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SUSTAINABLE LAND USE FORMATION FEATURES ON AGRICULTURAL LAND IN KAZAKHSTAN

Características de la formación del uso sostenible de la tierra agrícola en Kazajistán

Características da formação do uso s ostenível da terra agrícola em Cazaquistão

Galymzhan Ussipbayev
Kazakh National Agrarian Research University
Almaty, República de Kazajistán
ORCID 0009-0002-4099-011X
galymzhanussipbayev@gmail.com

Ardak Omarbekova
Kazakh National Agrarian Research University
Almaty, República de Kazajistán
ORCID 0000-0002-6607-7292
ardakomarbekova@outlook.com

Assem Aidarova
Kazakh National Agrarian Research University
Almaty, República de Kazajistán
ORCID 0009-0007-2411-5776
assem_aidarova@hotmail.com

Nurlan Ussipbayev
Al-Farabi Kazakh National University
Almaty, República de Kazajistán
ORCID 0009-0006-1444-0375
nurlan.ussipbayev@outlook.com

Dariga Sagandykova
Kazakh National Agrarian Research University
Almaty, República de Kazajistán
ORCID 0009-0005-3822-9825
d.sagandykova@hotmail.com

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ABSTRACT

The research aims to analyse the state of agricultural land in the Republic of Kazakhstan with the classification of scientifically based factors affecting the sustainability of land use. This study considers the systems of agricultural land management, noted the pace of development, and forms relationships on land redistribution to increase sustainable land use. It has been established that 80% of the country's territory consists of agricultural land, of which only 43% is used for its main purpose. The development of livestock and crop production system in conditions of severe drought in 2022 is assessed on the example of climatic conditions of Balkhash district of Almaty region. The practical significance of the work lies in the efficiency of agricultural production, considering all modern technological requirements and finding a dynamic balance between inputs and the corresponding increase in output.

KEYWORDS
Natural resources, agricultural production, climate, land fund, state regulation.

RESUMEN

Analizamos el estado de las tierras agrícolas en la República de Kazajistán con la clasificación de los factores con base científica que afectan a la sostenibilidad del uso de la tierra. En este estudio se consideran los sistemas de gestión de las tierras agrícolas, se observa el ritmo de desarrollo y se establecen relaciones sobre la redistribución de las tierras para aumentar su uso sostenible. Se ha establecido que el 80% del territorio del país está formado por tierras agrícolas, de las cuales sólo el 43% se utiliza para su fin principal. El desarrollo del sistema de producción ganadera y agrícola en condiciones de grave sequía en 2022 se evalúa tomando como ejemplo las condiciones climáticas del distrito de Balkhash, en la región de Almaty. La importancia práctica del trabajo radica en la eficiencia de la producción agrícola, teniendo en cuenta todos los requisitos tecnológicos modernos y encontrando un equilibrio dinámico entre los insumos y el correspondiente aumento de la producción.

PALABRAS CLAVE
Recursos naturales, producción agraria, clima, fondo de tierras, regulación estatal.

RESUMO

Analizamos o estado das terras agrícolas na República de Cazaquistão com a clasificação dos fatores com base científica que afetam à sustentabilidade do uso da terra. Neste estudo são considerados os sistemas de gestão das terras agrícolas, observa-se o ritmo de desesenvolvimento e establecem-se relações sobre a redistribução das terras para aumentar seu uso sustentável. Tem se estabelecido que o 80% do território do país está formado por terras agrícolas, das quais só o 43% se utiliza para seu fim principal. O desenvolvimento do sistema de produção de gado e agrícola em condições de grave seca em 2022 é avaliado tomando como exemplo as condições climáticas do distrito de Balkhash, na região de Almaty. A importância prática do trabalho radica na eficiência da produção agrícola, tendo em conta todos os requisitos tecnológicos modernos e encontrando um equilíbrio dinâmico entre os insumos e o correspondente aumento da produção.

PALAVRAS-CHAVE
Recursos naturais, produção agrária, clima, fundo fundário, regulação estadual.

Introduction

The economic importance of land consists of it being the main means of production in agriculture, contributing to the development of all other sectors of the economy. The land fund has historically been the driving force of the country's economy as a source of fodder, food, fuel, medicinal plants, and recreational area, but the most important category is agricultural land. According to Venkatesh et al. (2022), the Republic of Kazakhstan has established parameters of land endowment per capita which is 17 ha/person of which 1.5 ha/person is arable land. For comparison, it is necessary to compare the indicators of other countries, respectively: 3.8 and 0.75 ha/person for the United States, 0.8 and 0.08 ha/person for China, and 0.31 and 0.03 ha/person for Japan.

As defined by the United Nations Convention to Combat Desertification in their documents from 2023, the Earth is regarded as a distinct surface area. This encompasses all aspects of its near-surface or terrestrial biosphere, including near-surface climate, topography, soils, and surface water features like shallow lakes, rivers, and marshes. It also incorporates near-surface sediments and the associated groundwater, as well as plant and animal populations, human settlement patterns, and the cumulative impact of current and historical anthropogenic pressures on the environment. This comprehensive definition underscores the interconnectedness of various natural and human factors that contribute to the overall state of the Earth's terrestrial ecosystems. The economic benefits of land restoration are enormous.

The land is a relatively renewable natural resource because only when it is properly used, fertility, flora and fauna, opportunities for high yields and productivity are preserved. The efficient use of land resources should be the basis for stable and sustainable development of the agro-industrial complex and the livelihood of the population, but the processes of increasing degradation of land resources determine the causes of many negative consequences:

- social – reducing food quality and increasing disease;
- economic – reducing land productivity and sustainability of agricultural activities, and
- environmental – chemical pollution and reduction of soil fertility.

The agricultural land of the Republic of Kazakhstan is intended for crop and livestock use, but only one-fifth of it is cultivated. The research aims to assess the current state of agricultural land in the Republic of Kazakhstan by classifying scientifically based factors affecting the sustainability of land use.

Theoretical overview

Agricultural production is the backbone of a country's food security, but sustainable development requires the implementation of measures that contribute to the rehabilitation of productive and social infrastructure and improve its efficiency. Livestock products require production in centners of milk, live weight gain of cattle, sheep and goats, pigs, and 1000 eggs per 100 ha of agricultural land. The group of cost indicators included the value of gross agricultural output, costs of basic production, net profit per 100 hectares of agricultural land, and thousand tenge. The group of relative indicators included ploughing and shares of agricultural land and coefficients of utilisation of arable land areas.

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The efficiency of agricultural land use is heavily influenced by available capital, which is evaluated based on machinery conditions, quantity, and workload per unit. Factors like wear and tear, obsolescence, extended repair times, and downtime due to spare parts and specialist shortages can disrupt the timing of key agricultural operations such as planting, harvesting, and transportation. These disruptions have a detrimental impact on revenue, profits, and overall production profitability, underscoring the critical role of machinery maintenance, investment, and resource availability in optimizing agricultural land use and economic activity (Vdovenko et al., 2023; Sirenko and Mikuliak, 2022). As a result, it is the yield of marketable products, rather than its total volume obtained per unit of area and equipment at a comparable price, that is recognised as an important indicator of the economic efficiency of agricultural land use.

According to Mukanov (2023), the state program Digital Kazakhstan underscores the pivotal role of digital systems as the fundamental infrastructure for maintaining an automated information system of the national land cadastre. These digital systems facilitate various essential tasks, including the execution of land reclamation and soil protection measures, conducting soil-geological surveys, and effectively managing the allocation of crop areas and fodder bases (Wrzecińska et al., 2023).

In recent times, there has been a growing interest in organic agricultural production and environmentally friendly food products within the Republic of Kazakhstan. This surge in interest is driven by several factors, including the cost-efficiency of such production compared to Western Europe. Kazakhstan benefits from favorable environmental conditions, vast expanses of uncultivated land resources due to economic and financial constraints, and a readily available labor force, all contributing to lower production costs (Kerimkhulle et al., 2022).

In essence, the principles of organic farming have emerged as a reliable avenue for achieving high yields of ecologically clean crops and livestock products, as highlighted by Ussipbaev et al. (2022). These principles align with the broader goals of sustainable agriculture and environmental conservation, positioning Kazakhstan to harness its agricultural potential while meeting the demand for organic and environmentally responsible food products on both domestic and international markets. Natural and anthropogenic factors of land degradation affect the area of unused agricultural land: water erosion – 18-21%, wind erosion or weathering – 13-14%, primary and secondary soil salinization – 2.2%, soil overwatering – 6.4%, increased soil acidity. Soil degradation is differentiated as follows physical and mechanical disturbances of the soil profile; chemical – nutrient depletion, secondary salinization and mineralisation, contamination with toxic substances; biological – reduction of species diversity, the optimal ratio of different species of microorganisms, presence of pathogens, deterioration of sanitary and epidemiological indicators; hydrological – change of soil water conditions (Miroshkina and Borko, 2023).

The main methods of land restoration include tree planting, crop rotation using water harvesting techniques through watercourses and drainage, and the application of organic and mineral fertilisers. An important ecological process of land reclamation is the restoration of natural and safe landscapes for people, wildlife and plant communities, this process paves the way for ecosystem restoration and provides important economic development by helping to prevent natural disasters.

Materials and methods

The study on land resource formation in Kazakhstan is grounded in fundamental and conceptual development, employing various methodological approaches such as analysis and synthesis, statistics, abstraction and concretization, systematization, and generalization. The primary focus of the research is on the agricultural lands of Kazakhstan, including arable land, perennial plantations, fallow lands, hayfields, and pastures. Several key indicators serve as benchmarks for evaluating the development of effective agricultural production in Kazakhstan. These include the growth of agricultural production, the volume of agricultural risk insurance, the level of state funding, the competitiveness of national agricultural producers, the volume of finished product exports, the number of privatized enterprises in the agricultural industry, and the level of professional training among the staff. These indicators collectively provide insights into the state of agricultural development and land resource management in Kazakhstan.

The synthesis and analysis methods were used following the study area and practical value, determining the scales of use of the available production potential in the Republic of Kazakhstan agro-industrial complex. Considering the diversity of agricultural land as a means of production on the territory of the Republic of Kazakhstan, the factors influencing the efficiency of land, material and labour resources use in different natural-geographical zones are established. The features of land management in the Republic of Kazakhstan territory, as well as the prospects for the use of agricultural land of the land fund on the example of Balkhash district, Almaty region and the whole territory of Kazakhstan, are determined.

Analytical research of sustainability and efficiency of land resources use in agricultural production comprised the methods of statistical analysis, with the help of which the efficiency and effectiveness of agricultural land use were determined. Statistical information from the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan was analysed and processed. Achieving sustainability of land use relies heavily on information support, with the main basis for the disclosure of factors being the results of agrochemical surveys of soils, cadastral passports of land plots, statistical reports on the results of sowing crops and reports on output, costs, production costs and sales of crop production.

The study applies abstraction and concretization methods to identify cultivation issues across various crops on agricultural lands and evaluate marketable productivity in a complex agro-industrial system. It encompasses land resources, crop and forage production, livestock breeding (cattle, sheep, pigs, horses, poultry), and other sectors within the Republic of Kazakhstan economic entities. Through systematization, a modern structure is established, allowing data collection and analysis based on state resource regulation principles to determine high-quality crop and livestock productivity across different development levels. The SWOT analysis emerges as a comprehensive tool, categorizing phenomena and factors into Strengths, Weaknesses, Opportunities, and Threats, specifically for analyzing agricultural land in Republic of Kazakhstan. Generalization leads to recommendations for regulating the land fund management system, emphasizing commonalities and study outcomes related to the state of agricultural land in the Republic of Kazakhstan.

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Results

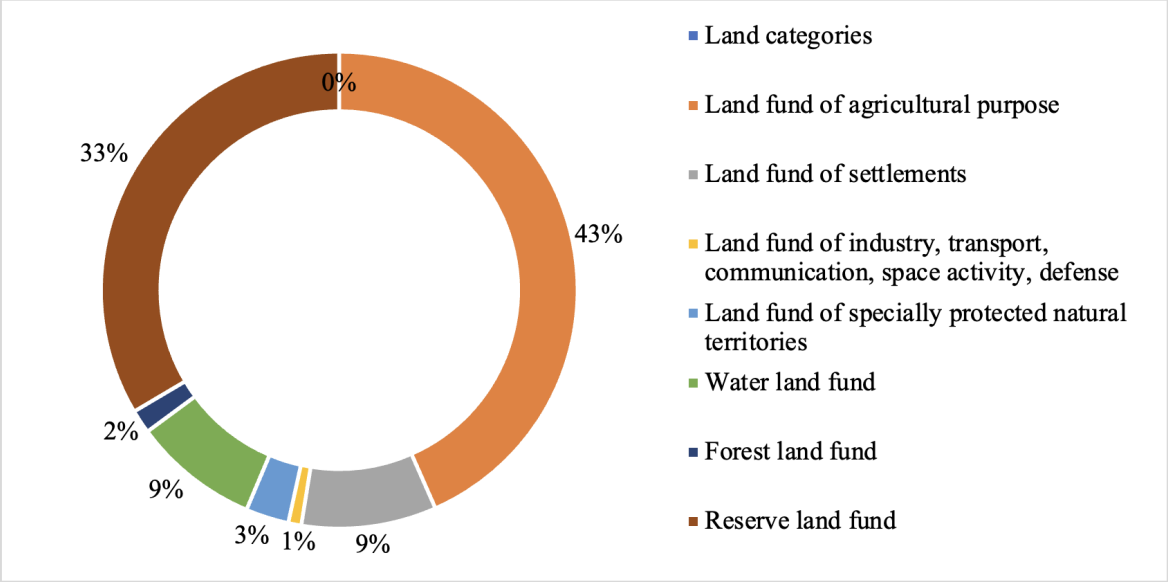
Kazakhstan's land use policies and trends have undergone significant evolution, shaped by historical context, economic shifts, and political changes. During the Soviet era, Kazakhstan was part of the larger Soviet Union, where land use was centrally controlled (Aitkhozhayeva et al., 2019). Collective and state farms were prominent, focusing on grain production, livestock, and industrial crops. Irrigation projects aimed to boost productivity, even on previously arid lands. Land ownership was collective under the Soviet system. Following independence in 1991, Kazakhstan shifted toward a market-oriented economy. Land reforms in the early 1990s led to the privatization of agricultural land, distributed among individuals, collectives, and private entities. The government sought to promote small-scale farming and diversify the agricultural sector.

Kazakhstan has been working on land reforms to address land concentration issues and promote sustainable agriculture. Measures were introduced to support small and medium-sized farms and encourage modern agricultural practices. There's a growing interest in organic farming and environmentally friendly food production. Kazakhstan committed to international agreements such as the United Nations Convention to Combat Desertification and sustainable land management promotion. Today, Kazakhstan faces the challenge of balancing agricultural and economic development with land conservation and sustainable practices. Issues of land ownership, concentration, and environmental conservation persist as the country strives for food security, economic growth, and natural resource preservation.

Sustainable use of agricultural land is determined by the area of production, qualitative and quantitative characteristics, soil condition and fertility, forest cover, settlement, desert, soil quality, thickness of organic horizon, humus content, and granulometric composition (Kuts et al., 2022). The land fund of the Republic of Kazakhstan is about 272.3 million ha, with agricultural land covering about 214.2 million ha, of which uncomplicated lands with negative features make up 41.5 million ha, and the area of agricultural land in the Akmola and North-Kazakhstan regions is not the same due to different natural and climatic conditions and the presence of large desert and semi-desert pastures. The area of agricultural land varies from region to region due to different natural and climatic conditions and the presence of large desert and semi-desert pastures, in Akmola and North Kazakhstan oblasts the area used for agriculture is 74-75%, while in contrast in Kyzylorda and Atyrau oblasts it is 11-25%, in particular in Almaty oblast it is 29%.

The diversity of soils in Kazakhstan is determined by climatic and geological conditions, which result in a wide range of agricultural production areas. Given the country's varied climate, it is essential to assess the spatial location of land, its effective utilization, compactness, remoteness, suitability for production, and the availability of engineering and social infrastructure. Agricultural land in Kazakhstan encompasses a variety of categories, including arable land, which refers to planned cultivated areas used for sowing crops, including perennial grasses. Fallow land comprises areas that have not been used for arable purposes for more than one year. Perennial plantations encompass orchards, vineyards, shrubs, and herbaceous crops that produce fruits, berries, and technical or medicinal products. Additionally, hayfields represent arable, dry, and waterlogged fodder lands covered with perennial grasses, while meadows consist of natural forage lands utilized for livestock grazing. The Republic of Kazakhstan land is categorised by main purpose and varies continuously from year to year; the percentages of its structure are shown in Figure 1.

Figure 1. Structure of land fund by categories for 2022
Figura 1. Estructura del fondo de tierras por categorías para 2022



Source: own elaboration based on Jangarasheva et al. (2023). Fuente: elaboración propia en base a Jangarasheva et al. (2023).

According to Aldazhanova et al. (2022), of the most valuable lands in the category of agricultural land, 97.9% are arable lands, of which 91.2% are irrigated, 41.7% are perennial plantations, 51.7% are fallow lands, 44.9% are hayfields, of which 36.6% are improved lands. Non-agricultural land includes protected plantations classified under other land categories: agricultural tracks, airstrips and forests of the protective belt, agricultural buildings and yards, wholesale market infrastructure and temporarily protected land. The following regions have significant areas of agricultural land: Karaganda region – 18.0 million ha, Aktobe region – 12.6 million ha, Kostanay region – 10.8 million ha, Akmola region – 10.9 million ha, East Kazakhstan region – 12.3 million ha, Almaty region – 8.6 million ha, North Kazakhstan region – 7.3 million ha. Table 1 shows the composition of agricultural land by type of agricultural land.

Table 1. Agricultural land areas by types of lands by regions as of the beginning of 2022, thousand ha
Tabla 1. Superficies agrícolas por tipos de tierras según las regiones a principios de 2022, en miles de hectáreas

Regions of the Republic of Kazakhstan	Agricultural land	Arable land	Perennial plantations	Deposits	Hayfields	Pastures
Akmola	10888	6042	2	250	153	4441
Aktobe	12396	705	-	268	126	11296
Almaty	8508	986	20	98	190	7213
Atyrau	2929	68	-	7	50	2865
East Kazakhstan	11995	1490	1	83	501	9920
Zhambyl	4558	782	4		120	3653
West Kazakhstan	7700	564	1	536	500	6097
Karaganda	17586	1227	1	213	233	15811
Kyzylorda	2369	181	1	38	37	2112
Kostanay	10689	6262	-	81	137	4248
Mangistau	2910	1	-	0.3	0.3	2909
Pavlodar	7033	1985	1	172	159	4715
North Kazakhstan	7052	4956	1	57	17	2021
Turkestan	4358	870	28	98	69	3293
Shymkent	-	-	-	-	-	
Almaty		-	-	-	-	
Astana	1	1	1	1	1	1
Total	110972	26120	62	1902	2293	80595

Source: own elaboration based on Jangarasheva et al. (2023). Fuente: elaboración propia en base a Jangarasheva et al. (2023).

Depending on climatic conditions, the main areas of cultivated arable land intended for growing valuable crops are located in Kostanay, Akmola and North-Kazakhstan regions, while in the regions of desert and semi-desert climate in Almaty, Karaganda West-Kazakhstan regions pasture areas and hayfields for grazing prevail. The total area of land fund of Almaty region is 22.4 million hectares, agricultural land – 8.5 million hectares, while the gross output of agriculture is high in RK at 425.3 billion tenge. In 2022, 21 billion tenge for livestock breeding, 6.7 billion tenge for crop production, 12 billion tenge for investment subsidies, 2.5 billion tenge for water management, 2 billion tenge for processing, and 3.6 billion tenge for lending to the rural population are allocated for the development of agriculture in Almaty region.

The largest and most developed agricultural region of Almaty Oblast is the Balkhash District, which is located in the northwest, with the northern border covering the southern shore of Lake Balkhash. Also Jangarasheva et al. (2023) note that the natural-climatic and soil conditions of Balkhash district contribute to the effective development of the two main agricultural sectors of livestock and crop production, leading the region in the production of corn for grain, sugar beet, soybeans, vegetables, fruits and berries, meat, milk, wool, and eggs. In 2022, the gross domestic product of Balkhash district totalled 21.5 billion tenge.

The Balkhash district occupies a huge area of agricultural land for crop production – 3739 thousand hectares, including 1133 thousand hectares of pastures, 64 thousand hectares of hayfields, 28.3 thousand hectares of irrigated land, which is divided into arable land, perennial plantations, vegetable gardens and service land.

Traditionally, agricultural enterprises in the Balkhash district have focused on pasture-raised meat sheep breeding. Meanwhile, the foothill areas, characterized by typical and mountainous sierozem soils, are utilized for dairy and meat and dairy cattle breeding. These activities take place at altitudes of approximately 400-450 meters above sea level. In terms of cattle numbers, the Balkhash district boasts a population of 124 thousand heads of cattle. Additionally, the district is home to some of the largest farm reproducers specializing in the breeding of the Kalmyk cattle breed. Notable among these are LLP Agrofirma Zheltorangy, LLP Agrofirma Dinara-Ranch, and LLP Otes Bio Asia. Furthermore, livestock enterprises within peasant farms, including Mynbay, Al-Aukat Meirzhan, and Zhaksylyk, play a significant role in the export of livestock products to neighboring countries. These activities contribute to the district's agricultural diversity and its role in regional livestock production. The Balkhash district is known for its fish potential, currently, 16 fish farms are registered in the region, with the main enterprises LLP Som i D, LLP Karoy balik—having the capacity to process up to 30 tonnes of fish per day.

According to forecasts, in the next five years, the cultivated area in Kazakhstan should increase to 25 million ha. According to the state programme for the development of the agro-industrial complex RK, it is established that in private ownership of Balkhash district, there is already 239.2 thousand ha of arable land, including for gardening – 5.4 thousand ha, peasant, and private farms – 114.6 thousand ha, production of commercial agricultural products – 89.2 thousand ha. To increase the volume of agricultural land, the state provides the right of temporary compensated land use in the territory of Balkhash district for a period of 10 years for peasant or farmer farming: Karoi, Bereken, Miyala, Zheltoranginsky, Bakanassky, Toparsky rural districts (for pastures), and Akdala (under irrigated arable land). The leasing agreements for territories within the Balkhash district incorporate a set of regulations to ensure the prudent utilization of agricultural land. These rules mandate the fulfillment of specific targets related to diversifying the structure of cultivated crops, aligning with the region's agricultural specialization. Lessees are required to adhere to scientifically sound agricultural practices, emphasizing the importance of employing advanced agro-technologies. Furthermore, lessees must comply with phytosanitary and quarantine requirements, prioritizing the health and safety of agricultural production in the district. These comprehensive guidelines contribute to the sustainable and responsible management of agricultural resources within the Balkhash district.

Based on data from the information and analytical agency APK Inform, it is reported that already in 2022, the sown areas of cereals and leguminous crops increased by 236.9 thousand ha to 16 million ha, including wheat increased by 749.9 thousand ha to 12.9 million ha. The area under oilseed crops increased by 197.3 thousand ha and totalled 3.1 million ha. The structural and functional organisation of agricultural land is changing in RK with constant diversification of the cropping pattern, increasing the cultivation of oilseed crops such as sunflower, rapeseed and flax, and from 2022 also soybeans. Due to changes in market conditions, it is expected that shortly the cultivation of oilseed crops such as safflower and mustard will be reduced, at the expense of which the areas for sunflower, potatoes and

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rice cultivation have increased. Cultivation of fodder crops in 2022 totalled 3.1 million ha, decreasing by 82.8 thousand ha, in particular: cotton 109.9 thousand ha – by 16 thousand ha, rice 96.8 thousand ha – by 7.3 thousand ha respectively. Compared to 2021, there was an increase in the area of sugar beet cultivation by 0.9 thousand ha – 21.7 thousand ha, potatoes by 1.4 thousand ha – 195.8 thousand ha, vegetables by 5 thousand ha – 168.6 thousand ha, melons by 8 thousand ha – 110 thousand ha.

Dairy and beef cattle are raised on pastures near farms where succulent forages are grown to increase the productivity of dairy farming. According to Pashkov and Mazhitova (2021), since 2020 there has been a growth rate of livestock in Turkestan, Kyzylorda and Almaty regions, accounting for about 16% of total production, in particular the number of cattle has increased by 7.7%. The analysis shows that the number of cattle grazing on private farms and personal subsidiary farms is 5.7 million heads, so following the maximum allowable load, it is necessary to provide them with additional areas of 8.9 million ha. There are 183.4 million ha of pasture areas in RK: 82.4 million ha on agricultural land, 63.9 million ha on protected land, 21.2 million ha on land adjacent to settlements, and 15.9 million ha on forest plantations, specially protected areas, and industrial land. At the beginning of 2020, RK has 1.55 million ha of irrigated land with water infrastructure, which produces more than 40% of the country's crop production. At the same time, only 210.4 thousand ha or 14% of the total area is under modern drip or sprinkler irrigation. The rest of the area is irrigated by outdated and wasteful methods such as drainage and surface irrigation. As a result, the average yield of irrigated land in RK is 2-4 times lower than in countries with developed agriculture in the USA and Canada. Irrigated land is mainly concentrated in the southern regions: about 38% is in Turkestan province, 29% in Almaty province, 14% in Kyzylorda province and 8% in Zhambyl province.

The gross production of crop and livestock products in RK is constantly growing. Assessment of agricultural output in kind or value terms concerning production costs is an indicative factor in the development of sustainable land use. According to the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, the dynamics of crop and livestock yields were established, which determined significant growth rates of profitability of agricultural land use for 2018-2022 in value terms of million tenge per thousand hectares, noted in Table 2.

Table 2. Dynamics of indicators of economic efficiency of agricultural land use, 2018-2022 in value terms

Tabla 2. Dinámica de los indicadores de eficiencia económica del uso de la tierra agrícola, 2018-2022 en términos de valor

Economic efficiency of the agricultural land fund, m tenge/ thousand ha	2018	2019	2020	2021	2022
Crop production	90.3	112.2	121.2	127.2	137.4
Livestock breeding	11.3	12.9	13.4	13.6	13.8

Source: own elaboration. Fuente: elaboración propia.

The most cultivated crops occupying significant areas in the Republic of Kazakhstan include maize, oats, millet, barley, buckwheat, rice and spring wheat, oilseeds, sugar beet, grapes, melons, apples, potatoes, flax and cotton. Livestock production includes cattle breeding and dairy cattle breeding, goat breeding, pig breeding, camel breeding, horse breeding, and sheep breeding, as well as the modernisation of various technologies to improve the gene pool and animal productivity. New information systems and digital technologies open up promising opportunities for land management, and their introduction will help to address economic, social, and environmental aspects in the Republic of Kazakhstan (Table 3).

Table 3. SWOT analysis of the formation of agricultural land in RK
Tabla 3. Análisis DAFO de la formación de tierras agrícolas en RK

Strengths (S)	**Weaknesses (W)**
Accumulation of moisture in the soil through mulching. Absence of water and wind erosion. Formation of an active microbiota rich in micronutrients and macronutrients. Carbon storage in the soil; reduction of CO_2 emissions into the atmosphere.	Ploughing fields with pesticide application before planting and during the growing season.
Opportunities (O)	**Threats (T)**
The natural increase in humus and nutrient reserves. Improvement of agrophysical and agrochemical properties of soil. Introduction of new resource-saving technologies. Development of new markets for agricultural products. Modernisation of agricultural machinery.	Risk of soil erosion Pests and diseases Economic damage due to a lack of fertilisers and reduced soil fertility.

Source: own elaboration based on Hnatkivskyi et al. (2022). Fuente: elaboración propia en base a Hnatkivskyi et al. (2022).

Important elements of sustainable land use development are the interaction of material and labour resources to maintain fertility, reducing the debt of agricultural producers, increasing investment and subsidies for the purchase of new machinery and quality seeds, mineral and organic fertilizers, and plant protection products.

Discussion

The sustainability of land use in the Republic of Kazakhstan is influenced by the legal relationship between economic entities and the state, as evidenced by the registered ownership or lease rights of land plots with a definite validity and renewal period to make the lessee an efficient land user with unlimited potential and commitment to improve soil quality and increase the country's yield. According to the international standard ISO 19152:2012 (ISO, 2012), the Land Administration Domain Model (LADM) is proposed, which covers the main information-related components of land administration over water and land by parties. The LADM provides the simplest terminology for land administration based on various national and international tools that can be used in practice and can integrate different sources of land administration information consistently.

To achieve a high level of land resource processing and efficient land management in Kazakhstan, it is essential to cover 100% of the country's territory with a specialized digital agricultural map containing current photographic images of the terrain. These agricultural maps primarily focus on delineating land by its actual use, classification, features, and struc-

ture. In a recent study by Romero-Gainza and Stewart (2023), the importance of implementing new Artificial Intelligence (AI) systems for the development of sustainable agricultural land use systems is highlighted. To effectively manage land, various numerical data sources are crucial, including the Internet of Things (IoT), Global Positioning System (GPS), Geographic Information System (GIS), Earth Remote Sensing (ERS), Cyber-Physical Systems (CPS), and Big Data Analysis (BDA). Integrating these technologies can enhance precision and efficiency in land resource management and agricultural practices.

According to Mukanov (2023), the state programme Digital Kazakhstan describes digital systems as the basic basis for maintaining an automated information system of the national land cadastre, carrying out land reclamation and soil protection measures, soil-geological surveys, placement of crop areas and fodder bases. Interest in organic agricultural production and environmentally friendly food products has recently been growing in the Republic of Kazakhstan (Mero et al., 2023). The costs of such production are lower than in Western Europe due to environmental conditions, large areas of land resources that are not cultivated due to economic and financial constraints, and cheap labour. In general, the principles of organic farming are a reliable way to obtain high yields of ecologically clean crops and livestock products (Ussipbaev et al., 2022).

Arable land in the Republic of Kazakhstan can be divided into the following types: rainfed, irrigated, flooded, irrigated, with lime irrigation, cleared, saline, stone-filled, with open and closed drainage. Diversification of the structure of cultivated areas began in 2019, due to the transition to the cultivation of technical oilseed crops, the pace of soil dehumidification with the removal of biogenic macronutrients accelerated. In the Republic of Kazakhstan territory, the emerging environmental problems and risks of agricultural land use associated with the degradation of agro-landscapes, primarily arable land, are substantially stated. Farming on sloping lands provokes erosion processes, especially water erosion of fertile lands, worsening the natural and technological condition of arable land.

The arable land of the Republic of Kazakhstan regions is subdivided into separate subspecies: rainfed, irrigated, flooded, with irrigation network, firth irrigation, clean, saline, stone clogged, drained by open and closed drainage. Besides, they are the basic basis: for maintenance of the automated information system of the state land cadastre, carrying out meliorative and soil protection measures, soil and geobotanical surveys, placement of sowing areas and fodder base. The data are used as a basis for the development of the automated information system of the state land cadastre. At present, there is about 1.5 million ha of agricultural land in the Republic of Kazakhstan, which is served by water infrastructure, but only 14% of the land is irrigated by modern methods, and the rest of the land is irrigated by outdated and uneconomic methods. Implementation of technical, organisational, and economic measures aimed at improving soil, agro-climatic and hydrological conditions will ensure high crop yields and sustainable use of soil fertility. In economically developed countries of the world, 40-50% of arable land is reclaimed (Omarbekova et al., 2017). In the United States the percentage of arable land is 40%; in China – 54%; in India – 40%; in France – 25%; in Germany – 42%; in Great Britain, Turkey, and Israel – 26%.

Agricultural land is subject to degradation, pollution, and loss of fertility reproduction capacity. In different regions of the Republic of Kazakhstan, there is a tendency towards the steady deterioration of land quality, including reduction of humus and nutrient content in

the soil, change of species composition and productivity of vegetation. The only way to restore soil fertility is to intensify production through the use of mineral and organic fertilisers and growth regulators (Dykyi et al., 2022; Kravchuk et al., 2023). It is necessary to develop programmes for rational land use, to strengthen state control over land protection in combination with other environmental protection measures, to provide for the development of mortgages based on land and land tenure security, to attract foreign investment for the development of fallow lands in the prescribed manner.

State regulation plays a pivotal role in Kazakhstan's agro-industry, offering promising prospects for improving export performance in the rapeseed, flax, and poultry sectors. This strategic approach aims to position Kazakhstan as one of the world's leading cereal crop producers swiftly, aligning with the Eurasian Economic Union (EAEU) and the World Trade Organization (WTO) while meeting stringent regulatory requirements for both domestic and international markets. The overarching objectives of ensuring land use sustainability in Kazakhstan encompass reorienting economic agents towards holistic agriculture to equalize disparities in land quality, transitioning to an economically balanced land use structure, promoting economically advantageous crop rotations, and enhancing the fertility of agricultural land, particularly arable land. This transformation also involves moving away from monoculture farming in favor of diversifying crops with a focus on rapeseed, flax, and soybeans, thus fostering agricultural sustainability and competitiveness.

Conclusions

The agricultural sector in the Republic of Kazakhstan exhibits irrational resource use and insufficient investment. The study underscores the importance of expanding monitoring efforts across diverse lands in the Republic of Kazakhstan, emphasizing soil-geographical zoning and climate observation for both cultivated areas and natural pastures. The intensive agriculture enterprises in the Republic of Kazakhstan, including peasants, farms, and personal subsidiary farms, play a vital role in food production. The intensive farming system relies on high yields through active land use, fertilizers, pesticides, irrigation, and cultivation of high-yielding varieties. Extensive land use is also gaining popularity, promoting organic farming with reduced chemical inputs. Livestock and fodder production in the Republic of Kazakhstan have moderately increased, despite reduced sown areas for fodder crops. The shift towards rational and sustainable land use involves resource-saving, economically sound farming technologies that minimize tillage and incorporate modern environmental protection measures.

On the example of climatic conditions of Balkhash district of Almaty region, the assessment of system development of livestock and crop production in conditions of severe drought in 2022 is given. It was found that the region has 1133 thousand ha of pastures, 64 thousand ha of hayfields, 28.3 thousand ha of irrigated land and specialises in pasture and distant sheep breeding and cattle breeding of dairy and meat and dairy cattle breeding, in addition, the fish potential is rapidly developing. Several 10-year state land lease programmes are also available in Balkhash district, which contributes to the increase in the cultivation of agricultural land. For the rational use of land resources, it is recommended to protect and reproduce land and resource potential, optimise efficient land use technologies, especially digital technologies, establish national and regional management and monitoring systems, create efficient land markets, and regulate land ownership relations.

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Based on the research findings and the need for rational and sustainable land use in Kazakhstan's agricultural sector, are actionable steps that agricultural enterprises, farmers' groups, and policymakers can consider. Agricultural enterprises should prioritize investments in modern farming technologies, including precision agriculture and digital tools for better resource management. Encourage the adoption of resource-saving farming practices such as reduced tillage, efficient irrigation, and integrated pest management to minimize the environmental impact. Promote and incentivize sustainable agricultural practices, including organic farming, to ensure long-term soil fertility and environmental health.

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