. Degradation of agricultural land. 2. Regression and reduction of productivity of pasture areas. 3. Runoff of lands around rural settlements. 4. Desertification and moving sands around rural settlements. 5. Negative impact of the drained Aral Sea bed. 6. Salinization and reduction of soil fertility. 7. Reduction of tugai forest areas.

Main problems of the sector: degradation of agricultural lands, including use of land plots not for their intended purpose; reduction of land resources productivity due to low scientific and technological level of management, incomplete observance of land use rules (crop rotation, pasture rotation, fertilizer application, water regime).

In Kyzylorda region there are natural deserts Kyzylkum (5 million ha) and Karakum (1.5 million ha). In addition, about 2.8 million ha are subject to wind erosion.

In recent decades, a new desert Aralkum with an area of more than 2.5 million ha (in the Kazakh part) was formed on the dried bed of the Aral Sea, from where dozens of dust and salt storms rise every year.

According to KazNIGMI data, the first strip of the territory - 20-30 km from Aralkum - receives on average 140-150 tons/km2 of dust-salt aerosol, which corresponds to 3-15 salt tons/km2. At a distance of 65 km, 25 tons/km2 is deposited, and at 120 km about 5 tons/km2 of dust-salt aerosol is deposited. The impact of dust-salt aerosol is mainly confined to a 30-50 km strip of territory around the former sea area, with smaller dust-salt particles being transported thousands of kilometers away.[61]

[61] www.kazaral.org

SWOT-analysis of water sector in the region

Strengths	Weaknesses
1. Kazakhstan is a party to the UNECE Convention on the Protection and Use of Transboundary Rivers and International Lakes (Helsinki, 1992). 2. Availability of the 2003 Water Code of the Republic of Kazakhstan regulating water relations on issues of management and regulation of use by population and sectors of economy and protection of water resources. There is also a set of environmental laws aimed at maintaining a favorable environment. 3 Existence of the Aral-Syrdarya Basin Authority for regulation of water resources use and protection, which maintains water balance and assesses the degree of water resources involvement in economic use, sets limits and issues permits for special water use to all subjects of economic sectors. 4. The Basin Council operates under the Basin Authority and meets regularly twice a year. Basin agreements are concluded with major water users and nature users on water conservation and rational water use issues. 5. All water bodies have established water protection strips and zones, where the regimes of their use are stipulated, respectively, their boundaries are marked with signs of the established form. 6. Availability of specialized republican state organizations for operation and maintenance of water infrastructure, delivery of water resources to water users at approved tariffs. 7. There are monitoring hydrological and hydrochemical posts in the Syrdarya river basin, equipped with appropriate equipment and instruments. 8. There are large hydrotechnical nodes and structures that allow water withdrawals in accordance with the limits established for each irrigation area. All large hydraulic structures and canals have hydrometric posts for monitoring water discharges. 9. There are non-governmental organizations (NGOs) in the field of water resources protection and use in the region, uniting in their ranks leading scientists, specialists,	1. After the collapse of the Soviet Union, the existing monitoring network for water quantity and quality (hydrological and hydrochemical posts) in the Syrdarya river basin was reduced due to the allocation of insufficient funding for their maintenance. For the same reason, for a long time no attention was paid to equipping observation points with modern measuring instruments and appropriate office equipment. 2. Early warning services for emergency situations (ES) related to changes in river water availability are insufficiently equipped with modern systems and, as a consequence, the level of coordination between the structures of the parties on emergency situations and other services during floods and severe drought in the river basin is insufficient. 3. Water management infrastructure was mainly built during the Soviet period and is reaching the end of its service life, which may create problems for effective water flow management. Moreover, a significant part of water infrastructure is unused and/or unsuitable for further operation. 4. Water management infrastructure (especially in agriculture) is insufficiently equipped with modern means of measuring water levels and discharges, outdated and insufficiently efficient water use technology is used, and there are no automated control systems for technological processes in water use. 5. Sufficient funds are not allocated to ensure the safety of technologically waste water accumulators, utilization of solid domestic waste, deep treatment of wastewater from cities and other settlements, reduction of industrial enterprises' emissions into the atmosphere, etc. 6. No funds are allocated for relocation of facilities of economic sectors outside water protection strips, treatment of solid domestic and other wastes of artificial origin. 7. Despite the importance of the river, economic, organizational and legal measures taken by the Government of the Republic of

ecologists, educators, cultural workers, public figures and veterans with an active civic position. 10. There are hydrogeological-ameliorative expeditions (in Turkestan and Kyzylorda regions), which monitor ameliorative condition of irrigated lands and prepare recommendations on improvement of soil condition, and Zhakhayev Kazakh Research Institute of Rice Growing, which develops optimal irrigation regimes for rice and related crops, is engaged in variety testing and search for alternative crops suitable for conditions of rice irrigation systems. 11. The World Bank project "Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea" (RRSSAM-1) has been implemented in the region. All major hydraulic structures have been reconstructed and their capacity increased in order to pass annually the required amount of water to the Northern Aral Sea and delta lake systems. 12. There is a higher education institution in the region - Korkyt-Ata Kyzylorda State University, which is engaged in graduation of bachelors and masters in water resources and water use.	Kazakhstan, they are not adequate to the status of the Syrdarya River. The river is still not referred to water bodies of special state importance. As a consequence, solving the problems of the river is not given due attention. 8. Imperfection of normative legal and normative technical base in terms of water saving requirements (for example, water supply from main and distribution canals is carried out without taking into account the level of operation of irrigation systems and their equipping with water-metering posts); 9. Lack of investment in infrastructure is observed both in the construction of new facilities to provide access to water and in the maintenance of existing infrastructure; a significant part of the irrigation and drainage infrastructure is in an abandoned state. 10. Coordination of work on water resources management between different ministries and agencies is not organized efficiently enough. 11. There is a shortage of specialists in the water sector with knowledge and skills in forecasting and optimizing the balance of water resources, justifying and evaluating investments, and improving the efficiency of water consumption. 12. Lack of mid-level water sector employees: technicians-hydrotechnicians for irrigated agriculture, technicians-hydrogeologists for pasture watering.
Opportunities	**Threats**
1. Existence of political basis for interstate water cooperation. Interaction on water resources use and protection in the Syrdarya river basin is based on the "Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on cooperation in joint management of interstate water resources use and protection" dated February 18, 1992 (Almaty). 2. Existence of the Interstate Commission for Water Coordination (ICWC) with executive bodies: BWO "Amudarya" and BWO "Syrdarya", Scientific-Information Center (SIC) and Secretariat.	1. Non-compliance of upstream states with operation regimes of Toktogul reservoir on the Naryn River, Bakhri-Tochik (Kayrakkum) reservoir on the Syrdarya River and Charvak reservoir on the Chirchik River. 2. New reservoirs were constructed (Rezaksai reservoir with a volume of 175 million cubic meters), as well as bulk reservoirs, in the Fergana Valley (Central Fergana reservoir with a volume of 350 million cubic meters) and in the Hungry Steppe zone (Sardoba reservoir with a volume of 600 million cubic meters). 3. A water intake structure from the Dostyk canal with a capacity of 60 cubic meters for water discharge into the Aidarkol lake system of Uzbekistan has been constructed.

3. Presence of the Central Asian Power Ring and the Coordination Dispatch Service, which ensures power flow between the post-Soviet Central Asian states. 4. Availability of the Naryn-Syrdarya reservoir cascade (NSCWC), which allows to distribute water resources of the Syrdarya river basin in accordance with the Scheme of integrated use and protection of water resources 1982 and its Corrective Note 1984. 5. A separate Agreement between the Republic of Kazakhstan and the Republic of Uzbekistan on water allocation downstream of the Farkhad hydroscheme is under consideration.	4 There is a project for construction of the Karaman reservoir at the end of the South Golodnostepsky main canal with a volume of 500 million cubic meters and a project for a canal for transferring runoff from the Charvak reservoir to the left bank of the Syrdarya River. 5. Insufficient capacity of treatment facilities of cities and industrial enterprises, their poor technical condition poses a great threat in terms of possible implementation of volley discharges of untreated wastewater. The coastal zones of rivers within the boundaries of cities and settlements are built up, which can lead to flooding and washing away of houses and other buildings, pollution of river water resources. All this may be an additional source of deterioration of water quality of transboundary water bodies.

Main problems of the sector: Moral and technical backwardness of the water sector from modern science-based and international requirements; lack (deficit) of qualified personnel (higher level: engineers; middle level: technicians); need for planned training of water sector employees in modern innovations (requirements) of this sector; insufficient implementation of measures to improve the capacity of water users (Extension, Field Schools for Farmers).

SWOT-analysis of the agro-industrial complex of the region

Strengths	Weaknesses
1. Favorable soil and climatic conditions for the development of crop and livestock farming. 2. Availability of agricultural lands with fertile soils, natural hayfields and pastures. 3. The region is the main producer of rice in the republic. 4. Financial support of the industry by the state. 5. Availability of inexpensive natural gas (for winter heating in greenhouses and other needs). 6. Increase in the number and productivity of livestock through the program “Sybagha”, “Kulan”, “Altyn asyk”, which will give the opportunity to increase the volume of exports. 7. Active renewal of machinery (471 units of agricultural machinery have been purchased over the last three years). 8. Availability of fishery, fishing in the Aral Sea (the share of the region in the total national volume of fish catch amounted to 8.3%). 9. Availability of internal and external markets for sale of agricultural products.	1. Low labor productivity. 2. Increased periods of dry and low-water periods. 3. Irrational use of water resources. 4. Provision of water bodies with stable hydrological regime. 5. Dependence on weather conditions. 6. Low level of genetic potential of used seeds and livestock. 7. Weak fodder base, lack of complete feed and, as a consequence, low productivity of livestock and poultry. 8. Lack of fixed and current assets of the majority of agricultural producers. 9. Shortage of raw materials for industrial processing and low share of deep processing of domestic raw materials. 10. Critical condition of watering facilities in remote pasture lands. 11. Lack of processing shops for livestock products (wool, hides, karakulch krimmer skin) in the region. 12. Physical and moral deterioration of agricultural machinery and equipment. 13. Lack of financial capacity of economic structures in purchasing the necessary equipment. 14. Small-scale (fragmented) agricultural production, production of the main share of meat and milk (90%) in individual sectors.
Opportunities	**Threats**
1. Availability of land to increase the amount of arable land. 2. Availability of pasture lands. 3. Availability of infrastructure in the agro-industrial sector for the formation of agricultural clusters. 4. Creation of large-scale greenhouses in the south of the region. 5. Introduction of new innovative agro-technologies. 6. Cultivation of organically clean products. 7. Opportunity to enter foreign markets. 8. Active state support of the industry. 9. Establishment of cooperatives, service and procurement centers (SPC), processing facilities by uniting rural individual producers	1. Risks of natural character (drought, frost, freezing, flooding, mass disease of plants and animals, etc.). 2. depletion of the Syrdarya River. 3. Salt and dust storms from the dried bottom of the Aral Sea. 4. Land degradation and desertification. 5. Competition from Russia, China and WTO countries and high risk of competition of cheap imported meat, dairy products. 6. Shortage (deficit) of qualified middle-level workers.

of milk, meat, poultry eggs, potatoes, vegetables, melons and other products. 10. There are strong positions for the prospective development of livestock breeding, including meat production, fishery and fish processing with high export potential.	

SWOT analysis of healthcare in the region

Strengths	Weaknesses
1. Improving accessibility of high-tech medical care for the population within the guaranteed scope of medical care. 2. Development of cardiac surgery service. 3. The territory is one of the regions with relatively low registration of HIV infection.	1. Environmental situation in the region affecting the health of the population. 2. Shortage and insufficient level of qualification of medical personnel. 3. High level of morbidity of the population with socially significant diseases. 4. Tuberculosis morbidity rate remains high compared to the indicators for the Republic of Kazakhstan. 5. Insufficient quality of provided medical services. 6. Insufficient level of equipment of health care organizations.
Opportunities	**Threats**
1. Improving the quality of health care services by attracting highly qualified specialists, particularly in rural communities. 2. Improvement of the environmental situation in the region, contributing to the reduction of morbidity rates. 3. Expansion of health care financing to improve the equipment of health care organizations, which will improve the quality of medical services.	1. Provision of medical services to the population not in full and not at the quality level due to the shortage of medical personnel and insufficient equipment of health care organizations. 2. Deterioration of the environmental situation will lead to an increase in the incidence of socially significant diseases.

Main problems of the sector: unfavorable environmental situation in the region, which affects the health of the population; high incidence of socially significant diseases, especially tuberculosis; low health index of pregnant women; poor-quality medical care, which causes an increase in the number of complaints from the population; insufficient quality of medical services provided; unresolved personnel issues (shortage and insufficient level of qualification of medical personnel); insufficient level of material and technical equipment of the organizations; poor quality of medical services; insufficient quality of medical services provided to the population.

SWOT-analysis of labor and social protection in the region

Strengths	Weaknesses
1. Unemployment rate in KR (5.0%), by RK (5.0%). 2. The share of self-employed population (27.1%) is lower than in the RK (29.5%). 3. Decrease in the number of those who applied for state targeted social assistance for two years by 48.2%. 4. The Rehabilitation Center for the Disabled, equipped with the latest technologies for rehabilitation measures and improving the quality of health of the disabled, is functioning. 5. NGOs provide special social services for disabled children with psychoneurological pathologies and locomotor disorders in a day hospital. 6. Addressing issues of providing disabled persons with access to facilities and services in all spheres of life (special road signs, pedestrians, ramps, etc.). 7. Creating conditions and opportunities for people with disabilities to start their own business. 8. Medical and social institutions are equipped with new modern technologies to help reduce the disability group and improve the health of people with disabilities.	1. Unemployment persists, with particularly high female (5.7%) and youth (5.1%) unemployment rates (RK 4,8% and 4.2% respectively). 2. Labor market imbalance of the labor force, deficit of qualified workers, with significant unemployment there are unfilled vacancies. 3. Every year in the region there is a surplus of labor force, varying from 4.5 to 4.8 thousand people. 4. Tension in the labor market does not increase, but there is an imbalance: the demand for one job is observed in 4-5 unemployed people. 5. Shortage of qualified personnel in rural areas. 6. Lack of a systemic vision of entrepreneurship development in districts and, accordingly, of Maps of entrepreneurship development in districts (rural districts). 7. Lack of collateral for obtaining microcredits. 8. Increase in the number of disabled people, among them - disabled people with nervous system disorders. As a result, there is a shortage of places in residential care facilities. 9. Insufficiently effective integration of disabled persons into society (difficulties in obtaining medical care, employment, education, cultural life, sports, access of disabled persons to social, transportation and recreational infrastructure).
Opportunities	**Threats**
1. High demand from the unemployed, self-employed and low-income people for microcredit. 2. Increase in the number of places in the state organization “Rehabilitation Center for the Disabled”. 3. Increase of social activity of disabled people. 4. Provision of primary stages of rehabilitation measures to persons with disabilities at the level of districts/towns, villages.	1. The risk of unemployment growth due to the closure of enterprises in the crisis. 2. Growth of unemployment rate among young people. 3. Increase in the number of recipients of state targeted social assistance. 4. Lack of additional sources of funding due to increased demand for social rehabilitation organizations. 5. Passivity of citizens with disabilities.

Main problems of the sector

In labor and employment: low level of average per capita monetary income in the region; strengthening of structural disproportion in the labor market, associated with the growing shortage of personnel of certain qualifications and professions; lack of labor supply with sufficiently necessary demand (permanent vacancies for working specialties); excess of specialists with higher education and shortage of qualified workers; shortage of persons with qualifications and competencies necessary for the development of the region's economy, including the innovation sector, including due to the outflow of innovation-oriented youth and highly qualified specialists from the region to territories with a higher standard of living and attractive working conditions; persistent violations of labor and production discipline; belonging of the region to an environmental disaster zone.

In social security: growing need for rehabilitation of disabled people and other categories of citizens (high waiting list for psychoneurological boarding schools); lack of accessible living environment for persons with disabilities.

SWOT analysis of the region's macroeconomy

Strengths	Weaknesses
1. Favorable soil and climatic conditions for the development of agriculture. 2. Rich natural-resource potential: 66% of all-Kazakhstan balance reserves of vanadium, 14% of uranium, 16% of zinc, 11% of lead, copper, titanium, gold, molybdenum, zirconium, etc. are concentrated in the region. 3. Availability of transit transport infrastructure. 4. The inflation rate is within moderate limits. 5. Sufficiently developed diversified agricultural and industrial production. 6. Presence of export-oriented industries (mining, metallurgical industry). 7. Positive results of implementation of the strategy of economic diversification through the development of metallurgy, building materials industry, agro-industrial complex, machine building. 8. Availability of labor resources, availability of multidisciplinary universities for training of engineering and technical personnel in the field of industry, construction, agriculture. 9. Availability of historical and cultural sights. 10. Favorable investment climate.	1. Existence of a significant imbalance in the structure of production - overwhelming predominance of the mining industry over the manufacturing industry. 2. Low share of manufacturing industry in industrial production, the specific weight of manufacturing industry in the GRP structure is only 2.2%. 3. Environmental problems of the Aral Sea region. 4. Low level of innovative activity of business. 5. Insufficient activity of small business and its contribution to the development of the economy and social sphere of the region. 6. Shortage of personnel of technical specialties and specialists for work in agriculture. 7. Underdeveloped tourist infrastructure.
Opportunities	**Threats**
1. The established mining and agrarian specialization of the region create conditions for the development of these industries due to growing domestic and foreign markets for products. 2. Availability of vanadium, iron, copper, titanium reserves is a good condition for the development of metallurgical industry.	1. Dependence on the price environment for raw materials and food due to the mono-industrial structure of the economy. 2. Growing unemployment rate due to imbalance in the labor market of the region. 3. Energy dependence of the region from neighboring regions.

3. Advantageous geographical location, the highway “Western Europe - Western China”, construction of the passenger terminal of the regional center allow to realize the transit potential in the direction of development of roadside infrastructure, development of small and medium-sized businesses, access to the markets of Europe and Asia. 4. The presence of Baikonur cosmodrome, historical cultural heritage and recreational potential allow to develop tourism. 5. Integration within the EAEU and attraction of strategic investors, including for the development of SMEs and new trade formats.	4. Loss of internal and external markets due to the low competitiveness of the region's products. 5. Increased deficit of water resources.

Main problems of the sector: depletion of the raw material base (in the oil and gas sector); low provision of technological equipment, high degree of wear and tear of the main production assets of the majority of enterprises; reduction of the share of exported food products; decrease in demand and narrowing of sales markets for manufactured products; dominance of Chinese, Russian and other foreign manufacturers' products in the Kazakhstani market restrains the establishment of supplies in the Republic by enterprises producing competitive products; low competitiveness and high resource intensity of products; high energy and water deficit of the region; insufficient volume of own production by agricultural producers.

SWOT analysis of the region's industry

Strengths	Weaknesses
1. Availability of mineral resources used in the manufacturing industry. 2. Utilization of the potential of the export-oriented oil and gas industry for the development of the entire sector. 3. 3. Availability of large industrial enterprises, drivers of technological development. 4. Prospects for the development of lead-zinc production in Zhanakorgan district and vanadium processing in Shiyeli district. 5. The share of production of products of chemical industry of the region in the RK for 2010-2014 increased from 0.1% to 3.8%. 6. Implementation of major projects in cooperation with international banks and organizations: European Bank for Reconstruction and Development, Asian Development Bank, International Bank for Reconstruction and Development, Islamic Development Bank, OECD. 7. Availability of labor resources and multidisciplinary educational institutions for training in the field of industry.	1. High imbalance between mining and manufacturing industries. Predominance of mining over manufacturing industry - 90.5% and 6.5% respectively. 2. Dependence on neighboring regions for energy carriers, high degree of wear and tear of energy supply networks. 3. Insufficiently high rates of productivity growth in the industrial sector. 4. Insufficiency of financial resources at existing enterprises for modernization and renewal of fixed assets. 5. Weak competitiveness of manufactured products, low level of export-oriented goods. 6. Uneven placement of industrial capacities on the territory of the region (concentration in Kyzylorda).
Opportunities	**Threats**
1. Availability and development of mineral deposits - proven reserves of vanadium, iron, copper, titanium is a good condition for the development of metallurgical industry. 2. Modernization of production in order to increase labor productivity and competitiveness of the industry. 3. Creation of metallurgical cluster. 4. Rich undeveloped deposits of metal ores. 5. Increase in the volume of agricultural raw materials for the development of the manufacturing industry.	1. Decrease in oil production due to depletion and high water cut in production wells of Kumkol, South Kumkol, Kyzylkiya and Aryskum fields. 2. Dependence on prices for raw materials and food due to the mono-industrial structure of the economy. 3. Preservation of raw material orientation of export of raw materials sector products. 4. Loss of domestic and foreign markets in favor of imported goods. 5. Shortage (deficit) of skilled workers, middle-level workers.

Main problems of the sector: decrease in industrial production and investment in fixed capital; low level of industry diversification; high share of mining industry in the structure of industry; uneven industrial development in the context of the region's territories; insufficient rates of technological renewal and productivity of industries; low rates of building up the value-added chain in industry; decrease in industrial output due to the decline in oil production in recent years, resulting from the watering of fields by up to 90%.

SWOT analysis of SMEs and trade in the region

Strengths	Weaknesses
1. Annual increase of budget expenditures for entrepreneurship support. 2. Provision of microcredits for rural entrepreneurship development. 3 Availability of institutional structures established for long-term financing and coordination of SME activities: Regional Investment Center "Kyzylorda", House of Entrepreneurs, Concession Commission, service centers for entrepreneurs in districts. 4. Experience in implementation of modern trade formats in retail trade. 5. Existing system of monitoring prices for socially important goods.	1. Lack of own working capital and collateral assets of SMEs and, as a consequence, the problem with the availability of financial resources for SMEs. 2. Lack of a systemic vision of entrepreneurship development in the districts and, accordingly, lack of maps of entrepreneurship development in the districts (rural districts). 3. Low level of innovation activity of SMEs. 4. Presence of administrative barriers to business development. 5. Insufficient awareness of entrepreneurs about the implementation of sectoral programs, including in the districts of the region. 6. Large volume of shadow economy within the framework of trade markets activity.
Opportunities	**Threats**
1. Financing from the republican and local budgets of new investment projects, as well as projects aimed at modernization and expansion of production. 2. Creation of new competitive productions. 3. Development and increase of efficiency of small and medium-sized businesses through the use of state support measures within the framework of entrepreneurship development programs. 4. Creation of new jobs through the implementation of investment projects. 5. Integration within the EAEU and attraction of strategic investors for the development of SMEs and new trade formats.	1. Unfavorable changes in the macroeconomic environment: exchange rate, interest rate, supply of money, appreciation of capital, export of inflation. 2. Decrease in entrepreneurial activity. 3. Impact on SMEs of a decrease in demand for the products of backbone companies in the context of deteriorating foreign economic situation, with which SMEs are connected. 4. Decrease in financing of state sectoral programs due to the deficit of budgetary resources.

Main problems of the sector

Currently, the potential of the SME sector is not fully utilized. The share of SMEs in the region's economy is still far below the target value (50% by 2050); there are problems in the development of rural and innovative small business, modern trade formats, e-commerce, and lack of business competencies. The main problems of the industry are the concentration of the majority of SMEs in the sphere of trade, agriculture; lack of production facilities, improvement of the business climate in the region, training of qualified personnel; inaccessibility of financial resources and others. At the same time, the effective development of private entrepreneurship is hindered by a number of problems, including: limited access to credit resources due to the lack of collateral, high interest rates, long periods of consideration of documents in credit institutions; lack of benefits in the field of credit relations, taxation; low coverage of rural settlements with state support instruments; the need to further simplify permitting procedures and reduce administrative barriers; low innovation activity of SMEs; growing competition from foreign manufacturers.

Institutions created recently - the Regional Investment Center “Kyzylorda”, the House of Entrepreneurs, the Commission on Concession, service centers for entrepreneurs in the districts - have not worked in full measure. The unified database of entrepreneurs' projects, the database of commodity producers of the region, the database on purchases of large companies and state organizations, the register of qualified suppliers are at the stage of formation and have not yet had any effect.

The region is characterized by high importance of markets, low share of modern trade formats, underdevelopment of electronic commerce. A significant share of trade markets work unorganized and are not brought to a modern format, in addition, there is a low level of service, unsanitary conditions, as well as a high share of shadow turnover, which does not contribute to effective tax administration and increase in tax payments.

The main reasons for the low intensity of retail modernization lie in the hidden resistance of the shadow market, lack of business incentives, and lack of competence among entrepreneurs.

SWOT analysis of interregional cooperation in the region

Strengths	Weaknesses
1. There is a significant potential of commonly occurring minerals for the development of the construction industry. 2. Raw materials and production resources allow to produce a wide range of food products. 3. The region is the main producer of rice. 4. Convenient geographical location, significant potential of the transit corridor “Western Europe - Western China”.	1. The mechanisms of state support for the types of products created on the basis of interregional cooperation have not been worked out. 2. The interregional information infrastructure is not developed to cover all subjects of interregional cooperation with its services. 3. Monitoring of interregional cooperation is hampered. 4. The logistics infrastructure is poorly developed.
Opportunities	**Threats**
1. Creation and development of high-tech, competitive industries (transfer of advanced technologies to the region, creation of joint ventures). 2. Integration of the potential of the domestic economy and inclusion in regional inter-economic relations. 3. The possibility of transformation and development of interregional ties to the international level. 4. Increase of Kazakhstani content in large production projects implemented in Kazakhstan (including by Kazakhstani producers). 5. Construction of the Kyzylorda - Uchkuduk (RU) railroad.	1. The industries to be involved in the region will not be oriented towards the production of high value-added products (i.e. they will be mainly of raw material nature). 2. Predominance of imports to the detriment of domestic products. 3. Shortage (deficit) of skilled workers and middle-level employees.

Main problems of the sector: lack of industrial cooperation due to the low technological base of the region's industry; narrow range of manufactured products; power shortage limiting the growth of competitive production; low investment attractiveness of the region; low competitiveness of manufacturing sector products compared to key partner countries (China, EAEU countries), which causes the dominance of imports in key segments of consumer and investment demand and does not allow Kazakh companies to use the available potential of the domestic market; low level of innovation activity of the region's enterprises; lack of working capital and inaccessibility of “long” loans with low interest rates.

SWOT analysis on innovation and investment in the region

Strengths	Weaknesses
1. Favorable investment climate in the region (including through the creation and development of industrial zones). 2. Increase in the volume of investment through additional exploration of reserves of iron and polymetallic ores, uranium, oil, table salt, limestone, quartz sands, creation and development of industrial zones, etc.). 3. Stimulation of innovations through the work of the department of commercialization of technologies at KSU named after Korkyt Ata. 4. Presence of large industrial enterprises - drivers of technological development. 5. Training of personnel for metallurgy in Russian universities at the expense of grants from Russia and abroad.	1. Insufficient understanding of the essence of innovation activity by business and population. 2. Lack of organized networking within the innovation system of the region. 3. 3. Insufficient level of qualification and coordination with central structures within the framework of the work of public information centers. 4. Reduction of budget expenditures for the development of investments and innovations due to the deterioration of the external economic situation.
Opportunities	**Threats**
1. Development of industry, investment and innovation within the framework of National Projects. 2. Market processes of clustering of non-ferrous metallurgy and agro-industrial complex. 3. Innovative development through the construction of alternative energy facilities (wind, solar).	1. Conservation of low competitiveness of the region's industry as a result of low rates of innovation activity. 2. Energy deficit, increasing dependence of the region on neighboring countries and regions for energy resources. 3. Depletion of the region's mineral resource base as a result of irrational use of resources.

Main problems of the sector

In innovation: lack of domestic solvent demand for advanced technologies and industrial innovations; high innovation costs; low level of SME innovation activity; lack of organized networking within the region's innovation system, including weak links between large industrial enterprises and local universities, and lack of information on technologies; insufficient financing of R&D as well as innovation projects; lack of qualified personnel, especially at the middle level; weak demand for innovations on the part of industry; insufficient understanding of the essence of innovation activity on the part of the population and businesses.

In investment: predominance of investments in the mining sector; reduction of budget expenditures on investment development due to the deterioration of the foreign economic situation.

SWOT analysis of tourism in the region

Strengths	Weaknesses
1. Presence of natural and recreational potential and cultural and historical monuments: “Baikonur” complex, memorial complex Korkyt-Ata (Karmaksha district), Syganak ancient settlement, mud and water cures in sanatoriums ‘Zhanakorgan’ and mountain ranges Karatau (Zhanakorgan district), lake Kankozha, Telikol (Shieli district), Jetiasar oasis, Aral Sea and lake Kamystybas (Aral district), ancient settlement Zhankent (Kazalinsk district). 2. Favorable geographical location on the route of the ancient world-famous Great Silk Road. 3. Reconstruction of the international airport “Korkyt-Ata” will improve the comfort and quality of service for potential tourists. 4. The platform of the annual investment forum “Baikonyr” promotes the development of event tourism, as well as attracting investors in the tourism industry. 5. Availability of the Roadmap of tourism development of the region - the basis for systematization and allocation of priorities for the development of the sphere. 6. Positive dynamics of private business involvement in investments in hotel and restaurant business.	1. Insufficient quality of engineering, transportation and social infrastructure in tourism destinations. 2. Poor quality of service to visitors in places of accommodation (hotels, campsites, guest houses, vacation homes). 3. Insufficient quantity and quality of service of roadside infrastructure facilities along the highway “Western Europe - Western China”. 4. Lack of qualified personnel in the tourism sector - guides, interpreters, managers of accommodation and restaurants. 5. Insufficient development of information infrastructure of the tourism industry (website, virtual map, booklets, signposts). 6. Weak inter-sectoral interaction (education, public transportation, catering, retail trade, banks). 7. Lack of local professional associations in the tourism, restaurant and hotel business (business initiative to increase the quality of services is not provided).
Opportunities	**Threats**
1. Passage through the territory of the region of the international highway “Western Europe - Western China”. 2. Prospects of clustering within the framework of the Concept of tourism development in Kazakhstan (development of integrated tourist products with Turkestan region and other regions, use of national operators to attract visitors). 3. Prospects of participation in the tourism project of the Assembly of Peoples of Kazakhstan. 4. Development of children's and youth tourism within the framework of the program of development of the sphere of services in RK. 5. Training of training guides within the framework of the Program of development of the sphere of services in RK. 6. Cooperation with national professional associations in the sphere of tourism.	1. Decrease in business tourism due to the slowdown in the global economy. 2. Currency exchange rate distortions due to turbulence in the foreign economic situation.

7. The presence of a nature reserve and wildlife sanctuaries can serve as an impetus for the development of tourism activities in the region.	

Main problems of the sector: insufficiently developed logistical, engineering, transportation, social and information infrastructure in tourism destinations; insufficient skills in intra-regional planning of industry development with the involvement of business, professional associations and NGOs (in order to involve other resources in addition to government support); the need to work out an action plan for the development of the cluster with the regions of Kazakhstan that are part of the Southern Tourism Cluster, taking into account inter-sectoral interaction; poor development of domestic tourism (it is necessary to launch regular excursions on the route “Kyzylorda - Baikonur”, promising development of school tourism, including tours for children with disabilities and children from low-income families); difficult accessibility of tourism objects (in the future it is advisable to use small aircraft on the route “Kyzylorda - Aral”); it is necessary to develop roads for access to tourist objects in Kazaly, Karmaksha, Syrdarya, Zhanakorgan districts, as well as modernization of transport and social infrastructure in Toretam and Akai villages of Karmaksha district, located near Baikonur city; lack of qualified personnel in the tourism sector; low quality of service to visitors in accommodation facilities; underdeveloped business standards and quality of personnel training due to the lack of professional associations of representatives of the tourism and hotel business; insufficient quantity and quality of service of roadside infrastructure facilities; insufficient development of the information infrastructure of the tourism industry (including the need to create an online calendar of all cultural and exhibition events); the system of signposts to tourist infrastructure objects on the region's highways is underdeveloped.

CONCLUSIONS

In Kyzylorda region there is a positive demographic dynamics: if in 1991 the population was 592.4 thousand people, then on June 1, 2023 the population increased to 838.3 thousand people (by 40%), including 393.5 thousand people (46.9%) - urban, 444.8 thousand people (53.1%) - rural residents.

The infant mortality rate fell from 33.9 to 9.72; life expectancy increased to 70.8 years; the proportion of the population below the poverty line or with incomes below the subsistence minimum fell to 5.1%.

The income concentration coefficient (Gini index) improved by 18% in 2022 compared to 2001.

The food basket of Kyzylorda residents is dynamically improving and becoming more caloric and diverse. For example, in 2021 compared to 2001, the consumption of meat and meat products increased from 27.3 kg/person to 65.1 kg/person; fish and seafood - from 8.7 kg/person to 16.4 kg/person; milk and dairy products - from 144.4 kg/person to 192.4 kg/person; eggs - from 45.8 pcs. to 148.4 pcs.; fruits - from 40.4 kg to 78.2 kg.

It should be noted that the marriage rate decreased from 11.2 to 7.2 (by 36%), the divorce rate increased from 1.6 to 2.08 (23%).

All this indicates a certain positive dynamics of welfare of the population of the Aral Sea region from the water management, environmental and socio-economic activities carried out in the region. However, weak work of local executive bodies with young people in the sphere of strengthening and development of the family institution is observed.

Progressive development of economic sectors of Kyzylorda region with predominance of industry, including oil and gas, mining, metallurgy, provides sustainable growth of gross regional product (GRP). The volume of industrial production in January - May 2023 amounted to 411,850 million tenge, the volume of GRP of agriculture, forestry and fisheries in January - May 2023 amounted to 29327.2 million tenge.

It should be noted that in all considered sectoral SWOT-analyses there is a need for infrastructural development, technical modernization, improvement of human resources, scientific support and financial support taking into account the requirements of natural ecosystems.

It is proposed to consider natural resources, and water resources in particular, not only from the perspective of Integrated Water Resources Management (IWRM), but also within the framework of long-term target indicators, planning of water resources management in the perspective of seven generations.

For example, at present in Central Asia the renewable water resources are about 3800 m3/person/year. If the current population growth rate of 1.5% per year is maintained, the water availability per person in the region will decrease in 2050 - 1700 m3/person/year, 1000 m3/person/year in 2080 and less than 500 m3 in 2120 (FAO, WB 2022).

At the same time, current adaptation and mitigation processes should include solutions for the conservation of water resources and water bodies (watercourses) close to conditionally natural conditions.

In recent years, there is a tendency of increasing land degradation, development of water and wind erosion, while the humus content of most soils is reduced to 40-45%. Degradation of pastures is observed to a greater extent in the plain territories, where 95% of all knocked down pastures are located. The main causes of land degradation and reduction of soil fertility are climate change, as well as anthropogenic impact on the natural environment.[62]

In this context, it is necessary to strengthen measures to develop a cross-sectoral and systematic approach to water and land management in the context of climate change, disaster

---

[62] G.A. Bimendina, Director of the State Institute for Land Survey

risks and environmental degradation. In addition, the Government of RK envisages strengthening of water and land policy and regulatory framework for investments.

Management should be measurable. Therefore, improved spatial and temporal monitoring as well as data and information management on water and land resources to determine quantity and quality is required. This will include increased attention to data and information on groundwater and cryosphere, land holdings (agricultural; forest; water). More comprehensive, interconnected and harmonized data and information on water and land resources at local, regional and global scales should facilitate the best possible decisions related to climate change and other environmental and social changes.

OPINION:

Based on the results of the conducted expert studies in the Kazakhstan part of the Aral Sea basin (on the example of Kyzylorda region), the main cause-and-effect relations of climate change, land and water resources degradation were identified, on the basis of which the following **RECOMMENDATIONS** are proposed:

- Improvement of the region's strategic development under developing risks of climate change, increased water stress, degradation of natural resources and changes in demographic indicators (in the medium and long term, 2040 and 2050, respectively).
- Step-by-step and planned transition of the region's economic sectors to resource-saving (water and land) management models, taking into account scientific recommendations and positive international experience. At the same time, economic sectors need to develop several development trajectories in accordance with the threshold values proposed by Falkenmark (if the amount of water is below 1700 m3 per person per year - water deficit, if below 1000 m3 - acute water deficit; and below 500 m3 - absolute water shortage).[63]
- Multi-directional and inclusive approach to diversify the region's economy. In particular, in preservation and modernization of engineering-prepared irrigated lands at the level of 1991. At the same time, force introduction of scientific recommendations of domestic research institutes in the field of agro-industrial complex (water conservation, soil conservation, seed production, crop rotation, fertilizers, etc.).
- Development and modernization of water and land resources monitoring system. Information on water quantity and quality, land resources condition should be available and understandable to the general public - this will significantly increase the water and land resources utilization rate.
- In the area of drinking water supply it is also necessary to strengthen monitoring systems and services. *For example: in Kazakhstan, sampling of drinking water is usually limited to water treatment plants. There is no practice of systematic and regular sampling of drinking water at the end-users of the water supply network, although until 1990 this work was carried out.*
- Digitalization of water and land management will allow to increase adaptation to climate change, increase intersectoral interaction and help to reconsider the very essence of water and land not only in terms of profit per cubic meter of water or per hectare, but also to consider it as the basis of life activity of natural ecosystems.
- Full compliance with agro-technologies and basic normative and legal documents in the field of Agro-industrial complex (AIC) and ecology of the republic will contribute to sustainable development of natural ecosystems of the region.

[63] Dankova, R., Burton, M., Salman, M., Clark, A. and Peck, E. 2022. Modernization of Irrigation Systems in Central Asia. Investment Directions, Edition 6. Rome, FAO and the World Bank. https://doi.org/10.4060/cb8230ru

- Increasing the level of the main indicators of the Human Development Index (HDI) of the region under consideration will be ensured through the development of Human Capital, creation of favorable conditions for small and medium-sized businesses, gender equality, and increasing the investment attractiveness of the region.
- Increased attention and support in the state programs and projects of the republic to measures on automation of water and land resources management, water conservation, soil conservation and prompt response to emergencies related to natural phenomena (floods, floods, droughts).
- Establishment of a business incubator in the region to train and build capacity of local residents in financial literacy, small and medium green business management, business promotion skills, and small grants attraction.
  For example, aquaculture development, deep processing of fish products, establishment of fodder production from fish bones, production of fishing nets, production of local wool and leather products, production of biohumus and fertilizers from local farm waste, production of dairy products, production of construction materials.

The COVID-19 pandemic has highlighted the urgency of action to prevent diseases that have complex transmission pathways from humans, animals and the environment that are interconnected in a single ecosystem. Therefore, a cardinal approach to water supply, sanitation and hygiene (WSSH) is required to prevent environmental pollution pathways, sensitive aquatic environments and human exposure to pathogens. These approaches require increased cross-sectoral collaboration between different sectors - water, health, agriculture for higher levels of service delivery and more comprehensive risk identification and management. For example, risks from toxic pollutants and domestic effluents along the entire watercourse (in this case the Syrdarya River) associated with human, animal and industrial activities threaten environmental and human security.

The COVID-19 pandemic and natural events associated with climate change have demonstrated the critical importance of WASH in households, schools and health facilities as a sustainable mechanism to prevent and control many infectious diseases, including diarrheal diseases, cholera and neglected tropical diseases.

References

1. Aral-Syrdarya Basin Inspectorate for Regulation of Water Resources Use and Protection of the Water Resources Committee of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan
2. http://aral.uz/wp/
3. https://kazaral.org/2021/02/05/
4. https://kazaral.org/aral-zabota-obshhaya/
5. https://kazaral.org/aral-zabota-obshhaya/
6. https://yuz.uz/ru/news/ejegodno-plne-buri-arala-vnosyat-do-75-mln-tonn-peska-i-soli-na-territoriyu-uzbekistana-i-drugix-stran-tsa
7. https://www.kazhydromet.kz/uploads/files/39/file/600aabe6ad292byulleten-tg-perenos-2020-god-rus-iyaf.pdf
8. https://eldala.kz
9. Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, Akimat of Kyzylorda region
10. 1 https://www.gazeta.uz/ru/2021/04/30/aral-sea-region/
11. http://kazaral.org/kartograficheskie-materialy/
12. https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana
13. Baisholanov S.S. Vulnerability and adaptation of agriculture in the Republic of Kazakhstan to climate change. Astana, 2017. – 128 pages.
14. https://ingeo.kz/?page_id=2340 , https://cesdrr.org/разработки-мчс-рк
15. https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate
16. https://www.ipcc.ch/report/ar6/wg1/
17. https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana
18. http://seakc.meteoinfo.ru/images/seakc/monitoring/cis-climate-2022.pdf
19. https://www.ipcc.ch/report/ar6/wg1/
20. 20 https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/
21. https://www.wcrp-climate.org/wgcm-cmip
22. Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. 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, 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. In Press. Interactive Atlas available from Available from http://interactive-atlas.ipcc.ch/
23. https://www.ipcc.ch/report/ar6/wg1/
24. IPCC, 2021: Annex II: Models [Gutiérrez, J M., A.-M. Tréguier (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, 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. 2087–2138, doi:10.1017/9781009157896.016.
25. https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6
26. https://climpact-sci.org/get-started/ , https://github.com/ARCCSS-extremes/climpact2
27. 27. IPCC, 2021: Annex VII: Glossary [Matthews, J.B.R., V. Möller, R. van Diemen, J.S. 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, 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. 2215–2256, doi:10.1017/9781009157896.022
28. 7th National Communication and 3rd Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2017 - 304 pp.
29. Babagalieva Zh. Forecast of climate change impact on the change of water flow of water management basins of the Republic of Kazakhstan for the period up to 2100 in the framework of the project on development of the eighth National Communication of the Republic of Kazakhstan to the UNFCCC and preparation of biennial reports. Nur-Sultan. - 2021, 34 pp. (https://www.undp.org/ru/kazakhstan/publications/прогноз-воздействия-изменения-климата-на-изменение-стока-воды-водохозяйственных-бассейнов-республики-казахстан-на-период-до 2100 г.)
30. The 7th National Communication and the 3rd biennial report of the Republic of Kazakhstan on the impact of climate change on the change of water flow of water management basins of the Republic of Kazakhstan for the period up to 2100 within the framework of the project on development of the 8th National Communication of the Republic of Kazakhstan to the UNFCCC and preparation of biennial reports. Nur-Sultan. - 2021, 34 pp. (https://www.undp.org/ru/kazakhstan/publications/прогноз-воздействия-изменения-климата-на-изменение-стока-воды-водохозяйственных-бассейнов-республики-казахстан-на-период-до 2100 г.)
31. Baisholanov S.S. Vulnerability and adaptation of agriculture of the Republic of Kazakhstan to climate change. - Astana, 2017 - 128 pp.
32. Kozhakhmetov P.J. Meteorological conditions and method of forecasting the beginning of spring shearing of sheep //KazNIGMI. 1990. Ed. 108. p. 117-119.
33. 8th National Communication and 5th Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2022 - 514 pp.
34. Development of cost standards per unit of the main types of agricultural products of crop and livestock // Kazakh Research Institute of Agroindustrial Complex Economy and Rural Development LLP - Almaty, 2009. - 332 p.
35. III-VI National Communication of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. - Astana, 2013. - 274 p.
36. https://gfcs.wmo.int/sites/default/files/Fact_Sheets/Health/GFCS_healthflyer_ru.pdf 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
37. https://www.who.int/globalchange/publications/climchange.pdf
38. https://documents1.worldbank.org/curated/en/552631515568426482/pdf/122328-WP-PUBLICWorldBankClimateChangeandHealthDiagnosticMethodologyJan.Pdf
39. 8th National Communication and 5th Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change. Astana, 2022 - 514 pp.
40. http://adilet.zan.kz/rus/docs/K2100000400
41. Collection of archival and reference materials for the period 1974-1991 on issues related to regulation of water resources use in the Syrdarya, Amudarya and Aral Sea basins. Moscow, 1992.
42. Alamanov S. K. Transboundary water resources of Kyrgyzstan. 2015
43. Water resources of the Kyrgyz Republic. 2012. Materials from www.eco.kg.
44. Chirchik (river) - Wikipedia
45. Arys (river) - Wikipedia
46. Surface Water Resources of the USSR, Volume 14. Central Asia. Vol. 1, Syrdarya River Basin. L., Gidrometeoizdat, 1969. 439 pp.
47. Reference book of water resources of the Syrdarya River. Materials from Wikipedia.
48. Kenshimov A.K. Interstate water allocation in the Aral Sea basin. Royal Gasconning Final Report, Annex to the Report, 2003.
49. Scheme of complex use and protection of water resources in the Syrdarya river basin. Volume 1, Book 1, Summary note. Production Cooperative “Institute Kazgiprovodkhoz”. 2008
50. Project “Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea. Edition 1. Production cooperative “Institute Kazgiprovodkhoz”. Almaty 2017.
51. Project “Regulation of the Syrdarya river channel and preservation of the northern part of the Aral Sea. Edition 1. Production cooperative “Institute Kazgiprovodkhoz”. Almaty 2017.

52. Scheme of integrated use and protection of water resources in the Syrdarya River basin. Volume 1., book 1, Summary note. Production cooperative “Institute Kazgiprovodkhoz”. 2008
53. The Aral Sea and the Priaralie. Scientific Research Center of the Interstate Commission for Water Coordination supported by UNESCO. “Complex Print. Tashkent, 2020.
54. Kazakhstan Today. 04.03.2023
55. Kipshakbaev N. Yup de Schutter. Dukhovny V. et al. Restoration of ecological system in the Syrdarya delta and northern part of the Aral Sea. Almaty. Izd. “Evero”. 2010
56. https://akorda.kz/ru/ob-utverzhdenii-perechnya-nacionalnyh-proektov-1391918
57. https://www.gov.kz/memleket/entities/kyzylorda/documents/details/120558?lang=ru
58. https://www.gov.kz/memleket/entities/ecogeo/press/news/details/141320?lang=ru
59. Speech by Akmaral Alnazarova, Deputy of the Senate of the Parliament of the Republic of Kazakhstan, at the third meeting of the Commission on Cooperation between the Senate of the Parliament of the Republic of Kazakhstan and the Senate of the Oliy Majlis of the Republic of Uzbekistan on November 5, 2022, Samarkand, Uzbekistan
60. Speech by Aizhan Esmagambetova, Vice-Minister of Health - Chief State Sanitary Doctor of the Republic of Kazakhstan, at the International Scientific and Practical Conference “Environment and health of the population of the Aral Sea region”, October 20, 2022, Kyzylorda.
61. Speech by Vice-Minister of Health of the RK Vyacheslav Dudnik at the meeting with the Minister of Health of the RK Azhan Giniyat and heads of medical organizations of Kyzylorda region, 21 February 2023, Astana - Kyzylorda (online).
62. Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan. Consolidated analytical report on the state of land resources of the Republic of Kazakhstan. 2021.
63. www.kazaral.org
64. Gini coefficient - an indicator of the evenness of distribution of consumption and income in society, is a number from 0 to 1, where 0 - full equality, 1 - full inequality.
65. Bimendina G.A. Director of the State Institute for Land Survey
66. Dankova, R., Burton, M., Salman, M., Clark, A. and Peck, E. 2022. Modernization of Irrigation Systems in Central Asia. Investment Directions, Edition 6. Rome, FAO and World Bank. https://doi.org/10.4060/cb8230ru