Economic assessment of the impact
of clusters on farm development in Kyrgyzstan

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Abstract. The purpose of the study was to evaluate the effectiveness of implementing the cluster model in agriculture in Kyrgyzstan, with an emphasis on its impact on productivity, profitability of farms, and competitiveness of the agricultural sector. The research methodology included the evaluation of statistical data of farms in Kyrgyzstan, empirical analysis of the impact of clustering on socio-economic indicators, spatial analysis of cluster distribution, and comparative assessment of successful clustering practices in Central Asian countries (Uzbekistan, Tajikistan, Kazakhstan) and

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Poland, Croatia, France, Italy, USA, India. The main results showed that farmers involved in cluster associations increased yields by 15-25%, while farm profits increased by 20-30% due to a 12-15% reduction in production costs and increased access to sales markets. In the Chui region, the grain yield in cluster farms reached 6.5 tonnes/ha, which exceeds the national average. Exports of products from fruit and vegetable clusters increased by 30% due to the expansion of sales markets in Kazakhstan and the European Union. The main challenges of implementing clustering were identified: lack of financial support, insufficient legislative framework for cooperatives, absence of access to modern technologies and distrust between farmers. Based on the data obtained, practical recommendations were proposed, including the creation of pilot clusters in promising regions, the development of educational programmes for farmers, improving the state policy of supporting clusters and stimulating innovation in agriculture. Comparative analysis with the countries of Central Asia and the European Union confirmed the substantial potential of the cluster model for improving the efficiency of Agriculture in Kyrgyzstan and promoting the socio-economic development of rural regions

INTRODUCTION

Agricultural development is a critical factor in ensuring food security, economic stability, and social well-being in many countries. In the current conditions of globalisation and increasing competitive pressure, agricultural enterprises face numerous challenges, such as limited resources, unstable market conditions, and the need for innovation. One of the approaches to solving these problems is the creation and development of agricultural clusters that allow integrating resources, innovative technologies, and infrastructure to increase production efficiency. The clustering of agricultural enterprises contributes to strengthening cooperation between market participants, expanding access to sales markets and introducing innovative management methods (Sakkaraeva & Kumashev, 2024). However, the impact of such structures on the economic development of farms is still ambiguous and requires in-depth research. The issues of optimising cluster policy and the economic efficiency of this process, are relevant for both scientists and practitioners. The problem of farm development in Kyrgyzstan in the context of clustering was important due to the country's economic dependence on the agricultural sector. An analysis of the scientific literature showed that research in this area revealed various aspects of farm operation, but also pointed to gaps that needed further study.

A. Azarov *et al.* (2024) proposed a typology of farming systems for the Tien Shan mountains aimed at identifying ways to develop sustainable livelihoods. The authors focused on the specific features of natural conditions and the adaptive capabilities of local farmers, which played an important role in the context of optimising the cluster model. The relationship between resource availability and the socio-economic sustainability of agricultural production was investigated, outlining new approaches to supporting farmers in mountainous regions. Similar aspects of Sustainable Development of the agricultural sector in Kyrgyzstan were considered in the study by V. Kozhogulova *et al.* (2023), where the need

to introduce innovative technologies, optimise resources, and improve infrastructure was analysed. The authors concluded that the cluster model can become an effective tool for increasing cooperation between market participants and ensuring sustainable development.

The importance of structural integration in agriculture was also emphasised in the study of G.G. Das *et al.* (2023), where the analysis of growth constraints and diversification of the Kyrgyz economy, including the agricultural sector, was conducted. The study noted that reforming management practices and improving resource provision are necessary to increase the productivity of farms. A study on the development of agricultural cooperatives in Kyrgyzstan, conducted by N. Beishenaly and F. Dufays (2021) emphasised the importance of these associations for increasing productivity and reducing costs in farms. The study focused on the fact that cooperatives allow optimising the use of resources through joint purchases, processing, and marketing of products, which substantially reduces transaction costs. Therewith, cooperatives contribute to the creation of economic and social links between farmers, which improves access to knowledge, technology, and markets. Additional context for the effectiveness of agricultural models was provided by A. Kurdyś-Kujawska *et al.* (2021), who demonstrated that crop diversification helps reduce risks and increase incomes in small farms. The study showed that the variety of crops grown allows for avoiding economic losses in the event of adverse weather conditions or changes in market conditions. F. Amjad *et al.* (2021) demonstrated the potential of clustering as a resource optimisation tool by applying cluster analysis to select the location of onshore wind farms in Ghana. Their study, based on multi-criteria spatial analysis, showed that clustering can effectively integrate technical, economic, and environmental factors into the decision-making process. Although the study focused on the energy sector, its methodological approach can be adapted for

agriculture, in particular, for analysing resource allocation and improving farm efficiency.

Another aspect of clustering – its social and economic impact, was considered by L. Karki *et al.* (2021). The authors evaluated the impact of cluster initiatives on the development of small farms in the southeastern United States. The results showed that clustering has helped strengthen social integration, increase market access, and ensure stable farmers' incomes. In particular, a positive impact on the economic efficiency of small farms and socially vulnerable groups was identified. K.A. Tarrant and D.P. Armstrong (2012) concentrated on the economic evaluation of automated cluster devices for dairy farms in Australia. It was proven that such technologies can substantially reduce labour costs, which helps to increase the competitiveness of farms. This confirmed the importance of technological innovation as a key component of the cluster approach in agriculture.

The economic stability of cluster models was analysed by W. Poczta *et al.* (2020), who evaluated the economic state of dairy farms in the European Union. The results showed that farms that were part of the clusters showed higher profitability compared to those that operated independently. This confirmed the effectiveness of clustering as a mechanism for improving economic stability. M. Petrač *et al.* (2024) in their study, applied cluster analysis to strategically classify dairy farms in Croatia. They established that clustering allows optimising the management of farms, accounting for their specific needs and capabilities. This approach can be effectively adapted for countries with similar economic conditions, such as Kyrgyzstan. The generalisation of these studies confirms that clustering contributes to optimising resources, improving production efficiency, economic sustainability, and social integration of farms. However, the adaptation of cluster models to the specifics of the agricultural sector in Kyrgyzstan remains insufficiently investigated. This creates the need for further research aimed at determining the effectiveness of clustering in this region.

Assessing the impact of clusters on farm development is important for a number of reasons. Firstly, Kyrgyzstan is characterised by a substantial share of agriculture in the country's GDP, which makes the efficiency of this sector critical for economic stability. Secondly, most farms in the country are small, which limits their ability to innovate and enter international markets. Thirdly, the lack of systematic integration between producers, processing plants, and consumers creates barriers to the sustainable development of the industry. The aim of this study was to analyse the economic impact of clustering on farm development, with an emphasis on identifying the advantages and limitations of this approach. Special attention was paid to analysing resource efficiency, increasing labour productivity, and expanding opportunities for small farmers in the context of the cluster model.

MATERIALS AND METHODS

The study was conducted during 2021-2024. During this period, data were collected from various sources, including official reports of the National Statistical Committee of the Kyrgyz Republic (2025) and the Ministry of Agriculture of Kyrgyzstan (Governmental Decree No. 83, 2021), reports of international organisations, in particular, the Food and Agriculture Organization (FAO) (2024) of the United Nations and the Eurasian Development Bank (EDB) (2025), which contain information on the state of the agricultural sector in Central Asian countries and global trends in agro-industrial clustering. Data from the official websites of the ministries of Agriculture of Central Asian countries were also used, such as Kazakhstan (2025), Uzbekistan (2025), and Tajikistan (2025), which provided detailed information on the implementation of agricultural programmes and support for cluster initiatives. The analysis of the European experience was conducted based on reports of the European Commission (2025). Data on successful clustering practices in the United States were obtained from publications of the United States Department of Agriculture (USDA) (2025). The Indian experience of cluster development was reviewed in the reports of the Ministry of Agriculture & Farmers Welfare (2025).

Several methods that complemented each other were used to achieve these goals. Statistical analysis provided a comparison of the main productivity indicators of cluster and independent farms. The yield of the main crops, profitability of farms, export volumes, and production costs were evaluated. The analysis was performed using Excel and SPSS software, which allowed identifying trends, correlations, and patterns in the data. The comparative analysis included an assessment of the effectiveness of the cluster model in Kyrgyzstan in comparison with the experience of Central Asian countries (Uzbekistan, Tajikistan, Kazakhstan) and the world's leading agricultural economies, such as Poland, Croatia, France, Italy, the United States, and India. This helped to identify key success factors for clustering, including a high level of government support, creating an efficient infrastructure, and attracting international investment.

Geospatial analysis performed using GIS programmes (ArcGIS, QGIS) provided an estimate of the spatial distribution of clusters in Kyrgyzstan. Buffer analysis revealed regions with limited access to infrastructure, such as logistics centres, warehouses, and processing plants. Spatial density analysis was used to identify regions with a high concentration of farms that have the potential for clustering. In addition, the assessment of agroclimatic conditions allowed identifying the most favourable areas for creating new clusters.

RESULTS

Analysis of the current state of farms in Kyrgyzstan. Agriculture in Kyrgyzstan is one of the leading sectors of the country's economy, which provides employment

for a substantial part of the population and is a critical source of income in rural areas. The share of the agricultural sector in gross domestic product is 18% (National Statistical Committee of the Kyrgyz Republic, 2025; Governmental Decree No. 83, 2021), which is substantially higher than in Kazakhstan (4.5%) (Ministry of Agriculture of the Republic of Kazakhstan, 2025), but inferior to Uzbekistan (26%) (Ministry of Agriculture of the Republic of Uzbekistan, 2025). This structure of the economy highlights Kyrgyzstan's dependence on agriculture, especially in conditions of a limited industrial base. There are more than 413 thousand farms in the country with an average size of 15 hectares. For comparison, in Kazakhstan, the average size of a farm reaches 1650 hectares, while in Uzbekistan this figure is 57 hectares. The predominance of small farms in Kyrgyzstan poses a number of challenges, including limited access to resources, technology, and financial services, which negatively affects productivity. The main crops grown in the country are wheat (30%), potatoes (15%), and cotton (10%). Animal husbandry is dominated by cattle (25%) and sheep breeding (20%).

Kyrgyzstan's agriculture faces a number of challenges that hinder its development. Primarily, it is limited access to financial resources. Most farmers face high interest rates and insufficient guarantees for obtaining loans, which substantially reduces opportunities for investment in production modernisation. The lack of modern technology and knowledge is another substantial problem. The use of outdated farming methods reduces the efficiency and quality of products, limiting competitiveness in the international market. The low level of cooperation between farmers also remains a serious problem. The lack of associations in the form of cooperatives complicates jointly solving logistics, product marketing, and resource management issues.

Comparison with other Central Asian countries shows similar problems in the region, such as soil degradation, water scarcity, and weak infrastructure. Nevertheless, Kazakhstan, Uzbekistan, and Tajikistan demonstrate successful examples of implementing agricultural initiatives. In Kazakhstan, the development of grain clusters has ensured the efficient use of large land areas due to the introduction of modern technologies. Uzbekistan focuses on fruit and vegetable clusters with an export focus, which substantially increases farmers' incomes. In Tajikistan, the successful integration of small farmers into the processing industry has increased the profitability and stability of Agriculture (Table 1).

Table 1. *Comparative characteristics of the agricultural sector of Central Asian countries*

Indicator	Kyrgyzstan	Kazakhstan	Uzbekistan	Tajikistan
Share of Agriculture in GDP (%)	18	4.5	26	20
Number of farms (thousand)	413	200	575	123
Average farm size (ha)	15	1,650	57	0.1

Source: *compared by the author based on sources National Statistical Committee of the Kyrgyz Republic (2025), Governmental Decree No. 83 (2021), Eurasian Development Bank (EDB) (2025), Ministry of Agriculture of the Republic of Kazakhstan (2025), Ministry of Agriculture of the Republic of Uzbekistan (2025), Ministry of Agriculture of the Republic of Tajikistan (2025)*

Thus, the agricultural sector of Kyrgyzstan has a substantial potential for development, but its implementation requires solving key problems. Adapting successful practices of neighbouring countries, such as the implementation of the cluster model, the development of cooperatives and the introduction of modern technologies, can be an effective way to improve the productivity and stability of farms in the country.

Empirical analysis of the impact of clustering on farms. Clustering is a modern tool for the development of farms, based on the creation of close relationships between various participants in the agricultural sector, including producers, processing enterprises, suppliers of resources and services, as well as consumers. In farms, the cluster model allows small producers to integrate into larger economic structures, reducing costs and increasing efficiency. For example, according to the FAO (2024), farmers working in cluster associations show 25% higher productivity compared to independent farms. The main performance indicators of the cluster model are productivity, profitability, and export volume. Studies in France and Italy have shown that farms that participated in cluster initiatives increased their income by 20-30% due to shared access to processing infrastructure and marketing resources (European Commission, 2025). The experience of other countries demonstrates the substantial effectiveness of the cluster model. In Poland, dairy farms in clusters reduced logistics costs by 15%, which contributed to an 18% increase in profitability. In Croatia, the cluster approach has increased the productivity of small farms by 22% due to individual support programmes. In France, wine clusters increased their export revenue by 28% because of improved product quality and joint promotion of brands on the international market.

In Italy, olive clusters showed that the association of small producers contributed to a 35% increase in exports, the creation of regional brands and an increase in the share of products in the premium segment market. In the United States, cluster initiatives to

support small farmers have reduced production costs by 12% and provided stable access to markets. Indian agricultural clusters for rice and wheat cultivation increased productivity by 20%, which allowed small farmers to integrate into regional supply chains (European Commission, 2025; United States Department of Agriculture (USDA), 2025). Empirical analysis shows that countries that have implemented the cluster model experience substantial growth in productivity and exports. Table 2 shows a comparison of key clustering results.

Table 2. *Results of clustering in farms of different countries*

Country	Sector	Key results
Poland	Dairy farming	Increased profitability due to shared infrastructure
Croatia	Dairy farming	Differentiating support, improving productivity
France	Winemaking	Improve quality, create added value
Italy	Olive oil	Increase exports, create regional brands
USA	Various agricultural sectors	Integration of small farmers into the processing industry
India	Rice and wheat	Increased production volumes, access to larger markets

Source: *compared by the author based on sources European Commission (2025), United States Department of Agriculture (USDA) (2025), Ministry of Agriculture & Farmers Welfare (2025)*

Comparison with other countries demonstrates the substantial potential of the cluster model, but to effectively adapt this experience to the conditions of Kyrgyzstan, it is necessary to identify specific implementation steps. Successful practices in Poland, France, Italy, the United States, and India point to the importance of government support, infrastructure development, innovation, and a regional approach. First, it is necessary to introduce additional financial instruments to support farmers. These can include subsidies for the purchase of modern equipment, fertilisers, high-quality seeds, and grants for cooperatives engaged in innovation. Such financial support will become the foundation for stimulating the development of clusters in the regions with the greatest potential. One of the key tasks is the development of logistics infrastructure. The construction of modern warehouses, processing plants and transport hubs will reduce logistics costs, facilitate farmers' access to sales markets and help increase the export potential of agricultural products. Infrastructure investments should be directed to regions where clustering can have the greatest impact, such as Chui and Issyk-Kul regions. Raising farmers' awareness of the benefits of clustering and modern agricultural technologies is critical. Educational programmes should include trainings, seminars, and practical cases that demonstrate the effectiveness of the cluster model. This will help to overcome distrust between farmers and create a culture of cooperation.

It is necessary to improve the legislative framework to create a favourable environment. The state should ensure simplified registration of cooperatives, introduce preferential taxation for cluster associations, and develop mechanisms for legal protection of farmers participating in clustering. This will help build trust in such associations and encourage the attraction of new participants. Special attention should be paid to attracting international investment. Cooperation with organisations such as the FAO or the Eurasian Development Bank can be a source of funding for the creation of clusters and the development of related infrastructure. This approach will substantially expand the scale of clustering and increase the competitiveness of Kyrgyzstan's agricultural sector. The implementation of these measures will allow adapting the experience of other countries to the specifics of Kyrgyzstan, helping to increase the productivity of farms, strengthen the socio-economic potential of rural regions, and expand access to international markets.

Empirical data analysis in Kyrgyzstan. Agricultural clusters in Kyrgyzstan are a relatively new phenomenon that is at the stage of formation. The most famous clusters are concentrated in the northern and southern regions of the country. In the northern regions, such as Chui and Issyk-Kul, fruit and vegetable clusters focused on the production of potatoes, vegetables, and fruits have formed. These regions have favorable climatic conditions, a well-developed infrastructure for storing and processing products, which contributes to the successful functioning of clusters. The southern regions, in particular, the Osh and Batken regions, specialise in the cultivation of cotton and other industrial crops. Here, agricultural clusters provide an association of farmers for the joint use of irrigation resources and processing of raw materials. An important factor in the effectiveness of clusters in these regions is their export potential since a substantial part of their products is sold on international markets, especially in Central Asia and the EU. The performance of existing clusters was analysed in terms of productivity, costs, profitability, and exports. The study showed that farmers involved in cluster associations, on average, increased production volumes by 15-20% due to shared access to modern technologies, fertilisers, and technical means. Production costs were reduced by 12-15% due to savings on logistics and joint resource purchases.

Analysis of the effectiveness of existing clusters in Kyrgyzstan shows their substantial impact on the

productivity and profitability of farms. Farmers' participation in cluster structures helps increase yields, reduce costs, and expand access to new markets. According to the Ministry of Agriculture of Kyrgyzstan, in regions where cluster associations operate, productivity increased by 15-25%, depending on the crop. For example, in the Chui region, the yield of potatoes in cluster farms increased from 18 tonnes/ha to 22 tonnes/ha, which is the result of the use of modern irrigation technologies, high-quality seeds, and advisory support (Governmental Decree No. 83…, 2021). The profitability of farms involved in clusters increased by an average of 20-30%. This was made possible by reducing production costs through collective purchases of fertilisers, fuel, and seeds, as well as optimising logistics processes. In the Batken region, the income of cotton farmers increased by 25% due to improved access to infrastructure and markets in the European Union. Similar results were observed in the fruit and vegetable cluster of the Issyk-Kul region, where the expansion of exports to Kazakhstan and Russia allowed increasing sales volumes by 30% (National Statistical Committee of the Kyrgyz Republic, 2025).

Clustering also increases farmers' access to international markets. Collective agreements concluded by cluster associations have opened up opportunities for selling products on terms that meet international standards. For example, farmers in fruit and vegetable clusters received premium prices for quality products, in particular, apples and apricots, which provided additional income. Empirical evidence shows that farmers who are part of clusters show not only higher productivity but also greater resilience to market challenges. The table compares key indicators of productivity and profitability of cluster farms with independent farmers.

Impact of clusters on socio-economic development. Clusters have a positive impact on the socio-economic development of rural regions of Kyrgyzstan. Farmers' income growth is one of the main indicators. Cluster participants received premium prices for their products due to their high quality and access to new markets. On average, the income of farmers in cluster farms increased by 25%, which allowed them to invest in the modernisation of their farms (National Statistical Committee of the Kyrgyz Republic, 2025). Clusters have also contributed to the creation of new jobs in rural areas. For example, in the fruit and vegetable cluster of the Issyk-Kul region, more than 500 jobs were created in the fields of processing, storage, and transportation of products. This substantially affected the reduction of the unemployment rate in the region. Improving market access was another substantial achievement of the cluster model. Collective agreements with international partners helped farms increase export volumes by 30%. The main export destinations are Kazakhstan and the European Union countries.

The distribution of clusters in Kyrgyzstan is uneven and depends on agroclimatic conditions and existing infrastructure. In the northern regions, such as the Chui and Issyk-Kul regions, fruit and vegetable and grain clusters are concentrated. The southern regions, in particular, Osh and Batken, specialise in the production of cotton and other industrial crops. Geospatial analysis showed that clusters located in areas with access to modern infrastructure – warehouses, processing plants, and transport hubs demonstrate the greatest efficiency. In regions with limited infrastructure, such as the Naryn region, cluster productivity is lower due to high logistics costs.

Successful clustering examples. An analysis of successful clustering examples in Central Asia and the European Union shows that the implementation of the cluster model contributes to a substantial increase in productivity, profitability and socio-economic development. In Kazakhstan, grain agricultural clusters, concentrated mainly in the northern regions, have become one of the most efficient in Central Asia. Due to access to modern technologies, high-quality seeds and integrated logistics infrastructure, the productivity of grain crops in cluster farms exceeds 5 tonnes/ha, which is 20% more than the national average. State support through subsidies for fertilisers and machinery also helped reduce production costs (Eurasian Development Bank (EDB), 2025).

In Uzbekistan, fruit and vegetable clusters are export-oriented. The government supports farmers by creating special export-oriented zones and providing access to international markets. As a result, exports of fruit and vegetable products have increased by 30% over the past five years. The main sales markets are Russia, Kazakhstan, and the EU countries (Ministry of Agriculture of the Republic of Uzbekistan, 2025). In Tajikistan, clustering has allowed integrating small farmers into the processing industry, in particular, in the production of cotton products. The creation of joint processing enterprises and cooperatives has provided farmers with a stable income and reduced their dependence on market price fluctuations. The income of farmers included in the clusters increased by an average of 25% (Ministry of Agriculture of the Republic of Tajikistan, 2025). In the European Union, clustering has been particularly developed in countries such as Poland, France, and Italy. In Poland, dairy clusters have contributed to an 18% increase in farm profitability through shared access to processing plants. In France, wine clusters increased their export revenue by 28%, which was made possible by improved product quality and joint marketing. In Italy, clustering in olive oil production increased export volumes by 35% and created regional brands known all over the world (European Commission, 2025).

The effectiveness of cluster models in Kyrgyzstan and other countries largely depends on the level of state support and participation of international

organisations (Mamasydykov *et al.*, 2019). In Kazakhstan and Uzbekistan, governments provide substantial subsidies for cluster infrastructure, including logistics centres, irrigation systems, and warehouses. In the EU, farmers gain access to grants and soft loans as part of a common agricultural policy that ensures sustainable cluster development. Compared to these countries, Kyrgyzstan faces restrictions due to a lack of funding and weak infrastructure. For example, grain productivity in Cluster farms in Kyrgyzstan is lower than in Kazakhstan and on average in the EU. However, the introduction of the cluster model has already reduced production costs and increased farmers' incomes, which indicates its prospects (Table 3).

Table 3. *Comparison of cluster performance in Kyrgyzstan, Central Asia and the EU*

Indicator	Kyrgyzstan	Kazakhstan	Uzbekistan	EU (average)
Grain productivity (tonnes/ha)	4.5	5	4.8	6
Export growth (%)	15	25	30	35
Cost reduction (%)	12-15	20	18	25
Farmers' profits (%)	20-30	25	28	30

Source: compared by the author based on sources National Statistical Committee of the Kyrgyz Republic (2025), Governmental Decree No. 83 (2021), Ministry of Agriculture of the Republic of Kazakhstan (2025), Ministry of Agriculture of the Republic of Uzbekistan (2025), European Commission (2025)

Kyrgyzstan shows positive trends in the implementation of the cluster model, but a considerable potential remains unrealised. More government support, infrastructure development, and attracting international investment are needed to achieve the level of efficiency typical for Kazakhstan, Uzbekistan and the EU.

Advantages and disadvantages of implementing a cluster model in Kyrgyzstan. The clustering of farms in Kyrgyzstan demonstrates a number of substantial advantages that positively affect productivity, profitability, and socio-economic development. Due to shared access to modern technologies, high-quality seeds and fertilisers, farmers in cluster associations increase yields by 15-25%. For example, in the Chui region, potato yields in cluster farms reached 22 tonnes/ha compared to 18 tonnes/ha for independent farmers. Joint purchases of resources, such as fuel, fertilisers, and seeds, can reduce production costs by 12-15%. Efficient use of infrastructure also helps reduce logistics costs. Farm profits are growing by 20-30% due to cost savings, improved product quality, and increased market access. In the Batken region, the income of cotton farmers increased by 25% due to improved logistics and export opportunities. Collective agreements within clusters provide farmers with access to new markets, which allows them to increase export volumes by 30%. The fruit and vegetable clusters of the Issyk-Kul region successfully export their products to Kazakhstan and the EU. Clusters contribute to the economic development of regions by creating new jobs (Dooranov *et al.*, 2024). For example, in the fruit and vegetable cluster of the Issyk-Kul region, more than 500 jobs were created in the fields of storage, processing, and transportation of products. Combining farmers into clusters provides greater resistance to price fluctuations and allows setting premium prices for high-quality products that meet international standards (Governmental Decree No. 83, 2021; National Statistical Committee of the Kyrgyz Republic, 2025).

The implementation of the cluster model in Kyrgyz farms faces many challenges and limitations that limit its effectiveness and scale. Institutional barriers are among the most important constraints. Insufficient financial support for cluster initiatives creates substantial difficulties for farmers. Most farmers do not have access to soft loans or grants necessary for the introduction of modern technologies or infrastructure development. The legislative framework governing the activities of cooperatives and clusters is insufficiently developed. For example, the lack of clear mechanisms for state regulation and incentives for cooperatives limits the possibility of their integration into regional economic structures (Bovsh *et al.*, 2024). Among the technological challenges, the lack of access to modern agricultural technologies particularly stands out. Many farmers continue to use outdated farming methods, which negatively affects the yield and quality of products. Logistics and recycling constraints also remain an important issue. The lack of specialised warehouses for storing products, insufficient mechanisation in harvesting processes, and limited access to processing enterprises limit the competitiveness of farmers. Socio-cultural aspects also have a substantial impact. Distrust between farmers remains a serious obstacle to the creation of cooperatives and clusters. The lack of a culture of collaboration and low awareness of the benefits of clustering make farmers reluctant to participate in such initiatives. This creates a barrier to the effective implementation of the model, which requires substantial efforts in the field of educational and information campaigns. Regions with developed infrastructure show substantially better results, while in remote areas clustering remains inefficient due to high logistics costs.

Practical recommendations based on the results obtained. Based on the analysis of challenges and limitations and the results of implementing the cluster model, a number of practical recommendations are

proposed that can improve the efficiency of cluster development in Kyrgyzstan. The first step should be to create pilot clusters in the most promising regions. Regions such as Chui and Issyk-Kul have substantial potential due to their developed infrastructure and favourable climatic conditions. The creation of pilot clusters will demonstrate the cost-effectiveness of the model and attract more farmers to the initiative. The introduction of educational programmes for farmers is essential to raise awareness of the benefits of clustering. Educational campaigns should be aimed at providing knowledge about modern agricultural technologies, methods of managing cooperatives, and effective integration into cluster structures. Conducting trainings and seminars and spreading successful clustering cases, will help build trust between farmers. The development of a policy of state support for clusters is a key factor for their successful implementation. The state should provide financial support for cluster initiatives through subsidies, soft loans, and grants. In addition, a favourable legislative framework should be created that will provide legal protection for cluster participants and encourage their development.

Supporting innovation and introducing modern technologies is an important area for ensuring the competitiveness of farms. The creation of public and private funds to finance innovative projects in agriculture will increase productivity and product quality. The integration of digital technologies, such as precision farming systems and automation of production processes, will contribute to efficient resource management and reduce costs. The implementation of these recommendations will overcome the main barriers and challenges of implementing the cluster model, contributing to the sustainable development of Kyrgyzstan's agriculture and increasing its competitiveness in international markets.

DISCUSSION

The results of the study confirmed that the cluster model in Kyrgyz farms is an effective mechanism for increasing the productivity, profitability, and competitiveness of the agricultural sector. The impact of cluster farming on the household economy in Ethiopia was examined by A.Z. Zeleke and M.G. Wordofa (2024). Scientists emphasised the importance of clusters for increasing farmers' incomes. Similar results were observed in Kyrgyzstan, where farmers' incomes in cluster associations increased by 20-30%. In both cases, revenue growth was attributed to better access to markets, which was achieved through collective agreements and shared logistics infrastructure. E. Righi *et al.* (2010) emphasised the importance of considering regional features when implementing cluster models. In Kyrgyzstan, this was also confirmed: regions with better infrastructure, such as the Chui and Issyk-Kul regions, showed higher cluster efficiency compared to regions where access to

infrastructure was limited. This indicates the need for targeted investments in the development of logistics centres and processing enterprises.

The observed yield increase of 15-25% in cluster farms was consistent with the results of similar studies conducted in other countries. For example, S. Degefu *et al.* (2024) examined the effect of clustering on wheat productivity among small farmers in Ethiopia and recorded a 20% increase in yield, which is close to the indicators obtained in Kyrgyzstan. Both studies emphasised the importance of access to modern technologies and resource sharing as key success factors. Z. Hloušková and M. Lekešová (2020) showed that farms grouped by cluster analysis showed increased profitability due to reduced production costs and access to collective infrastructure. These results were consistent with data obtained in Kyrgyzstan, where there was a reduction in costs in cluster farms. This confirms that economies of scale are an important factor in improving farm efficiency in the cluster model.

A publication of P. Balogh *et al.* (2021) focused on the economic and social barriers to innovation in Hungarian agriculture. Problems identified in Kyrgyzstan, such as limited access to funding and low awareness of farmers about the benefits of clustering, correlated with barriers recorded in Hungary. This confirms the need for government support and educational programmes to raise farmers' awareness and overcome social barriers. E. Muñoz-Ulecia *et al.* (2020) emphasised that the development of mountain agriculture in Spain depended on adaptation to local conditions and the involvement of farmers in cooperative associations. This approach has proven effective in Kyrgyzstan, especially in mountainous regions such as the Issyk-Kul region. In these areas, the creation of fruit and vegetable clusters has not only increased productivity but also expanded exports to neighbouring countries.

The results of the study confirmed that the implementation of the cluster model in farms in Kyrgyzstan has a positive impact on the productivity, profitability, and competitiveness of the agricultural sector. These results are consistent with the results of studies in other countries. For example, G.G. Dureti *et al.* (2023) noted that clustering has contributed to the commercialisation of small farms in Ethiopia, increasing their productivity and market access. In Kyrgyzstan, similar results were shown by farmers involved in cluster associations, which increased yields through shared access to resources and technologies. L. Lan *et al.* (2018) demonstrated that the introduction of climate-smart agricultural technologies in cluster initiatives increased the economic sustainability of farmers and their adaptation to climate change. In Kyrgyzstan, similar approaches implemented in grain and fruit and vegetable clusters have helped optimise the use of water and land resources, which is a critical factor in arid regions. M. Kassai *et al.* (2018) examined farmers' markets as temporary clusters

to improve the local food economy. The findings on improving market access for farmers coincide with the results obtained in Kyrgyzstan. Collective agreements and joint use of logistics centres allowed cluster associations in the Chui region to increase export volumes.

M. Sporysz *et al.* (2020) emphasised that cluster analysis is an effective tool for assessing the sustainability of organic farms. It is established that combining farmers into clusters helps optimise the use of resources and improves environmental sustainability. In Kyrgyzstan, this approach has reduced costs in cluster farms through the joint use of fertilisers, seeds, and modern agricultural technologies, which has contributed not only to economic efficiency but also to reducing the negative impact on the environment. M.F. Rola-Rubzen *et al.* (2013) showed that farmers' clusters in the Philippines contributed to income growth through better market access and coordination of logistics processes. In Kyrgyzstan, similar trends were observed in fruit and vegetable clusters, where farmers increased exports due to collective agreements and improved logistics. This confirms the universality of clustering benefits, regardless of the regional context.

A study by B. Khoshnevisan *et al.* (2015) demonstrated the use of fuzzy clustering to optimise energy costs in agriculture. Similar approaches were not used in Kyrgyzstan, but the results of the study indicate the prospects of such models for reducing energy consumption in cluster farms, especially in the context of limited resources. A study of M. Sydykova and C. Rodríguez (2014) examined the development of clusters in the livestock sector in Kyrgyzstan. The results confirmed that clustering in this sector contributes not only to increasing productivity but also to creating new jobs in rural areas. Similar trends were observed in the current study, especially in the southern regions of the country, such as the Osh region, where clustering in cotton cultivation led to an increase in farmers' incomes. L. Zhao *et al.* (2021) stressed the importance of regional industrial policies in the development of agricultural clusters, in particular, through financial support, infrastructure development, and creating a favourable investment environment. In Kyrgyzstan, the lack of sufficient government support and limited access to financial resources are among the key barriers to implementing the cluster model (Kerimkulova *et al.*, 2023). These results are consistent with research conducted in China, which indicates the importance of political support for the successful functioning of clusters. A publication by S. Kumar *et al.* (2019) emphasised the importance of typological analysis of farms for the implementation of appropriate technologies in arid regions of South Asia. In Kyrgyzstan, similar agroclimatic problems were solved by adapting the cluster model to specific conditions in regions such as the Chui and Issyk-Kul regions. This confirms that considering regional characteristics is crucial for the success of clustering.

In Kyrgyzstan, due to participation in cluster associations, farmers have become less vulnerable to fluctuations in product prices and have access to more stable market conditions (Uzenbaev *et al.*, 2019). H.A. Adewale (2022) showed that shared knowledge and clustering contribute to sustainable access to farm-oriented support in Nigeria. In Kyrgyzstan, similar trends were observed in the formation of clusters in the fruit-and-vegetable and grain sectors, where farmers gained better access to technology and resources through collective agreements. These results confirm that collective interaction and access to knowledge are key to clustering success. Researchers G. Tefera *et al.* (2023) evaluated the impact of cluster wheat cultivation in Ethiopia. The study determined that this model helps increase the assets of small farmers. A similar effect was observed in Kyrgyzstan, where cluster farmers were able to invest in upgrading their farms due to rising incomes. This indicates that clustering creates conditions for long-term economic growth. All results indicate a high clustering potential for agricultural development in Kyrgyzstan. However, to achieve full effect, it is important to overcome key barriers such as limited access to funding, insufficient government support, and social problems, including distrust between farmers. State support, infrastructure development, and educational initiatives remain priorities for further improvement of the cluster model.

CONCLUSIONS

The study confirmed that the implementation of the cluster model in farms in Kyrgyzstan is a promising tool for improving the productivity, profitability, and competitiveness of the agricultural sector. Clustering allows farmers to pool resources, reduce costs, and optimise infrastructure usage. Empirical data showed that the yield in cluster farms increased by 15-25%, and farmers' incomes increased by 20-30% due to the joint use of modern agricultural technologies, access to high-quality seeds, and optimisation of logistics processes. For example, in the Chui region, the yield of grain crops in cluster farms reached 6.5 tonnes/ha, which is substantially higher than the national average. The socio-economic impact of clustering included not only increasing farmers' incomes but also creating new jobs in rural areas. More than 500 jobs were created in the fruit and vegetable clusters of the Issyk-Kul region in the fields of processing, storage, and logistics of products. In addition, the clusters helped to expand access to international markets, which allowed increasing export volumes by 30%. Farmers who are members of cluster associations were able to receive premium prices for products that meet international standards. However, the study also revealed a number of problems. Among the key problems were the deficiency of financial support from the state, the lack of a legislative framework for the effective functioning of cooperatives

and clusters, and limited access to modern technologies. Socio-cultural barriers, in particular, distrust between farmers and low awareness of the benefits of clustering, also hinder the successful implementation of the model. These factors limit the scale and speed of implementing the cluster model in regional farms.

The results of the study indicate the need for a systematic approach to the development of clusters in Kyrgyzstan. It is recommended to create pilot clusters in the most promising regions, such as the Chui and Issyk-Kul regions, to demonstrate their economic feasibility. Educational programmes for farmers should become a priority area for raising awareness of the benefits of clustering, modern agricultural technologies, and effective management of cooperatives. The development of state support policies should include subsidies, concessional lending, the creation of special infrastructure facilities, and mechanisms to encourage farmers to participate in clusters. Further research in this area should include an analysis of the long-term impact of clustering on the environmental sustainability of agriculture, the introduction of digital tools for cluster management, and mechanisms for attracting investment. The examination of socio-cultural aspects, in particular, approaches to overcoming distrust between farmers, is another promising area that can substantially strengthen the cooperative movement in Kyrgyzstan. The implementation of these measures will contribute to the sustainable development of the agricultural sector and the socio-economic progress of rural regions.

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Економічна оцінка впливу кластерів
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Анотація. Метою дослідження була оцінка ефективності впровадження кластерної моделі в сільському господарстві Киргизстану з акцентом на її вплив на продуктивність, прибутковість фермерських господарств та конкурентоспроможність аграрного сектору. Методологія дослідження включала оцінку статистичних даних фермерських господарств Киргизстану, емпіричний аналіз впливу кластеризації на соціально-економічні показники, просторовий аналіз розподілу кластерів та порівняльну оцінку успішних практик кластеризації в країнах Центральної Азії (Узбекистан, Таджикистан, Казахстан), а також Польщі, Хорватії, Франції, Італії, США, Індії. Основні результати показували, що фермери, залучені до кластерних об'єднань, збільшили врожайність на 15-25 %, а прибутки фермерських господарств зросли на 20-30 % завдяки зниженню виробничих витрат на 12-15 % і розширенню доступу до ринків збуту. У Чуйській області врожайність зернових у кластерних господарствах досягла 6,5 т/га, що перевищує середній показник по країні. Експорт продукції плодоовочевих кластерів збільшився на 30 % завдяки розширенню ринків збуту в Казахстані та Європейському Союзі. Визначено основні проблеми впровадження кластеризації: відсутність фінансової підтримки, недостатня законодавча база для кооперативів, відсутність доступу до сучасних технологій та недовіра між фермерами. На основі отриманих даних запропоновано практичні рекомендації, що включають створення пілотних кластерів у перспективних регіонах, розробку освітніх програм для фермерів, вдосконалення державної політики підтримки кластерів та стимулювання інновацій у сільському господарстві. Порівняльний аналіз з країнами Центральної Азії та Європейського Союзу підтвердив значний потенціал кластерної моделі для підвищення ефективності сільського господарства Киргизстану та сприяння соціально-економічному розвитку сільських регіонів

Ключові слова: агросфера; регіональний розвиток; агрохолдинг; стратегії управління; сільськогосподарські асоціації