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State regulation instruments for the development of the agro-industrial complex under martial law in Ukraine

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▸ **Abstract.** Amidst the crisis in the food sector of the country caused by the Russian invasion and on the way to Ukraine's association with the European Union, the role of state regulation is growing. The study aimed to provide proposals for improving the food industry development programmes in the agro-industrial complex to improve the food supply of the population, innovative development of enterprises and ensure food security in Ukraine. General scientific methods were used in the study: dialectical, statistical, structural and functional analysis, tabular, systematic generalisation, and comparisons. The study summarises the existing programmes of support and development of the agricultural sector of Ukraine at the governmental and interstate levels. The problems of food and agricultural enterprises in the context of Russian aggression in Ukraine are identified, in particular, in terms of environmental damage and pollution, instability of energy supply, and rising logistics costs. The author notes the effectiveness but selectivity of grant support with the participation of foreign capital. The programme documents for the development of the agro-industrial complex and the food industry are systematised and their interconnection is analysed. These documents include the National Economic Strategy and the strategy for the development of its agricultural component, sectoral support programmes, sectoral strategies, and international and national programmes. The article presents proposals for the programme documents for the development of the food industry aimed at post-war recovery and further innovative development. The proposals take into account foreign experience, industry specifics and changes to the current legislation. Sectoral development programmes should be in line with the strategic guidelines until 2030 and the provisions of the Association Agreement with the European Union, contribute to solving environmental pollution and climate change, waste recycling and creating closed production cycles with high added value. The results obtained can be used in further research, programmes, recommendations and strategies of legislative and executive authorities for the effective development of the food industry as part of the agri-food complex and the improvement of food supply to the population

▸ **Keywords:** food supply; state regulation of exports; development programmes; food industry; support; food security

▸ Introduction

The agro-industrial complex is an integral part of the economies of the world, and its uninterrupted operation is a guarantee of food security. In the context of transformational changes in the economy, recent crises caused by the COVID-19 pandemic and Russian aggression in Ukraine, there is a growing need to implement effective measures and state regulation aimed at overcoming crisis phenomena and processes, restoring agricultural potential and ensuring sustainable economic development. The Sustainable Development Goals by 2030, proclaimed at the United Nations (UN) Rome Summit in 2015 and approved in Ukraine by the Presidential Decree in 2018,

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serve as a benchmark for economic and social development in Ukraine and the world (United Nations, 2015; Decree of the President of Ukraine No. 722..., 2019). Under these conditions, the study and justification of the effectiveness of state regulatory instruments and means are particularly relevant today.

Many scientists addressed the problems of state regulation of the agro-industrial complex, implementation of appropriate measures and state programmes to ensure the country's food security. O. Kinzerska *et al.* (2021) studied the issues of financial strategy for sustainable environmental and economic development in the agricultural sector. The authors identified the economic, environmental and social feasibility of the development of the agro-industrial sector and the benefits of a financial strategy for the sustainable economic development of the agro-industrial sector until 2030, grouped the objects and factors of managing the sustainable development of the agricultural sector.

O. Kovalenko *et al.* (2020) developed the conceptual framework for the formation of economic policy and mechanisms for the development of the food industry, and substantiated methodological approaches to the formation of economic policy in the food sector. Agrarian policy should strengthen the domestic market and expand exports, as well as the coherence of the food chain. M. Sychevskyi (2019) substantiated the strategic guidelines for the development of the food industry based on sustainable development, the key focus of which is a person and well-being. The foreign economic priorities for the development of agri-food enterprises in the context of European integration and indicators for assessing the export potential of enterprises were substantiated by Shpychak *et al.* (2022). The problems of food exports of European countries and the role of Ukraine were analysed by O. Kovalenko *et al.* (2023). The researchers concluded that the level of economic development of countries influences their food export potential. At the same time, the issue of programme documents for the development of the agro-industrial complex (AIC) and the food industry within it requires more detailed research.

J.L. Pomeranz & D. Mozaffarian (2022) assessed the marketing regulatory component of the US baby food market. The study noted that the country relies on market self-regulation, while at the same time, countries around the world are trying to limit the market for unhealthy food and beverages for children. Therefore, appropriate measures should be taken to counteract the distribution of such food, including the regulation of the Federal Trade Commission's powers. I. Gok & E.K. Ulu (2019) assessed the development and regulatory aspects of the functional food market in Turkey and found limited consumer awareness of the functional food market and the lack of an appropriate labelling system. To increase consumption and sales of products, it is necessary to inform and educate consumers, introduce promotional activities and improve legislation. I. Kovalchuk *et al.* (2022) noted the importance of regulatory levers for the sustainable development of all parts of the agri-food sector.

The analysis of existing studies demonstrated that, although many aspects of state regulation of the agro-industrial complex and the food industry have been studied, the issues of programme documents for the development of these industries require more detailed study, so the purpose of this study was to provide proposals for improving the programmes for the development of the food industry in the agro-industrial complex to improve the food supply of the population, innovative development of enterprises and ensure food security in Ukraine. This will contribute to the restoration and innovative development of production capacities, improvement of food supply chains, growth of the country's export potential, and increase in the efficiency of the industry's enterprises.

Materials and methods

The study employed *general scientific methods* of cognition to address the set topic. The *analysis method* was used to review the achievements of scientists in the field of state regulation, in particular, food programmes and tools to support the functioning and development of the agricultural sector, legislative acts and other regulatory documents. The problems and trends in the agro-industrial complex and individual food industry sectors were assessed using *statistical* and *comparative* methods. *The dialectical method* was used to assess the basic principles and the state of development and shortcomings of strategic and programme documents for the development of the economy and the agricultural sector. In particular, such as the Strategy for the development of the innovation sector for the period up to 2030 (Order of the Cabinet of Ministers of Ukraine No. 526-r..., 2019), and the strategy for the development of exports of agricultural, food and processing products of Ukraine for the period up to 2026 (Order of the Cabinet of Ministers of Ukraine No. 588-r..., 2019). The dialectical method was also used to analyse programme documents previously developed for the bakery and meat processing industries ("Ukraine needs a state program...", 2021; National livestock development programme..., 2021). *Structural-functional analysis* was used to build a structural diagram of the interaction of programme documents for the development of the agro-industrial complex and the food industry. The structural diagram was used to assess the relationship between the National Economic Strategy until 2030 (Resolution of the Cabinet of Ministers of Ukraine No. 179..., 2021) and the programme documents for the development of the agricultural sector. The *systematic synthesis method* was used to assess and provide proposals for existing development programmes, as well as draft programme documents that have not been implemented for the bakery, meat and dairy processing, sugar and oil and fat industries. Grant programmes to support small and medium-sized businesses are summarised in a *tabular* format.

The information basis includes the regulatory and legislative framework of Ukraine – a decree of the President of Ukraine (Decree of the President of Ukraine No. 722..., 2019), resolutions and orders of the Cabinet of Ministers of Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 870..., 2011; Resolution of the Cabinet of Ministers of Ukraine No. 780..., 2016, and others). The UN international legislation is also used as a database (United Nations, 2015). The regional-level studies used orders of regional state administrations (Order of the Head of the Regional..., 2022). The database of the State Statistics Service of Ukraine was used to assess the state and

problems of the bakery, dairy, and sugar industries (Official website of the State..., n.d.). Data on international and Ukrainian grant programmes were used – U-Lead with Europe (n.d.), Gardens of Viictory (n.d.), etc. The principles of the Swiss-supported food programme – Quality FOOD Trade Programme (QFTP) (Switzerland will assist..., 2023) and others – were also used. Research on the state and problems of the agro-industrial complex is currently limited by the lack of up-to-date information from the State Statistics Service due to the war in Ukraine.

▸ Results and Discussion

The National Economic Strategy for the period up to 2030, adopted in March 2021, supplemented during the Russian aggression against Ukraine on 21.04.2023, and entered into force on 04.05.2023 (Resolution of the Cabinet of Ministers of Ukraine No. 179..., 2021), serves as a policy document for the economy as a whole. The policy document serves as a basis for the development of strategies, programmes and regulations by the relevant ministries and executive authorities.

This strategy and the analytical report of the National Institute for Strategic Studies (Sobkevych *et al.*, 2022) pointed out negative phenomena in the agricultural sector:

- imbalance in the structure of production in the agricultural sector, as industrial enterprises are engaged in the production of profitable crops (sugar beet, sunflowers, cereals), while labour-intensive production of – livestock, potatoes, and vegetables is mainly carried out by households;
- low level of added value creation, in particular, exports are dominated by raw materials (wheat, corn);
- a critical decline in cattle numbers and milk production;
- insufficient development of the agricultural market infrastructure, lack of adequate transport and storage capacity;
- depletion of soil, pollution of territories and environmental degradation;
- dependence of agricultural producers on imports of equipment, technologies and selective materials;
- inefficient policy regarding exporters, including lack of awareness of export markets and opportunities, corruption, inefficient product insurance, and complexity of customs procedures;
- insufficient adaptation to global climate change.

The food industry's downstream processing sector faces problems common to the entire industry, including a decline in industrial production, high energy intensity and energy consumption, high depreciation of fixed assets, underdevelopment of the innovation and investment component due to a lack of working capital, high levels of monopolisation in certain industries and shadowing of the market. The current taxation system is not sufficiently conducive to the development of the food industry.

The National Economic Strategy, in the area of "agriculture and food industry", defines strategic goals to address the accumulated problems and further innovative development (Fig. 1).

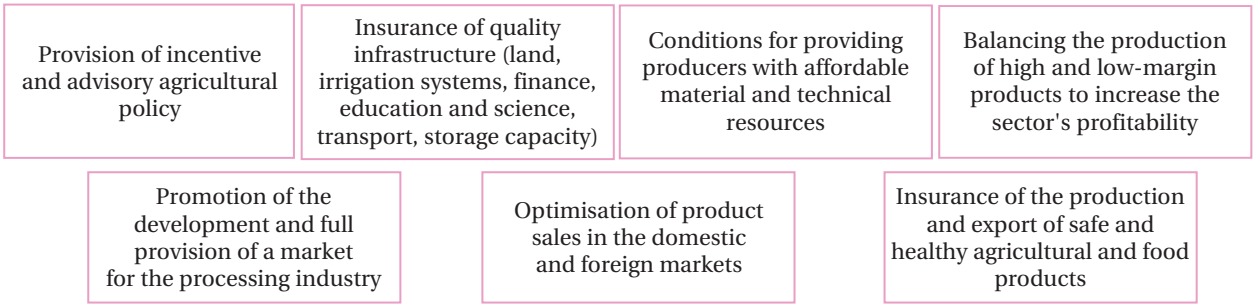

Figure 1. Strategic goals of the agricultural sector and the food industry
Source: compiled by the authors based on Resolution of the Cabinet of Ministers of Ukraine No. 179 "On the Approval of the National Economic Strategy for the Period up to 2030" (2021)

The Strategy's conclusions on the areas of focus include the need for an effective government policy and the poor state of elevator and transport infrastructure. It is important to expand access to material and financial resources. The need to increase the technological efficiency of production is also noted, as only large enterprises have the opportunity to purchase imported high-tech equipment, while small and medium-sized producers use a smaller range of technologies. The structure of Ukrainian agriculture is unbalanced, with crop production accounting for almost 80% of the sector. In most EU countries, crop production accounts for 57% and livestock production for 43% (in Poland, 48% and 52%, respectively) (Resolution of the Cabinet of Ministers of Ukraine No. 179..., 2021).

The Ukrainian livestock sector faces challenges related to the poor quality of milk and the predominance of poultry production (more than half of all meat in Ukraine, compared to 8-23% in the European Union). A significant share of poultry production in Ukraine is export-oriented. Due to the low level of automation of technological processes and inadequate production facilities, livestock products are more capital-intensive and do not ensure sufficient quality.

A significant problem is the decline in the number of cattle. In 1991, there were 8.38 million cows in Ukraine, in 2001 – 4.96 million, and in 2021 – 1.67 million cows, which is five times less than at the beginning of the country's independence. During the period of war in Ukraine (2022-2023), the number of cows decreased by almost 13% – from 1.54 to 1.35 million (Resolution of the Cabinet of Ministers of Ukraine No. 179..., 2021; Official website of the State..., n.d.).

The overall situation in the dairy industry is correspondingly challenging. In 2021, 8.71 million tonnes of

raw milk were produced, which is almost 23% less than in 2010 (11.25 million tonnes) and 2.8 times less than in 1990, and the marketability of products is also declining. In 2022, according to preliminary data, 7.77 million tonnes of raw milk were produced, which is 89% of the previous year's volume (Official website of the State..., n.d.). A significant problem for the meat and dairy industries is the decline in consumer demand due to rising product prices and lower real incomes.

Industrial production of bakery products decreased from 1.801 million tonnes in 2010 to 0.845 million tonnes in 2021, i.e. more than halved (Official website of the State..., n.d.). Compared to 1990 (6.70 million tonnes), production has decreased by almost 8 times due to diversification, changes in the dietary pattern and shadowing of the market. There is a problem with the quality of grain, which is labelled according to the grain standard adopted in 2019, in grades 1-4. Out of the 20.7 million tonnes of wheat harvested in Ukraine in 2022, about one million tonnes, or 4% of the crop, was suitable for baking (grades 1 and 2). Therefore, it is advisable to propose to provide flour mills and bakeries with preferential loans for the purchase of Grade 2 grain suitable for baking.

Among the critical problems for bread and flour producers, as well as for the entire agricultural sector, is the high risk of disruption of energy supply due to the war in Ukraine. After all, the energy received from generators is more than twice as expensive as that from the power grid (Work on generators..., 2022). Since 2015, the problems raised by flour producers have not been resolved, including the lack of adequate support for Ukrainian machine building, the lack of grain carriers and covered wagons for transporting products, and the tariffication of rail transport (Seven challenges hindering..., 2015).

As for the current state of the sugar industry, in 2021, the country produced 1.45 million tonnes of sugar, which is one and a half times more than in the previous year and almost equal to the figures for 2015 (1.5 million tonnes). The industry's enterprises are capable of producing up to 2 million tonnes of products and exporting them. Due to the war in Ukraine, sugar beet acreage has decreased. However, the crop yield in 2022 was the highest in the last 5 years and reached the 2018 figure of 49.8 t/ha, compared to 47.9 t/ha in 2021. In 2023, 249.9 thousand hectares were planted with sugar beet, compared to 220 thousand hectares in pre-war 2021 (Official website of the State..., n.d.). The main way to develop the industry is through exports. A mechanism for Ukrainian exporters is being developed, with 30 plants currently operating. Given the export orientation of the industry, the urgent problems are finding logistics routes and importing countries for Ukrainian sugar, reducing unproductive costs and losses, and ensuring further processing of production waste.

A common problem for all food processing companies is the significant rise in energy prices – gas and electricity, other cost components, as well as petrol and diesel fuel – which affects the cost of transport logistics. In particular, for the first time, the cost of energy and operating expenses exceeded the cost of raw materials in the cost of bread. Given the imported component of fuel and currency fluctuations, further appreciation of the dollar will lead to higher product prices.

Significant resources and capacities must also be deployed to overcome the extraordinary damage to the environment, arable land, production and logistics facilities, housing and human capital caused by the Russian aggression against Ukraine. The amount of damage to the environment is currently USD 57 billion, and this is not the final figure (Environmental damages in Ukraine..., 2023).

The losses of the agricultural sector during the war exceeded USD 40 billion, including USD 9 billion in direct losses. Therefore, it is necessary not only to restore the lost environment and territories but also to give impetus to its further innovative development on the way to Ukraine's association with the EU (Losses in the agricultural sector..., 2023). In this context, the issue that is also highlighted in the National Economic Strategy for the period up to 2030 is relevant – the need to extend value chains, which will ensure greater profitability of the sector, as well as a reorientation to high value-added products (Resolution of the Cabinet of Ministers of Ukraine No. 179..., 2021). The solution to this problem lies in reducing losses and unproductive costs, as well as in the construction of additional production facilities close to the raw material base and production of key products. Relevant tasks should be included in sectoral development programmes or other regulatory and legislative documents that are consistent with the Strategic Goals of the agricultural and food industry, following the National Economic Strategy until 2030. Effective assistance to the agrarian sector in this regard is provided by the USAID Programme, which aims to increase productivity and market access in targeted value chains and improve support functions and the regulatory framework in the agrarian sector (USAID program for agrarian...., n.d.).

An urgent problem is the supply of baby food products to the Ukrainian market. The previous State Targeted Social Programme for the Development of Baby Food Production for 2012-2016 worth UAH 643.43 million was approved in 2011. 70% of the cost was to be covered by the state budget, the rest by local budgets and other sources (Resolution of the Cabinet of Ministers of Ukraine No. 870..., 2011). The programme document provided for the reservation of state budget funds, state support for technical re-equipment of enterprises; creation of new production facilities and laboratory equipment; and improvement of the regulatory framework. The implementation of the programme contributed to a partial improvement in the situation with baby food but was constrained by the limited financial capacity of enterprises and the state. Since 2021, the supply of baby food has improved, thanks to government support and approaches to healthy eating for children, particularly in schools. However, the necessary financial investments for further development of this segment are limited due to the war in Ukraine.

The plan of directions of state support for agricultural production for 2022, developed by the Ministry of Agrarian Policy, contained 16 points of state aid to agricultural enterprises, including partial compensation for the cost of agricultural machinery, advisory services, support for livestock, potato growing and niche crops, and organic production (State support of the agro-industrial..., 2021). Financial support was also envisaged by reducing the cost of loans, which were cancelled due to the martial law in

Ukraine and the redistribution of funds to the reserve fund (State support for the development of..., n.d.).

At the same time, the state programme "Available credits 5-7-9" was launched and widely used to develop agricultural enterprises with the participation and assistance of the Ministry of Agrarian Policy and authorised banks. In January-September 2023, 11.3 thousand enterprises received 58.8 billion UAH of loans for business development, of which 8.8 thousand enterprises received 34.4 billion UAH under this programme (Available credits 5-7-9..., 2023). The leaders in terms of loans received are Kyiv, Vinnytsia, Dnipro, Kirovohrad and Odesa regions, and in terms of the 5-7-9 programme – Kirovohrad, Vinnytsia, Odesa and Kyiv regions.

With the support of the Ministry of Agrarian Policy, a grant programme for the development of horticulture has been in place since 2022, with agricultural enterprises from 14 regions of Ukraine participating as of September 2022. The amount of grants was 145.5 million UAH (Participants of the horticultural..., 2022). The procedure for obtaining grants was as follows: an authorised bank reviews the applicant's documents within 5 days and submits them to the Ministry of Agrarian Policy, which decides on granting a grant within 10 days; if the decision is positive, the bank opens an account within 5 days, the applicant pays its share of the financing within the next 30 days and can immediately use the grant funds freely. The only condition is the targeted use of the funds. The project implementation period is 18 months, and an authorised bank checks the condition of the plantations for 5 years. If 50% of the grant is paid in taxes, the monitoring by the authorised bank may be terminated early (Grants for the development..., 2024). This grant programme serves as an effective start for other grant programmes, subject to the availability of funding.

International experience has confirmed the effectiveness of such projects, which stimulate the development and support of entrepreneurship, which is especially important for Ukraine in the context of post-war recovery. Starting in 2022, the Department for the Development of the Real Sector of the Economy of the Ministry of Economy of Ukraine will be responsible for providing grants for the creation or development of processing enterprises. To be eligible for grants, companies must submit a business plan, an application and a set of documents and meet the established criteria (number of points based on the results of the performance assessment). Among the 17 grants approved by the order of the Ministry of Economy No. 150 dated 06.10.2023, there are food industry enterprises that received 8.0 million UAH each for production development: Blahom'yaso LLC (Zaporizhzhia region), Yaytse-Raytse LLC (Ternopil region), and Smak Hliba LLC (Ivano-Frankivsk region) (Grants for processing enterprises, n.d.).

On 1 September 2022, the Ministry of Agrarian Policy announced the introduction of two state support programmes for farmers – payments per hectare of land (3,100 UAH per 1 ha, up to a maximum of 120 ha) and subsidies for cows (5,300 UAH per cow for owners of 3 to 100 cows). Applicants can receive funds by applying to the State Agrarian Register (State support for farmers..., 2022).

In 2021-2022, regional programmes for the development of the agro-industrial complex were introduced as part of decentralisation. They were posted on the websites of regional state administrations (Regional target programs, n.d.; Order of the Head of the Regional..., 2022). Regional programmes are formed based on an analysis of the state of agriculture and the food industry in the region, identification of the main problems, ways of solving them and sources of funding, a list of tasks (programme areas) and performance indicators. The main administrators of the funds are the Department of Agricultural Development and Economic Policy of the Regional State Administration and the Standing Committee of the Regional Council on Agricultural Complex, Land Relations and Rural Development. The Kyiv Regional Military Administration has introduced and is implementing development programmes in the areas of agriculture and rural areas, energy conservation (energy efficiency), healthcare and the use of natural resources in the region, etc.

The cooperation of the national government and regulatory authorities – the Ministry of Agrarian Policy and Food and the State Service of Ukraine for Food Safety and Consumer Protection – with experts from the Swiss-Ukrainian programme "Development of Higher Value-Added Trade in the Organic and Dairy Sectors of Ukraine" (Quality FOOD Trade Programme, QFTP), which agreed on a plan for the restoration and development of the organic and dairy sectors affected by the war, is effective. The recovery of the sectors is planned to take at least two years, with support for four years (Switzerland will assist..., 2023). The programme aims to increase production and trade in high-value-added products. The programme includes improvements to the regulatory framework in line with EU standards, liberalisation measures an increase in trade in domestic and foreign markets, and tighter control over product quality.

International programmes designed to achieve self-sufficiency of communities with basic food products within the framework of decentralisation and modern waste management have proven to be effective – Victory Gardens (n.d.), U-Lead with Europe (n.d.). The Victory Gardens programme is implemented with the support of the Government of Canada and ensures the efficient use of land by the population for growing, processing, storing essential food and reducing the risks of full-scale aggression. As of 2023, EUR 176 million has already been invested through U-Lead with Europe, a programme of cooperation between the Government of Ukraine and the EU and its donor member states, including for agricultural sector projects, 99 regional development projects have been prepared, and 9 draft laws have been supported.

At the same time, despite the optimisation of these processes in 2016 and the granting of more powers to the State Service of Ukraine on Food Safety and Consumer Protection, the mechanism of interaction between different institutions is not effective enough. The State Service of Ukraine on Food Safety and Consumer Protection monitors compliance with product safety and quality indicators. The Ministry of Health develops and communicates regulations on product safety and consumption volumes. The Ministry of Agrarian Policy approves hygienic requirements for the safety of products recommended

for consumption and oversees the development of product standards and other areas of food supply. The large number of structures complicates communication between them and slows down decision-making. In Europe, however, there is a single structure that adopts regulatory documents on product safety and monitors their implementation. In Ukraine, working groups are engaged in harmonising standards and developing technological regulations in line with EU requirements and rules.

The current norms of food consumption per person in Ukraine do not correspond to modern realities, as the overall structure of the population's diet has changed. For example, the norm of bread consumption (101 kg), which is observed in Ukraine, exceeds actual consumption (Resolution of the Cabinet of Ministers of Ukraine No. 780..., 2016). In EU countries, this figure does not exceed 30 kg, in post-Soviet countries – up to 50 kg per year. The share of the shadow market is significant. For example, the actual consumption of dairy products calculated by the State Statistics Service is usually underestimated because it does not cover the self-sufficiency of the population in its calculations.

Ukraine has made progress in organic production. In 2023, the State Register of Operators for the Production, Circulation and Labelling of Products was launched. So far, four Ukrainian organic production operators have been registered and granted certificates (The first 4 organic product..., 2023). However, their activities are hampered by the contamination of the territories by the military operations in Ukraine. The Food and Agriculture Organization of the United Nations (FAO) and the German-Ukrainian Cooperation in Organic Agriculture (COA) project, at the request of organic operators, provided them with 25 generators in 9 regions of Ukraine free of charge (Ukrainian organic operators..., 2023).

The export component is an important area of activity for the food industry, which provides foreign exchange earnings to the country's budget, income and jobs in production, supplies surplus products to foreign markets and ensures global food security. In 2019, the government approved and in 2023 amended the Strategy for the Development of Exports of Agricultural, Food and Processing Products of Ukraine for the Period up to 2026 (Order of the Cabinet of Ministers of Ukraine No. 588-r..., 2019). The document introduces export potential assessment mechanisms, strengthens cooperation between the Ministry of Agrarian Policy and industry associations, introduces quality standards for products following the EU-Ukraine Association Agreement, takes measures to stimulate producers, improves phytosanitary measures, improves organisational and legal conditions of activity, and other components. The implementation of this strategy, along with other factors, resulted in an increase in food exports and an improvement in the business environment for exporters. However, there is still a need to solve logistical problems, restore production and reach mutually beneficial agreements with EU countries on food exports. A promising direction is to shift from exports of raw materials to a significant increase in the share of high-value-added products. In addition to export-oriented products such as grains, oil, sugar, and chicken, it is necessary to increase foreign sales of dairy products.

The Strategy for the Development of the Innovation Sector until 2030, adopted in July 2019, emphasises that Ukraine has competitive advantages in terms of market capacity, ability to innovate, availability of educated personnel, and scientific schools that promote innovation (Order of the Cabinet of Ministers of Ukraine No. 526-r..., 2019). Furthermore, the agricultural sector "has a high potential for modernisation, introduction of new technologies and increase of the level of processing of its own products, but its prospects are limited" in terms of impact on the gross domestic product (GDP) of the state. At the same time, the export potential of the agricultural sector and its contribution to global and national food security were not taken into account, as food meets the basic needs of human life.

The ambitious plan of the Strategy for the development of the agro-industrial complex, presented in July 2023 by the Ministry of Agrarian Policy, envisages a significant increase in agricultural production, in particular fruit and berries, by up to 8 times (Strategy for the development..., 2023). Ukraine is a global food supplier for more than 600 million people, which is important for global and national food security. The Strategy for the Development of the Agro-Industrial Complex presents global trends and defines the vision of Ukraine as a global food supplier. Through vertical integration and import substitution, it is planned to provide food production with its mineral fertilisers, agricultural machinery and plant protection products, and a developed irrigation system. Support for agricultural industries is expected to produce 200 million tonnes of agricultural products, including a 4.5-fold increase in the production of vegetables, root crops and melons. In line with current trends and economic needs, it is planned to achieve up to 50% of production through deep processing. The goal of waste processing is to accelerate the development of green energy and increase methane production in the amount of 10 billion cubic metres per year as an additional source of energy.

The investment attractiveness of agricultural production facilities is driven by high domestic demand and the possibility of exporting products, the availability of a raw material base and the payback of projects. The powerful strategic directions for the development of the agro-industrial complex will be implemented in the context of Ukraine's post-war recovery, so it is necessary to take into account internal and external challenges and realities of today and focus efforts on rebuilding the country and overcoming the unprecedented damage caused to the agricultural sector and the country's economy.

In the current environment, grant programmes for business development have proved to be effective, and most of them are to be extended for the next period (Table 1). The experience of the economies of developed countries (the US, the EU) and Ukraine has proven the importance of supporting business development, especially in times of crisis. The mechanisms of direct lending to small and medium-sized businesses, such as the Affordable Loans 5-7-9 programme for production development, microgrants, and grant programmes for enterprise development, are effective. In 2024, it is planned to resume financing the cost of Ukrainian agricultural machinery and allocate 1 billion UAH for this purpose.

Table 1. Grant programmes for small and medium-sized businesses in force in 2023

No.	Program	Program goal	Program indicators, geography*
1	State programme "eRobota" (Ukraine)	For small and medium-sized businesses, including agriculture: to start own business; greenhouses; development of horticulture, berry growing, viticulture	During the year of its existence, 4,600 entrepreneurs received 3 billion UAH up to 250 thousand UAH 2-7 mln UAH
2	Grant competition of the USAID project "Cybersecurity of Ukrainian Critical Infrastructure"	For Ukrainian developers of cyber defence solutions	Budget of 500 thousand USD USA
3	USAID Competitive Economy Programme	25 grants for small and medium-sized processing enterprises; 30 grants to improve the human resources potential of businesses for small and medium-sized farming enterprises	75-150 thousand USD USA 35-150 thousand USD up to 40 thousand USD USA Poltava, Sumy, Kyiv, Chernihiv regions
		Business development support: business marketing support projects; online business consultations; the Startup of the Year Award and other projects	from 10 thousands USD USA
4	MHP-Community Charitable Foundation with the support of the Kurator brand	For catering companies	Up to 100 thousand UAH for 13 regions of Ukraine
5	Lars Seier Christensen's Danish investment fund Seier Capital A/S	For blockchain startups	from 5 thousand to 50 thousand EUR, continuously
6	Ideas Powered for Business from SME fund	Financing for the protection of intellectual property of small and medium-sized enterprises	from 1 thousand to 1.5 thousand EUR
7	Charitable Foundation "SOS Children's Villages Ukraine"	For opening a business for internally displaced persons and families with children	Up to 150 thousand UAH Kyiv, Poltava, Ivano-Frankivsk, Lviv, Chernivtsi regions
8	A comprehensive programme of support and development of agriculture	For enterprises in the field of organic production	Up to 150 thousand UAH Lviv region
9	EBRD – U4U business	Consulting projects for small and medium-sized businesses. Internship in an experienced European company with an entrepreneur	85% of the project cost 75% of internship costs, online – free of charge
10	Single Market Programme	Patenting ideas, protecting trademarks and designs	1-1.5 thousand EUR Up to 08.12.2023
11	Mercy Corps support programme	For businesses that are relocated or in the process of relocation Assistance to temporarily displaced persons for micro businesses Restoring farming lost due to the war	Up to 20 thousand USD Ivano-Frankivsk, Lviv, Kherson, Ternopil regions up to 1,500 thousand USD Dnipro region; up to 1,500 thousand USD Poltava, Sumy, Chernihiv regions
12	International Organisation for Migration (IOM)	For war-affected micro and small businesses	4.5-20 thousand EUR for 10 regions of Ukraine and Kyiv city

Note: * – regions of Ukraine are indicated for programmes that operate only in certain regions
Source: compiled by the author based on I. Krytska & D. Dzysiuk (2023)

The State Budget for 2024 envisages the continuation and resumption of state programmes for direct support, stimulation and development of business in the country, the total cost of which will amount to 40 billion UAH (In the state budget, 40 billion..., 2023). Based on the results of the analysis of legislation, strategies and programmes for the development of the food industry, the main programme documents for the development of the food industry as part of the agricultural sector were identified (Fig. 2).

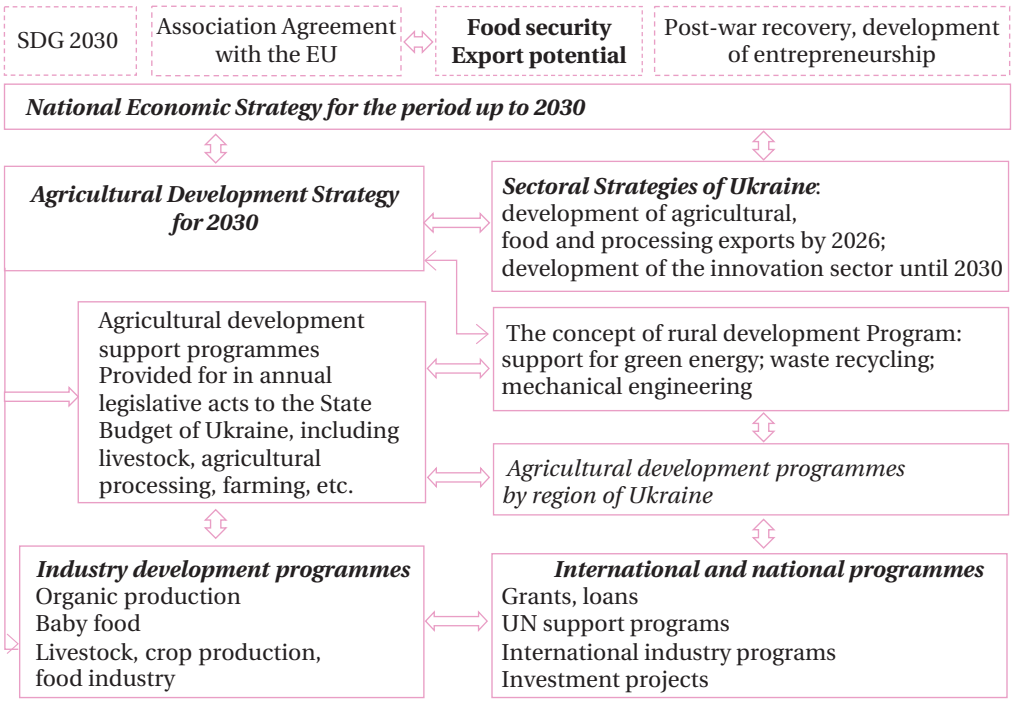

Figure 2. Structure diagram of interaction between programme documents for the development of the agro-industrial complex and the food industry
Note: SDG – sustainable development goals
Source: compiled by the authors

The National Economic Development Strategy of Ukraine until 2030, which was developed in 2021 and adapted in 2022 during the military operations in Ukraine, is based on the SDG 2030 and the provisions of the Association Agreement with the EU and serves as the basis for strategies and programmes for the development of the agro-industrial complex. The vector of development of the agro-industrial complex and food industry is closely linked to sectoral strategies, in particular, export development and innovation. The expenditure side of the budget includes funding for agricultural support programmes based on regional needs. Agricultural development programmes by regions of Ukraine contain an analysis of the state of the agricultural sector in the regions, problems, ways to solve them, and a justification of the needs and development potential. However, control over the implementation of budget programmes, their economic benefits, and management decisions in case of failure to implement them are not effective enough. Despite the effectiveness of grant support and targeted investor financing, which are now being actively used in war-torn Ukraine, the drawbacks of such programmes are the selectivity of regions and enterprises. Pilot programmes in certain regions need to be supported by the government and expanded to other regions of Ukraine, but this process is currently hampered by a lack of funds and a lack of interest from all participants, including businesses.

Current priorities and programme directions for the development of the food industry are substantiated in documents that differ in form but have common content: sectoral sections of the overall strategy (programme) or concept; development programmes, business plans or business justifications for grants, investments, loans, and joint international programmes. The justification of these policy documents at the sectoral level requires an analysis of the demand for Ukrainian products and the identification of critical points.

The development of policy documents in the food sector should be based on international experience and the latest research findings. In particular, food traceability in Europe, the United States and China (Stazi & Jovine, 2022) is relevant, as it is proven that food regulation poses scientific, economic, legal and technological challenges in the future. A systematic review of 100 sources on agri-food supply chains is beneficial (Yadav *et al.*, 2022).

The issue of the relationship between diet and food security is an urgent concern, with researchers concluding that food and nutrition security influence food choices and that barriers to consumption act as an intermediate step (Thomson *et al.*, 2024). This is an essential factor to consider when formulating public policy. For Ukraine, as well as for the whole world, the problem of school meals is relevant. In particular, in Europe and the Western Pacific, despite a moderate improvement in the diet of children in schools, the measures taken were insufficient (Matela *et al.*, 2024).

Food safety is receiving substantial international coverage, both *by public authorities* and the scientific community, in line with countries' desire for consolidated *responsibility* and uniform quality rules and standards across regions, as exemplified by the United States, Canada, and Latin America (Sayler, 2024; Leake, 2024).

When developing approaches to regulatory and legal regulation of the agri-food sector, food risks, constraints

and strengths need to be assessed. Therefore, researchers have developed a new methodology (NAM) that addresses risks and constraints, strengths and weaknesses, and identifies key areas that require government regulation (Manful *et al.*, 2023). The experience of Italian scientists on the possibility of using the coherence matrix as a standardised practice in regional food policy is useful (Monticone *et al.*, 2023).

Development programmes for the food industry in Ukraine should be based on the consolidation of state structures and public administration bodies, businesses, the public and investors. The main issues of such programmes lie in two fundamental areas: post-war restoration of the raw material base, production and logistics; and innovative development of the industries on the way to Ukraine's association with the European Union.

The *bakery industry* urgently needs an implementation of the State Programme for the Revival of Bread Quality, which was emphasised in October 2021 at a meeting of the Head of the State Service of Ukraine for Food Safety and Consumer Protection with the heads of the largest bakers' associations that determine the food policy of the industry – the All-Ukrainian Bakers Association and Ukrkhlibprom and the PU "Flour of Ukraine" ("Ukraine needs a state program...", 2021). It is also necessary to address the immediate issues of grain quality for baking, *currently* by providing loans for the purchase of Grade 2 grain by millers and bakers, and subsequently by improving the quality and grade of grain. The issues of regulating relations between producers and trade, stimulating the growth of health and functional products, resource and energy saving measures (in particular, the use of heat generated in the production process for heating premises), and controlling the quality of water and raw materials are also relevant. It is important to coordinate the problems of providing products to socially vulnerable groups of the population and preventing the shadow market and flour smuggling.

Meat processing and dairy industries primarily require the recovery of cattle of various types, a high-quality feed base and developed logistics, the restoration and reconstruction of processing enterprises, and the establishment of sustainable logistics. In 2021, proposals were collected for the formation of the National Livestock Development Programme in key areas: restoration of cattle, development of pig production, dairy farming, poultry farming, etc. (National Livestock Development Programme..., 2021). It is also necessary to strengthen support for small and medium-sized farmers and processing enterprises, innovative solutions for the feed base, review the terms of trade with the EU, and move away from a raw material focus. To promote the production of high-value-added products, a special value-added tax regime that is directly applied to the creation of value chains could be an effective lever.

Given the high ploughing of Ukrainian land, it is necessary to promote the expansion of hayfields and encourage farmers to restore livestock farms. In the dairy industry, there is a need to improve the quality of milk, deepen the value chain and increase exports of value-added products. It is also necessary to solve the problem of domestic processing of high-quality meat raw materials, which were mostly exported. To increase the value chain and reduce unproductive costs, it is advisable to implement the international experience in creating closed-loop associations, such as the experience of Denmark, where the milk processing association is united with raw material producers. It is equally important for the meat and dairy processing industries to address the issue of environmental pollution, as more than 40,000 livestock complexes and farms produce 900 million cubic metres of manure containing about 2.5 million tonnes of nitrogen. Almost 10% of the nitrogen goes into water bodies (Environmental problems of farms..., n.d.). An effective tool for the development of the food industry is the Swiss-Ukrainian programme "Development of Higher Value Added Trade in the Organic and Dairy Sectors of Ukraine", which addresses the issue of *organic production* in Ukraine, in particular through certification of products by producers.

In the *sugar industry*, despite the steady performance in 2022-2023, the development programme should focus on the production of closed-loop products, including the location of advanced waste-to-energy facilities near sugar factories. It is also necessary to increase support and incentives for sugar beet producers and expand foreign markets.

It is also necessary to intensify the *baby food* programme by expanding the range of products based on plant and animal raw materials and resuming the production of canned meat and fish.

The *oil and fat industry* suffered significant losses during the war in Zaporizhzhia and Kherson regions. Previously, 95% of sunflower was processed into oil (mostly unprocessed), but now sunflower exports and logistics costs have increased significantly, and investors have left the industry (Kozachenko, 2022). The programme document for the development of the industry should take into account: its restoration and modernisation with the involvement of grants and investments; the creation of a closed production cycle with high added value, with a predominance of processed oil, as well as the widespread production of advanced processing products – meal and pellets; increase in exports of processed oil; and the introduction of a waste management programme.

Grant programmes for the development of horticulture and greenhouses, berry growing, viticulture, and hop growing are relevant for supporting the population and ensuring food security. However, in the horticultural processing industry, it is also necessary to create closed cycles and promote the production of advanced processing products, such as apple pectin and pharmaceuticals, and to implement programmes to support self-sufficiency.

In general, all sectoral programmes for the development of the food industry are concerned with supporting producers of raw materials and processed products, introducing resource and energy-saving technologies with a focus on green energy, and bridging the innovation gap with developed industries. An important area is the further implementation of legislation in line with EU requirements and rules. The programmes should be in line with the 2030 Agricultural Development Strategy and the provisions of the Association Agreement with the EU.

The quality and environmental friendliness of products will be enhanced by measures to encourage compliance with optional standards and environmental protection. The introduction of lean management approaches in production facilities is orienting manufacturers towards

the ideology of economical use of resources, ensuring the creation of closed production chains and export of high-value-added products, and promoting a clean environment. A healthy lifestyle has become popular in society today, which is driving companies to increase the health products segment.

Improvement of the regulatory environment for the agricultural sector should be aimed at ensuring food security and the adoption of laws of Ukraine on food security (to regulate terms, provisions, and interaction of market participants in the field of food security); internal trade (to regulate the relationship between producers and trade); and support and development of innovation. The methodology for determining the main food security indicators should be updated to reflect the best practices of the FAO. Legislation on stimulating innovation, customs control, and tax invoices needs to be regulated in line with EU requirements.

The disadvantage of state programmes was the lack of adequate funding and insufficient justification of the funds allocated for their implementation, failure to achieve the planned results and the absence of a mechanism for punishing failure to implement programmes. The experience of Ukraine, the EU and the US confirms that grant programmes and sectoral development programmes in certain areas were more effective (for example, the Swiss-Ukrainian programme "Development of Higher Value Added Trade in the Organic and Dairy Sectors of Ukraine" – Quality FOOD Trade Programme, QFTP (Switzerland will assist..., 2023). However, these programmes are selective in terms of the subjects covered and the scale of dissemination, due to the lack of funds and local initiative. Programmes to support the self-sufficiency of the population with foreign participation, such as U-Lead with Europe and Victory Gardens, have economic and social effects but have not yet found widespread and state support. The ambitious provisions of the Strategy for the Development of the Agro-Industrial Complex presented by the Ministry of Agrarian Policy of Ukraine need to be discussed, as the high targets should be clarified given the state of the economy in 2023 (Strategy for the Development..., 2023). The limitation of the prospects for modernisation and introduction of new technologies in the agricultural sector in terms of the impact on GDP, as outlined in the Strategy for the Development of Innovation Activities for the period up to 2030 (Order of the Cabinet of Ministers of Ukraine No. 526-r..., 2019), is debatable. Proposals to take into account the experience of Turkey's strategic initiatives in the functional food market should be expanded by the experience of other countries in this area (Gok & Ulu, 2019). The mechanisms for the development of the food industry at the present stage will need to be supplemented by an environmental component (Kovalenko *et al.*, 2020). The practice of food traceability also requires consideration of environmental aspects (Stazi & Jovine, 2022).

J. Szulecka & N. Strøm-Andersen (2022) studied the aspects of waste management on the way from industrial self-regulation to state regulation in Norway and justified the need for state intervention in these processes, but the thesis on strengthening state waste management is debatable. The study should focus on stimulating the self-regulation of enterprises and gradually limiting state intervention.

F. Von Kaufmann & V. Skafida (2023) addressed the interaction between government, industry, and other stakeholders in the development and regulation of the market for alternative protein products in the United States in 1960-1980, the motivation for the introduction of products in schools, which gave impetus to the adjustment of modern school feeding programmes not only in the United States but also in other countries. In Ukraine, national school meals are currently being diversified. G.E. Schneider (2021) proved that the evolution from family farms to large industrial agribusiness was accompanied by an increase in ultra-processed food, and the use of herbicides and pesticides following the example of the modern US food industry. A return to healthy food and community empowerment, along with other measures, requires government support. By comparison, Ukraine has gone from a post-Soviet business organisation to the creation of large agricultural holdings that require government support. Current trends are to implement healthy eating principles and limit harmful additives. Small and family businesses began to develop with the transition to market relations, and their effective development depends on empowering communities. The instruments of state regulation of the development of the agro-industrial complex, including the food industry, have not been developed systematically enough since Ukraine's independence, and a significant number of indicators have not been achieved for subjective and objective reasons. Therefore, there is a need for more widespread grant programmes, with the involvement of other sources of funding.

Conclusions

The results of the study, obtained according to the set goal, provide proposals for improving the food industry development programmes in the agro-industrial complex. Implementation of these proposals will contribute to the innovative development of enterprises, optimisation of food supply chains, growth of the country's export potential, and increase of the efficiency of enterprises in the industry.

Among the problems faced by the food industry in the agro-industrial complex in the context of Russian aggression against Ukraine are the following: disruption of uninterrupted operation and logistics chains of production and supply; environmental damage and pollution; dependence on imported equipment; instability of energy supply; and the prevalence of logistics costs over raw materials in the cost of food products.

The existing grant support for food and agricultural enterprises with foreign capital has proved to be effective but selective. The generalisation of grant programmes for small and medium-sized businesses shows a wide range of users of such programmes, so it is necessary to spread awareness among enterprises and the population about the opportunities for business recovery and development, as well as means of support. The proposed structural scheme of interaction and interconnection of programme documents for the development of the agro-industrial complex and the food industry is focused on the development strategy, sectoral support programmes provided for in the country's budget, sectoral strategies (including

export development, and innovation), international and national programmes. Proposals to the food industry development programme documents should focus on post-war recovery and further innovative development on the path to the EU Association, considering international experience and sectoral specifics, and be guided by the strategic benchmarks until 2030. Sectoral development programmes should contribute to addressing environmental pollution and climate change, waste recycling, and the creation of closed production cycles with high-added value. Prospects for further research include assessing the impact of government regulation on the functioning of food value chains in the context of current challenges and post-war recovery.

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Conflict of interest
The authors of this study declare no conflict of interest.

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Інструменти державного регулювання розвитку агропромислового комплексу в умовах воєнного стану в Україні

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► **Анотація.** В умовах кризових явищ у продовольчому секторі країни, спричинених агресією російської федерації і на шляху до асоціації України з Європейським Союзом зростає роль державного регулювання. Метою дослідження було надання пропозицій щодо вдосконалення програм розвитку харчової промисловості в системі агропромислового комплексу для покращення продовольчого забезпечення населення, інноваційного розвитку підприємств та забезпечення продовольчої безпеки України. У процесі виконання дослідження використано загальнонаукові методи: діалектичний, статистичний, структурно-функціонального аналізу, табличний, системного узагальнення, порівнянь. За результатами роботи узагальнено діючі програми підтримки та розвитку аграрного сектора України на урядовому і міждержавному рівні. Визначено проблеми харчових та аграрних підприємств в умовах агресії російської федерації в Україні, зокрема щодо збитків та забрудненості навколишнього середовища, нестабільності енергопостачання, зростання логістичних витрат. Зазначено дієвість, але вибірковість грантової підтримки за участю іноземного капіталу. Систематизовано програмні документи розвитку агропромислового комплексу і харчової промисловості та проаналізовано їх взаємозв'язок. Ці документи включають Національну економічну стратегію і стратегію розвитку її аграрногої ланки, галузеві програми підтримки, секторальні стратегії, міжнародні та національні програми. У статті надано пропозиції до програмних документів розвитку харчової промисловості, які спрямовані на післявоєнне відновлення та подальший інноваційний розвиток. Пропозиції враховують іноземний досвід, галузеві особливості та зміни до чинного законодавства. Галузеві програми розвитку мають відповідати стратегічним орієнтирам до 2030 року і положенням Угоди про асоціацію з Європейським Союзом, сприяти вирішенню проблем забрудненості навколишнього середовища та протидії кліматичним змінам, перероблення відходів та створення замкнених циклів виробництва з високою доданою вартістю. Отримані результати можуть бути використані в подальших наукових дослідженнях, програмах, рекомендаціях і стратегіях органів законодавчої та виконавчої влади щодо ефективного розвитку харчової промисловості у складі агропродовольчого комплексу та покращення продовольчого забезпечення населення

► **Ключові слова:** продовольче забезпечення; державне регулювання експорту; програми розвитку; харчова промисловість; підтримка; продовольча безпека

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Current state and prospects for the development of agriculture in the Vinnytsia region

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► **Abstract.** The agriculture of the Vinnytsia region plays an important role in the economy of this region, ensuring food security, employment stability and socio-economic development. The study aims to analyse the current state and peculiarities of the functioning of agriculture in the Vinnytsia region, as well as to identify prospects for the development of this sector of the region's economy. To achieve this goal, the following methods were used: abstract-logical, system-structural, method of analysis and comparison, economic-statistical, tabular, graphical and other methods. The study analyses current trends in agricultural development, covering information up to 2022, as there are currently no official statistics for 2023. It is established that 2022 was a difficult year for the country, as evidenced by the decline in plant production in the region from 2018 to 2022, but at the same time, there was a certain increase in the production of animal products. The study examines the structure of production and efficiency indicators of agriculture, which indicate both positive and negative trends. In particular, the positive side of the dynamics is the increase in the number of agricultural enterprises and the stability of the region's share in the national agricultural production. However, negative trends include a decline in production, a decrease in the profitability of operating activities and other indicators that reflect the impact of economic and technological factors on the industry. The study noted that proper use of fertilisers is essential for increasing land productivity. Several challenges that limit the productivity and sustainability of agricultural development in the region were identified. Climatic conditions, such as temperature and precipitation, environmental, economic and social problems that require an integrated approach to address them. The article substantiates the prospects for agricultural development, namely: optimisation of land use, introduction of modern technologies, support for agriculture and stimulation of ecological agricultural production. Examples of the introduction of modern technologies and innovations in the region's agriculture, including the cultivation of products without the use of chemical fertilisers and pesticides, and the use of precision farming and biogas projects, are considered. Initiatives and programmes to support small and medium-sized enterprises and organic agriculture are also highlighted. These aspects can be used to create development strategies and make informed decisions

► **Keywords:** agricultural crops; indicators; development; production; ecological production; crop production; livestock production

► Introduction

The current extremely difficult political situation in the country, caused by the Russian invasion of Ukraine, has led to a sharp decline in the national economy. Due to the occupation and hostilities, a large part of Ukraine has suffered considerable losses and has become, one might say, incapacitated. Therefore, in such circumstances, the central and western regions of the country must ensure their maximum productivity.

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Agriculture is the most basic human activity, encompassing both the cultivation of crops and the feeding of animals. A. Gamage *et al.* (2023) determined that agricultural land is an important resource in the world from which humanity feeds and houses itself. The industry under study provides a significant part of economic activity around the world. People rely on agriculture to feed their families, earn a living and start businesses, regardless of their size (Abhilash *et al.*, 2022).

F. Mathlouthi *et al.* (2022) concluded that the growing demand for agricultural products globally is creating a variety of employment opportunities that cross over into different economic sectors and societal sectors. First, it creates new jobs in agriculture in the region itself, including farms, processing plants and farm support services. In addition, increased agricultural production requires expanded trade and transport, which opens opportunities for jobs in logistics.

Ye. Marynchenko (2023) emphasises that agriculture is an industry that must constantly evolve and look for innovative approaches based on the use of high-yielding seed varieties, chemical fertilisers, water, pesticides, etc. New challenges, such as climate change, high market competition and limited resources, make it necessary for agriculture to find effective and sustainable solutions. According to the author, land is a special object of innovation.

The importance of investment support for the technological growth of the agro-industrial sector of the economy was emphasised by Yu. Sahachko *et al.* (2023). The researchers believe that one of the most promising areas is attracting foreign investment, as Ukraine has great potential in agriculture. In addition, it is crucial to provide financial support to small and medium-sized agribusinesses by creating favourable conditions for obtaining loans and other financial resources and developing support programmes in the agricultural sector.

In their study of agriculture, M. Wrzecińska *et al.* (2023) and M. Boiko (2023) examined the impact of modern technologies on increasing the efficiency of agricultural production. The introduction of IT solutions in agriculture facilitates data processing, visualisation, and decision-making, which leads to reduced costs, increased efficiency, and improved food security.

Numerous scientists, including F.H.M. Tang *et al.* (2021) and M. Tudi *et al.* (2021), argue that agrochemicals used for crop treatment include a wide range of pesticides that can be toxic not only to the plant species in question but also to the environment. According to F. Isbell *et al.* (2023), the addition of fertilisers to agricultural land also leads to the loss of biodiversity and the decline of many ecosystems.

The current state of agriculture in the Vinnytsia region is determined by a complex of factors, such as land use, agricultural production, financial support for agricultural enterprises, as well as the impact of climate change and other environmental factors. Analysis of current trends and challenges provides effective strategy planning and informed decision-making for the further development of the region's agriculture. Given the above, the issues raised are quite relevant and require further research. The study aims to analyse the current state and peculiarities of the functioning of agriculture in the Vinnytsia region, as well as to identify directions for the development of this sector of the region's economy.

Materials and methods

Due to the variety of existing research methods, those that provide an accurate result and cover all aspects of the processes under study are important. The study was based on the following methods:

1) abstract and logical methods to summarise theoretical approaches to the formation of the foundations of agricultural development in the region;

2) systemic and structural methods to analyse the potential of the agricultural sector of Vinnytsia region;

3) analysis and comparison methods to assess the level of agricultural development in the region;

4) economic and statistical methods for processing statistical data and assessing the current state of agriculture;

5) tabular and graphical methods for visualising changes in the agricultural sector.

The study addresses the economic and mathematical statistics methods that form the basis for assessing the current level of agricultural development and allow for mathematical interpretation of the results of such analysis. The study also focuses on substantiating scientific, theoretical and practical aspects and developing recommendations on regional peculiarities of agricultural development.

The theoretical and methodological basis of the study includes the basic principles of general economic theory, achievements of advanced science and practice in improving the economic efficiency of agriculture in the Vinnytsia region. The overall structure of the study includes successive stages. The first stage is an analysis of the current state of agricultural development in the Vinnytsia region for the period of 2018-2022. This stage of the study is based on analytical and statistical data from the Official website of the State Statistics Service of Ukraine (n.d.), Main Department of Statistics in Vinnytsia Region (n.d.), Analysis of water resource provision for population and economic sectors (n.d.). The data on agricultural development used in this paper includes information up to and including 2022, as official statistics for 2023 are not yet available due to the collection and processing of updated data, which requires significant time, especially during the period of martial law in Ukraine.

The second stage of the research aims to study the main challenges that hinder the effective development of agriculture. The theoretical basis of this stage includes scientific publications on the topic under study (Said *et al.*, 2020; Abdel-Fattah *et al.*, 2021), materials of the Programme of Economic and Social Development of Vinnytsia Oblast for 2024 (Order of the Chief of the Regional Military Administration No. 1465…, 2023).

The third stage of the study involves, based on the analysis of the current state of functioning of agriculture in the Vinnytsia region, substantiation of further prospects for the development of this sector of the region's economy, namely the optimisation of land use (Bubyr, 2021), the introduction of modern technologies (Nyaga *et al.*, 2021; Gorobets *et al.*, 2021). Support for agriculture (Petliuk & Miedviedkova, 2021; Vdovenko *et al.*, 2022; Dobrunik & Kuznietsova, 2022) is one of the key factors in ensuring the

sustainable development of this sector. It is also necessary to stimulate the ecological production of agricultural products (Joshi, 2023; Abas,2023). Sources of information included agricultural development programmes (Resolution of Vinnytsia Regional Council No. 922..., 2020; Resolution of Vinnytsia Regional Council No. 978..., 2020), examples of leading agricultural enterprises in the region (MHP Food UK Limited, n.d.; Farm enterprise "Ukraine", n.d.).

▸ Results and Discussion

Vinnytsia region has a temperate climate and fertile land. Therefore, agriculture is the main sector of the region's economy, which determines the food supply, employment and socio-economic development of the region. Over a long period, there has been a steady upward trend in the production of many types of agricultural products. However, according to I. Tomashuk (2022), active military operations in much of Ukraine have led to large-scale problems that have a destructive impact on the current state and prospects of agricultural development.

As for the Vinnytsia region, according to M.Franchuk (2020), 2012.0 thousand hectares of agricultural land are used in the region, of which 1730.5 hectares are arable land, 48.0 hectares are perennial plantations, 48.8 hectares are hayfields, and 183.9 thousand hectares are pastures. In terms of agricultural land, the region ranks ninth among other regions of Ukraine. For a comprehensive analysis of the current state of development of the region's agro-industrial complex (AIC), it is necessary, first of all, to analyse the dynamics of agricultural production (Table 1).

Table 1. Gross agricultural production

Indicators	Years					Deviation, %	
	2018	2019	2020	2021	2022	2022/ 2018	2022/ 2021
Agricultural enterprises of all categories							
Agricultural production, million UAH, incl.	56,520.9	57,168.9	48,688.6	59,467.8	48,597	-14.0	-18.3
▸ crop production, mln. UAH	41,738.0	39,426.9	30,841.8	42,039.2	31,537.1	-24.4	-25.0
▸ husbandry, mln. UAH	14,782.9	17,742.0	17,846.8	17,428.6	17,059.9	+15.4	-2.1
Enterprises							
Agricultural production, million UAH, incl.	40,876.3	42,411.8	35,169.1	45,409.3	35,608.3	-12.9	-21.6
▸ crop production, mln. UAH	30,833.0	29,100.7	21,521.9	31,754.4	21,948.5	-28.8	-30.9
▸ husbandry, mln. UAH	10,043.3	13,311.1	13,647.2	13,654.9	13,659.8	+36.0	+0.04
Household farming							
Agricultural production, million UAH, incl.	15,644.6	14,757.1	13,519.5	14,058.5	12,988.7	-17.0	-7.6
▸ crop production, mln. UAH	10,905.0	10,326.2	9,319.9	10,284.8	9,588.6	-9.3	-6.8
▸ husbandry, mln. UAH	4,739.6	4,430.9	4,199.6	3,773.7	3,400.1	-28.3	-9.9

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.); Main Department of Statistics in Vinnytsia Region (n.d.)

As can be seen, 2022 was a difficult year for the country, as evidenced by the minimum value of agricultural production in the region (UAH 48,467.8 million) for the period from 2018 to 2022. It is worth noting that this decline in production in 2022 was due to a significant decrease in the volume of plant products produced, in particular, by 25% compared to 2021 and by 24.4% compared to 2018.

Despite the lack of published statistics for 2023, it is worth noting that, according to Oleh Sidorov, Director of the Regional Military Administration Department of Agricultural Development (In Vinnytsia region..., 2023), Vinnytsia region is the leader in agricultural production among all regions of Ukraine (during 10 months of 2023, there was an increase in agricultural production in the region by almost 30%). It is worth noting the better state of livestock production. For example, the value of this indicator in 2022 increased by 15.4% compared to 2018. However, compared to the previous year, 2021, the volume of livestock production decreased slightly by 2.1%. This positive trend in livestock production is determined by the sustainability and efficiency of enterprises, where in 2022 the volume of output increased by 36% and 0.04% compared to 2018 and 2021, respectively. Considering the structure of agricultural production, it should be noted that in the period 2018-2022, the majority of products in the region, namely 63.3-73.8%, are plants, while livestock accounts for about 26.2-36.7% (Fig. 1).

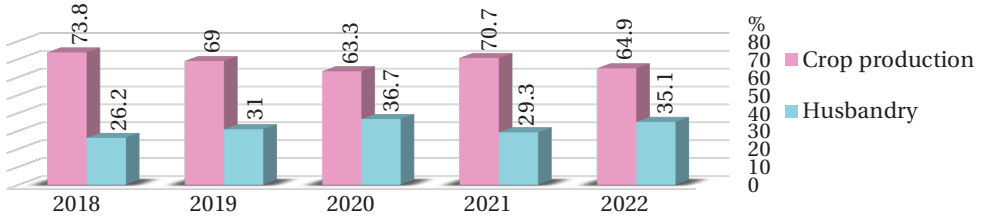

Figure 1. Dynamics of the structure of agricultural production, %

Source: calculated per data from the Official website of the State Statistics Service of Ukraine (n.d.); Main Department of Statistics in Vinnytsia Region (n.d.)

Analysing the key performance indicators of agriculture in the Vinnytsia region (Table 2), it is necessary to note a positive trend in the growth of the number of business entities in the studied sector of the economy. For example, the number of agricultural enterprises increased from 2,715 in 2018 to 2,908 in 2022. It is worth noting that this growth is partly the result of the relocation of enterprises from the southern and eastern regions of the country.

Table 2. Key indicators of agricultural efficiency in the Vinnytsia region

Indicators	Years					Deviation, %	
	2018	2019	2020	2021	2022	2022/ 2018	2022/ 2021
Number of enterprises, units.	2,715	2,765	2,751	2,858	2,908	+7.1	+1.7
Share of the region in the national output, %.	8.4	8.4	8.0	8.3	8.4	0	+1.2
incl.: ▸ crop production	7.9	7.3	6.5	7.2	7.8	-1.3	+8.3
▸ husbandry	10.4	12.5	12.9	13.2	10.1	-2.9	-23.5
Production output per 100 ha of agricultural land, thousand UAH.	2,806.1	2,841.4	2,419.9	2,956.6	2,684.5	-4.3	-9.2
Production output per 1 person, UAH.	36,044	36,814	31,672	39,141	33,214	-7.9	-15.1
Number of employees, thousand people	36.3	35.5	33.0	33.8	32.2	-11.3	-4.7
Labour productivity per employee, thousand UAH.	1,491.3	1,536.8	1,399.1	1,759.4	1,509.2	+1.2	-14.2
Profitability of operating activities of enterprises, %.	20.2	10.7	16.7	18.5	16.1	-20.3	-13.0

Source: calculated per data of Official website of the State Statistics Service of Ukraine (n.d.); Main Department of Statistics in Vinnytsia Region (n.d.)

According to the studies, the region's share in the national production continues to remain at the level of 8.0-8.4%, which is a crucial indicator of the successful development of agriculture in the region. A negative downward trend in 2022 occurred in several important indicators related to agriculture, such as output per 100 hectares of land, per person, number of employees employed in the industry, and labour productivity. This may be caused by a decrease in agricultural production in the current year, as well as the impact of technological changes, automation and new management approaches in agriculture.

An analysis of the operating profitability of agricultural enterprises in the Vinnytsia region over the past five years has revealed several significant trends and changes in this indicator. In 2018, the profitability was 20.2%, which indicated a high level of profitability for most companies in the industry. However, this figure declined in the following years. In 2019, the profitability was 10.7%, which may be due to the economic situation, changes in the agricultural market and the cost of new technologies. In 2020-2021, the profitability increased to 16.7% and 18.5%, respectively, indicating an improvement in operating efficiency. However, in 2022, there was another decline to 16.1% due to the difficult economic and political situation in the country.

The opinion of M. Franchuk & H. Khaietskyi (2021) that the main factor in increasing the yield of land resources in the Vinnytsia region is the use of mineral and organic fertilisers is notable. In particular, the dynamics of mineral and organic fertiliser application to the soil by enterprises in the study region for the period 2017-2022 are shown in Table 3.

Table 3. Dynamics of mineral and organic fertiliser application to the soil by Vinnytsia region enterprises in 2017-2022

Indicators	Years					
	2017	2018	2019	2020	2021	2022
Mineral fertilisers						
Fertiliser applied, thousand tonnes	162.7	160.2	153.5	187.6	148.6	213.8
Fertilised area, thousand ha	1,103.9	1,040.3	966.5	988.5	979.8	999.4
Share of fertilised area, %.	94.1	94.9	91.9	95.3	90.7	94.9
Fertiliser applied per hectare, kg, including:						
▸ exact sown area	139	146	146	190	138	203
▸ area treated with fertilisers	147	154	159	181	152	214
Organic fertilisers						
Fertiliser applied, thousand tonnes	511.7	803.1	625.5	725.8	600.8	645.4
Fertilised area, thousand ha	22.8	42.9	37.1	40.0	45.5	39.9
Share of fertilised area, %.	1.9	3.9	3.5	3.9	4.2	3.8
Fertiliser applied per hectare, kg, including:						
▸ exact sown area	512	622	598	700	556	613
▸ area treated with fertilisers	15,230	16,179	16,505	18,154	13,213	16,176

Source: compiled based on Analysis of water resource provision for population and economic sectors (n.d.)

Based on the data presented in Table 3, it is possible to conclude that there were slight fluctuations in the application of mineral and organic fertilisers between 2017 and 2022. However, in 2022, despite the difficulties in the country, companies in the region were able to increase the volume of mineral fertilisers applied by 65.2 thousand tonnes and organic fertilisers by 44.6 thousand tonnes compared to 2021. Analysing the situation in crop production in the period from 2020 to 2022, it is worth noting the stability of the area of land used for crops, which varies between 1628.0 and 1653.1 thousand hectares (Table 4). However, a detailed analysis of structural changes in the dynamics of sown areas shows a decrease in the area under grain crops by 89.9 thousand ha in 2022. This led to an increase in the area under industrial crops, in particular oilseeds, soybeans, mustard, sunflower and rapeseed, in the region.

Table 4. Dynamics of sown areas under crops, thou hectares

Crop type	All farm types			Enterprises			Household farming		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Agricultural crops	1,628.0	1,653.1	1,631.5	1,207.8	1,232.1	1,210.6	420.2	421.0	420.9
Cereals and legumes:	878.6	900.9	811	709.5	722.4	638.5	169.1	178.5	172.5
▸ wheat	316.1	317.5	320.1	261.1	258.0	263.7	55.0	59.5	56.4
▸ corn	451.7	458.9	386.7	389.8	393.3	323.2	61.9	65.6	63.5
▸ barley	88.6	94.0	80.7	46.5	51.0	38.3	42.1	43.0	42.4
▸ rye	1.8	3.2	2.0	0.6	1.9	0.9	1.2	1.3	1.1
▸ oats	0.8	1.0	0.8	0.4	0.6	0.4	0.4	0.4	0.4
▸ buckwheat	6.7	6.9	8.8	3.0	3.2	5.1	3.7	3.7	3.7
Grain and legumes	9.0	9.4	10.2	4.3	4.6	5.4	4.7	4.8	4.8
Industrial crops:	429.1	511.2	572.1	460.3	479.2	540.2	37.8	32.0	31.9
▸ oil crops	442.9	450.0	523.1	416.1	423.0	496.2	26.8	27.0	26.9
▸ soy	103.0	84.1	105.3	91.2	72.2	93.4	11.8	11.9	11.9
▸ mustard	-	0.4	0.7	-	0.2	0.5	-	0.2	0.2
▸ winter rapeseed and kohlrabi	50.2	64.6	89.1	49.4	63.8	88.3	0.8	0.8	0.8
▸ sunflower	289.0	311.6	328.0	275.1	297.6	314.0	13.9	14.0	14.0
▸ sugar beet	48.5	49.6	48.4	43.4	44.5	43.4	5.1	5.1	5.0
Roots and tubers. Vegetables and melons:	132.8	126.8	130.9	0.5	0.4	0.5	132.3	126.4	130.4
▸ potatoes	109.6	101.8	105.7	0.2	0.2	0.3	109.4	101.6	105.4
▸ vegetables	21.1	22.4	23.1	1.1	-	14.2	20.0	22.4	8.9
▸ melons and gourds	2.1	2.3	2.1	-	-	-	2.1	2.3	2.1
Fodder crops:	124.2	114.3	117.3	37.5	30.1	31.4	86.7	84.2	85.9
▸ fodder beetroot	19.7	16.9	18.2	-	-	-	19.7	16.9	18.2
▸ fodder corn	21.5	14.7	18.7	21.2	14.5	18.5	0.3	0.2	0.2

Source: calculated per data of Official website of the State Statistics Service of Ukraine (n.d.); Main Department of Statistics in Vinnytsia Region (n.d.)

Considering the various aspects of this study, it is worth noting that many challenges impede agricultural development and lead to a decrease in crop productivity. As noted by M.E.S. Said *et al.* (2020) and M.K. Abdel-Fattah *et al.* (2021), the quantity and quality of the crop are largely influenced by climate. First, air temperature affects physiological processes in plants, such as photosynthesis and fruit development. For example, high temperatures cause stress to plants and lead to lower yields. Secondly, precipitation is important for soil moisture and water regime, which in turn affects plant growth and development. Therefore, understanding climatic conditions and their impact on crop production helps farmers develop better management strategies to ensure adequate yields and quality of agricultural products.

Furthermore, the development of agriculture in the region is affected by environmental issues, high production costs, low productivity, market competition, lack of access to foreign export markets, insufficient infrastructure and technology, and socio-economic problems in rural areas, which require a comprehensive approach and joint efforts by the government, rural communities, businesses and the public.

It is worth noting that the Programme of Economic and Social Development of Vinnytsia Region for 2024 (Order of the Chief of the Regional..., 2023) identifies numerous risks and possible challenges, including difficulties in exporting products due to the destruction or complications of transport logistics, the suspension of the grain corridor and further blockade of Black Sea ports, a decrease in lending and investment, etc. These problems, caused by the ongoing war on the territory of the country, are a serious obstacle to the development of the agricultural sector in the region and the country.

The prospects for the development of agriculture in the Vinnytsia region cover a wide range of aspects, from the efficient use of land resources to the introduction of new technologies and the development of agricultural enterprises. Thus, optimisation of land use means rational and efficient use of agricultural land to maximise

its potential. To achieve this goal, it is important to ensure the preservation of soil fertility, rational location of agricultural land, efficient use of water resources, application of modern geospatial analysis technologies, and stimulation of rural cooperatives. The statement of N. Bubyr (2021) that determining the optimal ratio of different types of land in the structure of land use in a particular territorial community will help to streamline the land fund formed on the territory is noteworthy. These measures will increase agricultural productivity, preserve the environment and improve the quality of life of the rural population.

Among the main prospects for the development of agriculture in the Vinnytsia region is the use of modern technologies, which cover a wide range of innovative solutions, from the introduction of automated farm management systems to the use of drones and modern agricultural machinery and equipment. According to J.M. Nyaga *et al.* (2021), and N. Gorobets *et al.* (2021), the use of such technologies increases production efficiency, reduces labour and fuel costs, improves product quality and increases the competitiveness of agricultural enterprises.

An example of the effective implementation of modern technologies and methods of agriculture in the Vinnytsia region is the international company MHP (MHP Food UK Limited, n.d.). Many of MHP's crop production enterprises, including PJSC Zernoproduct MHP, have already implemented a full range of precision farming elements. For example, by using double, autumn and spring verti-till technology, the company managed to increase soybean yields by 0.3-0.5 tonnes compared to conventional tillage, not including savings on fuel, technological operations and fertilisers. Furthermore, the use of a precision seeder can reduce the number of seeds per hectare by up to 100,000, while ensuring uniform sowing and increased uniformity of germination. The use of strip-till for tillage contributes to an increase in corn yield by 4 cwt/ha or more, which is especially important in conditions of sufficient rainfall, which was typical for most regions in 2022.

Since 2016, MHP has been actively developing its digital platform, which is currently forming the Digital Agro 360 ecosystem, which includes digital tools to increase agricultural productivity (MHP Food UK Limited, n.d.). Studies have shown that when the spreader sections are automatically switched off, fertiliser overruns are within 0.5-0.6%. In the case of manual spreading control, this figure increased to more than 5%. Based on all the figures, the difference between automatic and manual control is more than $6 per hectare, which has a significant impact on the efficiency of resource use when cultivating large areas. It is also important to note that spreaders with automatic control reliably adhere to the set application rate (instead of the prescribed rate of 200 kg/ha, they can set 180 or 190 kg/ha).

At the same time, the company continues to actively implement biogas projects, in particular, the Ladyzhyn Biogas complex leads to a reduction in greenhouse gas emissions, estimated at 100 thousand tonnes of CO^2 equivalent annually. In addition, organic fertilisers, which contain abundant nutrients necessary for plant growth, are a valuable product obtained from biogas complexes.

Another exemplary example of the use of modern technologies for growing and processing agricultural products in the region is Farm Enterprise "Ukraine" (Farm Enterprise "Ukraine", n.d.). The farm uses a modern No-Till tillage system. This approach is an agricultural technology that eliminates traditional methods of tillage before sowing seeds or planting plants. Instead, plant residues, such as stems and roots, are left on the field even after harvesting, which helps to preserve soil moisture, maintain soil structure, reduce erosion and help increase yields. The company has managed to increase organic matter by 0.25% to 0.75% on its No-Till fields. In addition, No-Till reduces the use of machinery and fuel (40-60 litres of diesel per hectare), which leads to lower emissions and contributes to more sustainable and environmentally friendly agriculture.

It is worth noting that to develop the region's agro-industrial production, the Action Plan for 2021-2023 for the implementation of the Strategy for Balanced Regional Development of Vinnytsia Region until 2027 (Resolution of Vinnytsia Regional Council No. 922..., 2020) sets out the introduction of agrotechnologies using IT innovations and support for the development of the organic agricultural sector as one of the main tasks.

An important aspect of ensuring the stability and development of agriculture is its support, which includes financial assistance, access to credit and subsidies, as well as advice and information support on agricultural technology, marketing and management (Petliuk & Miedviedkova, 2021; Vdovenko *et al.*, 2022; Dobrunik & Kuznietsova, 2022). It is also necessary to support the development of agricultural infrastructure, including the construction of roads, irrigation systems, crop storage facilities, etc. O. Yushkevych (2019) argues that support for agriculture contributes to job creation, raising farmers' incomes, and supporting sustainable rural development.

To support the business environment in the region, the Regional Programme for the Development of Small and Medium-Sized Enterprises for 2021-2027 (Resolution of Vinnytsia Regional Council No. 978..., 2020) was developed, with the priority goals of creating conditions to promote entrepreneurship, increasing the ability of small and medium-sized enterprises to obtain financial resources, creating infrastructure to support business, increasing competitiveness and developing the innovative potential of enterprises.

It is worth emphasising that an important task in ensuring the sustainable development of the region's agricultural sector is to promote organic agriculture (Joshi, 2023; Abas, 2023). In particular, providing financial incentives and subsidies to farmers who use environmentally friendly production methods, supporting the introduction of organic farming and growing products without the use of chemical fertilisers and pesticides. It is also essential to support research and development of new technologies aimed at reducing the environmental impact of agricultural activities, such as the use of alternative energy sources and waste minimisation. Promoting organic agriculture contributes to the conservation of biodiversity, human health and the sustainable use of natural resources.

Thus, the study of agriculture in the Vinnytsia region revealed several key trends. First of all, the region has significant areas of agricultural land, which makes it an

important player in the national agricultural sector. Despite a slight decline in agricultural production, especially of crops, in 2021-2022, there was a certain recovery in the region's agricultural sector. Therefore, it is necessary to improve agricultural development strategies to encourage the introduction of modern technologies, optimise the use of land resources and support environmentally friendly agriculture.

Conclusions

Thus, agriculture remains an important sector of the Vinnytsia region's economy, which determines the food supply, employment, and socio-economic development of the region and the country. The region under study has all the potential natural and economic opportunities.

The analysis of the current state of agricultural development in the Vinnytsia region demonstrated a stable situation, given the current military conflict in the country. Thus, the volume of agricultural production in 2022 (when the military invasion began) decreased by 18.3%. However, in 2023, agricultural production in the region increased by almost 30%. In addition, it is worth noting that the area under crops accounts for 95% of the region's arable land, which indicates the efficient use of land resources. Moreover, a positive aspect of the development of the industry under study is its leading position among the country's regions, namely 8.4%. The value of this indicator is important, as a significant part of Ukraine's territory is currently incapacitated due to the ongoing hostilities and mining of agricultural land.

It is worth noting that many challenges hinder the development of agriculture and lead to lower crop productivity: climatic conditions, environmental problems, high production costs, low productivity, market competition, lack of access to foreign export markets, insufficient infrastructure and technology, as well as socio-economic problems in rural areas. However, such challenges require finding ways and directions to reduce their negative impact on the industry under study.

Further research should specify proposals for the development of agriculture through a deeper study of such aspects as optimising the use of land resources, considering their fertility and agricultural-climatic conditions, and introducing innovative modern technologies in all areas of agricultural production, design and implementing effective programmes to support agricultural development, including financial and technical assistance to farmers, as well as promoting environmentally friendly practices in agriculture by encouraging the use of organic production methods and conservation of natural resources.

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Conflict of interest

None.

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Сучасний стан та перспективи розвитку сільського господарства Вінницької області

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▸ **Анотація.** Сільське господарство Вінницької області відіграє важливу роль у економіці даного регіону, забезпечуючи продовольчу безпеку, стабільність зайнятості та соціально-економічний розвиток. Метою дослідження було проведення аналізу сучасного стану та особливостей функціонування сільського господарства Вінницької області, а також визначення можливих перспектив розвитку даного сектору економіки регіону. Для досягнення цієї мети були використані наступні методи: абстрактно-логічний, системно-структурний, метод аналізу та порівняння, економіко-статистичний, табличний, графічний та інші методи. В статті проведено аналіз сучасних тенденцій розвитку сільського господарства, що охоплює інформацію до 2022 року, оскільки наразі немає офіційних статистичних даних за 2023 рік. Встановлено, що 2022 рік був складним для країни, що підтверджено зменшенням виробництва рослинної продукції у регіоні за період з 2018 по 2022 рік, але одночасно відбувся певний ріст у виробництві продукції тваринного походження. Досліджено структуру виробництва та показники ефективності сільського господарства, які свідчать про відчутні як позитивні, так і негативні тенденції. Зокрема, позитивною стороною динаміки є збільшення кількості сільськогосподарських підприємств та стабільність частки області у загальнодержавному виробництві сільськогосподарської продукції. Проте, негативними тенденціями є зниження виробництва продукції, зменшення рентабельності операційної діяльності та інші показники, що відображають вплив економічних та технологічних факторів на галузь. Зазначається, що належне використання добрив є важливим чинником підвищення урожайності земель. Виокремлено низку викликів, які обмежують продуктивність та стійкість розвитку сільського господарства у регіоні. Зокрема, кліматичні умови, такі як температура та опади, екологічні, економічні та соціальні проблеми, які потребують комплексного підходу для їх вирішення. Обгрунтовано перспективи розвитку сільського господарства, а саме: оптимізацію використання земельних ресурсів, впровадження сучасних технологій, підтримка сільського господарства та стимулювання екологічного виробництва сільськогосподарської продукції. Розглянуто приклади впровадження сучасних технологій та інновацій у сільське господарство області, зокрема вирощування продукції без застосування хімічних добрив та пестицидів, використання точного землеробства та біогазових проєктів. Висвітлено ініціативи та програми підтримки малих і середніх підприємств та екологічного сільського господарства. Розуміння цих аспектів дозволяє розробляти стратегії розвитку та приймати обґрунтовані рішення

▸ **Ключові слова:** сільськогосподаські культури; показники; розвиток; виробництво; екологічне виробництво; рослинництво; тваринництво

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Effectiveness assessment of technical innovations in the implementation of the modern model of the agricultural sector of Ukraine

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▸ **Abstract.** The agricultural sector of Ukraine requires fundamental changes to improve efficiency, rural development and sustainability, which is possible through the implementation of an innovative development model. The study aimed to assess the effectiveness of the introduction of one of the types of technical innovations – agricultural drones – in the agricultural production of Ukraine. The study uses the dialectical method of scientific cognition, analysis and synthesis, systematic generalisation, comparative analysis, rating method, and the mathematical method of calculation "solution optimisation" using Excel. The study analyses modern approaches to assessing the efficiency of individual processes, which helped to formulate its algorithm for calculating the efficiency of land cultivation using agricultural drones. At the first stage of the study, the technical advantages of agricultural drones were identified, which are manifested in increased labour productivity. The second stage of the study calculated the increase in the main crops (corn, wheat, sunflower, barley, soybeans, rapeseed, peas, buckwheat, and millet) that can be obtained as a result of the use of agricultural drones on a national scale. The third stage of the study yielded an indicator of the economic efficiency of introducing agricultural drones into agricultural production, as well as a forecast of the social and environmental effects. It is emphasised that state support for the Ukrainian production of agricultural drones in various forms (subsidies, preferential lending, leasing, etc.) will contribute to the development of innovative Ukrainian industry, which will positively affect the change in the sectoral structure of the national economy and significantly increase the country's gross domestic product. The following conclusions, suggestions and practical recommendations may be useful in developing relevant programmes and measures aimed at developing the agricultural sector of Ukraine

▸ **Keywords:** efficiency; agricultural sector; agriculture; innovation; agricultural drones; productivity; sectoral structure

▸ Introduction

The importance of fundamental changes in the development of the national economy as a whole, in particular in the agricultural sector, is determined by many scientists, practitioners and ordinary citizens who need a significant increase in the socio-economic conditions of well-being as a degree of satisfaction of human needs. The need to find and use innovative ways to overcome the extremely low standard of living in Ukraine is also clear. The war has further complicated the socio-economic situation in the country, which requires adequate actions to address its economic, environmental and social consequences, especially in the agricultural sector. O. Shubravska (2023), analysing the specialisation of Ukraine's agriculture and food exports, its pre-war trends and post-war prospects, notes that the negative impact of many factors on the post-war development of Ukrainian agriculture can be significantly reduced by intensifying *innovation processes*, which will also

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form the areas of specialisation of Ukrainian agricultural production and exports following the needs of long-term sustainability. V. Mamchur & G. Studinska (2023) prove that the fundamental reason for the economic lag of the Ukrainian economy with its significant natural (resource), geographical, and intellectual potential from modern developed technological countries is its *inefficient sectoral structure*, which requires government intervention, support from the legislature, and strategic and innovative changes in public administration. An analysis of changes in the sectoral structure of Ukraine's gross domestic product (GDP) shows that the trend towards an increase in the share of the primary sector, which includes agriculture, continues. A. Petrenko (2019) cites the results of a World Bank study that predicts that it will take Ukraine 40-50 years to catch up with Poland and 100 years to catch up with Germany in terms of living standards. The full-scale Russian invasion of Ukraine has exacerbated the impact of destructive processes in the development of the agricultural economy. The *raw materials export-oriented model of development of Ukraine's agricultural sector* has proved to be insufficiently sustainable and socially oriented. The current challenges may open new opportunities for agribusiness development, in particular, the agricultural economy should be restored to support small and medium-sized agribusinesses and promote the development of agricultural processing. K. Shatnenko (2023) emphasises that raw material specialisation stimulates the growth of economic inequality, constant problems with the country's balance of payments and dependence on external borrowing, and consolidates the oligarchic social structure, which is not interested in innovative development but has rent-seeking behaviour. The development of the processing industries prompts further research on changing the sectoral structure of Ukraine's economy. The changes should be significant, rapid, and permanent for a long time, which is possible only under conditions of a clear professional organisation of public administration and through the formation of an innovative model of agricultural development, which is presented as a set of technological, technical, organisational, institutional, legal, and marketing innovations. The introduction of each type of innovation requires an assessment of the effectiveness of their use and payback.

The transformation of the role of agriculture in Ukraine into a strategic one is deeply flawed. According to M. Kalinchyk *et al.* (2023), the reasons for the devastating misrepresentation of the role of agriculture in Ukraine are that "top managers of state institutions and final recipients of benefits from the exploitation of human, land, water and other natural resources have imposed on society the stereotype that the agricultural sector is the "engine of the Ukrainian economy", the "growth point", and that grain is "Ukrainian oil and gas". It naturally follows that being a raw material donor to industrialised countries is an honourable and "economic miracle", as Ukraine has historically had inexhaustible natural, human and other comparative and competitive advantages.

Global experience demonstrates an opposite practice that can provide a country with the desired economic breakthrough. Experts of the International Monetary Fund R. Chérif & F. Hasanov (2019) advise poor countries with a raw material structure to implement an active technology policy similar to that of the Asian tigers. They emphasise that standard recipes – improving the business climate, improving institutions, developing infrastructure, investing in education, and maintaining macroeconomic stability – are not enough to move to a dynamic and sustainable growth trajectory. They suggest three key success factors: 1) support for producers in *technology-based industries*; 2) export orientation; and 3) a commitment to fierce competition with strict accountability. These factors will certainly have an impact on changing the sectoral structure of the Ukrainian economy. A striking example of the use of these success factors is the economic achievements of South Korea, which has chosen an innovative path of development through the creation and promotion of technology brands.

The introduction of each type of innovation requires an assessment of the effectiveness of their use and payback, which determined the purpose of the study – to assess the effectiveness of the introduction of one of the types of technical innovations – agricultural drones – into agricultural production in Ukraine. According to the goal, the following tasks are set: 1) to collect and analyse information on the types of agricultural drones on the Ukrainian market; 2) to study their technical characteristics, advantages, disadvantages and price; 3) to substantiate the production potential of agricultural drones and assess the efficiency of agricultural drones in Ukraine.

▸ Literature review

Many scientists addressed the experience of innovation, in particular, O. Garazha *et al.* (2023), using comparative analysis, generalisation, synthesis and analysis methods for this process in Eastern Europe (to which Ukraine belongs), identify the development of innovations through the introduction of modern agricultural production technologies and the development of organic farming as promising.

Z. Yanchenko (2013) addressed the criterion of efficiency of innovation activity in agricultural production through "maximisation of profit per unit of agricultural land at minimum costs and optimal use of available capital and minimum environmental impact". The researcher emphasises that the assessment of the effectiveness of innovation in the agricultural sector should reflect the degree of rational use of land and other means of production, as well as the return on investment in agricultural production, which fully meets the requirements of the current national sustainability policy and affects our choice of method for assessing the effectiveness of agricultural drones in Ukraine. To assess the level of efficiency, the author proposes an index method, which involves calculating a list of indices: productivity growth, energy intensity reduction, productivity growth, reduction of environmental costs, and total costs of innovation. In addition, the author calculates the economic efficiency of innovations in the agricultural sector through their impact on the use of land resources.

A. Bakhtiar *et al.* (2022) assessed the productivity of innovation systems in different countries in general by considering two indicators of efficiency and effectiveness.

A *descriptive-analytical approach to assessing efficiency and effectiveness indicators* in 126 countries, including Ukraine, the USA, Switzerland, China, Iran, Armenia, Egypt, Australia, Qatar, Russia, and others was employed by comparing a range of indicators of socio-economic development and competitiveness. As a result, the researchers obtained a matrix with two vectors and proposed a corresponding classification of these countries. Ukraine received similar coordinates in this matrix, along with Moldova, Armenia, and Iran, where innovation systems are effective but inefficient, which reminds us of the need for comprehensive innovation changes in the country.

The result of a 6-year study of innovation effectiveness in manufacturing companies in various industries by J. Björk *et al.* (2023) was nine recommendations for improving innovation measurement in real practice, grouped into three main topics: strategy, organisation, and measurement design. A *case study analysis* was used to conclude innovation assessment efficiency. For the overall assessment of the effectiveness of our model of innovative development of the agricultural sector of Ukraine, it is useful to recommend not to overload mathematical calculations with a large list of indicators. Therefore, this study assesses the effectiveness of introducing only one innovation in agricultural production.

Given that the introduction of agricultural drones in Ukraine is intended for most small and medium-sized farms, the findings of W.A. Srisathan *et al.* (2023), who studied open innovation processes in 615 small and medium-sized enterprises in Thailand using the *second-order factor analysis* (a statistical method used to study the relationships between a set of sub-dimensions or factors that make up a higher-order construct), including multigroup analysis of structural invariance, were important for us.

Y. Ulko (2019) addressed the problem of assessing innovative measures and implementation in organic agriculture, and their adaptive and flexible use of modern and advanced technological solutions. The author used a combination of scientific methods to analyse various aspects of this problem, in particular, *constructive and calculation methods* to calculate the indicators of economic efficiency of yield growth from the application of biological products. As a result of the calculations made, the author concludes that the economic efficiency of organic production depends on the type of crop and the conditions of their cultivation, which proves the author's vision of a differentiated assessment of the efficiency of implementation of each agricultural innovation.

The methodological approach of Ukrainian researchers to assessing the effectiveness of innovative technology park projects by M. Petryna *et al.* (2020), based on globally accepted performance indicators: *net present value, profitability index, internal rate of return and payback period*, was used to conclude on the possibility of accelerating the process of selecting innovative projects and their implementation and intensifying innovation activities in the country. As a result of the study, the researchers focused on the need for stable legislation in Ukraine, which affects the performance indicators of innovative projects.

Correlation analysis and econometric modelling are widely used methods for assessing certain objects and processes in the national economy in general and in agriculture in particular. L. Kucher *et al.* (2022) used the first method to identify and assess the closeness of the relationship between the factors influencing the formation of financial support for the implementation of innovative projects of agricultural enterprises; the second method was used to build a *mathematical model of the dependence of investment profit of agricultural enterprises on production costs*. Other Ukrainian scientists L. Skorokhod *et al.* (2022) applied *correlation analysis* to assess the environmental and economic costs of using organic land for engineering and to evaluate the feasibility of developing organic production.

J.F. Reyes-Rodríguez *et al.* (2023) employed a *sustainable value creation model* and identified strategies suitable for small and medium-sized enterprises in Colombia, thus highlighting their potential in a developing country to contribute strategically to sustainable development, given their unique characteristics through the implementation of a portfolio of innovations.

The *cost method of calculating the efficiency* of agricultural drones in agricultural land cultivation is the easiest to apply, which contributed to its use by Ch. Mamedova (2020) in calculating the efficiency of using the Atrice 200 agricultural drone for aerial chemical work in the agricultural holding Mriya LLC. Using this method, the author predicted the amount of profit from this agricultural holding. The considered methodological approaches and research on assessing the effectiveness of innovations in the agricultural sector should be used to develop a methodology for assessing the introduction of agricultural drones in Ukraine.

Materials and methods

The empirical research was conducted according to the standard algorithm: 1) organisation – formation of research goals and objectives, selection of the object and subject of research, development of research methodology, drafting of a study plan; 2) achievement of the goal, which was carried out in three stages. The research was conducted at the National Research Centre "Institute of Agrarian Economics" in 2023. The study collected and analysed information on 20 types of agricultural drones for Ukrainian and foreign production.

The first stage of the study covered the research of agricultural drones offered by official dealers and Ukrainian manufacturers, as well as companies providing services for agricultural land processing with agricultural drones. The information was collected using the Internet and by phone. The results of the survey are presented in Table 1.

Table 1. List of agricultural drones, their performance and price in Ukraine for 2024

No.	Agricultural drone name	Functionality and productivity	Manufacturer/ supplier	Price, thsnd. UAH
1	Reactive Drone Agric RDE616 (PROF) Fuel tank of 20 litres	a) Spraying of plant protection products – 2-3.5 ha per cycle, up to 10-12 ha/hour; b) Spraying with organo-mineral fertilisers – 1.5-2.0 ha per cycle, up to 6-8 ha/hour; c) Solid fertiliser application – 1.0-1.5 ha/cycle, up to 5-6 ha/hour; d) Application of trichograms – up to 60 ha/hour.	Ukrainian manufacturer of agricultural drones – LLC "Reactive Drones", Dnipro, has been operating since 2016	500
2	Reactive Drone Agric RDE-410 Fuel tank of 10 litres	1) Up to 8 hectares/hour (up to 2 hectares per flight) – on simple fields without elevation differences with 500-1000 m spans; 2) Up to 6 hectares/hour (up to 1.5 hectares per flight) – on complex fields with small elevation differences and spans of 500-1000 m; 3) Up to 4 ha/hour (up to 1 hectare per flight) – on complex fields with elevation differences of up to 20 m and spans of 500-1000 m.		325
3	Reactive Drone Agroc RDE618 (PROF) 480,000 Fuel tank of 30 litres	For spraying plant protection products, fertilisers, and microelements. Professional model up to 15 ha/ hour (5 hectares per flight) on simple fields without elevation differences with spans of 500-1,000 m.		580
4	"Flying tractor" Fuel tank of 5-30 litres	Field cultivation, aerial reconnaissance, patrolling, mapping. In one flight (15 minutes), it can process up to 4 hectares of field with a working solution consumption of 2 litres/ha.	Ukrainian manufacturer IT KIT (n.d.), Kyiv presented domestic production drone in 2019	200
5	UAS6-50 Fuel tank of 50 litres	UAS6-50 productivity is 20 hectares per hour. 600 hectares per shift. Maximum speed of 8 m/s Maximum flight time is 129 minutes and minimum operating altitude is 1 m. Operational range – 3 km.		$55,000
6	UAS6-50G Fuel tank of 15 litres	Capable of cultivating any crops, orchards, vineyards, or forests (due to vertically turbulent flow of more than 20 m/s).		
7	Kray Protection Unmanned Aerial System Fuel tank of 22.5; 15 litres	Multi-rotor quadcopter for fertiliser application Drone productivity – up to 27-48 ha per hour, 300-500 ha/day.	Kray Technologies, Kyiv 2018	200
8	DJI Agros T30 Fuel tank of 30 litres	Processes up to 16 ha in one hour. Capable of recognising crops in any weather, from any angle.	Made in China DJI – 2/3 of global market	640; 660.5; 748
9	DJI Agros T 10 Fuel tank of 10 litres	Productivity is 40 ha/day.		209.3; 313.9
10	XAG V40 Standat mini kit (no LNT) Fuel tank of 16 litres	For MSMEs and agricultural producers with a land bank of 100 hectares or more. Covers up to 120-150 hectares in one shift. Maximum efficiency: 40 kg/min.		328; 370
11	XAG V40 Double kit 2 fuel tanks, each of 40 litres	Productivity of 2 drones per shift is up to 250 ha. During the desiccation of rapeseed, sunflower and other crops, a fleet of two drones ensures uniform application.		780
12	XAG P40 drone sprayer Fuel tank of 20 litres	Spraying, broadcasting, filming and mapping. Tank for applying plant protection products – 20 litres. Field map stitching performance – 6.67 hectares per 10 minutes.		315
13	XAG P100 Fuel tank of 40 litres	Spraying, sowing. Processing speed: up to 25 ha/h or 250 ha/10h. Payload: up to 40 litres or up to 70 kg of fertiliser and granules.		455
14	XAG P 100 pro 2023 agricultural drone Fuel tank of 50 litres	Processing speed: up to 30 ha/h or 250 ha/10h. Payload: up to 50 litres or up to 80 kg of fertiliser and granules.		1,500
15	XAG P100 Fuel tank of 40 and 60 litres	Capacity up to 5 tonnes per shift. The P100 is equipped with a 40-litre tank for working with pesticides and can process about 200 hectares in one shift.		330

Source: compiled by the authors based on DroneUA (n.d); ACASOM (n.d); Kray Technologies (n.d.); Reactive Drone (n.d.)

Stage two of the study involved collecting information on the conditions of use of agricultural drones, technical advantages and disadvantages of individual brands, prices of technical equipment or their lease, the cost of training to operate an agricultural drone and the cost of its maintenance, as well as the performance of agricultural drones, which provided grounds for a *comparative analysis* and *rating method* to identify the leaders among manufacturers, distributors and service providers of agricultural drones in the Ukrainian market. The information sources at this stage were the official websites of global manufacturers of agricultural drones (their official distributors, as well as feedback from consumers of services for the processing of land plots using agricultural drones).

The third stage of the research was devoted to the direct application of the mathematical method of evaluation "solution optimisation" using Excel to calculate the efficiency of using agricultural drones in agricultural land cultivation. The parameters used in the calculation were the production capacity of agricultural drones, including their speed and processing area, the amount of nutrient solutions consumed, and the structure of the land. The calculations were aimed to determine the optimal number of agricultural drones for processing agricultural land, considering its size, and to determine the number of agricultural drones that should be purchased or leased. This data was further used to calculate the efficiency of using agricultural drones, based on the projected increase in yields from their use and the average cost of an agricultural drone. The efficiency of using agricultural drones in the cultivation of agricultural land was calculated using the following formula:

$$E_d = \frac{\sum_i^n (V_i * P_i)}{\sum (V_j * P_j)}, \quad (1)$$

where E_d – additional income from the use of agricultural drones, billion UAH; V_i – increase in the volume of the harvest of the crop, thousand tonnes; P_i – average market price of the crop, UAH/tonne; V_j –the number of drones of the j-th type to be purchased by group 2 farmers, units; V_j – the average price of agricultural drones of the *j*-th type to be purchased, million UAH.

▸ Results and Discussion

L. Filipishyna *et al.* (2018), S. Ramazanov & M. Petrova (2020) emphasise that many enterprises are seeking ways to improve efficiency and maintain competitive advantages in the agribusiness sector, as in the context of the innovation economy and EU policy in the agricultural sector, green transformation, innovation can contribute to improving the efficiency of economic activity. The research methodology of the first group of Lithuanian scientists is based on a *combination of theories of economic system management in the context of globalisation, convergence and transnationalisation of the market economy*. The second group of researchers proposes modelling based on an *integrated object-subject approach, a conceptual model, and a generalised model of synergistic dynamics with uncertainties considered.*

A. Poltavets & M. Bahin (2022) addresses the issue of increasing the efficiency of land use as a factor in the growth of agricultural production, noting that "the efficiency of agricultural land use is the main factor that significantly affects the socio-economic situation both in individual regions and in the country as a whole", and therefore is the main mission of an agricultural entity. In this regard, the use of agricultural drones is a crucial element in preserving the quality of the land while increasing the productivity of farmers, yields (by reducing losses) and the efficiency of agricultural production in general.

Soil quality has a major impact on crop yields and requires a scientific approach to preserving, maintaining and improving this quality. G. Tigabu Asfaw (2023) investigated the need for soil and water conservation in different slope classes in Ethiopia and concluded that soil and water conservation improve soil erosion control results on steep slopes and has a significant impact on some physical and chemical soil parameters. The use of agricultural drones allows farmers to preserve soil quality by avoiding soil compaction and optimising the spraying of nutrients.

As a result of a comparative analysis of the efficiency of Ukrainian agriculture with European countries, V. Dmytriieva (2021) concluded that there is a positive trend in the development of agriculture in Ukraine, however, the current way of farming is insufficient and inefficient to become a prosperous country. Among European countries, Ukraine has the largest area of soil for sowing various crops, grains, vegetables, and fruits, but receives the lowest profit from land use. Agricultural production requires fundamental changes that can be achieved using agricultural drones, which are capable of significantly increasing farmers' productivity, crop yields, crop quality, and the overall economic and environmental efficiency of agricultural production.

Researchers, studying the state and trends in the development of innovation-oriented agriculture and food enterprises in the context of updating the management of business infrastructure and the business ecosystem, conclude that the use of more productive machinery reduces the security risks of agri-food enterprises due to higher labour productivity, respectively, wages, qualifications and motivation of employees. The efficiency of agricultural production is analysed through the dynamics of the indicator of agricultural land per employee. It is worth noting that this indicator characterises labour intensity rather than efficiency. An indicator of agricultural production efficiency is the yield, the volume of output per worker, or the volume of food exports per 1 ha of arable land. In particular, a study by M. Kalinchyk *et al.* (2023) shows that these are the indicators used in EU countries to assess the efficiency of agricultural production.

The analysis of the mentioned studies proves the relevance of performance evaluation and the dependence of its methodology on many criteria. Evaluation of the effectiveness of each project provides important information on the adoption of a certain strategy for the implementation of the object, the research process, or the selection of contractors for the implementation of this project, or on understanding the feasibility of the project in general, i.e. the results of the evaluation of effectiveness are a guarantee of certain project results or a warning of possible risks of its implementation. The choice of evaluation method primarily depends on the field of research, which determines a certain specificity of the choice of criteria

and indicators. Equally important is the information base of statistical data, its structure and scope, as the degree of accuracy of the results is directly proportional to the depth of the evaluation. These conditions influenced the choice of a method for assessing the effectiveness of the introduction of agricultural drones in Ukraine. It should be noted that this was the first time that such a task was carried out, which does not allow comparing the results with similar ones, but instead forms a source for comparative analysis in the future. The accuracy of calculations of the effectiveness of the use of technical innovations, in particular agricultural drones, will depend on the horizon of taking into account the factors and components of the revenue and cost parts formed in the process of applying this innovation to the country's agricultural production as a whole.

The analysis of the information collected at the first stage of the study (Table 1) demonstrated that most of the demand for agricultural drones by Ukrainian farmers is satisfied by foreign companies through official distributors, even though Ukrainian-made agricultural drones successfully compete with foreign analogues both in terms of technical characteristics and price. Ukrainian companies that manufacture agricultural drones find consumers all over the world, which proves their competitive ability. The problem of the prevalence of foreign-made agricultural drones in the Ukrainian market is related to the weak investment base in our country, as well as the non-competitive marketing policy of Ukrainian manufacturers to promote their products.

The extent to which agricultural drones are used in farming on a national scale depends on a deep understanding of the effectiveness of their use by farmers and financial support for their use by the state. Information on the productivity of agricultural drones, considering their working potential, and the structure of land by size, gave rise to the division of agricultural producers into two groups. The first group includes business entities that cultivate land plots from 5 to 50 hectares, for which it is advisable to use the services of agricultural drones, and the second group includes business entities that cultivate land plots of 50 hectares and more, which are interested in owning agricultural drones, as shown in Table 2.

Table 2. Calculating the number of agricultural drones in Ukraine by 2030

	Entities with agricultural land		Estimation of the number of agricultural drones in Ukraine		
	units	Land area, ha	Average area of 1 p/a, ha	Normative need for agricultural drones, units	Total number of agricultural drones, units
Drone rental					
Up to 5 ha	1,766	5,818	3	1	1,766
5-10 ha	1,827	14,318	8	1	1,827
10-20 ha	3,036	47,206	16	1	3,036
20-50 ha	9,460	353,432	37	1	9,460
Total:	x				**16,089**
Drone acquisition					
50-100 ha	5,167	373,475	72	1	5,167
100-500 ha	9,371	2,290,292	244	1	9,371
500-1000 ha	3,228	231,4079	717	1	3,228
1000-5000 ha	4,845	10,150,358	2,095	2	9,690
More than 5000 ha	601	5,273,845	8,775	3	1,803
Total:	x				**29,259**
In Ukraine in total:	39,301	2,0822,823	x	x	x
Total number, of units					**45,348**
Costs, million UAH	x				20,481

Source: compiled by the authors

The estimates in Table 2 show that the total number of agricultural drones required for farming in Ukraine is 45,348 units, of which 16,089 units are required through farming services and 29,259 through the purchase of agricultural drones. The total cost of the drones in the latter group was calculated based on the average price of an agricultural drone – 700 thousand UAH.

According to the Ukrainian Club of Agrarian Business Association of the Union of Ukrainian Entrepreneurs and DroneUA, the largest integrator, importer and distributor of the world's leading drone manufacturers (2023), 2.2 million hectares of land were cultivated by agricultural drones in 2021 and 2022; up to 350 thousand tonnes of crops were additionally harvested; fuel savings of up to 12.1 million litres were achieved (compared to conventional wheeled vehicles); as an environmental effect, carbon emissions were reduced by 30.8 thousand tonnes, and water savings amounted to about 440 thousand tonnes (Union of Ukrainian Entrepreneurs... , n.d.; DroneUA, n.d.). In addition, up to 1,000 jobs were preserved, which is crucial in a time of war. According to DroneUA (DroneUA, n.d.), the elimination of soil compaction using agricultural drones alone reduces crop yields by at least 20%, and the absence of damage to crops by the wheels of ground sprayers adds 5 to 10% to the yield.

In addition to preventing soil compaction and crop damage, the increase in crop yields will be influenced by the accuracy of fertiliser application, timely desiccation, increased spray efficiency due to the optimal droplet size of the solution, etc., but there is no data on the result of such an impact yet, which is why further calculations of

the efficiency of agricultural drones should be based on the minimum value mentioned above – 30% (20% + 10%).

The expected increase in harvest volume for the main crops grown in Ukraine in 2023 is shown in Figure 1.

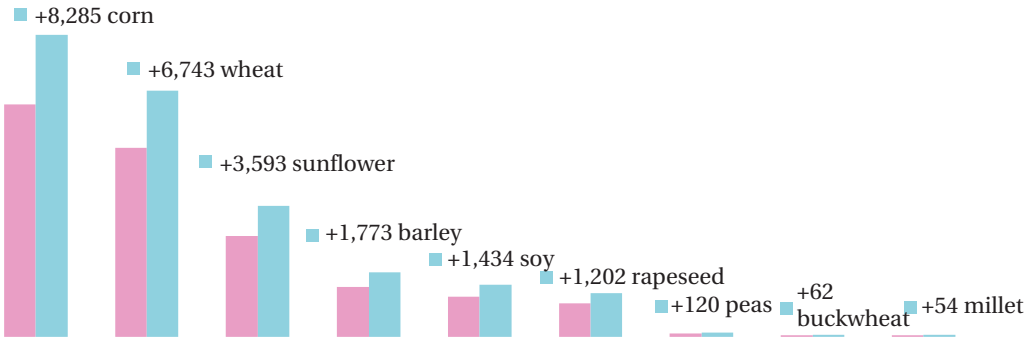

Figure 1. The annual increase in the yield of major crops due to the use of agricultural drones, thousand tonnes
Source: calculated by the authors

Based on these data, the estimated annual additional income that can be generated using agricultural drones by all business entities in agricultural production is presented in Table 3. The calculations show that the total projected additional income for the main crops alone could amount to almost 133 billion UAH.

Table 3. Annual additional income from increased yields generated by using agricultural drones

	Volume, thousand tonnes	Growth, thousand tonnes	Average price, UAH/t	Additional income, UAH million
1	2	3 = 2 * 30%	4	5 = 3 * 4
Corn	27,615	8,284.5	5,200	43,079.40
Wheat	22,478	6,743.4	4,800	32,368.32
Sunflower	11,975	3,592.5	3,647	13,101.85
Barley	5,909	1,772.7	1,772	3,141.22
Soy	4,779	1,433.7	16,200	23,225.94
Rapeseed	4,005	1,201.5	13,500	16,220.25
Peas	400	119.9	7,938	951.37
Buckwheat	208	62.3	9,000	560.25
Millet	180	54.0	6,373	344.14
Additional income, UAH million		x	x	**132,993**

Source: calculated by the authors

The effectiveness of the use of agricultural drones in the cultivation of agricultural land is calculated using the conventional formula (1). The efficiency of using agricultural drones in the cultivation of agricultural land will be 649%, according to the calculations in Formula (1), which means that the payback period for investments in such an innovation is minimal. For a farmer, an investment of 700,000 UAH or more is substantial, therefore, government support for the introduction of agricultural drones will not be superfluous. The form of such support can be different – low lending rates, leasing, subsidies, etc. Moreover, state support for the Ukrainian production of agricultural drones will contribute to the development of an innovative industry, which will positively affect the change in the sectoral structure of the national economy and significantly increase the country's GDP.

The cost part of the calculation of the effectiveness of the introduction of agricultural drones in practice will be increased due to the high payment for the operators of agricultural drones, payment for their training, and maintenance of these innovative technical means. At the same time, the income can also be increased due to the above-mentioned savings in water, energy, and fertilisers, as well as from an additional increase in yields, which is not accounted for and mentioned above. The availability of such statistical data will refine efficiency calculations.

A significant socio-economic effect of the introduction of agricultural drones in agricultural production will be an increase in the number of young people who will have material reasons to stay in rural areas and develop them. Given that the additional effect reported by DroneUA was obtained from the use of agricultural drones on an area of 2.2 million hectares, and the total area of Ukrainian land is much larger, the additional annual environmental effect should include a reduction in carbon emissions of up to 350 thousand tonnes, water savings of up to 4,500 thousand tonnes, and a reduction in fuel consumption of up to 120 million litres, which is a significant contribution to the national sustainable development programme (DroneUA, n.d.). The results obtained demonstrate that there is a significant economic effect from the use of agricultural drones in Ukrainian agriculture. The environmental effect

of the use of agricultural drones is also noticeable, which makes their introduction on a national scale attractive. The calculations of the effectiveness of the use of agricultural drones on a national scale are a precedent for their comparison with similar ones in the future.

Conclusions

The challenges in Ukrainian agriculture have deep political roots, which are manifested in the inefficient sectoral structure of the national economy, where the share of the primary sector, which includes agriculture, is more than three times the global average, which significantly hinders the country's further development. The sectoral structure of the national economy is a basic determinant of the country's GDP, which is why there is not a single country in the list of developed countries that has chosen agriculture as the mainstay. Given the strategic role of Ukrainian agricultural production in shaping domestic food and national security, as well as its role in the global food market, the agricultural sector needs to undergo fundamental changes through the implementation of a system of innovations (technical, technological, organisational, institutional, marketing) that can significantly improve the efficiency of agricultural management, ensure a change in the sectoral structure of the national economy in favour of high-tech processing industries, and create a new economy. In particular, the use of agricultural drones in farmland cultivation can be one of the most powerful innovative solutions that will not only increase yields but also bring an additional annual GDP income of up to 133 billion UAH. The social and environmental effects that will result from the use of this innovative technology will be significant: a reduction in carbon emissions of about 350,000 tonnes, water savings of 4.5 million tonnes and fuel savings of 120 million litres, creation of new high-paying jobs, development of social infrastructure in rural areas, increased income levels and a significant improvement in the socio-economic conditions of rural residents. Further research will be focused on analysing and assessing the economic efficiency of agricultural drones in horticulture and vegetable growing, as well as conducting a comparative analysis of their use in comparison with the use of ground-based agricultural machinery, including ground-based agricultural drones.

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Conflict of interest

The authors of this study declare no conflict of interest.

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Оцінка ефективності впровадження технічних інновацій в реалізації сучасної моделі аграрної сфери України

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► **Анотація.** Аграрна сфера України потребує кардинальних змін для підвищення ефективності, розвитку сільських територій та стійкості, що можливо завдяки впровадженню моделі інноваційного розвитку. Метою статті було здійснення оцінки ефективності впровадження у аграрному виробництві України одного з видів технічних інновацій – аграрних дронів. У процесі дослідження використано діалектичний метод наукового пізнання, аналізу й синтезу, системного узагальнення, порівняльного аналізу, метод рейтингування, а також математичний метод розрахунку «оптимізація рішення» засобами Excel. В дослідженні розглянуто сучасні підходи до оцінки ефективності окремих процесів, що допомогло сформувати власний алгоритм розрахунку ефективності обробки земельних угідь засобами аграрних дронів. На першому етапі дослідження встановлено технічні переваги аграрних дронів, що мають прояв у підвищенні продуктивності праці. За другим етапом дослідження було розрахований приріст по основним сільськогосподарським культурам (кукурудза, пшениця, соняшник, ячмінь, соя, ріпак, горох, гречка, просо), що може бути отриманий, як результат застосування аграрних дронів в масштабах України. Результатом третього етапу дослідження став показник економічної ефективності впровадження в аграрне виробництво аграрних дронів, а також прогноз розрахунків соціального та екологічного ефектів. Підкреслено, що державна підтримка українського виробництва аграрних дронів у різних формах (субсидії, пільгове кредитування, лізинг тощо) сприятиме розвитку інноваційної української промисловості, що позитивно вплине на зміну секторальної структури національної економіки та суттєво збільшить валовий внутрішній продукт країни. Висновки, пропозиції та практичні рекомендації можуть бути корисними у розробці відповідних програм та заходів, спрямованих на розвиток аграрної сфери України

► **Ключові слова:** ефективність; аграрна сфера; сільське господарство; інновації; аграрні дрони; продуктивність; секторальна структура

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Analysis of the agro-industrial sector of the Kyrgyz Republic

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▸ **Abstract.** In the light of global and regional crises, which have become increasingly frequent since the early 2020s, the issues of food security of individual states are particularly acute. For the Kyrgyz Republic, the task of ensuring its own independence from external food suppliers is also highly relevant. The purpose of this study was to conduct a comprehensive analysis of the agro-industrial sector in Kyrgyzstan. In the process of work, statistical analysis of data for 1990-2023 was carried out, as well as empirical research by remote written questionnaire survey of the target audience. As a result, the data on the growing dynamics of the gross product of the Kyrgyz Republic, the role of agrocomplex in the economy of the country were obtained, and the information on the increase in yields of key crops – raw cotton and melons – was confirmed. Separately, the foreign economic balance of the country was considered, which revealed a marked excess of imports to Kyrgyzstan over exports, which is an alarming signal. In the course of the survey conducted among the owners of small and medium-sized farms, information was obtained confirming the need to increase targeted support programmes and provide soft loans for the purchase of agricultural machinery and seeds. Also, as a result of the questionnaire survey, a management problem was identified, where the majority of owners prefer to manage their farms on their own, not trusting professional management. At the same time, almost all respondents confirmed their willingness to introduce additional processing lines in their farms, which would enable them to offer the market a higher-value product. The results of this study are important for the relevant ministries and agencies to ensure technological growth and efficiency of the agro-industrial complex of the Kyrgyz Republic

▸ **Keywords:** agriculture; farm management; yield; farming efficiency; concessional financing; state support

▸ Introduction

All over the world, agriculture is an important component of the economy and a guarantor of food sovereignty. A special role in it is played by the agro-industrial complex (AIC), which includes, in addition to the process of growing agricultural products, also the industries of processing raw materials, supplying means of production, and logistics infrastructure facilities. Agriculture also occupies a key position in the economy of the Kyrgyz Republic (KR), despite the significant part of mountainous and hilly territories that are not suitable for traditional farming. Kyrgyz scientists have repeatedly addressed in their studies the issue of increasing the efficiency of the national agro-industrial complex and analysing its actual indicators. In particular, A.A. Baimuratov *et al.* (2023) used a comprehensive methodology to assess the investment attractiveness of the agrarian sector of the Kyrgyz Republic, which proved the importance of state regulation. Among the priority areas of support from the state, the authors identified the financing of scientific and innovative developments, the development of public-private partnership mechanisms, as well as ensuring transparent tender procurement.

Sustainable development of the AIC of the KR in an integrated environment was the subject of the work by V. Kozhogulova *et al.* (2023). The analysis of trends in the development of agriculture in the conditions of Eurasian integration allowed identifying such structural features

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as the development of import substitution, factors of instability in logistics chains, and the formation of regional agro-clusters. The resource potential of sustainable agricultural development in the KR was also the subject of research by N. Parpieva *et al.* (2023). Having analysed the totality of land, material, technical and labour resources, the authors concluded that the volume and speed of resource reproduction in agriculture critically depend on the initial capitalization of the subject, its development strategy, as well as the general market conditions. The weak development of market infrastructure for agrarians and the lack of targeted government programmes were named among the challenges to the realization of this potential. When analysing the agriculture of Kyrgyzstan, researchers pay a special role to such a promising area as cotton growing. Natural and geographical features of the country allow developing this branch of the AIC to a strategic level. M.Zh. Abdiev *et al.* (2023), in their work, economically justified the importance of growing raw cotton in Kyrgyzstan and formed recommendations on the creation of appropriate infrastructure, as well as the creation of innovative inter-sectoral co-operatives that unite producers and processors.

K.D. Dzhumabayev *et al.* (2023) also wrote about the efficiency of agricultural cooperatives' investments, emphasizing the importance of involving the rural population of Kyrgyzstan in the regional economy of Central Asia. According to the new market approach proposed by the authors, the efficiency of agrarian cooperatives should be facilitated by the involvement of the State Fund of Agricultural Land, whose resource will be the basis for a phase jump in production. Such a step, according to the authors, will strengthen the competitive advantages of the KR in the conditions of regional integration. According to S.T. Umarov *et al.* (2022), another commodity group of agricultural products that deserves attention is plums. Using the example of cultivation and industrial processing of fruits of this crop, scientists managed to develop theoretical and methodological foundations of the economic growth platform, including the export of finished products from Kyrgyzstan to Germany. Despite the fact that the involvement of a high-margin foreign market implies a number of additional costs such as marketing activities, precise logistics and adaptation of the final product to local consumer characteristics, in the end, the authors' calculations proved that the implementation of such a project will be profitable.

As can be seen, the studies available at the moment cover certain aspects of the AIC of Kyrgyzstan. At the same time, a comprehensive analysis of the problems of management of the national agro-industrial production and development of ways to solve them is required. The purpose of this paper was to conduct an objective analysis of the agro-industrial sector of the Kyrgyz Republic and its management potential.

▸Materials and methods

In the course of this study, various aspects of the AIC in the KR were studied, both in historical perspective and in the context of further development of the sector. In particular, the impact of the COVID-19 pandemic and related quarantine restrictions on the activities of agricultural enterprises was assessed. The method of statistical economic analysis was applied to understand the dynamics of these processes. In the process of the study, the data in the period from 2018 to 2023 were also compared. At the same time, the key indicators of the development of the Kyrgyz AIC were gross production volumes of certain crops by regions and yield per hectare for wheat, melons, and raw cotton. The statistics on gross domestic product (GDP), available up to 2022 inclusive, provided by the GDP (current US$) – Kyrgyz Republic (n.d.), as well as the share of Kyrgyzstan's agriculture in GDP according to the open data of the Share of agriculture in GDP (n.d.), which are also available up to 2022 inclusive, were examined separately. For greater clarity of the dynamics of values, a number of indicators were displayed in the form of graphs in the context of years in a single coordinate system.

Based on the theoretical basis of a number of specialised publications, expert farmer opinions and other open sources, a holistic picture of the market of borrowed funds in agrarian business was formed, including participation in the financing of agribusiness by government programmes, as well as the peculiarities of Islamic lending, which is gaining popularity in the 2020s. Among the materials used in this study, in addition to those already mentioned, data from the Summary of the progress of harvesting crops by regions and districts of the KR as of 23 November 2023 (2023), Export-import operations of the KR in January-February 2024 (2024), Production of main types of livestock products in the KR as of 1 April 2024 (2024). Additionally, data from the Preferential loans to farmers are given in accordance with Islamic principles (2024), A horticulture development programme for 2024-2028 has been developed (2024), Brief express information on the main indicators of socio-economic development of the KR for January-August 2023 (based on preliminary data of the NSC) (2023) was utilised. Lastly, data from About Kyrgyz Republic. Key Industries. Agriculture (n.d.) were considered. In the process of work, structural analysis methods were also used to identify barriers and challenges faced by the agro-industrial sector of the KR – relatively small average land area, land reclamation problems, personnel issues with qualified management of agro-enterprises, weak cooperation between market participants, which complicates the creation of profile clusters.

As part of the empirical research, 250 Kyrgyz farmers who are owners of small and medium-sized businesses were questioned in writing by e-mail using the Computer Assisted Web Interviewing (CAWI) method. According to the Tax Code of the Kyrgyz Republic, these included organizations, and entrepreneurs whose total revenue for the previous year did not exceed 30 million soms. The questionnaire included 4 questions to which respondents were asked to answer using a ten-point system, where 1 is the lowest score and 10 is the highest. The questions had the following form.

1. How do you assess the current situation in the AIC of the Kyrgyz Republic?

2. Assess your farm's need for borrowed financial assistance.

3. To what extent is the management staffing problem solved at your company?

4. How ready are you to incorporate higher-value-added capacity into your production cycle?

In the process of processing the survey results, the method of calculating the average value was used – the scores for each of the questions were summed up and divided by the total number of responses received. In addition to feedback on the questions of interest, brief statistical information was also collected to understand the demographic profile of the respondent. Thus, based on the obtained data, using the extrapolation method, the conditions for further development of agro-industrial complex in Kyrgyzstan were forecasted and recommendations for relevant agencies were formed. All survey participants were informed about how their anonymity is ensured, the purpose of the survey, how their provided data will be used, and the associated risks. The study was conducted in accordance with the principles of The Declaration of Helsinki (1975).

Results

Challenges and opportunities for the development of agro-industrial complex of Kyrgyzstan. Since independence, the KR has been striving to improve its economic performance and the welfare of its population. In this context, the dynamics of the country's GDP growth, as well as the volume of agricultural products produced, both in absolute terms and in relative terms, are very indicative. Consequently, the first block of results analysed the state of the AIC on the basis of statistical data. The change in the size of gross domestic product over the previous decades can be observed in Figure 1.

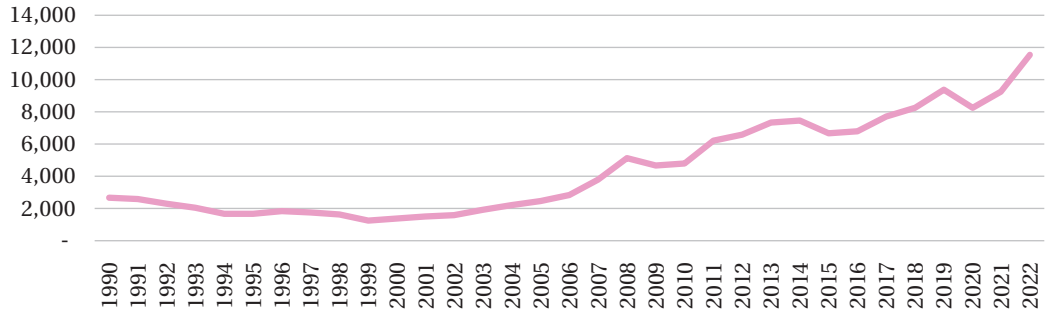

Figure 1. GDP volume of the Kyrgyz Republic by years, million USD
Source: compiled by the authors based on GDP (current US$) – Kyrgyz Republic (n.d.)

According to the chart above, despite a number of economic setbacks, Kyrgyzstan has managed to demonstrate a steady upward trend over the 30 years of independence. Among the stages of temporary decline, it is worth noting 1991-1999, when the economy of the young state was in the stage of formation and was directly dependent on external revenues; a small "setback" in 2008-2010, caused by the World Crisis, as well as a drop in the indicators of 2015-2016. The decline in Kyrgyzstan's GDP in 2020 due to the onset of the COVID-19 pandemic and the resulting quarantine restrictions deserves special attention. Globally, the regime of isolation of citizens and the transition to remote communications had a significant negative impact on the economy, but for the KR this effect was minimal and in the next year, 2021, the country managed to reach "pre-pandemic" financial indicators, and in 2022 to demonstrate growth of almost 25% more. Relative volumes of agricultural production in Kyrgyzstan in previous years are shown in Figure 2.

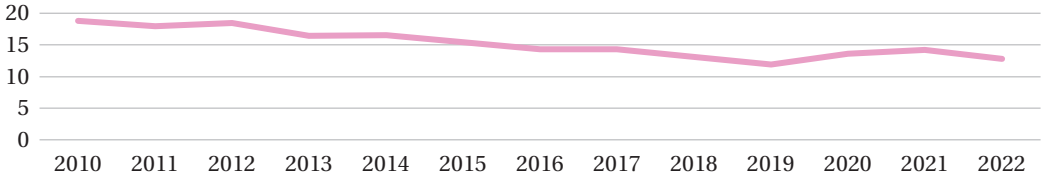

Figure 2. Share of agriculture in GDP of the Kyrgyz Republic, %
Source: compiled by the authors based on Share of agriculture in GDP (n.d.)

Despite the apparent decline in the indicators on the graph, it should be borne in mind that the above figures are relative indicators, i.e. per cent of the gross domestic product of the country. As can be seen from Figure 1, GDP indicators, especially in recent years, have a clearly pronounced positive trend, which means that the volume of AIC products is also growing. In Figure 2, it can be seen that since 2018, the share of agricultural products is in the region of 12%, which, provided that the economy as a whole is growing steadily, is a balanced indicator. For comparison, we can cite the figures of such recognised agrarian leaders as Ukraine (10-12%), Australia (12%), Greece (7%). In addition to general figures, for a detailed analysis of the AIC of Kyrgyzstan, it is necessary to study the indicators of development of individual crops that are important for agriculture in the country, and in the context of different regions. Wheat production volumes are shown in Figure 3.

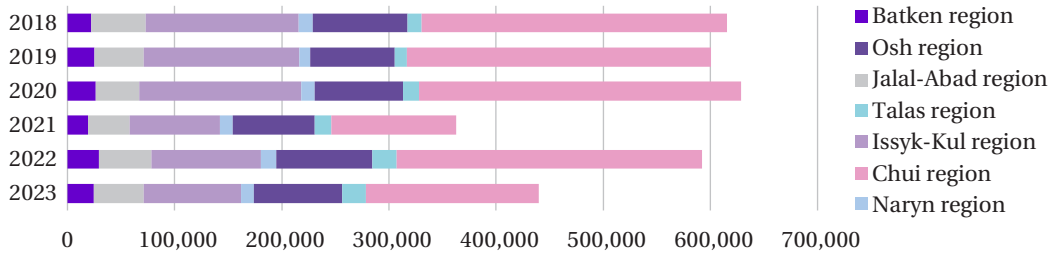

Figure 3. Volume of wheat production by regions of the Kyrgyz Republic by years, tonnes
Source: compiled by the authors based on the Summary of the progress of harvesting crops by regions and districts of the Kyrgyz Republic as of 23 November 2023 (2023)

According to official statistics, starting from 2018, there was a marked decrease in 2021 and 2023. This sample is not sufficient to form conclusions, but the situation is worrying and requires further monitoring. If such negative dynamics continue, government intervention will be required to restore the balance and maintain wheat production in the KR at the same level. At the same time, the dynamics of wheat production in Talas region should be separately noted – despite the general trend, the indicators of this region are growing from year to year. The specifics of raw cotton production are such that due to geographical and climatic reasons, only two regions of Kyrgyzstan can claim to be the leaders in production. Their volumes in the context of previous years are shown in Figure 4.

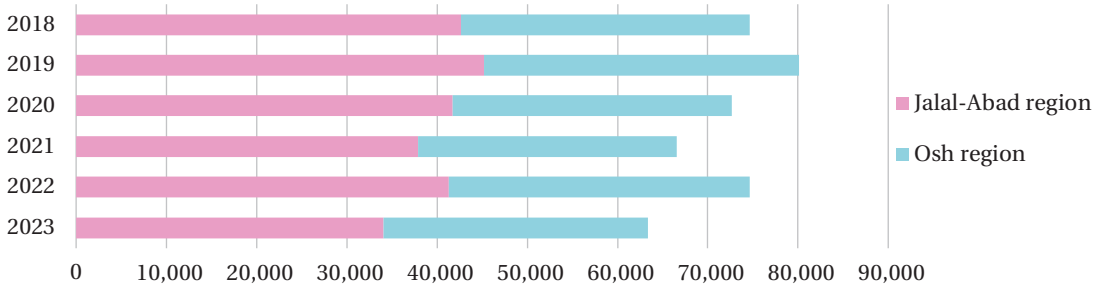

Figure 4. Raw cotton production by key regions of the Kyrgyz Republic by year, tonnes
Source: compiled by the authors based on the Summary of the progress of harvesting crops by regions and districts of the Kyrgyz Republic as of 23 November 2023 (2023)

As can be seen from the graph, Jalal-Abad and Osh regions maintain approximate parity in cotton production, but the overall non-systematic nature of production requires attention – the total amount changes dynamics almost every year, tending to a downward trend. The production volumes of the AIC of Kyrgyzstan in another strategic area, melon crops, are shown in Figure 5.

Melon crop production in Kyrgyzstan is a strategic area with characteristics of a unique trade offer in the macro-region. The existing statistics of the previous six years show a relatively stable trend without sharp spikes from jocks. At the same time, it is melons, due to the above reasons, that can become a kind of "locomotive" for promotion of Kyrgyz products to foreign markets. For a more detailed analysis of the reasons for the observed stagnation, it is necessary to separately examine the yields of key and strategically important for the KR agrarian crops. The dynamics of yields of wheat (in weight after processing), raw cotton (in net weight) and melon crops are shown in Figure 6.

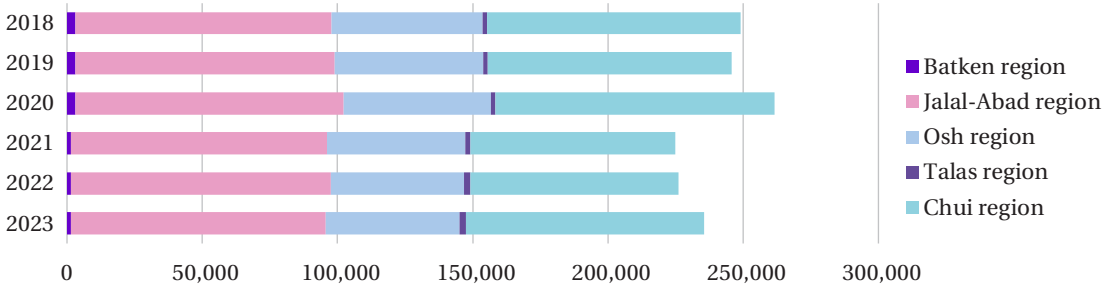

Figure 5. Volume of melon crop production by key regions of the Kyrgyz Republic by years, tonnes
Source: compiled by the authors based on the Summary of the progress of harvesting crops by regions and districts of the Kyrgyz Republic as of 23 November 2023 (2023)

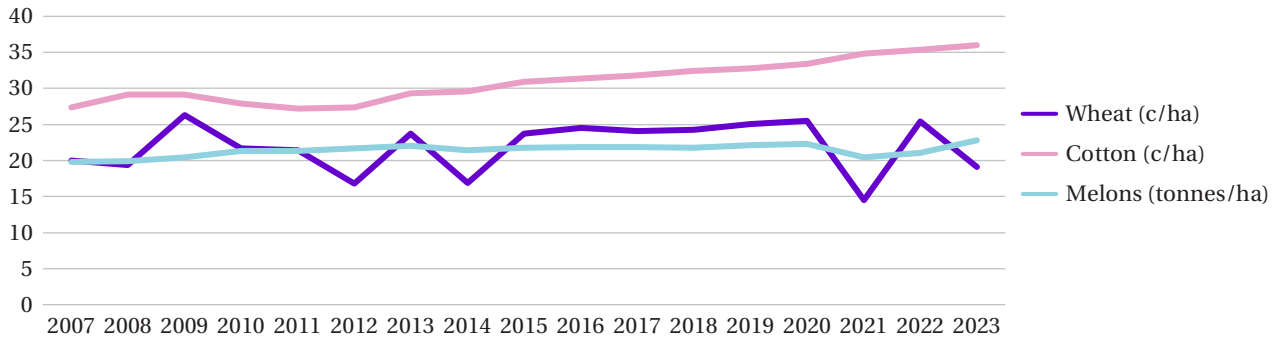

Figure 6. Dynamics of yields of key crops in the agro-industrial complex of the Kyrgyz Republic by years
Source: compiled by the authors based on Summary of the progress of harvesting crops by regions and districts of the Kyrgyz Republic as of 23 November 2023 (2023)

A clear positive trend in cotton and melon yields should be noted – this indicates that the decline in production of some items discussed above is not related to the intensity of farming. On the contrary, based on the results of the analysis, the solution to the problem of productivity of AIC lies in the plane of extensive growth, and it is necessary to take control of the issue of actual reduction of sown areas. Another crucial aspect of the agricultural economy is export-import operations. No country in the world can provide itself with a full range of agricultural products, and it is normal practice to purchase some assortment abroad. At the same time, it is important to maintain parity in sales of own products to foreign markets and purchase of necessary products abroad in order not to fall into food dependence on imports (Kryvenko, 2024). The dynamics of the total amount of purchases of agricultural products from external suppliers, as well as the volume of exports of own products, are shown in Figure 7.

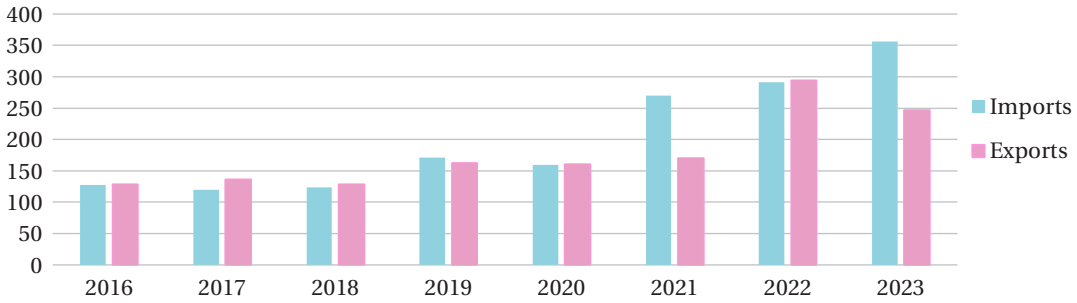

Figure 7. Dynamics of agro-imports and agro-exports to/from KR by years, million USD
Source: compiled by the authors based on the Export-import operations of the Kyrgyz Republic in January-February 2024 (2024)

Based on actual data, the current situation in the foreign economic direction of the Kyrgyz AIC is far from balanced. In 2023, exports did not even reach 70% of agricultural products purchased abroad, which puts the Republic in a certain dependence. Additional efforts should be made to increase exports and bring the ratio between imports and exports of agricultural products closer to the parity point. Access to "long money" – loans or other material assistance that does not need to be repaid in the short term – is of great importance for agricultural business. Unlike trading or brokerage services, which involve a quick turnover of money, working on the land requires planning and financing for many years ahead. This is why the government and international programmes currently operating in Kyrgyzstan are so important – some of them will be listed and analysed below.

The "Horticulture Development Programme" initiated by the A horticulture development programme for 2024-2028 has been developed (2024) encourages planting of fruit and berry trees from 2024 to 2028 and envisages the provision of preferential targeted loans to the population for almost 2 billion KGS, the establishment of 14 nurseries, 25 specialised cooperatives and 14 horticultural clusters. The authors of the project, among the goals and objectives of the programme, separately emphasise the importance of creating opportunities for export and increasing the competitiveness of Kyrgyz fruit in foreign markets. The traditional seasonal programme of preferential government loans for Kyrgyz farmers has started in 2024 (In the new season…, 2024). Under this project, state banks can provide up to 500 thousand soms at a reduced annual rate of 6 per cent to entrepreneur-agrarians with only one condition – that the funds are used in a specialised way.

"Agrofinance for value chains" is another €37 million programme funded by several EU structures (Supporting farmers in Kyrgyzstan…, 2023). An important difference from previous projects is the strict linkage of the programme to the financing of agrarian innovations, scientific developments, as well as the introduction of modern technologies in agriculture. These steps will make it possible to

switch the AIC of the KR from raw material specialization to the production of higher value-added agro-products more quickly. International programmes to support farming in the KR have different forms. For example, the Kyrgyz Republic: Remote household food security surveys (2023) helps Kyrgyz farmers grow wheat and then buys back their crops. A project called "Empowering Local Smallholder Farmers" selects small family businesses based on income level and number of children in the family, finances them, and then uses the purchased flour to provide food aid to those in need in the region.

Another project, but already initiated by the Farmer-to-Farmer (2023), is called "Farmer-to-Farmer" and is designed to improve the skills and technical equipment of Kyrgyz agrarians. Since the atomization of the educational base of the AIC in the KR often creates significant obstacles to obtaining quality crops, 118 experts from all over the world came to the country to transfer their experience and skills free of charge. In general, given the national and religious traditions of the Kyrgyz people, especially those living in rural areas, Islamic banking, which is gaining popularity, may be a solution to the issue of attracting external loans. According to official information from the Preferential loans to farmers are given in accordance with Islamic principles (2024), Aiyl Bank OJSC and RSK Bank provide preferential financing to private enterprises of crop production, livestock breeding and land reclamation in accordance with Islamic principles under the Murabaha deal. Farmers can take such a preferential loan for a period of two years and up to 500 thousand soms.

In addition to purely financial constraints, farms in the KR face a number of challenges. These include, firstly, the small size of land plots, problems with land irrigation and business management, as well as the lack of full-fledged communication between farms, which precludes the creation of not only technological agricultural clusters, but even simple co-operatives.

Analysis of the results of the survey of farmers in Kyrgyzstan. In the next, more practical part of the study, in order to thoroughly analyse the genesis of the current situation and to obtain an "inside" assessment, an electronic questionnaire was conducted among owners of small and medium-sized agribusinesses whose contacts were found in the public domain. A questionnaire containing four questions and an invitation to respond within 10 working days was sent to the e-mail accounts of 250 farmers. Each of the questions assumed a response format from 1 (lowest) to 10 (highest) points and publication of the answers on condition of anonymity. In terms of the generalised profile of respondents, with a total sample of 182, the gender ratio was 97% male (177) versus 3% female (5); average age was 48 years (range 28 to 65).

After the stipulated period, 193 completed questionnaires were returned, eleven of which were invalidated due to the presence of text formatting in some responses. The total qualitative response rate was 72.8%, which is quite low for a specialised f CAWI survey. The question "How do you assess the current situation in the AIC of Kyrgyzstan?" received a total number of 904 points. The average arithmetic assessment of this question by specialists was, thus, 904/182 = 4.97 points out of 10 possible. This is a low score, indicating serious problems in the industry from the point of view of ordinary market participants. For the task "Assess the need of your farm for borrowed financial assistance" the total number of points 1550 was obtained. This means that the arithmetic mean score is 1550/182 = 8.52 points out of 10 possible, which means that the demand of Kyrgyz farmers for external financial assistance for the development of agribusiness is still high. In response to the next question – "To what extent is the human resource management problem solved at your enterprise?" – respondents gave a total score of 1,314 points. The arithmetic mean score in this case was 1,314/182 = 7.2 points. This indicator turned out to be much higher than predicted and, as it was learnt as a result of clarifying analysis, was explained by the fact that the majority of small farmers prefer to manage their enterprise on their own, losing in quality, but gaining in wages for hired labour and efficiency of decision-making. Finally, the final question – "How ready are you to include higher-value-added facilities in your production cycle?" – a sum of 1,645 was obtained, i.e. an average of 9.04 points – the highest average score in the questionnaire. Such a high score indicates that farmers themselves understand the need to modernise production and switch from the supply of unprocessed agro-products and raw materials to goods of a higher level of processing, which implies higher earnings.

Thus, a comprehensive analysis of the current situation in the agricultural industry of Kyrgyzstan – both statistical and empirical – indicates such key trends: COVID-19 pandemic and the resulting quarantine restrictions in 2020-2021 did not have a significant impact on the industry; GDP of the KR is growing dynamically, the economic situation of the country as a whole is improving, the specific weight of the AIC in GDP is decreasing, but it is stable at the level of the leading agrarian powers; gross volume of actual production of key crops – wheat, cotton, melons – in previous years was in an unpredictable trend, but yields per hectare are steadily improving year by year; project support of agriculture in the form of targeted programmes, both by the KR authorities and international institutions, is at a high level, it is only necessary to control timely awareness of farmers about such initiatives. In addition, it should be noted that in the community of small and medium-sized farm owners there is a consensus on the need to increase the level of product processing to maximise profits, but smallest farm owners prefer to manage the business themselves, which is often less efficient and costlier in the long run than hiring a specialist. This stereotype needs to be corrected through a holistic communication strategy.

▸ Discussion

The agro-industrial sector in almost any state is not only a vast area for employment of the population, but also a guarantor of food security. That is why many scientific works all over the world are devoted to the study and analysis of this strategic industry, prospects, and programmes for its qualitative development. Some issues raised in this study are purely national in nature and imply the peculiarities of agricultural development in the Kyrgyz Republic, but most of the topics have significant parallels with international practice.

For example, the impact of the COVID-19 pandemic on AIC KR activities analysed above was found to be negligible, while in the work of G. Gruère & J. Brooks (2021), the authors identified the coronavirus as the cause of significant volatility in the industry. Among the key negative impacts of COVID-19 on agribusiness, labour shortages due to quarantine restrictions, changes in consumer demand for a number of technology crops such as biofuels, and disruptions in supply logistics, which affected demand for perishable agricultural products, were identified as key negative factors. Another group of authors, led by S. Arita *et al.* (2022), conducted an econometric assessment of the impact of the pandemic on the agribusiness sector and found that although trade in agro-products remained mostly stable during 2020-2021, the sector as a whole experienced notable fluctuation. For example, there was a redistribution of demand on the HoReCa side – whereas previously most restaurants and cafés prioritised a wide range of agricultural products, often exotic, COVID-19 restrictions forced them to narrow the list of services provided by the catering industry to courier delivery of ready meals, which significantly affected the range of fruits and vegetables ordered (Buka *et al.*, 2023).

Another important issue raised in this study concerns the financing of farmers through government programmes and private initiatives. Z. Yi *et al.* (2021) believed that concessional credit for agricultural production and supply from smallholder farmers with limited capital is particularly important in developing countries. In conformity with their research work, in addition to traditional bank financing, direct financing from creditworthy intermediary platforms also plays a major role. Moreover, it is with guarantee and direct financing that the production performance of small farm enterprises becomes higher. T. Havemann *et al.* (2022) also wrote about the importance of state support, examples of which were given in this paper in relation to the Kyrgyz situation. In their opinion, to achieve the global goals of sustainable development in agriculture, appropriate incentive programmes are also necessary. In general, it was proved that in order to achieve a significant level of investment in agriculture, it is necessary to attract all legal forms of support for farmers, including innovative ones (Shahini *et al.*, 2023).

C. Brown *et al.* (2021) wrote about subsidies to farming programmes from the European Union structures – the work of some of them in Kyrgyzstan was also discussed in the present article. The authors of the study of European motivational policy, after conducting several interviews, found that the determining factors for modern farmers are economic and structural factors, while environmental issues are of secondary importance to them. Thus, a number of support programmes need to be rapidly revised to take into account new motivational models. Farm management is also a rather complex and multidimensional issue (Yahelyuk *et al.*, 2023). According to the results of the survey conducted in the course of this work, the majority of small farm owners in Kyrgyzstan prefer to manage their farms themselves, but international experience casts doubt on this approach. For example, W. Sroka *et al.* (2023), studying various business models on the example of Poland, proved that the percentage of successful and profitable farms is significantly higher among those enterprises where hired professional managers are engaged in routine management, and owners participate only in solving strategic issues. As the authors proved, hired managers often have higher motivation and ability to establish personal relationships with customers.

It should be noted that there are also existing global trends that are not yet widely represented in the AIC of the Kyrgyz Republic. Such innovations include the "Internet of Food" described by N. Sundmaeker *et al.* (2016) and the integrated high-tech precision farming system studied by A. Monteiro *et al.* (2021). At the same time, while the term "Internet of Food", created by analogy with the Internet of Things (IoT) is promising to realise new levels of control and is able to form intelligent networks of connected agricultural objects, precision farming aims to conserve resources and manage the spatial and temporal variability of soils. Both high-tech initiatives need to be implemented in Kyrgyzstan – at least at the level of pilot projects. A lot of attention in the analysis was devoted to the export of agricultural products and the need to maintain a balance between imports and exports. V. Matkovski *et al.* (2022), who studied the export competitiveness of the agri-food sector, also focused on minimizing dependence on external suppliers. Using the example of the Western Balkan countries, where in previous years there was a marked intensification of trade in agro-industrial products, the authors promoted the idea of specialization of the national economy in a particular market segment. In the case of the Kyrgyz agricultural complex, as mentioned above, such a unique offer could be raw cotton and melons (Totubaeva *et al.*, 2023).

In addition to assortment decisions, it is important to consider possible logistical peculiarities when planning a long-term export policy. J.C. Beghin & H. Schweizer (2020) identified the most significant trade costs of agricultural products as the formation of transport consignments, renting regional warehouses in the country of discharge and maintaining the necessary storage regime. In turn, D.D.D. Fiankor *et al.* (2020) drew attention to another challenge to foreign trade in agricultural products – the inconsistency of different national standards, which include phytosanitary control requirements. As it was proved in the process of this study, one of the most important functions of the AIC is to ensure national food security. For Kyrgyzstan, with its arid climate, this thesis is especially relevant and farmers in the southern regions of the country literally fight for the harvest every year (Zheleuova *et al.*, 2020). As R. Mohtar (2021) noted in his work, that the neighbourhood of deserts forces national governments around the world to regularly make a difficult decision – whether to sell harvested agricultural products abroad or to use them as a buffer of food sovereignty.

A sound national food policy is also important for countries with more temperate climates – W.J. Deaton & A. Scholz (2022), using Canada as an example, examined the features of security programmes, wholesale price and duty statistics for key agro-industrial export categories, and developed an algorithm for calculating strategic reserves to maintain the country's food independence even in force majeure conditions. Similar calculations were observed in the study of M.F. Rabbi *et al.* (2021) who examined the relationship between food security and the transition

to the Sustainable Development Goals. After reviewing 25 indicators of food independence, the authors proposed a set of measures to facilitate their implementation in the national AIC and gave examples of practical implementation of such programmes in Central European countries.

Thus, most of the problems and challenges facing the AIC highlighted in the course of the analysis are not purely national or regional peculiarities. Globalization helps the responsible services of the KR to identify similar cases in the agriculture of other countries and adopt their positive experience. It is important, however, that such import of ideas and technologies takes place in a timely manner, legally and according to pre-planned algorithms.

Conclusions

In the process of detailed analysis of the AIC of the KR, the dynamics of its development were assessed, current trends in yields of strategically important crops were identified, and recommendations on future priorities of the industry were formed. In particular, such indicators as the country's GDP and the share of agriculture in the gross domestic product are on a positive trend, and the increasing yields of cotton and melon crops per hectare allow talking about the formation of these crops as a unique trade advantage for the national economy of the KR. At the same time, the study also revealed a number of challenges that require government intervention, such as problems with the financing of small farms and the unstable situation with the volume of harvested crops from year to year with a downward trend. Despite the presence in the country of a significant number of various state and cross-national programmes to support small farms, more activity is still needed in this area.

Speaking about specific indicators, it should be noted the growth of GDP of the KR in 2022 by almost 25%, the share of agrarian production in the region of 12% of GDP, the growth of cotton yields from 2013 to 2023 by 23%, as well as the imbalance of agrarian foreign economic activity of Kyrgyzstan in the amount of 30% in 2023. The results of the survey showed the following average score of answers to the questions: "How do you assess the current situation in the AIC of the Kyrgyz Republic?" – 4.97; "Assess the need of your farm for borrowed financial assistance" – 8.52; "To what extent is the human resource management problem solved at your enterprise?" – 7.2; "How ready are you to include in your production cycle the capacities of higher conversion?" – 9.04.

Thus, it can be stated that although the AIC of the KR is developing mainly in the right direction, the pace of this development lags behind the global level, which is especially noticeable in the example of innovation implementation. The use of international experience in the development of precision farming system deserves special attention and may become the subject of the next study.

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Conflict of interest

None.

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▸ **Анотація.** У світлі глобальних і регіональних криз, що проявляються з початку 2020-х років дедалі частіше, питання продуктової безпеки окремих держав постають особливо гостро. Для Киргизької Республіки завдання забезпечення власної незалежності від зовнішніх постачальників продовольства також є вкрай актуальним. Метою цього дослідження було провести всебічний аналіз агропромислової галузі Киргизстану. У процесі роботи було проведено статистичний аналіз даних за 1990-2023 роки, а також емпіричне дослідження методом дистанційного письмового анкетування цільової аудиторії. У результаті було отримано дані щодо зростаючої динаміки валового продукту Киргизької Республіки, ролі агрокомплексу в економіці країни, а також підтверджено інформацію про збільшення врожайності ключових сільськогосподарських культур – сирої бавовни та баштанних. Окремо було розглянуто зовнішньоекономічний баланс країни, в результаті якого виявлено помітну перевагу імпорту в Киргизстан над експортом, що є тривожним сигналом. У процесі проведеного серед власників малих і середніх фермерських господарств опитування, було отримано інформацію, що підтверджує необхідність збільшення адресних програм підтримки та надання пільгових кредитів для закупівлі сільгосптехніки та насіннєвого матеріалу. Також у результаті анкетування було визначено проблему управління, коли більшість власників надають перевагу самостійному управлінню господарством, не довіряючи професійному менеджменту. Водночас, майже всі респонденти підтвердили готовність упровадження у своїх господарствах додаткових технологічних ліній з переробки сировини, завдяки чому фермерства зможуть запропонувати ринку продукт більш високого переділу. Результати цього дослідження є важливими для профільних міністерств і відомств, покликаних забезпечити технологічне зростання та ефективність агропромислового комплексу Киргизької Республіки

▸ **Ключові слова:** сільське господарство; управління фермою; урожайність; ефективність землеробства; пільгове фінансування; державна підтримка

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Implementation of circular economy principles to promote the development of rural areas

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► **Abstract.** The relevance of the study lies in identifying and explaining the impact of implementing circular economy technologies on the development of rural areas within the framework of the state strategy for regional development in Ukraine, thereby contributing to ensuring the socio-economic stability of communities and the overall security of the country. The purpose of this study was to investigate the influence of utilising circular economy opportunities on the development of rural territories. The abstract-logical method was employed to substantiate the research methodology and formulate theoretical conclusions. The analytical and comparative methods was utilised to organise researchers' scientific approaches to theoretical aspects of circular economy development, refine the methodological basis, and substantiate the applicability of circular economy principles in rural development. The research utilised a graphical method to illustrate the findings and an abstract-logical approach to draw conclusions and recommendations. The study was divided into three main stages. The literature on the contemporary definition of "circular economy" was examined, and the driving forces and barriers to systemic circular economy in rural areas were analysed. The study investigated how European Union countries apply strategies to address environmental and economic issues through the lens of circular economy. The analysis of the experience in implementing circular economy practices in EU countries revealed a clear trend towards more sustainable resource utilisation and reduced environmental impact. The implementation of the "Farm to Fork" strategy under the European Green Deal is a crucial step towards ensuring sustainable resource use and implementing environmentally friendly practices in agriculture and the food industry. An assessment of the impact of implementing circular economy on the socio-economic development of rural areas was conducted, indicating that the development of circular models can be key to optimising resource utilisation, creating new employment opportunities, improving production efficiency, and increasing the profitability of agricultural enterprises. The implementation of circular methods in agriculture can reduce resource costs and provide more stable conditions for development. The results can be beneficial for government bodies, local administrations, agricultural enterprises, and cooperatives in Ukraine striving to achieve sustainable development of rural territories through the implementation of circular approaches in the economy

► **Keywords:** regional development; sustainable development; rural areas; regional growth; rural development

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▸ Introduction

Ensuring the sustainable development of humanity is one of the key challenges for the global community. The main goal is to meet all the needs of people – economic, social, and environmental – simultaneously, without causing harm to future generations. Many countries, including China, USA, European Union, India are taking measures to fulfill the Paris Agreement goals aimed at achieving sustainable development (Raiser *et al.*, 2020). The significance of the development concept has seen a considerable rise, particularly as humanity faces increasingly evident threats from significant environmental issues resulting from what is termed a "linear economy". This economic model relies primarily on the single-use consumption of resources, without the ability for their subsequent recycling or reuse.

One of the pressing environmental issues in Ukraine, according to L. Pronko (2022), is waste management, the volume of which is constantly increasing due to urban development, the growth of the service sector, and other factors. Society violates one of the basic principles of ecology – the closed material cycle in nature, by introducing secondary materials into the natural environment.

According to I. Honcharuk & V. Vovk (2020), Ukraine faces a serious problem in waste management, characterised by its large scale and significance. This is explained by both the prevalence in the national economy of technologies requiring large amounts of resources and generating high levels of waste, and the lack of an adequate response to this problem over an extended period. Uncontrolled accumulation of waste poses a threat to Ukraine's national security, environment, and public health. Agriculture generates a significant amount of waste, which could serve as raw material for biofuel production from various plant and animal sources. However, despite its value, such waste remains unused due to the lack of plans for their conversion into biofuels and their use to improve soil fertility. This underscores the need for effective waste management in agriculture (Soil and its regeneration…, n.d.).

In a situation of energy resource scarcity and exacerbated environmental problems, finding an ecologically safe way to handle them, including conversion into biogas, is an urgent and important task. According to data from 2020, the volume of waste from agricultural enterprises, processing enterprises of agriculture, and households exceeds 15 million tonnes. A significant portion of this raw material can be used for biogas production, underscoring the relevance of this issue (Mazur & Gontaruk, 2022).

The agricultural sector suffers the most from climate change and contributes to it through its own actions. The agro-industrial complex is a significant source of greenhouse gas emissions due to the use of fossil fuels, burning of plant residues, and failure to comply with waste disposal regulations. I. Honcharuk (2020) explores solutions to these problems by implementing environmentally friendly production and use of biofuels in agricultural enterprises, which will reduce CO_2 emissions, increase profitability and soil fertility, and ensure energy independence for the industry (Michelle *et al.*, 2021).

Due to a significant reduction in gas imports and a sharp increase in energy prices, utilising the biomass potential for biomethane production has become an urgent task to ensure the country's energy security. According to V. Bondarenko *et al.* (2023), sugar factories can serve as a basis for the rapid implementation of relevant production. Biomethane, which is a natural gas equivalent, can be used for heating, electricity generation, transportation fuel, and in the chemical industry, thereby aligning with the principles of the circular economy by converting agricultural by-products and household waste into sources of energy and fertilisers for agricultural lands. Such a transition could be a key factor in ensuring the country's energy security in the medium term.

According to N. Kuenzer (2021), for a smooth transition to a local economy that efficiently utilises resources and has development potential, a closed-loop economy serves as a key element of sustainable regional development. The interaction of the closed-loop economy in urban environments is already attracting the attention of many scientific studies. Therefore, it is important to consider how the implementation of closed-loop technologies can impact the development of territorial communities.

There is increasing attention to environmental conservation and ecosystem preservation. In this context, the closed-loop economy emerges as a new economic paradigm designed to effectively replace traditional linear growth models. Researchers (Ingrassia *et al.*, 2023) are convinced that agricultural production and tourism, in particular, can significantly contribute to achieving sustainable development goals through economic circularity. In the current context, ensuring the sustainable and effective utilisation of resources presents a pressing challenge, prompting shifts in production, consumption, and lifestyle patterns (Gómez & Martinez, 2023). According to E. Stamevska *et al.* (2020) circular economy aims to ensure that products, components and materials always have the highest utility and value. According to N. Kuenzer (2021), the economy of a closed cycle should be based on innovative potential and diversification.

The growing human impact on the natural environment, resulting from rapid and inefficient use of natural resources, leads to the disruption of ecological balance and exacerbates the global issue of climate change. The purpose of the study was to investigate and analyse the current environmental problems in Ukraine, particularly waste management and the impact of the agricultural sector on climate change. The research was focused on applying the principles of the circular economy to ensure sustainable development of rural areas.

▸Materials and methods

The research methodology was established using the abstract-logical method to support the study's framework and formulate theoretical conclusions. The analytical and comparative methods were employed to systematise the scientific approaches to the theoretical aspects of circular economy development, thereby enhancing the methodological foundation for advocating the application of circular economy principles in rural areas. These methods also helped identify potential barriers and challenges that may hinder the implementation of circular economy. Additionally, the graphical method was utilised to visualise the research results.

To analyse the dynamics of material circularity in EU countries, methods of data systematisation and statistical analysis were employed, and relevant data were collected from the Eurostat website (Database, n.d.). This indicator, which measures the proportion of materials that are recycled and reintroduced into the economy, was analysed using the abstract-logical method to support the theoretical framework of the study and formulate theoretical conclusions.

For the investigation of the European Investment Bank's (EIB) role in the development of the circular economy and support for projects addressing major environmental issues, a detailed analysis of the EIB's activities in the context of circular economy support and environmental problem-solving was conducted. This analysis helped identify key aspects of the bank's role in these processes and delineate the main directions of its activities. An examination of the financial instruments and consultations provided by the EIB to project initiators was carried out to ascertain how the bank contributes to the transition to a circular economy and the achievement of sustainable development goals. These methods facilitated an analysis of the EIB's role in circular economy development and identified the main directions of its activities in this field. Additionally, they helped identify examples of projects and initiatives supported by the EIB to build a more sustainable economy.

The research can be seen as a long process divided into three main stages. In the first stage, a literature review of L. Pronko (2022), V. Bondarenko *et al.* (2023), The Circularity Gap Report (2023) was conducted on the current definition of circular economy and its drivers and barriers were analysed. In addition, the spatial factors that were key to the creation of a systemic circular economy in rural areas were identified. During the second stage of the research, the focus was on analysing how European Union countries applied strategies to address environmental and economic issues through the lens of the circular economy. The experience of EU countries in implementing the circular economy was examined (Database, n.d.), showing a trend towards more sustainable resource use and reduced environmental impact. The third stage involved assessing the impact of implementing the circular economy on the socio-economic development of rural areas, which included a statistical evaluation of the socio-economic development of rural areas in Ukraine based on data from the State Statistics Service of Ukraine (Official web-site of the…, n.d.) and developing recommendations to enhance the positive impact of the circular economy on rural development.

▸ Results and Discussion

Definition of circular economy: key factors and spatial aspects in the context of rural areas. It is entirely true that there is a growing interest among researchers and experts from various fields in the concept of the circular economy in recent times. However, research focused on rural areas remains relatively limited compared to urban regions. The participants of the Systemic circular economy holds great potential for rural areas (2023) project understand not only waste management, but also systemic thinking from product development to use and recycling.

In general, the concept of a closed-loop economy is most effectively implemented on large scales. However, the implementation of this concept is also possible in individual regions or even within a single company (Abbaszade, 2021). F.-C. Mihai *et al.* (2022) highlight significant deficiencies in knowledge regarding waste management in rural areas. According to the researchers, rural communities become accomplices in plastic pollution due to issues with household waste disposal and illegal dumpsites (Cutting plastics pollution…, 2023).

Managing solid waste and its impact on the environment, health, well-being, and resources is becoming increasingly challenging in remote areas. These challenges primarily stem from inadequate infrastructure, limited land availability, high waste collection costs, and low levels of environmental awareness. A study conducted by H. Salim *et al.* (2023) investigated the factors influencing sustainable solid waste management practices. The study conducted by M. Geissdoerfer *et al.* (2018) explored the feasibility of implementing circular business models and circular supply chains as key components for realising the principles of sustainable development.

M. Briguglio *et al.* (2021) argue that the circular economy is largely dependent on institutional and regulatory factors. It is worth agreeing with the researchers' opinion that public policy can create a favourable environment for innovation and entrepreneurship. The researchers suggest that government bodies can implement various instruments and programmes aimed at stimulating the development of the circular economy, providing financial support, and incentives for enterprises adopting circular practices. The state can regulate the market to promote circular practices by establishing standards for environmentally friendly production and resource use, and implementing tax incentives for companies operating in the circular sector. Government procurement can be directed to support circular producers and suppliers by creating demand for circular goods and services, thereby stimulating the market and increasing its volume.

Numerous researchers from Ukraine have explored the concept of the circular economy and the advantages of adopting it, drawing from the expertise of the European Union, which is globally recognised as a pioneer in this field. In particular, N. Horbal & Y. Lomaha (2022) analysed the implementation of circular economy principles and give examples of successful application of its business models. They identified the most pressing global problems that can be solved only by the circular economy. The study conducted by M. Ruda & Ya. Myrka (2020) examined findings regarding the circular economy and its advantages when applied in Ukraine, drawing insights from the European Union's practices. The researchers outlined the recommendations, which can be considered by the governments of the country, taking into account the critical environmental situation in the world. The possibilities of creating and developing circular business models in Ukraine, using the best European practices in the field of waste management, are also substantiated.

Starting a business in rural areas is a way to promote sustainable development and responsible use of shared resources, such a business is oriented towards a circular economy model in which the concept of waste is eliminated, reuse is included and supply chains are reduced (Stamevska *et al.*, 2020). By its very nature, the circular

economy promotes interaction between different stakeholders and industries to achieve maximum potential. This requires joint, coordinated efforts at different levels of government, starting from local and regional to national and European levels.

As noted by researchers (Ekins *et al.*, 2019), circular economy practices are already being implemented at the enterprise level. However, it is evident that these practices have not yet become widespread. From this, it can be concluded that there are factors that contribute to the implementation of the circular economy and, in certain circumstances, to its development, but there are also barriers that prevent its more widespread application. Studying both the driving factors and barriers for the circular economy provides a valuable foundation for developing interventions to enhance the approach's effectiveness, overcome obstacles, and bolster driving forces.

When analysing the drivers and barriers of the circular economy, it is important to distinguish between internal and external barriers. The external environment allows businesses to adapt to changes and identify new development opportunities. Internal barriers are often associated with factors such as insufficient staff qualifications, inadequate financial resources, or lack of leadership skills within the team. On the other hand, external barriers may include economic, social, political, technological, and environmental trends. It is important to understand that not all external factors are obstacles; some of them can act as motivators for businesses, offering new opportunities or prompting changes. In summary, distinguishing between internal and external barriers helps businesses better understand their environment, identify key factors affecting their operations, and develop strategies for success in their surroundings (Fig. 1).

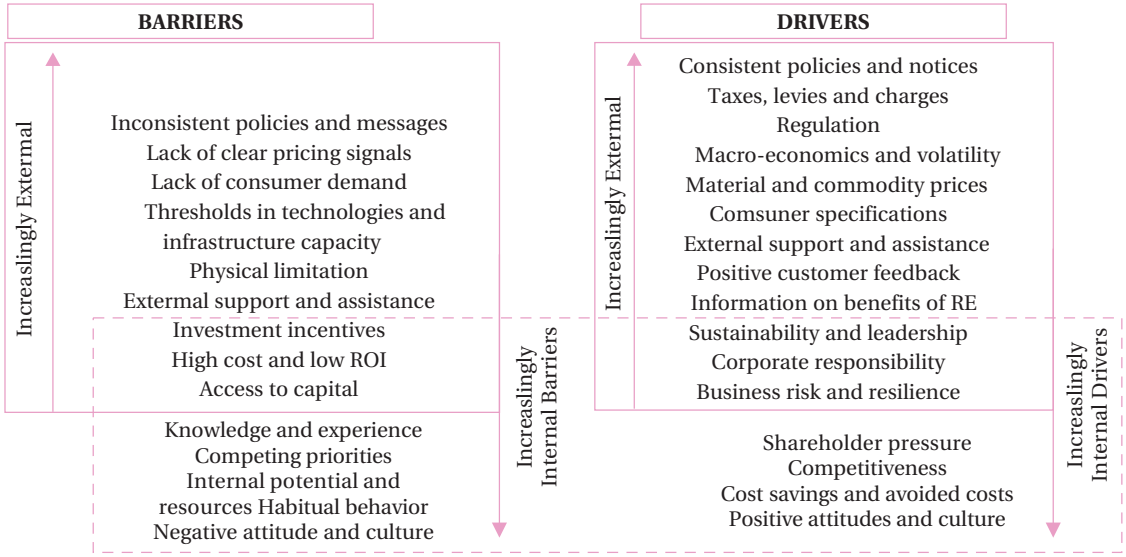

Figure 1. Barriers and drivers of circular economy development
Source: developed by the authors based on P. Ekins *et al.* (2019)

Moreover, findings from the OECD (Fig. 2) survey underscore common obstacles to this transition, including cultural, regulatory, and financial challenges. Additionally, addressing issues related to information, awareness, engagement, political will, and having a coherent vision are essential for overcoming these barriers and promoting a more circular economy. Overall, concerted efforts from companies, governments, and society are needed to implement the transition to a more sustainable and circular economic model.

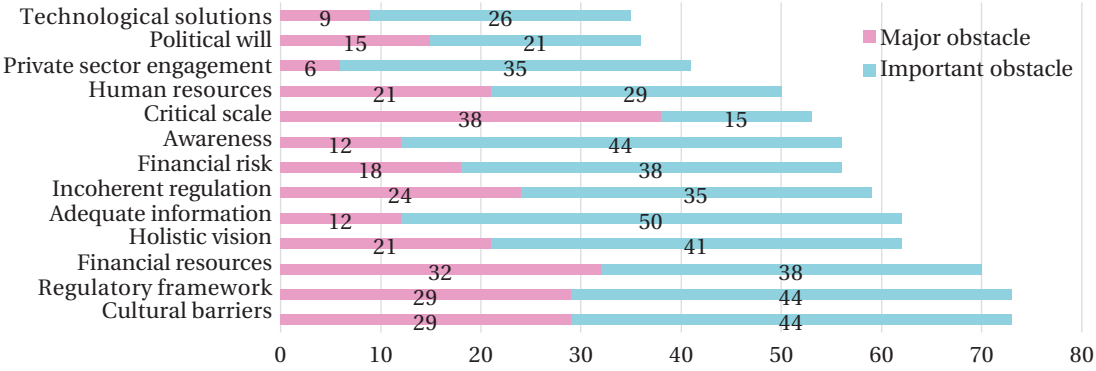

Figure 2. Obstacles to transitioning to a circular economy for cities and regions
Notes: defined in %
Source: developed by the authors based on The circular economy in cities and regions (2019)

Hence, obstacles and drivers for any participant or organisation may be categorised as either internal, pertaining to internal operations and choices, or external, associated with external circumstances that they have limited direct influence over, according to the OECD survey (2019). There are important synergies between different categories of barriers/drivers, between internal and external differences, and between perspectives at the firm, individual, and government levels.

Analysis of the experience of the EU countries in implementing the circular economy in the agro-industrial complex. Shifting towards a circular economy offers advantages for enterprises. Through reassessing business models, production methods, and product design, companies embracing circularity can notably diminish expenses associated with materials, energy, and waste management. Consequently, this can result in heightened profitability and a strengthened competitive edge. This approach is reflected in the new Circular Economy Action Plan adopted by the European Union, which is a key element of the European Green Deal and a new strategic direction for Europe's sustainable development, New circular economy action plan for the European Union (n.d.). The sustainability principles identified in the plan include improving durability, reusability, renewability and maintainability, addressing the presence of hazardous chemicals in products and increasing the content of recycled products. These new rules and initiatives have been developed with the participation of businesses and stakeholders and will be implemented by the European Commission to support sustainable development.

Analysing the experience of EU countries in applying the circular economy reflects a trend towards more sustainable resource use and reduced environmental impact (Table 1). However, it is important to consider that the effectiveness of the circular economy may vary depending on the context and conditions of each country. Therefore, national specificities and opportunities need to be considered for successful implementation of these strategies.

Table 1. Dynamics circular material use rate of the EU countries

Countries	2018	2019	2020	2021	2022
Belgium	20.8	20.7	23.0	23.7	22.2
Bulgaria	2.5	4.1	5.9	4.8	4.8
Czechia	10.4	10.5	11.5	11.4	11.9
Denmark	8.0	7.6	7.6	8.0	7.4
Germany	12.1	12.5	12.9	12.7	13.0
Estonia	13.9	15.4	16.5	15.9	16.0
Ireland	1.7	1.6	1.7	1.9	1.8
Greece	3.0	3.4	4.2	3.5	3.1
Spain	8.9	9.0	9.2	6.9	7.1
France	19.5	18.1	18.7	18.7	19.3
Croatia	5.0	5.3	5.5	5.7	5.8
Italy	18.8	18.8	20.6	19.0	18.7
Latvia	4.7	4.7	5.2	5.6	5.4
Austria	11.9	11.6	11.5	12.8	13.8
Poland	10.5	9.2	7.3	9.1	8.4
Portugal	2.2	2.3	2.5	2.6	2.6
Romania	1.6	1.4	1.5	1.4	1.4
Slovenia	10.0	10.2	9.9	10.1	9.4
Slovakia	4.9	8.4	10.4	8.2	9.1
Finland	4.4	4.5	4.4	1.6	0.6
Sweden	6.6	6.4	6.9	6.2	6.1

Source: developed by Database (n.d.)

Analysing the dynamics of material usage in European Union countries reveals several important trends. Firstly, there is significant diversity in circularity levels among different countries. Netherlands and Ireland, for example, demonstrate high levels of circular material usage throughout the study period, indicating efficient utilisation of secondary materials. Secondly, there are certain trends in the change of circularity levels over time within each individual country. For instance, Bulgaria and Romania may observe an increase in circularity over the study period, while others like Spain may experience fluctuations in this dynamic. Overall, the analysis of this data underscores the importance of developing the circular economy as an effective tool for reducing environmental impact and ensuring sustainable resource utilisation. Half of EU cropland relies on pollinators, but these populations are declining. Droughts inflict EUR 9 billion in yearly damages across agriculture, energy, and water. Overuse of antibiotics in healthcare fuels a crisis, causing an estimated 33.000 deaths in Europe each year. Rising temperatures are projected to decrease major crop yields by 3-10% per degree Celsius (Database, n.d.).

The EU's Green Deal, aiming for a climate-neutral Europe by 2050, includes the Farm to Fork strategy (Farm to Fork strategy, n.d.). This strategy seeks to make EU food production more sustainable. The goal is a resilient system with a positive environmental impact, combating climate change and biodiversity loss. It should also ensure food security, good nutrition, and fair economic practices for all.

Agriculture, food processing, and fisheries generated over 55 million tonnes of waste in the EU in 2020, representing nearly 3% of all industrial waste. Food waste is a significant concern, with an average person in the EU discarding 131 kg of food in 2021 (Key figures on the European food chain 2023 edition, 2023). Households are the biggest culprit, contributing over half of this waste. Food processing generates the most food waste within the industry, though households remain the primary source in most EU countries. Notably, some countries like Belgium and the Netherlands see higher food waste from processing than households. The EU is implementing policies to encourage a circular economy, where resources are reused and recycled. This approach aims to reduce environmental impact and promote sustainable development. Data shows a variation in circularity levels among EU countries, highlighting the need for tailored strategies.

Assessment of the impact of the implementation of the circular economy on the socio-economic development of rural areas. Ukraine is one of the largest agricultural countries in the world, and a large amount of biological waste in the form of plant and animal residues can be used for the production of biofuels, organic fertilisers, biogas, and other products that can be used in agriculture or processed into higher value goods. Plant and animal waste can be processed into biofuel, which can be used for energy purposes or as alternative fuel for transportation. Biogas obtained from the processing of organic waste can serve as a source of energy for electricity generation or heating. In agriculture, transitioning to the principles of a circular economy involves adopting a "zero waste" system, where all produced products are either used as end products or as raw materials for other production. This helps address the problem of natural resource scarcity and reduces dependence on imported materials, especially amid constraints in international trade. Implementing circular practices can foster the development of new technologies aimed at sustainable production, which, in turn, can contribute to economic growth in the agricultural sector. The use of soil restoration technologies, such as composting and green manure, allows increasing soil fertility and reducing the use of chemical fertilisers. For example, through composting, organic waste can be transformed into nutrient-rich compost, which can then be used for irrigation of crops or added to the soil to enhance its fertility. The use of water-saving technologies and the restoration of water resources enable optimisation of water use in agriculture, while the creation of closed-loop systems for processing and utilising products, allows minimising losses and optimising resource utilisation. The socio-economic development of rural areas is based on the advanced development of the agricultural sector in a specific region and aims to address the social, environmental, and demographic needs of the local population (Table 2).

Table 2. Employment and average monthly wages in agriculture in Ukraine

Indicators	2019	2020	2021	2022	2023
Employed in agriculture, thousand persons	407.1	408.0	376.5	360.4	369.4
Average monthly wage across all sectors of the economy, UAH	9,308.05	10,889.92	11,969.90	17,319.36	14,577.39
In agriculture, UAH	7,764.67	8,090.19	9,392.56	10,918.97	11,898.75

Source: developed by Official web-site of the State Statistics Service of Ukraine (n.d.)

In 2023, 369.4 thousand people were employed in agriculture in Ukraine, constituting 51.2% of the total employed population. However, the number of workers directly employed in agricultural enterprises decreased by 37.7 thousand compared to 2019 (Official web-site of the..., n.d.). This trend negatively impacts the socio-economic status of rural residents, potentially leading to increased unemployment, income reduction, and economic challenges in rural communities. Low wages compared to other economic sectors, lack of stable employment, absence of professional growth opportunities, and deterioration of social infrastructure in rural areas diminish the desire of young people to work in agricultural production, prompting migration of the workforce from rural areas in search of alternative, better-paying jobs in regions with higher living standards. This adversely affects the reproduction of human and labour potential in rural settlements and exacerbates the problem of demographic decline in rural populations.

The development of circular models in agriculture can optimise resource utilisation and create new employment opportunities. For instance, the development of waste processing industry may require the establishment of new plants or recycling enterprises, employing local residents. Additionally, the production of secondary raw materials may open up new markets for selling products and services, which also demands additional personnel. Thus, the advancement of circular models in agriculture can serve as a powerful catalyst for increasing employment and improving the living standards of local populations.

The implementation of circular methods in agriculture can significantly reduce resource costs, such as water, fertilisers, and energy. Reduction in expenses enhances production efficiency and increases the profitability of agricultural enterprises. Moreover, the adoption of circular methods can help agricultural farms become more resilient to fluctuations in resource and energy prices, ensuring more stable conditions for development and growth. As a result of these measures, agricultural enterprises can achieve higher income levels, enabling them to invest in further development and modernisation of farms, and increase payments to their employees, contributing to economic growth and raising the living standards of the local population. Most initiatives aimed at implementing circular business models require significant investments, while small and medium-sized agricultural enterprises continue to operate in conditions of uncertainty compounded by environmental constraints and social challenges.

Conclusions

During the study, the main challenges facing rural areas in the context of sustainable development were identified. Modern global challenges such as population growth, resource depletion, and climate change require the implementation of a new approach to economic management - circular economy, especially due to its closed-loop model.

The analysis of the experience in implementing circular economy practices in EU countries has revealed a clear trend towards more sustainable resource utilisation and reduced environmental impact. The implementation of the "Farm to Fork" strategy under the European Green Deal is a crucial step towards ensuring sustainable resource use and implementing environmentally friendly practices in agriculture and the food industry. This strategy aims to ensure food security, preserve the environment, and support economic profitability, highlighting the importance of adopting circular practices for the sustainable development of rural and urban areas.

In 2023, agriculture in Ukraine accounted for 51.2% of the total employed population, but the number of workers in agricultural enterprises decreased by 37.7 thousand people compared to 2019, leading to socio-economic challenges in rural communities. The development of circular models can be key to optimising resource utilisation and creating new employment opportunities, and improving production efficiency and increasing the profitability of agricultural enterprises. The implementation of circular methods in agriculture can reduce resource costs and provide more stable conditions for development.

In the future, it is worth analysing the impact of other types of concepts of sustainable development, provided that they are implemented in the development of the region, and to compare them with the concept of cyclical economy. This study will provide valuable insights into sustainable development principles, aid other authors in their research endeavours, and contribute to the analysis of the socio-economic conditions in various regions of Ukraine, among other potential applications.

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Conflict of interest

None.

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Впровадження принципів циркулярної економіки для сприяння розвитку сільських територій

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► **Анотація.** Актуальність дослідження полягає у виявленні та розкритті впливу впровадження технологій циркулярної економіки на розвиток сільських територій в контексті державної стратегії регіонального розвитку в Україні, сприяючи забезпеченню соціально-економічної стабільності громад та загальної безпеки країни. Метою даного дослідження було вивчення впливу використання можливостей циркулярної економіки на розвиток сільських територій. Для обґрунтування методології дослідження та формування теоретичних висновків використано абстрактно-логічний метод. Аналітичний та порівняльний методи використано для впорядкування наукових підходів науковців до теоретичних аспектів розвитку циркулярної економіки, удосконалення методологічної бази та обґрунтування застосовності принципів циркулярної економіки у розвитку сільських територій. Для ілюстрації результатів дослідження використовувався графічний метод, а для отримання висновків і рекомендацій – абстрактно-логічний. Дослідження було розділено на три основні етапи. В статті вивчалася література щодо сучасного визначення поняття «циркулярна економіка» та аналізувались рушійні сили та бар'єри для системної циркулярної економіки в сільських місцевостях. Проаналізовано, як країни Європейського Союзу застосовують стратегії для вирішення екологічних та економічних проблем через призму кругової економіки. Аналіз досвіду впровадження практик кругової економіки в країнах ЄС показав чітку тенденцію до більш стійкого використання ресурсів та зменшення негативного впливу на довкілля. Реалізація стратегії «Від ферми до виделки» в рамках Європейського зеленого плану є ключовим кроком у забезпеченні сталого використання ресурсів та впровадженні екологічно чистих практик у сільському господарстві та харчовій промисловості. Проведена оцінка впливу впровадження кругової економіки на соціально-економічний розвиток сільських територій та визначено, що розвиток кругових моделей може бути ключовим для оптимізації використання ресурсів та створення нових можливостей для зайнятості, а також покращення ефективності виробництва та збільшення прибутковості сільськогосподарських підприємств. Впровадження кругових методів у сільському господарстві може зменшити витрати на ресурси та забезпечити більш стабільні умови для розвитку. Результати дослідження можуть бути корисними для державних органів, місцевих адміністрацій, аграрних підприємств та кооперативів в Україні, що прагнуть досягти сталого розвитку сільських територій за допомогою впровадження циркулярних підходів в економіку

► **Ключові слова:** регіональний розвиток; сталий розвиток; сільська місцевість; розвиток регіонів; сільський розвиток

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Organisational and economic support for the development of business enterprises in agriculture under martial law

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▸ **Abstract.** Entrepreneurs in agriculture ensure the potential of the country's food security and environmental protection. The study aims to substantiate the social, economic and conceptual foundations of the activities of business entities in agriculture under martial law. The research methodology is based on the provisions of system-functional analysis and institutional economic theory. Graphical, and abstract methods of systematisation of results were used. The study found that in 2023, more than 50 thousand business entities (92% of them were farms) produced products. 1.6 thousand agricultural businesses received loans worth 60.1 billion UAH. The author substantiates the need to keep the preferential financing of agricultural entrepreneurs under the "Affordable Loans 5-7-9%" programme as "survival loans" with the expansion of the limits to 130-140 million UAH and a reduction of the interest rate to 5%. The study determined that small business and family farming are the primary guarantors of employment. It is proved that in the period 2017-2022, 84.64% of the variation in net profit is explained by the variation in the level of agricultural products sold by business entities. The article substantiates the expediency of applying the organisational and economic principles of business development in wartime, developing comprehensive indicators for assessing the state of development of business structures in the agricultural sector of the economy and the impact of entrepreneurship on the development of rural areas. The indicators of development and efficiency of agricultural enterprises are characterised. The information and analytical material can be considered when developing regional programmes for the development of agrarian entrepreneurship

▸ **Keywords:** business entity; agrarian enterprises; development indicators; performance indicators; performance efficiency; functioning strategy; logistics; adaptation to martial law conditions

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▸ Introduction

In Ukraine, the functioning of business entities is associated with the risks of the military factor, which has radically changed the characteristics of the institutional environment. The development of agrarian enterprises in wartime is regulated by the state's establishment of special rules of economic interaction in the market. These rules determine performance indicators, motivation for cooperation, principles of gaining competitiveness, opportunities for realisation of the institutional potential of business forms, strategic priorities for entrepreneurship development and other factors of organisational and economic development of agrarian business entities. Under martial law, entrepreneurial activity takes place in modified institutional conditions, which relates to the establishment by the state of special rules for organising business. These rules affect the behaviour of entrepreneurs, but the principles and purpose of entrepreneurial activity remain the same – "risk and profit". In this context, it is worth considering the problems of the functioning of business entities in agriculture, regardless of their organisational and legal form, size, and potential. The need for state support for the further development of entrepreneurial activity is becoming more urgent.

M. Nehrey & O. Trofimtseva (2022) analysed the functioning of Ukrainian agriculture in wartime. The study determined that the decline in the purchasing power of the population; disruption of logistics chains; theft of equipment and products; occupation of territories; lack of resources for production; reduction of the domestic market and labour problems are the main problems for agricultural businesses during the war. Human capital is a determining factor in the development of entrepreneurship. N. Sirenko & K. Mikuliak (2022), during their research using PESTEL-analysis, found that the "shadowing" of the economy, unstable exchange rates and difficulty in entering the market are threats to the socio-economic security of business entities in agriculture. V. Kyfyak *et al.* (2022) substantiated the impact of extreme operating conditions on the development of business entities. The lack of sources of financing is one of the significant problems of business functioning. Cooperative and integration relations help business entities to survive. A. Panteleimonenko *et al.* (2022) focused on the factors that determine the need for entrepreneurs to participate in agricultural service cooperatives. The lack of information about profitable suppliers and the lack of funds and access to credit resources intensify the need for business entities to cooperate.

Following V. Tarariko & V. Velychko (2022), production adaptability correlates with the improvement of industrial structure on a bioenergy basis. Indeed, this increases the profitability of production and strengthens its resilience to negative factors. The introduction of digital technologies into the development system of business entities increases the sustainable state of production, competitiveness, and innovative attractiveness (Abu Hasan *et al.*, 2022).

N. Tanklevska *et al.* (2023) addressed financing as an element of the effective economic activity of business entities in agriculture. The relationship between the sources of functioning and the net profit of business entities in 2014 and the first half of 2023 was revealed, which can be used to adjust the development strategies of regional agricultural business entities and their state support programmes for 2024-2027. Z. Sinaj *et al.* (2023) assessed agricultural production, wages, and ways to increase labour productivity in agriculture. The authors substantiate the need to increase the mechanisation of agricultural production, increase state financial support, reduce dependence on imported goods, and increase agricultural exports.

R. Stonozhenko & I. Androshchuk (2023) highlighted the problems of functioning and peculiarities of crisis management of business enterprises in agriculture. The study emphasises that agriculture is the main source of budget revenues. O. Palenychak (2023) substantiated the conceptual features of the development of environmentally oriented agricultural production and changes in trends in the concentration of land resources in large farms. N.A. Abdul Rahman & Z. Abdul Rahim (2023) developed a structure of technological, organisational, and environmental factors of effective activity of business entities based on supply chain technology as intermediaries, the theory of innovation diffusion, and technologies for organising the market environment. N. Hussin *et al.* (2023) conceptualise a digital culture strategy to increase the sustainability and competitiveness of medium-skilled farmers. They demonstrate a close link between increasing agricultural productivity and the introduction of digital culture. However, some issues of the organisational and economic foundations of the formation of an entrepreneurial environment in extreme conditions remain insufficiently researched. The study aims to evaluate and substantiate the conceptual and some applied principles of the development of agrarian business structures in the current operating environment from the standpoint of functional analysis.

▸Materials and methods

The research was based on the Law of Ukraine No. 2952-IX "On the Amendments to Certain Legislative Acts of Ukraine Regarding the Protection of the State Border of Ukraine" (2023), Law of Ukraine No. 9352 "On Amending Certain Legislative Acts of Ukraine to Create Conditions for Attracting Funds to Agriculture" (2023). Publications of national agencies were used (Finances, n.d.; Analytical review of the land ..., 2023; Official website of the State ..., n.d.), etc. The study is based on the works of international scholars (Abu Hasan *et al.*, 2022; Abdul Rahman & Abdul Rahim, 2023; Mohamad Fauzi *et al.*, 2023). In addition, the results of studies by Ukrainian scientists (Kyfyak *et al.*, 2022; Kucherenko *et al.*, 2023; Rudenko *et al.*, 2023) on the development of processes of adaptation of business entities in the agricultural sector of the Ukrainian economy to wartime activities, etc. were used.

The study is based on the methodological principles of systemic functional analysis and the concept of institutionalisation. The methods of logic and abstraction were used to determine the essence of the processes of survival of business entities in crisis conditions. Graphical, and regulatory methods were used to implement empirical assessments of business entities; approaches to generalising the results to formulate proposals; and establishing interrelationships in characterising the development of individual groups of business entities.

The parameters were found using the least-squares method, which involves the formulation and solution of a system of normal equations:

$$y = a_0 + a_1 \times x, \quad (1)$$

$$\begin{cases} a \cdot \sum x^2 + b \cdot \sum x = \sum x \cdot y \\ a \cdot \sum x + b \cdot n = \sum y \end{cases}, \quad (2)$$

where y – theoretical values of the resultant trait; a_0 – the start of the countdown under the condition that $x=0$; a_1 – regression coefficient; x – value of the factor trait; n – observation count.

By solving it, we obtain coefficient values and an analytical expression of the dependency:

$$y = a_0 + a_1 \times x. \quad (3)$$

Furthermore, for a system of two linear equations with two unknowns, the Kramer formulas are calculated as follows:

$$x1 = \frac{\Delta 1}{\Delta};\ x2 = \frac{\Delta 2}{\Delta}, \quad (4)$$

where x1 and x2 are the unknown elements of the system; Δ is the determinant of the system matrix; Δ1 and Δ2 are the determinants of the matrices A1 and A2, respectively; A1 and A2 are the matrices obtained from the system matrix by replacing the corresponding column with the vector of the right-hand sides of the system.

Correlation and determination coefficients are calculated using the following formulas:

$$r = \frac{\sum\left(t_{x_i} \times t_{y_i}\right)}{n} = \overline{t_{x_i} \times t_{y_i}}, \quad (5)$$

$$t_x = \frac{x_i - \bar{x}}{\sigma_x};\quad t_y = \frac{y_i - \bar{y}}{\sigma_y}, \quad (6)$$

$$\sigma_x = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}};\quad \sigma_y = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n}}, \quad (7)$$

$$d = r^2, \quad (8)$$

where $\bar{y}$ – average value of the resultant trait; $\bar{x}$ – average value of the factor trait; i – experiment; r – linear correlation coefficient; t_x, t_y – intermediate indicators for calculation; σ_x – standard deviation of the factor trait; σ_y – standard deviation of the resultant trait; d – coefficient of determination (or the square of the correlation coefficient). The calculation of the coefficient of determination provides information on the share of the total variation of the resultant attribute that is caused by the factor attribute.

Web-based versions of Word, Excel, and trend analysis were used to calculate and forecast annual changes in agricultural sales and net profit for 2030.

Results and Discussion

The Russian military aggression against Ukraine has caused significant damage to the country's agricultural sector, and business enterprises have suffered significant losses. The first thing to note is the change in the institutional conditions for the functioning of the national agricultural sector and the development of business activities, namely a dramatic deterioration in logistics in domestic and foreign markets; disorganisation of infrastructure and sales channels for agricultural products and food; a decrease in Ukraine's share in global agricultural production and sales; an increase in the cost of cost components and significant volatility in domestic market prices (supply prices). Rural areas have been destroyed. Production volumes of key products have decreased, transport, logistics, social and marketing infrastructure is being destroyed; there is an outflow of personnel outside Ukraine; 20% of arable land is unavailable for agricultural production due to mining and temporary occupation; and the functioning of large-scale production is becoming more difficult. The industry changed: the structure of production and its restructuring in terms of sown areas, specialisation, and sectoral capacities in the regional context; changes in the structure and composition of crops grown; challenges in terms of staffing; rising costs of product logistics; significant losses from military operations in the territories – destruction of entire segments of the economy – industries, individual enterprises in general; mining of territories; changes in the institutional structure and number of business entities in the industry (Tables 1, 2)

Table 1. Operating business entities and individual entrepreneurs in agriculture in 2010-2022, units

Years	Large enterprises. total	Medium enterprises		Small enterprises		Micro enterprises		Share of individual entrepreneurs in the structure of small businesses
		total	*	total	*	total	*	
2010	13	3,077	3	69,268	23,623	65,254	23,499	**34.10**
2015	29	2,200	2	68,057	25,804	63,401	25,758	**37.92**
2019	34	1,963	2	66,235	20,337	61,162	20,246	**30.70**
2020	36	1,827	3	64,834	19,354	59,769	19,266	**29.85**
2021	49	1,791	3	62,700	18,876	57,471	18,808	**30.11**
2022	39	1,482	3	46,570	16,627	41,940	16,577	**35.70**
2022 in % up to 2010	**+200**	**-51.83**	**0**	**-32.77**	**-29.62**	**-35.73**	**-29.46**	
2022 in % up to 2021	**-20.41**	**-17.26**	**0**	**-25.73**	**-11.91**	**-27.02**	**-11.86**	

Note: * – including individual entrepreneurs

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Table 2. Key indicators of the number of operating businesses and employed workers in agriculture in 2017-2022

Indicators	2017	2018	2019	2020	2021	2022	2022 in % up to 2017	2022 in % up to 2021
The number of operating entities and units includes:								
Large	18	23	34	36	49	39	**+116.66**	**-20.41**
Medium	2,073	1,988	1,963	1,827	1,791	1,482	**-28.51**	**-17.26**
Small	67,445	67,585	66,235	64,834	62,700	46,570	**-30.95**	**-25.73**
Micro	62,484	62,505	61,162	59,769	57,471	41,940	**-32.88**	**-27.02**
Several employees, and persons, including:								
Large	27,537	32,779	43,062	38,584	43,346	34,492	**+25.26**	**-20.43**
Medium	278,911	268,913	nd	nd	nd	nd	**nd**	**nd**
Small	250,079	247,562	nd	nd	nd	nd	**nd**	**nd**
Micro	131,449	131,980	126,115	123,447	130,757	99,820	**-24.06**	**-23.66**

Note: nd – no data published

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Thus, in 2012-2023, the number of large enterprises increased by 3 times or by 10-15% annually. At the same time, the number of medium and small businesses decreased by 2-4% per year on average, and by 0.5-1% for small businesses. These processes were influenced by mergers and acquisitions of large, medium, and small businesses. The share of individual entrepreneurs among small entrepreneurs remains stable at 30-35%. The main indicators of economic activity in 2018-2022 tend to increase, except in 2022 (Table 3).

Table 3. Key indicators of economic activity of operating business entities in agriculture for 2018-2022 (UAH million; in constant prices of 2016; end of year)

Indicators	2018	2019	2020	2021	2022	2022 in % up to 2018
The volume of products sold, including:	**504,514.3**	**537,548.2**	**587,728.9**	**890,979.3**	**651,942.9**	**+29.22**
Large	54,757.9	74,131.9	78,052.23	114,806.3	111,514.9	+103.6
Medium	253,929.6	259,697.5	273,895.2	450,567.3	286,212.1	+12.71
Small	195,893.6	203,805.6	235,869.3	325,714.9	254,261.6	+29.79
Micro	60,057.9	64,740.7	76,536.3	101,823.7	75,843.7	+26.28
Net profit	**703,77.3**	**92,786.9**	**81,421.1**	**237,571.9**	**84,788.6**	**+20.47**
Net profit per 1 employed employee, including:	**0.13681**	**0.18453**	**0.17057**	**0.49604**	**0.20840**	**+52.32**
Large	0.34222	0.11672	0.22490	1.11367	0.53647	+56.76
Micro	0.03711	0.04618	0.00840	0.19165	0.06207	+67.26
Profitability of all operations, % incl:	**14.2**	**16.6**	**14.0**	**37.8**	**13.7**	**-03.52**
Large	21.2	6.1	9.7	42.4	14.5	-31.60
Medium	15.2	25.0	14.7	35.5	13.9	-08.55
Small	11.0	9.6	14.9	38.3	13.1	+19.09
Micro	7.9	9.0	15.3	35.3	9.8	+24.05
Labour costs	**37,789.5**	**44,865.8**	**47,261.7**	**54,183.3**	**51,485.8**	**+36.24**
Average monthly salary per employee, UAH	**6,121**	**7,435**	**8,251**	**9,427**	**10,546**	**+72.27**
Capital investments in tangible assets, of which:	**70,304.7**	**61,290.7**	**49,969.5**	**67,835.4**	**–**	**-03.51***
Large	7,638.9	10,491.7	6,627.3	9,870.6	–	+21.29*
Medium	32,196.7	28,366.5	26,862.9	34,485.8	–	+07.11*
Small	24,417.3	19,078.1	15,765.7	21,984.9	–	-09.96*
Micro	6,051.8	3,354.4	713.6	1,494.1	–	-75.31*
Capital investments in tangible assets per 1 ha of agricultural land	**1.69452**	**1.48299**	**1.20959**	**1.64207**	**–**	**-03.09***

Note: * – 2021 in % up to 2018

Source: Official website of the State Statistics Service of Ukraine (n.d.)

The correlation between the volume of products sold by operating business entities and net profit for 2017-2022 in million UAH at constant prices of 2016 is established (Tables 4, 5).

Table 4. Data to establish the relationship between profit and sales of operating businesses

Indicators	2017	2018	2019	2020	2021	2022
Products sold, **Xi**	437,369.7	504,514.3	537,548.2	587,728.9	890,979.3	651,942.9
Net profit (loss), **Yi**	68,202.7	70,377.3	92,786.9	81,421.1	237,571.9	84,788.6

Source: Official website of the State Statistics Service of Ukraine (n.d.)

Table 5. Estimated values of intermediate indicators for establishing a linear dependence function

	x_i^2	x	y	y_i^2	$x_i y_i$
1	**191,292,254,478.09**	437,369.7	68,202.7	**4,651,608,287.29**	**195,943,862,765.38**
2	**254,534,678,904.49**	504,514.3	70,377.3	**4,952,964,355.29**	**259,487,643,259.78**
3	**288,958,067,323.24**	537,548.2	92,786.9	**8,609,380,975.54**	**297,567,448,298.78**
4	**345,425,259,895.21**	587,728.9	81,421.1	**6,629,395,525.21**	**352,054,655,420.42**
5	**793,844,113,028.49**	890,979.3	237,571.9	**56,440,407,669.61**	**850,284,520,698.10**
6	**425,029,544,860.41**	651,942.9	84,788.6	**7,189,106,689.96**	**432,218,651,550.37**
Σ	**2,299,083,918,489.93**	**3,610,083.3**	**635,148.5**	**88,472,863,502.9**	**2,387,556,781,992.83**

Source: compiled by the author following a formula (1-4)

The following results were calculated using formulas (1-4). Thus, with an increase in the volume of agricultural products sold by business entities by 1 million UAH, net profit increases by 0.427 million UAH. Let us calculate the correlation coefficient (Table 6).

The following data were calculated using formulas (5-8). Thus, the value of the correlation index of 0.9200 calculated according to the table indicates that the actual amount of deviations of the resultant trait is approximately equal to the limit. The coefficient of determination, which characterises the part of the variation of the resultant trait that depends on the variation of the factor trait, is 0.8464. During 2017-2022, 84.64% of the variation in net profit is explained by the variation in the level of agricultural products sold by business entities. Thus, the impact of the remaining factors on the analysed population is not significant. Changes in products sold by business entities and net profit in 2030 were calculated (Fig. 1).

Table 6. Estimated values for determining correlation and determination coefficients

	x	$x_i - \bar{x}$	$(x_i - \bar{x})^2$	y	$y_i - \bar{y}$	$(y_i - \bar{y})^2$	t_x	t_y	$t_x t_y$
1	437,369.7	**-164,310.9**	**26,998,071,858.8**	68,202.7	**-37,655.4**	**1,417,929,149.2**	**-1.13**	**-0.63**	**0.7119**
2	504,514.3	**-97,166.3**	**9,441,289,855.7**	70,377.3	**-35,480.8**	**1,258,887,168.6**	**-0.67**	**-0.59**	**0.3953**
3	537,548.2	**-64,132.4**	**4,112,964,729.8**	92,786.9	**-13,071.2**	**170,856,269.4**	**-0.44**	**-0.22**	**0.0968**
4	587,728.9	**-13,951.7**	**194,649,932.9**	81,421.1	**-24,437**	**597,166,969**	**-0.10**	**-0.41**	**0.0410**
5	890,979.3	**289,298.7**	**83,693,737,821.7**	237,571.9	**131,713.8**	**17,348,525,110.4**	**1.99**	**2.21**	**4.3979**
6	651,942.9	**502,62.3**	**2,526,298,801.3**	84,788.6	**-21,069.5**	**443,923,830.3**	**0.35**	**-0.35**	**-0.1225**
Σ			**126,967,013,000.2**			**21,237,288,496.9**			

Source: compiled by the author following formulas (5-8)

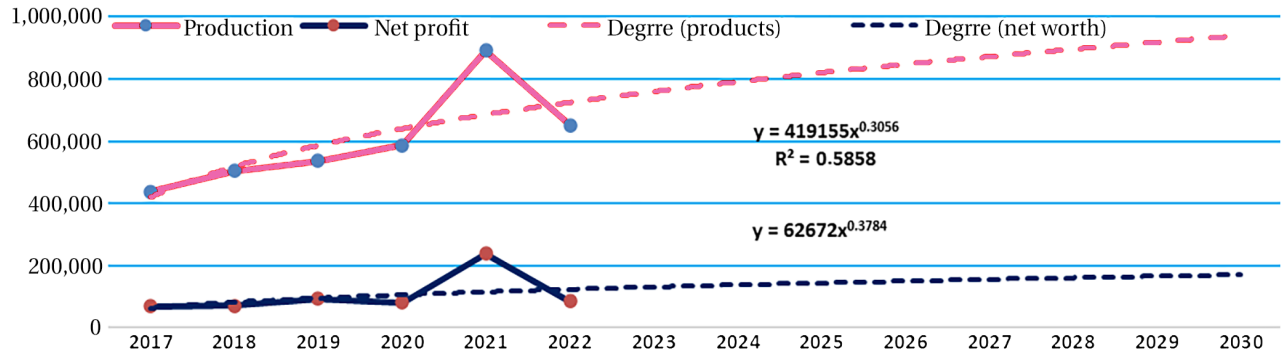

Figure 1. Forecast of changes in products sold by business entities and net profit in 2030 (UAH million; in constant 2016 prices)

Note: $y = 41915 \times x^{0.305}$ – power function for forecasting changes in products sold by business entities in 2030; $y = 62672 \times x^{0.378}$ – is a power function for forecasting net profit in 2030; the correlation coefficient is 0.678

Source: Official website of the State Statistics Service of Ukraine (n.d.)

However, qualifying the organisational and economic foundations of the development of entrepreneurial formations, it is worth noting that it relies on resource provision and significantly affects the efficiency and

effectiveness of their production and economic business activities, and improvement of their business results is possible with an optimal combination of human, intellectual, material and financial resources. By comparison, changes in land use mean not only the loss of agricultural land but also a decrease in landscape diversity, which is a negative phenomenon, especially in the spatial context of sustainable rural development.

The state provides institutional support to business entities to strengthen their capacity to operate under martial law. Such measures include creating conditions for access to sales channels and logistics of obtaining resources (seeds, fertilisers, fuel, etc.). One of the segments of institutional support is digitalisation, which applies to all segments of the organisation of functioning and market interaction. Today, it is necessary to preserve the opportunities for the functioning of agricultural enterprises that have problems with staffing.

Businesses should implement measures to improve production efficiency through the introduction of rational concentration, specialisation; diversification of production; alternative energy; forms of production organisation; and cooperation and integration. More than 50 thousand business entities produce agricultural products. Almost 92% of them are farms. There are approximately 32.5 thousand active business entities, with 29 thousand of them cultivating 4.7 million hectares of land (Hromov, 2023). Small agricultural businesses have a significant growth potential in terms of quantity and quality (in 2022, compared to 2018, the volume of products sold increased by 29.79%, the level of profitability of all activities by 19.09%, and labour costs by 59.91% (Table 3)) and family farming businesses. This sector institutionally acts as the primary guarantor of employment, capacity building, and opportunities for active economic and rural recovery.

In the future, the creation of small business forms, such as family farms, craft businesses, public services, etc. is expected to increase. This is related to the flexibility of small businesses, and their institutional capacity to quickly restructure their activities and even relocate to another region. A radical change in the mechanism of organisational and economic development of agrarian entrepreneurial formations, cooperation and agro-industrial integration is needed in the following areas: reorientation from the raw material export model of management to the model of deep processing of agricultural products; activation of small farm businesses and craft production; spread of cooperative integrated formations; involvement of territorial communities' resources in the mechanism of entrepreneurial activity through the creation of commercial and communal agrarian enterprises.

Among the organisational and economic factors that influence the development of agrarian businesses, in addition to a decrease in the production of certain types of products, higher transport and logistics costs, and restrictions on imports, prices for certain types of agricultural products are important. In an interview with Suspilne, Oleh Skrynchuk, director of an agricultural enterprise in the Khmelnytskyi region, stated that in 2024, the area under some crops may be reduced due to unprofitable production (Konovalova & Porobok, 2023). As of September 2023, the current wheat prices are 5.4-6.0 thousand UAH/t including VAT, barley – 3.5 thousand UAH/t, and rapeseed – 14 thousand UAH/t. These prices do not cover the costs of growing these crops. Farmers may decide not to grow these important crops, which are essential for food security.

State support for the development of business structures ensures the achievement of positive results. For example, the allocation of 645 million UAH to support farms in 2019, which was received by more than nine thousand farms, ensured a 19.5% increase in gross output in 2021 compared to 2018. In general, the agricultural sector of the economy saw a 19.9% increase in gross output in 2014-2023. Gross value added grew by 6.4%, while the rural population of active age (16-59 years) decreased. The decline in the rural population can also be considered a reason for the 16% decline in livestock production in households in 2021 compared to 2015. The growth of gross value added over this period was influenced by a 1.7-fold increase in capital investment and indirectly by the average monthly wage growth from 3,000 to 9,000 in 2021 (Official website of the State..., n.d.).

State support for business development during the war period is provided through concessional lending. In 2022, 22,000 loans worth 86 billion UAH were issued in the agricultural sector. More than half of these loans were issued under the Affordable Loans 5-7-9% programme. The Ministry of Agrarian Policy also launched the State Agrarian Register as a basis for receiving donor assistance to farmers. As part of the State Agrarian Register, in 2022, 3,000 business entities received financial support worth 1.6 billion UAH. A total of 2,763 businesses received 1.3 billion UAH for the development of crop production. In addition, 275 business entities received 0.3 billion UAH for the development of livestock (Finances, n.d.). In 2023, 1.6 thousand agricultural businesses received loans worth 60.1 billion UAH. However, 9,000 businesses received 34.8 billion UAH under the programme "Affordable Loans 5-7-9%" (Cabinet of Ministers has amended..., 2023). In the period from 09.10-16.10.2023 alone, 235 business entities received loans worth 1.3 billion UAH under the "Affordable Loans 5-7-9%" programme. Banks granted 21 thousand loans worth 75 billion UAH since the beginning of 2023. Businesses mostly use loans for anti-crisis and anti-war purposes. Agricultural businesses received UAH 35 billion to support their operations. It has been established that in 2023, preferential financing of agricultural businesses under the "Affordable Loans 5-7-9%" programme should be retained, but not as "trust loans", but as "survival loans"; the limits should be expanded to 130-140 million UAH; and interest rates should be reduced to 5% (Finances, n.d.).

The Cabinet of Ministers of Ukraine amended the mechanism of state support for businesses under the Affordable Loans 5-7-9% programme (Cabinet of Ministers has amended..., 2023). These changes will apply to businesses located in areas of high military risk (de-occupied). Participants in the Affordable Loans 5-7-9% programme will be able to reimburse interest under the programme up to 1% for the first two years; 5% for investment purposes starting next year and 3% for working capital needs. In addition, the loan term is being extended to 10 years for investment purposes.

For businesses operating in the de-occupied territories, the programme limit may be increased to 150 million

UAH. For all other businesses that create increased added value and implement energy modernisation, the loan term is extended to 10 years and the programme limits for investment purposes are increased to 150 million UAH. However, for all other cases, the rate of 13% p.a. for working capital formation remains the same and the rates of 5-7-9% for investment purposes remain. In addition, financial state support is provided to business entities, and the maximum term for using factoring financing is set at 30 days. Support for business entities under factoring agreements is provided by the Entrepreneurship Development Fund within the limits of the funds received and provided for in the state budget (Cabinet of Ministers has amended..., 2023).

As a result of the "Development of Access to Capital Markets for Ukraine's Agricultural Sector" project, 773 agricultural loan certificates (5.66 billion UAH) were issued by agricultural producers in 2023. In 2023, compared to 2022, the average loan amount was 22% lower; loans were more often granted against financial agricultural receipts; the largest loan amount was issued against corn, sunflower, and rapeseed (Finances, n.d.). One of the tools for raising funds is the adoption of the Law of Ukraine No. 9352 "On Amending Certain Legislative Acts of Ukraine to Create Conditions for Attracting Funds to Agriculture" (2023) to allow raising funds under the guarantee of the right to use leased land.

In 2023, 118 agricultural businesses received 476.7 million UAH of development assistance under the E-work programme, which has been in place since 1 July 2022 and provides support to small and medium-sized businesses to develop their own business in the "New Level", "Your Garden", "Your Business" and "Your Greenhouse" programmes. A total of 99 business entities received 378 million UAH for the development of horticulture. Another 19 business entities received 98.7 UAH million for the development of greenhouse production. In 2023, these grants were fully disbursed to 97 businesses. For the period from 1 July 2022 to November 2023, 127 business entities have already been paid 525.7 million UAH (21 business entities received 112.7 million UAH for the development of greenhouse production; 106 business entities received 413 million UAH for the development of horticulture, berry growing and viticulture) (Finances, n.d.).

The war has affected the dynamics of land sales and purchases by businesses. In areas close to the frontline, investors are reluctant to invest. Investments in land in this area are only possible if the investor sees that the return on these plots will be higher than in other regions. Entrepreneurial action has also kicked in. According to Dobrozem (Land market in wartime..., 2023), the ratio of supply to demand for land has changed in Ukraine. Before the war, the number of people willing to buy land accounted for 60-70% of the market, and during the war, 30-40%. In the western and central regions, the demand for land plots is higher than in the southern and eastern regions.

Agricultural entrepreneurship provides positive results in Ukraine's economy. The companies' activities ensured the highest profitability of operating (20.3%) and total (13.6%) activities in the context of the war and obstacles to sales. However, companies suffered significant losses as a result of the hostilities. Only 8% of companies were able to achieve a positive financial result. The share of unprofitable enterprises increased by 3.17% in 2021 and to 21.6% in 2022, but it is the smallest among all types of economic activity. The need to expand exports of agricultural products with high value-added is also problematic.

Business activities in the war zone have been suspended. But there are production problems in the rest of the country as well, including the rising cost of material and technical resources. The total cost of logistics in hryvnia terms has increased 2-3 times. There is a shortage of labour, especially of machine operators. The problem of selling agricultural products has not been fully resolved. The key problem is the blockade of ports (Mykolaiv, Odesa, Kherson). Most (over 90%) of agricultural exports are carried out by sea. About 150,000 hectares of agricultural land remain uncultivated (Land market in wartime..., 2023). This is a measure caused by military operations, but it affects the state of farmers' business activities.

The study of the conceptual and applied principles of survival of business entities in agriculture under extreme operating conditions is a common problem. Studying the issues of manifestation of the essence and peculiarities of the development of business entities in agriculture, scientists define the concept of "entrepreneur" and determine that for the development of entrepreneurship, a favourable environment is important, which will allow to intensify this process (Kucherenko *et al.*, 2023; Polhorodnik, 2023; Ihnatenko *et al.*, 2023). The authors also consider the theoretical essence of entrepreneurial potential as a basis for the development of entrepreneurial activity and describe the prospects for its development. It is possible to agree with the opinion that the basis for the further development of rural areas is small entrepreneurial structures, both agricultural and non-agricultural. The further development of entrepreneurial activity is realised through family farms, cooperatives and legal entities-entrepreneurs.

The position of A. Bitkowska *et al.* (2022) on the fact that the use of the conceptual framework of Agile Business Process Management allows entrepreneurs in agriculture to more effectively implement radical actions in the business environment is noteworthy. O. Dovgal (2022) revealed the basic principles of implementing a circular business model of development. Considering the specialisation of the value chain, the author substantiates the scheme of organisational forms of business models of the circular economy. The socio-economic benefits of the transition of entrepreneurs to the system of the circular development model are evident. B. Hnatkivskyi *et al.* (2022) highlighted the peculiarities of land use by business entities in agriculture. In 2022, the average purchase and sale price of agricultural land in Ukraine was 38,560 UAH/ha, which is 40.11% higher than the average normative monetary value of land in the country (27,520 UAH/ha). However, as of July 2023, the weighted average purchase and sale price of agricultural land was 35,367 UAH/ha, which is 28.51% higher than the average normative monetary value of land in the country (Analytical review of the land..., 2023). It is possible to agree with the authors that the development of business entities in agriculture is extensive, and business entities themselves do not want to sell land yet.

D. Shelenko *et al.* (2022) highlighted the potential for the development of agricultural cooperatives by 2023 and

found that the size of net profit is most influenced by the area of agricultural land, the number of business entities and employees, and the total cost of production. However, as of 01.10.2023, compared to 01.10.2022, the number of agricultural production cooperatives decreased by only -01.81%, and service cooperatives by -02.13%. In July 2023, 32.7 million hectares of agricultural land were registered, which is 20.84% less than at the beginning of 2022 (Official website of the State..., n.d.; Analytical review of the land..., 2023). It is worth noting that only through the concentration of cooperative structures, and the introduction of innovative technologies and production automation systems will entrepreneurs' incomes increase.

The results of the study by O. Shust (2023) on the ways of the post-war revival of the agrarian economy with financing processes based on the principles of public-private partnership are noteworthy. In the future, entrepreneurs should focus on the production of high-value-added products; the development of beef cattle and sheep breeding with a high return on investment; diversification of production activities of corporate sector entrepreneurs specialising in grain crops. We can agree with S. Jerčinović (2023), who reveals the implementation of the possibilities of effective and competitive marketing strategies of business entities in agriculture and elements of sustainability of marketing strategies with the peculiarities of organisational culture transformation, as well as with the opinion of N. Patyka *et al.* (2023) that over the period 1991-2023, the crisis in rural areas continues to worsen. This is evident in a reduction in employment, increased unemployment, rising poverty, mass migration of peasants, deterioration of infrastructure and access to social services. O. Garafonova *et al.* (2023) revealed the components of losses by categories of the agricultural sector and identified potential sources of formation of a model for the post-war revitalisation of business entities in agriculture in the de-occupied territories. The opinion of the authors is valid, as the creation of cooperative-integrated business structures, clusters, and non-agricultural business entities can improve socio-economic conditions and support the population.

S. Kucherenko *et al.* (2023) determined that cost recovery has the highest priority in the system of entrepreneurship development in agriculture. The statement that the security and financial components of survival in extraordinary operating conditions reflect the factors of increasing competitive advantage is valid. The overall socio-economic situation of business entities in agriculture directly affects the food and national security of the country. It is also worth supporting the position of Y. Polhorodnik (2023) that the strategic management of the development of an entrepreneurial entity is the process of forming and implementing a development strategy to achieve maximum results, adapt to changes in the environment and implement strategic plans, as well as the opinion of researchers M. Ihnatenko *et al.* (2023) that focusing, cost reduction, combined and differentiation strategies should be implemented by entrepreneurs in wartime. The system of adaptation to the crisis state of the economy, optimal relationships with business partners, effective management of financial and labour resources, and an adequately selected competitive strategy affect the mechanism of increasing the potential of investment attractiveness.

C. Rudenko *et al.* (2023) emphasise the link between risk management and the need to ensure business continuity in agriculture. The implementation of a risk management system enables entrepreneurs to respond adequately to the realities of the market environment. The statement of A. Tkachenko (2023) that crisis management helps businesses to remain competitive, adapt to changes, and find new opportunities for development with minimal losses is valid.

The study proved that an adaptive approach to functioning under martial law is associated with the development of strategies for reflecting the impact of the crisis by a small business entity (Kravchenko *et al.*, 2023). T. Sus *et al.* (2023) substantiated the need to implement a model of cooperative financing for farms. It is possible to conclude that the amount of self-financing of an entrepreneur depends on the level of income and the possibility of tax exemption.

N. Shandova & A. Tarasiuk (2023) proposed a mechanism for ensuring the development of innovation activity that allows organising effective interaction of structural agents of development and purposeful management of changes in innovation activity. The main tasks of launching the processes of post-war infrastructure modernisation and developing competencies for the formation of new competitive advantages are to intensify the innovation activity of an enterprise. The implementation of the business process reengineering algorithm by O. Lyzunova *et al.* (2023) can significantly reduce the cost of resources, fuel, labour, etc. The authors of this study agree that the use of an innovative reengineering model can change the way business entities operate in agriculture and accelerate the processes of their adaptation to extreme operating conditions.

I. Tomashuk *et al.* (2023) substantiated the need for a transition to a green economy system. The concept of "green growth" highlights the importance of integrating the socio-economic and environmental policies of the enterprise to establish new sources for the socio-economic growth of small businesses in agriculture. The article reveals the direction of development of the green economy as a factor in ensuring the transition to sustainable development of the country. Important economic indicators of sustainable ecological and economic development are the nature intensity of the economy, investments in agriculture, and the share of output. M. Ilchuk *et al.* (2023) proposed a mechanism of environmental taxation for entities to stop the negative processes of soil degradation. S.N. Mohamad Fauzi *et al.* (2023) assessed the risk factors for new business entities. As a result of risk identification and assessment, it was found that the qualities of the entrepreneur are the most important risk factors in business.

The parameters of the economic crisis impose new requirements for the formation of an effective system for the survival of business entities and the adaptation of their economic mechanism to extreme conditions. Entrepreneurs in agriculture were able to adapt to the crisis more quickly. The following remain as obstacles to the development of entrepreneurship structures in agriculture: the focus of programmes on supporting large producers; low

level of information and advisory support; risky business start-ups; and low liquidity of production.

Conclusions

The organisational and economic foundations of the development of agrarian entrepreneurial formations are associated with the risks of the military factor, which changes the characteristics of the institutional environment of management, regulated by the rules of economic interaction in the market established by the state. These rules determine the principles of gaining competitiveness, strategic priorities for the development of entrepreneurship, and influence the behaviour of entrepreneurs, but the principles and purpose of entrepreneurial activity as a socio-economic phenomenon remain constant – "making a profit". The author proposes a classification of organisational and economic principles of development of entrepreneurial entities and outlines prospects for their development depending on the size and status under martial law and the role of state support through preferential lending in improving the efficiency of entrepreneurial activity of business entities. The primary guarantor of employment is small business and family farming.

Trends in changes in the organisational and economic factors influencing the development of entrepreneurial formations are identified, in particular: a decrease in the production of certain types of products; an increase in the cost of material and technical resources; a 2-3-fold increase in transport and logistics costs; restrictions on import operations; a shortage of mechanic personnel; changes in prices for certain types of agricultural products, etc. It is established that the need to expand exports of agricultural products with a high content of added value is quite problematic. It is substantiated that an increase in the volume of agricultural products sold by business entities by 1 million UAH leads to an increase in net profit by 0.427 million UAH.

Further research should clarify the strategic directions of entrepreneurship development in accelerating the post-war development of the country's economic system. It is also necessary to address the need to develop regional programmes for the development of business entities and their cooperative associations of various specialisations for the period up to 2030 and to provide state support for starting their business, spreading financial and socio-economic literacy, protecting property rights, employing rural producers, and increasing the export potential of business entities in the system of post-war economic reconstruction.

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Conflict of interest

None.

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Організаційно-економічне забезпечення розвитку суб'єктів підприємництва в сільському господарстві в умовах воєнного стану

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► **Анотація.** Суб'єкти підприємництва в сільському господарстві забезпечують потенціал продовольчої безпеки країни та збереження навколишнього середовища. Мета статті полягала в обґрунтуванні соціальних, економічних та концептуальних засад діяльності суб'єктів підприємництва в сільському господарстві в умовах воєнного стану. Основою методології дослідження слугували положення системно-функціонального аналізу та інституціональної економічної теорії. Використано графічний, абстрактний методи систематизації результатів. В процесі дослідження встановлено, що у 2023 році продукцію виробляли понад 50 тис. суб'єктів підприємництва (92 % з них – фермерські господарства). 1,6 тис. суб'єктів підприємництва в сільському господарстві одержали кредитів на суму 60,1 млрд грн. Обґрунтовано необхідність залишення пільгового фінансування суб'єктів підприємництва в сільськом господарстві по програмі «Доступні кредити 5-7-9 %» як «кредитів виживання» з розширенням лімітів до 130-140 млн грн. та зменшенням відсоткової ставки до 5 %. Виявлено, що первинним гарантом зайнятості населення є мале підприємництво та сімейний фермерський бізнес. Доведено, що в період 2017-2022 рр. 84,64 % варіації чистого прибутку пояснюється варіацією рівня реалізованої суб'єктами підприємництва продукції сільського господарства. Обґрунтовано доцільність застосування організаційно-економічних засад розвитку підприємницької діяльності в умовах воєнного часу, розробку комплексних індикаторів оцінки стану розвитку підприємницьких структур в аграрному секторі економіки та вплив підприємництва на розвиток сільських територій. Охарактеризовано індикатори розвитку та ефективність діяльності аграрних підприємств. Інформаційно-аналітичний матеріал можливо враховувати при розроблені регіональних програм розвитку суб'єктів аграрного підприємництва

► **Ключові слова:** суб'єкт підприємницької діяльності; аграрні підприємства; індикатори розвитку; ефективність діяльності; стратегія функціонування; логістика; адаптація до умов воєнного стану

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