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Investment and Innovation Development of Agriculture in Ukraine

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► **Abstract.** The tasks facing agro-industrial production in Ukraine are to stimulate the processes of accumulation and effective use of investment resources according to the priorities of economic growth, and prospects for the development of innovation activities. The prerequisite for this is macroeconomic stability, which contributes to the accumulation of internal and external factors and resources by increasing investor confidence in economic regulatory policy and reducing the level of risk of investment activity. The issues covered in the study will primarily concern such important factors in ensuring the development of agro-industrial enterprises as innovation and investment. These concepts are widely reflected in the research of many economists, but the management of innovation projects and investment activities to ensure the economic security of agribusiness entities is not sufficiently developed. This determines the relevance of the article. The purpose of the study is to determine the nature and features of agricultural innovations, to examine the conditions and factors of innovative development of agriculture, to assess the challenges and prospects of using the latest advanced technologies in agriculture and their financial support. The following methods were used in the investigation: dialectical, systematic approach, monographic, economic-statistical, tabular, graphical, comparative analysis, abstract-logical and analytical forecasting. The features of the introduction of innovative technologies in the agrarian sector of the economy are analysed and it is revealed that agro-innovations are closely related to agrotechnical conditions of production, are linked to living organisms, are seasonal and, accordingly, have a high level of risk. The analysis of material costs for the production of cereals and the dynamics of their prices was carried out. Using the example of one of the farms of the Vinnytsia Oblast, it is calculated how precision farming technologies and energy-saving technologies can reduce the cost of grain production. The main trends in investment support for agriculture, the relationship between capital investment and GDP are identified, and their role in the implementation of agricultural innovations is clarified. The prospects of investment support of innovative activity of Ukrainian agriculture in the war period are determined. The measures to address the issues related to the introduction of innovations in agriculture are proposed. They will help to improve the production process, increase the efficiency of using internal ones and maximise the attraction of external investment in the implementation of innovative ideas

► **Keywords:** the agricultural sector, agricultural innovations, capital investments, precision farming, tillage technologies, food security

► Introduction

A prerequisite for sustainable development of the state is investment and innovation support of its economy. According to the modernist theory of economic growth of Harvard economist Robert Solow, "Economic growth has three components: Capital, labour, and general productivity (the level of technology, innovation, and quality of management)" [1].

Sustainable economic growth of agriculture requires a high level of scientific support for agricultural production (science, technology, production experience, scientific and technological personnel) and intellectualisation of the production process. Perception and implementation of innovative solutions should be a prerequisite for their implementation

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in the economic activities of agricultural production entities in a competitive market environment. However, the aggravation of a number of existing systemic problems in agriculture due to the deterioration of the material and technical base, and unequal exchange of agricultural products for industrial resources narrows the investment and financial component of economic entities and weakens their innovation activity. New determinants of innovation and investment development of agricultural production, GDP growth, can significantly intensify investments in innovation and other resources [2]. Accordingly, the implementation of innovative processes in agriculture should increase the food security of the country, provide the population with food in the required quantity and quality, and industry with raw materials [3].

In a market economy, the vast majority of agricultural enterprises need to invest in a simple and expanded renewal of fixed capital, the introduction of innovative solutions, acquisition of new varieties of plants and animal breeds, and other capital-intensive innovative and investment projects. This raises the question of finding new forms and methods of activating the organisational and economic mechanism for the development of innovation and investment activities.

One of the methods of such activation is the creation of a highly productive export-oriented agricultural sector with further innovation and investment development, focused on the introduction of advanced achievements in science and technology to update the technical, technological, organisational base of agricultural production and obtain competitive high-tech products. The increase in the share of investment indicates a significant change in the structure of expenditures in the economy: an increase in the level of savings of the population, and increased investment activity in modernization and technological innovation.

For economies with low levels of fixed capital formation, which is typical for Ukraine, investments are crucial. Since the beginning of the 2000s, the annual volume of capital investments in the Ukrainian economy is 11-20% of GDP. In times of major economic expansion in China, the level of capital investment was up to 50% of the GDP. For a sharp economic recovery, Ukraine must invest at the level of 35% of GDP for at least 5 consecutive years. This is 70-80 billion US dollars annually [1]. And in the agro-industrial complex in general, over the past five years, the index of physical volume of investments in fixed assets amounted to only 3.3%, which is insufficient for the country's economic growth.

In the current conditions of agricultural production, many problems related to the prospects for investment support for innovative activities of the agricultural sector of the Ukrainian economy have become more acute. The main ones are: an increase in prices for goods and services consumed in agriculture, limited imports of agricultural products due to military operations on the territory of Ukraine and

partial occupation, and a decrease in investment resources for the expanded reproduction of the main production assets of agricultural producers.

That is why the purpose of the study was to investigate the state of investment support for innovative development of agricultural production and determine its prospects in the war and post-war period.

The relevance of the study of investment and innovation activities of agricultural enterprises is due to increased competition in the food market and the integration of Ukraine into the international economic space, which is determined by the need to form an innovative investment model for the development of the agricultural sector of the Ukrainian economy. And these issues will be especially relevant during the post-war economic recovery. They will constitute the basis of our further research and elaborations.

The issues concerning innovative and investment development of agricultural production are the subject of research of many Ukrainian and foreign scientists. Rui Hou, Shanshan Li, Hongyan Chen, Guowen Ren, Wei Gao, Lijun Liu investigated the communication mechanism and prospects for the development of an innovative ecosystem in smart agriculture based on blockchain [4]. They firstly analyse the linkage mechanism between blockchain smart agriculture and the innovation ecosystem; secondly, they distinguish the innovation ecosystem evaluation index system and measure the development efficiency of innovation ecosystems through the SBM model, which calculates the coordination of innovation ecosystem connectivity in different regions, and analyses spatio-temporal, regional differences and spatial agglomeration; thirdly, they propose to increase the efficiency of the innovation ecosystem by combining and coordinating its individual components.

The researchers argue that building an innovation ecosystem is consistent with the trend of expanding the scope of innovation, the growth of the innovation platform and the emergence of innovative behaviour helps to overcome the uncertainty, complexity and ambiguity of the innovation environment in the context of the new norm, the emergence of new ways of mass innovation, crowdsourcing and crowdfunding, as well as the cultivation of new economic formats such as e-commerce, internet finance and intelligent logistics to form a new point of economic growth.

The impact of promoting farmers' awareness of new agricultural technologies through systematic linkages in the research and development continuum on their adoption was investigated by a group of scientists Yigezu Atnafe Yigezu, Amin Mugeru, Tamer El-Shater, Aden Aw-Hassan, Colin Piggan, Atef Haddad, Yaseen Khalil, Stephen Loss [5]. They believe that the low and slow adoption of innovative technologies in agriculture among small agricultural producers often hinders the development and promotion of technologies. This is especially true for those technologies that require a large initial investment.

Researchers' findings show that providing exposure and awareness of no-till technology through organised field days and demonstration trials, complemented by providing free access to expensive no-till equipment for first-time users, increases the propensity, speed and intensity of its adoption. The intensity of implementation is also positively affected by the access of agricultural producers to loans. They emphasise the importance of initial outreach to agricultural producers and the ease of testing new agricultural technologies, especially those that require large upfront investments, at low or no cost to ensure their rapid and widespread adoption.

New agricultural technologies introduced in developing countries are mostly characterised by low and slow implementation, which is disappointing for researchers, practitioners, policy makers, and investors. Any innovation carries both risks and opportunities, and agricultural producers are likely to try a new technology that is less risky and has greater expected benefits than the prevailing technology. Deciding whether to apply the technology is even more difficult when the new technology involves a large initial investment.

The ease with which innovation can be tested to confirm its benefits increases the tendency and speed of adoption by farmers, and this may depend on the extent to which it can be tested at low or no cost. The compatibility of innovation with an existing set of resources, practices, and technologies can also affect the intensity of implementation.

The decision to adopt an innovation in agriculture at the individual farm level is defined as the possibility of using a new technology in the long term, when the farmer has full information about the technology and its potential.

Lina Bjerke and Sara Johansson in their study "Innovation in Agriculture: An Analysis of Swedish Agricultural and Non-Agricultural Companies" [6] presented a quantitative analysis of how the innovation capabilities of agricultural enterprises and enterprises in other sectors differ. With unique data from a survey of Swedish firms, they showed that one-third of companies in the agricultural sector are authors of innovations. Moreover, technological innovation at the enterprise level is no more common in agriculture than in other sectors. These results indicate that agriculture is not a special case in terms of innovative products, however, it is dominated by technological innovation. The uniqueness of the study lies in the fact that it investigates the acquisition of relevant innovations by agricultural enterprises and their doubts about the state policy of innovation support. Therefore, they more often point to the need to strengthen their own knowledge in agricultural enterprises. This will improve their ability to collaborate with partners working at higher levels in the knowledge system and benefit from collaboration.

They insist on the need for an in-depth study of the features of innovation potential in agricultural firms. Many aspects of agricultural production distinguish agricultural firms from companies in other

sectors, but the development of the agricultural sector suggests that there are also many similarities. In recent decades, agricultural enterprises have grown, introduced more advanced technologies, become more diversified and more market-oriented. There is a growing understanding that agricultural enterprises today initiate and implement innovation processes and should be recognized as creators of innovations, not only as consumers.

Most enterprise-level innovation studies distinguish between small and large enterprises, where the latter are expected to have more internal resources spent on innovation. The hypothesis that follows from this assumption is that large firms are more innovative than small ones. Nevertheless, research shows that a significant proportion of small enterprises engage in innovation, and the benefits of innovation are similar to those observed in large enterprises. Small firms are often more flexible and adapt faster to changing market conditions, allowing small firms to take advantage of being small through innovation. Primary sector research, however, generally proves that the impact of firm size (measured as the number of employees) on innovation is positive.

They also insist that human capital is a mandatory factor influencing the innovation potential of enterprises. It allows absorbing and assimilating knowledge in processes where ideas are transformed into commercial products and processes.

Using forecasting to understand the relationship between research findings and the future of agriculture and the food system is the research focus of Steven D. Prager, Keith Wiebe [7]. In the context of agriculture, long-term forecasting allows to investigate how investments can help agricultural development, given the expected future related to various factors ranging from climate change or policy environment to increasing production efficiency.

The researchers argue that foresight approaches, whether quantitative models, qualitative participatory processes, or a combination of both, allow to explore a large number of scenarios and evaluate the results in terms of specificity, desirability, plausibility, return on investment, equity, etc.

An important asset of forecasting approaches, in particular quantitative models, is their capacity to assist in developing an insight into how agricultural systems may respond differently in space and time to interventions. Factors that affect agriculture and the food system have temporal and spatial differences. This allows for a better appreciation of how the productivity of the food system can be improved through investment in agriculture.

A model for studying technical changes in EU agricultural enterprises is considered in their research by Amr Khafagy and Mauro Vigani [8]. The parameters of a methodology that describes the productivity of factors of production, the elasticity of substitution between two factors, and technical changes that increase productivity can be determined both exogenously and endogenously. To verify reliability, they examine the availability of Hick-neutral

technical changes and Cobb-Douglas production technology.

In their research, scientists concluded that innovations in physical capital are not enough to increase productivity, but they must be complemented by higher quality of labour. For example, innovative digital technologies and precision machines must be accompanied by qualified workers who can operate them.

Polish scientists Arkadiusz Sadowski, Monika Malgorzata, Wojcieszak-Zbierska, Patricia Beba in their study "Territorial differences in agricultural investments co-financed by the European Union in Poland" [9] investigate the relationship between the active use of EU investment support programmes by Polish farmers on the one hand, and local conditions of socio-economic development and natural and structural characteristics of agriculture on the other.

The synthetic Hellwig development indicator was used to represent complex phenomena. The study revealed a strong link between the implementation of co-financed investments and the agricultural structure at the local level. Other factors were insignificant. This suggests that the path of agricultural development does not fully depend on socio-economic and environmental conditions.

Based on the findings of their research, they concluded that there is a strong link only between the territorial heterogeneity of farmers' investment activity and the agrarian structure. There is also a high correlation between the amount of investment per farm, and between the share of investing farms and the share of farms with an area of more than 10 hectares.

They found that the processes of agricultural development at the local level are somewhat autonomous. The intensity of investment activities carried out by producers from different regions was generally independent of their wealth and availability of infrastructure.

Ukrainian scientists have also studied the essence and features of innovation activity in the agricultural sector, the development of precision farming technologies and energy-saving technologies. Among them are Mykola Rudenko [10], Taras Dudar [11], Nelya Chorna [12], Vadym Petrov [13].

Innovation and investment development of Ukrainian agriculture is at the stage of stagnation. Therefore, the results presented in the article are relevant, timely and necessary.

► Materials and Methods

The methodological basis of the study is a dialectical method of cognition and a systematic approach to the examination of economic features of investment and innovation development of agricultural production. At the same time, the following methods were used in the research process: monographic (in covering the standpoints scientists on the issues and problems under study, in the investigation of innovative technologies and equipment for agriculture); economic and statistical (in the analysis of the current

state of investment and innovation support for agricultural production) tabular and graphic (when visually displaying the results of the study in the form of figures and tables), empirical (when studying the economic efficiency of introducing innovative technologies in an agricultural enterprise); comparative analysis (to compare the cost of growing grain using traditional and innovative technologies); analytical forecasting method (to predict the volume of investments in military and the post-war period); abstract-logical (generalisation and formulation of conclusions).

The main stages of the study are: identifying the features of agricultural production and the introduction of innovative technologies in it, their importance for the development of agriculture; calculation of the economic efficiency of grain cultivation with traditional and innovative production technologies; analysis of precision farming technologies and energy-saving technologies, their cost and economic efficiency; analysis of sources and volumes of investment support for innovative activities in agriculture; forecasting investments in agriculture; forecasting of investments in agriculture in the war and post-war periods.

The analysis and calculations were carried out based on the materials of the State Statistics Service of Ukraine (volumes of capital investments in agriculture, the ratio of GDP and capital investments), financial statements of agricultural enterprises (to calculate the effectiveness of the introduction of innovative technologies in grain production), prices of dealers of innovative agricultural machinery and other material and technical resources and services for agriculture and the author's calculations.

► Results and Discussion

Agriculture makes a significant contribution to the development of the national economy. It produces UAH 612 billion of products, forming 10.8% of gross added value and about 45% of exports. Ukrainian agriculture uses fixed assets worth UAH 540 billion and 41.3 million hectares of agricultural land [14]. At the same time, the innovative activity of enterprises in terms of introducing technological innovations is only 0.1-0.2% of their total number [15].

The consequence of technological modernisation determines the current state of the agricultural sector. In an effort to adhere to the basic principles of agro-innovative development, it is necessary to consider the specifics of agricultural production [16]. They are primarily related to the main factor of agricultural production – land, in particular: close connection with the reproduction of living organisms, seasonal nature of production, high level of risks, etc. Besides, the features of the innovation process are the diversity of agricultural products and products of their processing, differences in production technologies, agrotechnical and climatic conditions depending on the region, territorial dispersion.

The special features of the introduction of innovative technologies in agriculture are the diversity

of enterprises by ownership forms – collective, private, open and closed joint-stock companies, cooperatives, LLC, state enterprises; farms, private farms, and, most innovatively active, holding companies. All of them operate on their own and leased lands, ranging from 2 to 10 thousand hectares.

The permanent rise in the price of fuel, mineral fertilisers, plant protection products, seeds (Table 1),

and other material and technical resources forces farmers to use them more efficiently and encourages them to introduce innovative technologies. The use of innovative technologies in agriculture allows to increase the profitability per 1 hectare due to the combination of optimal costs of material resources included in the cost price and maximum yield.

Table 1. Average price of material and technical resources and services, used in agriculture

	Year					
	2018	2019	2020	2021	2022 (6 months.)	2022 to 2018, %
Petroleum products	UAH per t					
motor gasoline	27123.8	25185.0	19980.7	28326.6	37983	140.0
gas oil (diesel fuel)	23863.2	21488.2	16466.1	28110.8	41602.9	174.3
Mineral fertilisers	UAH/q					
nitrogen	733.7	747.9	585.3	1337.4	29990	> 40 times
phosphorous	939.2	1001.0	909.3	1950	17750	> 18 times
potash	890.2	942.1	857.4	1457.6	21220	> 24 times
complex (concentrated NPK fertiliser)	1019.1	1169.2	1025.5	1800	25090	> 24 times
Plant protection products	UAH/kg					
Insecticides	388.9	460.5	374.1	762	1000	> 2.5 times
Fungicides	407.4	504.1	372.4	440	1436	> 3.5 times
Herbicides	728.6	268.4	905.8	1428	1181	162.1
plant growth regulators	107.5	180.8	79.5	175	470	> 4.3 times
Services	UAH/ha					
Crop protection	247.4	269.5	259.2	300	300	121.3
Plowing	697.1	717.0	721.9	600	850	121.9
Cultivation	379.0	433.3	426.8	400	600	158.3
Harvesting of agricultural crops	651.8	924.1	959.2	1,100	1500	> 2.3 times
Fertilisation	381.5	384.4	356.1	350.0	350	91.7

Source: compiled according to the State Statistics Service of Ukraine [14] and Agroantal [17]

The analysis of the table data shows that while the price of petroleum products, and, accordingly, services in agriculture for 2018-2022 increased by more than one and a half times, plant protection products – up to 4.3 times, and mineral fertilisers went up tenfold due to rising gas prices. This is due to the fact that the share of gas in the cost of fertiliser production is up to 80%, which is both raw material and energy carrier. Plant protection products, according to the results of the study, also increased in price. According to Ukrainian Agribusiness Club analyst Svitlana Lytvyn, the rise in price is caused by disruptions in the production of active substances for plant protection products by Chinese pesticide manufacturers, which are the largest in the world as a result of the energy crisis [18].

According to the World Bank, energy and food prices are expected to rise significantly in 2022. Its reason being Russia's war against Ukraine. According to forecasts, the rise in world energy prices will be at the level of 50.5% compared to 2021, with a further decrease by 12.4% in 2023. At the same time,

food prices are expected to increase by 22.9%, with a decrease of 10.4% in 2023. These data are presented in the quarterly report of the World Bank Commodity Markets Outlook Report [19].

Referring to the same resource, Markiyan Klymkovetskyi notes that, since the 1970s, the rise in energy prices in the last two years has been the most significant, and for food and fertilisers, of which Ukraine and the Russian Federation were the main producers, – the highest since 2008 [19].

The Russian military invasion of Ukraine in February 2022 resulted in material losses in agriculture of almost USD 4.3 billion. only in the first three months of the war. And this is almost two-year investment income in Ukrainian agriculture. Agricultural land was damaged, equipment was destroyed (approximately USD 1 billion), and livestock was killed [20].

Process charts are the main source of technological documentation. They include technologies of production, costs of material and labour resources, volumes of operations and means of production. For each culture, such maps are drawn up separately,

considering rational and advanced production technologies of enterprises.

The study analysed the standard costs of growing winter wheat at an agricultural enterprise in Vinnytsia Oblast. Their volume at a yield of 64 c/ha amounted to UAH 25,000 per 1 ha. Accordingly, the cost price of 1 ton of wheat was UAH 3,906. Material costs accounted for 60% of the total production cost. Therefore, their optimisation with innovative solutions can be substantial savings for the company.

In 2021, the average cost of growing cereals, legumes and oilseeds in the surveyed farm was UAH

30,500 per 1 ha. Although a significant share of material resources was acquired by the company in the previous season, in 2022 production costs are expected to increase by 30.2 % (from UAH 30,500 to 39,700 per ha).

Calculations have shown that it is possible to reduce material costs by up to 35% with the help of competent and timely application of agricultural innovations. Carrying out such measures by increasing yields and gross harvest will also help to increase income by USD 150-300 per ha. An example is the above-mentioned farm (Table 2).

Table 2. Efficiency of implementation of innovative technologies for growing winter wheat on the example of farms of Vinnytsia Oblast in 2022

	Costs under conventional technology		Costs with regard to innovative solutions		Reduce costs	
	UAH	%	UAH	%	UAH	%
Total cost price of crop production	25,000	100	19,700	100	5,300	100
Material costs	15,000	100	9,700	100	5,300	35.3
incl.						
Seeds and planting material	3,000	20	2,850	29.4	150	5.0
Mineral fertilisers	6,000	40	3,000	30.9	3,000	50.0
Fuel and lubricants	4,500	30	3,400	35.1	1,100	24.4
Plant protection products	1500	10	450	4.6	1,050	70.0
Depreciation	2,000	8	2,000	10.2	X	X
Labour Remuneration	2,000	8	2,000	10.2	X	X
Other expenses	6,000	24	6,000	30.5	X	X

Source: author's calculations

In 2022, there was an increase in regulatory costs for growing winter wheat to UAH 38,000 per 1 ha. The reason for this was the increase in the value of the main cost components – fuel, mineral fertilisers, plant protection products and other material and technical resources. The calculations showed a possible reduction of costs by 7,000-8,000 UAH due to the introduction of innovative solutions-precision farming technologies, energy-saving technologies, combined tillage units. Technical innovations will help to achieve positive results in agribusiness in 2022 despite the decline in yields and rising prices for material and technical resources.

Today it is impossible to solve the problems in crop production by conventional mechanical means. Precision farming technologies can do this. The current level of scientific and technological progress makes it possible to involve electronic automated systems and GPS in their solution. Along with the information function, they control compliance with the agrotechnical requirements of production to obtain the programmed yield with the specified quality characteristics. The basic principles of precision agriculture are determined by the use and management of mobile agricultural machines regardless of their location, selective application of fertilisers

and plant protection products depending on plant parameters and soil fertility in different parts of the field.

Statistics show that in the United States and Germany, 70-80% of agricultural producers use various elements of precision farming [21]. In Europe, precision farming technologies are used on an area of 0.5 hectares or more. Despite the high cost of such technologies, investments in their acquisition pay off within a year. About 90% of agricultural producers who have tried some elements of precision farming technologies, introduce their other elements.

According to the estimates of the analytical company Research and Markets, the volume of the global market for technical solutions for precision farming technologies will grow from EUR 2.7 billion in 2020 to EUR 3.7 billion in 2025 [22]. However, in Ukraine, precision farming currently covers only 15% of agricultural land.

The main users of precision farming technologies are large agricultural enterprises, farms and agricultural holdings that have an area of more than 1000 hectares and use powerful tractors of over 100 kW. They will benefit more from the installation of precision farming systems compared to low-power ones.

Systems of “precision farming”, assuming a complete system, are quite expensive for both small

and most medium-sized farmers. For example, the average price of autopilot for a tractor or sprayer (automatic driving system) is UAH 200,000, agrocopter – UAH 600,000, precision seeder – UAH 600,000, self-propelled sprayer – UAH 5 million. Furthermore, additional costs should be taken into account, because the seeder or autopilot will not operate on itself, it requires a tractor. The agrocopter also needs a mixing unit, a barrel and lighting (if the drone is used for spraying). Also, a vehicle for its transportation is a necessity. All these devices require trained specialists who could operate them. Therefore, the volume of expenses is actually much larger.

The Ukrainian market of technical means for precision farming, including sets of equipment, additional canopies and aggregates for machinery, software products, services and agricultural drones today is USD 60-70 million [23].

Due to the high costs of implementing precision farming technologies, its application is limited to large enterprises and agricultural holdings. The most innovatively active were: Kernel – USD 2.7 million per 540 ha; AR Group – USD 2.0 million per 400 ha; MHP – USD 2.5 million per 360 ha; Astarta – USD 1.0 million per 250 ha; IMC – USD 1.0 million per 124 ha; Harveast – USD 1.0 million per 123 ha; Epicentr – USD 420,000 per 112 ha [24].

The successful examples of the implementation of agro-innovations in Ukraine are the Astarta agricultural holding and Kernel. Using the GPS fuel consumption monitoring system, Astarta managed to reduce and save USD 15 million in 4 years, which is more than the annual investment volume of the seven largest agricultural holdings in Ukraine. Through differentiated fertilization, Kernel managed to save USD 120-300 per hectare, depending on the crop.

Despite the large initial investment in innovation, the invested funds are quickly recovered due to the reduction of time, material, and labour resources. Increased investment risks will be offset by rising global prices for food resources and will contribute to additional incomes of agricultural producers and an acceptable level of return on their investments.

Analysis of the effectiveness of implementing new technologies shows that the easiest way to switch to precision farming technologies with minimal costs is to analyse and map the soil. This makes it possible to increase the efficiency of technologies and reduce resource consumption by more than 20% [25].

Autopilot technology can save 10-15% of working time, 40 liters of fuel per 100 ha, 3% of seeds, 5% of plant protection products and, at the same time, improve the quality of technological operations [26].

It is possible to save 3-8% of seeds by accurately calculating the density of plant growth, considering soil fertility, humidity, and relief, by applying the technology of variable seeding rate. Seed drills with a differentiated seeding rate adjust the seeding rate depending on the specified conditions [27].

Parallel driving increases the efficiency of agricultural production by an average of 10%. In particular, it saves 10% of working time and, accordingly, 10% of wages, reduces depreciation of equipment

and fuel by 10%. A widely used innovative product is the spot spray system. Modern optics, along with computing capabilities, apply the herbicide only to the detected weed. It allows reducing its costs by up to 90% [28]. Simultaneous tillage, sowing with differentiated application of various types of mineral fertilisers reduces their consumption by up to 50%. Due to the complexity of the operation, 40% of fuel is saved [28].

The issue of trampling crops (3-5% when spraying with ground equipment) and damage to the tops of plants during spraying can be avoided by using agricultural drones. Another advantage of the agrocopter, as opposed to ground equipment, is the ability to work immediately after the rain and with the possibility of local processing of field areas [29].

Today in Ukraine, precision farming systems are used for 5% of arable land, and its individual elements for 20 %. In the current conditions, the use of resource-saving technologies of soil cultivation is also relevant in Ukraine. These are no-till, mini-till, strip-till, verti-till technologies. Working with these technologies, agricultural producers can increase the economic efficiency of production by saving fuel, reduce technological impact on the soil, increase the environmental friendliness of the process of growing crops by reducing weather and climate impact. The main disadvantages are significant initial costs for the purchase of equipment, the growth of weeds and pests in the fields, pesticide load on the soil.

Each tillage system has its own advantages and disadvantages. When deciding upon the adoption of one of them, it is necessary to consider the features of the relief of the field, the natural density of the soil, its chemical composition, the amount of precipitation and the temperature regime throughout the year. In addition, the choice is affected by the level of intensity of technology and biological characteristics of the crops grown.

By applying moldboardless tillage technology, it is possible to save 27% of fuel consumption on pre-sowing works, mini-till – 43%, no-till – 86%. Improvement of the structure of the machine-tractor fleet and rational aggregation of tractors contributes to saving up to 20% of fuel and lubricants, combined units of soil cultivation simultaneously with sowing, application of mineral fertilisers and pesticides – 10-15% [30].

Generally, the use of resource-saving technologies and combined soil cultivation units reduces general production costs by 15%, and minimum tillage and precision farming technologies – by 20%. The key condition for sustainable economic development and growth of the national economy is investment in innovations, which is why they are under the focus of the state's economic policy. New highly productive and technological activities will not be possible without investment resources and no diversification of the development of the Ukrainian agricultural sector will take place. Usually, the growth of capital investment as a basis for innovation precedes the growth of gross domestic product (Table 3).

Table 3. Dynamics of gross domestic product growth and capital investment in agriculture in 2010-2021

Year	Capital investments, mln UAH	Investment growth	GDP agricultural, mln UAH	GDP growth
2010	11311	1.16	195390	1.23
2011	16703	1.48	261331	1.34
2012	19086	1.14	269983	1.03
2013	18640	0.98	315546	1.17
2014	18388	0.99	381227	1.21
2015	29310	1.59	558788	1.47
2016	49660	1.69	655569	1.17
2017	63401	1.28	727352	1.11
2018	65059	1.03	871971	1.2
2019	58555	0.9	866138	0.99
2020	50189	0.86	766532	0.89
2021	62700*	1.25	876913	1.14
Average for 2010-2021	X	1,2	X	1.07

* – estimated

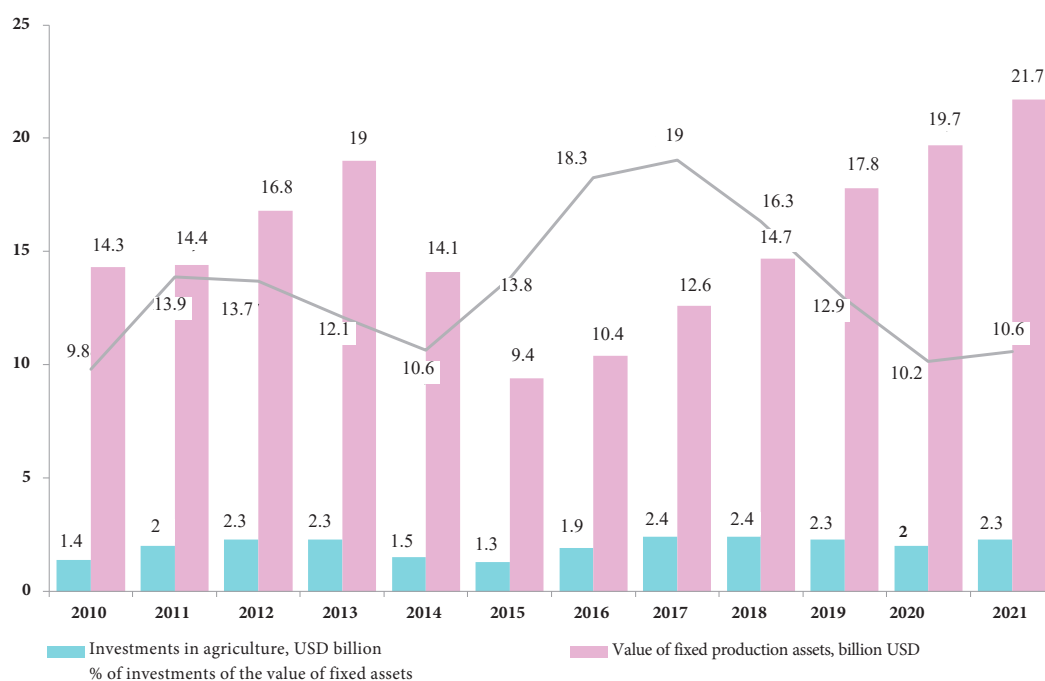
Source: calculated according to the State Statistics of Ukraine [14]

The role of investment support in the operation of the agro-industrial complex of the country is that investment resources allow the introduction of advanced technologies, the latest equipment, new highly productive varieties of plants and animal breeds, innovative forms of labour organisation and production management. Innovations, new technologies and organisational solutions allow enterprises to overcome crisis situations, ensure high competitiveness of products and enterprises.

After a small investment crisis in 2019-2020 (the decline in investment was up to 20%), in 2021

the investment and innovation activities of agricultural producers intensified and again reached a figure of over USD 2.3 billion which is one of the best results since Ukraine's independence (Fig. 1) [31].

There were expectations that this process would continue in 2022, but the war will negatively affect subsequent investment processes. During 2016-2021, the total amount of capital investments per 1 ha of agricultural land ranged from USD 70 to 100. However, the innovative modernization of the agrarian sector can only be considered if the investment is no less than USD 150 per ha [23].

**Figure 1.** Dynamics of the cost of fixed assets and investments in agriculture in Ukraine**Source:** calculated according to the State Statistics of Ukraine [14]

Mykola Kisil claims that the negative feature of the investment process in agriculture is the reduction of participation of small agribusiness in it. If its share in the total volume of capital investments in 2017 was 42.9%, then in 2018 – 37.6, in 2019 – 32.5, and in 2020 – 31.5%, in 2021 – less than 30.0% [32]. As for their share in the fixed production assets of agriculture, as can be seen from the figure, starting from 2017, it has been rapidly decreasing and in 2021 amounted to only 10.6% of the value of fixed assets.

Small businesses sell their products mainly to market intermediaries at lower prices. In addition, they have relatively higher risks of losing products and property as a result of raider attacks, fewer opportunities for lending and receiving state support, etc. More than 90.8% of all investments are funds of enterprises and organisations, 8.5% – bank loans and borrowings. The state's share is 0.43% [14]. Supporting and stimulating investment activities of small agribusiness entities should be one of the most important tasks of the state's agricultural policy.

The influence of large agribusiness on decision-making on the use of budget funds and the lack of transparency in the distribution of finances strengthen monopolism in the industry and restrain the investment processes for the development of small and medium-sized agricultural enterprises. The increase in agricultural raw material exports, which provides a fairly high level of profitability, negatively affects the development of both individual companies that lose incentives to invest additional investments, including in innovations, and the entire industry, as well as hinders the development of the processing industry.

The war in Ukraine will lead to a decrease in 2022 not only in the volume of exports of agricultural products and food but also in investment and innovation in the development of agri-food sectors of the economy. As a result of military operations and the occupation of part of the territory, more than 20 million tons of grain were blocked in Ukrainian seaports, most of which were intended for the UN World Food Programme [33].

Instead, the growth of world food prices will compensate only part of the loss of income of producers and increase the level of investment attractiveness of agriculture and food industry of Ukraine. Taking this into consideration, it is advisable for the national agribusiness, even in the conditions of war, to make the most of the opportunities to intensify investment and innovation activities. To this end, national, regional and local measures are needed to improve investment support for agribusiness development.

Scientists of the Institute of Agrarian Economics predicted an increase in investment activity in agriculture before the Russian military invasion of Ukraine. The volume of investments in the industry in 2022 should have amounted to UAH 72 billion. However, the impact of the war negates this forecast. It is likely that capital investments will decrease to USD 1.1-1.2 billion. [34], and investment resources

will mainly be used for simple reproduction of fixed capital, maintaining existing production capacities and replenishing working capital.

No significant changes should be expected in the structure of sources of financing for capital investments for agricultural development in 2022. It is assumed that the main source of investment financing will continue to be the own funds of enterprises and organisations (more than 90% of the total), which depend on the profits received. The projected volume of capital investments in 2022 will not fully ensure the creation of appropriate conditions for the expanded reproduction of Agricultural Capital, which in the future may negatively affect the production potential of the industry and the development of innovations.

During the war, it is possible to slow down the introduction of innovative technologies due to the reduction of capital investments, problems with the logistics of agricultural machinery, seeds, plant protection products, etc. Despite the difficulties, innovatively active enterprises will continue to implement innovative solutions.

The formation of an effective agricultural policy and giving it an investment-oriented character should be considered one of the most important tasks of the state policy of socio-economic development. Although innovative investments in agriculture play an important role, investors are still investing in the production of a limited range of the most profitable low-capital and export-oriented types of agricultural products, the creation of elevator capacities, and increasing logistics and export potential. At the same time, mainly machinery and technologies, seed material and plant protection products of foreign production are used. These features of innovations in the investment process led to the fact that most of the added value created in the National Agriculture flows out of the state, and the material and technical base of the national innovation infrastructure, especially agricultural science institutions, does not develop properly.

For the successful development of the agro-food sectors of the economy in Ukraine, it is necessary to form an appropriate agricultural policy following the example of OECD member countries, where through various mechanisms of state regulation the prices for sold agricultural products exceed the input prices for production resources, which is considered as support for producers. At the same time, production output and consumed resources are estimated in world market prices. In the vast majority of countries, the ratio between the output and input prices of agricultural producers for products and resources, as well as the share of their support, is now more than one, which allows producers to form their own sources of financing investments for expanded capital reproduction, and only in Ukraine this ratio is minimal or even negative [35].

Increasing the investment attractiveness of the agricultural sector can be achieved by carrying out national measures to reform the economy and state

institutions with the functions of protecting investors, ensuring conditions for the development of entrepreneurship, state investment support for small and medium-sized agricultural businesses, ensuring the interaction of scientific institutions with agricultural enterprises in order to quickly implement innovative ideas, international investment, innovation, scientific and industrial cooperation. These measures will be especially relevant in the post-war period.

► Conclusions

Thus, the widespread use of innovations and their investment support are essential elements of modern agricultural production. They will contribute to solving socio-economic issues in the agricultural sector related to the search for solutions to improve the economic efficiency of enterprises in the industry and food supply of the population. Investment and innovation development of agriculture will ensure its qualitative modernisation based on the growth of both production indicators and the improvement of the socio-economic mechanism of the agricultural sector and related industries.

This process should be accompanied by continuous use of the latest technologies for the production and processing of agricultural products, new agricultural machinery, plant varieties and animal breeds, and modern information technologies.

The main issues that currently prevail in the agricultural sector are the lack of investment resources, limited state support, inactive or partially effective legislation, and other problems caused by the war, which hinder the effective and high-quality investment and innovation development of agriculture in Ukraine.

However, it is worth noting that the use of the proposed measures to solve the problem of introducing investments and innovations in agriculture will improve the production process, increase the efficiency of using internal and maximise the attraction of external investment in the introduction of investment technologies. Thus, creating favourable conditions for investment and innovative development is a priority task for Ukraine. Otherwise, it is impossible to achieve economic growth, in particular, in enhancing the country's competitiveness in the world market.

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Інвестиційно-інноваційний розвиток сільського господарства України

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► **Анотація.** Необхідною передумовою сталого розвитку держави є інвестиційно-інноваційне забезпечення рівня її економіки. Згідно модерністської теорії економічного зростання гарвардського економіста Роберта Солоу, «економічне зростання має три складові: обсяг капіталу, обсяг праці та загальний фактор продуктивності (рівень технологій, інновації та якість врядування)». Завдання, які стоять перед агропромисловим виробництвом України, є стимулювання процесів накопичення та ефективне використання інвестиційних ресурсів за пріоритетами економічного зростання, перспективи розвитку інноваційної діяльності. Передумовою цього є макроекономічна стабільність, яка сприяє накопиченню внутрішніх та зовнішніх чинників і ресурсів шляхом підвищення довіри інвесторів до економічної регуляторної політики та зниження рівня ризику інвестиційної діяльності. Питання, висвітлені в статті, стосуватимуться, насамперед, таких важливих факторів у забезпеченні розвитку підприємств агропромислового комплексу як інновації та інвестиції. Вони знайшли своє місце в дослідженнях багатьох економістів, але управління інноваційними проектами та інвестиційною діяльністю для забезпечення економічної безпеки суб'єктів АПК недостатньо розроблені. Це визначає актуальність цієї статті. У процесі дослідження використано такі методи: діалектичний, системний підхід, монографічний, економіко-статистичний, табличний, графічний, порівняльний аналіз, абстрактно-логічний та аналітичне прогнозування. Метою даної статті є визначення сутності та особливостей аграрних інновацій, дослідження умов та факторів інноваційного розвитку АПК, оцінювання проблем і перспектив використання новітніх прогресивних технологій у сільському господарстві та їх фінансового забезпечення. Досліджено особливості впровадження інноваційних технологій в аграрному секторі економіки і виявлено, що агроінновації мають тісний зв'язок з агротехнічними умовами виробництва, мають зв'язок з живими організмами, мають сезонний характер і залежно від цього мають високий рівень ризику. Проведено аналіз матеріальних витрат на виробництво зернових та динаміку цін на них. На прикладі одного з господарств Вінницької області розраховано, як за допомогою технологій точного землеробства та енергоощадних технологій можна зменшити собівартість виробництва зернових культур. Виявлено основні тенденції інвестиційного забезпечення сільського господарства, зв'язок капітальних інвестицій і ВВП та з'ясовано їх роль в впровадженні агроінновацій. Запропоновано заходи з вирішення проблем впровадження інновацій в сільському господарстві

► **Ключові слова:** аграрний сектор, агроінновації, капітальні інвестиції, точне землеробство, технології обробітку ґрунту, продовольча безпека



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Assessment of Economic Efficiency of New Potato Varieties as Intellectual Property Objects

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► **Abstract.** In the context of market relations development and rapid changes in technological support and technologies, it is necessary for enterprises to use not only publicly available material and financial resources, but also to operate with non-material resources, namely intellectual property objects, to ensure competitive advantages. This is an effective approach to increase the profitability and competitiveness of the enterprise. Improving the methodology and organisation of evaluation of potato varieties for various economic purposes as intellectual property as part of intangible assets is relevant and allows determining the market value of the variety, eliminates errors in calculating the price, and contributes to profit. The purpose of the study is to develop methodological recommendations for assessing the value of potato varieties as an object of intellectual property. The study was based on theoretical elaborations of Ukrainian and foreign scientists. The materials of statistical reporting of agricultural enterprises engaged in the production of seed potatoes, developments of research institutions, data of the Ministry of Agrarian Policy and Food of Ukraine, the State Statistics Service of Ukraine were used for the research. The economic evaluation of breeding stages of creation of potato varieties for different economic purposes was carried out. Methodological approaches to assessing the value of potatoes as an object of intellectual property, and economic mechanisms for ensuring the acquisition of intellectual property rights and use of newly created potato varieties, have been developed. The stages of the breeding process of creating a variety from an economic point of view are studied. The most expenditure stages of breeding are determined. The importance of the direction of use of the variety and the impact on the cost of its creation are analysed. Methodological recommendations for estimating the cost of potato seeds have been elaborated, allowing to establish the payback period of the variety

► **Keywords:** potatoes, cost estimation, economic indicators, technical, table and diet varieties, costs

► Introduction

Potato growing is one of the priority branches of agricultural production in Ukraine. Ukraine is among the five leading countries in the world in terms of gross potato production. A further successful strategy for the development of potato growing is possible with the use of the latest scientific achievements, primarily breeding. Plant varieties are valuable objects of intellectual property in the agriculture of Ukraine and one of the most important factors of the enterprise activity, which guarantees successful business development. Although the identification of such objects as farm assets requires a qualified approach [1; 2].

Plant varieties are a popular and competitive product, and this is a reality. Today, more than 10 thousand plant varieties, including 194 potato varieties, are suitable for commercial distribution in Ukraine [3]. To become an object of property and generate income,

a variety must acquire legal protection, which is certified by a patent. The commercial carrier of the variety is seeds/planting material. And it is the patent holder who uses and disposes of the property rights to the variety and seed material of the variety [4].

All official methods of valuation of intellectual property, including varieties, are defined by National Standard No. 4 "Valuation of Intellectual Property Rights" [5]. Most often the assessment is carried out using the income approach, but also the cost approach or comparative (market) approach can be used. Thus, the income approach is that the value of rights to a variety is determined as a function of income. That is, what income can be generated by the use and/or disposal of this intellectual property in the future. According to O.V. Zakharchuk, "the cost approach is based on the assumption that the cost of an intellectual property object is equal to the cost

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of its creation, bringing it to working condition and depreciation" [4; 6]. Conventionally, if €1-2 million is spent on creating a variety in Europe, then the income from use should not be less than the costs [7].

The comparative (market) approach consists in comparing the object being evaluated with objects of similar purpose, qualities and usefulness that were sold during this time in a similar market. That is, the price is set by the market as fair and satisfies both the seller and the buyer [8; 9].

As a rule, the variety is effectively used in economic activity for at least 5-6 years or even during the entire period of validity of property rights – up to 30 years [1]. The main factors that affect the fair value of an object are as follows: rating, volume, term of use and, in accordance with the agreed interest, royalties [10].

In the process of assessing the value of the variety, it is necessary to ensure compliance with the provisions of legislative and regulatory legal acts of Ukraine. In practice, different approaches are used to determine the real value of intellectual property rights and the actual price of the license (permit), among which the most common are the so-called global, analytical and experimental methods [11; 12].

The methodological basis for research on the assessment of the cost of new varieties, including potatoes, and the efficiency of their production are theoretical developments of Ukrainian and foreign scientists. The economic efficiency of seed production and prospects for the development of seed production in Ukraine, along with the experience of commercial circulation and evaluation of the productivity of varieties are investigated in the works of V. Zakharov [13]; O. Zakharchuk [8; 14; 15]; M. Molotskyi; S. Vasylyvskyi; V. Kniazuk; V. Vlasenko [16]; V. Mosakovskiy [17]; O. Tomchuk, J.C. Stark, M. Thornton [18].

Despite the significant contribution of these researchers and the value of their findings, a number of unresolved issues remain. Assessment of the value of plant varieties as objects of intellectual property for scientific breeding institutions and institutions is one of the most urgent and pressing issues.

The research is based on the systematic and comprehensive study of economic phenomena and will be conducted using methodological approaches that are used in international practice [4]. The economic profitability of new varieties as objects of intellectual property that will improve the competitiveness of potatoes was also considered. To improve and change certain economic indicators for obtaining better quality seed material at low cost [16].

The materials of statistical reporting of agricultural enterprises engaged in the production of seed potatoes, developments of research institutions, data of the Ministry of Agrarian Policy and Food of Ukraine, and the State Statistics Service of Ukraine will be used in the study [3; 19; 20].

► Materials and Methods

The following methods were used to estimate the value of the variety: cost, analogues and income. The cost method is based on the principle of replacing the best and most efficient use of resources with a new variety, balancing the economic size and economic distribution of costs between the author of the variety and its consumer. The income method establishes the present value of future revenues expected to be received as a result of the use or alienation of intellectual property rights to a plant variety by assessing the annual expected effect of the implementation of property rights to this variety using discounting methods by year. The analogue method (comparative) determines the value of a variety based on actual cases of its sale in an active and transparent market of analogue varieties and if there is information about concluded transactions for the sale of property rights to analogue varieties, the results of a comparative analysis of the main indicators of similar plant varieties and adjustments to actual prices on the market of property rights to plant varieties [6; 14].

The methodological basis for research on the assessment of the cost of new potato varieties and the efficiency of their production are theoretical developments of Ukrainian and foreign scientists. Today, there are three classical approaches to the valuation of rights to potato varieties: cost, market and financial. The cost approach is based on the statement that the cost of a variety is equal to the cost of its creation, obtaining planting material and depreciation. The market approach is based on the method of sales comparison, that is, the newly created variety is compared with similar varieties that have been sold in a similar market. The financial approach involves setting the current value future income that is planned to be received through the use or alienation of property rights to the potato variety. At the same time, the annual estimated effect is calculated by applying discounting methods by years [1; 4; 21]. A number of methods have been applied in course of the research, the most significant of which are theoretical generalisation, comparison and analysis.

► Results and Discussion

In practice, various approaches are used to determine the real value of intellectual property rights and the actual price of a license. The study focused on potato varieties selected by the Institute of Potato Growing for table purposes: Fotynia, Mysteriya, Rodynna – medium ripening; Zhytnitsya – early ripening. In Tables 1-4, the cost of each of the varieties at each stage of the breeding process was calculated. Thus, according to the calculations, the cost of the Fotynia variety is UAH 1,000,000, while the cost of the Mysteriya variety is UAH 1,200,000, which is 20% more. This is primarily due to the cost of research to determine the complex of features: morphological, biochemical, and suitability for processing.

Table 1. Calculation of the cost estimate of the Fotynia variety

Years	Stages	Expenses, UAH
2007	Study of character collections and selection of samples for use by parental forms	120,000
2008	Conducting crosses in Polissya and Carpathians and obtaining hybrid seeds for breeding	70,000
2009	Study and selection in the first generation	70,000
2010	Study and selection of genotypes in the first tuberous generation by yield, shape, quantity and quality of tubers	80,000
2011	Study and selection by a complex of traits; yield, grade to the year of potatoes of the 1 st year, starchiness, phytophthora resistance	90,000
2012	The main test in the conditions of Polissya: yield, biochemical parameters, resistance to nematodes, phytophthora resistance, virus resistance, culinary qualities	90,000
2013	Competitive ecological trial of the first year in Polissya, Forest-steppe, Steppe: yield, starchiness, adaptability, quality, resistance to cancer, potato nematode, shelf life and suitability for processing	90,000
2014	Competitive environmental testing in different zones of Ukraine based on the same criteria. Propagation to the required volumes	90,000
2015	Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	100,000
2016	State variety testing of the 2 nd year. Distribution of planting material to all points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	100,000
2019	State variety testing. Listing in the register of plant varieties of Ukraine. Primary seed production	100,000
Total		1 000 000

Source: developed by the authors on the basis of accounting and breeding research data

Table 2. Calculation of the cost estimate of the Rodynna variety

Years	Stages	Expenses, UAH
2008	Study of character collections and selection of samples for use by parental forms	132,000
2009	Conducting crosses in Polissya and Carpathians and obtaining hybrid seeds for breeding	84,000
2010	Study and selection in the first generation	84,000
2011	Study and selection of genotypes in the first tuberous generation by yield, shape, quantity and quality of tubers	96,000
2012	Study and selection by a complex of traits; yield, grade to the year of potatoes of the 1 st year, starchiness, phytophthora resistance	108,000
2013	The main test in the conditions of Polissya: yield, biochemical parameters, resistance to nematodes, phytophthora resistance, virus resistance, culinary qualities	108,000
2014	Competitive ecological trial of the first year in Polissya, Forest-steppe, Steppe: yield, starchiness, adaptability, quality, resistance to cancer, potato nematode, shelf life and suitability for processing	108,000
2015	Competitive environmental testing in different zones of Ukraine based on the same criteria. Propagation to the required volumes	108,000
2016	Competitive ecological trial of the 1 st year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, keeping quality, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests	120,000
2017	Competitive ecological trial of the 2 nd year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, keeping quality, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests	108,000
2018	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	72,000
2019	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	72,000
2020	Listing in the Register of plant varieties suitable for distribution in Ukraine	
Total		1,200,000

Source: developed by the authors on the basis of accounting and breeding research data

The most expensive varieties are *Mysteriya* and *Zhytnytsya*, their price reaches UAH 1,300,000, which is related to the specifics of these varieties.

Thus, one variety has purple tubers and yellow flesh; the other variety has pink tubers and creamy flesh.

Table 3. Calculation of the cost estimate of the *Mysteriya* variety

Years	Stages	Costs, UAH
2008	Study of character collections and selection of samples for use by parental forms	143,000
2009	Conducting crosses in Polissya and Carpathians and obtaining hybrid seeds for breeding	91,000
2010	Study and selection in the first generation	91,000
2011	Study and selection of genotypes in the first tuberous generation by yield, shape, quantity and quality of tubers	104,000
2012	Study and selection by a complex of traits; yield, grade to the year of potatoes of the 1 st year, starchiness, phytophthora resistance	117,000
2013	The main test in the conditions of Polissya: yield, biochemical parameters, resistance to nematodes, phytophthora resistance, virus resistance, culinary qualities	117,000
2014	Competitive ecological trial of the first year in Polissya, Forest-steppe, Steppe: yield, starchiness, adaptability, quality, resistance to cancer, potato nematode, shelf life and suitability for processing	117,000
2015	Competitive environmental testing in different zones of Ukraine based on the same criteria. Propagation to the required volumes	117,000
2016	Competitive ecological trial of the 1 st year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests	130,000
2017	Competitive ecological trial of the 2 nd year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests	117,000
2018	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	78,000
2019	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	78,000
2020	Listing in the Register of plant varieties suitable for distribution in Ukraine	–
Total		1,300,000

Source: developed by the authors on the basis of accounting and breeding research data

Table 4. Calculation of the cost estimate of the *Zhytnytsya* variety

Years	Stages	Expenses, UAH
2008	Study of character collections and selection of samples for use by parental forms	143,000
2009	Conducting crosses in Polissya and Carpathians and obtaining hybrid seeds for breeding	91,000
2010	Study and selection in the first generation	91,000
2011	Study and selection of genotypes in the first tuberous generation by yield, shape, quantity and quality of tubers	104,000
2012	Study and selection by a complex of traits; yield, grade to the year of potatoes of the 1 st year, starchiness, phytophthora resistance	117,000
2013	The main test in the conditions of Polissya: yield, biochemical parameters, resistance to nematodes, phytophthora resistance, virus resistance, culinary qualities	117,000
2014	Competitive ecological trial of the first year in Polissya, Forest-steppe, Steppe: yield, starchiness, adaptability, quality, resistance to cancer, potato nematode, shelf life and suitability for processing	117,000
2015	Competitive environmental testing in different zones of Ukraine based on the same criteria. Propagation to the required volumes	117,000
2016	Competitive ecological trial of the 1 st year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, keeping quality, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests.	130,000
2017	Competitive ecological trial of the 2 nd year in Polissya, Forest-steppe and Steppe: adaptability, yield, starchiness, keeping quality, shelf life, processing and culinary qualities. Assessment of resistance to major diseases and pests.	117,000
2018	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	78,000

Table 4, Continued

Years	Stages	Expenses, UAH
2019	State variety testing of the 2 nd year. Distribution of planting material to different points of the State Service for the Protection of Plant Variety Rights. Propagation using seed measures	78,000
2020	Listing in the Register of plant varieties suitable for distribution in Ukraine	–
Total		1,300,000

Source: developed by the authors on the basis of accounting and breeding research data

Important indicators during the research is the structure of production costs for each of the varieties. Thus, in 2020, the production costs of Fotynia variety amounted to UAH 192,300 per 1 ha, Rodynna

variety – UAH 174,800 per 1 ha, Zhytnytsya variety – UAH 150,300 per 1 ha, and Mysteriya variety – UAH 199,300 per 1 ha (Table 5).

Table 5. Structure of potato production expenses in 2020

Expense items	Fotynia variety, UAH/ha	Mysteriya variety, UAH/ha	Rodynna variety, UAH/ha	Zhytnytsya variety, UAH/ha
Seed material	140,000	147,000	122,500	98,000
Fertilisers	8,300	8,300	8,300	8,300
Protective equipment	20,300	20,300	20,300	20,300
Fuel and lubricants	3,800	3,800	3,800	3,800
Labour remuneration	600	600	600	600
Storage expenses	11,900	11,900	11,900	11,900
Depreciation	6,800	6,800	6,800	6,800
Other direct and general production costs	600	600	600	600
Total	192,300	199,300	174,800	150,300

Source: developed by the authors based on accounting and reporting data of the Institute of Potato Growing

Naturally, production expenses vary from year to year, as they depend on inflation and market prices. Potatoes are a very capital-intensive crop. Although, when fully realised, its profitability is expected to be very high. This is related to the price on the market and also depends on the sales channels. Usually, food potatoes do not have a sufficiently high price on the market, for example, compared to seed potatoes. Potatoes intended for processing into starch will be lower in price than food potatoes. This determines the level of profitability.

According to the research of the Department of Scientific and Economic Research of the Institute of

Potato Growing, the planned indicator of profitability of potato production by varieties is (Table 6): Fotynia variety as a food potato, which will be sold at an average market price of UAH 42 per kg – 243.2%; Rodynna variety with an average selling price of UAH 35 per kg – 286.2%; Zhytnytsya variety at a price of UAH 28 per kg – 399.0%; Mysteriya variety, provided that such potatoes are sold at a price of UAH 42 per kg – 351.6%. The most expensive is the Mysteriya variety. However, it did not provide high yields and is quite laborious and demanding to grow. Thus, the Zhytnytsya variety has the highest percentage of profitability in the presence of a fairly low production cost.

Table 6. Estimated economic indicators of potato production for different uses

Economic indicators	Fotynia Variety	Mysteriya Variety	Rodynna Variety	Zhytnytsya Variety
Expenses, UAH per ha	192,300	199,300	174,800	150,300
Yield, t/ha	55	60	45	50
Cost price, UAH per 1 ton	3 496,4	3 321,7	3 884,4	3 006,0
Sales revenue, UAH	660,000	900,000	675,000	750,000
Net income, UAH	467,700	700,700	500,200	599,700
Profitability, %	243,2	351,6	286,2	399,0

Source: developed by the authors based on accounting and reporting data of the Institute of Potato Growing

In 2019, the income from the main activities of the Institute of Potato Growing, that is, from the sale of varieties as objects of intellectual property, amounted to UAH 1,506,588. In 2020, these figures increased and amounted to UAH 1,765,639. As of 2021, the income amounted to UAH 3,867,380 which is 61% more than in 2019. This trend indicates the economic efficiency of new varieties as objects of intellectual property, increasing the level of their profitability, and the total income of the institution.

► Conclusions

Increasing the volume of potato production, reducing costs and increasing profitability is the main task of producers. The variety in modern economic conditions is of exceptional importance, and the use of new-generation varieties is the most affordable and cost-effective step to obtain additional gross yields. In our research, the varieties showed a yield of 45-60 t/ha, the cost of 1 ton of products is UAH 3.0-3.88 thousand, the level of profitability is 243-399%. The share of newly bred high-yielding potato varieties in

the increase in yield is 35-40%. Potato growing in the issues of ensuring food security of the state is a strategic branch of agricultural production, further development of which is impossible without improving the efficiency of the current system of breeding and seed production. The guarantor of increasing potato production, as evidenced by world experience and numerous publications, is timely variety replacement and variety renewal. Therefore, producers of various forms of ownership need to constantly update the line of potato varieties in farms, use high-quality seeds of high generations, which in turn will be the key to improving the efficiency of potato production and significantly affect the level of demand for newly created varieties.

The formation of economic relations on the basis of calculations based on the market price of the license object, the licensee's operating income, the licensee's expenses for the creation of new varieties will allow to develop and improve the market of intellectual property, including in potato growing.

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Оцінка економічної ефективності нових сортів картоплі як об'єктів інтелектуальної власності

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► **Анотація.** В умовах розвитку ринкових відносин і швидкої зміни технологічного забезпечення та технологій підприємствам для забезпечення конкурентних переваг необхідно використовувати не лише загальнодоступні матеріальні та фінансові ресурси, а й оперувати ресурсами не матеріального характеру, а саме об'єктами інтелектуальної власності. Це слугує дієвим способом підвищення прибутковості і конкурентоспроможності підприємства. Удосконалення методики й організації оцінки сортів картоплі різного господарського призначення як інтелектуальної власності у складі нематеріальних активів є актуальним і дозволяє визначити ринкову вартість сорту, унеможливорює помилки у розрахунку ціни, сприяє отриманню прибутку. Метою статті є розробка методичних рекомендацій з оцінки вартості сортів картоплі як об'єкта інтелектуальної власності. У процесі дослідження використано теоретичні розробки українських і зарубіжних вчених. Для досліджень використані матеріали статистичної звітності сільськогосподарських підприємств, що займаються виробництвом насіннєвої картоплі, розробки науково-дослідних установ, дані Міністерства аграрної політики і продовольства України, Державної служби статистики України. Здійснено економічну оцінку селекційних етапів створення сортів картоплі різного господарського призначення. Розроблено методичні підходи до оцінки вартості картоплі як об'єкту інтелектуальної власності, а також економічні механізми забезпечення набуття прав та використання інтелектуальної власності на новостворені сорти картоплі. Досліджено етапи селекційного процесу створення сорту з економічної точки зору. Визначено найбільш затратні етапи селекції. Проаналізовано важливість наряду використання сорту та вплив на вартість його створення. Розроблено методичні рекомендації щодо оцінки вартості насіння картоплі, що дає змогу встановити термін окупності сорту

► **Ключові слова:** картопля, оцінка вартості, економічні показники, технічний, столовий та дієтичний сорти, витрати



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Post- and Neo-Industrial Technologies in the Post-War Development of the Agrarian System in Ukraine

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► **Abstract.** The study focuses on the identification of directions of innovative development of the agrarian system of Ukraine in the war and post-war periods. The relevance of solving this fundamental scientific and practical task lies in the fact that the agrarian structure of Ukraine in modern socio-economic conditions requires the introduction of new and fundamentally different from the pre-war ways of development, which would make the most of modern science-based methods of development of organisational and legal entities. The purpose of the study is to outline the challenges facing Ukrainian agriculture in the post-war development of the agrarian system and their solutions based on post- and neo-industrial technologies. System-structural analysis and synthesis, monographic, historical methods, methods of abstraction and economic comparisons were used in the investigation. Theoretical and methodological included concepts, provisions, findings presented in the academic publications of Ukrainian and foreign scientists, theories of innovation, communication, information technology. The study considered the substance of technological structures and their influence on economic development in the historical aspect, along with modern models of industrialization and the level of innovative development both in Ukraine and other world countries. The results and challenges of the innovative development of the agro-industrial complex of Ukraine for 2000-2020 are analysed, the branches whose low rates of development threaten the food security of the country and the further development of the agro-industrial complex, in particular the challenges and threats caused by the Russian Federation's full-scale war and occupation of part of the territory of Ukraine, are highlighted. Modern innovative post- and neo-industrial technologies (in particular, technologies of drip irrigation, production of vegetables in the closed ground, precision farming, production of vegetable meat, etc.) were identified and singled out, the broad introduction of which in the post-war period will not only restore the pre-war potential of the agro-industrial complex, but also ensure its further competitive development. The obtained conclusions and findings can be used in practice: enterprises, rural and urban households – producers of agricultural products and food products on the widespread introduction of drip irrigation technologies, greenhouses, precision farming and robotics, non-animal production of meat and dairy products with high efficiency; specialised scientific institutions and start-ups on the deployment of extensive research towards the creation of new innovative post- and neo-industrial technologies for the production of agricultural products and food; state executive authorities to stimulate the widespread introduction of these technologies to ensure post-war recovery and further competitive innovative development of the agro-industrial complex

► **Keywords:** agro-industrial complex, post-war development, innovative technologies, efficiency, agricultural policy

► Introduction

As a result of the denationalisation and privatisation of agricultural enterprises by 2010, instead of the collective and state farm system, the agrarian system, which can be defined as "private-rental", was formed in independent Ukraine. Its characteristic features are private ownership of land, property and production results, the introduction of a limited

agricultural landsational and legal forms of the market economy [1].

In 2020, agricultural production was carried out by a total of 47,523 agricultural enterprises on an area of 20252,4 thousand hectares, including 31,851 farms on an area of 4280,1 thousand hectares of agricultural land. The majority of agricultural production

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for the needs of the domestic agro-food market has moved to the household sector, which now owns 14418,7 thousand hectares, or 34.9% of the country's agricultural land [2]. The leading export positions were occupied by large transregional integrated corporate agro-industrial associations and groups (so-called agro holdings), which, according to recent estimates, control about 8.7 million hectares (21.1%) of the country's agricultural land [1].

The volume of gross agricultural production (in constant prices of 2016) from 2000 to 2020 increased by 162.6%, including in agricultural enterprises by 246.6% (in particular in farms by 721.6%), in family farms by 110.8%. At the same time, the share of family farms in the production of gross agricultural output, which in 2000 was 61.6%, during this period decreased to 35.4% due to a significant increase in production volumes both in agricultural enterprises and in farms [2].

Exports of agricultural products during this period have increased by over 25 times. Ukraine, which was an importer in the second half of the twentieth century, has become an exporter of agricultural products. According to the data for the year 2020, the foreign trade turnover of agricultural products amounted to \$ 28.7 billion, of which \$ 22.2 billion accounted for agricultural exports, which accounted for 39.8% of Ukraine's total exports [2]. Ukraine's share in world grain exports is currently about 10%, which makes it possible to feed about 400 million people [3].

These gains were achieved due to the denationalisation and privatisation of agricultural land and property of former collective and state farms and the transparency of the economy of the democratic state of Ukraine, which created conditions for the entrepreneurial initiative of farmers in the implementation of organizational, economic, technical, and technological innovations accumulated in the world practice. Hardworking and educated farmers began to introduce new productive varieties of agricultural plants, new high-performance machinery, widely use plant protection products, other components of advanced technologies of agro-industrial production and elements of precision farming, and the agriculture of Ukraine firmly embarked on the path of innovative development.

The issues of innovation processes, innovations, organisational and technological modes of economic development are studied by renowned scientists: M. Tuhon-Baranovskyi, who formulated the law of investment theory of cycles [4], J. Schumpeter, who introduced the concept of innovation in the theory of economic development [5], S. Glazyev on the evolution of technical and economic systems [6], J. Keynes on the theory of state anti-crisis regulation of the economy [7], V. Vasilenko, L. Gurieva, M. Parkhomets on the evolution of technological devices [8-10], O. Shabluk, L. Antoniuk, O. Datsiy on the development of innovative processes in agro-industrial production of Ukraine [11-13], M. Rudenko on digitalisation of management and precision farming systems in agricultural enterprises [14] et al.

At the same time, the restoration of the economies of countries, minimisation, and elimination of the consequences of military conflicts in the context of globalisation requires conducting scientific research to provide not evolutionary, but revolutionary ways to support the innovative development of agro-industrial production.

In February 2022, Russia waged a large-scale war against Ukraine. The hostilities resulted in the bombing of thousands of apartment buildings in cities and rural households of Ukraine, tens of thousands of agricultural lands were mined, production and social infrastructure (including in rural areas) were completely or partially destroyed, agricultural machinery, grain and fertilisers were stolen from the temporarily occupied territories and taken out of Ukraine, many farm animals were killed, logistics of Ukrainian exports was disrupted due to the blockade of ports on the Black and Azov Seas.

The State Statistics Service is not yet able to record the exact statistics of damage caused by hostilities, but according to rough estimates of the Ministry of Agrarian Policy, in 2022, about 30% of agricultural land will be withdrawn from agricultural turnover, and given the difficulties in providing resources, the expected gross harvest of agricultural crops will be about 40% lower compared to 2021 [3]. And although the country's food security will be generally maintained, the volume of agricultural exports will fall significantly with all the negative consequences for the economy of the state and the threat of hunger for the whole world.

An issue of post-war restoration of agro-industrial production in the country and ensuring further increase of its competitiveness has become apparent. According to the author, the information presented in this investigation can serve as a public search for solving this problem.

The purpose of the study is the formation of avenues and approaches to the modernisation of the agrarian system in the post-war conditions of development of Ukraine on the basis of post- and neo-industrial technologies.

► Materials and Methods

The study used:

- system-structural analysis and synthesis for determining the periods of technological modes of production, monographic and historical methods for outlining the evolutionary, process-historical provisions of the formation of the theory and methodology of development of industrialisation models of the world, which made it possible to determine the main directions of further innovative development of agro-industrial production in Ukraine.
- Methods of abstraction and economic comparisons to determine the essential provisions of institutional transformations and develop proposals on ways to improve the institutional environment aimed at establishing conditions for the formation of innovative development of the agrarian sector of the national economy.

– Theoretical and methodological basis: concepts, provisions, conclusions presented in the studies conducted by Ukrainian and foreign scientists, theories of innovation, communication, information technologies

Besides scientific publications [6; 7; 11], a large number of publications on the exchange of leading practices and promotional materials on the Internet [15; 16; 17], data from statistical collections “Agriculture of Ukraine” [2], and also operational data and forecasts of the Ministry of Agrarian Policy for March-April 2022 [3] were used in the study.

► Results and Discussion

It was J. Schumpeter who noticed that the development of innovations is discrete in time. He called the

periods of time when there is a surge in innovation “clusters” (bundles). Other researchers use the terms “waves of innovations”, “technical and economic paradigm” for this phenomenon [8; 18], in Russian literature the phrase “technological way of life” is used [6; 9], in Ukrainian literature the term “technological structure” is used more often in recent years [19]. According to the academic dictionary, the structure is an established social order, a system of organisation. The technological structure is several interconnected and successive generations of equipment and technologies that evolutionarily implement the general technological principle [20]. From a historical perspective, there are 7 technological systems that succeed one another in the process of innovative development (Table 1).

Table 1. Periodisation of technological paradigm

No. of tech. of paradigm		Year	Key factor	Core of paradigm
First		1772	The invention of spinning machines	Textile industry, the mechanisation of labour, the establishment of mass production
Second		1825	The invention of the steam engine	Steam shipping, coal mining, railways
Third		1875	Inorganic chemistry (converter, dynamite)	Ferrous metallurgy, railways, shipbuilding, production of explosives
Fourth		1908	The internal combustion engine, conveyor production, wired telephone service,	Automotive industry, aircraft construction, petrochemicals
Fifth		1971	Advancements in microelectronics, computer science, biotechnology, genetic engineering, new sources of energy, materials, space exploration, satellite communications, etc.	Electronic industry, computer engineering, fiber-optic equipment, software, telecommunications, robotics, natural gas production and processing, information technology
Sixth	2004	nanotechnology, cellular technologies	Nanoelectronics, molecular and nanophotonics, nanomaterials and nanostructured coatings, nanosystem engineering, biotechnology, nanobiotechnology, information technology, Cognitive Sciences, socio-humanitarian technologies, convergence nano-, bio-, info- and cognitive technologies	–
Seventh	~2060	The era of cognitive technologies	Cognotropic drugs, cognitive assistants, virtual interfaces that carry out communication of the “human-computer” type, adaptive support systems	–

Source: developed by the authors based on [9; 10; 21]

On the basis of the summary of publications on the evolution of technological structures, the Institute of Encyclopedic Research of the National Academy of Sciences of Ukraine identified the following modern models of world industrialisation [22]:

- traditional industrialization – with a predominance of extractive industries, heavy and low-tech mechanical engineering with technologies mainly of the 3rd and 4th paradigmes, being modernised to meet the modern market challenges;

- necroindustrialisation – the state of the industries with the sectors of the 3rd and 4th paradigmes, which are experiencing the processes of deindustrialisation of the first type, i.e. reduction of production capacities due to their physical deterioration and lack of market demand for products;

- post-industrialisation – transition to technologies of the 5th paradigm, which is accompanied by processes deindustrialisation the second type, that is, the withdrawal of low-tech industries outside

the country, the introduction of modern high-tech production facilities focused on the production of products with a high share of added value, informatisation of society, and the development of modern high-tech services;

- neoindustrialisation – transition to technologies of the 6th paradigm, with the production of high value-added products, characterised by individualisation, nanotechnology, biotechnologisation, cognitisation, development 3D printing, and reindustrialisation that is, an increase in jobs in the national economy based on these technologies, mainly in the small and medium-sized businesses.

In developed countries (USA, Germany, England, France, Japan, China, etc.), 5th paradigm technologies predominate, and 6th paradigm technologies are being formed. The economy of Ukraine is still characterised mainly by technologies of the 3rd and 4th technological paradigm (their share in industrial production is about 96%, the share of industrial products of the 5th and 6th paradigmes is 4%). The volume of production and investment of capital for technical re-equipment and modernisation of the agro-industrial complex is mainly at the level of the 3rd technological paradigm. Therefore, Ukrainian industrial goods and food products cannot compete on the world market, and the Ukrainian economy, including the agro-industrial complex, remains mainly raw materials [12].

It is necessary to introduce innovative technologies of the 5th and 6th technological paradigmes to ensure further development of the country's agro-industrial complex and increase its competitiveness, and, consequently, to carry out post-industrialisation and start neo-industrialisation of agriculture at an accelerated pace.

Thus, rather than restoring the pre-war state of agriculture, it is advisable to address the challenges of its development through the introduction of equipment, technologies and organisation of agricultural production and high value-added food production based on post- and neo-industrialisation technologies.

Based on the summary of the findings of scientific research and world practices [10; 21; 22], the authors of this paper identified the main post- and neo-industrial innovative technologies, the development and implementation of which, along with the post-war restoration of the potential of the agro-industrial complex, will ensure the innovative development of its main sectors [12].

Post-industrial technologies in vegetable production. First of all, we pay attention to the branches of vegetable, berry and fruit growing, since the production of these low-tech industries in the pre-war 2020 was concentrated mainly in family farms (respectively 84.6% and 83.21%), and the level of self-sufficiency of the country's population in agricultural products of these industries, according to the State Statistics Service, was respectively 104.6% and 75.9%, that is, barely met the needs of the country's population [2].

During the First and Second World Wars the project "VICTORY GARDENS" was implemented in the USA, Great Britain, Canada, Australia, and Germany and which included vegetable, fruit and herb gardens planted in private residences and public parks. They helped these countries to survive in the most difficult times. A similar picture is observed in Ukraine, where the industrial production of tomatoes, onions, fruit, and melons is concentrated mainly in the South, which is temporarily occupied. Therefore, the Ministry of Agrarian Policy and the Ministry of Community Development have started implementing such a project in Ukraine. According to project experts, due to military operations in 2022, Ukraine may lose about 68% of the tomato crop. As a result, if big and family farms fail to cover domestic demand, Ukraine will have to raise imports. Experts also report disappointing estimates for the production of onions, eggplants, fruit and melons [15].

As for the production of cucumbers, berries, leafy greens, cabbage, etc., the industrial output of these products to supply urban residents is concentrated around the cities, and due to the specifics of the hostilities for their defense, a significant part of private farms and agricultural enterprises in the combat zone are looted, contaminated, mined, and the agricultural land is subject to reclamation. And if rural farms and a small part of urban farmers will be able to satisfy the basic needs for berry and vegetable products through their cultivation on their backyards and summer cottages (gardens), the majority of urban residents will face a significant increase in demand over supply with all the financial and quality consequences. The most rational solution to this issue is to develop drip irrigation, greenhouse, and greenhouse farming, including vertical farms in urban environments.

Drip irrigation is a method of rationed watering of all types of garden and vegetable plants. It consists in supplying water in small portions directly to the roots. The liquid enters through droppers located above the soil near each plant. Thus, only the soil covered by the root system remains moist, and water is supplied directly to the roots.

Drip irrigation technology was invented in the 1950s in Israel, when the young state began to develop its desert lands. Having used it in the most acute water shortage, the Israelis have developed a powerful agricultural industry and achieved a high level of greening of arid territories in 10 years. This made it possible to increase crop yields by 50% and save up to 40% of water. Today it is widespread in the Middle East, Israel, India, Spain, South and North America [23].

Climate change in recent years has exacerbated this particular problem in Ukraine. Therefore, rational use of energy and water is relevant in all regions. Drip irrigation systems allow [16]:

- * increasing the yield by 2-3 times;
- * saving water, fertilisers, and electricity;
- * reducing labour costs;

- * getting higher early yields;
- * limiting weed growth;
- * avoiding burns and mechanical damage to the leaves;
- * minimising the development of fungal and bacterial contamination;
- * applying active substances directly to the soil;
- * eliminating erosion of the topsoil;
- * maintaining air permeability of the soil;
- * watering with minimal working fluid pressure.
- * automating the irrigation process;
- * providing water to all types of plantings – beds, bushes, large-sized trees, and greenhouses.

Pioneering farmers and rural farm owners in Ukraine are already actively using drip irrigation technologies in their operations, and equipment for drip irrigation systems is widely available in online stores and construction markets. The next step is to encourage farmers and rural communities to adopt these technologies on a large scale.

Greenhouse farming and production of indoor vegetables. Vegetables and other products grown with these technologies are kept in special cultivation facilities:

- greenhouses with solar, biological or technical heating, intended mainly for growing seedlings and vegetable products;
- tunnels on film shelters or insulated soil for heating plants in early spring, growing mushrooms;
- greenhouses equipped with heating, lighting, water supply and ventilation systems;
- greenhouses for the cultivation of exotic fruits, flowers and equipment of places for recreation.

Greenhouse vegetable growing is an intensive form of production, characterised by a high degree of technological development and allows growing vegetables and other greenhouse products throughout the year, providing 25-40 kg of products from 1 square meter of winter or block greenhouses. Spring greenhouses have fewer heating devices and can be made of film. In these facilities, vegetables are grown from April to October, using the sun, biofuels, and electric energy as heat sources. The productivity of spring film greenhouses is 15-25 kg of vegetables per 1 sq. m [16].

Greenhouses in the Netherlands, which cover almost 10 thousand hectares, have increased the production of agricultural products by 15 times. Half of these greenhouses are vegetable greenhouses, the rest are used for growing flowers and fruits. Despite the high cost of indoor production, its output due to a much higher price in the winter-spring period allows receiving guaranteed profits. In addition, the influence of soil and climatic conditions on the final cropping result is thus minimised [23].

Vertical farms. These are greenhouses with a multi-tiered arrangement of plants. They are “stuffed” with high technologies that control climate, water, and lighting. Such farms can be placed not only on the ground but also on the roof and in the basement. Their dimensions range from a meter-long cabinet or cargo container to a large greenhouse complex. The main advantages are efficient use of

space and water, being independent of the weather, accelerated crop ripening, and the ability to harvest crops all year round. Plants do not grow in the soil, they are grown by hydroponics and aeroponics. Pesticides are not used, so the products are environmentally friendly. In international practice, vertical farms gained popularity in the last 20 years in various structural modifications, in particular [24]:

Vertical modules in basements, rooms or roofs are installed in private or apartment buildings in urban areas. Thus, Estonians expressed the aspiration to have healthier foods at home in 2009. The startup Click&Grow has developed “smart” baskets and cabinets for growing greens, herbs, tomatoes, which are in great demand [25].

Refrigerator cabinets. They are installed at home, in offices, restaurants, and even supermarkets. In such greenhouses mainly greens are grown, less often – other vegetables. The modules of the German manufacturer Infarm are popular around the world. Its cabinets-refrigerators are available in Canada, USA, Europe [24].

Sea Containers. This idea was brought to life by Kimball Musk's company Square Roots. The first system was installed in New York. The entrepreneur wants to supply container farms for growing herbs, vegetables, and strawberries in all cities of the United States [24].

Large greenhouse farms consist of horizontal layers stacked vertically, equipped with IT technologies for climate control, dosed supply of water substrate, etc. They are built in many countries of the world mainly in cities or suburban areas to reduce the cost of logistics and improve the quality of products sold.

Thus, the vertical farm of the company CAN-Agri from South Africa is located in Pretoria and looks very different from a typical greenhouse. It consists of rows of vertical “plant walls”, which are placed in a structure with sufficient space between the rows – so that each wall fully receives plenty of sunlight. The irrigation system pre-processes the water, dispenses fertilisers, and then disinfects the water for irrigation and reuse [26].

French vegetable producer Lufa Farms has announced the construction of its fourth rooftop greenhouse in Montreal. The building will have an area of 163,800 square feet (about 3 football fields), making it the largest rooftop farm in the world and will feed 2% of Montrealers with fresh local vegetables [27].

The Dutch company Havecon is completing the construction of a high-tech greenhouse in New York, USA. This large-scale greenhouse project is called “Green Empire Farms” (GEF) and involves the construction of greenhouse complexes in 7 locations. They will grow berries, tomatoes, cucumbers, and peppers [28].

The main advantages of vertical farming are environmental friendliness, fast harvests and proximity to the buyer. Compared to traditional agriculture, vertical farming can grow 350 times more produce in the same space, using 95% less water and 95% less fertiliser [27].

Ukraine is already developing projects to replace bombed and damaged apartment buildings with modern residential complexes with bomb shelters, supermarkets, restaurants, etc. Vegetable vertical modules of various capacities should also feature prominently in these projects, thus accelerating the development of urban vegetable growing and the level of provision of citizens with vegetable and mushroom products. It is necessary to stimulate entrepreneurship development in this area both on the part of private entrepreneurs and condominiums. At the same time, it is desirable to implement programmes to support drip irrigation and greenhouse vegetable production projects of suburban households and family vegetable farms.

Post-industrial technologies for the production of grain and industrial crops. Enhancing the farming culture and development of industrial and intensive technologies for growing grain and industrial crops based on the use of new high-performance machinery, high-yielding zoned varieties, resource-saving and water-saving methods of soil cultivation, compliance with scientifically based crop rotations, seeding rates, fertilisers and pesticides, etc. allowed to increase yields from 2000 to 2020:

- grain and leguminous crops from 19.4 to 42.5 c/ha, or 2.2 times;
- sugar beet from 176.7 to 461.1 c/ha, or 2.6 times;
- sunflower seeds from 12.2 to 20.2 c/ha, or by 165.6%.

The production volumes of export-oriented cereals and legumes increased to 64.9 million tons or 2.7 times, sunflower to 13.1 million tons or 3.8 times, and sugar beet for sugar production mainly for domestic needs decreased to 9.1 million tons or 30%. Exports of cereals and legumes, including products of their processing in terms of grain, reached 52.2 million tons, and in terms of sunflower oil exports, Ukraine firmly ranks 1st in the world [2].

However, in 2022, according to the forecasts of the Ministry of Agrarian Policy [3], due to hostilities, the volume of grain exports may decrease to 21.0 million tons, sunflower oil – up to 40%, which may cause a global food crisis.

Therefore, the agro-industrial complex of Ukraine faces the challenge of raising the production of grain and industrial crops on the sown areas. This can be achieved through the widespread adoption of post-industrial IT technologies for precision farming.

Precision farming is a comprehensive high-tech agricultural management system that includes global positioning technologies (GPS), geographic information systems (GIS), yield monitoring technologies, variable rate technology, remote sensing technologies (RS) and Internet of Things solutions.

Precision farming technologies are based on the concept of managing crop yields in accordance with the conditions of each specific field, rather than solely on the scientifically based recommendations of agronomists for their cultivation, in particular, natural and climatic zone.

Each specific field, and even its individual parts, may have a different configuration, different qualitative composition of nutrients in the soil, different moisture content, contamination, etc., which, with an average approach to agricultural technology of growing a particular crop, leads to overspending of fuel, fertilisers, pesticides and herbicides, labour, etc., and shortage of crops due to suboptimal conditions for growing crops in this particular field. Therefore, the technology of precision farming is faced with the task of creating optimal conditions for growing a particular crop in each specific field.

This requires:

1. Collection of data on agrochemical and agro-physical properties of soil on the basis of space monitoring data, aerial photographs using agrodrones, special analytical sensors in certain areas of the field and their positioning in the GPS positioning system.

2. Research and accumulation of the collected data using special software of electronic field maps with the help of geographical information system (GIS), yield maps using Yield Monitor Technologies and determination of the exact number of resources needed using Variable Rate Technology, formation of an environmentally friendly plan for agricultural operations.

3. Automated performance of agricultural operations with reference to the specific features of each field. For this purpose, the following most popular elements of precision farming are used:

- autopilot and direction finder (agronavigator) – when installed on agricultural machinery (tractor, combine) allows to avoid skips or blocking of passes of machinery during pre-sowing tillage, sowing, crop care with the application of fertilizers and plant protection products, harvesting. A significant reduction in the consumption of fuel, seeds, fertilizers, plant protection products (up to 30%) is achieved, prevents crop losses during harvesting, makes it possible to cultivate fields in case of deteriorating visibility (at night, in fog, smoke, dust);

- system of automatic shutdown of sprayer sections – turning off sprayer sections when applying liquid fertilisers and plant protection products during overlaps and depending on the presence of nutrients in the soil, plant pests and weeds in certain areas of the field. It significantly saves the cost of fertilisers and plant protection products, prevents excessive processing of crops with herbicides and fungicides. Allows saving 4-6% of fertilizers and plant protection products on fields of regular shape and up to 20% – on fields with complex geometry [14];

- the system of automatic shutdown of seeder sections and its equipment with seeding monitoring sensors – implements the technology of precision sowing, depending on the seeding rates of plant varieties and agrotechnical and agrochemical characteristics of the soil in different parts of the field determined using the field map and yield. Significantly saves seed consumption, ensures optimal crop density;

- retrofitting the spreader for differentiated application of manure and granular fertilisers depending

on the content of nutrients in the soil in certain areas of the field. It allows saving 10-15% of manure [14];

- drone, UAV – for alternative application of fertilisers, plant protection products by spraying from the air and monitoring the condition of the fields. Solves the issues of trampling, soil compaction and damage to the field drying out. Compared to the ground sprayer, investment and operating costs are 2-3 times lower [14].

The introduction of precision farming requires extensive investment. The practice of its implementation shows that these investments pay off when the size of the farm is 500 hectares and above. Therefore, most small agricultural enterprises and family farms introduce elements of precision agriculture gradually, making an investment calculation for the implementation of each element, or, if profitable, using the services of maintenance enterprises, which are becoming more and more numerous in Ukraine [14].

Since 2010, with the development of robotics, various modifications of autonomous (unmanned) tractors – robot tractors – have appeared on the market. Thus, built on the basis of the John Deere 8R harvester, the drone is equipped with a GPS module and six stereoscopic cameras for panoramic viewing and detection of possible obstacles. Images captured by the cameras are transmitted to a neural network that analyses each pixel and determines with an inch accuracy where the tractor is located and what it is doing. The farmer only needs to deliver the car to the field and set it up for autonomous operation. While the machine is working, the farmer can go about their daily business, monitoring the status of the machine from their mobile device [29].

Such equipment can work around the clock and almost without interruption, so it will be in demand both among large agricultural companies and smaller farmers.

The above shows that precision farming systems and robot tractors can be effectively used not only for the production of cereals and industrial crops but also for other open-ground crops, such as orchards and berry gardens.

Post- and neo-industrial technologies in animal husbandry. Despite the measures taken by the Government of Ukraine to stimulate the development of livestock industries, compared to crop production, the rates of their progress are significantly behind. Thus, the authors' analysis of data [2] for the period from 2000 to 2020 showed that the number of cattle decreased from 9423,7 to 2874,0 thousand heads, or 3.3 times, including cows, from 4958,3 to 1673 thousand heads, or 3.0 times. Moreover, this decrease is observed both in agricultural enterprises and in family farms. The number of pigs in 2020 was 76.8%, among them in farms 42.9% since 2000, and the number of sheep and goats is 61.1% and 67.7%, respectively. During this period, only the number of poultry of all species increased by 162.2% due to the development of poultry farming in agricultural enterprises. Livestock and pig breeding industries in Ukraine are gradually declining. In 2020, the level

of self-sufficiency of the population of Ukraine (production to domestic consumption) was: for meat and meat products – 110.1% due to an increase in the production of poultry meat, milk 99.1%, eggs 125%. Ukraine faces the threat of becoming an importer of cattle and pig products.

The roots of the decline in the number of cattle lie primarily in the high labour intensity of livestock maintenance. According to the author's calculations [29], with the existing low-mechanised maintenance of cows in households, the labour intensity of keeping one cow (including labour costs for feed preparation) is about 2/3 of an 8-hour working day. But maintaining a farm also requires the allocation of labour time to perform other household and social tasks. The working hours of the farmer start at dawn and end late in the evening. Therefore, most rural households refuse to keep livestock, and this trend will persist in the future.

Another significant factor in the reduction of livestock is the low investment attractiveness – the high cost of investment combined with a long pay-back period hinders investment in the development of the industry. This makes the expansion of livestock breeding in agricultural enterprises and farms unattractive.

A similar, though less prominent, picture of relatively high labor intensity is observed in the pig farming. The investment attractiveness of this industry is also declining due to the constantly occurring outbreaks of the African plague. In 2022, another threat was added to this – the military aggression of the Russian Federation, which unleashed a full-scale war against Ukraine. The invaders slaughter and export livestock and pigs from the occupied parts of Ukraine, destroying the production base.

Thus, to preserve and develop the livestock industry, especially cattle and pig breeding, it is necessary to dramatically increase labour productivity in livestock through the development and implementation of new innovative technologies.

The grouping of enterprises by the number of livestock kept at the end of 2020, carried out by the authors on the basis of statistical data, shows that milk and beef production is mainly concentrated in a small number of agricultural enterprises with a livestock population of 500 heads and above: out of 1911 farms engaged in cattle breeding, 642 farms or 33.6% keep 80.3 livestock. In the pig farming industry, 244 farms out of 1,491 contain more than half of the pig population (51.8%) [2].

Thus, the scale effect is manifested, in which the increase in the level of mechanisation and automation of operations allows improving the investment attractiveness of livestock industries.

Milking parlours of the “carousel” or “parallel” type, free-stall cattle keeping, mechanised and automated preparation and distribution of feed and manure cleaning, computer tracking of the health status of each animal allowed to increase the productivity of cows and the quality of milk in specialised enterprises.

However, for a sharp increase in labour productivity and milk quality, it is necessary to switch to more efficient post-industrial technologies for milk and meat production, in particular to develop robotic farms.

Robotic farms in the standard configuration are equipped with robots – milkers and/or robots-pushers.

Milking robot as a rule, consists of a manipulator for spatial movement of udder teat cleaning systems with brushes and cleaning solution, a device for putting on and taking off milking cups, control and sensor devices, scales for automatic weighing of cows, milk and concentrates, a system for controlling the volume and speed of milk production not only for a single cow, but even for each teat, a system for monitoring milk quality by colour, conductivity, temperature, acidity, etc. The system rejects products of undesirable quality by separating them into a different container and monitors the health of each cow using a sensor attached to the ear or neck of the animal. The computer programme combines these elements into a single robotic milking system with placement in a separate box or even with several boxes. The most popular single-box systems are capable of supporting 50-70 cows.

Most milking robots operate on a voluntary milking system – the cow itself goes to the milking station. The operator only watches the herd.

The main advantage of the milking robot is the reduction of labour costs of farm workers by about 2/3 compared to the “herringbone” system, and each milking robot replaces 2.5 workers [30]. In addition, the milk yield increases up to 15% due to the increase in the number of teats during free-stall milking. Another important advantage is the improvement of milk quality due to the rejection of low-quality milk and compliance with EU standards for bacterial contamination.

Robot pusher is an automatic system for performing the laborious process of turning and hilling the feed when feeding animals, which do not just eat the feed on the feed table, but choose the tastier parts and, as a result, scatter. Therefore, during the day one has to turn and huddle the feed several times. The robot not only pushes the food onto the feed table, but also simultaneously refreshes and mixes it and adds concentrates, which makes the food more attractive. As a result, livestock consume more feed, which contributes to higher productivity [31].

The system can automatically transport various types of feed, including any mono-mixtures, straw, hay, and fresh grass to move independently not only in the cowshed but also between yards. The system eliminates deviations from the route, has an auger, which is completely safe for people and animals. Security sensors are installed around the perimeter of the machine. If there is an obstacle in its way (for example, a cow), the sensor will be triggered and the robot will stop, and then continue to move along a given trajectory.

The first robotic farm in the world was put into operation in 1992 in the Netherlands [32]. Today, there are more than 60 thousand farms with robotic farms in the world [33].

Interest in the introduction of robotic farms in Ukrainian farms is growing rapidly. However, their widespread implementation is hindered by high costs for the purchase and maintenance of equipment. Therefore, it is advisable to make long-term loans for the purchase of equipment more accessible and attract foreign investment. In the near future, the industrial production of plant-based meat and dairy products (vegetable milk, vegetable meat), and cultivated (artificial) meat looks especially promising for solving the meat and dairy industry crisis.

Plant-based meat. The functional purpose of the development of livestock industries is the production of meat, milk, eggs, etc. to meet the consumer needs of the population. From this point of view, a cow or pig can be considered as a living apparatus for converting crop products into meat. With the development of info-, bio- and nanotechnologies it becomes possible to transform crop production into meat in an industrial way, by creating a sort of robo-cows, robo-pigs and robo-chickens.

The first product, “plant-based chicken”, was sold by Beyond Meat, a startup from California, in 2013. There was no chicken as such in it. The product consisted entirely of vegetable components: pea and soy proteins, flour, oils, and seasonings. Already in 2014, Beyond Meat developed a beef imitation product. By 2016, the startup has announced the sale of 25 million plant-based burgers. Today, the startup's products can be bought in more than 53 thousand points in the United States, and since 2018, sales have been launched in Europe. The company claims that it uses 90% less water, 93% less land, 46% less energy and emits 90% less CO² compared to companies that grow animal meat [17].

In Ukraine, plant-based meat from the American startup Beyond Meat became available in 2019. It tastes no different from real beef in texture, smell, taste, and colour, although it consists of pea protein, rice, beetroot, water and oil and is 100% vegan. The only ingredient in meat that cannot be synthesised from plants is cholesterol, so it is not found in a vegetable burger. Burger patties are sold in a wholesale package – 42 patties at a price of UAH 90 per piece. For comparison, the average wholesale price of an animal cutlet is UAH 13-15. Such a high price is explained by the fact that large investments were made in the experimental development of plant-based meat [17]. With the establishment of industrial production of plant-based meat, the price will fall to the level of animal meat prices.

Cultivated (artificial) meat. In 2021, meat grown in vitro appeared on the shelves of US stores. This goal was set by the San Francisco-based food tech startup Memphis Meats [34]. Along with Californians, several other laboratories in different parts of the world are developing technologies for the production of lab-grown meat. In particular, Aleph Farms, Beyond Meat, Mosa Meat, MorningStar Farms, Tyson Foods, etc.

Food tech startups have taken the achievements of fabric engineering as a basis. Stem cell samples are taken from the animal whose meat is to be obtained.

They are placed in a bioreactor – a tank with “broth”, which contains growth factors, vitamins, minerals, and other nutrients. In this environment, oxygen-supplied stem cells actively multiply. The process takes about three weeks. When a critical mass of cells is gained, they merge to form muscle fibers. Thus, lab-grown meat, also known as clean or cultured meat is a product of animal origin. This is natural meat obtained in a non-standard way. It was not part of the carcass of a slaughtered animal, it was literally grown in a laboratory. In early 2016, the Americans showed a meatball made from artificial beef, and in the spring of this year they cultivated chicken and duck meat [34].

Lab-cultured meat is considered safe and potentially even healthier than natural meat. In the process of cultivation, it is possible to regulate the nutritional value of the product – for example, to reduce the content of cholesterol and “harmful” fats and increase the proportion of useful ones. Another advantage of in-vitro meat is its “purity”. The product is created in a sterile environment, without the involvement of animals, which means that pesticides and antibiotics, which are widely used in animal husbandry, will not be ingested by humans. It is hoped that the new production method will limit the spread of bacterial resistance to antibiotics.

The development of technologies for the production of plant-based and cultivated meat can forever change the market of the meat industry. After all, it will be possible to produce meat products industrially in cities, similar to the way bread is baked today: from bread factories to bakeries and home baking.

Plant-based milk. Vegetable milk is an extract from seeds, cereals, or nuts. They are soaked, crushed together with water, and then pressed [35]. The result is a drink that looks and even tastes like cow's milk. However, it has other properties. The most popular types of vegetable milk are coconut, soy, almond, oatmeal, and buckwheat [35; 36]. There are also options such as rice, walnuts, cashews, flax, sesame, and other products. It can either be bought in a store or made at home. It requires only the main ingredient, water, and a blender.

Unlike cow's milk, vegetable milk does not contain such substances as:

- cholesterol (contrariwise, helps to remove it from the body)
- Lactose – some people are intolerant to milk sugar (lactose) as they lack the enzyme to digest it.
- casein – is poorly broken down in the stomach and can cause inflammatory processes in the body.

However, plant-based milk is also associated with some disadvantages [37]. Therefore, before choosing to consume this product, it is essential to be conscious of these aspects.

1. Plant-based milk cannot completely replace dairy milk. After all, protein and calcium from traditional milk are absorbed by the body more easily and efficiently.

2. Plant-based drinks are not always dietary. Some varieties have even more calories than traditional milk.

3. To improve the taste and increase the shelf life, sugar, preservatives, stabilisers, and vegetable oil are sometimes added to the drink. Plant-based milk is recommended for the following categories of people:

- vegans and raw foodists who have consciously chosen not to consume animal products;
- fasting people;
- persons for whom milk is contraindicated for medical reasons (lactose intolerance, etc.);
- gourmets who want to diversify their diet with new flavours.

Widespread introduction of new post- and neo-industrial technologies of agro-industrial production will not only increase the volume of agricultural products for the inhabitants of our country in the post-war period, but will also have other equally important effects: creation of conditions for the restoration of the agricultural sector, increasing employment in agriculture, transition of the agricultural sector to the sixth-seventh technological system, formation of a positive image of a modern innovative and developed state, acceleration of the transition to the information society, etc.

► Conclusions

In the war and post-war periods, the agro-industrial complex faced the task of not only restoring production capacities, ensuring food security and competitiveness of Ukrainian agricultural products on world markets in such difficult conditions, but also identifying solutions and implementing measures for further innovative development of agro-industrial production. One of such possibilities is the widespread introduction of new post- and neo-industrial technologies of agricultural production.

In vegetable, berry, and mushroom growing – it is a large-scale application of drip irrigation and development of greenhouse farming, including the construction of vertical farms as a part of the reconstruction of bombed residential and commercial infrastructure of cities with the transfer of part of the production infrastructure of indoor crops to suburban and urban areas.

In the production of open ground crops – introduction of elements of precision farming and agricultural robotics. In the production of meat, dairy and other livestock products, in addition to the development of robotic farms, it is advisable to develop the production of plant-based and cultured and artificial milk with the placement of industrial capacities in places of mass consumption, that is, in places of residence of urban residents.

The introduction of post- and neo-industrial technologies of agricultural production will solve the challenge of growing vegetable and meat and dairy production and ensure further innovative development of the agro-industrial complex. The agricultural order of Ukraine will also change significantly, as the production of some agricultural products will be expanded to urban areas.

Given the prospects and significance of industrial production of indoor vegetables, plant-based

and cultivated meat and dairy products, it is advisable for scientific institutions of NAAS to develop and implement special scientific and technical research programmes related to this issue to develop effective technologies for their industrial production at enterprises, family farms and households in both rural and urban areas.

The widespread adoption of post- and neo-industrial technologies requires large amounts of investment. Therefore, it is necessary to redirect the allocation

of state support funds in favour of the implementation of innovative projects for the introduction of new innovative technologies in the agro-industrial complex, to boost foreign investment for these objectives.

It is also expedient to create a state network of specialised advisory services for free advisory assistance to rural farms and households in the development and implementation of their investment projects on the introduction of post- and neo-industrial technologies for agricultural production.

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Пост- та неоіндустріальні технології в повоєнній розбудові аграрного устрою в Україні

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► **Анотація.** Стаття присвячена ідентифікації шляхів інноваційного розвитку аграрного устрою України у воєнний та післявоєнний періоди. Актуальність вирішення цієї фундаментальної науково-практичної проблеми полягає в тому, що аграрний устрій нашої держави в сучасних соціоекономічних умовах потребує впровадження новітніх і принципово відмінних від довоєнних шляхів розвитку, які б найбільш повно використовували сучасні науково-обґрунтовані методи розвитку організаційно-правових суб'єктів господарювання. Метою роботи є висвітлення викликів, які стоять перед сільським господарством України в повоєнній розбудові аграрного устрою та шляхів їх вирішення з використанням пост- та неоіндустріальних технологій. У процесі дослідження використано системно-структурний аналіз і синтез, монографічний, історичний методи, методи абстракції й економічних порівнянь. Теоретико-методологічна основа: концепції, положення, висновки, що розглядаються в наукових працях українських і зарубіжних вчених, теорії інновацій, комунікацій, інформаційних технологій. Розглянуто сутність технологічних устроїв та їх вплив на розвиток економіки в історичному аспекті, а також сучасних моделей індустріалізації та рівня інноваційного розвитку в країнах світу і в Україні. Проаналізовано результати і виклики інноваційного розвитку АПК України за 2000–2020 роки, виокремлено галузі, низькі темпи розвитку яких загрожують продовольчій безпеці країни та подальшому розвитку АПК, зокрема виклики і загрози в результаті розв'язання РФ повномасштабної війни та окупації частини території України. Виявлено та виокремлено сучасні інноваційні пост- та неоіндустріальні технології (зокрема технології крапельного зрошення, виробництва овочів закритого ґрунту, точного землеробства, виробництва рослинного м'яса тощо), широке впровадження яких в повоєнний період дозволить не тільки відновити довоєнний потенціал АПК, а і забезпечити його подальший конкурентоспроможний розвиток. Отримані висновки та результати можуть бути використані в практичній діяльності: підприємств, сільських і міських домогосподарств – виробників сільськогосподарської продукції та продуктів харчування щодо широкого впровадження технологій крапельного зрошення, тепличного господарства, точного землеробства та робототехніки, нетваринного виробництва м'ясо-молочної продукції з високою ефективністю; спеціалізованих наукових установ та стартапів щодо розгортання широких досліджень в напрямі створення нових інноваційних пост- та неоіндустріальних технологій виробництва продукції сільського господарства та продуктів харчування; органів державної виконавчої влади щодо стимулювання широкого запровадження цих технологій для забезпечення повоєнного відновлення і подальшого конкурентоспроможного інноваційного розвитку АПК

► **Ключові слова:** АПК, повоєнний розвиток, інноваційні технології, ефективність, аграрна політика



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Methodology for the Assessment of Forestry Competitiveness in Ukraine

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► **Abstract.** Considering the economic, social and environmental potential of the forestry sector of Ukraine, and the rather low level of its efficiency, an important task is to create conditions for the competitive development of the forestry industry. A precondition for such development is an objective assessment of the regional competitiveness of forestry complexes, which requires the elaboration of appropriate methodological and methodological approaches. The regional approach to competitiveness assessment ensures that the specific features of all natural zones on the territory of Ukraine, characterised by different soil and climatic conditions and unequal forest cover, are taken into account. The purpose of this study is to substantiate and test methodological and methodological approaches to assessing the competitiveness of forestry in Ukraine. The methodological basis of the research was the methods of analysis and synthesis, system generalisation and dialectical method. Methodological and methodical approaches to the assessment of the competitiveness of forestry in Ukraine are substantiated. The main challenges of forestry enterprises that form the potential of the industry are identified. The factors that form the level of competitiveness of forestry are highlighted. Positive and negative trends in the competitive development of regional forestry complexes are identified. Based on the assessment of the competitiveness of forestry complexes, their classification in the major natural zones of Ukraine was completed. The conducted research will serve as a basis for assessing the efficiency of individual forestry enterprises in the context of strengthening their competitiveness. The main advantages (disadvantages) of competitive development of business entities can become an objective prerequisite for making appropriate management decisions

► **Keywords:** forestry enterprises, natural Area, regional approach, forest resources, efficiency, competitive advantages, criteria

► Introduction

Ukraine is a low-forest country in terms of forest cover, as it ranks only 31st on the European continent in terms of forest area per inhabitant. At the same time, according to such absolute indicators as the total area of the forest fund and the total stock of wood on it, it occupies the 9th and 7th positions in the ranking of European countries, respectively [1; 2]. A fairly high level of forestry potential is levelled by the current data on the efficiency of its use. According to the annual review of the forest products market (2020-2021) of the Food and Agriculture Organisation of the United Nations [3], Ukraine ranks 30th in Europe in terms of forestry production (\$ 5.5 billion annually). And in terms of the efficiency of forest resources use and according to the FAO Forest Products Yearbook (2019) [4], Ukraine ranks 32nd, with USD 681 per cubic meter of impersonal wood. The Republic of Poland, having approximately the same area of forest land, annually produces products

worth USD 39.4 billion and receives USD 1,203 per cubic meter of impersonal wood [5].

The extremely low level of efficiency of the use of forest resources in Ukraine is primarily driven by the lack of a national strategy for the development of the forest industry, which is necessary to determine objective forecasts of the economic growth of all economic entities. Only on the basis of the approved strategy, it is possible to determine and, accordingly, meet the planned volumes of timber production, including the sale of part of it for export. An important prerequisite for the development of such strategic guidelines is the implementation of an objective assessment of the competitiveness of forestry in the domestic market, as forestry enterprises have different potential opportunities for their development. First of all, it depends on their geographical location and the specific soil and climatic conditions. The issues of developing methodological approaches and

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guidelines for assessing the competitiveness of industries have been studied and covered in the scientific contributions of many renowned scientists.

Michael Porter made an invaluable contribution to the development of theoretical approaches to assessing the competitiveness of an enterprise (industry). His famous model of the “five forces” allows for analysis of the competitive environment of the industry and includes the following elements: the power of buyers; the power of suppliers; competitive rivalry; the threat of new entrants; the threat of substitute products [6; 7]. Then M. Porter developed a cluster approach to competitiveness management and proposed a methodology for calculating microeconomic competitiveness [8], according to which the assessment should include: the operational and strategic maturity of companies; the quality of the business environment and the state of cluster development. M. Porter also developed a cluster approach to competitiveness management and proposed a methodology for calculating microeconomic competitiveness [8], according to which the assessment should include: the operational and strategic maturity of companies; the quality of the business environment and the state of the cluster development.

The ADL/LCD model proposed by Arthur D. Little [9], according to which such an assessment of an enterprise (industry) should be carried out for each of the stages of the life cycle of the subject of assessment, is considered to be a significant contribution to the study of competitiveness assessment. Traditionally, it goes through four stages: birth, growth (or development), maturity, ageing (decline). That is, at different stages of the life cycle of the enterprise (industry) there are different competitive positions, which certainly affect the overall level of competitiveness of the subject of valuation.

Michael Enright was the first to introduce the concept of a regional cluster as a set of economic entities of related industries, united by geographical principle, which leads to a synergistic effect of their joint activities. M. Enright's concept of regional clusters is based on the assumption that competitive advantages are formed only at the regional level, since each region has its own historical development, which affects the formation of regional traditions of conducting business and specific features of production and certain qualifications of local residents, etc. Analysis of the competitiveness of various industries located in certain regions allowed identifying regional and local benefits [10]. At the same time, Michael Storper identified regional clusters as the only tool for the effective development of small and medium-sized businesses in the industry [11].

The adherents of cluster approaches to assessing competitiveness Edward Bergman and Edward Feser substantiated their own visions of the possibility of development of a particular industry only by the cluster model, in particular, it is reflected in the theories of

innovation environment and foreign economy; concepts of inter-firm and cooperative competition [12].

Tanapola Virasa and John Tang used the index method to assess the competitiveness of the industry, in particular, they substantiated the use of the index of technological and trade activities [13], which to some extent can lead to the subjectivity of the assessment. Their technological potential and production characteristics were included in the coefficient of technological activity. The authors proposed to calculate trade characteristics using trade performance indicators, for which they determined multi-attribute indicators. These two indexes were used to determine the state of the industry for a specific time period. A higher value of the technological activity index means a greater expansion of technological opportunities and an increase in production in the industry. A higher value of the trade activity index determines the international competitiveness of the industry.

The purpose of the study is to substantiate methodological and improve methodological approaches to assessing the regional competitiveness of forestry, which would include socio-ecological and economic features of the industry.

► Materials and Methods

The study was conducted in three stages, the first of which summarises the existing methodological base for assessing the competitiveness of the industry and substantiates the regional approach as the most optimal for assessing the forestry of Ukraine. The second stage consisted in calculating all certain criteria (indicators) of competitiveness of the forest industry. The third stage included ranking regional forestry complexes by their level of competitiveness and identifying the main trends in their development.

The research is based on the use of the dialectical method of cognition, which involves the analysis of processes and phenomena in their development and interrelation and interdependence. For a deeper understanding of the challenges of forestry development in Ukraine, such general scientific research methods as observation, scientific cognition, analysis, synthesis, comparative analysis, and systematic generalisation were also applied. In the calculation of partial indicators that form the criteria for Integral assessment of regional forestry complexes (profitability of activities, coefficients of financial condition, fund return, workforce productivity, average monthly salary and profitability of sales), the method of average values is used. Competitiveness criteria are calculated using their index, that is, the ratio of the value of the corresponding indicator to its highest value among the entire set of indicators of forestry enterprises in the region.

The calculation of the integral indicator of the competitiveness of the forestry enterprise assumed using the formula [14]:

$$K_i = \sqrt[8]{K_1 * P_1 * K_2 * P_2 * K_3 * P_3 * K_4 * P_4 * K_5 * P_5 * K_6 * P_6 * K_7 * P_7 * K_8 * P_8} \quad (1)$$

where K_i is an integral indicator of the competitiveness of a forestry enterprise; $P1-P8$ – values of the evaluation criteria of competitiveness; $K1-K8$ – corresponding weight coefficients.

Scientists have already calculated the values of the above weighting coefficients of the competitiveness criteria of forestry enterprises [15].

Given the geographical features of the forestry industry, the methodology for assessing the competitiveness of the forestry sector of Ukraine is based on the regional approach, which consists in comparing the level of competitiveness of the entire set of forestry entities (individual forestry enterprises as legal entities) of one administrative unit (region) in the main natural zones of Ukraine, in particular [16]:

- Polissya – on the example of the activities of forestry enterprises of the Zhytomyr Regional Forestry and Hunting Range Administration (hereinafter – ZhRFRA);

- Forest-steppe – on the example of the activities of forestry enterprises of the Cherkasy Regional Forestry and Hunting Range Administration (hereinafter – CRFRA);

- Steppe – on the example of forestry enterprises of the Mykolaiv Regional Forestry and Hunting Administration (hereinafter – MRFHA).

This methodological approach made it possible to assess the level of regional competitiveness of forestry complexes throughout the country and to identify the main factors (in addition to such commonly recognised factor as forest cover, it is necessary to consider the level of labour productivity, average monthly wages, area of forest regeneration, etc.) that affect the formation of competitive advantages of a particular region.

The study was conducted on the basis of statistical data of the State Agency of Forest Resources of Ukraine, performance indicators of Zhytomyr, Cherkasy and Mykolaiv regional forestry and hunting departments, and scientific contributions of Ukrainian and foreign scientists on the issue of determining methodological approaches to assessing the competitiveness of industries. Data from Internet resources, including expert opinions and reports on important events that significantly affect the competitive development of Ukrainian forestry, were also used.

► Results and Discussion

Currently, there are two main groups of methodological approaches to assessing the competitiveness of an enterprise (product, industry), in particular, qualitative and quantitative. Qualitative methods are characterised by subjectivity and the absence of any formalisation, which determines their limited use in determining the ways and directions of improving the competitive position of the subject of evaluation. Quantitative methods are considered more effective and practical, as they provide grounds for the implementation of necessary organisational, managerial and economic decisions aimed at improving the competitive position of the subject of valuation since they possess a certain objective basis.

In terms of assessing the competitiveness of forestry, it is necessary to additionally consider the socio-environmental characteristics of the functioning of economic entities in the industry, due to various protective, sanitary, health and recreational functions of forest plantations. It is suggested to consider a number of indicators: distribution of forest plantations by age groups; area of reforestation and afforestation; share of forestry enterprises in the total amount of taxes and fees (at the local and state levels), the average level of remuneration of workers in the industry and their share in the national economy, an annual average growth of timber per 1 ha of forest land, etc. [17]. Using these indicators in dynamics, it is possible to calculate the general trend of growth (decline) in the level of competitiveness of the socio-ecological component of forestry.

To date, it has been proved that the economic efficiency of forest resources is a rather conditional conception, the implementation of which is possible only in certain timber regions of Ukraine. This claim is conditioned by the low proportion of forest lands covered with vegetation in the southern and southwestern territories of the country, which leads to constant budget subsidies for forestry enterprises on them [2].

Based on the analysis of existing methodological approaches conducted by I.A. Gubareva and I.V. Yaroshenko [18] and the research team of the Dolishnyi Institute of Regional Research of NAS of Ukraine [19], it can be concluded that the most accurate and comprehensive assessment of the competitiveness of forestry is the integrated competitiveness of enterprises and regions that form the industry.

It is worth noting that the issue of assessing the competitiveness of an individual forestry enterprise has not been practically investigated. At the same time, forestry enterprises are characterised by a number of features, which necessitates the development/improvement of the methodology of competitiveness assessment. In particular, the following features should be noted:

- state (municipal) form of ownership and as a result – the practical absence of credit funds;
- a long period of forest cultivation and, accordingly, obtaining the main share of income in the long term;
- dependence of financial performance on natural, climatic and soil conditions;
- the presence of a practically monopoly position in the domestic market of forest products;
- significant physical and moral deterioration of fixed assets, etc. [20]

Noteworthy is the methodological approach to assessing the level of competitiveness of forestry entities, substantiated in the studies by I.V. Andriychuk and I.R. Pinchuk [14]. They argue that such an assessment should be based on the definition of a set of socio-economic criteria involving the possibility of applying the methods of strategic analysis and further calculation of the integral indicator of competitiveness. The definition of socio-economic criteria is based on the selection and calculation of the relevant

partial indicators, which have been improved (the authors applied the methodology on the example of three forestry enterprises in Ivano-Frankivsk oblast in the period 2014-2017, when the export of unprocessed forest products was allowed):

- production efficiency criteria (profitability of operations);
- criteria related to the assessment of the financial condition of the business entity (working capital turnover ratio, autonomy and absolute liquidity coefficients, solvency coefficient);
- criteria that reflect social efficiency (average salary of staff);
- criteria that determine the competitive potential of the enterprise (workforce productivity and return on capital);
- criteria characterising the sustainability of production (volumes of natural regeneration and artificial reforestation);
- criteria that reflect the efficiency of sales of products and services (profitability of sales);
- a criterion that reflects the competitiveness of products (a relative indicator of the ratio of product quality to its cost based on expert evaluation);
- a criterion that characterises the image of an enterprise (a qualitative indicator determined by comparing the results of a survey of industry experts on the image of a manager, employees, and product quality).

The last two criteria require a separate explanation, as they have lost their significance in the current conditions of Ukrainian forestry. Firstly, state forestry enterprises are considered to be monopolists in a certain regional market, since forestry enterprises of communal ownership occupy an insignificant share of the area of forestry land, and their participation in the production of sectoral products is generally negligible. Thus, the image of the enterprise, subordinated to the State Agency of Forest Resources of Ukraine, is virtually impossible to compare with other entities in the industry (private ownership in forestry is practically absent). As for the competitiveness of products, it is also approximately

the same for forestry enterprises of the same natural zone, which is due to the typical breed composition of forest stands on it. The quality of finished products primarily depends on the available technologies, machines and equipment that are used in the cultivation, harvesting and processing of wood. In modern conditions, forestry enterprises are purchasing a limited range of equipment, in particular, forest planting machines (KLB-1.7, SBN-1A, MLU-1, PLA-1), cultivators (KL-2,6, KRL-1, KBL-1, KLB-1.7 and DKLN-6/8), along with Kolesov's sword for manual forest planting, which is determined by the standardised forestry technologies in Ukraine.

Forestry uses feller-bunchers and feller-bunching machines, jaw loaders, heavy-duty timber transport, a set of hand-held motor tools for cutting trees and pruning branches, as well as standard units, automated lines and machines for primary wood processing. The presented summaries suggest the criterion of competitiveness of products and image of all forestry enterprises to be taken as a unit, which will balance their rating according to the specified criteria. Calculation of the integral indicator of competitiveness of the forestry enterprise using the formula (1).

Having carried out calculations, in particular, having determined all the indicators that form an integral assessment of the competitiveness of each individual business entity in the region, Table 1 was compiled, in which the average (generalised) indicators of competitiveness of enterprises of the Zhytomyr Regional Forestry and Hunting Range Administration are reflected dynamically. There are such positive trends as an increase in the level of average monthly wages and labour efficiency. At the same time, the decrease in the profitability of operations and sales, the turnover ratio of working capital, the rate of return and the area of forest regeneration at the end of the study period is negative, which indicates an unsatisfactory trend of decline in the business activity of the forestry complex of the region, a decline in the efficiency of fixed assets and a rapid decline in the overall performance (profitability) of economic entities.

Table 1. Dynamics of competitiveness indicators of forestry enterprises of ZhRFRA

No.	Indicator	2017	2018	2019	2020
1	Profitability of operations, %	3.09	2.69	1.12	0.69
2	Coefficient of autonomy	0.58	0.57	0.57	0.56
3	Solvency ratio	1.09	1.11	1.13	1.19
4	Absolute liquidity ratio	0.28	0.26	0.27	0.28
5	Working capital turnover ratio	9.58	8.61	7.86	7.41
6	Fund return	7.13	7.04	6.99	6.81
7	Workforce productivity	265.7	284.45	315.76	374.31
8	Return on sales, %	30.10	21.82	18.84	16.60
9	Average monthly salary, UAH	7,153	7,932	8,841	9,945
10	Area of reforestation, ha	7,143	7,032	6,974	6,764

Source: authors' calculations based on the data of the State Agency of Forest Resources of Ukraine [21]

Similarly, the calculations of indicators (criteria) of competitiveness of all business entities attributed to the Cherkasy Regional Forestry and Hunting Range Administration for the period of the study were carried out, the analysis of the competitiveness of which practically does not differ from the previous one. The calculation of the indicators (criteria) of competitiveness of all business entities referred to the Mykolaiv Regional Forestry and Hunting Range Administration revealed positive trends in their development, in particular: a fairly significant increase in profitability and profitability of sales, the volume of reforestation in the region, the level of average

monthly salary and the rate of return on capital, a slight increase in workforce productivity.

Substituting the obtained results into the formula (1) (with two or more indicators in one criterion, it is necessary to use the index transformation), the calculations were carried out (Table 2) and an integrated assessment of the regional competitiveness of forestry complexes was provided in the context of regions and in dynamics. Using the obtained values, it is possible to assess the level of competitiveness of typical regional forestry complexes in the main natural zones of Ukraine and to analyse the results obtained.

Table 2. Integrated assessment of the competitiveness of regional forestry complexes

No.	Enterprise	2017	2018	2019	2020
1	Zhytomyr RFRA	0.0951413	0.0943989	0.0902536	0.0897820
2	Mykolaiv RFRA	0.0369046	0.0378451	0.0484851	0.0542621
3	Cherkasy RFRA	0.1065572	0.1058128	0.1048257	0.1044882

Naturally, the region with the highest integral index is the most competitive. On the basis of these calculations, the ranking of forestry complexes of

Zhytomyr, Cherkasy and Mykolaiv regions was carried out according to the descending trend, as illustrated in Table 3.

Table 3. Ranking of regional forestry complexes by level of competitiveness

No.	Enterprise	Integral indicator	Rank
1	Cherkasy RFRA	0.1065572-0.1044882	1
2	Zhytomyr RFRA	0.0951413-0.0897820	2
3	Mykolaiv RFRA	0.0369046-0.0542621	3

The above data suggests that the forestry enterprises of the Cherkasy Regional Forestry and Hunting Range Administration have the highest rating, which is due to the presence of the best competitive positions in terms of profitability and sales efficiency, along with the criteria of social efficiency and competitive potential (in 2020 – second to the Zhytomyr region, which is also the trend in 2021). Accordingly, the conclusion was made about more effective organisational, managerial and economic activities of business entities in this area. The lowest rating was given to the forestry enterprises of Mykolaiv Regional Forestry and Hunting Range Administration, which is primarily due to the extremely low stock of forest resources in their territories.

According to the results of the calculations, there is a negative trend towards a decrease in the level of regional competitiveness of forestry complexes of Cherkasy and Zhytomyr oblasts and an increase (as a result of the restoration of state funding) in the level of competitiveness of enterprises in Mykolaiv oblast.

Thus, despite the lower level of timber reserves in Cherkasy oblast compared to Zhytomyr oblast (in terms of area and volume), the regional competitiveness of forestry is higher, because according to the analysis, it depends primarily on the quality composition of forest resources (more valuable hardwoods

prevail) and the efficiency of the use of financial, economic and industrial potential of economic entities.

► Conclusions

According to its intended function, the forestry of Ukraine performs, first of all, soil and water protection, protective, sanitary and hygienic, health, recreational, aesthetic, historical, cultural and other functions, and at the same time serves as a source of raw materials for furniture, pulp and paper, pharmaceutical, chemical and other sectors of the national economy.

The functioning and development of the forestry sector of Ukraine is determined by certain properties that require a special methodological approach to assessing its competitiveness, in particular: only 0.1% of forestry land is privately owned, which determines the monopoly position of business entities regionally; a fairly high level of depreciation of fixed assets in the industry; lack of public-private cooperation and cheap financial resources, which makes it impossible to timely update equipment, machinery and technologies; obtaining the bulk of revenues from financial and economic activities in the long term (80-100 years); reliance of the performance of forestry enterprises on their geographical location (climatic and soil conditions), etc.

Given the specific features of Ukrainian forestry, a regional methodological approach (using natural

zoning – Polissya, Forest-Steppe and Steppe) to assessing its competitiveness is proposed, the purpose of which is an assessment of the competitiveness of all economic entities in the industry of a typical administrative region from each of the identified natural zones and their comparison with each other using the assessment methodology that is closest to reflecting the socio-ecological and economic function of forestry.

Based on the analysis of existing methodological approaches, it is concluded that for a comprehensive assessment of the competitiveness of the forestry sector of Ukraine should use a method based on the calculation of the integral indicator of the competitiveness of enterprises that form regional forestry complexes. The improved and tested methodology for assessing the competitiveness of forestry enterprises contains certain disadvantages associated with the attributability (triple) of the forest industry, in particular: the sufficient complexity and labour intensity of calculations of certain criteria (indicators) and the availability of subjective expert

assessment of the competitiveness of products and the image of state forestry enterprises.

The ranking of the studied regional forestry complexes shows that the Cherkasy Regional Forestry and Hunting Range Administration received the highest competitiveness score (but the trends of certain criteria are negative), and the Mykolaiv Regional Forestry and Hunting Range Administration – the lowest. Thus, the level of regional competitiveness depends not only on the area and reserves of forest resources (in the Zhytomyr region – they are the highest) but also on the effective use of environmental and social competitive advantages, along with the quality of forest resources and the efficiency of financial and economic operations of individual forestry enterprises in Ukraine.

Conclusions, proposals and practical recommendations can be used in the elaboration of the national strategy for the development of forestry in Ukraine, and also serve as a basis for assessing the efficiency of the industry at both micro and macro levels.

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Методологія оцінки конкурентоспроможності лісового господарства України

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► **Анотація.** Враховуючи економічний, соціальний та екологічний потенціал лісового господарства України, а також достатньо низький рівень його ефективності, важливим завданням є створення умов для конкурентоспроможного розвитку лісової галузі. Передумовою такого розвитку є об'єктивна оцінка регіональної конкурентоспроможності лісогосподарських комплексів, що вимагає розробки відповідних методологічних та методичних підходів. Регіональний підхід до оцінки конкурентоспроможності забезпечує врахування особливостей всіх природних зон на території України, що характеризуються різноманітними ґрунтово-кліматичними умовами та неоднаковими показниками лісистості. Мета статті – обґрунтувати та апробувати методологічні і методичні підходи до оцінки конкурентоспроможності лісового господарства України. Методологічну основу дослідження склали методи аналізу та синтезу, системного узагальнення та діалектичний метод наукового пізнання. Обґрунтовано методологічні і методичні підходи до оцінки конкурентоспроможності лісового господарства України. Встановлено основні проблеми функціонування лісогосподарських підприємств, які формують потенціал галузі. Виокремлено чинники, що формують рівень конкурентоспроможності лісового господарства. Виявлено позитивні та негативні тенденції конкурентоспроможного розвитку регіональних лісогосподарських комплексів. На основі проведеної оцінки конкурентоспроможності лісогосподарських комплексів здійснено їх ранжування в основних природних зонах України. Здійснені дослідження слугуватимуть основою для проведення оцінки ефективності діяльності окремих лісогосподарських підприємств в контексті зміцнення їх конкурентоспроможності. Визначені основні переваги (недоліки) конкурентоспроможного розвитку суб'єктів господарювання можуть стати об'єктивною передумовою прийняття відповідних управлінських рішень

► **Ключові слова:** лісогосподарські підприємства, природна зона, регіональний підхід, лісові ресурси, ефективність, конкурентні переваги, критерії



UDC 332.3

Market Turnover of Agricultural Land in Ukraine: Monitoring and Analysis

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► **Abstract.** The main objective of the land reform in Ukraine, which was launched 22 years ago, is to involve agricultural land in full, efficient, and transparent economic (market) turnover. During different stages of transformations in land relations, in scientific, political, and social circles, the issue of market turnover of agricultural land was particularly acute and always caused many disputes about precisely what the market turnover of land should be. With the introduction (from July 2021) of the market turnover of agricultural land, questions about its functioning not only remained, but, on the contrary, additional tasks were added: which model of market turnover Ukraine has chosen; what are the results of the functioning of the market turnover of agricultural land; whether the model of market turnover of agricultural land corresponds to the European integration direction of Ukraine's development, etc. This study is focused on highlighting such issues, clearly revealing the essence of the subject through the analysis of statistical data, which in turn forms the relevance of the results presented. The purpose of the study is to cover and analyse the outcomes of the market turnover of agricultural land in Ukraine and to identify the existing issues. The purpose of the study is a comprehensive examination of the results of purchase and sale transactions of ownership rights to agricultural land plots concluded in Ukraine during 07/01/2021 – 07/01/2022 to determine the main trends in the results. The methods of analysis of the given subject were general scientific, including structural and functional (description and explanation of pricing and functioning of the market turnover of agricultural land); comparison (identification of discrepancies in the data of land value and the basis of its calculation on the basis of collected statistical data on the results of the market turnover of land), abstract and logical (generalisation and formulation of conclusions). Based on the findings, the results of the functioning of the market turnover of agricultural land were analysed, the causes of overstatement of land value were identified and the main price trends were established. The value of agricultural land is calculated by applying the median, the results are compared with the calculations of the average value. It is argued that the state authorities' data on the value of agricultural land is calculated incorrectly. The number and structure of concluded contracts for the sale and purchase of agricultural land in the context of regions are investigated. The value indicators of agricultural land depending on the location, purpose and type of land are highlighted. The main difficulties in the functioning of the market turnover of agricultural land have been identified. Prospects for further research are to find solutions to the existing problems of market turnover of agricultural land by applying the findings of the study

► **Keywords:** land value, purchase and sale, land area, average cost, median cost

► Introduction

Since the first of July 2021, in accordance with the Law of Ukraine "On Amendments to Certain Legislative Acts of Ukraine on the Conditions of Agricultural Land Turnover" No. 552-IX (dated 03/31/2020), agricultural land has been brought into market circulation [1].

A detailed study of this Law, which effectively formed the Ukrainian model of market turnover of agricultural land, indicates that this model does not contain any positive aspects for the agricultural

sector of the country and is completely opposite to the European and world practice of building and organising the agricultural land market [2, p. 116-122].

First of all, the form of the legislative act on the land market itself only amends other laws and is not an independent, clearly structured, holistic legal act. For example, in Poland, the Law "On the Formation of the Agricultural System" No. 64 of 04/11/2003, clearly formulates the objectives of the law, has a purpose, explanations on the interpretation of the terminology used, etc. [3].

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At the same time, the Law of Ukraine “On Amendments to Certain Legislative Acts of Ukraine Regarding the Conditions of Agricultural Land Turnover” No. 552-IX (dated 03/31/2020) is missing the essential point – the purpose of adopting this regulatory legal act, the goals, and issues to which this law is aimed. Only the explanatory note to this law specifies its objective:

- formation of a legislative field for the introduction of market turnover of agricultural land;
- guaranteeing the constitutional rights of Ukrainian citizens to free disposal of their property;
- creating transparent conditions for the acquisition of ownership of agricultural land plots by citizens and legal entities of Ukraine [4].

During the 12 months of functioning of the market turnover of agricultural land, a voluminous information and statistical base on transactions of sale and purchase of ownership rights to agricultural land were formed. To determine the main key indicators and trends in the value of agricultural land in Ukraine in the context of regions and months, depending on the location (including settlements) and purpose of land, to determine the European integration direction in the Ukrainian model of land market turnover, this statistical information requires scientific research.

► Literature Review

The issue of market turnover of agricultural land is always relevant for Ukrainian agrarian science. The study of neoliberal approaches to the market turnover of land in agriculture in relation to the volume of taxes and fees to the budgets of all levels, increase of investments in the agricultural sector of the economy and opportunities for lending to enterprises secured by agricultural land is widely covered by O.B. Khodakivska and O.M. Mohylnyi [5, p. 9-15].

B.Ya. Mesel-Veseliak, M.M. Fedorov most extensively elaborated on methodological approaches to determining the index of normative monetary valuation of land. Scientists have developed theoretical and methodological principles and methodological definition of the monetary valuation of agricultural land, according to which their monetary valuation was carried out in Ukraine, the results became the basis for determining the market value of agricultural land [6, p. 18-23].

B. Zhuk and Y. Bezdushna highlight the approaches and methodology of market valuation of agricultural land as a factor of pricing for its market turnover and capitalisation [7, p. 69-74].

T. Kolesnyk, T. Ivanova et al. in their research emphasise the need to strengthen state regulation and institutional support of the market turnover of agricultural land in Ukraine. Scientists have underlined the need to form an adaptive institutional field to support the effective functioning of the land market turnover [8, p. 682-689].

Market turnover of agricultural land is a topical issue for the international scientific community. The study of “perfect” and “imperfect” market turnover

of agricultural land in terms of the impact of the price of agricultural land on the productivity of land cultivation is carried out by Wanjun Yao and Chun-an Wang [9, p. 24].

B. James Deaton and Chad Lawley discuss the issues of modelling changes in agricultural land prices, due to the current focus on econometric identification and variation in the value of estimated relationships [10, p. 96].

A group of researchers from Slovakia, including J. Lazíková, L. Rumanovská, I. Takáč, P. Prus and A. Fehér, analyse the functioning of the market turnover of agricultural land from the point of view of the sustainability of agricultural production through the correlation of land prices and soil quality. Scientists identify a trend in which land with lower fertility is sold at a higher price than land with better soil quality, which leads to the risk of a land buyout for the purpose of their use by investors for non-agricultural purposes and displacement of agriculture from certain regions [11, p. 2].

B. Britosa, Manuel A. Hernandezb, M. Roblesc and Danilo R. Trupkind study the influence of market turnover of agricultural land on the distribution of land and the efficiency of its use in agriculture [12, p. 2].

A. Klimach, A. Dawidowicz, M. Dudzińska and R. Erróbek analysed the effect of the marketing system of control over the sale of agricultural land on the protection of agricultural land during market operations in Poland [13, p. 7].

Given the significant scientific achievements of the Ukrainian and foreign scientific community, the market turnover of agricultural land in Ukraine requires further analysis and exploration of solutions for its development.

► Materials and Methods

The study is based on the materials of monitoring of land relations of the State Service of Ukraine for Geodesy, Cartography and Cadastre for 07/01/2022–07/01/2022 [14]. General scientific, economic, and statistical research methods are used. The study is based on analytical and statistical tools and an empirical approach, which allowed to calculate: the number and area of purchase and sale transactions and their structure by region; the dynamics of land purchase and sale transactions by month, the number of agricultural land purchase and sale transactions depending on location; the dynamics of the average monthly value of agricultural land; the value of agricultural land, including by region and depending on their location; the dynamics of the average monthly price of agricultural land; the cost of agricultural land, including by regions and depending on their location.

The comparison method was used in: the study of transactions for the purchase and sale of agricultural land, the value of which is more and less than 150 thousand UAH/ha; the study of land purchase and sale transactions depending on their location, in terms of their quantity; when comparing land purchase and sale transactions depending on

the location, in terms of their value; study of the cost of land purchase and sale transactions by region.

The abstract-logical method made it possible to identify the main problems of market turnover of agricultural land and formulate appropriate conclusions.

To localise the cost values and determine the value of agricultural land more accurately, two methodological approaches were applied through statistical measures of central tendency: calculation of the cost by using an arithmetic mean and median. Given that the information and statistical base has significant fluctuations in the value of the cost, the calculation of the cost using the median provides the most accurate result. To obtain the results that

most accurately characterise the market turnover of agricultural land in Ukraine, and to avoid data on land plots used for other purposes, the calculation was carried out considering transactions worth less than 150 thousand UAH/ha.

► Results and Discussion

During the 12 months of the market turnover of agricultural land in Ukraine, the share of transactions of purchase and sale of property rights amounted to 29% of all transactions. The largest share of 66% of all transactions is made up of inheritance. The trend continues in areas where, on average, inheritance contracts predominate in purchase and sale agreements by 3 times (Table 1).

Table 1. Number and area of alienated agricultural land plots by oblast, 07/01/2021–07/01/2022

Oblast	Purchase and sale			Inheritance	Gifting
	Number, thousands	Thousand ha	Share	Share	Share
Vinnitsia	6.4	11.4	30%	64%	6%
Volyn	3.2	4.6	22%	74%	4%
Dnipropetrovsk	4.5	17.6	39%	53%	7%
Donetsk Region	1.6	6.1	28%	68%	4%
Zhytomyr	3.2	5.6	23%	70%	6%
Zakarpattia	1.2	1.2	28%	64%	8%
Zaporizhia	2.6	9.4	38%	58%	4%
Ivano-Frankivsk	1.4	0.7	10%	85%	4%
Kyiv	5.8	8.2	33%	59%	8%
Kirovograd	4.9	15.5	45%	46%	8%
Luhansk	1.2	5.9	25%	70%	4%
Lviv	2.1	2	11%	85%	4%
Mykolayiv	2.9	10.7	37%	59%	4%
Odesa	1.9	5.1	36%	60%	3%
Poltava	6.7	16.6	38%	57%	5%
Rivne	1.6	1.5	15%	81%	4%
Sumy	7.1	12	34%	63%	3%
Ternopil	2.2	3.2	12%	84%	4%
Kharkiv	9.3	32.7	48%	47%	5%
Kherson	4.2	17.7	40%	54%	5%
Khmelnysky	5.6	10	29%	62%	8%
Cherkasy	2.8	5	30%	64%	6%
Chernivtsi	1.4	1.3	19%	72%	8%
Chernihiv	4.4	8.9	27%	70%	2%
Ukraine	88.3	213	29%	66%	5%

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

It should be noted that Kharkiv Oblast is the only region where the largest number of transactions of sale and purchase and alienation of agricultural land was registered. According to the data of the State Service of Ukraine for Geodesy, Cartography and

Cadastre, 9,300 transactions of purchase and sale of agricultural land with a total area of 32,700 hectares were concluded in Kharkiv region. Besides, the share of sale and purchase transactions exceeds the share of inheritance transactions by 1% in Kharkiv Oblast [14].

During the year, 213,000 hectares of agricultural land were alienated in Ukraine through the sale and purchase, which is 83% less than the 389,000 hectares inherited.

According to the dynamics of purchase and sale transactions and the area of agricultural land, the peak was in December, in which there were 19,400 transactions with a total area of 59,700 hectares (Fig. 1).

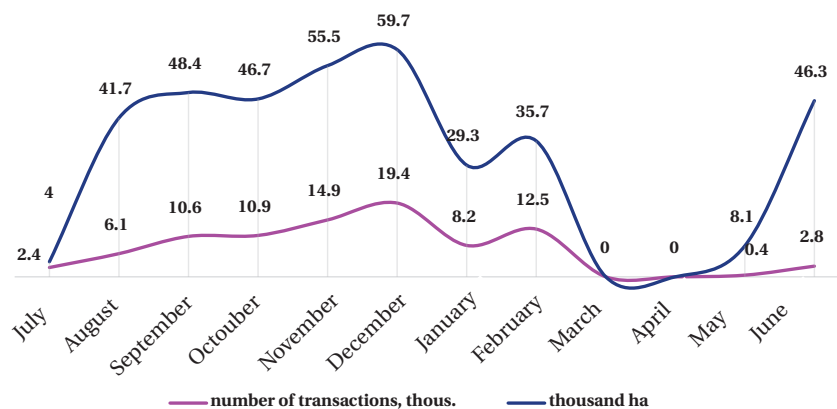


Figure 1. Dynamics of purchase and sale transactions and areas of agricultural land by months

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

As a result of the war launched by Russia against Ukraine, there were no transactions on the sale and purchase of agricultural land in March and April. By May, the market turnover of agricultural land in Ukraine has fully resumed its operations.

The study of transactions on alienation of agricultural land plots for the period under review shows that, given the fact that Ukrainian citizens have been granted the right to freely dispose of land, the vast majority of transactions are made under inheritance agreements.

Depending on the location, the largest number of purchase and sale transactions were concluded for agricultural land outside settlements – 72,500 transactions with a total area of 201,300 hectares, which is 82% of all transactions depending on the location. 14,000 purchase and sale transactions with an area of 11,100 hectares were concluded within villages, which is 16% of all transactions, and 1,900 purchase and sale transactions with an area of 564 hectares were concluded within cities, which is 2% of all transactions depending on the location (Fig. 2).

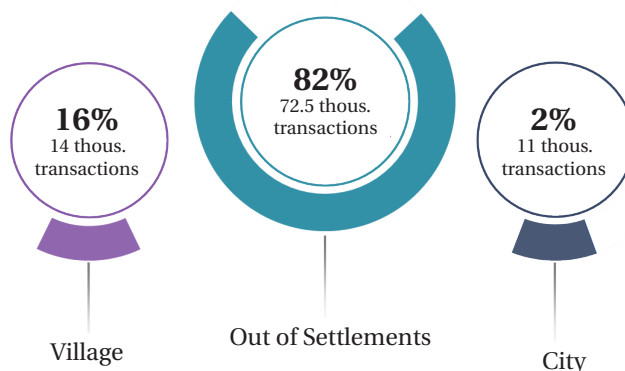


Figure 2. Number of transactions for the purchase and sale of agricultural land, depending on the location

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

According to the official data of the Ministry of Agrarian Policy and Food of Ukraine and the State Geocadastre, the average price of agricultural land, considering all sales transactions, for the first year of the market functioning was 37,800 UAH/ha.

The most expensive land plot that was sold in Ukraine during the year of functioning of the agricultural land market is located in Kozyn, located 9 km from Kyiv along the Dnipro River. The area of this land plot is 0.4531 hectares, and the price for which the

ownership of it was alienated is UAH 24.2 million or UAH 53.4 million per hectare. Similar cases were recorded in the Kyiv, Odesa, and Lviv Oblasts. The abnormally high cost of land plots is explained by their proximity to megacities, with a high probability of their purchase for changing the designated purpose and subsequent construction, rather than agricultural use.

To avoid distortion of data and to obtain an objective price of agricultural land, the land plots

whose value does not exceed 150,000 UAH/ha were taken for calculations. The obtained data on the average value of agricultural land confirmed the

erroneousness of taking into account the land worth more than 150,000 UAH/ha in the calculations (Fig. 3).

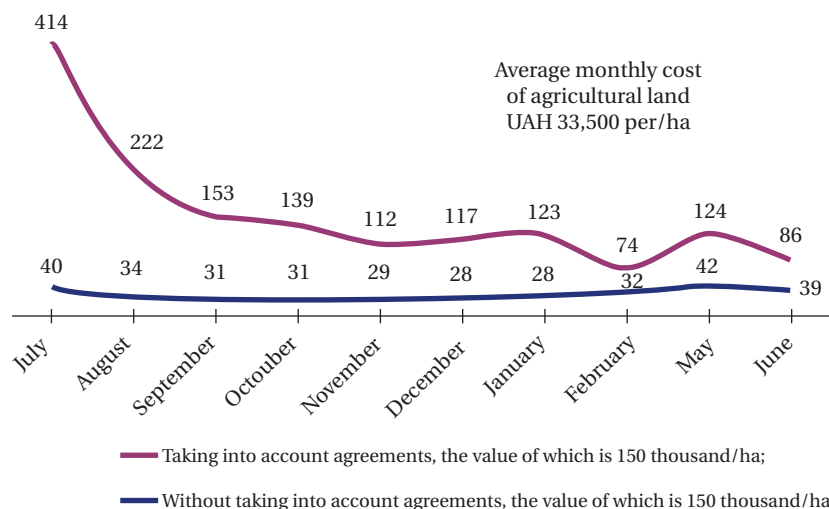


Figure 3. Dynamics of the average monthly cost of agricultural land in Ukraine between 07/01/2021 and 07/01/2022

Notes: excluding transactions exceeding the value of 1 ha > UAH 150,000

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

According to the calculations, in July 2021, the cost of agricultural land amounted to 414,000 UAH/ha (including transactions with a value of 1 ha <150,000 UAH/ha) and 40,000 UAH/ha (excluding transactions with a value of 1 ha <150,000 UAH/ha). The first month after the opening of the market turnover of agricultural land had the highest land values (taking into account transactions with the value of 1 hectare <150,000 UAH/ha), but in November the value decreased almost 4 times. However, the discrepancy in the data on the value of agricultural land persists

for 12 months and averages 2-3 times. The average monthly price of agricultural land for the study period is 33,500 UAH/ha.

The average price of agricultural land in Ukraine for 12 months of functioning of market circulation amounted to 30,500 UAH/ha. The highest price of agricultural land was recorded in the western Oblasts of Ukraine, namely: Ivano-Frankivsk – 65,000 UAH/ha; Rivne – 49,400 UAH/ha; Lviv – 46,900 UAH/ha; Zakarpattia – 45,100 UAH/ha; Chernivtsi – 43,800 UAH/ha; and Ternopil – 43,200 UAH/ha (Fig. 4).

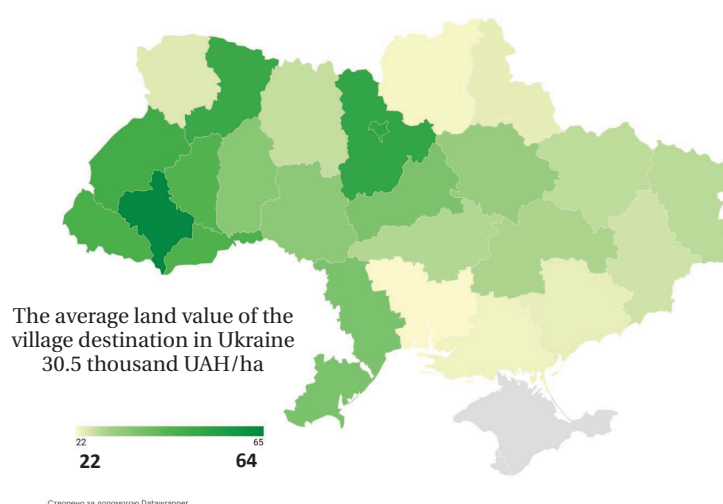


Figure 4. The value of agricultural land in Ukraine 07/01/2021 – 07/01/2022, thousand UAH/ha

Notes: excluding transactions with the value of 1 ha >150,000 UAH and excluding transactions for which there is no information on the value

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

In the central regions of Ukraine, the average price of agricultural land is 26,900 thousand UAH/ha, in the Kyiv Oblast – 51,000 UAH/ha.

The lowest price of agricultural land was recorded in Mykolaiv Oblast – 22,000 UAH/ha and Chernihiv Oblast – 22,500 UAH/ha regions.

The location of the land plot is the main factor determining its current and future use. A land plot located within the city limits is potentially more attractive to the buyer than a similar land plot located in the countryside or outside the settlement.

As noted above, the location of agricultural land has a direct impact on demand and its value, which is confirmed by the calculations obtained. The results of the study show that agricultural land

plots located within cities have the highest value. For example, in the city of Kyiv, the cost of agricultural land is 99,400 UAH/ha, in Dnipro – 98,700 UAH/ha, in Zaporizhzhia – 96,800 UAH/ha. The lowest value of land within cities is in Luhansk – 2,500 UAH/ha; Mykolaiv – 15,300 UAH/ha and Volyn Oblast – 17,100 UAH/ha. The total value of agricultural land located within cities in Ukraine is 59,700 UAH/ha (Fig. 5).

Considering the value of land within the villages, the western regions have the highest prices: Ivano-Frankivsk – 65,800 UAH/ha; Lviv – 64,300 UAH/ha. Instead, in the Mykolaiv Oblast, the cost of land within villages is also the lowest – 19,700 UAH/ha. The average cost of agricultural land within villages in Ukraine is 41,400 UAH/ha.

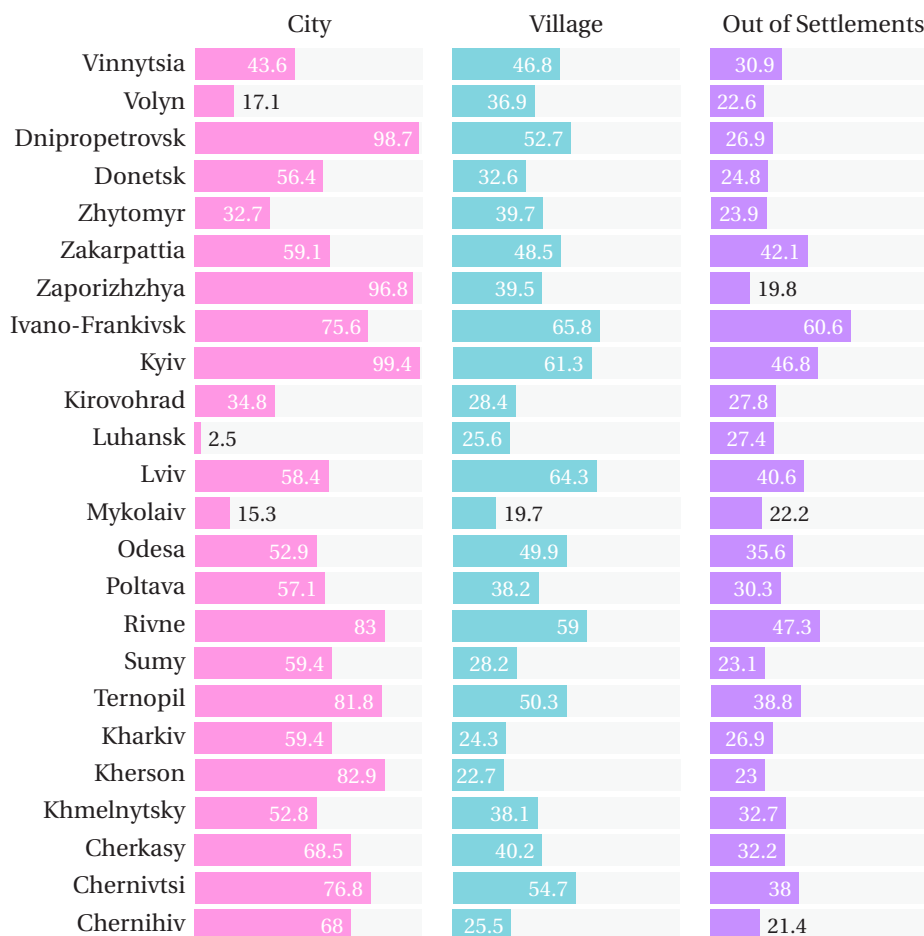


Figure 5. Value of agricultural land depending on geographical location (by oblast), UAH ths.

Notes: excluding transactions with the value of 1 ha > 150,000 UAH and excluding transactions for which there is no information on the value

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

Outside of localities where most agricultural land is concentrated, the highest land value is also in the western regions: Ivano-Frankivsk – 60,600 UAH/ha; Rivne – 47,300 UAH/ha; Zakarpattia – 42,100 UAH/ha. The lowest land value was recorded in Zaporizhzhia Oblast – 19,800 UAH/ha. The average value of agricultural land outside settlements in Ukraine is 31,900 UAH/ha.

Despite the fact that Mykolaiv Oblast has the lowest value of land within cities and villages, it is in this oblast that the value of land outside settlements is higher than the value in cities and villages. It should be noted that Ivano-Frankivsk Oblast has a relatively balanced prices: city – 75,600 UAH/ha; village – 65,800 UAH/ha; outside the settlement – 60,600 UAH/ha.

For a more in-depth study of the value of agricultural land, the calculations used the sample median as an alternative to the arithmetic mean, because it is resistant to abnormal deviations.

The main property of the median is that the sum of absolute (modulo) deviations from the median (mean) value gives the minimum possible value when compared with deviations from any other value, including less than the arithmetic mean. Thus, the median is the level of an indicator that divides the dataset into two equal halves – in one half the values are lower and in the other half they are higher than the median.

For 12 months in Ukraine, the median value of agricultural land, including all transactions for which

information on their value was provided (including transactions worth more than 150,000 UAH/ha), is 29,500 UAH/ha. The obtained data of the median cost differ from the official data by UAH 8,300.

Using the median for a more accurate calculation of the value of agricultural land is confirmed by the data of the median weekly value of agricultural land. The data obtained indicate that during the study period the median weekly land value is 28,800 UAH/ha. The highest median value was recorded at the beginning of the first Sunday of the opening of the land market turnover – 61,000 UAH/ha, but the next week the cost is halved and remained almost at the same level throughout the entire period (Fig. 6).

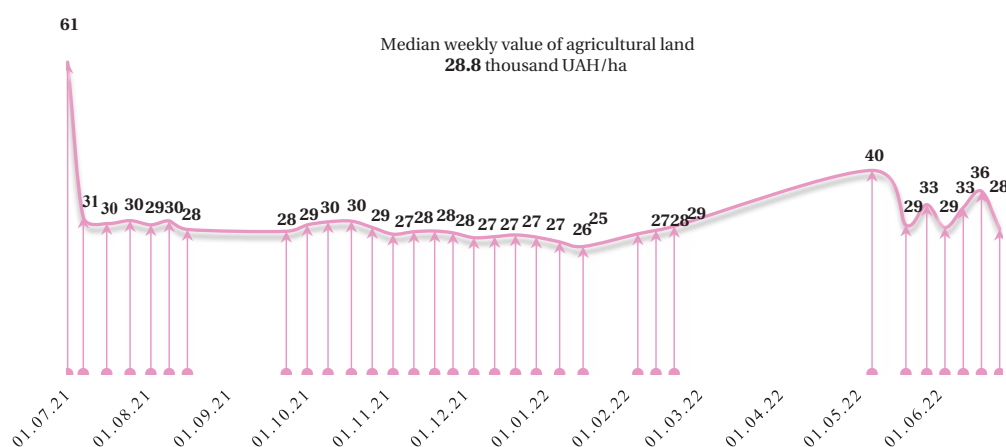


Figure 6. Median weekly value of agricultural land in Ukraine, UAH thousand

Notes: excluding transactions for which the cost of 1 ha >150,000 UAH.

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

Later, the only case of an increase in the median weekly value was recorded in May – 40,000 UAH/ha, when the market turnover of agricultural land after almost two months of break resumed its work. The last week of the study recorded the median weekly price at the level of 28,000 UAH/ha.

The cost of the most valuable land for agriculture – arable land – amounted to 33,600 UAH/ha. At the same time, the total area of registered arable land purchase and sale transactions is 189,700 hectares or

89.1% of the total alienated area. The value of land differs significantly depending on its intended purpose. Land for commercial agricultural production, farming and personal farming has a value of 29,400 and 28,300 UAH/ha, respectively. Land for subsidiary farming – 42,900 UAH/ha, for individual gardening – 80,600 UAH/ha. According to the results of the study, collective horticultural land has the highest value – 97,200 UAH/ha (Table 2).

Table 2. Key indicators of market turnover of agricultural land in Ukraine (07/01/2021–07/01/2022)

Average value of agricultural land plot	30,500 UAH/ha
Average cost of arable land	33,600 UAH/ha
The average value of an agricultural land plot depending on its location (within):	
City	64,900 UAH/ha
Village	43,200 UAH/ha
Outside the settlement	30,100 UAH/ha
The average value of agricultural land depending on the intended purpose:	
Commercial agricultural production	31,300 UAH/ha
Farm	29,400 UAH/ha
Household plot	28,300 UAH/ha

Table 2, Continued

Auxiliary farming	42,900 UAH/ha
Individual gardening	80,600 UAH/ha
Collective gardening	97,200 UAH/ha
Average value of agricultural land plot	29,500 UAH/ha
Number of completed purchase and sale transactions, total	88,300
Area of registered purchase and sale transactions, total	212,900 ha
incl. :	
arable land	189,700 ha

Notes: excluding transactions with the value of 1 ha > 150,000 UAH and excluding transactions for which there is no information on the value

Source: developed by the author based on the data of the State Service of Ukraine for Geodesy, Cartography and Cadastre [14]

During the operating of the market turnover of agricultural land, issues with land valuation have arisen. The core of the problem is that the automatic calculation of the assessment provides radically different data of the day of one land plot. Ten adjacent plots (land shares) may have ten different valuations on one field. For example, a land plot (share) of 2 hectares of agricultural land has an expert estimate of 36,000 UAH/ha, and on the same field 0.35 hectares has an expert estimate of 200,000 UAH/ha.

As it turned out, the automatic calculation of agricultural land valuation included an analogue valuation method based on determining the valuation through the selection and comparison of similar land plots. The basis for comparing this method were ads for the sale of land plots from commercial online marketplaces OLX and LUN. When placing an advertisement for the sale of a land share on these sites, the seller set the price that he considers necessary (often much higher than it should be according to economic indicators). On the basis of these data, the system formed “inadequate” indicators of agricultural land valuation. That is, no economically and scientifically substantiated formulas, correction coefficients that would include qualitative characteristics, location, area, and most importantly the agricultural value of land plots were included in the automatic calculation of agricultural land valuation. Thus, the market turnover of agricultural land was launched as a regular real estate market, and the value of agricultural land was neglected.

The mechanism of pre-emptive right, which in European practice has been previously employed for the distribution of agricultural land in favour of those who live and work on the land – family farmers, in the Ukrainian model of land market turnover has no such purpose and is not functional [15, p. 6-7]. The pre-emptive right to purchase an agricultural land plot is levelled by the practice of termination of the lease agreement, which accelerates the conclusion of a purchase/sale agreement. However, termination of the lease agreement has certain risks for both the buyer (lessee) and the seller (lessor). For example, after the termination of the lease agreement, the seller (lessor) may change his mind about selling the land to the former tenant, or even sell it and lease it again, but to another person. At the same time, the

procedural requirements for the preemptive right are not observed in the absence of the person (of the first turn) who has the preemptive right. Or when a person with a preemptive right buys land, but the intention is not registered, the relevant terms are not calculated. There are also manipulations and abuses of the pre-emptive right in terms of its transfer to a third party, which in turn, after acquiring such a right, does not use this right, and the right to purchase passes to the “desired” buyer.

The electronic database of the State Service of Ukraine for Geodesy, Cartography and Cadastre is not complete in terms of information on agricultural land. Some of the information about land plots does not contain all the data that is available on paper. Information on land consolidation received from the purchaser in the electronic databases of the State Service of Ukraine for Geodesy, Cartography and Cadastre and the State Register of Property Rights is often inconsistent. The necessary verification of the compliance of information takes considerable time, resulting in higher notarial services fees. On average, such an inspection process takes two weeks, and its estimated cost is UAH 10,000.

Legal uncertainty is a problem in obtaining a loan from a bank for the purchase of agricultural land. The bank considers a loan to individuals for the purchase of land as a consumer loan, in turn, there are different interpretations of the law on consumer lending, according to which a non-consumer loan to an individual cannot be granted, and a consumer loan for the purchase of the land (used for business activities) is prohibited by this law [16]. Therefore, any bank can based on the current legislation, legally refuse to grant a loan for the purchase of land. Currently, banks consider the market turnover of land until 2024 as a pilot project and do not expect to work actively until legal entities and foreigners enter the market.

► Conclusions

According to the study on the functioning of the market turnover of agricultural land in Ukraine for the first 12 months after the introduction of the turnover, it can be argued that, despite the effective operation of the market turnover of land and the right to dispose of land shares, owners are in no hurry to

alienate their land plots. The share of transactions for the purchase and sale of agricultural land is 29%. Most of the purchase and sale transactions for agricultural land plots were concluded on land located outside of populated areas – 82%.

The monitoring of agricultural land sale and purchase agreements revealed transactions where the value of 1 hectare was more than UAH 10 million, and the area of the land plot itself was less than 0.5 hectares. Such land plots are located near megacities and are purchased for the purpose of further commercial construction. To avoid distortion of data in the calculation of the value of agricultural land, transactions, with the value of the land plot of more than 150,000 UAH/ha, were not considered.

According to the calculations obtained, the average monthly value of agricultural land is 33,500 UAH/ha, and the average value in Ukraine is 30,500 UAH/ha. The highest value of agricultural land is in the Western regions of Ukraine – an average of 45,000 UAH/ha.

Depending on the location of the land plot to settlements, its cost is 59,700 UAH/ha within cities, 41,400 UAH/ha within villages and 31,900 UAH/ha outside settlements. The median value of agricultural land, which allows for calculating the cost more accurately, is 29,500 UAH/ha.

Among the issues of the agricultural land market turnover operation are the following: erroneous method (analogue, comparison) of land valuation at the start of market turnover; non-use of scientifically and economically sound method of land valuation; inefficient and completely inoperative mechanism of pre-emptive right; incomplete electronic databases of the State Service of Ukraine for Geodesy, Cartography and Cadastre on agricultural land, the reluctance of the banking system to provide mortgage loans for individuals; neglect and failure to use European practice regarding the use of tools and methods for the establishment and operation of the market turnover of agricultural land.

Summarising the above, it can be stated that the market turnover of agricultural land, which has been functioning in Ukraine for more than a year, has no purpose other than the purchase and sale of land. In terms of international experience, this looks like a utopia, as every country with developed agriculture and functioning market turnover of land clearly defines the goals of such turnover. For example, such countries as Poland, Germany and France have a legally enshrined goal of agricultural land

market operation – the development of farming, which is the main vector of agricultural policy.

The results of the study addressed a number of questions and formed new challenges for further research on this topic, including: the determination of the effectiveness (social, economic, environmental) of the functioning of the market turnover of agricultural land; definition of the definition of “perfect/imperfect” market turnover, research on the pricing of agricultural land, etc.

The practical value of the conclusions is formed by the key findings of the study, which are based on a detailed analysis of the state of functioning of the market turnover of agricultural land in Ukraine and provide an opportunity to quickly adjust and overcome the gaps and shortcomings of this turnover with its approximation to successful European and world practices. Among the main measures to address these issues are:

- definition of farming development (including family farming) as the main goal of land market turnover at the legislative level;
- implementation of structural changes in legislation in terms of forming a regulatory policy on the functioning of the market turnover of agricultural land (strict state control over turnover);
- revoking the right of the State Service of Ukraine for Geodesy, Cartography and Cadastre to dispose of state-owned agricultural land on behalf of the state;
- establishment of an appropriate state institution for supervision and control over the market turnover of agricultural land;
- establishment of a financial state institution with the exclusive right to grant loans secured by agricultural land;
- development of a scientifically and economically substantiated method of land valuation by the leading professional scientific institutions of the country that have been engaged in this subject for at least 10 years;
- building a mechanism of pre-emption following the European experience.

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Ринковий обіг земель сільськогосподарського призначення в Україні: моніторинг та аналіз

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► **Анотація.** Основним завданням земельної реформи в Україні, яка була розпочата 22 роки тому, є залучення земель сільськогосподарського призначення в повноцінний, ефективний та прозорий економічний (ринковий) обіг. Протягом різних етапів здійснення перетворень в земельних відносинах, в науковому, політичному та соціальному колах питання ринкового обігу земель сільськогосподарського призначення стояло особливо гостро та завжди викликало багато розбіжностей в поглядах на те, яким саме має бути ринковий обіг земель. Із запровадженням (з липня 2021 року) ринкового обігу земель сільськогосподарського призначення, питання щодо його функціонування були не тільки не зняті, а навпаки, до них додалися нові: яку саме модель ринкового обігу обрала Україна; які результати функціонування ринкового обігу земель сільськогосподарського призначення; чи відповідає модель ринкового обігу земель сільськогосподарського призначення Євроінтеграційному напрямку розвитку України тощо. Саме на висвітлення таких питань спрямоване це дослідження, через аналіз статистичних даних чітко розкриває суть проблематики, що в свою чергу формує актуальність представлених результатів. Метою статті є висвітлення та аналіз результатів ринкового обігу земель сільськогосподарського призначення в Україні та виявлення проблем даного обігу. Завданням дослідження є комплексне вивчення результатів угод купівлі-продажу прав власності на земельні ділянки сільськогосподарського призначення, що були укладені в Україні протягом 01.07.2021 р. – 01.07.2022 р., для визначення основних тенденцій результатів. Методами аналізу проблеми стали загальнонаукові, серед яких структурно-функціональний (опис та пояснення ціноутворення та функціонування ринкового обігу земель сільськогосподарського призначення); порівняння (виявлення розбіжностей в даних вартості земель та бази її розрахунку на основі зібраних статистичних даних за результатами ринкового обігу земель), абстрактно-логічний (узагальнення та формулювання висновків). За результатами дослідження здійснено аналіз результатів функціонування ринкового обігу земель сільськогосподарського призначення, виявлені причини завищення вартості земель та встановлені основні цінові тенденції. Розраховано вартість земель сільськогосподарського призначення шляхом застосування медіани, отримані результати порівняно з розрахунками середніх показників вартості. Доведено, що дані державних органів щодо вартості земель сільськогосподарського призначення обраховані некоректно. Досліджено кількість та структуру укладених договорів купівлі-продажу земель сільськогосподарського призначення в розрізі областей. Висвітлено вартісні показники земель сільськогосподарського призначення залежно від місця розташування, цільового призначення та виду угідь. Встановлено основні проблеми функціонування ринкового обігу земель сільськогосподарського призначення. Перспективи подальших досліджень полягають в пошуку шляхів вирішення проблем ринкового обігу земель сільськогосподарського призначення, через використання отриманих результатів дослідження

► **Ключові слова:** вартість земель, купівля-продаж, площа земель, середня вартість, медіанна вартість

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