Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Ecological monitoring of the biodiversity sustainability in the regions of Southern Kazakhstan during observed drought

Rimma Turekeldiyeva[1], Rakhat Kurmanbayev[2]*, Zhanat Idrisheva[3], Natalya Korogod[4], Shilibek Kenzhegali[5], Almira Bukunova[6], Manira Zhamanbayeva[6], Madina Daniyarova[6]

1. Department of Ecology and Life Safety, Institute of Water Management and Environmental Management, Taraz Regional University named after M.Kh.Dulaty, Taraz, Kazakhstan
2. Department of Biology, Geography and Chemistry, Institute of Natural Sciences, Korkyt Ata University, Kyzylorda, Kazakhstan
3. Department of Academic Activities, D.Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan
4. Higher School of Natural Science, Margulan University, Pavlodar, Kazakhstan
5. Department of Transport and Mechanical Engineering, Institute of Water Management and Environmental Management, Taraz Regional University named after M.Kh.Dulaty, Taraz, Kazakhstan
6. Department School of Earth Sciences, D.Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan

** Corresponding author's E-mail: rakhat72@mail.ru*

ABSTRACT

Environmental protection assessment is one of the main procedures in the sustainable environment planning process, and therefore, paying attention to it in policymaking and planning is inevitable. The present study was conducted to measure and evaluate the level of environmental sustainability in the southern region of Kazakhstan. In this study, some geographical, biodiversity, and environmental assessments were conducted by extracting information on precipitation, temperature, and drought in the study area. So, in the first step, the indicators affecting the environment in the four main branches of atmosphere, water, soil, and biodiversity were evaluated from the perspective of experts. The results show that, due to recent droughts, the environmental criteria of atmosphere and water are of the highest importance. It was also indicated that the southern regions of Kazakhstan are in a semi-stable and relatively unstable position in terms of environmental sustainability and require greater priority for implementing targeted and sustainable development programs for environmental diversity.

Keywords: Environment, Biodiversity, Ecology, Drought.
Article type: Research Article.

INTRODUCTION

Monitoring biodiversity changes is an important and necessary measure to achieve ecosystem sustainability, preserve species with conservation value, and ensure ecosystem services derived from biodiversity. The environment includes all areas surrounding life, including land, air, and water, where humans, plants, and animals live. In other words, it includes natural resources, both renewable and non-renewable, all living organisms, artificial environments (residential, industrial areas, roads, etc.), and landscapes (Kamp *et al.* 2016). Biodiversity is an important part of the environment that includes the diversity of life on Earth at all levels, from the gene level to the ecosystem and related evolutionary and ecological processes (Zheleznova *et al.* 2022). Biodiversity was declared the most important environmental issue (Suleimenova *et al.* 2021), bringing biodiversity to the forefront. The biodiversity is defined as the variation among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexity, including intraspecific, interspecific, and ecosystem

Caspian Journal of Environmental Sciences, Vol. 22 No. 5 pp. 1215-1222 Received: Feb. 27, 2024 Revised: May 21, 2024 Accepted: Aug. 02, 2024
DOI: 10.22124/CJES.2024.8339

Publisher: University of Guilan

diversity (Nendissa *et al.* 2023). After the Industrial Revolution, and following the uncontrolled increase in the world's population and the emergence of major concerns about the global environment, the destruction of nature and the loss of biodiversity have accelerated significantly. Global biodiversity continues to change (Malakhov & Dolbnya 2023; Beirami *et al.* 2024), and we are witnessing widespread extinction at the species and population levels worldwide (Zhexenbay *et al.* 2020; Salnikov *et al.* 2023). Various factors such as habitat destruction, overexploitation (hunting and fishing), pollution (point and non-point), global climate change (greenhouse effect and ozone layer depletion), basic social conditions (increasing per capita consumption, poverty, rapid population growth, economic and social policies) have led to a dramatic increase in the global biodiversity changes and the loss of animal and plant species. The loss of biodiversity on Earth has cost the world economy an estimated $500 billion per year in recent decades (Aralova *et al.* 2018). In the United States, the economic benefits of wild plants and animals account for approximately 4.5% of GDP. The global trade in wild plants is estimated to be worth $6 billion annually. The loss of diversity may reduce ecosystem resilience and significantly impact the human communities that depend on them (Kappas *et al.* 2020). All this while many of the world's plant and animal species are either unknown or lack accurate information about their habitats, and data on the spatial distribution of species are often very scarce and, in many cases, unrealistic. Therefore, monitoring biodiversity changes is an important and necessary measure to achieve ecosystem sustainability, preserve species with conservation value, and ensure ecosystem services derived from biodiversity, which can be considered a solution to save the planet. The most important activity in achieving biodiversity conservation goals is to update information on patterns of biodiversity changes at the global and regional levels, the drivers affecting biodiversity changes, and effective conservation policies (Yegizbayeva *et al.* 2024). Multiple studies are crucial for understanding temporal changes in biodiversity, assessing progress towards conservation and sustainable use, as well as planning and prioritizing conservation (Jiang *et al.* 2019) and can help in designing and monitoring national and regional biodiversity policies, using them in national reports for international agreements such as the Convention on Biological Diversity and the Sustainable Development Goals (Kirpotin *et al.* 2021), and providing data for global reports such as WWF's and CBD's. The ability of scientists to define, measure, and monitor changes in biodiversity is the most effective way to conserve biodiversity and provide useful responses to reduce biodiversity loss and adaptation plans. Before deciding on the best path to conserve biodiversity, one of the most important issues is to value and communicate the importance of biodiversity and how to do so. Drought is one of the main and oldest natural disasters that humans have been familiar with for a long time (Meshkov *et al.* 2009). Drought and reduced rainfall in any region can affect that region's water resources and agriculture. Wang *et al.* (2010) reported drought in different states of the United States using the standard precipitation index. In a study conducted by Linhai & Zvarych (2023), the standard precipitation index was used to determine drought characteristics in South Asia. In an another research, Tian *et al.* (2018) examined drought characteristics, including duration, total deficiency, severity, and extent of drought, on a regional basis and concluded that, except for duration, other drought characteristics are directly related to the long-term precipitation average. Reznikova *et al.* (2019) examined the impact of droughts on groundwater resources and concluded that the number of negative precipitation anomalies is greater than the number of positive ones and that the impact of human activities on negative groundwater anomalies is very significant. Given the rapid growth of urbanization and the widespread need for spatial occupation and development of urban communities, planners have paid attention to drought. Therefore, in this study, while reviewing the literature on environmental sustainability and its measurement and evaluation, an appropriate and comprehensive framework and method are presented for selecting indicators and measuring and evaluating the level of environmental sustainability in different regions of Southern Kazakhstan. The present study seeks to answer this question: What is the level of environmental sustainability? This study presents its findings using multi-criteria analysis methods and in the form of an expert weighting model for evaluating and measuring the level of environmental sustainability in southern regions of Kazakhstan.

Environmental assessment (EA)

EA is a method for ensuring that the environmental consequences of decisions are considered before a decision is made (Sheikh *et al.* 2015). An EA:

Specifies the main adverse environmental impacts; determines procedures to reduce adverse impacts on the environment.

Predicts main reasons that have side effects on the environment; includes a follow-up plan to verify the accuracy of the environmental assessment and the effectiveness of mitigation measures. Environmental assessment is a

planning and decision-making tool whose objectives can be summarized in two: to minimize or avoid environmental impacts before they occur.

Incorporates environmental factors into decision-making. Notably, environmental assessment should be carried out as early as possible in the planning stage. So that the authorities can reflect analytically on the proposed plans, including the incorporation of mitigation measures to consider their impacts.

Benefits of environmental assessment include: Avoidance or reduction of adverse environmental impacts; opportunities for public participation and local consultation; improved protection of human health; reduced project costs and delays; reduced risks of environmental damage and incidents; increased government accountability and coordination; reduced likelihood of transboundary environmental impacts; informed decisions that lead to responsible progress of natural resources. The Environmental Assessment Program of Parks Canada provides a general classification for environmental assessment, which can be divided into two types: strategic environmental assessment for policy, plan, and program proposals and project-level environmental assessment. EA can be undertaken for specific projects, such as a dam, highway, airport, or factory, or for general plans and programs (Strategic EA). Concern about environmental problems first emerged on a large scale in the 1960s and 1970s. The importance of urban environmental issues has never been more apparent today. Nowadays, cities are considered the most important achievements of human technological, economic, cultural, and social endeavors (Arifin *et al.* 2023). In general, the environmental challenges facing the city of the 21st century can be outlined as follows: (i) Drought; (ii) Air and noise pollution have increased various diseases and jeopardized human peace in the city; (iii) Pollution of groundwater and surface water by various types of urban sewage and depletion of groundwater aquifers; (iv) Qualitative and quantitative changes in water resources (Li *et al.* 2020). Strategic environmental assessment is a process in which the effects and consequences of adopting policies, strategies, and programs are systematically identified and evaluated. Then, the necessary solutions are adopted to reduce the environmental consequences of implementing policies and programs. Strategic environmental assessment can be defined as a systematic process of evaluating the environmental consequences of proposed policies, and programs to integrate environmental considerations into the initial stages of macro-economic and social decision-making.

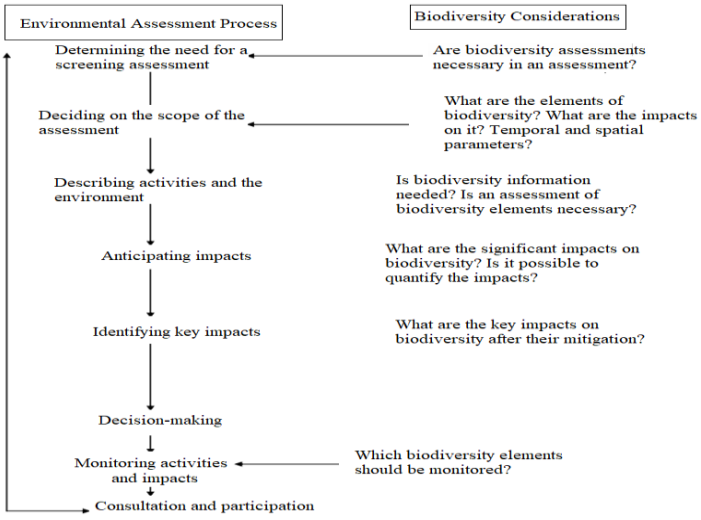

Fig. 1. Integrating the biodiversity framework with environmental assessment.

To conduct an environmental assessment in which biodiversity has its unique place, Fig. 1 shows the systems approach. The following studies should be carried out based on the systems approach according to Fig. 1 (Santos *et al.* 2017):

Selecting an affected area with ecosystem characteristics;

Identifying the ecological factors needed for management;

Collecting baseline information;

Selecting an affected area with ecosystem characteristics;

Identifying the ecological factors needed for management;

Collecting baseline information;

Identifying impacts on biodiversity and elements at risk;

Proposing a mitigation plan;
Selecting indicators;
Identify control areas;
Designing and implementing monitoring;
Identifying the relationship between indicators and objectives;
Analyzing trends and proposing management changes.

MATERIALS AND METHODS

The present research method is descriptive-analytical with an applied purpose. In this research, the library-documentary method has been used to collect data. This research aims to evaluate and classify the southern regions of Kazakhstan in terms of environmental sustainability. Therefore, the tool that can achieve this goal is multi-criteria decision-making techniques. In this research, the VIKOR method has been used to classify the studied region in terms of achieving environmental sustainability. Step One: The first step in this model is to present the indicators used in this model, so that the environmental indicators of the region are introduced. Then, their importance is evaluated based on the weighting of experts for each of these indicators.

Identifying the indicators

The selected indicators for measuring the environmental sustainability of cities are those that have been considered as: Per capita green space, Environmental diversity, Per capita waste production, Number of industrial units, Percentage of wastewater treatment plants, Fertilizer consumption rate, Per capita water consumption, Per capita air pollution production, Pollution control units, and Waste management. It is based on Canada's 2001 preliminary environmental indicators, the proposed environmental indicators of the United Kingdom, the components of the indicators and variables that make up the 2010 Environmental Sustainability Index, and the United Nations Commission on Sustainable Development's thematic indicators framework (Jiang *et al.* 2019). The study area in this study is the three southern provinces of Kazakhstan (Kyzylordinskaya, Yunjo-Kazakhstanskaya, Jambylslkaya) in the center of the Central Asian Plateau and adjacent to Uzbekistan (Fig. 2). Despite having large industries, this region is prone to drought due to its climate and weather conditions, and the intensification of past droughts has led to low agricultural productivity and biodiversity.

Fig. 2. Studied area, southern region of Kazakhstan.

RESULTS

To investigate the environmental impacts using rainfall and temperature reports over several years, the average precipitation pattern and temperature alterations in this region are presented in Fig. 3. Also, as shown in Fig. 3, the precipitation in the hot months of the year has decreased significantly over the past 10 years, indicating drought in this region. Obviously, the elevation in average temperature and drop in precipitation have affected this region's ecological diversity, especially in the warm seasons. In the next stage, the scoring of the studied indicators was evaluated based on experts' opinions, and the results are presented in Table 1. Table 1 indicates that the highest weight among the indicators is related to the per capita water consumption and air pollution production index, while the lowest to the number of industrial units index. Therefore, four main indicators are determined to form the environmental protection preference matrix for better evaluation and monitoring of each issue. In this regard, indicators have also been considered for environmental protection, divided into four main indicators: atmosphere, water, land, and biodiversity. Accordingly, in the present study, the above three indicators were selected as the main criteria for carrying out the hierarchical analysis process (Table 2).

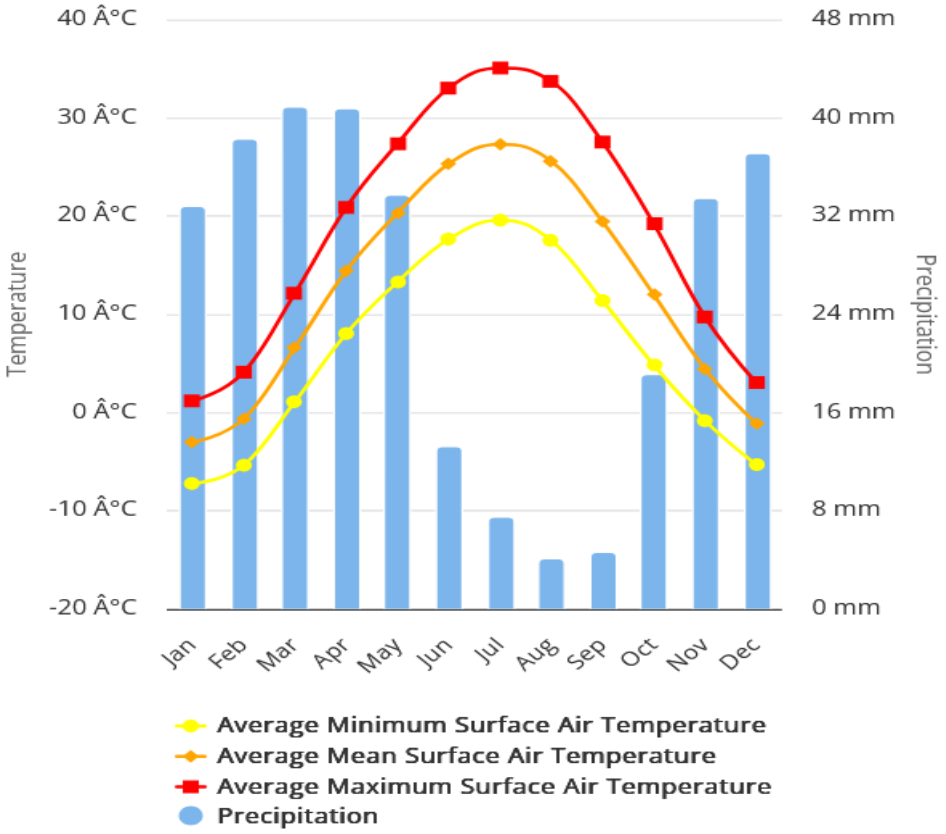

Fig. 3. Mean precipitation and temperature.

Table 1. Environmental indicators.

Index	Weight	Index	Weight
Per capita green space	0.070	Fertilizer consumption	0.053
Environmental diversity	0.075	Per capita water consumption	0.081
Per capita waste production	0.067	Per capita air pollution production	0.083
Number of industrial units	0.056	Pollution control units	0.069
Wastewater treatment plants	0.064	Waste management	0.071

Table 2. Environmental criteria for ranking the environmental protection index.

Main criterion	Sub-criterion	Description
Environment	Atmosphere	Climate change, ozone layer depletion, air quality
	Soil	Agriculture, forestry, desertification, urbanization
	Water	Drought, water quality
	Biodiversity	Ecosystem and species

The preferences of individuals for the main criteria are given in Table 1. According to the table, the highest preferences among specialists and experts were for atmosphere, water, soil, and biodiversity. Then, to determine the weight of the layers using the Analytical Hierarchy Process (AHP) method, after determining the importance of each parameter according to expert opinions, Expert Choice software was used, which showed that the inconsistency coefficient was less than 0.1.

Based on the results (Fig. 4), among the four main environmental criteria of atmosphere, land, water, and biodiversity, the highest priority was given to the atmosphere and water, with weights of 0.35 and 0.33, respectively. Also, the sub-criteria of land and biodiversity, with weights of 0.19 and 0.13, respectively, were ranked next and considered to be of almost equal importance.

In many development activities, ecosystems are highly vulnerable. However, this area is not fully explored in environmental assessment studies compared to the predicted impacts on other environmental parameters. To determine the ecosystem-level impacts of activities on biodiversity, the following questions need to be answered in the environmental assessment:

- Could the proposed activity cause the loss of communities and habitats in an ecosystem?

- Will the proposed activity affect the life-support functions of the ecosystem?

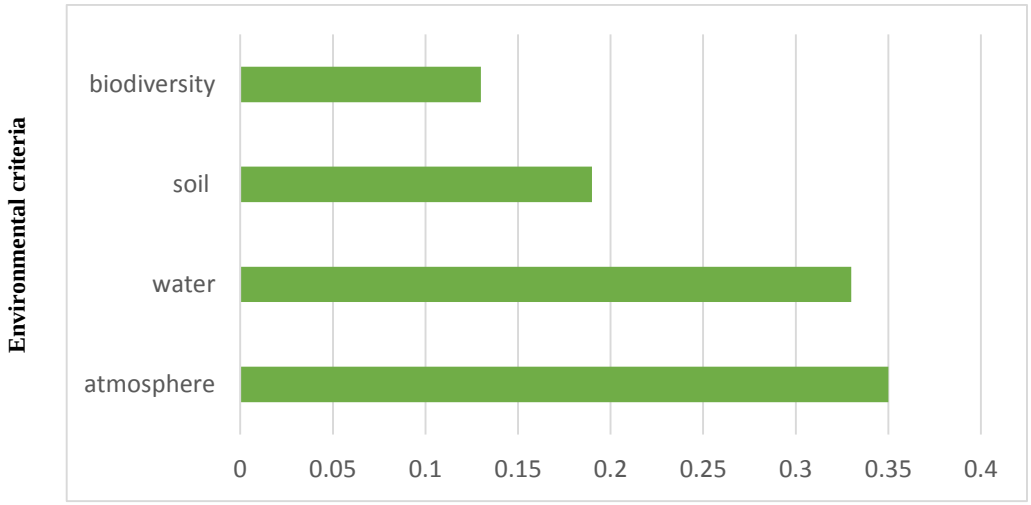

Fig. 4. Final weight under environmental criteria.

In an environmental assessment, factors such as communities, inanimate environments, and life-support functions in an ecosystem should be studied (Adedeji *et al.* 2020). The indication of potential impacts and expected degradation is one of the issues of particular importance in these studies about sustainable use and the alterations that occur in it. Therefore, it is important to study the communities and processes of the inanimate environment and their components, as well as the changes that are likely to occur in life-support functions (Li *et al.* 2023). In environmental assessment studies, plant communities are usually studied. In principle, this field has much primary information, and it is possible to study it using various methods, such as remote sensing techniques. In this field, plant communities should be mentioned in reports regarding structure, succession rate of species diversity, and composition. However, the relationship between plant and animal species is unimportant. Introducing a community's plant indicator species is one item that should be mentioned in an environmental assessment report (Carignan & Villard 2002). Providing the relationship of the abiotic environment, such as hydrological conditions (in terms of quantity and quality), alterations in soil properties, and climatic conditions with plants, are another essential items in a report. To predict the potential effects and changes in an ecosystem, it is particularly important to introduce limitations and relationships between primary uses of resources. Therefore, the basic processes should be introduced and explained, and in general, life-support functions are important from the perspective of maintaining the sustainability of biological diversity because of the benefits they provide to humans. Although evaluating the effects of a proposed activity on ecosystems is rarely mentioned in an assessment report, such an evaluation is possible by matching the current and future ecological conditions.

CONCLUSION

The issue of environmental protection is one of the most important issues currently being raised worldwide and has become the focus of attention of the global community. Therefore, indicators have been developed in recent years to assess the environment. It is impossible to ignore the environment's tolerable capacities at the expense of development and destroy the life-giving resources of the earth under the pretext of development. In this study, biodiversity was examined as an important indicator while stating the environmental protection indicators. Then, the importance and prioritization of environmental protection indicators were examined from the perspective of specialists and experts. The results indicate an understanding of the importance of the environment and its protection for achieving sustainable development, which makes the need to improve the status of the environment and pay more attention to it in the country's development programs more than ever before, and therefore environmental protection should be considered as one of the most important measures in the country. Given the importance of biodiversity in environmental protection and the increasing trend of destruction, especially at the habitat level, and considering that according to the approvals of the Supreme Council for Environment, environmental assessment has become mandatory for several large development projects in the country, it is

necessary to revise the framework of the environmental assessment model with greater emphasis on preserving biodiversity.

REFERENCES

Adedeji, O, Olusola, A, James, G, Shaba, HA, Orimoloye, IR, Singh, SK & Adelabu, S 2020, Early warning systems development for agricultural drought assessment in Nigeria. *Environmental Monitoring and Assessment*, 192: 1-21, DOI: https://doi.org/10.1007/s10661-020-08730-3.

Aralova, D, Kariyeva, J, Khujanazarov, T & Toderich, K 2018, Drought variability and land degradation in Central Asia: assessment using remote sensing data and drought indices. *Vegetation of Central Asia and Environs*: pp. 15-47, DOI: https://doi.org/10.1007/978-3-319-99728-5_2.

Arifin, Y, Putra, W, Maslikhah, TB & Sholeh, M 2023, The impact of green supply chain management on the economic performance of SMEs, considering environmental conditions. *Economic Annals-XXI*, 205: 34-38.

Beirami, AAM, Maghsoudlou, E, Nasrabadi, M, Sergeevna, KN, Abdullaev, S & Ibrahim, W 2024, An assessment of greenhouse gas emissions from diesel engines by adding carbon nanotubes to biodiesel fuel using a machine learning technique. *International Journal of Low-Carbon Technologies*, 19: 1358-1367, DOI: https://doi.org/10.1093/ijlct/ctae076.

Carignan, V & Villard, MA 2002, Selecting indicator species to monitor ecological integrity: a review. *Environmental Monitoring and Assessment*, 78: 45-61, DOI: https://doi.org/10.1023/A:1016136723584.

Jiang, L, Jiapaer, G, Bao, A, Kurban, A, Guo, H, Zheng, G & De Maeyer, P 2019, Monitoring the long-term desertification process and assessing the relative roles of its drivers in Central Asia. *Ecological Indicators*, 104: 195-208, DOI: https://doi.org/10.1016/j.ecolind.2019.04.067.

Kamp, J, Koshkin, MA, Bragina, TM, Katzner, TE, Milner-Gulland, EJ, Schreiber, D, Sheldon, R, Shmalenko, A, Smelansky, I, Terraube, J & Urazaliev, R 2016, Persistent and novel threats to the biodiversity of Kazakhstan's steppes and semi-deserts. *Biodiversity and Conservation*, 25: 2521-2541, DOI: https://doi.org/10.1007/s10531-016-1083-0.

Kappas, M, Degener, J, Klinge, M, Vitkovskaya, I & Batyrbayeva, M 2020, A conceptual framework for ecosystem stewardship based on landscape dynamics: case studies from Kazakhstan and Mongolia. *Landscape Dynamics of Drylands across Greater Central Asia: People, Societies and Ecosystems*: pp. 143-189, DOI: https://doi.org/10.1007/978-3-030-30742-4_9.

Kirpotin, SN, Callaghan, TV, Peregon, AM, Babenko, AS, Berman, DI, Bulakhova, NA, Byzaakay, AA, Chernykh, TM, Chursin, V, Interesova, EA & Gureev, SP 2021, Impacts of environmental change on biodiversity and vegetation dynamics in Siberia. *Ambio*, 50(11): 1926-1952. DOI: https://doi.org/10.1007/s13280-021-01570-6.

Li, C, Miao, L, Adyel, TM, Huang, W, Wang, J, Wu, J, Hou, J & Wang, Z 2023, Eukaryotes contribute more than bacteria to the recovery of freshwater ecosystem functions under different drought durations. *Environmental Microbiology*, 25(7): 1363-1373, DOI: https://doi.org/10.1111/1462-2920.16370.

Li, J, Pei, Y, Zhao, S, Xiao, R, Sang, X & Zhang, C 2020, A review of remote sensing for environmental monitoring in China. *Remote Sensing*, 12(7): 1130, DOI: https://doi.org/10.3390/rs12071130.

Linhai, W & Zvarych, R 2023, International trade of PRC and its place in environmental sustainability.

Malakhov, D & Dolbnya, O 2023, Remote sensing as a tool for biological conservation and grassland monitoring in mountain areas of Southeastern Kazakhstan. *Journal of Applied Science and Technology Trends*, 4: 72-79. DOI: 10.38094/jastt401175.

Meshkov, VV, Baizakov, SB, Yeger, AV & Orozumbekov, A 2009, Forest rehabilitation in Kazakhstan. *Keep Asia Green*, 4: 83-129.

Nendissa, DR, Alimgozhaevich, IK, Sapaev, IB, Karimbaevna, TM, Bakhtiyarovna, SZ, Abdullah, D, Ugli Zokirov, KG & Sharifovna, AG 2023, Sustainable livestock grazing in Kazakhstan: Practices, challenges, and environmental considerations. *Caspian Journal of Environmental Sciences*, 21: 977-988. DOI: 10.22124/cjes.2023.7156

Reznikova, N, Zvarych, R, Zvarych, I & Shnyrkov, O 2019, Global circular e-chain in overcoming global waste. *Procedia Environmental Science, Engineering and Management*, 6: 641-647.

Salnikov, V, Talanov, Y, Polyakova, S, Assylbekova, A, Kauazov, A, Bultekov, N, Musralinova, G, Kissebayev, D & Beldeubayev, Y 2023, An assessment of the present trends in temperature and precipitation extremes in Kazakhstan. *Climate*, 11: 33, DOI: https://doi.org/10.3390/cli11020033.

Santos, CAG, Brasil Neto, RM, Passos, JSDA & da Silva, RM 2017, Drought assessment using a TRMM-derived standardized precipitation index for the upper São Francisco River basin, Brazil. *Environmental Monitoring and Assessment*, 189: 1-19, DOI: https://doi.org/10.1007/s10661-017-5948-9

Sheikh, MM, Manzoor, N, Ashraf, J, Adnan, M, Collins, D, Hameed, SL & Manton, MJ 2015, Trends in extreme daily rainfall and temperature indices over South Asia. *International Journal of Climatology*, 35(7). DOI: 10.1002/joc.4081.

Suleimenova, N, Kalykov, D, Makhamedova, B, Oshakbaieva, Z & Abildayev, Y 2021, A resource conservation technology for adapting agroecosystems to the new natural conditions of a warming climate in South-Eastern Kazakhstan. *OnLine Journal of Biological Sciences*, 21: 376-387, DOI: 10.3844/ojbsci. 2021.376.387.

Tian, L, Yuan, S & Quiring, SM 2018, Evaluation of six indices for monitoring agricultural drought in the south-central United States. *Agricultural and Forest Meteorology*, 249: 107-119, DOI: https://doi.org/ 10.1016/j.agrformet.2017.11.024.

Wang, W, Wang, WJ, Li, JS, Wu, H, Xu, C & Liu, T 2010, The impact of sustained drought on the vegetation ecosystem in Southwest China based on remote sensing. *Procedia Environmental Sciences*, 2: 1679-1691, DOI: https://doi.org/10.1016/j.proenv.2010.10.179.

Yegizbayeva, A, Koshim, AG, Bekmuhamedov, N, Aliaskarov, DT, Alimzhanova, N & Aitekeyeva, N 2024, Satellite-based drought assessment in the endorheic basin of Lake Balkhash. *Frontiers in Environmental Science*, 11: 1291993. DOI: https://doi.org/10.3389/fenvs.2023.1291993.

Zheleznova, I, Gushchina, D, Meiramov, Z & Olchev, A 2022, Temporal and spatial variability of dryness conditions in Kazakhstan during 1979–2021 based on reanalysis data. *Climate*, 10(10), DOI: https://doi.org/10.3390/cli10100144.

Zhexenbay, N, Akhmetsadykova, S, Nabiyeva, Z, Kizatova, M & Iskakova, G 2020, Using pectin as a heavy metals detoxification agent to reduce environmental contamination and health risks. *Procedia Environmental Science, Engineering and Management*, 7: 551-562.

ibliographic information of this paper for citing:

Turekeldiyeva, R, Kurmanbayev, R, Idrisheva, Z, Korogod, N, Kenzhegali, S, Bukunova, A, Zhamanbayeva, M, Daniyarova, M 2024, Ecological monitoring of the biodiversity sustainability in the regions of Southern Kazakhstan during observed drought, Caspian Journal of Environmental Sciences, 22: 1215.-1222.