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The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

The journal is also included in the Emerging Sources Citation Index (ESCI) of the Web of Science platform (Clarivate Analytics, since 2018).

Indexing in ESCI confirms the journal's compliance with international standards of scientific peer review and editorial ethics and is considered by Clarivate Analytics as part of the evaluation process for potential inclusion in the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (AHCI).

Indexing in Scopus and Web of Science ensures high international visibility of publications, promotes citation growth, and reflects the editorial board's commitment to publishing relevant, original, and scientifically significant research in the fields of geology and technical sciences.

«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылыметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

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ASSESSMENT OF ECOLOGICAL AND WATER MANAGEMENT PARAMETERS OF THE SYRDARYA RIVER

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Abstract. *Actuality.* The problem of the Aral Sea is one of the most urgent in Central Asia. The volume of the Aral Sea has decreased to almost tenth of its mid-20th century state, due to which the world's fourth largest sea has divided into several smaller water bodies, while large parts of the former lake bed have been transformed into the Aralkum desert. The current critical state of the Aral Sea affects the ecological environment of the region. *Purpose.* Additionally, due to the impact of climate change in Central Asia, there is an increase in temperature and decrease in precipitation, which in turn regulates dust and salt storm activities and droughts. These processes affect the strengthening of land degradation. In

the Aral Sea region, most which can be classified as arid land, the problem of desertification is extremely urgent. The causes of desertification are both natural and anthropogenic in origin. *Methodology.* This article discusses graph-analytical scenario of irrigated agriculture development in the Kyzylorda province in Kazakhstan and dynamics of water surface area of lake systems and wetlands in the Syrdarya river delta. The combined and interlinked impacts of climate change and ecological changes on human security in the Kyzylorda region are discussed. The article also provides an assessment of the surface water quality of the Syrdarya river in Kazakhstan part according to the Unified System of Water Quality Classification. *Results and conclusions.* The article examines the analysis of the problems of the Kazakh part of the Aral Sea region and shows the need for integrated water resources management, taking into account ecosystem protection, industrial diversification and scientifically based intensification of the agro-industrial complex. To solve environmental and socio-economic problems, it is recommended to develop an integrated strategy "Water-Energy-Food-Ecosystem", which will enhance investment attractiveness and help achieve Sustainable Development Goals.

Keywords: Aral Sea, ecology, dust-salt storms, water resources, climate change, water pollution, Central Asia

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СЫРДАРИЯ ӨЗЕНІНІҢ ЭКОЛОГИЯЛЫҚ ЖӘНЕ СУ ШАРУАШЫЛЫҚ ПАРАМЕТРЛЕРІН БАҒАЛАУ

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Аннотация. *Өзектілігі.* Арал теңізі мәселесі Орта Азиядағы ең өзекті және күрделі экологиялық проблемалардың бірі болып табылады. Соңғы бірнеше онжылдық ішінде Арал теңізінің көлемі XX ғасырдың ортасымен салыстырғанда оннан бір бөлігіне дейін азайып, әлемдегі көлемі бойынша төртінші орындағы теңіз бірнеше кіші су айдындарына бөлінді. Арал теңізінің бұрынғы кең аумағының көп бөлігі Аралқұм шөліне айналды, бұл аймақтың табиғатына және адамдардың өмір сүру жағдайына елеулі зиян келтірді. Қазіргі уақытта Арал теңізінің критикалық жағдайы ауа райының өзгеруіне, топырақ деградациясына, сонымен қатар ауыл шаруашылығына да тікелей әсер етуде. *Мақсаты.* Орта Азиядағы климаттың өзгеруіне байланысты аймақта ауа температурасы тұрақты түрде жоғарылап, жауын-шашын мөлшері азаяды, бұл шаңды және тұзды дауылдардың жиілеуіне, құрғақшылықтың белсенділігінің артуына әкеледі. Осы үрдістер жер ресурстарының деградациясына ықпал етеді. Басым бөлігі аридті жерлерге жататын Арал өңірінде шөлейттену мәселесі өзекті болып табылады және оның себептері табиғи сипатқа да, антропогендік факторларға да байланысты. *Әдістері.* Бұл мақалада Қазақстанның Қызылорда облысында суармалы егіншіліктің дамуының графо-талдамалық сценарийі қарастырылған. Сонымен қатар, Сырдария өзені атырауындағы көл жүйелері мен сулы-батпақты жерлердегі су бетінің динамикасы талданады. Мақалада климаттың өзгеруі мен экологиялық өзгерістердің адам қауіпсіздігіне тигізетін аралас және өзара байланысты әсері де қарастырылады. Сондай-ақ, мақалада Сырдария өзенінің Қазақстан бөлігіндегі жер беті суларының сапасы Су сапасы классификациясының бірыңғай жүйесіне сәйкес бағаланды, бұл аймақ экологиясы мен су ресурстарын басқаруда маңызды ақпарат болып табылады. *Нәтижелер мен қорытындылар.* Мақалада Арал өңірінің қазақстандық бөлігінің проблемаларын талдау экожүйелерді қорғауды, өнеркәсіпті әртараптандыруды және агроөнеркәсіптік кешенді ғылыми негізделген қарқындатуды ескере отырып, су ресурстарын кешенді басқару қажеттілігін көрсетеді. Экологиялық және әлеуметтік-экономикалық мәселелерді шешу үшін инвестициялық тартымдылықты күшейтетін және тұрақты даму мақсаттарына қол жеткізуге көмектесетін "Су-Энергия-Азық-түлік-Экожүйе" интеграцияланған стратегиясын дамыту ұсынылады.

Түйін сөздер: Арал теңізі экология, шаңды-тұзды дауылдар, су ресурстары, климаттың өзгеруі, судың ластануы, Орта Азия

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ОЦЕНКА ЭКОЛОГИЧЕСКИХ И ВОДОХОЗЯЙСТВЕННЫХ ПАРАМЕТРОВ РЕКИ СЫРДАРЬИ

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Аннотация. *Актуальность.* Проблема Аральского моря является одной из наиболее острых и значимых экологических проблем Центральной Азии. В течение последних десятилетий объём Аральского моря сократился почти до одной десятой от уровня середины XX века, в результате чего четвёртое по величине озеро мира распалось на несколько изолированных водоёмов. Значительные площади бывшего дна трансформировались в пустыню Аралкум, что оказывает негативное воздействие на региональные экосистемы. Современное критическое состояние Аральского моря формирует комплексные экологические, медико-биологические и социально-экономические последствия, влияющие на устойчивое развитие региона. *Цель исследования* - оценка взаимосвязанного влияния климатических изменений и антропогенных факторов на деградацию природных систем Приаралья, а также анализ устойчивости орошаемого земледелия и водных экосистем Кызылординской области Казахстана. *Методы.* В условиях изменения климата в Центральной Азии наблюдается устойчивая тенденция повышения среднегодовой температуры и сокращения количества атмосферных осадков, что способствует усилению пыльно-солевых бурь и увеличению

частоты засушливых периодов. В работе использован графоаналитический подход к моделированию сценариев развития орошаемого земледелия, проведён анализ динамики площади водной поверхности озёрных систем и водно-болотных угодий в дельте реки Сырдарьи. Особое внимание уделено комплексному воздействию климатических и экологических факторов на безопасность населения и устойчивость природных систем. Дополнительно выполнена оценка качества поверхностных вод реки Сырдарьи в казахстанской части дельты в соответствии с требованиями Единой системы классификации качества воды, что позволило определить текущее состояние экосистем и потенциальные экологические риски. *Результаты и выводы.* Проведённый анализ проблем казахстанской части Аральского региона показывает необходимость перехода к комплексному управлению водными ресурсами с учётом сохранения экосистем, диверсификации экономики и научно обоснованной интенсификации агропромышленного комплекса. Установлено, что деградационные процессы в регионе имеют кумулятивный характер и усиливаются под воздействием климатических изменений. Для преодоления экологических и социально-экономических вызовов рекомендуется внедрение интегрированной стратегии «Вода–Энергия–Продовольствие–Экосистема», направленной на повышение эффективности использования природных ресурсов, укрепление экологической безопасности и достижение целей устойчивого развития.

Ключевые слова: Аральское море, экология, пыльно-солевые бури, водные ресурсы, изменение климата, загрязнение воды, Центральная Азия

Introduction. On September 15, 2023, at the Summit of the Heads of Founding States of the International Fund for Saving the Aral Sea held in Dushanbe (Tajikistan), the Aral Sea basin countries expressed their concern about the aggravation of the Aral ecological disaster due to the impact of climate change, manifesting itself in the increasing frequency and intensity of natural phenomena like dust-salt storms, droughts, and mudflows, as well as the accelerated melting of the Central Asian glaciers. At this Summit, representatives of the Central Asian countries expressed their resolution to jointly confront this crisis and its negative consequences. At the same time, a firm commitment was made to find holistic solutions for problems related to the improvement of socio-economic and environmental conditions in the Aral Sea basin, especially in the zones exposed to the environmental crisis (Dushanbe Statement..., 2023).

Over the last half century, the volume of the Aral Sea has decreased by almost 90% and the world's once fourth largest lake, with a volume of up to 1089 km^3, has desiccated into several conditionally independent water bodies. In September 2023, the following water bodies could be observed: the Northern Aral Sea with a volume of about 20.15 km^3 and an average salinity of 12 g/l; the Western Aral Sea with a volume of 42.3 km^3 and a salinity of 170 g/l; and Lake Tushchibas with a

volume of 1.7 km^3 and a salinity of 90 g/l (Kipshakbaev et al., 2010; Narbayev et al., 2023).

Every year, winds lift up to 80 million tons of toxic salts from the dried-up Aral Sea bed. They are carried as dust storms over many thousands of kilometers - from Western Europe to the peaks of the Tien Shan and the Himalayas, having a negative impact on human health and ecosystems of all countries in the region Hundreds of thousands of people breathe air with toxic substances in its composition (Khaibullina et al., 2022). Salt dust covers high-mountain glaciers, which are the sources of feeding many rivers, with an impenetrable film. Salt transport processes have a detrimental effect on water quality not only at the regional level, but also at the national level, at a minimum. Eventually, salts carried from the Aral Sea bed ends up in water supply networks and wells located even thousands of kilometers away from the source (Zhupankhan et al., 2021). The most common diseases of people living in the coastal regions of the Aral Sea are diseases of the eyes, lungs, digestion, genitourinary system, blood and hematopoietic organs, etc. (Kamalov, 2003).

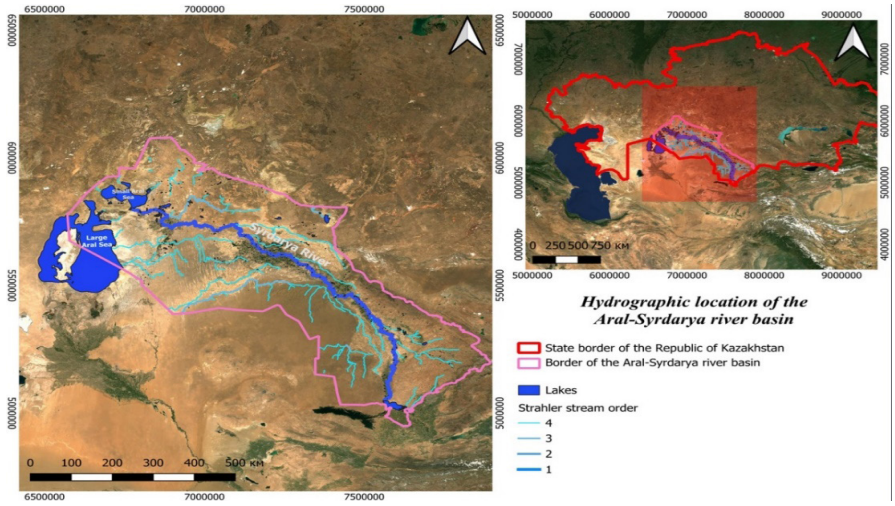

Figure 1. Geographical location of the Aral-Syrdarya river basin.

The Aral Sea is an inland water body located on the border of Kazakhstan, Uzbekistan and Turkmenistan. Due to desiccation of the lake, the Kokaral Dam was built in 2005 to control water levels in the Northern Aral Sea. This dam prevented the further decline of the Northern Aral Sea and by 2011 helped to maintain water levels the small Aral Sea (Figure 2).

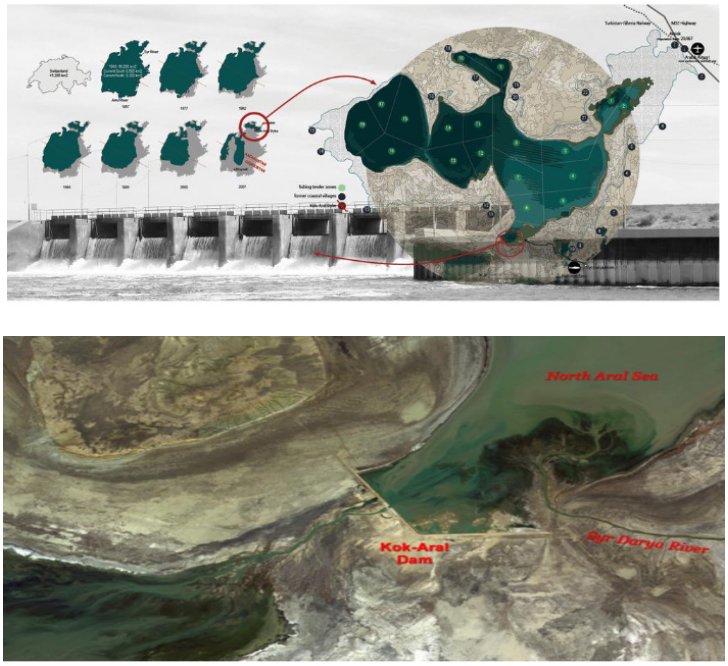

Figure 2. The North Aral and the Kok-Aral dam (Dursun, 2019).

Due to global climate change and its influence on arid Central Asia, the continued regression of the water bodies of the Aral Sea can be observed (Figure 3), which results in an increase of the concentration of fine salts in dust-salt storms in this region (Huang, 2022). More than 5.4 million ha (54 thousand km^2) turned into a salt desert – the Aralkum, which became a source of salt aerosol transfer to the Earth's atmosphere. About 2.0 million ha (20 thousand km^2) of the Aralkum are located in Kazakhstan (He et al., 2022).

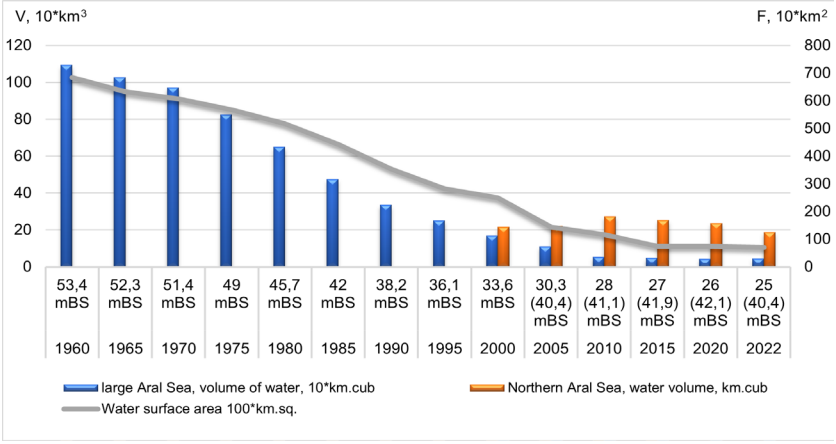

Figure 3. Aral Sea water resources dynamics (Source: SIC ICWC, EB IFAS in RK).

Figure 3 shows the development of the Aral Sea desiccation caused by intensive water usage, construction and operation of irrigation systems, overestimated irrigation norms, and a low level of interaction between science and agricultural production (Kipshakbaev et al., 2010).

At present, extensive orientation of nature use in the region is also observed. Practically the whole water potentials of the Amudarya and Syrdarya rivers are already regulated and used according to the principle of competitive intersectoral interaction, where the interests of natural ecosystems are considered on the residual principle, for instance such as the water-agriculture-energy nexus (WAEN) system (Zhang et al., 2024) where in figure 3 illustrate the dynamics of water withdrawal by the countries of the Aral Sea basin.

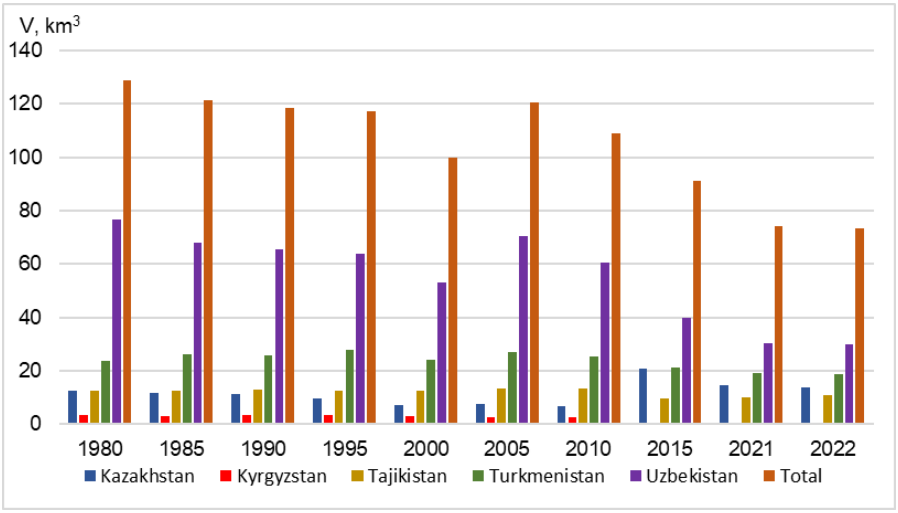

Figure 4. Water withdrawal dynamics of the Aral Sea basin countries (Amudarya and Syrdarya rivers, km^3) (Source: SIC ICWC, EB IFAS in RK).

Analysis of the graph shows that from 1980 to 2005 the dynamics of water withdrawal decreases and since 2005 it has increased due to climate change and an increase in water intake in neighboring countries.

In addition to excessive water withdrawal in the Syrdarya river basin, water pollution is also relevant. In the Fergana Valley, in addition to large and medium-sized reservoirs, there are about 40 small reservoir-ponds along the periphery, many of them heavily overgrown and silted up. About 20 million tons of salts are annually discharged into the Syrdarya river through collector-drainage water (Bekchanov et al., 2016). It should be noted about the presence of heavy metals in the river, the transportable mass of which decreases along the length of the river and ranges from 2 to 216 tons. At the exit from the Fergana Valley, the water quality deteriorates even more and remains mainly unsatisfactory up to the delta and discharge into the Northern Aral Sea. At the same time, permanent exceedance

of MAC (maximum permissible control) is not always detected due to the imperfect monitoring system (Martius et al., 2005)

For example, due to excessive pollution of the Syrdarya river by wastewater, Tajikistan's second largest city, Khujand, had to be switched to alternative sources of water supply. This decision was taken after research by ecologists and medical professionals in the city. They revealed that the water consumed by the residents of Khujand is the source of many diseases of the digestive tract and urinary system (Glazovsky, 2006).

According to the unified system of classification of water quality in water bodies of Kazakhstan (Unified system of water quality classification in water bodies, 2016), the Syrdarya river for the period 2019-2023 belonged to quality classes IV - > V in the territory of the Republic of Kazakhstan. In the Turkestan region, smaller rivers are characterized by quality classes III - > V, only the Aksu river is characterized by quality class I in recent years. The main pollutants of the Syrdarya river (Information bulletins…2019-2023) and its tributaries are suspended solids, mineralization, sulfates, magnesium, phenols, and cadmium (Table 1).

Table 1. Surface water quality in the Syrdarya river basin.

No. n/a	Name of water body	Quality class of surface water resources				
		2019	2020	2021	2022	2023
Turkestan region						
	Syrdarya river	Grade 4 (sulfates - 495.054 mg/dm^3 , magnesium - 60.388 mg/ dm^3 , phenols - 0.002 mg/dm^3 , cadmium - 0.0023 mg/ dm)^3	>5 grade. (suspended 81.233 mg/ dm)^3	>5 grade. (suspended 93.4 mg/dm)^3	Grade 4 (sulfates - 414.911 mg/dm^3 , phenols - 0.0014 mg/ dm)^3	Grade 4 (magnesium - 33.333 mg/dm)^3
	Keles river	Grade 4 (sulfates - 584.889 mg/dm^3 , magnesium - 65.544 mg/ dm^3 , phenols - 0.0015 mg/ dm^3 , cadmium - 0.0024 mg/ dm)^3	Grade 4 (sulfates - 584.198 mg/dm^3 , magnesium - 37.33 mg/dm^3 , phenols - 0.0013 mg/dm)^3	Grade 4 (sulfates - 554.32 mg/dm^3 , phenols - 0.0011 mg/ dm)^3	Grade 4 (sulfates - 389.429 mg/dm)^3	Grade 4 (sulfates - 358.204 mg/dm)^3
	Badam river	Grade 4 (magnesium - 38.95 mg/dm^3 , phenols - 0.0013 mg/dm)^3	Grade 4 (magnesium - 31.94 mg/dm^3 , phenols - 0.0016 mg/dm)^3	Grade 3 (magnesium - 21.5 mg/dm)^3	Grade 3 (magnesium - 23.7 mg/dm)^3	Grade 3 (magnesium - 22.55 mg/dm)^3

No. n/a	Name of water body	Quality class of surface water resources				
		2019	2020	2021	2022	2023
	Arys river	Grade 4 (magnesium - 41.808 mg/dm^3 , phenols - 0.0012 mg/ dm)^3	Grade 4 (magnesium - 32.017 mg/dm^3 , phenols - 0.0012 mg/dm)^3	Grade 3 (magnesium - 28.7 mg/dm)^3	Grade 3 (magnesium - 21.1 mg/dm)^3	Grade 3 (magnesium - 20.6 mg/dm)^3
	Aksu river	Grade 1	Grade 3 (magnesium - 22.467 mg/ dm)^3	Grade 1	Grade 1	Grade 1
	Katta Bugun river	Grade 4 (suspended solids - 19.633 mg/dm)^3	>5 grade. (suspended 41.167 mg/ dm)^3	>5 grade. (suspended 61.9 mg/dm)^3	>5 grade. (suspended 32.1 mg/ dm)^3	>5 grade. (suspended 44.625 mg/ dm)^3
	Wdhr. Shardara	Grade 5 (suspended solids - 26.683 mg/dm)^3	>5 grade. (suspended solids - 45.042 mg/dm)^3	>5 grade. (suspended 93.4 mg/dm)^3	Grade 4 (suspended solids - 21.477 mg/ dm)^3	>5 grade. (suspended 78.7 mg/ dm)^3
Kyzylorda region						
	Syrdarya river	Grade 4 (magnesium - 36.75 mg/dm^3 , mineralization - 1509,45 mg/ dm^3 , sulphates - 451,61 mg/ dm)^3	Grade 4 (mineralization - 1486.7 mg/ dm^3 , sulfates - 445.9 mg/dm^3 , magnesium - 35.8 mg/dm)^3	Grade 4 (sulphates - 457.8 mg/dm^3 , mineralization - 1450.6 mg/dm^3 , magnesium - 34.6 mg/dm)^3	Grade 4 (sulfate - 400.667 mg/dm^3 , magnesium - 36.493 mg/dm ,^{3} minera- lization - 1372,358 mg/dm)^3	Grade 4 (magnesium - 36.667 mg/dm)^3

Note: the table of surface water quality classes of the Syrdarya river basin is made in accordance with the Information Bulletins on the state of the environment for 2019-2023. RSE "Kazgidromet" MENR RK. Unified system of water quality classification in water bodies, approved by the Order of the Chairman of the Committee for Water Resources of the Ministry of Agriculture of the Republic of Kazakhstan from 09.11.2016 № 151. https://adilet.zan.kz/rus/docs/V1600014513

The contamination by the above substances is confirmed by earlier works (Burlibayev. et al. 2018).

Despite the decrease in the total volume of untreated wastewater, there are a number of unresolved issues related to the quality characteristics of industrial wastewater. (Absametov et al., 2024) A significant volume of wastewater from industrial enterprises, as well as TPPs (Thermal Power Plant), is discharged directly into municipal sewage treatment plants (up to 24% in some cities), which are not designed for industrial wastewater treatment. At the same time, the majority of municipal sewage treatment plants require modernization, and in some single-industry towns there is no sewage treatment plant at all (Sembayeva et al., 2024).

According to the environmental authorities, 50% of wastewater discharged by

large industrial enterprises does not meet the requirements, and concentrations of harmful substances in wastewater discharged into the sewage systems of settlements exceed MAC levels. Currently, there are no legal provisions obliging companies to enter into contracts with water management companies for additional wastewater treatment (Tairov et al., 2025). The majority of industrial enterprises do not have local WTPs (wastewater treatment plants) or violate the rules of pre-treatment. There are cases of illegal discharge of industrial wastewater without preliminary treatment, as well as illegal connection of industrial facilities to municipal sewage networks (Normatov et al., 2025).

In addition, a negative factor affecting and limiting species biodiversity and resource significance of plant complexes is water and soil pollution by various pollutants from agricultural facilities and irrigated fields (defoliants, pesticides, herbicides, heavy metals, etc.) (Shi, et al., 2021). Therefore, settlements located along the Syrdarya river need to increase requirements for water supply, sanitation and hygiene (Information bulletin…, 2020).

Figure 5 shows the development of the irrigated agriculture area in the Kyzylorda province and the share of rice as the leading crop in crop rotation.

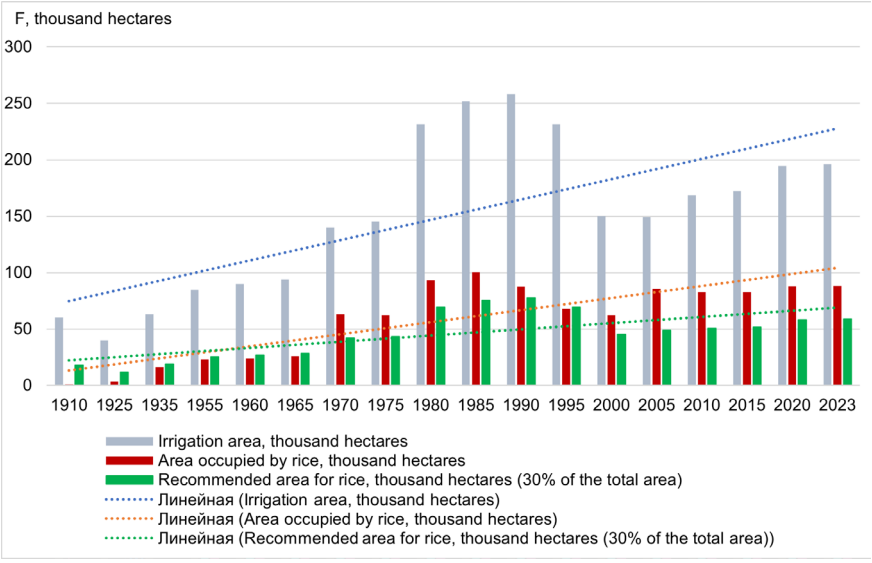

Figure 5. Dynamics of irrigated agriculture in Kyzylorda province, data was taken from RSE "Kazgidromet".

Until mid-1960, the Aral Sea and Priaralie were economically rich and ecologically clean areas. The sea and the Syrdarya delta represented a single balanced ecological system. Then began the era of extensive and large-scale land management without taking into account the basic needs of ecosystems.

According to expert studies, based on methods of comparative analysis, graph-analytical and spatial-temporal comparison of ecological and water management

parameters of the Syrdarya river basin, it can be stated that the conditional intersection of trend lines "area under rice - red color" and "recommended area under rice - green color" characterize the most optimal share of the leading crop in the crop rotation structure of Kyzylorda province (Figure 5). Only up to about 30% of the irrigated area should be used during the growing season. At that, the saved water should be determined for strengthening of natural ecosystems and development of biodiversity.

There are five lake systems in the lower reaches of the Syrdarya river: Kuandarya, Aksai, Kamystybas, Akshatau and Primorskaya. Today the total number of lakes is 207, in 1936 their number was equal to 558 lakes (Kai et al., 2015; Konyrbekov, 2015).

In 2012, a part of the Northern Aral Sea and wetlands of the lower reaches of the Syrdarya river with a total area of more than 330 thousand hectares received the status of a protected Ramsar site. These sites are important not only for 200 thousand migrating and nesting birds, but also for rare fish species such as Aral salmon and Aral whiskers, etc., which are also important for the Aral Sea.

The high degree of regulation of the Syrdarya river flow, the violation of the conditionally natural hydrological regime, and large water withdrawals caused irreparable damage to the whole ecosystem of the watercourse, especially to the estuary part (Figure 6).

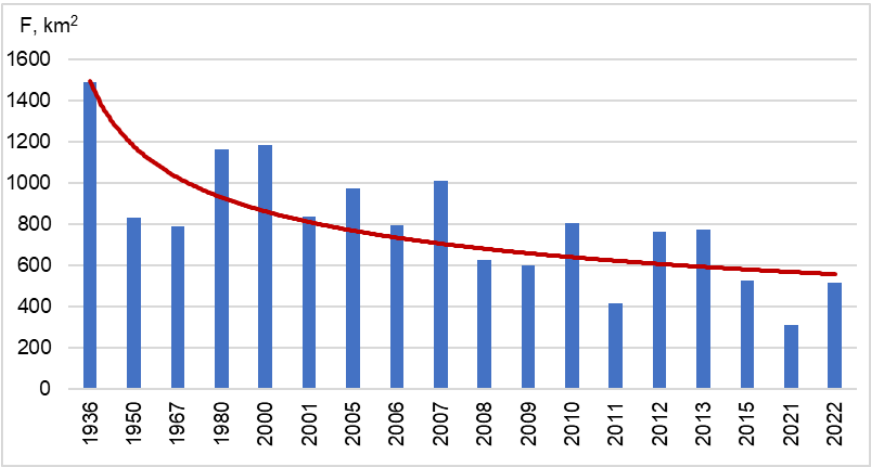

Figure 6. Dynamics of water surface area of lake systems and wetlands in the Syrdarya river delta (sq. km) (Source: IGWS, EB IFAS in RK).

The condition of lake systems and wetlands in inversely proportional degree (red trend line) demonstrates large-scale development of the water sector, violations of basic rules of agro-technologies in irrigated agriculture and low-efficiency management of agro-industrial complex in the Syrdarya river basin. At the same time, certain step excesses from the trend line indicate periods of anomalous excesses of precipitation and solar activity (during the period of glacier

melting), which favorably affected the hydrological flow of the watercourse under consideration.

After 2007, there is a general tendency to increase the depth of aridity of the climate and as a consequence further growth of anthropogenic load on the natural resources of the Syrdarya (He et al., 2022).

Billions of tons of toxic salts have been drained from the fields and accumulated in the Aral Sea. According to experts' estimates, there are about 107-114 billion tons of salt on the dried bottom of the Aral Sea. This circumstance, as well as the death of almost all spawning grounds, led to a catastrophic reduction in the fish stock, which numbered 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. The economic losses associated with the drying up of the Aral Sea are estimated from several hundred million to several billion dollars (Kipshakbaev et al., 2010; Narbayev et al., 2023).

The changes in microclimate and temperature that have occurred since 1960 in the area surrounding the Aral Sea are so large that they cannot be attributed only to general atmospheric processes characteristic of the region. The impact of the Aral Sea desiccation 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 KazHRI (Hydrometeorological Research Institute) (Figure 7).

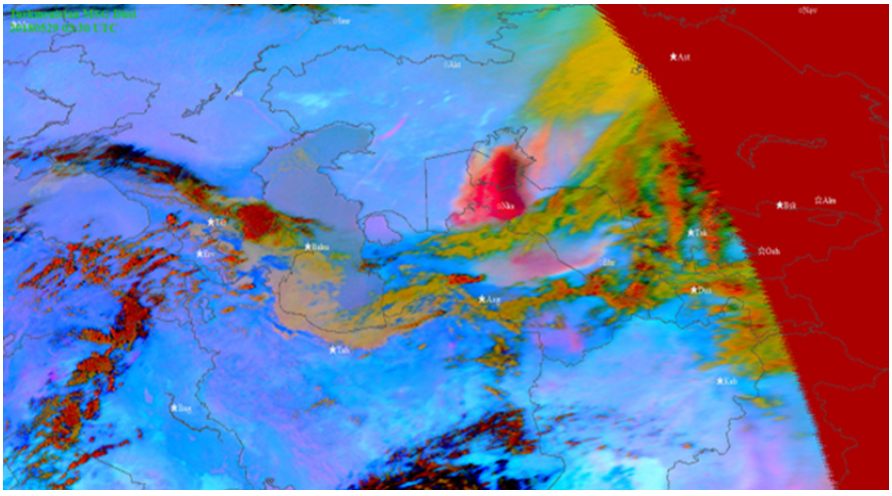

Figure 7. Formation of a dust-salt storm on the dried seabed of the Aral Sea (May, 2018) (UNECE, 2019).

A big problem is also the fact that strong winds lift tons of toxic salts from the exposed dry Aral Sea bed, which negatively affect the ecological environment. According to the conducted works of KazNIGMI (1980-1990), the first strip of territory 20-30 km from the dried Aral Sea bed receives on average 140-150 tons/

km^2 dust-salt aerosol, which corresponds to 3-15 tons/km^2 salt. At a distance of 65 km, 25 tons/km^2 is deposited, at 120 km about 5 tons/km^2. The impact of dust-salt aerosol is strongest in a 30-50 km strip of territory around the water area of the dried seabed of the Aral Sea (DSAS), but dust particles are also transported for thousands of km (Huang, et al. 2022).

The indicators of total dust deposition are confirmed by more recent studies of foreign scientists, which range from 50 to 1679 kg per hectare, with the highest deposition rates observed in the vicinity of the dried Aral Sea bed.

Smaller particles of dust-salt storms lifted from DSAS, as well as dust-sand particles of storms from desert territories and degraded lands of the Aral Sea basin cover high-mountain glaciers with impenetrable film, accelerate glacier deflation processes and pollute the zone of flow formation and water resources of the Syrdarya river (Rafikov, 2024).

In 2021, FAO specialists carried out works on soil salinity mapping in the Kyzylorda region. According to the data obtained, currently in the region almost 85% (20.3 million ha) of the total area of agricultural land (22.6 million ha) is saline. This situation requires immediate action to apply new technologies to regulate the rate and degree of salinization of the territory. Inefficient agriculture causes soil erosion, salt pollution, pasture dislocation and growing 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 salinization and irrational use of natural resources (FAO, 2012).

In the Kazakhstan part of the Aral Sea basin there is a tendency of salinization of water bodies and soils, indicators of secondary salinization of irrigated lands increased 3 times in comparison with 1990.

The disturbance of soil and water quality composition proportionally increases irrigation water consumption, significantly exceeding scientifically-based norms. According to forecasts, if the existing trend of salinization of water bodies and soils continues, most of the agricultural land in the Syrdarya river basin (and by analogy also in the Amudarya river basin) will become unsuitable for irrigated agriculture within several decades. The level of salt pollution of rivers will lead to unsuitable condition of water resources for drinking water supply. This type of river pollution can cause irreparable damage to the ecological and socio-economic development of Kyzylorda province.

Methods and materials. As mentioned above, the Aral-Syrdarya basin is the most vulnerable among other basins. Therefore, in order to describe the entire chronology of changes in water resources, statistical data analysis was applied for each economic sector.

The primary research method employed in this article is statistical analysis, encompassing its various types. In the modern information world, statistical methods have become an integral part of scientific work. One of the most common statistical methods is descriptive statistics (Helsel et al., 2020). The method of

statistical analysis is complex, due to the variety of forms of statistical patterns. In this regard, this article examines the analysis of the water intake of the Syrdarya river for planning the use of water for irrigation, energy, and other branches of the economy, including neighboring countries. Taking into account all economic sectors, the article also considered the analysis of the dynamics of irrigated agriculture in the Kyzylorda region, the dynamics of the water surface area of lake systems and wetlands in the Syrdarya river delta, and the quality of surface waters in the Syrdarya river basin. All the data were analyzed using the statistical method.

For this research methods of descriptive statistics were used for the annual characteristics. Moreover, the article incorporated a trend analysis.

The assessment of the quantitative composition of surface water is the result of data obtained by national hydrometeorological service Kazhydromet. Water quality assessment is conducted in accordance with the Unified System of classification of water quality in water bodies. The assessment is based on the application of the classical approach of comparing the concentration of a pollutant with its normative level. The innovation of the assessment approach according to the Unified Classification System is the presence of several (five) classes of water quality and five different standards for each class, accordingly.

Results and discussions. The Aral Sea catastrophe has created a number of specific health problems for the local population. The general morbidity of the population for the last 30 years has increased more than 3 times. The level of respiratory diseases has increased almost as much, the level of congenital anomalies has increased 10 times.

Negative dynamics of demographic indicators is observed. The birth rate in the Aral Sea region for the last 5 years has decreased by 13.6 percent, natural population growth - by 12.4 percent.

The health index of pregnant women living in the region is 1.6 times lower than the republican values. In the last 5 years alone, extragenital pathology was the direct cause of 80 percent 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 blood analysis 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 note the low bioavailability of iron in the diet of the Aral Sea region. This is due to the predominance of flour and bakery products, which contain a large amount of phytates that bind iron into a compound that is difficult to absorb. As a result, there is a correlation between low iron bioavailability and anemia in the area (Sorg et al., 2014).

In Kyzylorda region, the Health Index of conscripts leaves much to be desired. Many suffer from diseases of gastrointestinal tract, liver, kidney, high blood pressure, spine, vision and skin diseases.

Despite the positive dynamics of a number of basic medical and demographic indicators of the region's healthcare sector, there are many problematic issues that need to be addressed at the level of both the management of polyclinics and hospitals and the support of 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, technical equipment of medical facilities (Khaibullina et al., 2022).

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 thousand population.

In Kyzylorda region 164467 people are on dispensary registration for all diseases, of which 72128 patients receive 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, which indicates low activity of the work carried out by general practitioners. In addition, the effectiveness of screening tests is low.

In the region under consideration, when providing specialized care to patients with heart diseases, 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 2 times lower than the national average. The same unsatisfactory situation in the provision of medical care for stroke is observed in the low proportion of systemic thrombolysis in patients with ischemic stroke, also only 70% of stroke patients are registered at the place of residence.

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

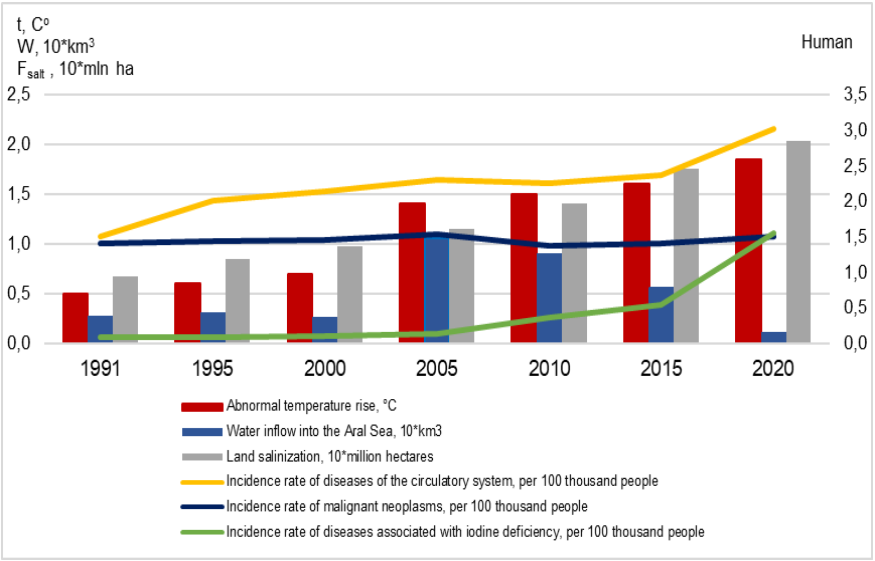

Figure 8. Impact of climate and eco-effects on human security in Kyzylorda region.

Dynamic growth of abnormal temperatures in Kyzylorda province predetermines increase of water consumption norms in the main sectors of economy, limiting natural needs of natural ecosystems.

The observed growth of land salinization indicators indicates "chronic" shortcomings in 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, to a certain extent, can be mitigated, provided a balanced diet and clean drinking water.

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

Conclusion. The article presents the dependence of Human Security in Priaralie on modern ecological and water management indicators in the Syrdarya river basin, recommends optimal ways to develop irrigated agriculture and restore natural ecosystems, improve socio-economic issues in the context of climate change.

The environmental disaster in the Aral Sea has led to a serious deterioration in the health of the region's population. Over the past 30 years, the overall incidence of disease has more than tripled, the number of respiratory diseases has increased significantly, and the rate of congenital anomalies has risen tenfold.

The demographic situation has deteriorated: over the past 5 years, the birth rate has fallen by 13.6%, and natural population growth by 12.4%. The health status of pregnant women is noticeably worse than the national average: anemia and hypertension are more common, and extragenital diseases have become the cause of most cases of maternal mortality.

Infant mortality also remains high, and the number of cases of heart attacks and cancer is rising. At the same time, there has been a decline in medical infrastructure—the number of hospitals has decreased significantly between 1991 and 2020.

Studies conducted in the Kyzylorda Region have revealed a clear upward trend in abnormal temperatures over the period from 1990 to 2025, an increase in the severity and frequency of droughts, persistent pollution of surface water resources, a steady rise in water abstraction from water bodies, and a rapid decline in lake systems. These parameters of the overall model of human-environment interaction exhibit complex trends of cumulative impact on the overall socio-environmental development of the local population and the region as a whole.

In the long term, the region in question should focus on implementing the recommendations of the Kunming-Montreal Global Biodiversity Framework, the Regional Strategy for Drought Risk Management in Central Asia, the Regional Strategy for Combating Sand and Dust Storms in Central Asia, and the UN Water Conference.

Therefore, for successful solution of urgent environmental and socio-economic

issues of the Aral Sea region we consider it expedient to develop multisectoral NEXUS "Water-Energy-Food-Ecosystem" relationship, which will certainly contribute to the increase of investment attractiveness in the region and achievement of Sustainable Development Goals (17 SDGs).

References

Absametov M.K., Ospanov K.T., Kenesbayeva B. (2024). Water quality of the Syrdarya River and groundwater of the Kyzylzharma field in the Kyzylorda region (Kazakhstan) Engineering Journal of Satbayev University. – Vol. 146. – No.1. – P. 30-38. https://doi.org/10.51301/ejsu.2024.i1.05 (in Eng.)

Anchita, Zhupankhan A., Khaibullina A., Kabiyev Z., Persson Y., Tussupova, K. (2021). Health impact of drying aral sea: One health and socio-economical approach. Water. – No.13(22). – P. 3196. https://doi.org/10.3390/w13223196 (in Eng.)

Bekchanov M., Ringler C., Bhaduri A., Jeuland M. (2016). Optimizing irrigation efficiency improvements in the Aral Sea Basin. Water Resources and Economics. – Vol. 13. – P. 30-45. https://doi.org/10.1016/j.wre.2015.08.003 (in Eng.)

Dennis R. Helsel, Robert M. Hirsch, Karen R. Ryberg, (2020). Stacey A. Archfield, and Edward J. Gilroy. Statistical Methods in Water Resources. https://doi.org/10.3133/tm4A3 (in Eng.)

Dushanbe Statement of the Heads of Founding States of the International Fund for Saving the Aral Sea. (2023) (in Eng.) ifas-meeting-2023_e.pdf - Yandex Documents

FAO. 2012. AQUASTAT Transboundary River Basin Overview – Aral Sea. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy. – P. 24. https://openknowledge.fao.org/handle/20.500.14283/ca2139en (in Eng.)

Glazovsky N.F. (2006) Izbrannyi trudy [Selected Works]. – Moscow. – Vol. 2. – P. 924. (in Russian)

He, H., Hamdi, R., Luo, G., Cai, P., Zhang, M., Shi, H., Li, C., Termonia, P., De Maeyer, P., & Kurban, A. (2022). Numerical study on the climatic effect of the Aral Sea. Atmospheric Research, 268. – P. 105977. https://doi.org/10.1016/j.atmosres.2021.105977 (in Eng.)

Huang, S., Chen, X., Chang, C., Liu, T., Huang, Y., Zan, C., Ma, X., De Maeyer, P., & Van de Voorde, T. (2022). Impacts of climate change and evapotranspiration on shrinkage of the Aral Sea. Science of The Total Environment, 845. – P. 157203. https://doi.org/10.1016/j.scitotenv.2022.157203 (in Eng.)

Kai W., Rooijen D., Soliev I., Mukhamedova N. (2015). Water Security in the Syr Darya Basin. Water 7. – No.9. – P. 4657-4684. https://doi.org/10.3390/w7094657 (in Eng.)

Kamalov Y. (2003). The Aral Sea: problems, legends, solutions. Water Science and Technology. – No. 48(7). – P. 225-231. https://doi.org/10.2166/wst.2003.0444 (in Eng.)

Konyrbekov, M. Z. (2015). *Studying the features of livestock sector growth in Kazakhstan within market environment*. Actual Problems of Economics, 169(7), 79–87. RL: http://nbuv.gov.ua/UJRN/ape_2015_7_12

Khaibullina Zh., Amantaikyzy A., Ariphanova D., Temirbayeva R., Mitusov A., Zhurumbetova Zh. (2022) Socio-economic and public health impacts of climate change and water availability in Aral District, Kyzylorda Region, Kazakhstan. CENTRAL ASIAN JOURNAL OF WATER RESEARCH 8(1). – P. 177-204. https://doi.org/10.29258/CAJWR/2022-R1.v8-1/177-204.eng (in Eng.)

Kipshakbaev N.K., Kipshakbaev N.K., Joop de Schutter, Dukhovny V.A., Malkovsky I.M., Ogar N.P., Khaibullin A.S., Yapryntsev V.V., Tuchin A.I., Yakhiyaeva K.K. (2010). Vosstanovleniye ekologicheskoy sistemy v del′te Syrdar′i i severnoy chasti Aral′skogo morya. [Restoration of ecological system in the Syrdarya delta and northern part of the Aral Sea]. Almaty: "EVERO". – 220 p. https://aral.uz/doc/north_aral%202010_en.pdf (in Russian)

Martius, C., Lamersb, J., Vleka, P., Eshchanovb, R., Rudenkob, I., & Salaevb, O. (2005). Water, Salt, Cotton and Soums: Shedding New Light on the Aral Sea Problem. The Global Food & Product Chain-Dynamics, Innovations, Conflicts, Strategies. Conference on International Agricultural

Research for Development. (PDF) Water, Salt, Cotton and Soums: Shedding new Light on the Aral Sea Problem (in Eng.)

Narbayev M., Dolgikh S., Kenshimov A., et al. (2023) Otchet po proyektu UNDP. Vzaimosvyaz′ izmeneniya klimata, degradatsii zemel′ i vodnykh resursov v regione Aral′skogo morya. [UNDP Project Report. Interrelationship of climate change, land degradation and water resources in the Aral Sea region]. – 102 p. (in Russian)

Normatov, I.S., Goncharuk, V.V., Bozorova, N. et al. (2025). Hydrochemistry and Quality of Irrigating Water in the Middle Reaches of the Syr Darya River in the Territory of the Republic of Tajikistan. J. Water Chem. Technol. 47. – P. 204-211. https://doi.org/10.3103/S1063455X25020079 (in Eng.)

Rafikov V. (2024). Assessment of the transfer of the dust-sand-salt material from the dry bottom of the Aral Sea. E3S Web of Conferences 575:04004. DOI: https://doi.org/10.1051/e3sconf/202457504004 (in Eng.)

Sembayeva A., Stella T., Orazgaliyev S., Xenarios S. (2024) Energy and industrial transitions in Kazakhstan. In book: Clean Energy Innovation Policies in Emerging and Developing Economies Publisher: International Energy Agency.https://iea.blob.core.windows.net/assets/3fae1cd7-bb92-4d03-be7c-4e60a6f94b03/CleanEnergyInnovation PoliciesinEmergingandDevelopingEconomies-Kazakhstan.pdf (in Eng.)

Shi H., Luo G., Zheng H., Chen C., Hellwich O., Bai J., Liu T., Liu S., Xue J., Cai P., He H., Ochege F.U., Van de Voorde T., de Maeyer P. (2021). A novel causal structure-based framework for comparing a basin-wide water–energy–food–ecology nexus applied to the data-limited Amu Darya and Syr Darya river basins. Hydrol. Earth Syst. – No.25. – P. 901-925. https://doi.org/10.5194/hess-25-901-2021 (in Eng.)

Sorg A., Mosello B., Shalpykova G., Allan A., Hill Clarvis M., Stoffel M. (2014). Coping with changing water resources: The case of the Syr Darya river basin in Central Asia. Environmental Science & Policy 43. – P. 68-77. https://doi.org/10.1016/j.envsci.2013.11.003 (in Eng.)

Tairov A.Z., Leman M., Tolekova A., Abdibekov D.U., Sorokina T.E. (2025). Hydrochemistry and ion flow dynamics of Syrdarya transboundary river within Kazakhstan. NEWS of the National Academy of Science of the Republic of Kazakhstan. Series of geology and technical sciences. – Vol. 2. – No.470. – P. 290-306. https://doi.org/10.3214/2025.2518-170X.456 (in Eng.)

UNECE (2019) Kazakhstan: Environmental Performance Reviews. Third review. – 495 p. https://unece.org/environment-policy/publications/3rd-environmental-performance-review-kazakhstan (in Eng.)

Zhang Y.F., Li Y.P, Huang G.H., Zhai X.B., Ma Y. (2024). Improving efficiency and sustainability of water-agriculture-energy nexus in a transboundary river basin under climate change: A double-sided stochastic factional optimization method. Agricultural Water Management. – Vol.292. – P. 108648. https://doi.org/10.1016/j.agwat.2023.108648 (in Eng.)

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