DOI: 10.63550/ICEIP.2025.55.67.003

Multivariate Analysis of Resource Availability and Agricultural Efficiency

Tatiana Lubova [1], Guzel Salimova [2]
Bashkir State Agrarian University, 34, 50th anniversary of October street, Ufa, 450001, Republic of Bashkortostan, Russian Federation
lubova@list.ru, salimovaguzel997@gmail.com

Keywords : Cluster analysis, Agriculture, Resource provision, Operation efficiency, Social efficiency, Regions.

Abstract : The article presents a spatial-dynamic analysis of the functioning of agriculture in the context of limited resources using the regions of the Volga Federal District of the Russian Federation as an example. The aim of the study is to determine the impact of resource provision on the performance of agricultural enterprises. The methodological basis was a cluster analysis, which made it possible to group regions according to similar characteristics of the resource base, economic and social efficiency. The study identified clusters of regions that differed in the level of resource provision, investment attractiveness and production indicators. The results showed that regions with high resource provision demonstrate increased productivity, but this does not always lead to improved financial results. For regions with low indicators, measures are recommended to attract investment, modernize funds and develop human resources. The study emphasizes the need for a differentiated approach to state support for agriculture, as well as the importance of interregional cooperation and innovation. The results can be used to develop strategies for sustainable development of the agro-industrial complex. The main conclusions are based on a multi-aspect grouping of regions and the formation of homogeneous clusters .

1 INTRODUCTION

The agro-industrial complex is a strategically important sector of the economy of any country. Agriculture as an important area of the agro-industrial complex, producing food products, raw materials for the processing industry, consuming means of production, is characterized by uneven development in different regions due to differences in natural and climatic conditions, the availability and provision of production resources, the level of state support and the introduction of innovations. In this regard, there is a need for a comprehensive analysis that will determine the factors affecting the efficiency of agricultural production , develop targeted measures of state support.

, scientists pay special attention to the use of multivariate data analysis methods, among which the cluster analysis method stands out . J. Capelli , P. R. de Sousa , M. W. Barbosa apply this method to assess and characterize the sustainability potential of agri - food companies, and , based on empirical data, distinguish three clusters with low, medium and high levels of sustainability) [1]. O. Ferdous , S. Yousefi , B. M. Tosarkani study the critical need to combine supply chain management, risk management and sustainability to systematically analyze the risks of disruptions due to the unpredictability of natural disasters, anthropogenic events and rapid technological progress in agriculture. A decision support system is proposed that takes into account the significance of multiple risk factors [2]. Based on a set of selected indicators related to demography, economy, accessibility, biodiversity, land use and geographical context, a group of scientists studies the dependence of the socio-economic development of territories on their remoteness level using spatial cluster methods [3]. Cluster analysis methods are widely used in studies of the level of digitalization of the agricultural sector. M. Metta , J. Dessein , G. Brunori study the integration of digitalization in multifunctional and diversified agriculture. Factors that explain the diversity of digitalization processes in

[1] https://orcid.org/0000-0001-7006-7591
[2] https://orcid.org/0000-0003-3568-760X

DOI: 10.63550/ICEIP.2025.55.67.003

diversified agricultural enterprises are identified. Digitalization in agriculture can be deployed through various strategies (minimization, mutual adaptation, grounding, digitalization expansion) and requires holistic and ambitious management decisions to ensure production sustainability [4]. In addition , Y. Luo, S. Liu, Y. Zhang, M. Zeng , D. Zhao note that moderate digitalization increases sustainability , while excessive digitalization introduces vulnerabilities . Mechanism analysis shows that digitalization stimulates income growth in rural areas and optimizes factor utilization, but excessive digitalization increases income inequality and causes resource outflow from agriculture [5] . Multivariate analysis allowed the scientists to determine the presence of heterogeneity in the implementation of digital technologies in agriculture and the key role of skilled labor availability in the development of the industry [6]. Multivariate analysis revealed that agriculture exhibits significant differences in production methods, efficiency, and business models compared with other industries. M. Ding , Q. Gao study the impact of artificial intelligence in agriculture on total factor productivity. It was found that artificial intelligence has a significant impact on production efficiency, increasing total factor productivity of agricultural enterprises by enhancing innovation potential, and optimizing the structure of human capital [7]. L. Ye notes that scientific understanding of the precise mechanisms by which digital technologies contribute to high-quality agricultural development remains poorly understood. Based on a complex assessment system that includes 21 indicators across five dimensions: innovation capacity, coordination efficiency, environmental sustainability, external opening up, and common prosperity, it identifies different scenarios for the impact of digital technologies on production sustainability: agricultural technology innovation enhances technological capabilities, human capital development promotes knowledge accumulation, and industrial structure optimization promotes the development of agricultural sectors. [8]. Input-output tables are used to assess the scale of added value of smart agriculture [9]. Multivariate methods are used to study the relationship between the degree of urbanization and rural revival, and the management of socio-economic development of rural areas [10]. Dehghani A. , Soltani A. , Nateghi K. use spatial data and identify various urbanization trends. The need for strategic land use planning for sustainable urbanization management is emphasized, which should certainly take into account the balanced development of rural areas[11].

the multivariate methods , panel data methods are also widely used. S. Zhang, R. Cai, S. Wang assess the impact of large - scale public investment in agriculture on the productivity of the industry [12]. A. O. Díaz , M. F. Segovia , N. A. Rivera identify regions with different production potential, technical efficiency , and poverty levels in order to determine the required amount of investment [13]. A group of scientists notes the need to transform and restructure the system of research and innovation in the field of agricultural sciences to solve multivariate and interrelated problems that exist in different geographic regions and scales [14], which also emphasizes the need to develop methods of multivariate analysis and their application in agricultural research .

The aim of the study is to study the resource provision of agricultural enterprises in the regions of the Volga Federal District of the Russian Federation and its impact on the results of their activities. In accordance with the goal, the following tasks have been defined:

- determine the indicators that will form the basis for constructing a multidimensional grouping of regions using the cluster analysis method;
- form cluster groups of regions of the Volga Federal District based on a set of indicators in 2021 and 2023;
- characterize the formed clusters by average values of indicators, evaluate the differences in the inclusion of regions in clusters in dynamics;
- develop recommendations for more efficient use and return of resources for the regions of each cluster, dynamic development of the industry;
- determine directions for further research.

The choice of the research object - the regions of the Volga Federal District of the Russian Federation - is due to the fact that 19.5% of the total population of the Russian Federation lives in the regions of this district (data as of the beginning of 2024), of which 27.6% live in rural areas (the average in Russia is 25.1%). The district ranks second in terms of agricultural production (in 2023) after the Central Federal District, which is home to 27.5% of the population of the Russian Federation. Thus, the activities of agricultural enterprises are of strategic importance for a significant part of the country's population, the products are also consumed outside the district, so studying the regions of this district will allow a scientifically sound study of the question posed.

2 MATERIALS AND METHODS

The research methodology is presented by the method of cluster multivariate analysis. Cluster analysis allows grouping regions by similar characteristics, which makes it an indispensable tool for assessing resource availability , comparing efficiency production , identifying hidden patterns (in particular, the dependence of production efficiency on the level of technical equipment and armament, the implementation of investments, the level of digitalization of the industry). The need to use cluster analysis in The study of the level of provision of agricultural enterprises with resources and production efficiency is determined by the dependence of the industry on many factors and parameters (arable land area, amount of equipment, climate, subsidies, etc.). Cluster analysis allows you to combine them into integral groups , simplifying the interpretation of data. Also, traditional methods, which involve comparing regions by individual indicators, do not provide a complete picture. Clustering identifies typological groups , which helps in developing differentiated agricultural policy. Analysis of highly efficient clusters allows you to identify successful business models (for example, a combination of precision farming and government support), which can be replicated in other regions. Clustering results help distribute subsidies and investments in a targeted manner, directing them to regions with the greatest potential or, conversely, requiring urgent measures. Identifying clusters with low resource availability helps prevent crises (for example, land degradation or personnel outflow) through timely interventions. The cluster analysis method diagnoses the current state of the industry and lays the foundation for strategic planning, promoting sustainable development of the agricultural sector.

The source of information for the study is the data of the official statistical service of Russia, presented in the statistical collection of Rosstat [15]. From the calculated and published statistical indicators, 21 indicators were selected, characterizing the resource provision, economic and social efficiency of the activities of agricultural enterprises. A system of indicators for analysis was built, including three groups of factors.

Group of indicators of resource provision of agriculture:

- availability of labor force, people per 1000 hectares of agricultural land;
- fixed assets per person employed in agriculture, thousand rubles (capital-labor ratio);
- fixed assets per 1 hectare of agricultural land, thousand rubles (asset provision ratio);
- the level of application of mineral fertilizers per 1 hectare of sown area of agricultural crops, kg of active substance;
- the level of feed consumption per 1 conventional head of cattle, centners of feed units;
- the level of depreciation of fixed assets in the agricultural sector, as a percentage of the initial value of fixed assets;
- the level of investment in fixed capital objects, thousands of rubles per 100 hectares of agricultural land;
- the level of internal expenditure on scientific research and development, in thousands of rubles per researcher in the field of agricultural sciences.

A group of indicators of economic efficiency of agricultural enterprises:

- yield of grain and leguminous crops, centners per 1 hectare;
- potato yield, centners per 1 hectare;
- milk yield per cow in agricultural organizations, kg;
- the level of gross agricultural output, thousands of rubles per employee (labor productivity indicator);
- the level of gross agricultural output per 1 hectare of agricultural land, thousand rubles;
- the level of gross agricultural output, rubles of output per 1 ruble of the value of fixed production assets (the return on assets indicator);
- financial result in agriculture per 1 enterprise, million rubles;
- profitability level of sales of plant products, %;
- profitability level of livestock product sales, %.

The group of indicators of social efficiency of agriculture and food supply of the population is represented by indicators of production per capita, kg: grain, potatoes, meat, milk.

The data processing program " STATISTICA " was used to conduct the cluster analysis. The regions were combined into clusters using the Manhattan distance. In order to visually represent the formed clusters, a graphical method was used - a cartogram was constructed.

3 RESULTS

As a result of the cluster analysis for 2021 and 2023, the regions of the Volga Federal District were divided into 2 clusters (2021) and 3 clusters (2023), the dendrogram of the association is presented in Figure 1.

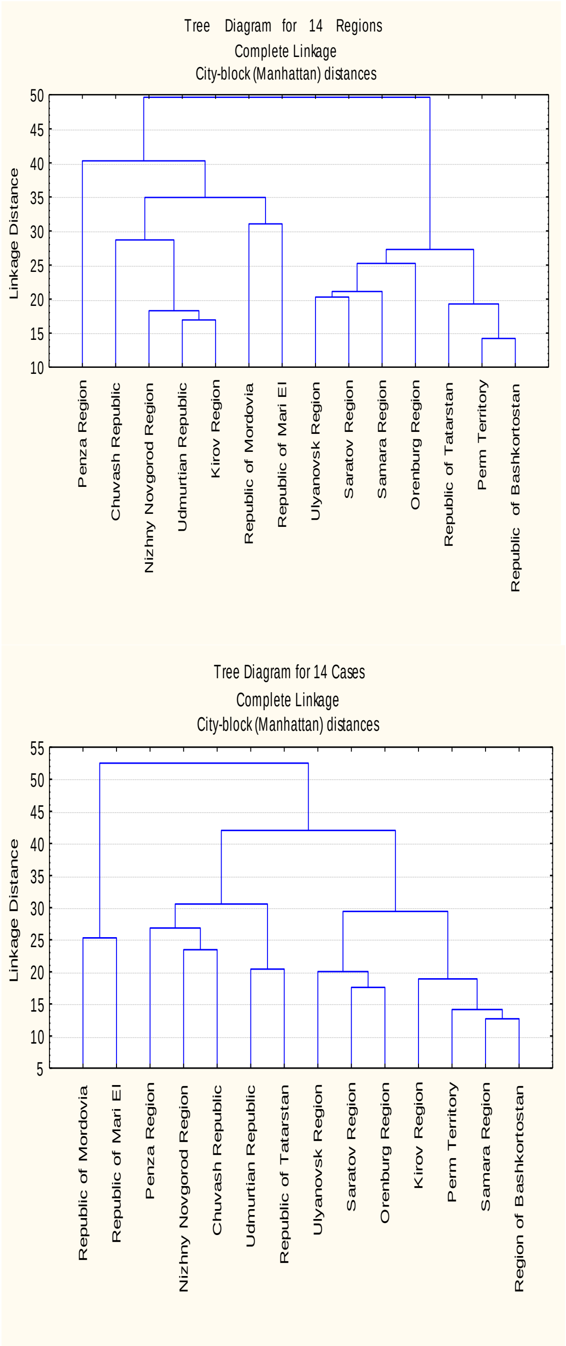


Figure 1: Dendrogram of the regions of the Volga Federal District based on data from 2021 and 2023.

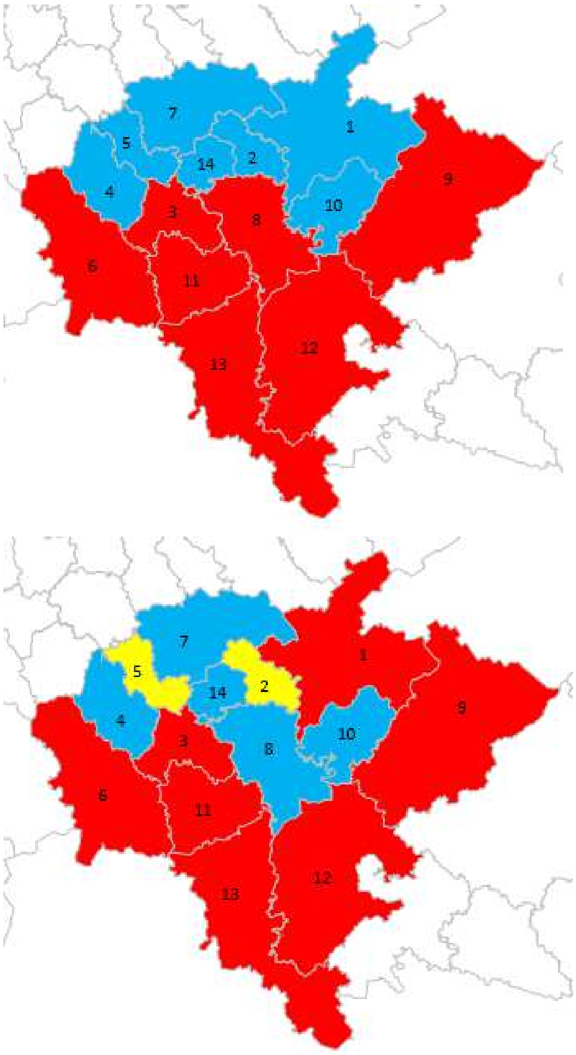
The selected groups of regions are presented in Table 1.

Table 1: Clusters of regions of the Volga Federal District of the Russian Federation.

2021 year		2023 year	
Cluster number	Cluster regions	Cluster number	Cluster regions
-	-	new	Republics: Mordovia, Mari El
I	Regions: Nizhny Novgorod, Kirov, Penza Republics: Mordovia, Chuvash, Udmurt, Mari El	I	Regions: Penza, Nizhny Novgorod Republics: Chuvash, Udmurt, Tatarstan
II	Regions: Samara, Saratov, Orenburg , Ulyanovsk Republics: Bashkortostan, Tatarstan Perm region	II	Regions: Kirov, Samara, Saratov, Orenburg, Ulyanovsk Republic of Bashkortostan Perm Territory

The distribution of regions by clusters is clearly shown in Figure 2. During the analysis period, two regions from the first cluster (2021) formed a separate cluster. In addition, there was a rotation of regions - the Kirov region moved to the second cluster, and the Republic of Tatarstan moved from the second cluster to the first. The main composition of the clusters obtained from the analysis of indicators in 2021 did not change significantly in 2023. Geographically, it is clear that the regions in the clusters are located adjacent to each other. This makes it possible to pursue a targeted state policy in the field of agricultural development in the regions of the identified clusters. There is a scientifically based opportunity for agricultural cooperation between regions and enterprises, integration of resources, technologies, scientific developments, testing of breeding achievements, and cooperation.

DOI: 10.63550/ICEIP.2025.55.67.003



1 – Kirov Region
2 – Republic of Mari El
3 – Ulyanovsk Region
4 – Penza Region
5 – Republic of Mordovia
6 – Saratov Region
7 – Nizhny Novgorod Region
8 - Republic of Tatarstan
9 – Perm Territory
10 – Udmurt Republic
11 – Samara Region
12 – Republic of Bashkortostan
13 – Orenburg Region
14 – Chuvash Republic

Figure 2: Cartogram of the distribution of regions of the Volga Federal District by clusters.

Each cluster included 7 regions (50% of the total population). Let us characterize each cluster by the average values of the system indicators (Table 2).

Table 2 **:** Values of indicators in clusters of regions of the Volga Federal District of the Russian Federation (2023 compared to 2021).

Indicators	The cluster is new	Cluster 1	Cluster 2	On average in the Volga Federal District	On average in the Russian Federation
Number of regions in a cluster, units.	2 / -	5 / 7	7 / 7	×	×
Indicators of resource provision for agriculture					
Labor force availability, persons per 1000 hectares of agricultural land	37.0 / -	25.7 / 27.6	14.2 / 16.9	16.7 / 17.1	19.6 / 49.4
Fixed assets per 1 person employed in agriculture, thousand rubles (capital-labor ratio)	2093.6 / -	2236.8 / 1884.2	1525.8 / 1278,5	1799.9 / 1527.7	2074.7 / 1782.9
Fixed assets per 1 hectare of agricultural land, thousand rubles (capital provision of agricultural land)	76.4 / -	52.7 / 48.5	21.6 / 22.1	30.0/26.1	40.6/36.1
Mineral fertilizers applied per 1 hectare of sown area of agricultural crops, kg of active substance	67.8 / -	71.0 / 58.6	35.9 / 40.5	50.6 / 48.8	76.0 / 74.6

Feed consumption per 1 conventional head of cattle, centners of feed units	24.8 / -	35.0 / 32.6	33.8 / 32.5	33.2 / 32.5	27.8 / 28.6
Depreciation of fixed production assets in agricultural sectors, as a % of the initial value of fixed assets	46.5 / -	38.6 / 40.3	43.7 / 45.2	42.1 / 42.1	42.9 / 43.2
The amount of investment in fixed capital assets, thousand rubles per 100 hectares of agricultural land	603.8 / -	364.1 / 353,0	139.5 / 178.7	218.6 / 207.4	320.0 / 283.3
The amount of internal expenditure on scientific research and development, thousand rubles per 1 researcher in the field of agricultural sciences	- / -	477.5 / 149.6	263.0 / 271.9	315.6 / 220.2	362.5 / 264.0
Indicators of economic efficiency of agricultural enterprises					
Yield of grain and leguminous crops, centners per 1 hectare	31.8 / -	29.6 / 19.6	21.3 / 14.5	24.1 / 16.1	31.0 / 26.7
Potato yield, centners per 1 hectare	184 / -	191.4 / 162.6	160.0 / 148.7	176.0 / 154.0	191.0 / 160,0
Milk yield per cow in agricultural organizations, kg	8556,0 / -	8195.2 / 7561.4	7077.7 / 6083.6	7838,0 / 6881,0	7911,0 / 7007,0
The volume of gross agricultural output, thousand rubles per 1 employed person (labor productivity indicator)	1987,1 / -	2245.2 / 1700.7	1969,5 / 1782.2	2116.7 / 1763.1	1926.9 / 1717,0
The volume of gross agricultural output per hectare of agricultural land, thousand rubles	73.0 / -	53.5 / 44.2	27.4 / 29.4	35.2 / 30.1	37.7 / 34.8
The volume of gross agricultural output, rubles of output per 1 ruble of the value of fixed production assets (indicator of return on assets)	0.97 / -	1.02 / 0.90	1.37 / 1.41	1.18 / 1.15	0.93 / 0.96
Financial result in agriculture per 1 enterprise, million rubles	44.4 / -	6.8 / 9.4	3.3 / 2.9	5.9 / 4.3	6.8 / 8.7
Profitability of sales of plant products, %	18.7 / -	25.3 / 14.0	13.4 / 27.0	17.5 / 33.9	25.4 / 48.5
Profitability of sales of livestock products, %	40.4 / -	13.0 / 13.9	13.4 / 8.0	18.7 / 13.2	18.5 / 12.6
Indicators of social efficiency of agriculture and food supply of the population					
Grain produced per capita, kg	1525 / -	1092 / 732	1188 / 739	1083 / 736	991 / 832
Potatoes produced per capita, kg	352 / -	250 / 238	96 / 110	166 / 154	138 / 125
Meat produced per capita, kg	442 / -	117 / 189	51 / 52	88 / 83	82 / 78
Milk produced per capita, kg	512 / -	440 / 434	330 / 298	368 / 346	231 / 222

The data in Table 2 allow us to conclude that the values of the indicators for the clusters take on different meanings. Analyzing the indicators of resource provision of agriculture, it can be noted that the regions of the new and 1 clusters are characterized by higher values of the indicators, namely: the provision of agricultural land with labor force, fixed assets, capital-labor ratio , the amount of investment in fixed capital of agricultural sectors per area of agricultural land. At the same time, almost all indicators of the new cluster exceed their average values for the Russian Federation. The regions of the new and first clusters are more attractive to investors, which is characterized by a significantly higher amount of investment per agricultural land compared to the average values for the Russian Federation. The values of the indicators of the second cluster are significantly lower than the corresponding average values for the Volga Federal District and the Russian Federation. Analyzing the dynamics of changes in indicators, an increase is noted in 2023 compared to 2021.

Analyzing the indicators of economic efficiency of agricultural enterprises, an increase in the productivity of agricultural crops and animals, labor productivity in 2023 is noted, however, no positive impact on the financial result and profitability of agricultural sectors was found. The new cluster formed in 2023 differs significantly from other regions in the values of production size indicators, financial result and profitability of livestock products. The production of agricultural products per capita in the regions of the Volga Federal District is higher than the average for the Russian Federation.

The regions of the first cluster are recommended to conduct an effective pricing policy. The development and application of modern scientific developments will allow to combine the provision of production resources and results. It is necessary to attract investments to the regions of the second cluster in order to increase the provision of agricultural resources. Renewal of funds, attraction of highly qualified workers will allow to increase the level of natural indicators of efficiency, which will inevitably entail an increase in financial results.

4 DISCUSSION

The results of our study are consistent with the results of global studies. I. Alnafrah, K. Alqararah , M. AlJaradin note that in modern conditions there is a transformative approach to global sustainability, a rethinking of the possibilities of maximizing the efficiency of *resource use while minimizing costs and waste* [16]. A particularly significant role in the development of agricultural production is given to investments, state support for the industry, both at the local and interstate levels. In this case, we are talking about the territorial development of entire groups of countries. Thus, foreign direct investment by countries significantly increases agricultural productivity in entire regions with a particularly pronounced effect in middle- and low-income countries. The importance of strategies to deepen investment cooperation and increase the sustainability of global agriculture and food security is emphasized [17]. The need for a comprehensive policy that increases the financial literacy of the population and the management of enterprises is noted [18] . Z. Yang , Y. Li , C. Wu studied the influence of factors and found that population aging has a negative impact on the sustainability of agricultural economy, the development of financial science and technology strengthens sustainability, and innovation in agricultural technology plays an important mediating role [19].

of optimization methods . This is confirmed by world research. S. Sivanandham , S. Srivatsa Srinivas develop a lightweight and scalable *decision support system based on operations research* for the distribution of food supplies to the population in order to save overall transportation costs [20] . This is relevant for Russia with its vast territories. Y. Shen , D. Zeng , A. Zuo found that optimal allocation of agricultural resources promotes income mobility , *mitigates income inequality* [21] . Based on the application of a system of environmental, social and technical-economic indicators, a team of scientists developed a comprehensive methodology for managing the flow of agricultural plastic waste. A suitability map for the placement of waste collection centers was obtained [22]. L. Zuo , G. Liu , J. Zhao , J. Li , S. Zheng , X. Su identify the spatio-temporal heterogeneity of the impact of a set of ecosystem services on sustainable development goals, and develop strategies for spatial planning and management [23]. To determine the differences between groups of regions , the use of multivariate regression models is recommended [3].

As the results of the conducted study show, the management of agricultural production in the regions and individual enterprises is important. In this regard, the team of authors evaluates the value chain (economic, socio-cultural and environmental) from the position of the mechanism for managing each stage of value creation (production, processing, distribution/marketing and consumption) [24]. It is noted that agriculture as a system is supported by a management model in which there is no cooperation and a unified opinion, and relies on low-paid labor. In this regard, it is necessary to develop a mechanism for distributing responsibility and costs for the transformation of the food system, taking into account the potential of retail trade, collective structures of farms and auxiliary industries [25]. This is emphasized in this study as the need to develop logistics links, cooperation between regions, commodity producers, and the cooperative movement in agriculture in the regions of Russia. Also, state policy should be focused on promoting cooperation between enterprises [1], implementing large-scale projects in agriculture [12]. At the same time, the use of multidimensional methods makes it possible to identify key microregions for the implementation of strategic investments depending on the specific needs of the territory – from technological advances and improvement of transport infrastructure to the creation of competitive rural banks [13], and to identify the need for scientific research to ensure the technological development of the industry [14] .

DOI: 10.63550/ICEIP.2025.55.67.003

5 CONCLUSION

The conducted cluster analysis revealed significant differences between the groups of regions in key indicators. The greatest potential is demonstrated by the regions assigned to the new and first clusters, which are characterized by significant land availability with labor resources, a higher level of capital-labor ratio , and significant volumes of investment in fixed capital per unit area. These regions have recorded an increase in productivity in the crop and livestock sectors, a higher level of labor productivity. At the same time, their positive impact on financial results and profitability is not observed. Particularly noteworthy is the new cluster formed in 2023, which significantly exceeds other groups in terms of agricultural production volumes, financial results, and profitability of livestock products. It is noteworthy that the indicators of agricultural production per capita in the Volga Federal District consistently exceed the Russian average.

For the regions of the first cluster, it is recommended to optimize pricing policy, implement innovative scientific developments, take measures to optimize resource potential and production results. The regions of the second cluster are recommended to work out the investment attractiveness for implementing additional investments, modernize fixed assets, develop human resources, and increase the level of natural performance indicators. The implementation of the proposed measures will contribute to the growth of financial results and sustainable development of the agro-industrial complex in the regions of all cluster groups.

Further research will be based on spatial-dynamic studies and forecasting of the level of indicators that determine the development of agriculture in the regions and are aimed at developing interaction and cooperation between territories, exchange of experience and knowledge, and joint scientific developments.

REFERENCES

Capelli , J., de Sousa, PR, Barbosa, MW, 2025. Supply chain resilience capabilities: an outlook on the Brazilian agri -food sector post COVID-19 pandemic. *International Journal of Disaster Risk Reduction* 123, 105486.

Ferdous , O., Yousefi , S., Tosarkani . BM, 2025. A multi-disruption risk analysis system for sustainable supply chain resilience. *International Journal of Disaster Risk Reduction* 116, 105136.

na Castillo, C.P., Jacobs- Crisioni , C., Barranco , R.R., Rodriguez, S.V., Curtale , R., Kompil M., Aurambout , J.-P., e Silva, F.B., Sulis , P., Auteri , D., 2024. Are remote rural areas in Europe remarkable? Challenges and opportunities. Journal of Rural Studies 105, 103180.

Metta, M., Dessein , J., Brunori . G., 2024. Between on-site and the clouds: Socio-cyber-physical assemblages in on-farm diversification. Journal of Rural Studies 105, 103193.

Luo, Y., Liu, S., Zhang, Y., Zeng, M., Zhao, D., 2025. Digital pathways to resilience: Assessing the impact of digitalization on agricultural resilience production in China. China Economic Review 90, 102375.

Song, Y., Zhang, R., Hao . Y., 2025. Digital economy, labor force transfer, and high-quality agricultural development. Finance Research Letters 74 (2025) 106692.

Ding, M., Gao, Q., 2025. The impact of artificial intelligence technology application on total factor productivity in agricultural enterprises: Evidence from China. Economic Analysis and Policy 86, 399–415.

Ye, L., 2025. Digital economy and high-quality agricultural development. International Review of Economics and Finance 99, 104028.

Zhang, S., Chen, R., Wu, J., Zhu, N., 2025. Scale measurement and economic effect evaluation of smart agriculture in China. Socio-Economic Planning Sciences 99 (2025) 102195.

Hu, S., Wang, Y. , 2025. Spatial pattern of rural authenticity and its relation to urbanization: Insights from Henan Province, China. Habitat International 156, 103291.

Dehghani , A., Soltani , A., Nateghi , K., 2025. Balancing Urban Growth and Environmental Change: Land Use Patterns in Tehran and Sydney, Environmental and Sustainability Indicators.

Zhang, S., Cai , R., Wang, S., 2025. Impact of public investment on agricultural productivity growth: Evidence from China. *Economic Analysis and Policy* 85 (2025) 1442–1455.

Díaz , AO, Segovia, MF, Rivera, NA, 2025. Stochastic frontier analysis and agricultural typologies: Applied to Mexico's sugarcane industry. *Regional Science Policy* & Practice 17, 100173.

Wu, B., Cao, C., Mosey, S., Daniell , T., Noy , P., Cui, Y., Rose, M., Snape, J., 2025. How does global agricultural research and innovation cooperation influence agricultural R&I system transformation in the South? Evidence from UK-China cooperation. Food Policy 131 (2025) 102813.

Regions of Russia. Socio-economic indicators 2024 (Moscow: Rosstat). https://rosstat.ru

I. Alnafrah , K. Alqararah , M. AlJaradin , 2025. From linear to circular: Evaluating the effects of circular economy on sustainable development progress in the EU economies . *Journal of Environmental Management* 382, 125383.

Xu, R., Chen, Y., Du, A.M., 2025. The impact of China's outward FDI on agricultural productivity. Research in International Business and Finance 77, 102886.

Zeng, Y., Chen, C., Wang, C., Zou, J., 2025. Education investment, social security, and household financial market participation. Finance Research Letters 77, 107124.

Yang, Z., Li, Y., Wu, C., 2025. Population aging, fintech , and agricultural economic resilience. International Review of Economics and Finance 97, 103756.

Sivanandham , S., Srivatsa Srinivas, S., 2025. Enhancing food security at the last-mile: A light-weight and scalable decision support system for the public distribution system in India. Socio-Economic Planning Sciences 98, 102166.

Shen, Y., Zeng, D., Zuo , A., 2025. Unveiling the impact and mechanism of agricultural input allocation on the income mobility of rural households: Evidence from China. China Economic Review 90, 102356.

Convertino , F., Vox , G., Blanco, I., Hachem , A., Schettini , E., 2025. Plastic waste management in agriculture through a GIS-based territory design approach. Resources, Conservation & Recycling 217, 108210.

Zuo , L., Liu, G., Zhao, J., Li, J., Zheng, S., Su, X., 2025. Spatiotemporal heterogeneity management: Optimizing the critical role of ecosystem services in achieving Sustainable Development Goals. Geography and Sustainability 6, 100211.

Blackstocka , K., Creaneya , R., Delgado- Serranob , M.M., 2025. Value chains for sustainable mountain development: a qualitative understanding of 23 European cases. *Journal of Rural Studies* 118, 103640.

J. - Aceituno , A., Collste , D., Aparicio , G., L.-Rodríguez, MD, Rolfer , L., Bote , M.A., Castro, A.J., Marín , L., C.-Calderon, S., G.- Tenorio , M.A., G.-Martín, B., 2025. Trade-offs for healthy and sustainable diets in Europe: Social-ecological dynamics in an intensive agricultural system. *Global Food Security* 44, 100829.