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Integrated Assessment of Agricultural Land Use for Sustainable Crop Production in Kazakhstan

Gulsim Aitkhozhayeva[1], Nurgali Turmanbetov[1], Yermek Anarbayev[2*], Toleubek Pentayev[1], Almas Mukhametov[3]

[1]Department of Land Resourses and Cadastre, Kazakh National Agrarian Research University, Almaty, Kazakhstan.
[2]Department of Architecture and Urban Planning, M. Auezov South Kazakhstan Research University, Shymkent, Kazakhstan.
[3]Department of Technology and Safety of Food Products, Kazakh National Agrarian Research University, Almaty, Kazakhstan.

ABSTRACT

Sustainable crop production in Kazakhstan increasingly depends on efficient agricultural land use under conditions of agrarian transformation, urbanization pressure, labor outflow, and environmental constraints. A combination of comparative, systems-based, statistical, economic-mathematical, and spatial analytical approaches was used to classify existing land-use assessment methods and evaluate their applicability to regional agricultural conditions. Statistical indicators, socio-economic characteristics, land-resource data, and GIS-based information were analyzed, with particular attention to Almaty Region and the Ili and Talgar districts as contrasting examples of agricultural development. The results showed that an integrated analytical framework combining econometric, optimization, agroecological, and GIS-based methods provides the most informative basis for assessing land-use efficiency, sustainability risks, and production potential. The study concludes that integrating socio-economic and spatial analysis can support more effective agricultural planning and resource allocation in Kazakhstan, with practical value for crop scientists, land-use planners, and decision-makers involved in sustainable agricultural development.

Keywords: *Agroecological assessment, GIS, Kazakhstan, Land-use dynamics, Regional agriculture, Resource optimization*

Corresponding author: Yermek Anarbayev
e-mail ✉ anarbaev-ermek@mail.ru
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INTRODUCTION

In the context of rapid economic and social transformations taking place in Kazakhstan, the transformation of agriculture becomes one of the key tasks of national development. Agriculture continues to play an important role in ensuring the country's food security; however, the efficiency of its functioning largely depends on the rational use of land resources. In this regard, the study of land-use dynamics acquires particular significance, as it reflects not only natural conditions but also socio-economic processes influencing the development of the agrarian sector (Svensson & Lindberg, 2026).

Rational land use is one of the most important factors in the sustainable development of agriculture and in ensuring Kazakhstan's food security. Current demographic changes, such as population migration from rural areas to cities, a decline in the rural population, as well as fluctuations in employment levels and incomes of rural residents, have a significant impact on the structure and dynamics of agricultural land use. In addition, the development of agrarian enterprises and the introduction of new technologies transform traditional forms of land use, which requires a comprehensive and systematic approach to their study (Hao *et al*., 2025).

The relevance of this study lies in the absence of systematized methodological approaches for a comprehensive assessment of agricultural land-use dynamics and their implications for sustainable crop production. Although various methods are available for evaluating natural conditions and economic activity, an integrated framework that simultaneously considers social, economic, and environmental factors is still insufficiently applied in Kazakhstan. This limits the development of effective agricultural strategies aimed at improving land-use efficiency, maintaining crop productivity, and ensuring the long-term sustainability of agricultural systems (Hao *et al*., 2025; Kunie *et al*., 2025).

MATERIALS AND METHODS

To achieve the stated goals and solve the objectives of the article, a set of methodological approaches was used to ensure a comprehensive analysis of the dynamics of socio-economic land use in the agriculture of Kazakhstan. The main focus was placed

on the systematisation and classification of existing methods, considering their applicability to different levels of analysis and types of data.

The research materials included statistical data from state authorities of Kazakhstan, comprising indicators on the structure and dynamics of the rural population, levels of employment and income in rural areas, as well as information on land resources and agrarian enterprises. In addition, the study employed the results of satellite monitoring and geographic information systems (GIS), which made it possible to obtain spatial data on the distribution and changes in land use.

The methodological framework included comparative analysis, a systems approach, and classification methods. Comparative analysis was applied to evaluate various land-use research methodologies and to identify their strengths and weaknesses. The systems approach ensured a comprehensive consideration of the interaction of social, economic, and natural factors influencing the dynamics of land resource use. Classification methods made it possible to structure the methods by levels of analysis (local, regional, national) and types of data (qualitative, quantitative, spatial).

In addition, analytical methods for processing statistical information were used, including correlation and regression analysis, which helped to identify relationships between socio-economic indicators and changes in land use. All the above methods ensured a well-founded and systematic study of land-use dynamics, adapted to the conditions of Kazakhstan and its agrarian sector.

RESULTS AND DISCUSSION

Modern methodologies for analysing land-use transformations are based on several groups of models that complement each other (Verburg *et al*., 2004; Guillen & Pereira, 2024). First, econometric models make it possible to quantitatively assess the influence of economic determinants (prices, incomes, labour costs) on the structure and intensity of land use; such approaches are widely described in the literature on land-use modelling (Nautiyal *et al.,* 2017; Mishra *et al*., 2025). Second, optimization models (linear and goal programming) are applied to problems of optimal allocation of crop areas and water resources under constraints related to labour, land, and water availability. Classical mathematical programming methodology in the agrarian sector provides a basis for developing regional optimisation problems (Hazell & Norton, 1986; Damaševičius *et al*., 2025; Nagesh *et al*., 2025). Third, agroecological and integrated models take into account soil degradation, erosion, and climate risks and are necessary for assessing the sustainability of land use in the long term (FAO, 2021; Kowalski *et al*., 2024). Finally, spatial (GIS-based) models - CLUE-S, PLUS, and similar—enable scenario analysis while accounting for spatial heterogeneity and the interaction between urbanisation and agricultural land; these methods are particularly useful in developing land-use plans at the district or regional level (Liu *et al*., 2017; Huber *et al*., 2025; Salem *et al*., 2025).

International practice demonstrates successful examples of adapting these groups of models to national and regional conditions. In China, the application of spatial simulation models (CLUE-S, PLUS) has made it possible to forecast and adjust urbanisation processes while minimising the loss of highly productive agricultural land (Liu *et al*., 2017; Novak & Jelic, 2025). In the European Union, the CAPRI model is used to assess the impact of agricultural policy and subsidies on land-use structure and farm income, thereby ensuring a link between policy instruments and practical decisions at the local level (Britz & Witzke, 2014**,** Kwatra *et al*., 2024). In conditions of water scarcity (as in India and several African countries), optimisation models for the allocation of irrigated land and scenario-based water-use models have proven effective, making it possible to increase productivity while reducing water consumption (Shah *et al*., 2016).

From international experience, two practical recommendations applicable to Kazakhstan can be derived: (1) to use spatially determined scenarios in the development of land-use plans to reduce conflicts between urbanisation and agricultural activities; and (2) to introduce optimisation algorithms for water and land allocation in resource-constrained areas to improve efficiency and production sustainability (Liu *et al*., 2017; Zairkhanova *et al*., 2024; Abdoul-Latif *et al*., 2025).

An analysis of the applicability of methodologies to the practical conditions of Kazakhstan requires consideration of national specificities: vast areas with low population density, a high share of pasturelands, climate-dependent yields, and the simultaneous outflow of labour from rural areas. These characteristics determine the priority of economic and mathematical methods and the systematisation of statistical data, supplemented by expert assessments.

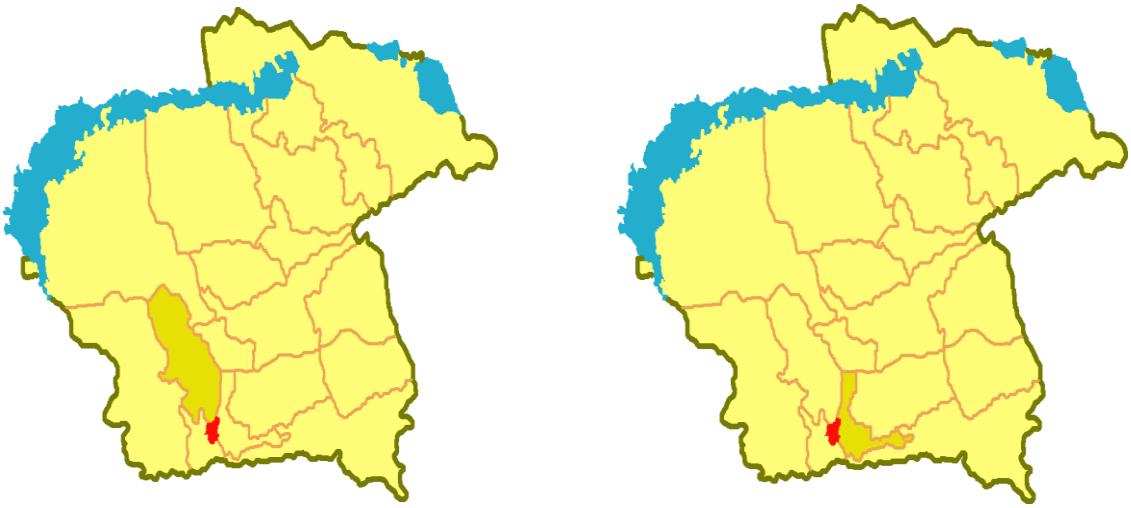
Almaty Region is one of the key agrarian regions of Kazakhstan, characterised by a diversity of natural and socio-economic conditions. The region has significant potential for agricultural development due to fertile soils, a favourable climate, and the availability of irrigation infrastructure. The land-use structure is dominated by arable land, pastures, and orchards. In recent years, trends toward intensification of agricultural production, increased investment in agrotechnologies, and the redistribution of land in favour of more efficient economic entities have been observed, making Almaty Region an important object for studying the dynamics of socio-economic land use **(Table 1).**

Table 1. Dynamics of the structure of agricultural land, 2024.

Territory	Total agricultural land area (,000 ha)	Arable land (000 ha)	Hayfields (000 ha)	Pastures (,000 ha)	Perennial plantations (,000 ha)	Share of arable land (%)	Share of pastures (%)
Almaty Region	4 300	459,8	63,1	3600	18,7	10,69	83,72
Ili District	365,3	39,1	5,4	127,3	1,6	10,71	34,8
Talgar District	220,8	23,6	3,24	5,4	0,96	10,54	2,45

In the Almaty Region, local factors significantly affect the efficiency of agricultural production. Of particular interest are the Ili and Talgar districts, which, despite their geographical proximity to Almaty, demonstrate different models of land use and socio-economic development.

Agriculture in the Ili District is characterized by a high share of arable land used for grain, fodder, and vegetable crops **(Figure 1)**.



(a) (b)

Figure 1. Scheme of (a) Ili District and (b) Talgar District of Almaty Region.

In recent years, there has been a tendency toward a reduction in agricultural land due to active urbanization pressure—especially in suburban zones, including the Ili District—which is confirmed by data on territorial changes and population growth in the suburbs of Almaty (see the "Comprehensive Plan for the Development of the Almaty Agglomeration") (Government of the Republic of Kazakhstan, 2023; Nguyen *et al*., 2025).

The production specialization of the district is associated with vegetable growing, potato cultivation, and maize cultivation, where yields are traditionally higher than the regional average. However, overall production volumes depend on the sown area, which tends to decline. For Almaty Region as a whole, 2024 recorded a record maize harvest—about 270 thousand tons with an average yield of 55 centners per hectare (Aksoy & Akaydin, 2024; Akimat of Almaty Region, 2025; Elango & Govindaraju, 2025).

The socio-demographic situation in the district reflects suburbanization processes: the population is growing, while employment in agriculture is declining **(Table 2)**. According to the "Comprehensive Plan for the Development of the Almaty Agglomeration," the population of the Ili District amounted to approximately 270.7 thousand people as of the beginning of 2023 (Government of the Republic of Kazakhstan, 2023; Jannath *et al*., 2024). A significant labor shortage in the agrarian sector is compensated for by partial mechanization and the use of seasonal workers. At the same time, the district faces environmental constraints—soil degradation, salinization, and a shortage of irrigation water - which reduces the sustainability of agriculture.

Table 2. Yields and production of major crops, 2024.

Territory	Wheat (q/ha)	Barley (q/ha)	Maize (q/ha)	Potatoes (q/ha)	Vegetables (q/ha)	Fruits (q/ha)
Almaty Region	20,6	16,8	55	242,1	250,8	92,8
Ili District	16,2	17,2	62	235,7	232,9	95
Talgar District	14,2	16,6	54	225	241,3	110

Unlike the Ili District, the Talgar District has a more diversified agricultural structure, in which horticulture and fruit growing occupy an important place **(Table 3)**. The district has traditionally been a centre of horticulture and fruit production in Almaty Region. Yields of orchard crops here are higher than the national average, which is facilitated by both natural conditions and intensive technologies—according to reports, crop production and livestock farming are actively developing in the Talgar District (Ogni Alatau, 2022-2024).

Table 3. Socio-economic characteristics of the rural population, 2024.

Territory	Rural population (,000 people)	Share of rural population (%)	Employment in agriculture, (,000 people)	Average wage in agriculture (,000 KZT)	Net migration gain/loss (people)
Almaty Region	1249,0	80,5	23,528	297,1	+17124

Ili District	274,5	100	3,9	285,0	+10435
Talgar District	183,1	73,7	3,5	290,0	+3026

The rural population of the district is partially involved in labor migration to Almaty; however, a significant share of employment in the agrarian sector is retained, including small-scale farms. Agriculture remains one of the main sources of income, which supports the sustainability of rural communities. According to publications, the Talgar District is one of the most dynamically developing districts in the region in terms of the number of small and medium-sized enterprises, which indirectly indicates activity in agricultural and related sectors (Benhmida & Trabelsi, 2024; DKN World News, 2024).

Environmental challenges of the district are associated with the degradation of irrigation systems and a deficit of water resources, which limit the possibilities for expanding intensive horticulture **(Table 4)**. At the same time, the natural conditions of the district make it possible to consider the further development of fruit growing as a priority area of specialization. (More detailed environmental statistics for the Talgar District are required to confirm the scale of these challenges.

Table 4. Economic efficiency of agriculture, 2024.

Territory	Gross agricultural output (billion KZT)	Physical volume index (% to previous year)	Labor productivity (million KZT per employed person)	Share of agriculture in regional GRP (%)
Almaty Region	385,4	102	4,24	2,7
Ili District	38,5	103	4,0	7,7
Talgar District	19,3	101	3,5	6,4

A comparison of the Ili and Talgar districts demonstrates differences in land-use models **(Table 5)**. In the Ili District, agriculture is oriented toward the production of cereals, potatoes, and vegetables, but faces a reduction in land resources and declining employment. In the Talgar District, the key focus is horticulture and fruit growing, where high profitability is maintained even with limited land areas.

Table 5. Environmental factors of land use.

Territory	Area of degraded land (,000 ha)	Saline land (,000 ha)	Land subject to erosion (, 000 ha)	Use of mineral fertilizers (kg/ha)	Share of irrigated land (%)
Almaty Region	2 582	210,4	1369	21,7	17,7
Ili District	191,3	15,6	101,4	24,1	24,4
Talgar District	90,7	7,4	48,1	20	22,1

Thus, both districts have significant potential, but the sustainability of their agriculture depends on different factors. For the Ili District, the key tasks are optimization of the arable land structure, improvement of irrigation efficiency, and the introduction of resource-saving technologies. For the Talgar District, priority areas include the modernization of horticulture, infrastructure renewal, and support for small-scale farms. Proximity to Almaty creates unique market opportunities for both districts; however, it also requires the adaptation of land use to urbanization processes and environmental constraints.

The regional context of the Almaty Region confirms the need for the integration of methods. Documents on the development of the Almaty agglomeration record active urbanization pressure on suburban agricultural lands, which directly affects the availability of arable land in the Ili District and requires scenario-based land-use analysis (Comprehensive Plan for the Development of the Almaty Agglomeration) (Government of the Republic of Kazakhstan, 2023). An assessment of the region's production dynamics shows that in 2024 Almaty Region achieved a record maize yield (≈55 q/ha; total output ~270.7 thousand tons), indicating a high potential for intensification amid shrinking sown areas. This phenomenon (yield growth with declining areas) requires the application of optimization models to determine the most efficient crop and production system on limited land resources.

A practical analysis of the Ili and Talgar districts confirms the diversity of land-use models within a single region: the Ili District represents a model of intensive vegetable and potato production with a risk of land losses due to urbanization; the Talgar District represents a model of specialization in fruit growing and horticulture with relative sustainability on smaller areas, but with constraints related to irrigation infrastructure.

Environmental constraints identified in national and departmental reports (consolidated analytical report on the state of lands of the Republic of Kazakhstan; national reports of the Ministry of Ecology) indicate the widespread occurrence of degradation processes (erosion, salinization) and the need to account for these factors in forecasting and land-use optimization models. Consequently, agroecological components should be integrated into optimization and scenario models at the stage of preparing policy recommendations and practical measures (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2024).

The conducted analysis confirms the initial hypothesis regarding the expediency of systematizing methods for studying the dynamics of socio-economic land use and adapting them to the specifics of Kazakhstan. The integration of economic-mathematical, spatial, and agroecological approaches provides the most reliable methodological basis for developing regional strategies to optimize land use and enhance the sustainability of agricultural production.

An analysis of contemporary studies demonstrates the complex dynamics of agricultural land use in Kazakhstan, driven by the interaction of environmental, social, and economic factors. In the work by Aitkhozhayeva and co-authors (2024), it is noted that "under conditions of limited land resources, rational land use becomes a critical factor in ensuring food security and the sustainable development of the agrarian sector". The authors emphasize the need for a balanced approach that combines productivity growth with the conservation of natural resources.
A study by Zhildikbayeva *et al*. (2023) focusing on the southern region of Kazakhstan revealed that "the fragmentation of land plots and a lack of investment in agrotechnologies significantly reduce the efficiency of land use by peasant farms". Low-income levels of the rural population and migration intensify land degradation, which negatively affects agriculture in the region.
In the western regions of the country, according to Tokbergenova *et al*. (2024), "climate change intensifies erosion and desertification processes, creating new challenges for rational land use". To adapt to these changes, innovative technologies and methods of sustainable farming are required.
An analysis of the formation of agricultural land shows that "the transition to market relations and changes in the legal regulation of land use have led to a transformation in the structure of land resource utilization" (Usipbaev *et al*., 2024). At the same time, Askarova *et al*. (2024) point out that "enhancing the sustainability of irrigated lands requires the introduction of modern water-saving technologies and effective management of irrigation systems".
An econometric analysis of grain production in Kazakhstan confirms that "the efficiency of land use directly depends on the level of investment in agrotechnologies and infrastructure, as well as on the socio-economic situation in rural areas" (Abraliyev *et al*., 2024). Tleubayev and co-authors (2024) note that "sustainable development of the agrarian sector requires alternative strategies for increasing gross value added with an emphasis on innovative land resource management methods".
A methodological review on SpringerLink (Nautiyal *et al*., 2017) and the studies by Lu and Yang (2023) emphasize the importance of an integrated land-use analysis that combines quantitative and qualitative methods, as well as spatial analysis, to identify regional differences. The theoretical approaches of Shanin (2022) to the spatial development of land use contribute to forecasting and planning effective land resource management strategies.
In accordance with FAO classifications and standards, the systematization of land-use analysis methods contributes to the unification of research and the improvement of its quality (FAO, 2021). The FAO report The Future of Our Land (FAO & UNEP, 1999) emphasizes the need to integrate environmental and economic aspects to ensure sustainable land use at regional and global levels.
The systematization of existing approaches demonstrated the need to integrate them into a unified analytical framework capable of accounting for economic as well as socio-environmental factors.
First, it was established that modern methods for studying land-use dynamics can be conditionally divided into three groups: econometric methods (focused on identifying relationships between socio-economic determinants and land-use structure), optimization methods (aimed at finding efficient scenarios for the allocation of limited resources), and agroecological methods (providing an assessment of sustainability while accounting for degradation processes and climate risks). Their combined application forms the basis for an objective assessment and forecasting of transformations in agricultural territories.
Second, an analysis of international experience showed that integrated models (CLUE-S, PLUS, CAPRI, etc.) make it possible to successfully combine economic and environmental factors within a single land-use planning system. The practices of China, the European Union, and India demonstrate that the adaptation of such models contributes to more rational use of land and water resources, mitigation of the negative effects of urbanization, and the enhancement of food security.
Third, the regional case of Almaty Region (the Ili and Talgar districts) confirmed the presence of divergent land-use models. The Ili District is characterized by intensive development of vegetable production and grain farming under high urbanization pressure and a shortage of labor resources. In contrast, the Talgar District is oriented toward horticulture and fruit growing, maintaining a more sustainable production structure, albeit constrained by the condition of irrigation infrastructure.
Fourth, the comparative analysis revealed the need for a differentiated land-use management policy: for the Ili District, the priority areas are optimization of the cropping pattern and modernization of irrigation systems; for the Talgar District, they include support for intensive horticulture, rehabilitation of irrigation systems, and development of farm enterprises.

CONCLUSION

The conducted study made it possible to comprehensively examine the methodological foundations for analyzing the dynamics of socio-economic land use and to assess their applicability in the agrarian sector of Kazakhstan. The obtained results have both theoretical significance, manifested in the refinement of the methodological framework for land-use analysis, and practical significance, expressed in the possibility of their application in the development of regional strategies for the sustainable development of the agrarian sector. The proposed framework may assist crop scientists and regional planners in identifying production constraints and prioritizing resource-efficient crop systems. In the future, it appears advisable to expand the use of spatial simulation and optimization models for the development of agricultural development scenarios in the regions of Kazakhstan.

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REFERENCES

Abdoul-Latif, F. M., Ainane, A., Saoudi, O., Mohamed, H., Ali, A. M., Cacciatore, S., & Ainane, T. (2025). Confrontation of the ambivalent roles of the intestinal microbiota in carcinogenesis: Oncogenic or anticancer agents? *Journal of Advanced Pharmacy Education & Research, 15*(2), 16–30. doi:10.51847/XocFRvwLrp

Abraliyev, O., Baimbetova, A., & Kusmoldayeva, Z. (2024). Econometric analysis of wheat production dynamics in Kazakhstan. *Reports of the Academy of Sciences of the Republic of Kazakhstan, 3*(409), 291–307. doi:10.32014/2024.2518-1467.768

Aitkhozhayeva, G., Zhildikbaeva, A., Pentaev, T., Baukhan, A., Zhumagalieva, N., & Gurskienė, V. (2024). The current state of agricultural land use in the context of sustainable development. *Izdenister, Netizheler, 3*(103), 380–387. doi:10.37884/3-2024/42

Akimat of Almaty Region. (2025, February 14). *Record corn harvest collected in Almaty region — 270 thousand tons.* https://www.gov.kz/memleket/entities/almobl/press/news/details/938789?lang=ru

Aksoy, C., & Akaydin, A. (2024). The impact of strategic leadership on employee performance: A study of the aviation industry. *Journal of Organizational Behavior Research, 9*(2), 42–53. doi:10.51847/3xix5orUCJ

Askarova, K., Pentaev, T., Aidarova, A., & Ferruh, Y. (2024). Problems of increasing the sustainability of the use of irrigated land in agriculture. *Izdenister, Netizheler, 2*(102), 425–433. doi:10.37884/2-2024/42

Benhmida, S., & Trabelsi, H. (2024). Fatty acid composition in bone fluid from knee osteoarthritis patients. *Journal of Biochemical Technology, 15*(2), 23–26. doi:10.51847/UNhuTqup51

Britz, W., & Witzke, P. (2014). *CAPRI model documentation 2014: Common Agricultural Policy Regionalised Impact Modelling System.* University of Bonn. CAPRI model documentation

Damaševičius, R., Maskeliūnas, R., & Blažauskas, T. (2025). Enhancing virtual medical history taking: Effects of customized guidelines in two serious games for medical education. *Annals of Pharmacy Education, Safety, Public Health Advocacy, 5*, 39–49. doi:10.51847/kNshKQSf5t

DKN World News. (2024, January 15). *Talgar district became one of the most active in SME development.* https://dknews.kz/ru/ekonomika/313740-talgarskiy-rayon-stal-odnim-iz-samyh-aktivno

Elango, R., & Govindaraju, L. (2025). In vitro evaluation of Kedo SDF gel effect on the micro-hardness of natural carious dentin. *Annals of Dental Specialties, 13*(2), 12–14. doi:10.51847/fQknFGnize

Food and Agriculture Organization of the United Nations, & United Nations Environment Programme. (1999). *The future of our land: Facing the challenge.* The future of our land

Food and Agriculture Organization of the United Nations. (2021). *Methods, standards, and classifications—FAO statistics.* FAO Statistics

Government of the Republic of Kazakhstan. (2023). *Resolution of the Government of the Republic of Kazakhstan of December 28, 2023 No. 1226 "On approval of the Comprehensive Plan for the Development of the Almaty Agglomeration for 2024–2028".* https://adilet.zan.kz/rus/docs/P2300001226

Guillen, J., & Pereira, R. (2024). Institutional influence on gender entrepreneurship in Latin America. *Annals of Organizational Culture, Leadership, External Engagement Journal, 5*, 28–38. doi:10.51847/RaQltcyzXu

Hao, C., Fang, L., & Lin, Z. (2025). Autonomous AI agent for QSAR modeling with dataset curation, descriptor selection, and domain assessment. *Pharmacophore, 16*(4), 11–21. doi:10.51847/Bhyi6RjARa

Hazell, P., & Norton, R. (1986). *Mathematical programming for economic analysis in agriculture.* Macmillan Publishing Company.

Huber, M. A., Bauer, L. S., Gruber, F. K., & Müller, E. W. (2025). Outcomes of everolimus combined with exemestane in HR-positive metastatic breast cancer after CDK4/6 inhibitor exposure. *Archives of International Journal of Cancer and Allied Sciences, 5*(2), 44–50. doi:10.51847/sJNxEiRZXn

Jannath, A., Sivapragasam, S., Viswanathan, K., & Sundaram, R. (2024). Intentional replantation with simultaneous periapical surgery: A case report with one year of follow-up. *Annals of Dental Specialties, 12*(3), 23–27. doi:10.51847/JIs54FRstW

Kowalski, T. W., Reis, L. B., Andreis, T. F., Ashton-Prolla, P., & Rosset, C. (2024). Rare co-occurrence of two mutational variants in NF1: Molecular testing reveals diagnostic surprises. *Journal of Medical Sciences and Interdisciplinary Research, 4*(2), 20–29. doi:10.51847/H2qQlZTYO7

Kunie, K., Kawakami, N., Shimazu, A., Yonekura, Y., & Miyamoto, Y. (2025). Examining the impact of managerial communication on the link between nurses' job performance and psychological empowerment. *Annals of Organizational Culture, Leadership, External Engagement Journal, 6*, 1–7. doi:10.51847/SF5ZX3J4OT

Kwatra, D., Venugopal, A., & Anant, S. (2024). Studying the efficacy of tolmetin radiosensitizing effect in radiotherapy treatment on human clonal cancer cells. *Bulletin of Pioneer Research in Medical and Clinical Sciences, 4*(2), 22–28. doi:10.51847/Uuhjk0fMC8

Liu, X., Liang, X., Li, X., Xu, X., Ou, J., Chen, Y., Li, S., Wang, S., & Pei, F. (2017). A future land use simulation model (PLUS) for simulating multiple land use scenarios by coupling human and natural effects. *Landscape and Urban Planning, 168*, 94–116. doi:10.1016/j.landurbplan.2017.09.019

Lu, J., & Yang, G. S. (2023). A review of research methods for coupling land use efficiency and spatio-temporal heterogeneity. *Journal of Innovation and Development, 4*, 93–99. doi:10.54097/jid.v4i2.12181

Ministry of Ecology and Natural Resources of the Republic of Kazakhstan. (2024). *National report on the state of land resources of the Republic of Kazakhstan for 2022–2024.* RGP "Kazgeodeziya."

Mishra, N., Dadhich, A., Vande, A. V., Saluja, H., Shah, S., & Mishra, M. (2025). A comparative assessment of topical 5-fluorouracil and modified Carnoy's solution for the treatment of odontogenic keratocyst. *Journal of Current Research in Oral Surgery, 5*(1), 11–16. doi:10.51847/OrVjjlmrxW

Nagesh, D., Lam Ip, C. Y. T., Li, K., Wong, H. S. L., & Chai, J. Y. H. (2025). Navigating support networks: A Somali woman's

experience of social alignment to overcome isolation during pregnancy and early motherhood. *International Journal of Social Psychology Aspects of Healthcare, 5*, 35–48. doi:10.51847/iJoPhqpXaV

Nautiyal, S., Kaechele, H., Tikhile, P., Subbanna, S., & Baksi, S. (2017). Study on land use dynamics: Appropriate methods for change estimation in social science research. *Earth Systems and Environment, 1*, 27. doi:10.1007/s41748-017-0029-3

Nguyen, T. T., Dinh, V. T., & Vu, L. H. (2025). An integrated FAHP–TOPSIS approach for evaluating and prioritizing medical tourism service types in Vietnam. *Journal of Organizational Behavior Research, 10*(2), 20–31. doi:10.51847/lnWweTmy0d

Novak, H., & Jelic, P. (2025). Comparing self-learning skill stations and instructor-led courses for cardiopulmonary resuscitation skill retention among hospital nurses: A randomized controlled trial. *Journal of Integrative Nursing and Palliative Care, 6*(2), 185–191. doi:10.51847/MFRNxbMHX7

Ogni Alatau. (2022–2024). *District materials on agricultural development in Talgar district.* https://ognialatau.kz

Salem, H. M., Watanabe, S., & Chang, A. H. (2025). Ethical concerns in managing anorexia nervosa: A content analysis of ethics consultation records. *Asian Journal of Ethics and Health Medicine, 5*, 25–35. doi:10.51847/oHEI6FgL3V

Shah, M. A. A., Anwar, A. A., Bell, A. R., & Haq, Z. U. (2016). Equity in a tertiary canal of the Indus Basin Irrigation System (IBIS). *Agricultural Water Management, 178*, 200–214. doi:10.1016/j.agwat.2016.09.018

Shanin, S. A. (2022). Theoretical approaches and regularities of the theory of spatial development of agricultural land use. *International Research Journal, 12-4*(114), 121–124. doi:10.23670/IRJ.2021.114.12.140

Svensson, A., & Lindberg, E. (2026). Explainable AI for pediatric dosing error prediction using prescription text and weight-based rules. *Pharmacophore, 17*(2), 1–11. doi:10.51847/v5wAxGMQYm

Tleubayev, A., Kerimkhulle, S., Tleuzhanova, M., Uchkampirova, A., Bulakbay, Z., Mugauina, R., Tazhibayeva, Z., Adalbek, A., Iskakov, Y., & Toleubay, D. (2024). Econometric analysis of the sustainability and development of an alternative strategy to gross value added in Kazakhstan's agricultural sector. *Econometrics, 12*, 29. doi:10.3390/econometrics12040029

Tokbergenova, A., Zulpykharov, K., Mirzabaev, A., Kalieva, D., Taukebaev, O., & Duysenbaev, S. (2024). Rational use of agricultural land of the West Kazakhstan Region in the context of climate change. *Journal of Geography and Environmental Management, 72*, 18–33. doi:10.26577/JGEM.2024.v72.i1.02

Usipbaev, G. B., Omarbekova, A. D., Sagandykova, D. N., & Begazimov, D. G. (2024). Analysis of formation of agricultural land destination in Kazakhstan. *Izdenister, Netizheler, 4*(104), 358–368.

Verburg, P. H., Schot, P. P., Dijst, M. J., & Veldkamp, A. (2004). Land use change modelling: Current practice and research priorities. *GeoJournal, 61*, 309–324. doi:10.1007/s10708-004-4946-y

Zairkhanova, L. N., Eremina, A. S., Burkhanov, R. R., Bersanova, M. M., Agerzhanokova, S. Z., Muskhadzhieva, F. A., Ataeva, A. I., & Esyunin, V. V. (2024). Investigation of the effectiveness of silver-containing drugs for the treatment of tuberculosis in the respiratory system. *Journal of Advanced Pharmacy Education & Research, 14*(3), 31–35. doi:10.51847/zhfsdGkmQi

Zhildikbayeva, A., Molzhigitova, D., Turganaliev, S., Elemesov, S., & Ashimkhan, N. (2023). Efficiency of land use by peasant farms in the southern region of Kazakhstan. *Izdenister, Netizheler, 1*(97), 110–118. doi:10.37884/1-2023/13