# MATHEMATICAL PROGRAMMING METHODS IN OPTIMIZING AGRICULTURAL CLUSTER SYSTEMS: OPTIMIZATION BASED ON LINEAR AND NONLINEAR MODELS

**Juraev Farrukh Dustmirzayevich**
*University of Economics and Pedagogy NTT*
*PhD in Economics, Professor*
*ORCID: 0009-0000-5657-9734*

**Annotatation:** *This article analyzes the use of mathematical programming methods, in particular linear and nonlinear models, in optimizing regional agrocluster systems. Based on the model, the economically optimal organization of production and processing processes, the possibilities of reducing production costs and increasing profits are assessed. The results of the study confirm that mathematical modeling methods can be used to increase the efficiency of the agrocluster system.*

**Keywords:** *Agrocluster, linear programming, nonlinear programming, optimization, mathematical modeling, resource allocation, production efficiency, agriculture, logistics.*

## INTRODUCTION.

Mathematical programming methods play an important role in the optimization of agrocluster systems. In particular, linear and nonlinear models can be used to identify opportunities for increasing the economic efficiency of farms within the cluster and rational use of resources. Such models serve to optimize production volumes, resource allocation, logistics, and market demand, taking into account the complex structure of the agrocluster system. Mathematical programming models are often used as an acceptable methodological basis, since they can be developed based on minimal data and constraints and can be adapted to the structure of such models. Mathematical models also expand the possibilities of farm management and provide optimal solutions to important economic issues[1,2].

## LITERATURE REVIEW.

Linear Programming (LP) is one of the effective methods in the process of optimizing the agrocluster system. This approach serves to increase production efficiency and improve overall economic results in resource-limited conditions [3].

According to the definition given by Manos and Papanagiotou on the use of linear programming in agriculture, this method provides the most efficient combination of production factors and allows for optimal management with maximum income or minimum cost for farms[4].

This method is widely used for setting up new farms and re-planning existing ones, helping farmers to achieve higher incomes or reduce production costs through more efficient use of resources. Also, Rozakis et al. [5] used a linear programming model in their study to determine the optimal crop plan for each farm and maximize annual gross profit.

The complexity of decision-making and the need for efficient use of resources in agriculture provide the basis for the use of multi-criteria linear and nonlinear programming models in the optimization of agro-cluster systems. Multi-criteria analysis, while maximizing gross profit, provides a broader analysis of the interests of farmers and takes into account various criteria that shape their decisions (risk reduction, labor cost optimization, efficient use of water resources)[6].

Analysis and discussion of results. Linear and nonlinear programming models play an important role in optimizing the agrocluster system. The model serves to improve decision-making and operational efficiency, taking into account the constraints in the production, processing and sales processes. The main goal is to optimize cluster efficiency through mathematical modeling and systematic analysis.

To effectively organize cooperation between agrocluster participants and improve economic results, it is necessary to optimize the interrelated processes of production, processing and sales. Includes linear and nonlinear models to identify and optimize the interaction between enterprises within regional agroclusters.

Model for optimizing the economic efficiency of the agrocluster system. A multi-criteria optimization approach has been developed that reflects the economic interests of agrocluster participants. This model is aimed at the most efficient organization of production, processing and product sales within the agrocluster.

The first criterion of the model, $f_x$, i.e. ensuring the maximum profit of the processing enterprise, is expressed by the following formula:

$$f_1 = \sum_{v \in V} c_v x_v - \sum_{q \in Q} c_q x_q^n$$

Here:

$x_v$ – volume of product type $v$ produced in the agrocluster;

$c_v$ – v selling price of a type of product;

$c_q$ – q purchase price of a type of raw material (for agricultural products);

$x_q^n$ – q volume of products sent for processing;

V and Q – sets of finished products and products intended for processing of the agrocluster, respectively.

This model serves to ensure the economically optimal organization of production and processing processes within the agrocluster. Based on the model, the agrocluster creates the opportunity for efficient allocation of resources, reduction of production costs and increase of total income.

The second criterion for optimizing the agrocluster system is the maximum profit received by agricultural producers. This is expressed by the following formula:

$$f_2 = \sum_{j \in J} c_j x_j^m - \sum_{i \in I} c_i^{'} x_i^n$$

Here:

$c_j$ – Income received from the sale of agricultural products by producers;

$c_i'$ – Costs per head of livestock or per hectare of cropland;

$x_j^m$ – j Production volume of various types of agricultural products;

$x_i^n$ – i number of livestock or cultivated area;

I va J – sets of types of production resources and types of agricultural products, respectively[7-11].

This model was developed to ensure the efficient use of resources by agricultural producers, reduce production costs and, as a result, increase income.

The structural structure of the model for optimizing cooperation between regional agro-cluster participants is shown in Table 1.

This model serves to increase overall profits by integrating production, processing and product sales.

The proposed model serves to ensure balance in the production, processing and distribution processes by optimizing cooperation between agro-cluster participants. The developed model, incorporating systematic constraints, allows for increased efficiency, reduced economic risks and more efficient use of resources. The research results showed that a well-structured mathematical model can significantly contribute to the stability and development of regional agro-industrial clusters.

Table 1

Structural model for optimizing cooperation between regional agrocluster participants

| | |
|---|---|
| Production restrictions block | Sets restrictions on the production of agricultural products |

| | |
|---|---|
| Connecting block | Describes the terms of cooperation between enterprises within the cluster |
| Recycling restrictions block | Sets restrictions on the processing of agricultural products |
| Implementation conditions | Determines the terms of sale of the processed product |
| A block of complex constraints | It harmonizes constraints by integrating production, processing, and sales processes. |

Linear and nonlinear models are used to optimize the agrocluster system and the models are described as follows: Linear optimization model. Used to analyze resource allocation among agrocluster participants. Helps optimize production, processing, and distribution processes. System constraints (e.g., production capacity, resource constraints) are expressed through linear equations.

Nonlinear optimization model. Used to describe complex system dependencies. Takes into account factors such as market demand changes, price volatility, and climatic conditions. The model constraints and objective functions have nonlinear relationships, allowing for approximation to the real situation.

System analysis model. Describes the cooperation between enterprises in an agrocluster. Shows the integration of production, processing and sales stages. The goal is to increase overall profit and minimize the risk of loss.

Optimization of the agrocluster system is carried out on the basis of linear and nonlinear programming models, and the results of the analysis are as follows.

Resource allocation is improved. As a result of the effective allocation of resources based on the model, production volume increases and costs decrease.

Processing efficiency increases. The profits of processing enterprises are maximized, as the supply of raw materials is optimally planned. The cost of production decreases, increasing competitiveness in the market. The ability to adapt to market demand increases. The model is optimized in accordance with changes in market demand by incorporating real-time data. This provides the agrocluster with the ability to make rapid strategic decisions.

Conclusion and Recommendations. This study confirms the effectiveness of linear and nonlinear modeling in optimizing the agrocluster system. The results of the study show that mathematical modeling is an important tool for building effective cooperation between processing enterprises. The linear programming model serves to optimally allocate resources and increase production efficiency.

The nonlinear programming model takes into account complex dependencies and changing demands in real economic conditions.

## REFERENCE:

1. Ewert, F.; van Ittersum, M.K.; Heckelei, T.; Therond, O.; Bezlepkina, I.V.; Andersen, E. Scale Changes and Model Linking Methods for Integrated Assessment of Agri-Environmental Systems. Agric. Ecosyst. Environ. 2011, 142, 6–17.

2. Reidsma, P.; Wolf, J.; Kanellopoulos, A.; Schaap, B.F.; Mandryk, M.; Verhagen, J.; Van Ittersum, M.K. Climate Change Impact and Adaptation Research Requires Integrated Assessment and Farming Systems Analysis: A Case Study in the Netherlands. Environ. Res. Lett. 2015, 10, 045004.

3. Alotaibi, A.; Nadeem, F. A Review of Applications of Linear Programming to Optimize Agricultural Solutions. Int. J. Inf. Eng. Electron. Bus. 2021, 13, 11–21.

4. Manos, B.; Papanagiotou, E. Fruit-Tree Replacement in Discrete Time: An Application in Central Macedonia. Eur. Rev. Agric. Econ. 1983, 10, 69–78.

5. Rozakis, S.; Tsiboukas, K.; Petsakos, A. Greek Cotton Farmers’ Supply Response to Partial Decoupling of Subsidies. In Proceedings of the 2008 International Congress, Ghent, Belgium, 26–29 August 2008

6. Prišenk, J.; Turk, J.; Rozman, C.; Borec, A.; Zraki´c, M.; Pažek, K. Advantages of Combining Linear Programming and Weighted ˇ Goal Programming for Agriculture Application. Oper. Res. 2014, 14, 253–260.

7. Т. С. Бузина, Математическое и информационное обеспечение моделей оптимизации взаимодействия участников в региональных агропромышленных кластерах, автореферат диссертации на соискание ученой степени кандидата технических наук, Иркутская государственная сельскохозяйственная академия, Иркутск, Россия, 2012.

8. Juraev, F. D. S. (2021). Problems Of Informatization Of Management Of Agricultural Industry And Modeling Of Agriconomic System In A Market Economy. The American Journal of Applied sciences, 3(02), 49-54.

9. Juraev, F. D., Mallaev, A. R., Aralov, G. M., Ibragimov, B. S., & Ibragimov, I. (2023). Algorithms for improving the process of modeling complex systems based on big data: On the example of regional agricultural production. In E3S Web of Conferences (Vol. 392, p. 01050). EDP Sciences. // https://doi.org/10.1051/e3sconf/202339201050

10. Mukhitdinov, K. S., & Juraev, F. D. Methods of Macroeconomic Modeling. International Journal of Trend in Scientific Research and Development (IJTSRD), e-ISSN, 2456-6470

11 Жўраев, Ф. Д., & Аралов, Ғ. М. (2023). Қишлоқ хўжалиги маҳсулотлари ишлаб чиқариш жараёнини эконометрик моделлаштириш заруриятининг асосий жиҳатлари. Educational research in universal sciences, 2(2), 36-43.

12 Jo'rayev, F. (2023). Agroklaster tizimini optimallashtirish usullari: noaniqlikni algoritm va model yordamida minimallashtirish. Iqtisodiyot va ta'lim, 24(6), 306-314. / https://doi.org/10.55439/ECED/vol24_iss6/%25x