



Efficient Use of Agricultural Production Resource Potential: Theory and Practice

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ABSTRACT

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The effective use of land resources in agricultural production is one of the key challenges of modern society, as population growth and accelerated urbanization increase the demand for land and exert pressure on ecosystems. The concept of sustainable and efficient land use, which aims to maintain a balance between the productive capacity of land and long-term environmental and social sustainability, plays a crucial role in achieving environmental, economic, and social objectives. Irrational practices such as deforestation, soil degradation, and biodiversity loss highlight the need for clear and comprehensive criteria for decision-making in the field of efficient land use. The purpose is to formulate suitable integrated criteria for sustainable land use and effective utilization of Kazakhstan's resource potential, based on an analysis of the current state of soil degradation processes and the synthesis of existing theoretical models used in foreign countries. The research focuses on the challenges of sustainable land use under conditions of soil degradation and climate change, as well as international models for integrating environmental, economic, social, technological, and managerial aspects to optimize the efficient use of land resource potential in agriculture. Methods—to study soil degradation processes, a comprehensive approach was used to ensure a thorough collection and analysis of data based on qualitative and quantitative methods. The analysis of secondary data includes the study of existing theoretical models and international practices, relying on data from ecology, economics, social sciences, and public administration in foreign countries. A comparative analysis method was applied to study the specifics of Kazakhstan's geographic, socio-economic, and environmental conditions for developing the conceptual foundations of effective land use. Results show that despite recognizing sustainability as a national priority, Kazakhstan continues to face land degradation and the inefficiency of unsustainable agricultural practices. These factors hinder the achievement of food security, environmental protection, and balanced economic development. Conclusions—for the effective use of resource potential, it is necessary to adapt the experience of foreign countries' strategies and initiatives to create a unified system of criteria for sustainable land use in Kazakhstan's agricultural production.

1. INTRODUCTION

The relevance of the research topic lies in the fact that the land resources of Kazakhstan are located over a vast territory and feature a diverse landscape ranging from steppes and deserts to fertile agricultural zones, facing serious challenges in their effective use in agricultural production. The growing demand for food, infrastructure, industry, and environmental protection exerts significant pressure on land use systems. The land resources of Kazakhstan cover an area of more than 2.7 million square kilometers and are crucial for ensuring food security, stimulating economic development, and maintaining ecological balance. However, the impacts of climate change—including altered precipitation patterns, rising temperatures,

and more frequent extreme weather events—threaten the integrity and productivity of these valuable land resources.

The geographical and climatic conditions make the land resources used in agricultural production particularly vulnerable to the consequences of climate change, leading to increased soil erosion, desertification, and loss of biodiversity. These challenges require a proactive approach to land use that not only promotes the growth of agricultural productivity and economic development but also ensures environmental preservation and the resilience of local communities.

Sustainable land use practices are key to mitigating these impacts while unlocking the potential of land resources for future generations. Land resource management in Kazakhstan is closely linked to agriculture, industrial activities, and

urbanization, which have historically prioritized short-term economic gain over long-term sustainability.

Agriculture plays a central role in Kazakhstan's economy: about 12% of the gross domestic product comes from this sector. The fertile plains of the northern regions provide significant wheat production, while the arid southern areas depend on livestock farming. The intensification of agricultural activity, combined with insufficient land management, has led to acute problems such as soil erosion, desertification, and loss of biodiversity. These challenges are exacerbated by the effects of climate change, manifested in increasingly frequent and severe droughts, fluctuations in precipitation, and rising temperatures—factors that significantly affect agricultural productivity and land resilience.

The above-mentioned problems necessitate the implementation of Kazakhstan's agricultural policy based on rational and sustainable land use through legislative regulations aimed at promoting environmental responsibility [1]. These include strategies for improving land tenure security, restoring degraded areas, and promoting sustainable agricultural practices.

However, the effective implementation of these strategies remains limited by insufficient funding, a lack of technical expertise, and low public awareness of sustainability principles. In this context, the concept of sustainable and efficient land use in agriculture becomes especially relevant, as it seeks to balance economic productivity with long-term environmental and social sustainability.

The degree of scientific development of the problem in this research article is represented by the discussion of several key tasks. First, it analyzes land use practices and agricultural productivity under conditions of soil degradation caused by climate change. Rational agricultural production is a key research area amid growing global challenges related to food security, environmental degradation, and climate change.

The study of existing theories, concepts, views, and conclusions regarding the effective use of land resources under the socio-economic consequences of environmental change shows that sustainable agricultural production can be defined as practices that maintain agricultural productivity while ensuring ecological balance and social justice. According to Pretty [2], sustainable agriculture represents a holistic approach integrating environmental health, economic profitability, and social equity. The Food and Agriculture Organization (FAO) emphasizes the importance of agroecological principles that promote biodiversity, resilience, and the efficient use of natural resources [3].

Researchers highlight several challenges threatening sustainable agricultural land use, including land degradation, climate change, and population growth. According to Lal [4], soil degradation affects about 30% of the world's arable land, reducing its productivity and threatening food security. Moreover, climate change aggravates these challenges by altering precipitation patterns and increasing the frequency of extreme weather events [5].

Scientific studies devoted to various sustainable agricultural practices focus on resource-conserving farming with minimal soil disturbance, permanent soil cover, and crop rotation, as emphasized by Derpsch et al. [6]. Agroforestry, which integrates trees and shrubs into agricultural systems, promotes biodiversity and improves soil conditions [7]. Organic farming, as noted by Reganold and Wachter [8], encourages the use of natural resources and helps maintain ecological balance in the

production of health-oriented goods.

Second, the degree of research on another key issue is reflected in the analysis of the experience of strategies and initiatives in foreign countries that are most applicable for assessing sustainable and efficient land use in Kazakhstan. Sustainable and efficient land use is widely recognized as a multidimensional concept that requires balancing economic productivity, environmental protection, and social equity. At the global level, emphasis is placed on optimizing land use to meet current needs while maintaining the ability of future generations to meet their own [9].

In the regional context, the development of optimal agricultural business structures [10] is influenced by the difficulty of balancing competing demands for food production, urbanization, industrial development, and ecosystem preservation. Sustainable agricultural production models play an important role in state measures to combat land degradation and protect the environment from destruction [11].

In Kazakhstan, the importance of sustainable land use is particularly high due to the vast and diverse landscapes of the country, which range from arid deserts and vulnerable steppe ecosystems to fertile agricultural zones and rapidly urbanizing regions. The government's commitment to the principles of sustainable development is reflected in the adoption of international frameworks such as the United Nations Sustainable Development Goals, as well as in the development of national strategies to improve land use efficiency [12]. Nevertheless, the practical implementation of these commitments is complicated by both structural and contextual constraints.

International studies emphasize that effective land use management requires clear criteria and measurable indicators. These typically encompass environmental aspects (soil quality, water availability, biodiversity), economic ones (land productivity and profitability), as well as social ones (land tenure security, food security, community involvement) [13]. Research focusing on Kazakhstan stresses the need to adapt these indicators to regional conditions. For instance, in urban planning, it has been proposed to use aggregated indicators combining economic, social, environmental, and infrastructural parameters to reflect the characteristics of the country's administrative regions [14].

Scientific research indicates that, in many foreign countries, an accessible and well-established theory of agrarian business has been developed and institutionalized within the educational system. As a result, a model of the farmer-entrepreneur has emerged—one who is actively engaged in and committed to the principles of environmental protection and ecological sustainability. By the time Kazakhstan transitioned to a market economy, global practice had already accumulated substantial experience in addressing land degradation processes to ensure the efficient use of land potential in agricultural production.

In Kazakhstan, however, there exists a specific social context within which the farmer class was formed. The historical prevalence of collective land use during the Soviet period, followed by a rapid transition to state and private ownership under market conditions, did not allow for the consolidation of environmental conservation principles in the consciousness of farmers. During the period of land reforms, agricultural producers were compelled to operate under conditions of uncertainty and limited financial resources. Consequently, a dominant "profit-maximization" mindset became widespread, which largely explains the neglect of

ethical standards and the culture of careful and responsible use of natural resources. As a result, society now faces the complex challenge of developing an integrated system aimed at overcoming environmental illiteracy.

The shortage of scientific research devoted to the development of comprehensive programs for mitigating land degradation in Kazakhstan's land-use system necessitates further investigation. This gap underscores the relevance of the present study and determines its focus on examining the problems of effective utilization of the resource potential of agricultural production, as addressed in this scientific article.

The theoretical and practical significance of this study lies in the fact that the proposed criteria will take into account the country's regional diversity and will make it possible to address specific issues associated with various types of land use. The analysis of collected data on land use practices and agricultural productivity under climate change conditions shows that extensive land resources face severe soil degradation and unsustainable agricultural production.

The research results are aimed at developing conceptual foundations for the effective use of agricultural land resources by analyzing the specifics of the country's geographical, socio-economic, and environmental conditions, taking into account existing theoretical models and international practices aimed at solving the identified problems.

2. METHODOLOGY

The assessment of the condition of land resources under climate change and environmental transformation was carried out using both general and agriculture-specific research approaches and methods. Quantitative data collection was conducted through statistical methods, while the discussion of the relevance and issues of the studied topic was based on monographic and abstract-logical methods.

Within the system of methodological principles and approaches applied in agricultural production, comprehensive generalized absolute statistical indicators were employed, including data on the increase in average annual air temperature over time and the accounting of eroded land areas across different territorial zones of the country, among others. These indicators are of critical importance for analyzing changes in the qualitative state of soils.

The combination of methods and techniques used to analyze changes in the productivity level of land resources under the influence of climatic conditions in the region, as well as the development of recommendations for improving existing problems, constituted the content of the research methodology.

The purpose of the methodology is to comprehensively study the current state of the resource potential of agricultural production based on qualitative and quantitative methods of analyzing the ecological environment and its impact on changes in soil productivity. For the effective use of resource potential, the application of constructive methods of agricultural management models and international practices from foreign countries was recommended.

The study employed theoretical and analytical methods to examine the concepts of sustainable and efficient land use and to develop a system of criteria applicable to the conditions of Kazakhstan. The approach was based on a theoretical review of sustainability science, ecological economics, and systems theory, which made it possible to integrate ecological, economic, social, technological, and managerial perspectives.

A comparative analysis of international systems and scientific concepts was conducted to identify best practices and adapt them to the socio-economic and environmental conditions of Kazakhstan. The research methodology has a conceptual nature and is aimed at synthesizing existing knowledge into a holistic system.

3. RESULTS AND DISCUSSION

3.1 Identification of resource potential problems related to climate change

Climate change poses serious threats to the environment and agriculture of Kazakhstan. A significant increase in average temperatures, changes in precipitation patterns, and the growing frequency of extreme weather events such as droughts and floods are among the key challenges. According to the Ministry of Ecology, Geology and Natural Resources of Kazakhstan, the country's average annual temperatures have risen by approximately 0.6°C per decade, which negatively affects biodiversity and agricultural productivity.

One of the most acute problems caused by climate change is desertification. Arid and semi-arid regions of Kazakhstan, which account for about 80% of the country's territory, are extremely vulnerable to land degradation. This issue is further aggravated by overgrazing, deforestation, and inefficient agricultural practices.

Changes in precipitation levels and increased evaporation due to rising temperatures have led to a significant reduction in water resources. This situation is particularly alarming for agriculture, which heavily depends on irrigation from major rivers such as the Syr Darya and Ili, whose water levels are steadily decreasing.

Studies indicate that significant climatic shifts have occurred in Kazakhstan over the past few decades. For instance, Salnikov et al. [15] report that the rate of increase in the mean annual air temperature across the territory of the republic since 1976 has amounted to 0.36°C per decade. Changes have also been observed in precipitation regimes: in some regions, precipitation has increased, whereas in others the frequency and intensity of droughts have risen [16]. These climatic transformations pose serious threats to agricultural production, water resources, and natural ecosystems.

Kazakhstan's economy heavily depends on agriculture, which makes it particularly vulnerable to climate variability. Changes in climatic conditions have already begun to affect crop yields and livestock production [17]. According to the World Bank [18], prolonged droughts have led to reduced wheat and barley production, raising concerns about food security. Furthermore, studies by Yu et al. [19] emphasize the need for adaptive agricultural practices to mitigate the negative effects of climate change.

Regions around the world—and Kazakhstan in particular—are facing the consequences of climate change, including rising temperatures, shifts in precipitation patterns, and increased frequency of extreme weather events. Climate variability in Kazakhstan may lead to natural disasters such as spring floods caused by snowmelt, summer droughts, and harsh winters accompanied by blizzards. In Kazakhstan, 2023 became the warmest year on record—by a significant margin. The country's average annual temperature in 2023 was +8.00°C, exceeding the climatic norm for the 1991–2020 period by 1.73°C. The previous record high average annual temperature was

observed in 2020, when the anomaly reached 1.07°C (see Table 1).

Table 1. Anomaly of the average annual air temperature (°C) over the last decade

Warm Years	Anomaly of the Average Annual Air Temperature (°C)
2023	1.73
2020	1.07
2013	1.04
2022	0.92
1983	0.91
2015	0.79
2021	0.73
2002	0.70
2004	0.68
2019	0.65

Source: Republican State Enterprise Kazhydromet (RSE “Kazhydromet”)

A steady increase in the average annual air temperature has been observed across all regions of Kazakhstan. On average, the rise in the country’s mean annual temperature amounts to 0.33°C per decade. For individual regions, the rate of increase varies from 0.21°C per decade (Karaganda Region) to 0.54°C per decade (West Kazakhstan Region).

Kazakhstan possesses diverse land resources that play a crucial role in its economy, environment, and cultural heritage. The qualitative condition of land resources in Kazakhstan is shaped by various factors, including soil composition, land-use practices, environmental degradation processes, and the impacts of climate change.

Kazakhstan’s soils are diverse and include steppe, desert, mountain, and wetland areas. The main soil types include:

- Chernozems (black soils): rich in organic matter; these fertile soils are mainly found in Northern Kazakhstan and are of key importance for agricultural activities;

- Chestnut soils: located in central and southern regions, have moderate fertility, and are primarily used for livestock grazing and crop farming;

- Solonchic and alkaline soils: widespread in low-lying and arid regions, where salinization processes negatively affect agricultural productivity.

Soil degradation is a growing concern due to factors such as deforestation, overgrazing, and inefficient agricultural management practices, leading to erosion and reduced soil fertility.

1. Land use in Kazakhstan is largely oriented toward agriculture, which occupies the majority of the country’s land resources. About 80% of rural lands are utilized in the agricultural sector, including crop production and livestock breeding. The cultivation of grain crops, especially wheat, is most common in the northern regions of the country. Vast areas are used for pasture-based livestock production, which is of vital importance to Kazakhstan’s economy and rural communities.
2. Despite the agricultural orientation, unsustainable farming methods—such as monoculture, excessive use of fertilizers, and insufficient crop rotation—have led to soil degradation and increased vulnerability to pests and diseases.
3. The total land fund of the Republic of Kazakhstan amounts to 262,930.8 thousand hectares. The area of land used by land users from other states decreased by 12.4 thousand hectares due to the return of part of the leased lands in the Kyzylorda Region by the Russian Federation. The area of land with restricted use remained unchanged.
4. Analysis of land cadastre data shows that certain changes occur annually in the distribution of areas by land categories, which is reflected in the information on the structure of the land fund for 2022 (Figure 1).

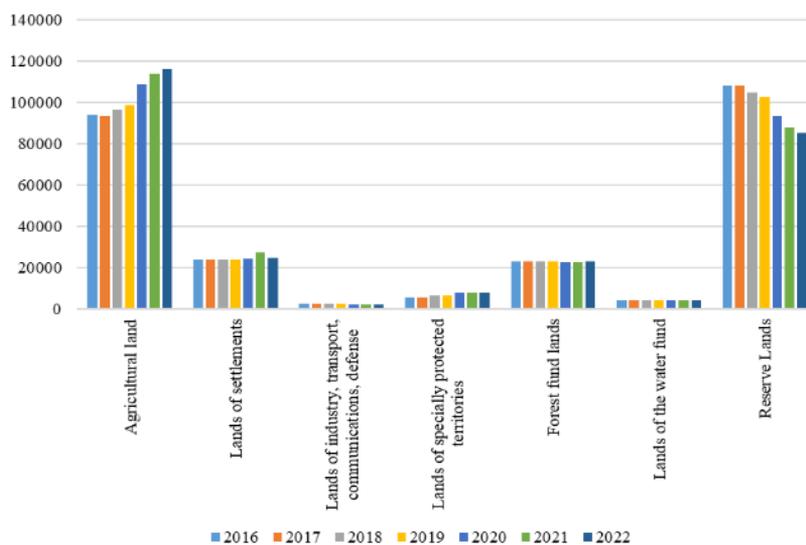


Figure 1. Distribution of the land fund by categories (thousand ha)

Natural and climatic factors play a decisive role in the formation of the fertile soil layer, thereby influencing land quality and methods of land use. These factors directly determine the purpose of land resources and their management. Natural zoning serves as a fundamental approach to addressing key issues of sustainable resource management, including the expansion and allocation of economic activities, specialization

in the agricultural sector, as well as land assessment, maintenance of land registries, and supervision of land conditions. Territorial zoning contributes to the development of strategies for the responsible use and conservation of land resources.

Erosion processes represent one of the most serious threats to land stability, leading to soil degradation, removing the top

humus-rich and nutrient-bearing layer, and reducing fertility. These erosion processes often arise and intensify as a result of human activity. Across the entire country, soil erosion combined with soil compaction is the most widespread form of land degradation.

Erosion causes significant economic and environmental damage, endangering the very survival of soil—a resource essential for agricultural production and a vital component of the biosphere. The progression of soil erosion is influenced by various natural factors, including climate, terrain, and soil composition, as well as by the scale of human activity and the level of land use, particularly in agriculture.

Soil degradation and loss of fertility are generally classified as water erosion and wind erosion, depending on their main causal factors. In Kazakhstan, more than 90 million hectares are classified as eroded or at risk of erosion, with

approximately 29.3 million hectares already affected. In addition, about 24.2 million hectares, or 11.2 percent of agricultural land, are subject to wind erosion. The adverse impact of wind erosion on soils is most pronounced in dry years when soil moisture levels are critically low.

The main areas of agricultural land affected by wind erosion comprise about 2 million hectares in the Almaty Region, 2.9 million hectares in the Zhetysu Region, and around 3.1 million hectares in the Atyrau and Turkistan Regions. The Kyzylorda Region covers approximately 2.8 million hectares, while the Zhambyl and Aktobe Regions each have more than 2 million hectares affected. A significant share of eroded agricultural land (over 30% of the total area) is located in the Almaty, Zhetysu, Atyrau, and Turkistan Regions. The Akmola, Karaganda, Kostanay, and North Kazakhstan Regions have the smallest proportion of eroded land—up to 5% (Figure 2).

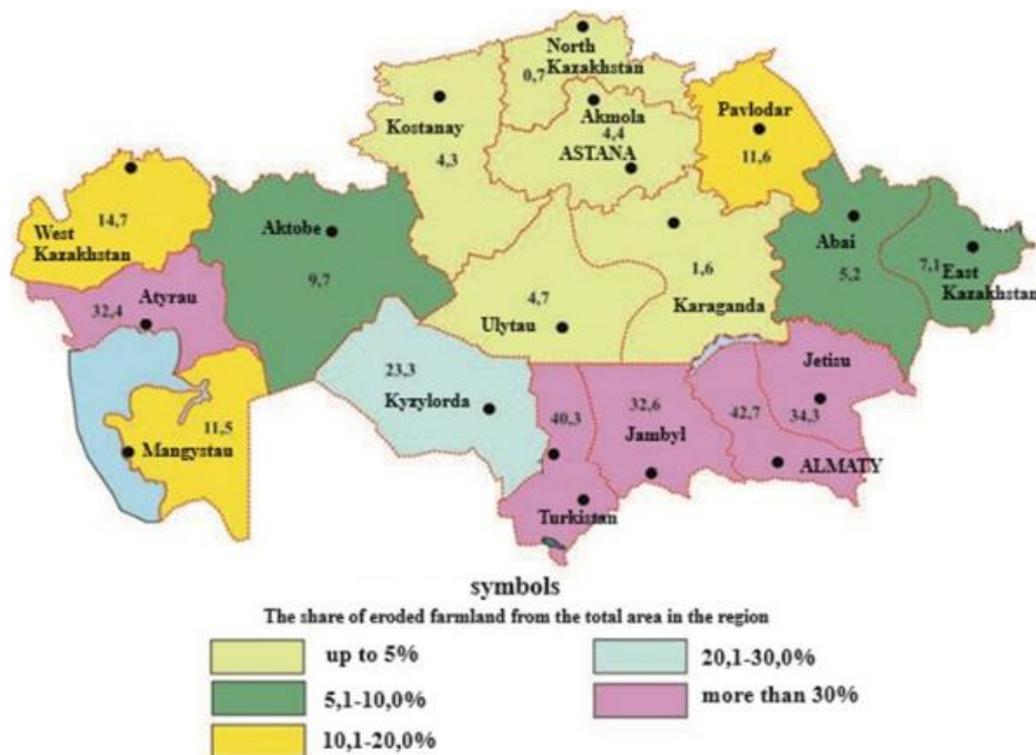


Figure 2. Susceptibility of agricultural land to erosion

Of the total eroded land area, 4.9 million hectares, or 2.3% of agricultural land, are affected by water erosion. Depending on the degree of erosion, arable land is classified as slightly eroded (418.1 thousand ha, or 80% of the total) and moderately to severely eroded (253.7 thousand ha, or 20%). These lands are mainly located in the Turkistan, Almaty, East Kazakhstan, and Akmola Regions.

3.2 Study of socio-economic aspects of sustainable agricultural land use

The level of socio-economic aspects of sustainable agricultural land use is interrelated with climatic and environmental changes. Sustainable land use is often associated with improving the living standards of small farmers. For instance, the study by Pretty and Bharucha [20] demonstrated that sustainable agriculture can increase crop yields and farmers' incomes while simultaneously strengthening food security in local communities. However, access to resources and markets is a decisive condition for the

successful implementation of sustainable practices.

Effective policy frameworks play an important role in promoting sustainable agricultural land use. Agricultural policy should aim to encourage sustainable practices through subsidies for environmentally friendly technologies and support for research and innovation in sustainable agriculture [21]. International agreements such as the Paris Agreement also play a crucial role by setting binding targets for emission reduction and supporting sustainable practices in developing countries [22].

To overcome the degradation of agricultural land resources in Kazakhstan, the wide implementation of sustainable land use methods is necessary to preserve soil quality, save water, and increase agricultural productivity. Among the key measures implemented are no-till farming and drip irrigation, as well as other innovative methods aimed at promoting sustainable agricultural development. No-till farming, also known as zero tillage, is a conservation agriculture technique that minimizes soil disturbance. This method offers several advantages, and farmers in Kazakhstan increasingly adopt no-

till practices that align with the goals of sustainable agriculture and combating desertification. Drip irrigation is an efficient method of watering plants that minimizes water loss by delivering water directly to the plant roots through a system of pipes and emitters.

The promotion of organic farming is another measure contributing to sustainable land use. Organic practices include the use of organic fertilizers, compost, and manure that enrich the soil without the use of chemicals common in conventional agriculture.

Technological innovations have become a promising direction for the efficient use of agricultural production potential. The introduction of precision irrigation systems in southern Kazakhstan has not only reduced water loss but also increased crop yields, demonstrating the potential to enhance both environmental and economic sustainability [23]. Moreover, combining modern technologies with community-based land management is described as an effective and scalable model for improving land use efficiency in irrigated zones.

Despite positive developments, serious obstacles remain. One of the most pressing problems is land degradation: according to estimates, about 66% of Kazakhstan's territory—approximately 180 million hectares—is affected by desertification or other types of degradation [24]. Key factors include unsustainable farming methods, overgrazing, and poorly managed infrastructure, which undermine productivity and biodiversity. The problem is exacerbated by the fact that current land use planning often lacks comprehensive environmental assessments and insufficiently accounts for the functional value of ecosystems. Additional challenges include low transparency of environmental reviews and weak integration of ecological principles into policy frameworks [25].

A recurring theme in the scientific literature is the gap between theoretical models of sustainable land use and their practical implementation in Kazakhstan. Although policies exist, they often lack unified criteria for measuring effectiveness and sustainability, as well as effective mechanisms for monitoring and control [26]. This gap underscores the need to move from general policy declarations to framework approaches that are operational, context-specific, and adaptive.

Several initiatives demonstrate efforts to address these issues. The National Land Use Planning Plan until 2025 emphasizes decentralization of management and infrastructure development for balanced regional growth [27]. Cooperation between the UN Development Programme and the Government of Kazakhstan in developing GIS-based tools has improved the ability to identify environmentally significant areas, providing a valuable basis for conservation and planning. Furthermore, studies show that implementing sustainable land management (SLM) practices has improved food security in rural households, particularly among vulnerable groups, although the effectiveness of such practices often depends on supportive policies, market access, and institutional support [28].

When viewed in a broader Central Asian context, Kazakhstan's challenges are not unique. Neighboring countries such as Uzbekistan, Kyrgyzstan, and Turkmenistan also face land degradation, inefficient irrigation systems, and rapid urbanization [29]. However, Kazakhstan stands out for its vast territory and dependence on large-scale agricultural production, which heightens risks associated with

unsustainable practices. At the same time, stronger institutional capacity and cooperation with international organizations place Kazakhstan in a better position to implement reforms. This regional contrast highlights the importance of transboundary cooperation, as many environmental challenges—such as desertification and water scarcity—transcend national borders and require collective solutions.

In a broader comparison, the experience of the European Union is noteworthy, where sustainability criteria are implemented through the Common Agricultural Policy (CAP). Within this policy, subsidies are linked to environmental standards, biodiversity conservation, and climate resilience. Farmers are encouraged to adopt practices such as crop diversification, soil conservation, and maintenance of ecologically significant areas [30]. Although Kazakhstan has not yet implemented similar integrated mechanisms, the EU experience demonstrates the potential of aligning financial incentives with sustainability goals. The comparison shows that Kazakhstan could benefit from adapting certain elements of this model—especially subsidy and regulatory mechanisms that directly reward sustainable practices.

Another example of global experience is China's "Grain for Green" program, one of the world's largest ecosystem restoration initiatives. By the end of the twentieth century, a fertile territory covering approximately 640,000 km² and inhabited by nearly 100 million people had become the most severely eroded land area in the world. Under an authoritarian governance system, and with financial support from the World Bank, strict restrictions were introduced on this territory, including bans on deforestation, cultivation of crops on mountain slopes, and uncontrolled livestock grazing. Farmers were financially compensated for converting agricultural land into ecologically protected forests and grasslands through the planting of trees and field vegetation, thereby enhancing biodiversity. In addition, farmers engaged in land restoration were granted tax incentives and long-term land-use contracts. Evaluations of the program's outcomes demonstrated that by 2016, approximately 11,500 km² of rainfed agricultural land had been converted into forests and grasslands, while vegetation cover increased by 25%, significantly reducing soil erosion and improving the productivity of land resources. Moreover, the program contributed to addressing social challenges, including job creation and the prevention of labor migration driven by the search for income. Launched in 1999, the program was aimed at reducing soil erosion, restoring degraded lands, and expanding forest areas by converting marginal agricultural lands back into forests or pastures.

By providing farmers with financial compensation and support for alternative income sources, the program combined environmental objectives with socio-economic development. Despite certain challenges, it significantly expanded forest cover and reduced soil erosion across vast areas of western China [31]. For Kazakhstan, where land degradation and rural poverty are closely linked, this experience shows that large-scale state initiatives can yield both environmental and social benefits if adapted to local conditions.

Effective use of Kazakhstan's agricultural land resources requires a multifaceted approach, combining policy reforms, technological innovation, capacity building, and community participation. Addressing existing gaps and establishing a comprehensive system of criteria adapted to the country's regional characteristics will make it possible to achieve meaningful progress toward long-term environmental

sustainability, economic resilience, and social well-being.

The study of existing theoretical models and international practices of foreign countries makes it possible to structure the criteria for sustainable and efficient land use into five categories: environmental, economic, social, technological, and managerial. Together, these categories form a comprehensive framework for assessing how agricultural land resources can be managed to combine productivity with long-term environmental and social sustainability. Although each category has its own specifics, they are interrelated and should be considered proportionally to one another (Table 2).

Environmental aspects are at the core of sustainable land

management. In Kazakhstan, the key tasks are combating desertification, restoring degraded pastures, and maintaining soil fertility. Environmental degradation not only reduces land productivity but also undermines water regulation, biodiversity, and climate resilience.

Economic criteria emphasize the need for productivity and profitability while maintaining the long-term viability of land resources. For Kazakhstan, it is crucial to increase yield per hectare and reduce production costs. The example of precision irrigation in the south of the country demonstrates how economic and environmental goals can align: yields grow while conserving scarce water resources.

Table 2. Criteria for sustainable and efficient land use: Kazakhstan and international parallels

Criterion	Key Aspects	Example in Kazakhstan	International Analogue
Environmental	Biodiversity, soil fertility, water, and climate resilience	Control of desertification; pasture restoration	China's <i>Grain for Green</i> program restored degraded agricultural lands by converting them into forests and pastures
Economic	Productivity, profitability, land-use efficiency	Precision irrigation in southern Kazakhstan, increasing yields and reducing water losses	The EU's Common Agricultural Policy, linking subsidies to sustainable farming practices
Social	Food security, community participation, and land tenure security	Community involvement in decision-making; prevention of rural depopulation	Community-based land management in Sub-Saharan African countries
Technological	Innovation, monitoring, precision tools	GIS and satellite monitoring in the land cadastre	Use of satellite monitoring in Canada and the EU for land-use planning
Managerial	Transparency, regulation, policy integration	National Plan until 2025, decentralization	The EU's Common Agricultural Policy, strong government initiatives in China (<i>Grain for Green</i>)

Social criteria highlight the human dimension of land use. Rural communities in Kazakhstan largely depend on agricultural lands for their livelihoods, food security, and cultural identity. Ensuring equitable access to land resources, guaranteeing land tenure rights, and involving communities in decision-making are essential conditions for achieving sustainable outcomes [32].

Technological innovations play an increasingly important role in bridging the gap between theory and practice. Advances such as precision agriculture, GIS-based monitoring, and remote sensing provide tools to assess land conditions, forecast risks, and optimize resource use. Kazakhstan's efforts to integrate satellite technologies into national monitoring systems can be viewed as a step forward [33].

Governance and policy criteria are critical for ensuring and maintaining progress across all other dimensions. Transparent land allocation, effective enforcement of environmental standards, and integration of environmental factors into planning are key to successful implementation. Kazakhstan's National Land Use Planning Plan until 2025 emphasizes decentralization and strategic infrastructure development. International experience, such as the European Union's Common Agricultural Policy and China's Grain for Green program, demonstrates that strong governance frameworks can align incentives with sustainable development goals.

For Kazakhstan, it is necessary to implement the following specific technical and legal mechanisms aimed at ensuring sustainable and efficient land use:

1. Adaptation of technical mechanisms for the restoration of eroded land resources through the introduction of state subsidy programs for rural entrepreneurs that integrate environmental and socio-economic objectives of sustainable agricultural development. This requires providing material incentives to farmers to shift from monoculture

cultivation to diversified cropping systems, to ensure the regulated and rational use of fertilizers, to apply scientifically substantiated crop rotation schemes, and to implement soil-improvement practices that contribute to the restoration of the ecological condition of the utilized territories.

2. Application of international experience in legal mechanisms, including:
 - the introduction of prohibitions on uncontrolled livestock grazing and the establishment of regulated grazing zones to prevent trampling, desertification, and degradation of the soil humus layer;
 - the provision of legal incentives, including long-term land lease rights, for farmers actively involved in the restoration of land resources;
 - the simplification of administrative and competitive procedures for granting land resources under long-term leases exceeding 10 years;
 - the introduction of land tax benefits for farmers;
 - the provision of additional state budget subsidies for the acquisition of seed material, the reduction of fuel and lubricant costs for agricultural machinery and technological production processes, and the implementation of leasing programs to supply farmers with technical equipment for crop production and livestock farming.

This integrated set of measures is intended to promote environmentally responsible land management, enhance agricultural productivity, and support the long-term sustainability of rural development in Kazakhstan.

4. CONCLUSIONS

The examination of the theoretical foundations and practical

experience of Kazakhstan and foreign countries regarding the efficient use of the resource potential of agricultural production under conditions of climatic anomalies and declining soil productivity allows the following conclusions and recommendations to be drawn.

The utilization of resource potential in Kazakhstan's agricultural sector contributes to the gradual growth of the agrarian economy; however, land degradation remains a major constraint on its development potential. This degradation is driven by climate change, the application of unsustainable agricultural practices, insufficient financial resources for technological modernization, and the failure of farmers to account for the functional value of ecosystems, which collectively lead to a persistent decline in land productivity and biodiversity.

There is a clear need for a strategy of strong governance based on laws and regulatory frameworks that, at the state level, enforces the integration of environmental protection principles within society. Legislative requirements should clearly define the responsibility of land users, while the identification of violations must trigger immediate and effective responses from state environmental control and protection authorities.

It is also necessary to develop state programs of financial support and subsidization for farmers who apply principles of sustainable land use and environmentally responsible management in agricultural production. This should include the introduction of land tax incentives and the provision of long-term agricultural land leases at minimal rental rates, thereby creating favorable conditions for the sustainable use of land resources and the long-term development of the agricultural sector.

For the effective use of Kazakhstan's agricultural production resource potential, ensuring food security, protecting natural resources, and improving environmental conditions, it is necessary to implement sustainable land-use methods such as no-till farming, drip irrigation, crop rotation, and organic agriculture. Sustainable land-use practices are gaining popularity and will play a decisive role in the sustainable development of the agricultural sector.

Sustainable and efficient land use represents a dynamic process that requires continuous adaptation of environmental, economic, social, technological, and managerial factors as integral components of societal development. Environmental, economic, and social outcomes are interrelated, and without a reliable governance system and technological support, progress in one area may come at the expense of another. Combating land degradation, increasing agricultural productivity, and ensuring the well-being of rural areas must be pursued simultaneously and within coordinated strategies.

Expanded framework approaches highlight the need to establish integrated monitoring and evaluation systems. The introduction of measurable indicators for each criterion will allow Kazakhstan to more systematically track progress, identify trade-offs, and adjust policies accordingly. Regional cooperation with other Central Asian states will enhance the effectiveness of national strategies, given that many land and water issues are transboundary in nature.

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“Development of organizational and economic measures to improve the efficiency of resource potential use in agricultural production.”

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