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APPLICATION OF ECONOMIC AND MATHEMATICAL MODELING FOR MANAGING THE PRODUCTION AND ECONOMIC ACTIVITIES OF AGRICULTURAL ENTERPRISES

Abstract: *For the purposes of long-term and strategic planning of the country's food security, the optimal use of land resources represents one of the key tasks of modern agricultural management. Efficient allocation and rational involvement of land in economic circulation form the foundation of a sustainable food balance, reduce dependence on external factors, and enhance the adaptive capacity of the agricultural sector to changing climatic and economic conditions.*

From a scientific standpoint, the careful use of land resources is not just a way to raise agricultural productivity. It also plays a key role in strengthening a country’s overall food security. When land is managed wisely, it helps maintain a realistic balance between economic goals, environmental limitations, and the needs of rural communities. This balance is essential for the long-term stability of agricultural landscapes and for supporting sustainable development in rural regions.

This study is aimed at developing an economic and mathematical model for managing the production and economic activities of agricultural enterprises specializing in livestock farming. The article examines forecasting, planning, and optimization methods aimed at increasing the profitability of agricultural enterprises, improving feed production, and preserving soil fertility. Implementation of the proposed model will make it possible to minimize risks, enhance the efficiency of land resource management, and contribute to the sustainable development of agriculture.

Key words: *economic and mathemeatical modeling, management, prodconomic and mathemeatical modeling, management, production and economic activity, agricultural enterprises, land resources, planning, optimization, efficiency criteria.*

Introduction

Modern agriculture operates under conditions of substantial uncertainty driven by shifting climatic parameters, volatile market prices, limited resource availability, and rising production costs. Within this context, the application of economic-mathematical modeling becomes an essential tool for evidence-based managment of production and economic processes. Such models provide a framework for quantitatively assessing the interactions among production, economic, and environmental-climatic factors, thereby supporting the development of optimal management strategies. This includes improving decision-making in resource allocation, crop structure planning, forage production organization, and the regulation of livestock systems [1-2].

Economic-mathematical modeling alsi provides a basis for determining the optimal balance among labor, land, material, and financial resources, enabling producers to minimize production costs and icrease costs and increase output per unit of input. One of the key areas of application of such models is the forecasting of economic performance in agricultural enterprises. Through mathematical analysis, it becomes possible to evaluate the consequences of alternative development scenarios in advance, estimate expected yields, production costs, and profitability under shifting market or environmental conditions.

Another important function of these models involves reducing production and financial risks. Modeling tools make it possible to identify critical factors that contribute to instability within production cyckes and develop adaptive strategies aimed at enchancing the resilience of agricultural sector by supporting rational land and natural resource use, promoting long-term soil fertility preservation, and reinforcingnational food security [3].

The adoption of this approach not only increases the economic efficiency of agricultural production but also establishes scientifically grounded prerequisites for transitioning toward a more sustainable, stable, and competitive model of agrarian developmant.

One of the persistent challenges in Kazakhstans agricultural sector is the limited level of funding allocated to scientific research. In many developed countries, agricultural science receives substantial state and private-sector investment; for example, annual public support for agricultural research in the United States exceeds USD 1 billion. In comparison with developed economies, Kazakhstan continues to experience a number of structural limitations that constrain the large-scale deployment of innovative technologies and impede the effective commercialization of research results. These systemic challenges significantly delay the practical application of advanced economic and mathematical tools in the management of agricultural enterprises, thereby limiting the sector’s overall competitiveness and technological modernization [4-5].

Economic and mathematical modeling serves as an essential analytical mechanism for agricultural management, providing structured tools for optimizing planning processes, allocating resources efficiently, and forecasting key economic indicators. Contemporary scientific literature presents a broad range of modeling approaches applied to agricultural systems. In particular, studies by S.N. Volkov, V.D. Kiryukhin, and A.A. Varlamov emphasize macroeconomic modeling frameworks aimed at analyzing and forecasting the development of the agro-industrial sector at the national level. However, such approaches are largely oriented toward state regulation and strategic planning, offering limited applicability for operational management and decision-making at the level of individual agricultural enterprises.

The design of effective management models for agricultural enterprises in Kazakhstan must be grounded in several fundamental methodological principles. First, a systems-based perspective is required to ensure an integrated assessment of production, economic, and environmental interdependencies. Second, the proposed models should exhibit sufficient flexibility to allow for the evaluation of alternative production and market scenarios under changing external conditions. Third, decision-making processes must be guided by optimization principles that rely on formalized mathematical methods and quantitative performance criteria.

According to the classification developed by V.E. Kulikov, economic and mathematical models can be differentiated across multiple dimensions. Based on their functional orientation, models are divided into theoretical-analytical frameworks, which investigate underlying economic patterns, and applied models designed to address specific managerial objectives. From the perspective of analytical scale, models may operate at the microeconomic level, focusing on enterprise-level decision-making, or at higher levels associated with sectoral regulation. In terms of methodological structure, models may take the form of optimization systems, simulation-based approaches, or game-theoretic models capable of reflecting competitive dynamics and risk-related interactions.

Within the scope of this study, an economic and mathematical management model is developed with consideration of the structural characteristics of Kazakhstan’s agricultural sector, encompassing both crop production and livestock farming. The proposed framework integrates several core analytical elements, including: optimization of crop allocation to support balanced forage production; forecasting of economic performance based on historical data and trend analysis; assessment of climatic and meteorological impacts on productivity and resource utilization; and evaluation of profitability under alternative land-use and management strategies.

The practical implementation of the proposed model is expected to reduce managerial uncertainty and enhance the quality of decision-making processes within agricultural enterprises. In the long term, this approach may contribute to strengthening economic sustainability, improving operational efficiency, and increasing resilience to external environmental and market-related risks.

Methodology of Related Work

In examining existing approaches to optimization in agricultural management, T.N. Belov emphasizes that traditional modeling practices in the sector predominantly rely on economic-mathematical models aimed at improving isolated technological processes such as the allocation of mineral fertilizers, the planning of machine and tractor fleets, and other narrowly focused operations [6]. Contemporary studies largely support this observation: many researchers continue to develop models that address only specific segments of production and economic activity. However, the absence of an integrated systems perspective significantly limits the practical applicability and overall effectiveness of such methods.

A strategically important direction in the optimization of agricultural management involves constructing models that ensure a coherent balance between herd age structure, scientifically grounded feeding regimes, efficient organization of forage production, and the capacity of livestock enterprises to meet their feed requirements under conditions of restricted land resources. Solving these interrelated tasks in a coordinated manner enhances reproductive performance, increases livestock productivity, and contributes to achieving superior economic outcomes.

Focusing solely on localized managerial tasks without considering the systemic interconnections among various components of agricultural production does not allow the shortcomings of traditional approaches to be adequately addressed. Ultimately, this lack of integration undermines the overall economic efficiency and sustainability of agricultural enterprises [7].

One of the major challenges in constructing management models for the agricultural sector lies in accounting for the multifactorial nature of the production environment. The variables influencing the production and economic performance of agricultural enterprises may be grouped into several broad categories:

1. Environmental and climatic conditions, including soil productivity, thermal characteristics, precipitation patterns, and other relevant meteorological variables that influence agricultural output.
2. Biological determinants, which comprise the biological properties of cultivated plant species, the quality and viability of seed material, as well as the genetic potential and physiological traits of livestock.
3. Zootechnical characteristics, reflecting herd size and structure, the condition and sufficiency of the feed base, and the effectiveness of feeding and animal maintenance systems.
4. Agrotechnical parameters, encompassing crop rotation practices, scheduling and methods of agricultural operations, and the degree of technical equipment and mechanization employed in production processes.
5. Economic and organizational factors, including the structure of production management, availability and utilization of machinery, labor resources, and financial support mechanisms.

A second significant methodological issue in economic-mathematical modeling concerns the selection of an appropriate optimality criterion. The scientific literature presents a variety of approaches to defining objective functions. N.Ya. Pridatko and V.I. Rotar emphasize minimizing labor inputs andmaximizing the diversity of agricultural outputs [7]. D.B. Yudin proposes minimizing the absolute deviation of net income from its average expected value [8].Ts.E. Bochvarov suggests maximizing enterprise net income while explicitly incorporating expected economic gains and risks, associated with shortages or surpluses of labor resources [9].

Notwithstanding the conceptual diversity of existing approaches, profitability continues to be the most widely used optimality criterion in economic-mathematical models applied to the management of agricultural enterprises. This indicator remains central due to its direct relevance to assessing economic efficiency and managerial performance.

With the aim of identifying an optimal management solution, the present study proposes an economic-mathematical model focused on enhancing production and economic decision-making in agricultural enterprises with a specialization in livestock production [10–11]. The core objective of the model is to maximize gross income, defined as the difference between the total value of produced output and the cumulative material expenditures incurred during its production over a planning horizon of L years following the base period. The base year corresponds to the point at which the optimization procedure is initiated.

An analysis of existing economic-mathematical models designed to support managerial decisions in agricultural production reveals a number of methodological limitations. These deficiencies indicate the need for a more comprehensive and structurally refined modeling framework capable of capturing the specific features of agricultural systems.

The most significant shortcomings identified in prior studies include the following:

– Inadequate consideration of land resource characteristics. Many models do not sufficiently account for key land parameters, including soil composition and its classification into agro-groups based on qualitative indicators; the historical use of individual land plots, which directly affects soil productivity and yield potential; and the duration of uninterrupted cultivation of specific crops on the same fields, a factor that plays a crucial role in maintaining soil fertility.

– Insufficient attention to long-term crop planning. A number of existing approaches neglect crop rotation requirements and scientifically justified rotational farming principles, resulting in inefficient land utilization and reduced sustainability of production systems.

– Excessive simplification of production processes. In several cases, mathematical descriptions of agricultural production are overly generalized or conceptually inaccurate, which can distort analytical outcomes and lead to suboptimal management decisions.

Economic-mathematical modeling remains a highly effective tool for strengthening the financial stability and operational efficiency of agricultural enterprises. However, these enterprises typically function under strict limitations related to labor availability, material inputs, financial resources, and access to information. According to official statistics as of January 1, 2024, agricultural organizations in the Ayyrtau District of the North Kazakhstan Region employed approximately 18,000 individuals, representing a decline of nearly 55% compared to 2001.

In the crop production sector, persistent shortages of modern equipment for primary processing continue to pose a serious challenge. These include sorting, washing, packaging machinery, weighing systems, and other essential technological facilities required for efficient post-harvest handling. The restricted availability of high-capacity agricultural machinery, combined with the substantial physical deterioration of existing equipment, limits production expansion, reduces overall sector efficiency, and adversely affects product quality.

As a result, agricultural producers face significant barriers in effectively managing production and economic activities, as well as in adopting advanced scientific developments, innovative technologies, and best agricultural practices within real operational conditions [12–13].

In this context, the development of comprehensive economic–mathematical models becomes essential for conducting an in-depth analysis of the factors that influence production and economic management in agricultural enterprises. Such models must incorporate multi-factor assessments, including indicators of managerial efficiency, profitability levels, and the interdependence between production processes, economic conditions, and natural–environmental variables.

One of the most significant cost-free reserves for maintaining and enhancing soil fertility is the optimization of crop-area structure, which enables rational land use and strengthens the sustainability of agricultural production systems. As part of the search for optimal managerial solutions, the study proposes the development of an economic–mathematical model aimed at improving production and economic management in agricultural enterprises specializing in livestock production.

The model's objective function focuses on maximizing gross income, defined as the difference between the total gross output and the aggregate material costs incurred for its production over L years following the base year [14-15]. The base year is considered to be the year in which the optimization procedure is conducted.

Mathematical Formulation:

1. To find the maximum of the objective function

$$L(x) = B(x) - Z(x) \tag{1}$$

where x is a set of positive real numbers

$$x = x_{i,j,k,l,p}, y_{i,l}^{u}, z_{i,l}^{u} \tag{2}$$

$x_{i,j,k,l,p}$– the area allocated to crop *i* on land category *k*, grown *p* years after crop *j* in year *l* [ha];
$y_{i,l}^{u}$ - the volume of crop *i* used as feed for dairy cattle within the farm in year *l* [centners];
$z_{i,l}^{u}$ - the volume of crop *i* used as feed for beef cattle within the farm in year *l* [centners];
$k = 0,1,\ldots,K-1$– index of land category;
$i = 0,1,\ldots,I-1$– index of the agricultural crop;
$j = 0,1,\ldots,I-1,\ j \neq i$– index of the agricultural crop that was grown on the given land plot prior to crop i;
$p = 0,1,\ldots,P_i-1$– number of years crop *i* can be grown on the same plot, equal to $p+1$;
$l = 0,1,\ldots,L-1$– number of years after the baseline year for which optimization is performed, equal to $l+1$.
The baseline year corresponds to the formal value $l = -1$.

2. Structure of Gross Income

$$B(x) = \sum_{i,j,k,l,p} P_{i,l}^{(kul)}\left(h_{i,l} - y_{i,l} - z_{i,l}\right) + \sum_l P_l^{(milk)} g_l + \sum_l P_l^{(meat)} w_l \tag{3}$$

$P_{i,l}^{(kul)}$– price of crop *i* in year *l* [thousand KZT per centner];
$h_{i,l}$ – harvested volume of crop *i* in year *l* [centners];
$P_l^{(milk)}$– price of milk in year *l* [thousand KZT per ton];
g_l – annual milk yield of the dairy herd in year *l* [tons];
$N_l^{(milk)}$ – number of lactating cows in year *l*;
w_l – annual slaughter weight of beef cattle in year *l* [tons].

3. Cost Structure

It will be assumed that the primary expenditures are associated with the production of agricultural crops.

$$Z(x) = \sum_{i,j,k,l,p} C_{i,j,k,l,p}^{(c)} x_{i,j,k,l,p} \quad (4)$$

where $C_{k,i,l}^{(z)}$ denotes the production costs of cultivating crop i on one hectare of land of category k in year l [tg/ga]

A number of external parameters–such as crop yields and market prices—are functions of the index l, i.e., they vary by year and therefore require forecasting based on the data available for the baseline year. Since these forecasts will change annually, the optimization procedure must likewise be repeated every year prior to the sowing season, reflecting updated economic and climatic conditions. Nevertheless, multi-year projections remain valuable, at minimum for accounting for yield variations associated with crop rotation and changes in crop sequence.

One of the key tasks is the formulation of a system of constraints, since at least one feasible solution must exist that satisfies all restrictions proposed by the authors. The general form of the constraints can be expressed as follows:

$$x_{k,i,j,p,l} \geq 0 \quad (5)$$

$y_{i,l} \geq 0$
$z_{i,l} \geq 0$

Constraints on Forage Crop Volumes

The total amount of each forage crop produced must be sufficient to cover the volume required for feeding the livestock. Accordingly, the harvested quantity of each crop must be greater than or equal to the amount allocated for animal feed.

Constraints on Land Resources

In the simplest formulation, the area of land within each category is assumed to remain constant throughout the planning horizon, meaning that the available land resources are fully destignated for agricultural use.

In more advanced formulations, however, it becomes necessary to account for the dynamic evolution of land resources, which plays a critical role in land-use optimization models. A rigorous problem statement requires consideration not only of changes in the total area of agricultural land but also of the redistribution of plots among different crops. In certain simplified scenarios, such redistribution may occur through expansion of arable land at the expense of previously fallow parcels. However, in more complex situations – such as the withdrawal or reallocation of part of the land fund – the process requires a more detailed analytical approach and the incorporation of additional influencing factors [16].

It is important to note that optimization techniques can determine only the aggregate land areas allocated to each crop; they do not provide the spatial allocation of these crops within specific fields. The development of a geographically explicit planting scheme constitutes an independent task that requires supplementary calculations and consideration of agro-landscape characteristics.

In subsequent calculations, it may be assumed that changes in the cultivated area of individual crops – driven by external factors – are known in advance and can be estimated through forecast-based assessments. Nevertheless, in practical applications such adjustments should be revised annually to reflect the current distribution of agricultural land. Within optimization models, however, it is acceptable to treat the total land area of each category as fixed, which contributes to improving the precision and adaptability of management decisions.

Accordingly, the area allocated to perennial crops in each subsequent year cannot exceed the corresponding area from the previous year. This requirement leads to the following constraint:

$$x_{k,i,j,p+1,l+1} \leq x_{k,i,j,p,l} \quad (6)$$

Let us introduce the variable $Y_{i,p}^{(k,l)}$, which represents the area occupied by crop *i* during its *p*-th year of growth. When this condition is satisfied, the total area allocated to crop *i* is sufficient to accommodate all relevant field plots, and, at the same time, these plots entirely fill the assigned area. Both requirements are ensured through the fulfillment of equalities (5).

The set of constraints (5) is sufficient to generate a unique allocation scheme for crop areas for year $l+1$, which is the primary objective. Naturally, this uniqueness is defined only up to the spatial placement of plots within the designated area. However, the geographic positioning of individual fields lies outside the scope of the optimization problem. As noted by researchers [17], procedures aimed at reducing field fragmentation – especially when combined with logistical considerations such as seed transport and crop harvesting – may necessitate adjusting the previously obtained optimal area values. The magnitude of efficiency losses resulting from deviations from the optimal solution should be quantified. Based on these estimates, it must be determined whether such deviations are acceptable in practice.

The following groups of constraints play an essential role within the model:
1. constraints related to pasture area;
2. constraints on feed units required for livestock;
3. requirements for digestible protein for dairy cattle;
4. requirements for digestible protein for beef cattle;
5. area constraints for each agricultural crop.

For any agricultural enterprise, an efficient balance between available resources and the final production outcomes is critical. When resources are insufficient, it becomes impossible to increase the output of crop and livestock production, which limits profit growth. Conversely, when resources are in excessn the costs associated with maintaining them reduce the net profit.

Therefore, identifying an optimal solution necessitates improving managment practices and optimizing production and economic activities. The economic-mathematical model proposed in this study is designed to support such optimization and to ensure the balanced and efficient utilization if available resources.

Results

To assess the efficiency of production and economic management practices in the agricultural sector, the agricultural enterprise «Meiram» was chosen as the empirical research base. The farm is situated in the Ayyrtau District of the North Kazakhstan Region, at a distance of approximately 100 km from the city of Kokshetau.

As is characteristic of many agricultural producers operating in Northern Kazakhstan, the economic activity of the «Meiram» farm is structured around three key areas of specialization:

1. Cattle breeding, primarily dairy production, which represents a major agricultural industry in the region.

2. Cultivation of grain and leguminous crops, including wheat, barley, peas, and other strategically important crops.

3. Production of forage crops and feed harvesting, which ensures stable feed supply and contributes to improved productivity of the cattle herd.

The strategic objective of the farm's development is to increase production volumes and enhance overall profitability. To achieve this, the enterprise is implementing innovative organizational and management technologies, such as automated production processes, digital field-monitoring systems, modern feeding and livestock-management practices, and tools of economic-mathematical modeling.

Improving the efficiency of production and economic management is particularly important for the Ayyrtau district, which is classified as a risk-prone agricultural zone. The modeling results, summarized in the key economic indicators, are presented in Table 1.

Analysis of the data presented in Table 1 indicates that the application of the proposed model results in a pronounced improvement in the key indicators of production and economic performance within the agricultural enterprise. The observed upward trend reflects steady strengthening of the farm's production capacity and a more efficient use of land resources [18]. Over the projected five-year period, the total gross income increases from 2.3 million ₸ to 10.5 million ₸, representing more than a fourfold rise. A similar pattern is evident in profit per unit area, where land profitability grows by more than 4.6 times – from 646.49 thousand ₸/ha to 3 million

Table 1 – Indicators of the Efficiency of Production and Economic Management at «Meiram» Farm

Indicators	2020	2021	2022	2023	2024	2025
Gross income, million ₸	2,3	3,5	4,9	6,2	8,0	10,5
Land productivity (thousand ₸/ha)	8119,85	9500	10300	11000	12000	13500
Land capacity (ha/million ₸)	0,0001	0,0001	0,00009	0,00008	0,00007	0,00006
Profit per unit area (thousand ₸/ha)	646,49	1100	1400	1800	2300	3000
Crop production output (c/ha) (centners per hectare)	44,69	45,5	46,2	47,0	48,0	50,0
Livestock production output (t/ha)	0,61	0,63	0,65	0,68	0,70	0,75
Land use coefficient	0,89	0,89	0,90	0,91	0,92	0,95
Targeted land use coefficient	0,80	0,85	0,90	0,95	1,00	1,00

The implementation of the proposed measures for improving production and economic management at the farm level leads to a significant increase in the profitability of agricultural enterprises in both livestock and crop production (Figure 1). These measures make it possible to establish internal production of forage crops in the necessary volumes, thereby ensuring a stable feed base for dairy and beef cattle and contributing to the preservation and enhancement of soil quality [19]. Consequently, the transition to modern management approaches in the agricultural sector facilitates the adoption of sustainable development principles, reduces environmental pressures, and improves the efficiency of land use, ultimately increasing the investment attractiveness of agricultural enterprises.

₸/ha.

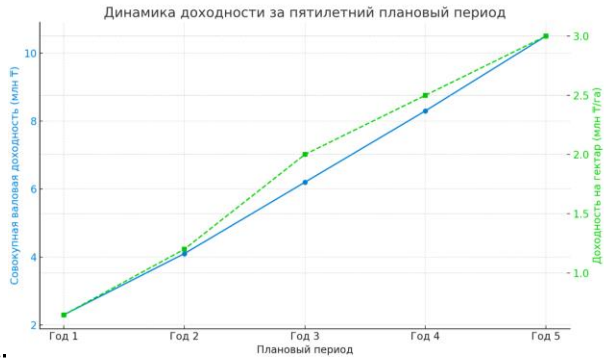

Figure 1 – Profitability dynamics over the five-year planning period

To evaluate the robustness of the proposed economic-mathematical model, a sensitivity analysis was conducted by systematically varying the key exogenous parameters that directly influence the objective function and constraint system. In particular, crop yield coefficients were adjusted within the ranges of ±10% and ±20%, output prices were varied by ±15%, and production costs per hectare were modified by ±10%.

For each alternative scenario, the optimization procedure was repeated while preserving the original structure of the constraint system. This approach made it possible to isolate the impact of individual parameter changes on the resulting optimal plan without altering the institutional and technological framework of the model.

The analysis focused on three interrelated dimensions of model behavior: the transformation of crop-area allocation patterns, the variation in gross income as the objective function value, and the degree to which the previously obtained optimal solution remained stable under modified parameter conditions. Such a methodological design allowed for an integrated assessment of both structural and financial sensitivity of the model.

Discussion

Overall, the analysis of the proposed model reveals a stable upward trend in the main economic indicators of agricultural production. The positive dynamics of profitability, productivity, and land-use efficiency confirm that the chosen trajectory of sectoral development is strategically sound. The results demonstrate that through consistent management and the implementation of effective technologies, it is possible not only to overcome periods of decline, but also to ensure sustained growth of Kazakhstan's agricultural sector.

The necessity of applying an economic-mathematical model in agricultural management is primarily driven by the high level of uncertainty that characterizes the modern agrarian economy. Continuous changes in climatic conditions, fluctuations in market prices, limited material and financial resources, and rising production costs require a shift from intuition-based management to scientifically grounded decision-making. In this context, economic–mathematical modeling – integrated into an information system – functions as an effective tool for the systemic analysis and optimization of production and economic processes.

The use of models of this type makes it possible to objectively assess the interrelationships among economic, technological, and natural-climatic factors, thereby supporting the development of rational solutions for crop-structure planning, forage production organization, and livestock management. Mathematical modeling enhances the efficiency of labor, land, and financial resource utilization by determining optimal allocation proportions, reducing costs, and increasing output while maintaining product quality [20-21].

One of the important advantages of employing such models is their capacity to forecast the outcomes of economic activity. Scientifically grounded modeling techniques make it possible to estimate yield levels, production costs, and profitability under varying external conditions, which, in turn, facilitates strategically balanced decision-making [22-23].

Furthermore, modeling enables the identification and mitigation of risk factors that contribute to instability in agricultural production, thereby strengthening the resilience of enterprises to economic and environmental shocks.

In a broader perspective, the introduction of economic-mathematical models contributes to building a sustainable foundation for agricultural development. It supports the rational use of land and natural resources, helps maintain soil fertility, and reinforces national food security.

Conclusion

The development of an information system based on a mathematical model for managing the production and economic activities of livestock-oriented agricultural enterprises represents an important step toward enhancing the resilience and efficiency of the agrarian sector. The model presented in this article is grounded in a systems approach that makes it possible to account for the complex interplay of natural, biological, and economic factors inherent to agricultural production. In addition, the formulation of the model is oriented toward creating an «investment-attractive» profit profile, thereby supporting the goal of mobilizing external financial resources for sectoral development.

The integration of forecasting, planning, and optimization methods within the proposed toolkit provides scientifically grounded support for managerial decision-making, aimed at the rational use of resources, improvement of profitability, and reduction of production risks. Particular emphasis is placed on maintaining a balance between production intensification and the preservation of agroecosystems, which is consistent with the core principles of sustainable agriculture. The research outcomes position the proposed model not only as an effective instrument for both operational and strategic management, but also as a foundation for the integration of modern digital and intelligent technologies into agricultural practice. The results can be used for the design of information-analytical decision support systems at the enterprise level, as well as for the development of evidence-based agricultural policy at regional and national scales.

The findings of this study indicate that the proposed economic-mathematical model is not limited to a single case and can be adapted to other regions with comparable agro-climatic and production conditions. However, successful transfer of the framework requires a substantial effort in assembling high-quality input data, including detailed land-use parameters, feed resources, herd structure, productivity indicators, and local economic constraints. The reliability of forecasting and optimization results strongly depends on the completeness and consistency of these datasets, which often necessitates extensive field surveys, digitization of farm records, and integration of heterogeneous information sources.

Therefore, future work should focus on expanding the empirical database and validating the model across multiple regional contexts to strengthen its generalizability and practical value for long-term agricultural planning.

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АУЫЛ ШАРУАШЫЛЫҒЫ КӘСІПОРЫНДАРЫНЫҢ ӨНДІРІСТІК-ЭКОНОМИКАЛЫҚ ҚЫЗМЕТІН БАСҚАРУДА ЭКОНОМИКАЛЫҚ-МАТЕМАТИКАЛЫҚ МОДЕЛЬДЕУДІ ҚОЛДАНУ

Елдің азық-түлік қауіпсіздігін перспективалық және стратегиялық жоспарлау мақсатында жер ресурстарын оңтайлы пайдалану қазіргі аграрлық басқарудың негізгі міндеттерінің бірі болып табылады. Жерді тиімді бөлу және оны шаруашылық айналымына ұтымды тарту тұрақты азық-түлік теңгерімін қалыптастырудың негізін қалайды, сыртқы факторларға тәуелділікті төмендетеді және аграрлық сектордың өзгермелі климаттық пен экономикалық жағдайларға бейімделу мүмкіндігін арттырады.

Ғылыми тұрғыдан алғанда, жерді пайдалану жүйесін оңтайландыру тек өндірістік тиімділікті арттыру құралы ғана емес, сонымен қатар ұлттық азық-түлік қауіпсіздігінің стратегиялық элементі болып саналады. Ол экономикалық мүдделер, экологиялық шектеулер және әлеуметтік қажеттіліктер арасындағы тепе-теңдікті қамтамасыз етуге мүмкіндік береді, бұл ауылдық аумақтардың ұзақ мерзімді дамуын және агроэкожүйелердің тұрақты қызметін жоспарлауда ерекше маңызға ие.

Осы зерттеу мал шаруашылығына маманданған ауыл шаруашылығы кәсіпорындарының өндірістік-экономикалық қызметін басқарудың экономикалық-математикалық моделін әзірлеуге бағытталған. Мақалада агроөндіріс табыстылығын арттыруға, жем-шөп өндірісін жетілдіруге және топырақ құнарлылығын сақтауға бағытталған болжау, жоспарлау және оңтайландыру әдістері қарастырылған. Ұсынылған модельді іске асыру тәуекелдерді азайтуға, жер ресурстарын басқарудың тиімділігін арттыруға және ауыл шаруашылығының тұрақты дамуына ықпал етуге мүмкіндік береді.

Түйін сөздер: *экономикалық-математикалық модельдеу, басқару, өндірістік-экономикалық қызмет, ауыл шаруашылығы кәсіпорындары, жер ресурстары, жоспарлау, оңтайландыру, тиімділік критерийлері.*

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ПРИМЕНЕНИЕ ЭКОНОМИКО-МАТЕМАТИЧЕСКОГО МОДЕЛИРОВАНИЯ ДЛЯ УПРАВЛЕНИЯ ПРОИЗВОДСТВЕННО-ЭКОНОМИЧЕСКОЙ ДЕЯТЕЛЬНОСТЬЮ СЕЛЬСКИХ ХОЗЯЙСТВ

В целях перспективного и стратегического планирования продовольственного обеспечения страны оптимальное использование земельных ресурсов представляет собой одну из ключевых задач современного аграрного управления. Эффективное распределение и рациональное вовлечение земель в хозяйственный оборот формируют основу устойчивого продовольственного баланса, способствуют снижению зависимости от внешних факторов и повышают адаптационные возможности аграрного сектора к изменяющимся климатическим и экономическим условиям.

С научной точки зрения, оптимизация землепользования является не только инструментом повышения производственной эффективности, но и стратегическим элементом национальной продовольственной безопасности. Она позволяет обеспечивать сбалансированное взаимодействие между экономическими интересами, экологическими ограничениями и социальными потребностями, что особенно актуально для долгосрочного планирования развития сельских территорий и устойчивого функционирования агроэкосистем. Настоящее исследование направлено на разработку экономико-математической модели управления производственно-экономической деятельностью сельскохозяйственных предприятий, специализирующихся на животноводстве. В статье рассматриваются методы прогнозирования, планирования и оптимизации, направленные на повышение доходности агропредприятий, улучшение

кормопроизводства и сохранение почвенного плодородия. Реализация предложенной модели позволит минимизировать риски, повысить эффективность управления земельными ресурсами и способствовать устойчивому развитию сельского хозяйства.

Ключевые слова: *экономико-математическое моделирование, управление, производственно-экономическая деятельность, сельскохозяйственные предприятия, земельные ресурсы, планирование, оптимизация, критерии эффективности.*

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