SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 28(4), 120-134

UDC 338.512:633.1
DOI: 10.48077/scihor4.2025.120

Cost structure in Kazakhstan's grain farming and methods of its optimisation

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Article's History:
Received: 10.11.2024
Revised: 01.03.2025
Accepted: 26.03.2025

Abstract. The optimisation of costs in Kazakhstan's grain farming is a pressing issue driven by the need to enhance the economic efficiency of agricultural production amid rising resource costs and increasing competition in the international market. The objective of this study was to substantiate approaches to reducing costs in grain farming by analysing cost structures and assessing the effectiveness of technological and economic measures. The study employed variation statistics, regression analysis, econometric modelling, cost-benefit analysis, and investment profitability calculations to evaluate the efficiency of various production strategies. The research

Suggested Citation:
Kerimbek G., Mamutova, K., Oralbayeva, A., Baimukasheva, Zh., & Nurbayeva, G. (2025). Cost structure in Kazakhstan's grain farming and methods of its optimisation. *Scientific Horizons*, 28(4), 120-134. doi: 10.48077/scihor4.2025.120.

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findings demonstrated that the key directions for cost optimisation included the introduction of minimum tillage technologies, particularly no-till and strip-till systems, automation of agrotechnical processes, rational use of fertilisers and plant protection products, as well as the utilisation of digital platforms for product sales. An analysis of statistical data for 2020-2024 indicated that the adoption of minimum tillage technologies contributed to a 50-60% reduction in fuel costs, a 20-25% decrease in machinery depreciation costs, and a 15-20% reduction in labour costs. Automated agricultural management systems enabled an 18-22% reduction in fertiliser and plant protection product costs due to precise resource distribution. Optimisation of logistical processes and constructing grain storage facilities contributed to a 12-18% reduction in product losses during transportation and a 10-15% decrease in logistics costs. The use of digital platforms for product sales ensured a 40-50% reduction in transaction costs and a 60% decrease in buyer search costs. The overall effect of implementing the proposed measures allowed for a 12-17% reduction in grain production costs, depending on farm scale and applied technologies. The proposed recommendations were aimed at reducing production costs, ensuring the financial stability of the agricultural sector, and enhancing the competitiveness of Kazakhstan's grain farming

Keywords: economic efficiency; technological innovations; minimum tillage; agricultural automation; resource management

INTRODUCTION

The rise in costs in Kazakhstan's grain farming is influenced by several factors, including increasing fuel and lubricant prices, rising costs of agrochemicals and seeds, changes in state agricultural policy, and climatic fluctuations affecting yield levels. In the context of global competition, effective management of cost structures is one of the key factors in ensuring the financial stability of the agricultural sector. The implementation of modern agrotechnologies, precision farming methods, and digital platforms plays a particularly significant role in optimising resource use and improving agricultural enterprise productivity. The lack of a systematic approach to cost reduction in grain production may lead to a decline in the competitiveness of Kazakhstan's agricultural products in the international market, necessitating the development of scientifically grounded strategies for optimising production costs.

Research on the optimisation of farming technologies and the enhancement of agricultural production efficiency encompasses various aspects of economic, environmental, and agrotechnical feasibility. The introduction of zero tillage technology in small farms in Kyrgyzstan, as analysed in the study by A. Tadjiev *et al*. (2023), demonstrated a 23% reduction in soil preparation costs and a 15% overall decrease in production costs. However, it was accompanied by an increase in hired labour costs (by 13%) and herbicide costs (by 15%). Moreover, the long-term effects of the technology on soil productivity, yield levels, and farm financial stability remained unassessed, along with macroeconomic factors influencing its effectiveness. The study by S. Turebayeva *et al*. (2022) assessed the productivity of winter wheat under direct seeding and various fertilisation schemes in arid regions of Southern Kazakhstan. It was established that phosphorus fertiliser application accelerated grain ripening, while the combination of nitrogen and phosphorus fertilisers prolonged the growing season, and the lowest production costs were observed with the use of growth stimulants with microelements. However, the long-term effects of the technology on soil fertility, economic risks associated with fluctuating agrochemical prices, and potential climatic variations that could impact the profitability of this method were not considered.

The research by S.B. Kenenbaev *et al*. (2021) examined resource-saving farming systems in South-Eastern Kazakhstan, focusing on soil moisture retention and soil fertility improvement. However, the study lacked a detailed economic efficiency analysis of the implemented technologies, including a comparison of costs and profitability of different tillage methods. The absence of an assessment of financial stability impacts on farms, as well as the social aspects of adapting new methods, limited the practical applicability of the findings.

The optimisation of water use through drip irrigation and the application of mineral fertilisers in South-Eastern Kazakhstan was the subject of a study by A.S. Sembayeva *et al*. (2025). The study recorded an increase in maize (*Zea mays* L.) yield ranging from 0.87 to 2.85 t/ha. However, it lacked an analysis of the long-term impact of these technologies on the physico-chemical properties of the soil, particularly potential salinisation processes. Additionally, the economic accessibility of these technologies for local farmers, which could influence their widespread adoption, remained unassessed. The study by N. Suleimenova *et al*. (2021) examined the environmental sustainability and productivity of rapeseed (*Brassica napus* L.) in South-Eastern Kazakhstan under shallow chisel tillage (mini-till). It was found that this approach increased yield by 21.3% and provided an additional income of 29.3 thousand tenge/ha. However, the study did not consider potential risks such as weed and pathogen accumulation, the impact of climate change on the technology's effectiveness, or comparisons with alternative rapeseed cultivation methods.

B.J. Olorunfemi and S.E. Kayode (2021) analysed post-harvest grain losses and the efficiency of modern storage technologies. The authors noted that the use of metal silos, improved bags, and wooden storage facilities helped reduce losses caused by pests and mould. They also emphasised the importance of implementing automated inventory management systems. However, economic barriers to adopting these technologies, their accessibility to small farmers, and the environmental aspects of long-term grain storage were not assessed, which could affect their real efficiency under different farming conditions. R.K. Zhapayev *et al*. (2023) studied the physico-chemical properties of soil and water balance under different tillage methods in South-Eastern Kazakhstan. It was established that zero tillage contributed to moisture retention (29.8-54.8 mm) but increased soil density (1.32-1.33 g/cm^3) and reduced nitrate nitrogen content. The highest yield (1.76 t/ha) was recorded with minimum tillage, confirming its effectiveness in rainy conditions. However, the long-term impact of soil compaction on fertility and the potential consequences of reduced nitrate nitrogen content for future yields remained unassessed.

The study by A.E. Kokenova *et al*. (2022) focused on grain production management processes and their economic efficiency. It proposed methods for diagnosing production problems and modelling factors influencing enterprise productivity. However, the study lacked empirical analysis of the effectiveness of the proposed strategies under real conditions and did not account for macroeconomic factors or the risks of implementing new management approaches. The issue of rational use of dark chestnut soils in Northwestern Kazakhstan was explored in the study by Z.M. Gumarova *et al*. (2025). It considered possibilities for restoring fallow land through the use of black fallow and leguminous crops. However, the study lacked an economic analysis of the profitability of these measures and the long-term impact of different tillage methods. Social aspects of their implementation and the influence of climate change were also insufficiently explored. A separate area of research is innovative agricultural management in Kazakhstan, studied by Z. Taishykov *et al*. (2023). Key directions were identified, including the introduction of modern technologies, financing agricultural science, genomic selection, and the optimisation of agrotechnical processes. However, the study lacked a detailed economic analysis of these innovations, risk assessments for small and medium-sized farms, and comparative analysis with countries possessing similar agroclimatic conditions.

The aim of the study was to develop scientifically grounded approaches to optimising the cost structure in Kazakhstan's grain farming based on an analysis of the main components of the cost base, an assessment of the efficiency of technological and economic solutions, and the modelling of strategies for reducing production costs.

MATERIALS AND METHODS

The study is analytical and aimed at assessing the cost structure in Kazakhstan's grain farming and developing strategies for its optimisation. The timeframe covers the period from 2020 to 2024, allowing for an evaluation of cost structure changes and the effectiveness of applied technological and economic measures. The research is based on the analysis of statistical data, economic calculations, and optimisation scenario modelling. Primary and secondary data were obtained from multiple sources to ensure a comprehensive analysis of the issue. The main sources of statistical data included the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), the World Bank (n.d.), and the Organisation for Economic Co-operation and Development (2023).

The study applied methods of variation statistics to analyse the distribution of costs in Kazakhstan's grain farming. The arithmetic means of expenses for specific resources (fuel, fertilizers, seeds, labour costs) and their standard deviation were determined, allowing for an assessment of the stability and variability of the cost structure across different regions of the country. The reliability of differences between cost groups was evaluated using Student's t-test at a significance level of $p \leqslant 0.05$. To identify the relationship between costs and economic efficiency, econometric analysis was applied, particularly regression modelling. Models were developed to establish dependencies between material cost levels and grain yields, enabling an assessment of the impact of specific cost categories on overall farm productivity. Correlation analysis identified interdependencies between the level of mechanisation in production processes and the share of labour costs. Additionally, to evaluate the economic feasibility of technological innovations and management strategies, the Cost-Benefit Analysis method was used. A comparative analysis of costs for traditional and innovative soil cultivation methods (conventional plowing, No-Till, Strip-Till) was conducted to assess their profitability. The Return-on-Investment analysis was also applied to determine the economic impact of implementing automated agricultural management systems and digital platforms for grain sales.

The interpretation of results was based on a comparison of obtained statistical indicators with data from previous years and international standards in grain production, particularly the provisions of the Codex Alimentarius (1963) and the regulations of the International Grains Council (n.d.). Analysing cost structure dynamics made it possible to identify key factors influencing production costs and the financial stability of farms. The results of optimisation scenario modelling were considered from the perspective of their potential impact on the long-term sustainability of Kazakhstan's agricultural sector. The assessment of the effectiveness

of economic measures and technological innovations took into account not only direct changes in cost structure but also prospects for increasing the competitiveness of the grain sector in the international market. The obtained results allowed for the formulation of well-founded recommendations for cost optimisation in Kazakhstan's grain farming. Identified correlations between cost levels and production efficiency contribute to the development of effective management strategies aimed at reducing production costs. The analysis of the economic feasibility of technological solutions and financial mechanisms enables the determination of the most promising development directions for the industry, considering modern challenges.

RESULTS

Analysis of cost structure in Kazakhstan's grain farming. The cost structure in Kazakhstan's grain farming is shaped by the interaction of technological, economic, and natural-climatic factors. The main components of the cost base include material expenses, particularly expenditures on fertilizers, seeds, and plant protection products, which have the greatest impact on production costs. A significant share of expenses also consists of energy costs, including fuel and electricity expenditures, which are highly dependent on fluctuations in energy prices. Labour costs and depreciation expenses create additional financial burdens on producers, especially considering seasonal employment fluctuations and the need to modernise agricultural machinery. Analysing the structure of these expenses allows for an assessment of the capital intensity of grain production and the identification of ways to improve its economic efficiency.

The dynamics of costs in Kazakhstan's grain farming reflect a trend toward an increasing share of material expenses, which may be linked to rising resource prices and stricter requirements for ensuring stable yields. At the same time, there is a decline in the share of labour costs, which may indicate an increasing level of mechanisation and automation in production processes (Tolepbergen, 2022). Different regions of Kazakhstan demonstrate variations in cost structure due to soil and climatic conditions, resource accessibility, and applied agrotechnologies. Evaluating these factors helps determine regional differences in production costs of grain crops and opportunities for their optimisation. Expenditures on fertilizers, seeds, and plant protection products are key components of the material base of production, determining the cost price and productivity of the agricultural sector. The analysis of cost distribution over the period from 2020 to 2024 allows for an assessment of key trends in resource use and the identification of directions for their optimisation (Fig. 1).

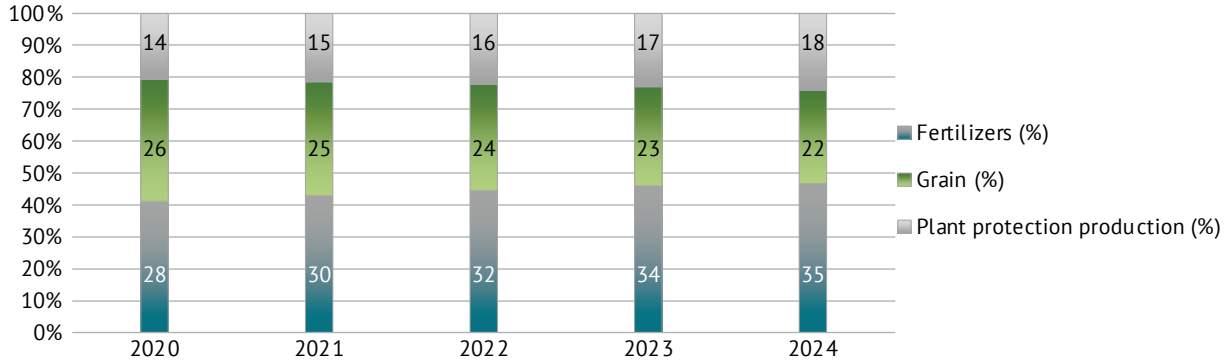

***Figure 1**. Distribution of expenditures on material resources in Kazakhstan's grain farming (%)*
***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

During the analysed period, a steady increase in fertilizer costs was observed, which may result from the intensified use of mineral fertilizers to maintain stable yields. This trend was also influenced by changes in soil chemical composition and the need for increased micronutrient application to preserve soil fertility. At the same time, the adaptation of precision farming technologies enabled agricultural enterprises to optimise fertilizer application, reducing losses and increasing efficiency. The reduction in the share of seed costs is associated with the improvement of breeding methods, which ensure the development of high-yielding varieties with enhanced agronomic characteristics. The introduction of more drought- and disease-resistant crops reduces the need for reseeding and increases the efficiency of seed material use. The increase in plant protection costs is likely linked to the spread of pests and diseases, necessitating more intensive use of pesticides and fungicides to maintain yields.

Fuel and lubricants represent another significant component of the cost structure. Given the vast areas of cultivated land in Kazakhstan, fuel expenses can account for 15-20% of total costs. Fluctuations in oil

and petroleum product prices directly impact this cost segment. Depreciation costs related to the use of agricultural machinery and equipment also constitute a substantial share of total expenditures. Depending on the intensity of machinery use and its cost, depreciation charges may reach 10-15% of total expenses. This highlights the importance of efficient asset management and investment in modern equipment. Labour costs form another crucial component of the cost structure. Due to the seasonal nature of grain farming, labour expenses may vary, but on average, they account for approximately 10% of total costs. Wage levels, the availability of skilled workers, and working conditions influence this indicator. An analysis of the dynamics of cost structure changes from 2020 to 2024 reveals a trend of rising expenditure on material resources, particularly fertilisers and fuel, which is associated with global price fluctuations (Fig. 2).

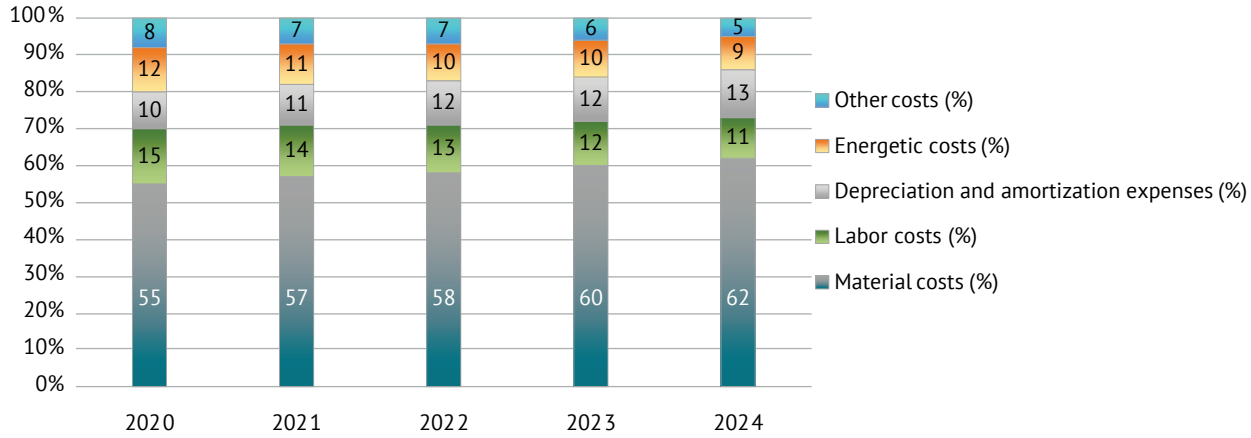

***Figure 2**. Cost structure in Kazakhstan's grain farming (%)*

***Note:** material costs include expenditure on seeds, fertilisers, and plant protection products. Energy costs cover fuel and electricity expenses. Other costs include administrative expenses, equipment repair, and maintenance costs*

***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

Figure 2 demonstrates a growing share of material costs in the overall cost structure of grain production, which may be attributed to rising prices for fertilisers and plant protection products. At the same time, the share of labour and energy costs has declined, which may indicate improvements in production efficiency and the adoption of energy-saving technologies. The increase in depreciation costs may be linked to the renewal of agricultural machinery and the implementation of modern production technologies. Regional differences in cost structure are also significant. In northern Kazakhstan, where most grain production is concentrated, fuel and depreciation costs are higher due to the larger cultivated areas. In southern regions, where climatic conditions allow for higher yields, expenditure on fertilisers and plant protection products tends to be higher due to the more intensive cultivation technologies. Macroeconomic factors such as inflation, exchange rate fluctuations, and government policies influence the cost levels of grain production. The depreciation of the national currency may lead to higher prices for imported material resources, increasing overall production costs. Government support in the form of subsidies and preferential loans can partially offset these negative impacts.

Technological innovations as a factor in cost optimisation in grain production. The adoption of technological innovations is one of the key areas for improving resource efficiency in Kazakhstan's grain production. The cost of grain production largely depends on the level of mechanisation, the use of modern soil cultivation methods, and the implementation of digital technologies. The use of no-till and strip-till techniques reduces fuel and lubricant consumption and minimises the number of mechanical treatments, contributing to lower production costs. The introduction of precision farming systems based on spatial data analysis enhances the efficiency of agrotechnical processes and promotes rational resource use. The choice of technology determines fuel and lubricant consumption levels, machinery wear and tear, labour requirements, and final production costs. Traditional ploughing remains a widely used method, but its high energy intensity and cost encourage the adoption of alternative approaches (Angon *et al.*, 2023). No-till (Jiang *et al.*, 2021) and strip-till (Różewicz, 2022) techniques reduce the number of mechanical treatments, lower fuel consumption, and optimise resource use. Table 1 presents a comparative analysis of costs for three main soil cultivation methods.

***Table 1**. Comparative analysis of costs for traditional ploughing, No-Till, and Strip-Till in Kazakhstan*

Indicator	Traditional Technology	No-till	Strip-till
Fuel costs (litres/ha)	25	10	15
Machinery depreciation costs ($/ha)	20	15	18
Labour costs ($/ha)	30	20	22
Total costs ($/ha)	75	45	55

***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

The comparative analysis results show a significant difference in cost levels between traditional ploughing and modern soil cultivation methods. The primary factor in cost reduction is lower fuel and lubricant expenses, which is particularly evident in no-till technology. This is due to the elimination of ploughing and the reduced number of machineries passes across the field, which also minimises agricultural equipment wear and tear. Although strip-till technology requires slightly higher machinery depreciation costs compared to no-till, it remains economically viable due to the optimal balance between soil structure preservation and efficient fertiliser application in the root zone. The reduction in labour costs in no-till and strip-till systems indicates a decreased need for fieldwork, which serves as an additional cost-saving factor. The lower per-hectare costs in farms using no-till and strip-till confirm the economic feasibility of transitioning to minimal soil cultivation. This serves as a key argument for implementing resource-saving technologies in Kazakhstan's grain production, particularly given the rising prices of energy resources and the need to optimise agricultural enterprises' cost bases. The development of digital technologies in grain farming enhances the accuracy of agro-production process monitoring. The use of Big Data, AI, and Internet of Things enables the analysis of large volumes of data on crop conditions, moisture levels, and the need for fertilisers or plant protection products. Kazakhstan is expanding the use of automated crop monitoring systems, which ensure precise application of agrochemicals and minimise unproductive costs. The implementation of GPS navigation and remote field sensing sensors reduces yield losses by enabling timely responses to adverse factors. The introduction of automated management systems for agrotechnical processes is an important step towards improving efficiency and reducing costs in Kazakhstan's grain farming sector. These systems optimise resource use, lower expenditure on fuel, fertilisers, and plant protection products, and enhance labour productivity. Figure 3 presents a comparative analysis of cost structures before and after the introduction of automated management systems.

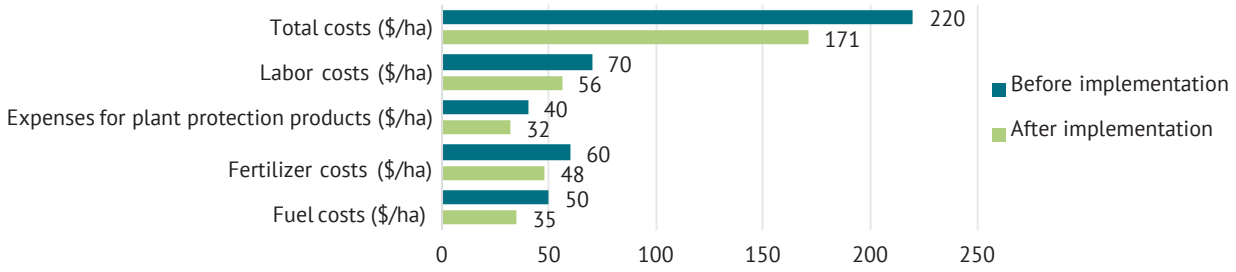

***Figure 3**. Changes in the cost base of farms following the implementation of automated agricultural process management systems*

***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

An analysis of the data presented in Figure 3 indicates a significant reduction in production costs following the introduction of automated systems. In particular, fuel costs decreased by 30%, which may be attributed to the optimisation of machinery routes and the reduction of unnecessary operations. Fertiliser and plant protection costs each decreased by 20%, indicating more precise dosing and targeted application of these resources due to automated systems. Labour costs also declined by 20%, likely resulting from the automation of routine processes and a reduced need for manual labour. Overall, the implementation of automated agricultural process management systems led to a 22.3% reduction in total costs per hectare. This highlights the economic feasibility of investing in such technologies to enhance the competitiveness and profitability of grain farms in Kazakhstan.

The impact of technological innovations on the cost base of farms is confirmed by statistical data, which show

a trend towards reducing production costs in farms that apply precision farming and automated systems. The reduction in fuel and lubricant expenses, along with optimised fertiliser and plant protection costs, contributes to lowering production costs by 10-15%. At the same time, integrating modern technologies ensures stable yield levels and allows farms to remain profitable even during adverse weather conditions. The development of digital platforms for agribusiness management contributes to reducing transaction costs and improving the efficiency of logistics operations in Kazakhstan's grain sector. The use of blockchain technologies to monitor grain supply chains enhances market transparency and reduces risks for producers. The improvement of technological processes, based on production data analysis, contributes to better yield predictability and cost optimisation. The expanded application of technological innovations in Kazakhstan's grain production ensures cost structure optimisation and more efficient resource use. The introduction of modern agrotechnologies helps reduce production costs, increase yields, and promote the long-term sustainability of the agricultural sector. This creates a foundation for further developing economically efficient farming models that ensure the stability of agricultural production in a competitive market environment.

Economic strategies for cost management in Kazakhstan's grain sector. The economic efficiency of grain farming largely depends on optimising costs related to production resources, transportation, storage, and product sales. Cost management involves implementing modern economic strategies aimed at improving resource efficiency and reducing production costs. In Kazakhstan, with its vast arable land and developed grain industry, key optimisation areas include cost standardisation, efficient land resource management, reducing transaction costs, and integrating digital technologies in logistics and grain marketing. Cost standardisation involves establishing optimal resource consumption norms per unit of land or production, helping to reduce overuse and improve production planning. The introduction of a differentiated approach to fertiliser and plant protection application, based on agrochemical soil analysis, minimises costs and enhances agrochemical efficiency (Sivojiene *et al.*, 2021). The use of remote sensing data in resource management enables more accurate assessment of plant water and nutrient needs.

The choice of soil tillage technology plays a crucial role in optimising the cost burden on Kazakhstan's grain farms. The cost of cultivating major crops largely depends on agroecological conditions, soil characteristics, and the intensity of applied technologies. The tillage method affects resource consumption, particularly fuel, fertilisers, and labour costs, ultimately determining the overall production cost (Dolia & Shevchenko, 2024). Table 2 presents a comparative analysis of wheat and barley cultivation costs depending on soil type and tillage technology.

Table 2. *Comparative analysis of grain crop cultivation costs in Kazakhstan by soil type and tillage technology*

Crop	Soil type	Tillage technology	Fuel costs ($/ha)	Fertilizer costs ($/ha)	Labour costs ($/ha)	Total costs ($/ha)
Winter wheat	Chernozem	Conventional	50	60	70	220
		No-till	35	48	56	171
	Chestnut	Conventional	55	65	75	235
		No-till	38	52	60	180
Spring barley	Chernozem	Conventional	45	55	65	205
		Strip-till	40	50	60	190
	Chestnut	Conventional	50	60	70	215
		Strip-till	42	53	63	195

Note: *chernozem soils are characterised by high natural fertility, significant humus content, and good water retention capacity, allowing for reduced fertiliser application and increased efficiency of traditional and minimal tillage technologies. Chestnut soils have lower humus levels, a higher tendency to dry out, and require additional fertiliser and moisture input to maintain stable yields. This results in higher cultivation costs for grain crops in such conditions, making no-till and strip-till technologies particularly suitable for conserving soil moisture and optimising production costs*

Source: *created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

The analysis of the data in Table 2 demonstrates that grain cultivation costs depend not only on the tillage technology used but also on soil type. On chestnut soils, total costs for both winter wheat and spring barley cultivation are higher compared to chernozem soils. This may be due to lower natural fertility, the need for increased fertiliser application, and additional measures to improve soil structure. At the same time, the introduction of minimal tillage technologies, particularly no-till and strip-till, contributes to cost reductions, making these technologies a viable option for resource-efficient farming. The application of no-till technology significantly reduces the costs of winter wheat cultivation regardless of soil type. This is due to lower fuel and

lubricant costs and reduced manual labour requirements resulting from fewer mechanical operations. The use of strip-till in spring barley production also demonstrates economic advantages, as it helps reduce fertiliser costs and optimise agrochemical use through localised application. Given the presented data, minimal tillage technologies can be recommended as an effective tool for reducing production costs and enhancing the resilience of agricultural production in Kazakhstan.

Optimising logistics costs is a key strategy for reducing total expenses in grain production. Transport costs can constitute a significant share of total costs, particularly given the large distances between production regions and export hubs. The use of automated logistics management systems enables route optimisation and minimises transport expenses. The construction of grain storage facilities close to production areas reduces interregional transportation needs and crop losses during transit. Minimising grain losses during harvesting and storage is another crucial economic aspect of cost management. The implementation of modern combine harvesters with loss control systems, automated aeration, and humidity control in grain storage facilities helps reduce product losses and improve quality (Kulazhanov *et al.*, 2024). The use of microclimate monitoring technologies in elevators contributes to optimising energy costs associated with drying and storing grain.

Reducing transaction costs is another area of production cost optimisation in Kazakhstan's grain sector. The consolidation of small and medium-sized farms into cooperative formations helps lower procurement, financing, and product marketing costs. The use of digital platforms for direct contracts between producers and consumers reduces intermediary costs and enhances price transparency in the grain market. Financial instruments such as crop insurance, credit financing, and government subsidies help mitigate risks and ensure production stability. Hedging mechanisms help reduce the impact of grain price fluctuations on farm profitability. Government support programmes, including subsidies for fertiliser purchases, machinery acquisition, and insurance, help alleviate the financial burden on producers. The introduction of digital platforms for grain sales has a significant impact on reducing transaction costs in agricultural enterprises. Digitalisation enables process automation, reduces the number of intermediaries, and increases transaction transparency. Figure 4 presents a comparative analysis of transaction costs in farms before and after the introduction of digital platforms.

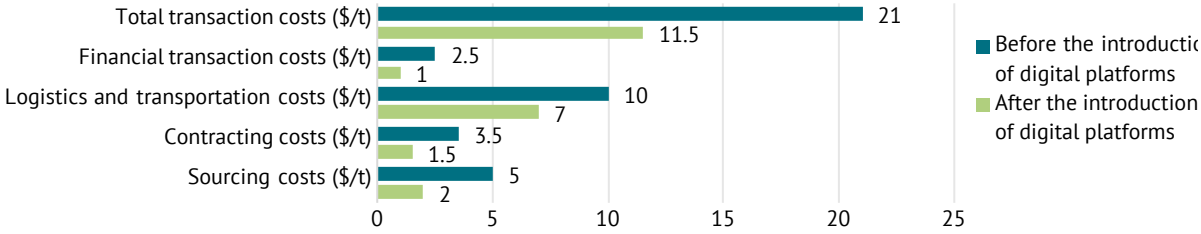

***Figure 4**. Comparative analysis of transaction costs in agricultural enterprises before and after the implementation of digital platforms for grain sales*

***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

An analysis of the statistical data presented in Figure 4 revealed that the introduction of digital platforms significantly reduces transaction costs in agricultural enterprises. Specifically, the costs associated with finding buyers decrease by 60%, demonstrating the effectiveness of digital solutions in establishing direct connections between producers and consumers. Contracting costs are reduced by 57% as digital platforms simplify and automate the documentation processes for agreements. Moreover, logistics and transportation costs decrease by 30% due to route optimisation and the use of modern supply chain management systems. Financial transaction costs drop by 60% thanks to the integration of electronic payment systems, ensuring fast and secure transactions. Overall, total transaction costs per ton of grain decline by 45%, enhancing the competitiveness of agricultural enterprises and contributing to their sustainable development. Thus, cost management in Kazakhstan's grain sector requires a comprehensive approach, including resource utilisation regulation, logistics optimisation, transaction cost reduction, and the adoption of modern digital technologies. The implementation of economically justified strategies increases the competitiveness of Kazakhstan's grain products and ensures the sustainable development of the agricultural sector in a fluctuating economic environment.

Recommendations for cost optimisation in Kazakhstan's grain sector. An analysis of the cost structure in Kazakhstan's grain sector has shown that the key factors influencing production costs are expenses for fuel, fertilizers, wages, transportation, and crop storage. The introduction of advanced agricultural technologies, digital solutions, and financial mechanisms can

significantly reduce production costs and improve the economic efficiency of farms. Given this, it is necessary to summarise the obtained data and assess the potential economic impact of implementing various cost optimisation strategies. Effective management of production resources requires a systematic approach that includes technological process modernisation, logistics improvements, and strengthening the financial stability of agricultural enterprises. To structure the results, Table 3 has been compiled, summarising the main cost optimisation strategies and their impact on key economic indicators.

***Table 3**. Key cost optimisation strategies in Kazakhstan's grain sector and their impact on economic indicators*

Optimisation strategy	Measures	Impact on economic indicators
Technological innovations	Adoption of precision farming, No-Till and Strip-Till technologies, automation of agro-technical processes	Reduction in fuel costs (-20-30%), fertilizer costs (-15-20%), and labor costs (-10-15%); decreased equipment wear
Rational resource management	Agrochemical soil analysis, targeted fertilizer and pesticide application, selection of adapted seeds	Reduction in fertilizer costs (-15%) and plant protection costs (-10%); increase in yield (+5-10%)
Logistics optimisation	Construction of grain storage facilities, optimisation of transportation routes, automated storage monitoring	Reduction of transport losses (-12-18%); decrease in logistics (-10-15%)
Financial mechanisms	State subsidies, crop insurance, preferential lending	Increase in modernisation investments (+15-20%); reduction of financial risks
Digital platforms	Trade automation, blockchain for transaction control, formation of cooperatives	Reduction in transaction costs (-40-50%); decrease in buyer search costs (-60%)

***Note:** all indicators are calculated based on statistical data analysis and expert evaluations regarding the impact of implemented technologies and economic measures in Kazakhstan's grain sector*
***Source:** created by the authors based on Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (n.d.), Food and Agriculture Organization (2024), Organisation for Economic Co-operation and Development (2023), World Bank (n.d.)*

Data analysis indicates that the greatest economic impact is achieved through technological innovations and digital solutions. In particular, the application of precision farming, No-Till, and Strip-Till technologies significantly reduces costs for fuel, fertilizers, and labour, increasing production profitability. The automation of agro-technical processes helps minimise equipment wear and extend its lifespan, reducing long-term depreciation costs. Optimisation of material resources, particularly the rational use of fertilizers and plant protection products, not only cuts costs but also enhances the environmental efficiency of farms. Targeted fertilizer application and adaptation of seed materials to local climate conditions contribute to preserving soil fertility, ensuring stable yields in the long run. At the same time, logistics solutions such as the construction of modern grain storage facilities and transportation automation help minimise product losses and improve its quality.

The use of financial mechanisms and digital platforms allows for significant reductions in operational costs and enhances product sales efficiency. State subsidies and preferential lending stimulate investments in agricultural sector modernisation, while digital platforms ensure market transparency and simplify contract agreements. This reduces transaction costs and improves access to international markets for Kazakhstan's grain. Overall, the implementation of comprehensive cost optimisation measures strengthens the financial stability of enterprises and solidifies Kazakhstan's position as a leading global grain producer.

DISCUSSION

The findings confirm that the implementation of modern technological and managerial solutions has contributed to the reduction of production costs in Kazakhstan's grain sector. Minimal tillage methods, particularly No-Till and Strip-Till, have helped lower fuel and equipment depreciation costs, as evidenced by statistical calculations. The automation of agro-technical processes has facilitated more efficient distribution of fertilizers and plant protection products, reducing expenses. Logistics optimisation, including improved transport routes and the development of grain storage facilities, has led to lower losses during storage and transportation. Economic cost management mechanisms, such as financial instruments and digital platforms, have decreased transaction costs and improved profitability. However, the efficiency of implemented measures varied depending on farm scale, regional characteristics, and access to innovative technologies, requiring adaptation of optimisation strategies to specific production conditions.

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The economic efficiency of the grain sector largely depended on logistics process optimisation and technological innovations (Kim *et al.*, 2025). The study by D. Prajapati *et al.* (2022) examined sustainable grain supply chain models, considering economic, environmental, and social factors such as transportation costs, carbon emissions, and product damage risks. This research focused on Kazakhstan's regional characteristics, the development level of grain logistics, and the digitalisation of supply processes. It was established that an integrated cost management approach contributed to reduced production costs, aligning with the conclusions of the analysed study, but with an added evaluation of specific financial and technological mechanisms in local conditions.

The development of digital financial mechanisms in agriculture helped reduce transaction costs and enhance the economic stability of Kazakhstan's grain enterprises. Similar issues were explored in the study by X. Guo *et al.* (2023), which assessed the impact of digital financial technologies on farmer incomes in China's leading grain regions. It was found that digital platforms improved access to credit resources, expanded entrepreneurial opportunities, and optimised financial flows. The difference in this research was the focus on the impact of digital technologies on the cost structure of grain production in Kazakhstan, particularly their role in financing the agricultural sector and improving product sales mechanisms.

Soil quality played a key role in increasing agroecosystem productivity and grain production efficiency. The study by I.C. Mendes *et al.* (2021) developed the Soil Quality Index for Fertility and Biological Assessment, combining chemical and biological indicators. It was found that optimal soil enrichment with organic carbon and macronutrients contributed to higher yields. While this research confirmed the effectiveness of various fertilisation methods, the main emphasis was on the economic impact of minimum tillage and precision farming technologies, ensuring cost optimisation in grain production. A key factor in the development of Kazakhstan's grain sector was not only the implementation of modern technologies but also the activation of entrepreneurial activity among farmers. The study by Y. Pan *et al.* (2024) examined the interaction between farmers' entrepreneurship and economic growth in China's agricultural sector, showing that innovative entrepreneurial activity contributed to regional economic development in areas with similar urbanisation levels. The analysis confirmed the importance of entrepreneurship in agriculture, aligning with the findings of this study. However, Kazakhstan's research focused on cost optimisation mechanisms through digital financial tools and logistics improvements, complementing conclusions of Y. Pan *et al.*

The effective functioning of the grain industry was determined by the choice of farming system, which influenced both cost levels and the long-term stability of agricultural production. The study by G. Han *et al.* (2021) found that the main motives for Iowa (USA) farmers transitioning to organic farming were economic benefits, environmental responsibility, occupational safety, and traditional farming methods. The analysis confirmed that most farmers considered this transition justified, although the public health aspect did not always meet expectations. The study of Kazakhstan took into account the economic feasibility of implementing modern agro-technologies; however, the primary focus was on cost optimisation through digitalisation and the introduction of precision farming technologies.

The sustainability of the grain industry depended not only on economic and technological factors but also on social aspects, particularly the issue of generational renewal among farmers (Yaheliuk *et al.*, 2024). The study by S.F. Conway *et al.* (2021) analysed the influence of the behavioural patterns of older generations of farmers on the transfer of farms to the next generation. The authors found that financial incentives were not always effective due to the deeply rooted perception of farming as a lifelong profession, which complicated the process of exiting the sector. The study confirmed that the workforce structure of farms influenced cost management efficiency and readiness to implement modern technologies. Unlike S.F. Conway *et al.*, the main focus was on economic and technological factors in cost optimisation; however, the obtained results indicated the necessity of considering demographic trends when developing long-term strategies for the development of Kazakhstan's grain industry.

The integration of digital technologies into Kazakhstan's grain industry was viewed as one of the key tools for improving cost management efficiency and optimising production processes. The study by C. Ayim *et al.* (2022) confirmed the effectiveness of information and communication technologies in enhancing farmers' access to agronomic information, although their implementation was limited by low digital literacy and weak infrastructure. Cost analysis in Kazakhstan's grain industry demonstrated that the use of Big Data, artificial intelligence, and automated platforms contributed to reducing production costs through more precise resource allocation. A distinctive feature of this study was its focus on the economic efficiency of digital solutions, assessing their real impact on the cost structure of the agricultural sector.

Technological innovations also played an important role in increasing the productivity and sustainability of the grain industry (Bulgakov *et al.*, 2020). The study by N. Khan *et al.* (2021) examined the potential of modern technologies, such as the Internet of Things, artificial intelligence, and autonomous systems, in transforming food systems. The authors emphasised the importance of appropriate regulatory policies for the successful implementation of innovations. The conducted study confirmed the effectiveness of digital technologies in reducing costs in Kazakhstan; however, the main emphasis was on modelling cost structures and assessing the profitability of innovations, taking regional characteristics into account.

Logistical processes were critical to the efficiency of the grain industry, as transportation and storage of grain accounted for a significant share of costs. The study by E. Mardaneh *et al.* (2021) proposed a decision-support system for selecting optimal grain storage and distribution strategies. It was found that storing the harvest directly on farms contributed to reducing losses and increasing profitability. The study confirmed the importance of logistical solutions in reducing costs in Kazakhstan while also focusing on regional infrastructure characteristics and the digitalisation of supply processes. The preservation of grain quality largely depended on the efficiency of logistical solutions. The study by Y.J. Kim and B.K. Lee (2022) analysed containerised logistics as an alternative to traditional grain storage and transportation, identifying its advantages in reducing losses due to spoilage and pest infestation. However, the authors noted that containerised logistics required significant initial investments. The study confirmed the feasibility of improving logistical processes in Kazakhstan, but the main focus was on assessing the financial efficiency of different transportation approaches and the potential of digital platforms in supply chain management.

Rationalising grain storage was a crucial factor in cost optimisation in the grain industry. The study by K.A. Rosentrater (2022) examined the economic aspects of storage, including the choice between on-farm storage and terminal elevators, as well as the impact of storage on overall production profitability. The author emphasised that investments in grain storage should be economically justified, considering market prices and planning horizons. The conducted study confirmed that an effective storage system contributed to reducing losses and increasing the profitability of farms in Kazakhstan; however, the focus was on adapting digital technologies to inventory management.

Enhancing the sustainability of the grain industry required a comprehensive approach that included not only economic efficiency but also environmental aspects. The study by A. Gohin (2023) evaluated the ability of the French food system to adapt to the European Union's Green Deal requirements, particularly regarding the reduction of fertilizer and pesticide use. It was found that such changes were possible without significant economic losses for farmers, provided there was effective government support. The conducted study considered similar aspects, but the emphasis was on adapting cost optimisation strategies to Kazakhstan's agro-climatic conditions, the availability of financial mechanisms, and the role of digital technologies in reducing production costs. Assessing the impact of technological innovations and climatic factors is an important aspect of the sustainability of the grain industry (Krychkovska *et al.*, 2025). The study by I.A. Baig *et al.* (2024) used econometric analysis to identify a positive correlation between rainfall levels, CO_2 emissions, and wheat yields, as well as the significant effect of modern agro-technologies. The study of Kazakhstan assessed the impact of precision farming and automated systems, focusing on their economic feasibility. Unlike I.A. Baig *et al.*, the primary emphasis was on financial mechanisms that facilitated cost structure optimisation.

Macroeconomic factors determined the strategies for developing the agricultural sector. The study by Â. Belletti and S. Schneider (2023) analysed Brazil's and China's export relations, considering institutional factors and Food Regimes. Kazakhstan also studied macroeconomic aspects, including government regulation and market fluctuations. The difference was the focus on regional mechanisms for cost optimisation. The impact of macroeconomic variables on agricultural production was assessed in S.B. Akpan and A.A. Umoren (2021), where the ARDL model showed that, in the long term, key determinants were per capita income, land use density, the consumer price index, and the exchange rate. The study of Kazakhstan also examined cost dynamics, credit accessibility, and government support, but the main emphasis was on technological and logistical solutions for cost optimisation, complementing the findings of S.B. Akpan and A.A. Umoren.

The study confirmed that the implementation of technological innovations, logistics optimisation, and the use of digital financial mechanisms contributed to cost reduction in Kazakhstan's grain industry. Methods of minimal tillage, automation of agro-technical processes, digital platforms, and improvements in logistical solutions ensured increased production efficiency, reduced losses, and lower transaction costs. At the same time, macroeconomic factors, such as government regulation, financial support, and market fluctuations, influenced the stability of the sector. The obtained results aligned with international research findings; however, the emphasis was placed on regional specifics and the economic feasibility of implementing innovative solutions in local conditions.

CONCLUSIONS

The study demonstrated a new approach to cost optimisation in Kazakhstan's grain industry through a

comprehensive analysis of cost structures, an assessment of the impact of technological and economic factors, and the modelling of strategies for their reduction. The obtained results made it possible to establish interconnections between key cost components, the level of mechanisation of production processes, and the application of innovative technologies, which contributed to substantiating ways to improve the economic efficiency of the sector. The analysis of cost structures in Kazakhstan's grain industry showed that the largest share of total costs was attributed to material resources, particularly fertilizers, seeds, and plant protection products, due to the need to maintain stable yields and adapt to changing agro-climatic conditions. At the same time, a trend of decreasing labour costs was observed, indicating a gradual increase in mechanisation and automation. Regional differences in cost structures were identified, depending on resource accessibility, soil-climatic characteristics, and the adoption of modern agro-technologies.

Research on technological innovations has shown that the implementation of minimum tillage, particularly No-Till and Strip-Till, allowed for a reduction in fuel costs by 50-60%, depreciation expenses by 20-25%, and labour costs by 15-20%. The use of automated agricultural management systems contributed to a more efficient allocation of resources, ensuring a reduction in fertilizer and plant protection costs by 18-22%. The evaluation of economic cost management strategies confirmed the effectiveness of financial mechanisms, logistical solutions, and digital platforms. Optimising logistics through the improvement of transport routes and the construction of grain storage facilities reduced product losses during transportation by 12-18% and overall logistics costs by 10-15%. The use of digital platforms facilitated a reduction in transaction costs by 40-50% and a decrease in buyer search costs by 60%, thereby enhancing the competitiveness of grain products.

The research faced several limitations, including insufficient statistical data detailing, which complicated the assessment of long-term changes in cost structures. The analysis of technological innovations was based on selective data, which might have affected the representativeness of the results. The impact of state support and regulatory mechanisms on cost optimisation requires further study. Additionally, climate risks, which can significantly influence the effectiveness of implemented measures in the future, were not fully considered. The developed recommendations for cost optimisation in Kazakhstan's grain farming sector included the adoption of modern technologies, adaptation of logistical schemes, and the expansion of digital solutions for production process management and product marketing. Future research may focus on assessing the long-term impact of technological changes on the cost of grain production, adapting economic strategies to various agricultural production models, and developing mechanisms to enhance the efficiency of state support for the agricultural sector.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Akpan, S.B., & Umoren, A.A. (2021). Agricultural production indicators and the dynamic macroeconomic variables in Nigeria: ARDL model approach. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 21(3), 111-124.

[2] Angon, P.B., Anjum, N., Akter, M.M., Shreejana, K.C., Suma, R.P., & Jannat, S. (2023). An overview of the impact of tillage and cropping systems on soil health in agricultural practices. *Advances in Agriculture*, 2023, article number 8861216. doi: 10.1155/2023/8861216.

[3] Ayim, C., Kassahun, A., Addison, C., & Tekinerdogan, B. (2022). Adoption of ICT innovations in the agriculture sector in Africa: A review of the literature. *Agriculture & Food Security*, 11, article number 22. doi: 10.1186/s40066-022-00364-7.

[4] Baig, I.A., Mohammad, S., Akram, V., Chandio, A.A., & Gupta, Y. (2024). Examining the impacts of climatological factors and technological advancement on wheat production: A road framework for sustainable grain production in India. *Environment, Development and Sustainability*, 26(5), 12193-12217. doi: 10.1007/s10668-023-03746-4.

[5] Belletti, Â., & Schneider, S. (2023). The relationship between agri-food production and macro-economic dynamics: A study on soybeans in Brazilian south and Chinese mainland. *Agricultural & Rural Studies*, 1(2), article number 0009. doi: 10.59978/ar01020009.

[6] Bulgakov, V., Nikolaenko, S., Holovach, I., Adamchuk, V., Kiurchev, S., Ivanovs, S., & Olt, J. (2020). Theory of grain mixture particle motion during aspiration separation. *Agronomy Research*, 18(1), 18-37. doi: 10.15159/AR.20.057.

[7] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. (n.d.). *Statistics of agriculture, forestry, hunting and fishery sector*. Retrieved from https://stat.gov.kz/en/industries/business-statistics/stat-forrest-village-hunt-fish/.

[8] Codex Alimentarius. (1963). Retrieved from https://www.fao.org/fao-who-codexalimentarius/home/en/.
[9] Conway, S.F., McDonagh, J., Farrell, M., & Kinsella, A. (2021). Going against the grain: Unravelling the habitus of older farmers to help facilitate generational renewal in agriculture. *Sociologia Ruralis*, 61(3), 602-622. doi: 10.1111/soru.12355.
[10] Dolia, S., & Shevchenko, M. (2024). Influence of primary tillage on some soil fertility indicators and corn yield. *Ukrainian Black Sea Region Agrarian Science*, 28(2), 33-41. doi: 10.56407/bs.agrarian/2.2024.33.
[11] Food and Agriculture Organization. (2024). *The state of food and agriculture*. Retrieved from https://www.fao.org/publications/fao-flagship-publications/the-state-of-food-and-agriculture/en.
[12] Gohin, A. (2023). On the sustainability of the French food system: A macroeconomic assessment. *Applied Economic Perspectives and Policy*, 45(2), 860-880. doi: 10.1002/aepp.13277.
[13] Gumarova, Z.M., Bulekova, A.A., Kushenbekova, A.K., Mukhomedyarova, A.S., Gubasheva, B.E., Jigildiyeva, Z.G., Sarsengaliyev, R.S., & Utegalieva, N.K. (2025). Optimizing tillage systems and cultivation practices for enhancing productivity of dark chestnut soils in Northwestern Kazakhstan. *International Journal of Agriculture and Biosciences*, 14(1), 164-171. doi: 10.47278/journal.ijab/2024.206.
[14] Guo, X., Wang, L., Meng, X., Dong, X., & Gu, L. (2023). The impact of digital inclusive finance on farmers' income level: Evidence from China's major grain production regions. *Finance Research Letters*, 58, article number 104531. doi: 10.1016/j.frl.2023.104531.
[15] Han, G., Arbuckle, J.G., & Grudens-Schuck, N. (2021). Motivations, goals, and benefits associated with organic grain farming by producers in Iowa, US. *Agricultural Systems*, 191, article number 103175. doi: 10.1016/j.agsy.2021.103175.
[16] International Grains Council. (n.d.). *Grain market report*. Retrieved from https://www.igc.int/en/gmr_summary.aspx.
[17] Jiang, S., Wang, Q., Zhong, G., Tong, Z., Wang, X., & Xu, J. (2021). Brief review of minimum or no-till seeders in China. *AgriEngineering*, 3(3), 605-621. doi: 10.3390/agriengineering3030039.
[18] Kenenbaev, S.B., Yesenbayeva, G.L., & Yelnazarkyzy, R. (2021). Resource-saving farming systems in the southeast of Kazakhstan. *Natural Volatiles & Essential Oils*, 8(4), 7938-7949.
[19] Khan, N., Ray, R.L., Kassem, H.S., Hussain, S., Zhang, S., Khayyam, M., Ihtisham, M., & Asongu, S.A. (2021). Potential role of technology innovation in transformation of sustainable food systems: A review. *Agriculture*, 11(10), article number 984. doi: 10.3390/agriculture11100984.
[20] Kim, S.-C., Chung, J.-K., Trusova, N., Akhmetova, Z., & Musayeva, N. (2025). Simulating global supply chain reverberations from Ukrainian grain shipment interruptions. *Revista Iberoamericana de Viticultura Agroindustria y Ruralidad*, 12(34), 192-207. doi: 10.35588/3c9rjg57.
[21] Kim, Y.J., & Lee, B.K. (2022). Containerized grain logistics processes for implementing sustainable identity preservation. *Sustainability*, 14(20), article number 13352. doi: 10.3390/su142013352.
[22] Kokenova, A.E., Beisenova, M.U., Shalbayeva, A.P., Maulenberdieva, G.A., & Moldalieva, R.N. (2022). Improving the efficiency of grain production by improving management processes. *Scientific Journal "Bulletin of NAS RK"*, 2, 343-355. doi: 10.32014/2022.2518-1467.291.
[23] Krychkovska, L., Bobro, M., Birta, G., Karpushyna, S., & Grytzaenko, Yu. (2025). Application of biologically active substances in agriculture preparations. *Plant and Soil Science*, 16(1), 9-22. doi: 10.31548/plant1.2025.09.
[24] Kulazhanov, T., Uazhanova, R., Baybolova, L., Yerzhigitov, Y., Kemerbekova, A., Tyutebayeva, K., Izembayeva, A., & Zhengiskyzy, S. (2024). Ensuring quality and safety in the production and storage of grain crops. *Caspian Journal of Environmental Sciences*, 22(5), 1279-1284. doi: 10.22124/cjes.2024.8343.
[25] Mardaneh, E., Loxton, R., Meka, S., & Gamble, L. (2021). A decision support system for grain harvesting, storage, and distribution logistics. *Knowledge-Based Systems*, 223, article number 107037. doi: 10.1016/j.knosys.2021.107037.
[26] Mendes, I.C., Sousa, D.M., Dantas, O.D., Lopes, A.A., Junior, F.B., Oliveira, M.I., & Chaer, G.M. (2021). Soil quality and grain yield: A win-win combination in clayey tropical Oxisols. *Geoderma*, 388, article number 114880. doi: 10.1016/j.geoderma.2020.114880.
[27] Olorunfemi, B.J., & Kayode, S.E. (2021). Post-harvest loss and grain storage technology – a review. *Turkish Journal of Agriculture-Food Science and Technology*, 9(1), 75-83. doi: 10.24925/turjaf.v9i1.75-83.3714.
[28] Organisation for Economic Co-operation and Development. (2023). *Agricultural policy monitoring and evaluation 2023: Adapting agriculture to climate change*. Retrieved from https://surl.li/kfccbx.
[29] Pan, Y., Zhang, S., & Zhang, M. (2024). The impact of entrepreneurship of farmers on agriculture and rural economic growth: Innovation-driven perspective. *Innovation and Green Development*, 3(1), article number 100093. doi: 10.1016/j.igd.2023.100093.
[30] Prajapati, D., Chan, F.T., Daultani, Y., & Pratap, S. (2022). Sustainable vehicle routing of agro-food grains in the e-commerce industry. *International Journal of Production Research*, 60(24), 7319-7344. doi:10.1080/00207543.2022.2034192.

[31] Rosentrater, K.A. (2022). Economics of grain storage. In *Storage of cereal grains and their products* (pp. 687-696). London: Woodhead Publishing. doi: 10.1016/B978-0-12-812758-2.00005-2.
[32] Różewicz, M. (2022). Review of current knowledge on strip-till cultivation and possibilities of its popularization in Poland. *Polish Journal of Agronomy*, 49, 20-30. doi: 10.26114/pja.iung.488.2022.49.03.
[33] Sembayeva, A.S., Ospanbayev, Z.H., Zhapayev, R.K., Kenenbayev, S.B., Pejic, B., Kunypiyaeva, G.T., Doszhanova, A.S., & Bekbauov, M. (2025). Corn hybrids assessment for grain yield under the soil tillage regimes and drip irrigation in Southeast Kazakhstan. *Journal of Breeding and Genetics*, 57(1), 46-55. doi: 10.54910/sabrao2025.57.1.5.
[34] Sivojiene, D., Kacergius, A., Baksiene, E., Maseviciene, A., & Zickiene, L. (2021). The influence of organic fertilizers on the abundance of soil microorganism communities, agrochemical indicators, and yield in East Lithuanian light soils. *Plants*, 10(12), article number 2648. doi: 10.3390/plants10122648.
[35] Suleimenova, N., Orynbasarova, G., Suleimenova, M., Bozhbanov, A., & Yerekeyeva, S. (2021). Environmental monitoring of the sustainability and productivity of the agroecosystem of oilseeds in South-East Kazakhstan. *Journal of Ecological Engineering*, 22(7), 89-99. doi: 10.12911/22998993/139114.
[36] Tadjiev, A., Djanibekov, N., & Herzfeld, T. (2023). Does zero tillage save or increase production costs? Evidence from smallholders in Kyrgyzstan. *International Journal of Agricultural Sustainability*, 21(1), article number 2270191. doi: 10.1080/14735903.2023.2270191.
[37] Taishykov, Z., Tolysbayev, B., Kuantkan, B., Koichubayev, A., & Baigabulova, K. (2023). Innovation management in agricultural production in Kazakhstan. *CABI Reviews*. doi: 10.1079/cabireviews.2023.0022.
[38] Tolepbergen, A. (2022). The role of labor market structure and shocks for monetary policy in Kazakhstan. *International Journal of Economic Policy Studies*, 16(1), 179-210. doi: 10.1007/s42495-021-00073-2.
[39] Turebayeva, S., Zhapparova, A., Yerkin, A., Aisakulova, K., Yesseyeva, G., Bissembayev, A., & Saljnikov, E. (2022). Productivity of rainfed winter wheat with direct sowing and economic efficiency of diversified fertilization in arid region of South Kazakhstan. *Agronomy*, 12(1), article number 111. doi: 10.3390/agronomy12010111.
[40] World Bank. (n.d.). *Kazakhstan overview: Development news, research, data*. Retrieved from https://www.worldbank.org/en/country/kazakhstan/overview.
[41] Yaheliuk, S., Fomych, M., & Rechun, O. (2024). Global market trends of grain and industrial crops. *Commodity Bulletin*, 17(1), 134-145. doi: 10.62763/ef/1.2024.134.
[42] Zhapayev, R.K., Kunypiyaeva, G.T., Mustafaev, M.G., Doszhanova, A.S., Isabay, B.T., Maybasova, A.S., Isabay, B.T., Myrzabayeva, G.A., & Omarova, A.Sh. (2023). Different tillage regimes' effect on soil-water physical and agrochemical properties under the environmental conditions of Southeast Kazakhstan. *Journal of Breeding and Genetics*, 55(5), 1831-1842. doi: 10.54910/sabrao2023.55.5.34.

Структура витрат у зерновому господарстві Казахстану та методи її оптимізації

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Анотація. Оптимізація витрат у зерновому господарстві Казахстану є актуальною проблемою, зумовленою необхідністю підвищення економічної ефективності сільськогосподарського виробництва в умовах зростання вартості ресурсів і посилення конкуренції на міжнародному ринку. Метою даного дослідження було обґрунтування підходів до зниження витрат у зерновому господарстві шляхом аналізу структури витрат та оцінки ефективності технологічних і економічних заходів. Для оцінки ефективності різних виробничих стратегій було використано методи варіаційної статистики, регресійного аналізу, економетричного моделювання, аналізу витрат і вигод, а також розрахунки інвестиційної прибутковості. Результати дослідження показали, що ключовими напрямками оптимізації витрат є впровадження технологій мінімального обробітку ґрунту, зокрема систем no-till та strip-till, автоматизація агротехнічних процесів, раціональне використання добрив та засобів захисту рослин, а також використання цифрових платформ для продажу продукції. Аналіз статистичних даних за 2020-2024 роки показав, що впровадження технологій мінімального обробітку ґрунту сприяло скороченню витрат на паливо на 50-60 %, амортизаційних витрат на техніку – на 20-25 %, витрат на оплату праці – на 15-20 %. Автоматизовані системи управління сільським господарством дозволили скоротити витрати на добрива та засоби захисту рослин на 18-22 % завдяки точному розподілу ресурсів. Оптимізація логістичних процесів та будівництво зерносховищ сприяли скороченню втрат продукції під час транспортування на 12-18 % та зменшенню логістичних витрат на 10-15 %. Використання цифрових платформ для продажу продукції забезпечило скорочення транзакційних витрат на 40-50 %, а витрат на пошук покупців – на 60 %. Загальний ефект від впровадження запропонованих заходів дозволив знизити собівартість виробництва зерна на 12-17 %, залежно від масштабу господарства та застосованих технологій. Запропоновані рекомендації спрямовані на зниження виробничих витрат, забезпечення фінансової стабільності аграрного сектору та підвищення конкурентоспроможності зернового господарства Казахстану

Ключові слова: економічна ефективність; технологічні інновації; мінімальний обробіток ґрунту; автоматизація сільського господарства; управління ресурсами