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Digitization as a tool for revitalizing the livestock industry

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► **Abstract.** Digitalization of the country's economy should currently be considered as an integral prerequisite for its development, the activation of which is necessary at all levels, from the state to the level of an individual citizen. In the agricultural sector, the introduction of digital tools and technologies is necessary in view of their significant potential in the context of increasing the productivity of resources and increasing the level of competitiveness of products, manufacturers, industries, and the state as a whole. The livestock industry in Ukraine is experiencing a severe lack of electronic digital services. The purpose of the article is to justify the importance of using digitization for the innovative development of the livestock industry. The following methods of scientific knowledge were used in the research process: theoretical generalization, analysis and synthesis, data analysis, economic-statistical, graphic, correlation-regression, cartographic and abstract -logical. The main tools of digitization of the process of resource provision of producers of livestock products were summarized. Systematized priority types of information technologies within the framework of digitalization of business processes of producers of livestock products depending on the field of application, the main of which are information systems for determining actual and potential resource needs, selection of potential suppliers and organization of purchase and sale operations (field of resource provision); technologies for monitoring the state of farm animals, optimizing the diet and veterinary measures, forecasting the state of the animal, disease outbreaks, livestock productivity (production); online platforms for selling livestock products, electronic document management services, etc. (sales of products). The directions of using geo-information systems and technologies in order to ensure the development of the animal husbandry industry, which involve taking into account the information needs of potential users (in particular, producers of livestock products, investors and/or creditors, executive authorities, consumers) and providing them with accurate, unbiased, operational data, are substantiated. necessary for making management decisions. Therefore, digitalization should be considered as one of the promising tools for intensifying the development of animal husbandry and increasing the efficiency of production and sale of animal products. The practical value of the work lies in the development of the systematization of priority types of information technologies within the framework of digitalization of business processes for the production of livestock products

► **Keywords:** geoinformation systems; information support; the market; digitization

► Introduction

Activation development of agricultural production, in particular industry animal husbandry, depends on modernization in management processes. Insufficient using new ones in modern technologies slows down this process.

Potentially promising for implementation in the process of production and distribution of livestock products are information technologies. As part of the digitization of production processes, it is advisable to use technologies

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for monitoring the state of farm animals, optimizing the diet and veterinary measures, forecasting the state of the animal, disease outbreaks, and livestock productivity. Development and active use of online platforms for the sale of livestock products, electronic document management services, etc., are promising as part of the digitalization of the sale of livestock products. Therefore, digitalization is the basis for making successful management decisions by both managers and investors. Modernization, optimization, and development of the animal husbandry industry based on digitalization of management processes requires a significant amount of time for implementation, which is associated with investment, as well as training of employees in new professional competencies.

Digitization at the level of individual business entities is usually carried out directly on their initiative and financing, however, not only business entities, but also society as a whole benefit. In a broad sense, digitization is the transformation of analogue data into a digital language, which, in turn, can improve business relationships between customers and companies, creating added value for the entire economy and society (Reis *et al.*, 2020). Digitization is an inevitable trend of modern society, which contributes not only to the improvement of the economic efficiency of the functioning and competitiveness of the agricultural sector, but also allows reducing the load on natural resources and the environment as a whole (Burliai *et al.*, 2019).

A number of scientific studies are devoted to the problems of digitalization in the agricultural sector, in particular, in the field of animal husbandry, and the use of modern technologies in ensuring the competitiveness of animal husbandry products. In particular, the process of animal husbandry development to ensure a “green” economy is analysed by J. De Boer & H. Aiking (2019). Attention to the issue of the application of modern technologies in agriculture is considered in the studies of S. Brewster *et al.* (2018). W. Ma *et al.* (2018) focused on the problem of using modern technologies in the context of increasing the productivity of agricultural animals using the example of dairy farms in New Zealand. The study of the development of the livestock industry in the context of changes in supply chains in the EU was carried out by A. Deppermann *et al.* (2018). In the area of changes in agrarian policy, changes in approaches to the use of agricultural land in the EU were highlighted by J.O. Karlsson & E. Rööös (2019).

The relevance of digitalization of the livestock industry and its practical significance determined the conduct of this scientific study and influenced its purpose, which is to justify the importance of using digital technologies to activate the effective development of the livestock industry. The research problem of digitalization of agricultural enterprises was reflected in the scientific work of Yu.O. Voloshchuk (2019), who noted that digitalization can help increase the level of competitiveness of all sectors of the economy and develop innovative entrepreneurship. As noted by K. Stoyanov *et al.* (2021), digitalization is already largely seen as a key competitive advantage for all businesses, regardless of their economic sector or industry. Traditional types of economic activity, such as farming and animal husbandry, were not left out of these innovative approaches. In particular, S. Neethirajan (2023) believes that “the advent of precision and digital animal

husbandry opens up the opportunity for sustainable animal husbandry practices that improve animal welfare and health”. The livelihood of the livestock industry is also directly related to solving environmental problems, as it creates an opportunity to control the state of feed production, disposal, and processing of waste, feeding animals and their health, which is directly related to human health and the state of the environment. Thus, in Germany and France, up to 35% of milking equipment are robots, in Denmark – more than 50%, in the Netherlands – 60% (Petrenko, 2018).

Ensuring the maximum level of efficiency from the introduction of digital tools requires their use at all stages of the economic activity of livestock producers. In addition, it is important to single out tools that will ensure the receipt of positive environmental and social effects and, accordingly, the development of socially and environmentally responsible business at the community, regional and state levels. This approach will ensure the systematicity of the formed recommendations in the context of digitalization of business processes of manufacturers of livestock products.

► Materials and Methods

The methodological basis is a systematic approach to the study of economic processes and phenomena, which made it possible to identify the main tools of digitization of the process of resource provision of animal husbandry production and to single out separate areas of information provision and decision-making in the field of animal husbandry, in particular, and producers of animal husbandry products, based on geographic information systems (GIS). An important basis of the study was informational statistical indicators of Ukraine regarding the display of the dynamics of production of livestock products by various farms of all categories (Verner, 2022). Using the method of analysis and synthesis, it was determined that digitalization is relevant within the scope of production work related to monitoring, forecasting the state of farm animals, livestock productivity, optimizing the diet, etc., as well as the active use of online platforms for the sale of livestock products, ensuring constant collection, analysing information for compliance safe measures.

With the help of methods of theoretical generalization, analysis and synthesis, the approaches of scientists to the problem of agricultural production in the conditions of digitalization, in particular in the field of animal husbandry, were investigated; the logical method was used throughout the study. The data analysis was used to generalize domestic and foreign experience in determining the essential characteristics of the key concepts of digitization. The economic-statistical method was used to process statistical data, in particular the dynamics of production of livestock products and the number of agricultural animals and poultry, which made it possible to make forecasts. The graphic method was intended for a visual representation of the system of indicators of the production of products in the field of animal husbandry and livestock of agricultural animals and poultry. When applying the correlation-regression method in the process of developing the methodology, indicators of the development of the livestock industry and building models were predicted. The cartographic method was used to display and monitor milk production and consumption per person

and cow population, as well as to analyse the level of food security in general and separately by economic, ecological and social components. Conclusions and proposals were formulated using the abstract-logical method.

► Results

The level of providing the population with food is considered as the most important factor and determining criterion of the level of social life of any country, the viability of its economic structure and state system. In solving this

problem, a special role is played by animal husbandry, which is traditionally an important and integral component of agriculture and determines the socio-economic condition of all categories of farms in Ukraine. In the period 2000-2021, the industry is in a crisis situation and has undergone the most destructive changes. The analysis of the level and dynamics of the production of the main types of livestock products, which provide the processing industry with raw materials, and the retail market with food products for the population, should be considered in Table 1.

Table 1. Dynamics of production of the main types of livestock products by farms of all categories

Types of products	Years						Ratio in% to thousand tons	
	2000	2017	2018	2019	2020	2021	2000	2020
Milk and milk products (in terms of milk)	12 657.9	10 280.5	10 064.0	9 663.2	9 263.6	8 713.9	68.8	94.1
Meat (in slaughter weight)	1 662.8	2 318.2	2 354.9	2 492.4	2 477.5	2 438.3	146.6	98.4
in particular beef and veal	754.3	363.5	358.9	369.5	345.4	310.5	41.2	89.9
pork	675.9	735.9	702.6	708.3	697.2	724.0	107.1	103.8
poultry meat	35.8	1 014.1	1 084.6	1 209.7	1 232.2	1 208.5	>33 times	98.1
other types of meat	196.8	204.7	208.8	204.9	202.7	195.3	99.2	96.4
Eggs, million pcs.	8 808.6	15 505.8	16 132.0	16 677.5	16 167.2	14 071.3	159.7	87.0

Source: calculated according to the data of the State Statistics Service of Ukraine (Verner, 2022)

For the period from 2000 to 2021, the dynamics of the production of the main types of livestock products shows an increase in the volume of meat production from 1 662.8 thousand tons to 2 438.3 thousand tons, or by 46.6%, and eggs by 59.7% over the corresponding period. The increase in meat production was due to the increase in pork production by 7% and poultry meat, which increased 33 times during the studied period, while the production of beef and veal decreased by 58.8% or 443.8 thousand tons. Milk production in 2021 decreased compared to 2000 by 31.2% or by 3944 thousand tons. Compared to 2020, the volume of livestock production decreased from 1.6% (meat) to 13% (egg production).

According to the received forecasts, a further decrease in the production of beef and veal is expected (by 26.04 thousand in 2025 compared to 2021 or by 8.4%) (Fig. 1). On the other hand, the volume of production of pork and poultry meat will increase. The poultry meat production industry will develop more rapidly (growth by 5.37% annually, in particular due to the increase in livestock). In 2025, the volume of poultry meat produced will be about 1 681.66 thousand tons, which is 308.16 thousand tons (or 22.44%) more than in 2021. As for the volume of pork production, in 2025, if existing trends and dependence are preserved, it may increase by 63.29 thousand tons or by 8.74% to 787.29 thousand tons.

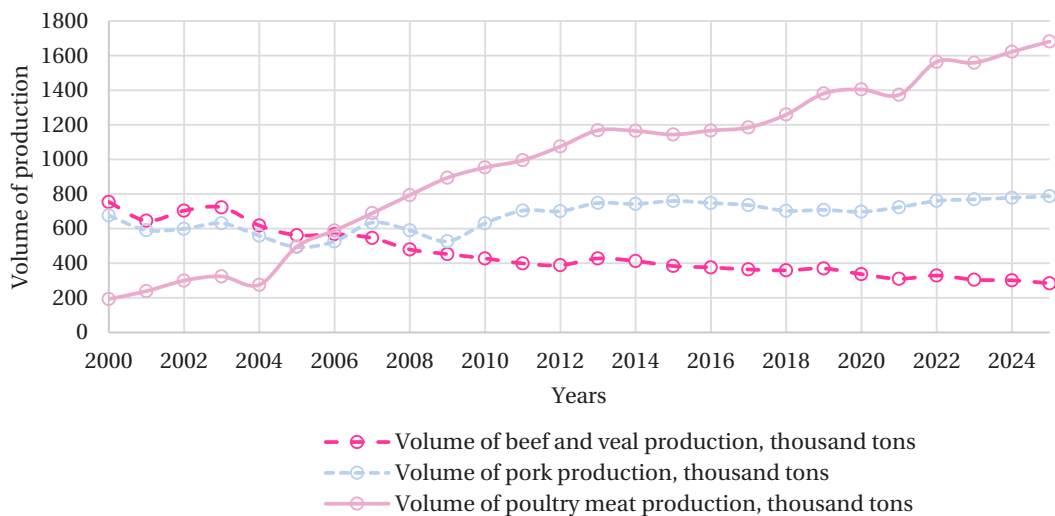


Figure 1. Projected values of meat production volumes until 2025

Note: 2022 is estimated data

Source: created by the authors

In 2025, the volume of milk production may decrease by 1 164 compared to 2 021.53 thousand tons (or by 12.57%), which in the annual equivalent will amount to

3.3% (Fig. 2). The largest projected increase in production is expected for eggs, which in 2025 could potentially reach 17.348 million eggs, which is 23.29% more than in 2021.

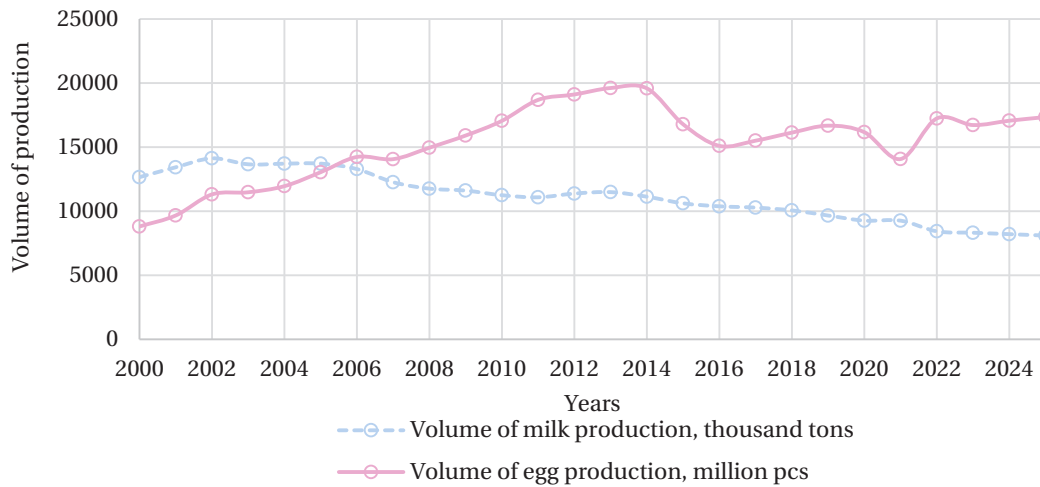


Figure 2. Projected values of milk and egg production volumes until 2025

Note: 2022 is estimated data

Source: created by the authors

Negative factors connected over time with changes in property relations and the implementation of other market transformations led to a catastrophic decrease in the number of cattle, cows, pigs, and poultry. And these are the means of production that are irreplaceable and only in their presence is it possible to produce milk and beef, pork, poultry, and eggs. That is, the number of agricultural animals and poultry and their productivity belong to the factors that decisively affect the volume of

livestock production, the level of development of the dairy and meat industry, and providing the population with the most valuable food products in sufficient quantities. The dynamics of the livestock of agricultural animals and poultry for 2000-2021 and estimated values for 2022 made it possible to forecast these indicators for the short term. Actual data on cattle population (hereinafter – cattle) for 2000-2021, estimated values for 2022 and projected levels for 2023-2025 are shown in Figure 3.

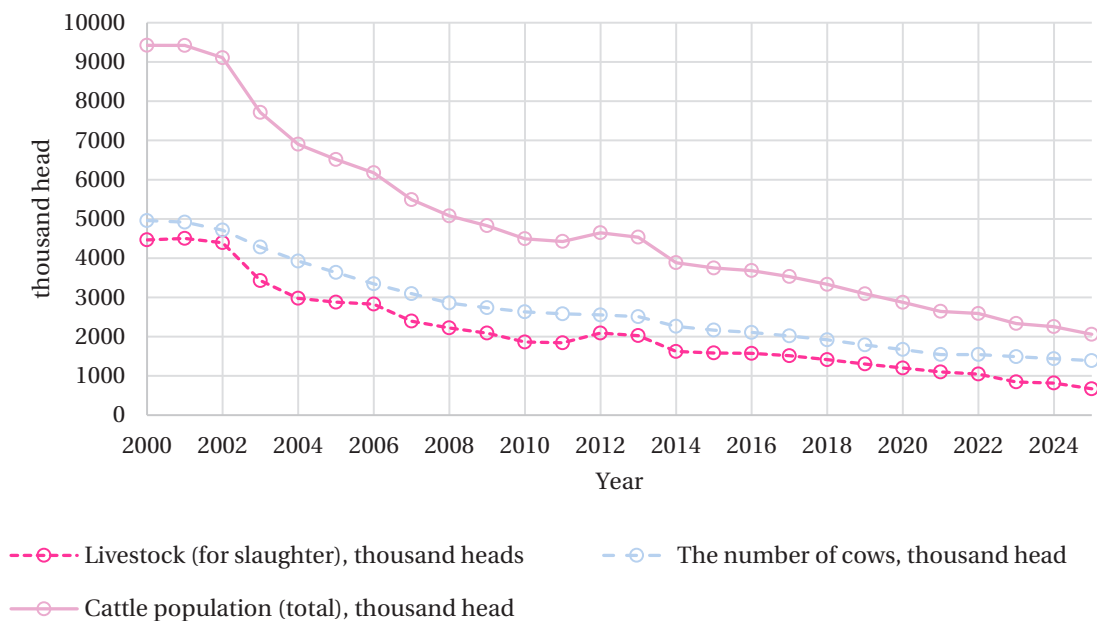


Figure 3. Trends in cattle population changes until 2025

Note: 2022 is estimated data

Source: created by the authors

Based on the forecasting results, it was established that the dynamics of the cattle population (both dairy herd and animals for slaughter) is characterized by a steady downward trend. At the same time, in the next 5 years, the rate of reduction in the number of cows is expected to decrease, while the number of cattle for slaughter will decrease somewhat more rapidly. In particular, in 2025, compared to 2021, a total decrease of 583.59 thousand of cattle (up to 2 060.42 thousand people) or by 22.07% is predicted. Annually, with an unchanged trend, the population will decrease by an average of 6.04%, which is a serious challenge to the country's food security. As mentioned above, firstly, such changes will be caused by the negative

downward trend of the number of cattle for slaughter, according to which it is expected to decrease by 428.25 thousand cattle in 2025 (up to 671.76 thousand people) or by 38.93%. On average, the annual decrease in the number of cattle for slaughter will be about 11.6%, which is an extremely negative trend. On the other hand, the number of cows, according to the constructed forecasts for 2025, will decrease by 284.34 thousand cattle or by 17% in 2025 compared to 2021 and will amount to 1 388.66 thousand cows. The annual decrease will be 3.67%. According to the results of forecasting the pig population, it was established that this indicator will remain relatively stable in the following years (Fig. 4).

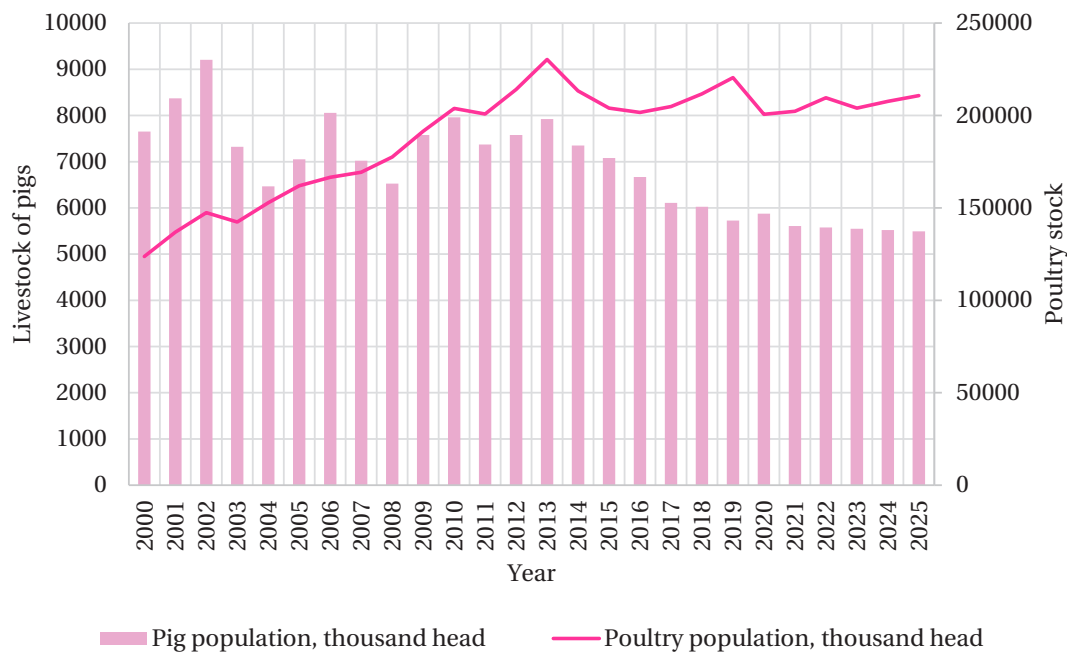


Figure 4. Trends in pig and poultry population changes until 2025, thousand goals

Note: 2022 is estimated data

Source: created by the authors

As for the poultry population, it will gradually grow, in particular thanks to the possibility of expanding the export potential of domestic producers. The annual reduction in the number of pigs in 2021-2025 will be approximately 0.52%. In particular, during this period, a decrease in the number of pigs by 116.600 heads is expected (or by 2.08%) to 5 492.2 thousand pigs. As for the poultry population, it will maintain the upward trend (annually by 1.03%) and in 2025 it will grow to 210 718.2 thousand heads or on 8 475.13 thousand heads (4.19%) compared to 2021. In the process of forecasting the population of agricultural animals, it was established that the main influencing factor is the time factor, which is a form of manifestation of scientific and technical progress (hereinafter – STP). Solving the problem of providing the population with food products of animal origin, guaranteed supply of raw materials to processing enterprises, and meeting the country's export needs necessitates the development of tools for revitalizing the development of the livestock sector, one of which is the use of digital technologies.

It is advisable to group the mechanisms and tools of digitization of the activities of producers of livestock products according to their areas of application, the basic of which are resource provision, production, and sales. The process of resource provision covers such sub-processes as determining the need for resources, searching for potential counterparties based on the price-quality ratio criterion, and, directly, buying and selling goods. Resource needs can be conditionally divided into potential needs, which are determined on the basis of planned indicators of production of livestock products and livestock of agricultural animals and poultry, as well as actual needs in accordance with the available current stocks of resources, the speed of their use and the needs of livestock at the current moment time. The main digitization tools that provide information support for the mentioned sub-processes include, firstly, inventory management systems and modules built into Internet of Things (IoT) systems that monitor the level of resource use.

Information systems focused on calculating potential resource needs are based on algorithms for determining the planned volume of production of each individual type of livestock production. To create such systems, it is necessary to develop and implement a universal (for small manufacturers) or specific (for medium and large manufacturers) methodology for determining planned production volumes, based on which the needs for each individual type of resource will be determined. To simplify the calculation procedure, it is considered appropriate to develop modules that will automatically calculate the enterprise's needs for resources based on an algorithm and mathematical models that will take into account the specifics of the economic activity of a specific manufacturer. Another type of information technology that can be used to determine the needs of producers of livestock products are special personalized services (including mobile applications)

designed to select optimal resources (in particular, feed, veterinary services, technical equipment, etc.) taking into account the key factors for the producer criteria (for example, available livestock, animal breeds, locations, etc.) (The competitive advantage..., 2018).

The search for necessary resources and suppliers, taking into account their prices, available volumes and quality characteristics of the supplier, can be carried out on the basis of special mobile applications, platforms, online marketplaces and services. Such platforms are able to select counterparties according to the specified criteria, perform a comparative analysis of various products and sellers, support online purchase and sale operations, serve as a basis for forming established relationships with the supplier, etc. In general, the main tools of digitization of the process of resource provision of producers of livestock products are shown in (Fig. 5).

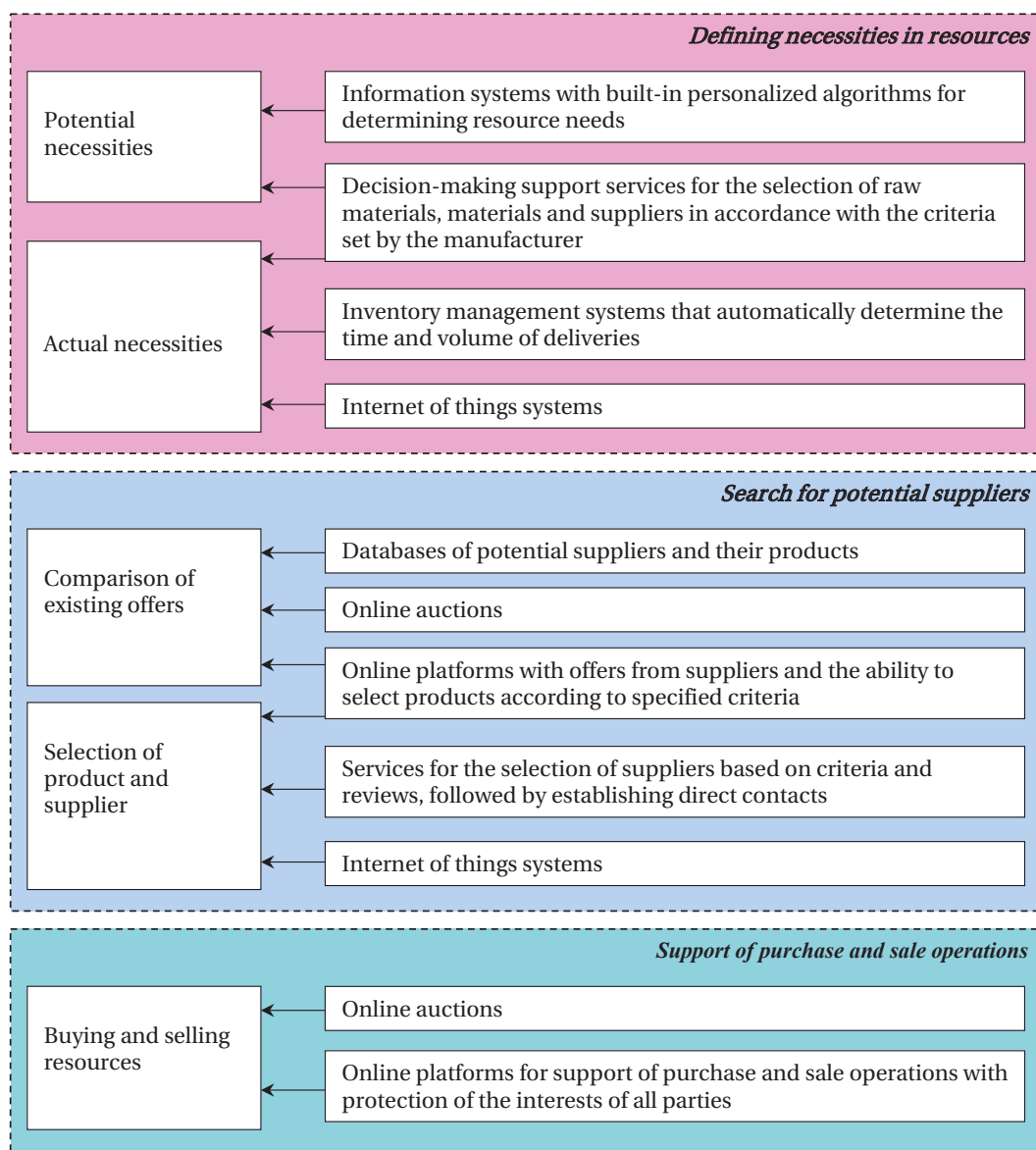


Figure 5. The main tools of digitization of the process of resource provision of producers of animal husbandry products

Source: author's development

As for the direct production of livestock products, there are currently a significant number of information systems and technologies that aim to collect, process, store, transfer data and automate a number of production functions and processes (Moroz, 2020). The main business processes that can be optimized with the help of information systems and technologies include, firstly, the monitoring of the state of health of animals and poultry, the planning of veterinary measures, and the determination of the optimal diet.

The use of hardware and software complexes based on IoT involves the installation of sensors, the use of special devices such as collars, tags for each individual farm animal, with the aim of further monitoring its health in real time and transferring relevant indicators and indicators to the user on a mobile application and/or an online platform. In the future, the obtained results will be used to determine the optimal ration (including for an individual animal if necessary), list of necessary veterinary services, control of the epidemiological situation, etc. The basis of the operation of such systems are algorithms for comparing the actual values of indicators of temperature, humidity, activity level, etc., which are continuously collected and stored in the database, with normative levels.

Remote monitoring with the help of such tools as cameras, unmanned aerial vehicles (UAVs) is proposed as another way of monitoring the health of farm animals. Such monitoring is based on computer vision technologies and specially developed and trained neural networks. The main advantages of using appropriate information systems are, firstly, the release of jobs related to animal monitoring, secondly, the observation of all livestock at the same time and, thirdly, the possibility of detecting atypical animal behaviour in real time and the formation of timely measures to find the cause and

eliminate the problem. In addition to direct monitoring of the state of farm animals, these systems are focused on data collection. In the process of processing large arrays of data, methods and technologies of artificial intelligence are involved, the purpose of which is to develop forecasts of physiological parameters of animals, their state of health and disease outbreaks. In addition, it is advisable to implement information systems into the economic process of producers of livestock products, which, based on the processing of collected data, determine the optimal ration for each individual farm animal or group of animals, taking into account their current condition, the level of provision of proteins, fats, carbohydrates, trace elements, etc.

Comprehensive monitoring of all operational processes in livestock complexes is carried out on the basis of specialized information systems and software and hardware complexes, which integrate the above-mentioned technologies. Such systems and technologies are implemented in the form of online platforms, web services, mobile applications, etc. Their main purpose is continuous monitoring by management personnel of business processes related to the analysis of animal health, feeding, veterinary care, etc. The final product of such systems is recommendations for optimizing individual operational processes based on the processing of economic process monitoring data. In general, the implementation of digital tools and technologies in the production process will enable a significant increase in the productivity of farm animals, including due to a personalized approach, round-the-clock monitoring, the use of precise mathematical algorithms and the processing of large arrays of objective information. A summary of digital tools designed to increase the efficiency of production processes in animal husbandry is shown in (Fig. 6).

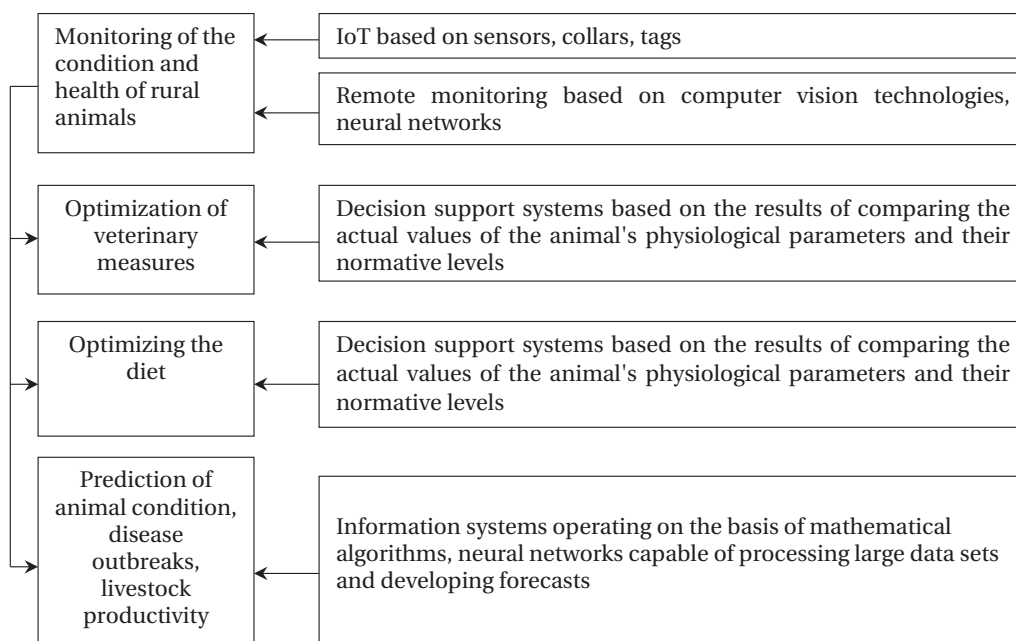


Figure 6. The main tools of digitization of the livestock production process

Source: author's development

Digitization of the process of sale of livestock products is primarily related to the digitization of data on the flow of finished products with the indication of the levels of its quality characteristics, the available volume, if necessary, photos and/or videos. With the help of online platforms, auctions, marketplaces, manufacturers will have access to the maximum number of potential buyers who are able to automate and secure purchase and sale operations. Electronic document management services are in growing demand (Electronic document management..., 2019), which make it possible to significantly save time and labour resources when working with documentation, ensure reliable storage of documents and significantly simplify the procedures for buying and selling goods.

One of the key needs of the livestock industry, without the satisfaction of which its further development is impossible, is the attraction of sufficient investment capital, which will ensure not only the expanded reproduction of the industry, but also its intensification due to the introduction of the latest technologies at all stages of the creation of the product chain, from resource provision to the realization of the finished product. Making investment decisions should be based on the analysis of the potential development efficiency of the investment object (Zakhodym, 2023). At the same time, it is necessary to take into account not only the efficiency of the direct economic entity or their aggregate at the community, regional or state level, but also the peculiarities and potential of the environment within which they function. Firstly, this concerns the availability of infrastructure facilities that are important for ensuring the business processes of producers of livestock products. Important is not only the existence of such objects, but also the possibility of forming and deepening interaction between them and producers.

Given the above, an integral element of the process of attracting investment resources is providing potential investors with the most accurate, complete information necessary for making an investment decision, in the most convenient format. One of the methods of visualization of relevant data is their presentation with reference to the coordinate system on the map. For this, geo-information systems and technologies are used, which make it possible to collect, record, process (including using modelling methods), transfer geospatial data, as well as support management decision-making. Currently, geo-information portals are being actively created at all levels of administration (primarily at the community and regional levels), which, although they perform different functions, have a common goal – ensuring the development of the respective territories.

The creation of geo-informational portals aimed at providing information for the development of the livestock sector has a number of significant advantages, namely: free, round-the-clock access to data. The main costs are the costs of creating a portal (one-time costs), its refinement and improvement (if necessary), administration (monthly expenses for the salary of a specialist), payment for virtual hosting services (monthly) and domain name (annually), solving non-trivial tasks within making management decisions (if necessary). In the case of using all the capabilities of geographic information

systems (GIS), the actual socio-economic benefits from the geoinformation portal may significantly exceed the listed and other types of costs; easy-to-understand format. In particular, data about objects (animal farms, complexes, pastures, processing enterprises, distribution networks, etc.) are displayed on the map with reference to their location. This makes it possible to significantly simplify the perception of data in various formats, to identify stable relationships between them, and to significantly improve the results of information analysis. Based on the analysis of spatial data, it is possible to form a mechanism for making informed political decisions within the framework of forming and changing the agrarian policy of the country and regions, including with regard to promoting the development of the livestock industry and ensuring the food security of the state; the possibility of spatial analysis, i.e., analysis of geographic data. The most common way of using the corresponding method is to optimize the placement of objects in space based on certain criteria and restrictions.

Geographic information systems are widely used to collect and process data, and are often used to create unique maps based on user requests. Agricultural universities and scientific institutions occupy a significant place among the key players in the development of these systems. This is due to the fact that researchers who use geographic information systems and technologies usually specialize in certain branches of agriculture. Moreover, they are often part of an extensive informal network of scientists in a university, region, or state specializing in issues related to the production, distribution, and consumption of livestock products.

In the context of decision-making in the field of providing the population with livestock products, spatial analysis can be used, firstly, to determine the locations of livestock farms, complexes, processing facilities, construction of infrastructure facilities; use for the management of natural resources involved in the production of livestock products. Based on official data, as well as processed data of satellite images, which are applied to the map, it is possible to organize continuous monitoring of water and land resources, in particular, to assess their availability, current state, and dynamics. An important stage of such an analysis is the assessment of the suitability of the land for animal husbandry and the determination of areas that are suitable for grazing (for example, according to the criteria of the presence and steepness of slopes, the suitability of vegetation cover, etc.). In addition, based on the results of geospatial data processing, it is possible to establish in which territories the grazing of agricultural animals is ecologically destructive. In such cases, a decision is made to temporarily refuse the use of the corresponding areas in animal husbandry until their restoration; decision-making support in the grazing planning process. In particular, such decisions can be based on the results of modelling the carrying capacity of pastures (Meehan *et al.*, 2018), take into account such factors as rotational grazing, periods of rest on pastures, distribution within the existing landscape, etc.; the possibility of monitoring the state and development of vegetation within pastures. Provision of continuous monitoring with automatic upload of new satellite images will make it possible to timely detect

degraded areas, which, among other things, arise due to excessive grazing.

On the basis of obtaining relevant operational data, decisions will be made regarding the provision of optimal grazing of animals not only by the criterion of economic efficiency and provision of the physiological needs of livestock, but also by the ecological criterion; infrastructure planning that will ensure business processes of production and distribution of livestock products. The corresponding function is implemented by planning and reconstruction/construction of infrastructure facilities taking into account the actual location of livestock farms and complexes, the concentration of consumers of livestock products; identification and continuous monitoring of regions with potentially increased demand for livestock products, in order to plan the infrastructure of sales markets; assessment of the potential eco-destructive effects of animal husbandry on the surrounding ecosystems. In particular, retrospective, current and potential assessments of the levels of water pollution, soil erosion, emissions of harmful substances (including carbon monoxide), etc. are determined. As part of the task of such an assessment, maps are created on which the state and dynamics of the relevant quantitative indicators are visualized. Such maps

can be used in the process of ensuring sustainable ecologically oriented development of animal husbandry.

The basic function of GIS in the process of development of the livestock industry and the markets of the corresponding products is the provision of information to all interested parties. Firstly, the following groups of users should be included in the circle of stakeholders: producers of animal husbandry products; potential and existing investors and/or creditors; decision-making subjects in the context of regulation of the livestock industry (at local, regional, state levels); consumers of livestock products; organizations and institutions for monitoring the ecological state of territories. The structure of the input data that will be loaded into the GIS should be determined taking into account the information needs of potential users, which, in turn, are determined by the types of decisions they make. This approach will ensure the systematicity of the data collection process (which can later be automated) and maximize the effectiveness of GIS implementation within the livestock sector. Therefore, special attention should be paid to the possibilities of implementation of geoinformation systems and technologies in the process of making management decisions. Table 2 details the types of livestock producer decisions that can be supported by GIS.

Table 2. Areas of information support and decision-making support for producers of livestock products based on GIS

Type of management decision	Required data	The technology of using GIS
Determination of the location of livestock farms/complexes	- pastures; - water bodies; - producers of crop production for fodder (location and capacity)	Data visualization on the map
	Land carrying capacity	- visualization of pastures (based on official data or satellite data with subsequent classification of surface types); - determination of the amount of photosynthetically active biomass within pastures (vegetation index); - calculation of throughput based on the standard of consumption of pasture grass; - optimization of the location of the farm/complex, taking into account the priority of factors (forage base, water bodies)
Determination of the location of processing facilities	Existing animal farms/complexes	- creation of shapes with data on the production capacity of producers of livestock products, roads (in particular, their classification by type); - optimization of the location of processing facilities
Determination of areas suitable for grazing	- territories of existing/potential pastures; - landscape of pastures; - water objects	- visualization of data on the map and superimposition of layers; - classification of territories according to the level of suitability for grazing, their carrying capacity
Determination of pastures subject to "rest"	Pastures with a low vegetation index, degraded pastures	- data visualization on the map; - classification of pastures according to the level of photosynthetically active biomass

Source: author's development

Most of them involve solving optimization problems with various optimality criteria and constraints. The key procedures in most of the presented problems are the classification of objects according to defined criteria, which will result in different display of objects of different groups. For example, in the case of classification of pastures by the level of the vegetation index, they can change

colour on the map from bright saturated green (high level of photosynthetically active biomass) to yellow (critically low level of the vegetation index).

When planning the livestock of agricultural animals on free grazing, it is considered extremely important to take into account the available fodder base from the point of view of potential green mass. M. Meehan *et al.* (2018)

suggest using GIS to determine the number of individual species of farm animals that graze on pasture during a specific period. The key condition for effective production of products within the framework of the relevant task should be that the number of animals does not exceed the carrying capacity of the available pastures. The latter is determined by the amount of green mass that can be obtained on a specific plot/pasture. At the same time, the condition should be

imposed that the optimal number of animals is such that it will ensure simple/extended reproduction of pastures in the form of preservation or improvement of the fodder base and other vegetation. As for other users of information about the state and dynamics of the development of both the livestock industry and the market for corresponding products and market infrastructure, the possibilities of using GIS to satisfy their own information requests are shown in Table 3.

Table 3. Areas of information support and decision-making support in the field of animal husbandry based on GIS (except for product manufacturers)

Type of management decision	Subject of decision-making	Required data	The technology of using GIS
Justification of the priority objects of stimulating the development of animal husbandry, areas of ensuring food security	Executive bodies	- indicators of the livestock sector; - consumption of livestock products; - the population of rural areas animals; - food safety	Visualization of data on the map with a mandatory emphasis on territories with an insufficient level of consumption of livestock products
Determination of the location of sales networks	Subjects are involved in the process of selling products	Location of producers and their capacity, processing facilities, roads	- creation of shapes with data on production, processing facilities, roads (including their classification by types); - optimization of the distribution network location
Justification of measures to preserve natural resources and ecosystems	Environmental institutions, organizations Executive bodies	- localization of natural resources and biological ecosystems; - location of farms/ complexes; - livestock density; - emissions of CO ₂ , CO	- data visualization on the map; - automation of data update based on updated satellite images; - determination of the amount of photosynthetically active biomass within pastures; - layering with stock density and CO ₂ emissions localization of biological ecosystems and biomass index

Source: author's development

Firstly, the category of stakeholders in the context of information provision should include executive authorities at all levels of management, who need the most accurate, unbiased and operational information about the current levels and dynamics of indicators in terms of the following groups of factors:

1) the structure of the livestock of agricultural animals – for monitoring the specialization of regions. For visualization, it is advisable to use pie charts;

2) stocking density per unit of the corresponding area. In particular, the specified information is useful for environmental monitoring in the context of emissions of environmentally hazardous substances, in particular, carbon dioxide. It is advisable to display the data in the form of charts, taking into account the time factor. In addition, such maps should display the main indicators of the ecological state, in particular, the amount of carbon dioxide emissions;

3) volume of production of the main types of animal husbandry products. For visualization, it is recommended to use choropleth maps, on which areas/regions will have different colours depending on the production volumes of each individual type of livestock production. Darker colours will represent areas with higher indicator levels;

4) available pasture areas by region for monitoring their dynamics;

5) level of livestock morbidity for monitoring the epidemiological status of livestock;

6) volumes of production and consumption of the main livestock products per capita, the level of satisfaction of physiological needs in the main types of livestock products. It is advisable to visualize in the form of choropleth maps, with the simultaneous display of diagrams of the dynamics of indicators.

Regarding the display of data as part of the analysis of the state and trends in the development of livestock product markets, the key indicators that should be displayed on cartographic images are the locations of existing sales markets (in particular, wholesale) (Brewster *et al.*, 2018). It also includes retail sales points, trading points, animal slaughter points, etc.), the number and concentration of the population, the capacity, and location of producers of livestock products. Examples of maps that can be used to monitor milk production and consumption per person and cow herd (Fig. 7) were given, as well as an analysis of the level of food security in general and separately by economic, ecological and social components (Fig. 8).

In general, the generalized concept of implementation of geo-information systems and technologies into the system of institutional support for the development of the livestock industry and markets for the corresponding products is presented in Figure 9.

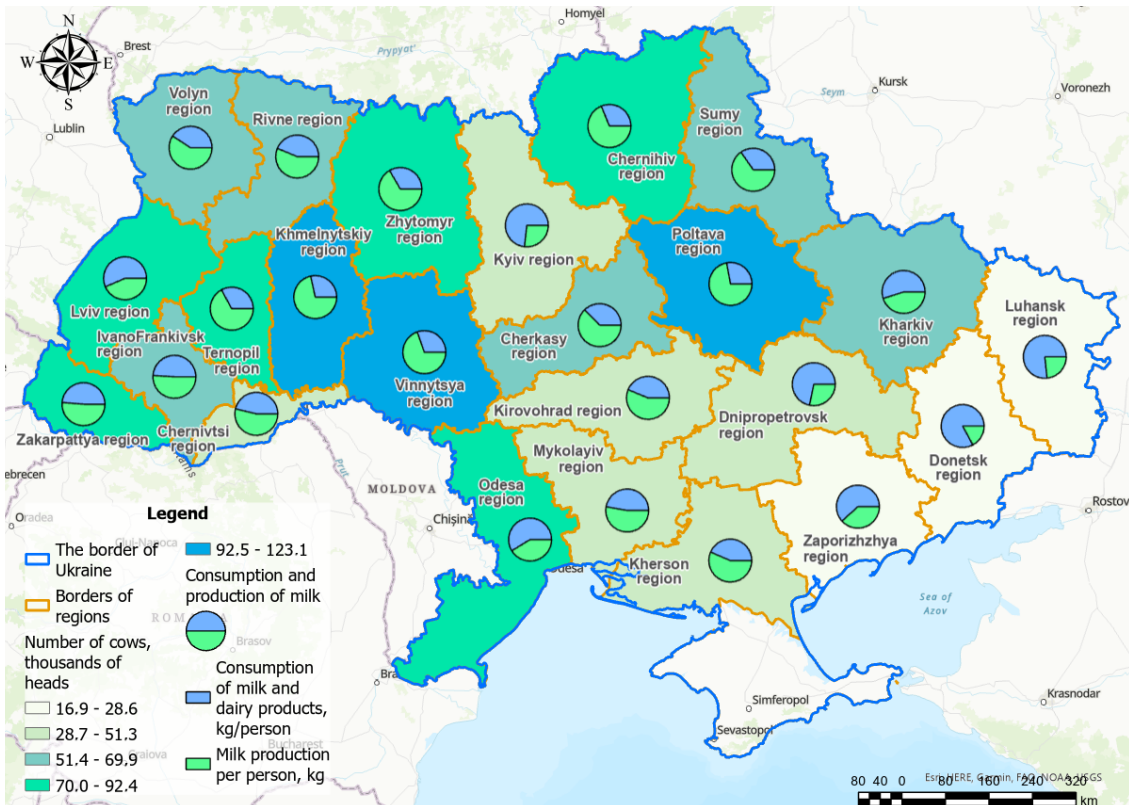


Figure 7. Map of the distribution of regions of Ukraine according to the number of cows, volumes of milk production and consumption

Source: author's development

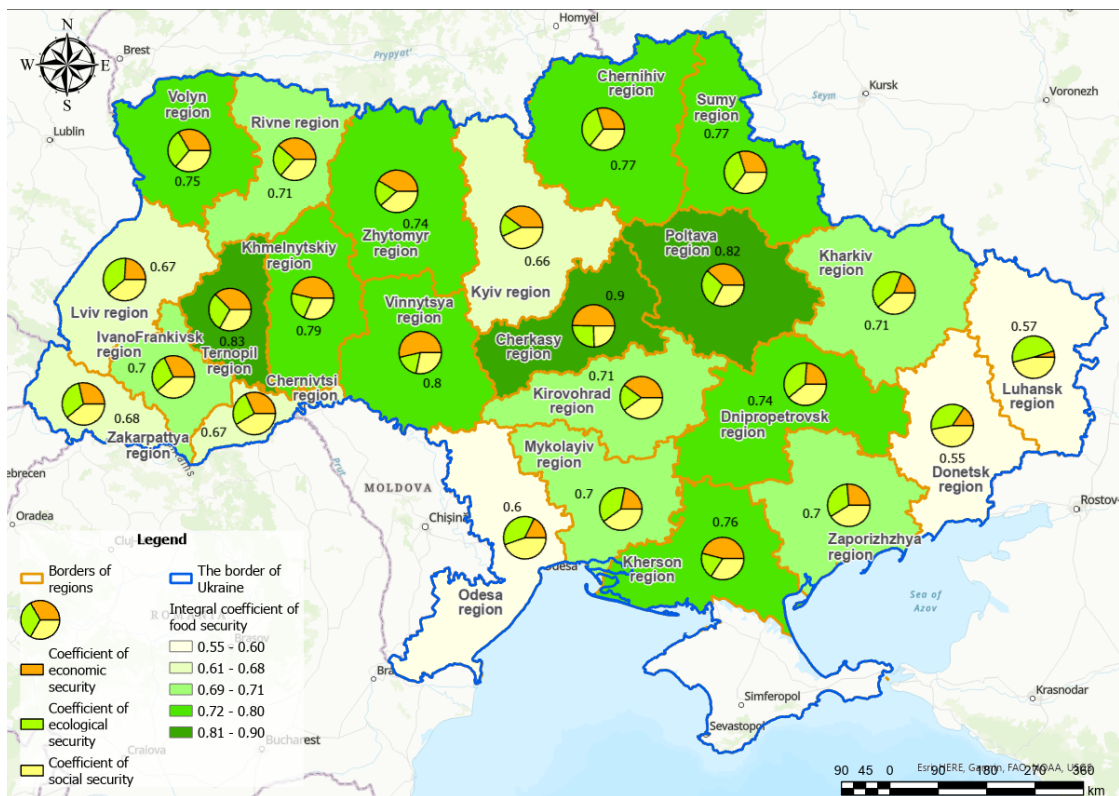


Figure 8. Map of the distribution of regions of Ukraine according to the level of food security

Source: author's development

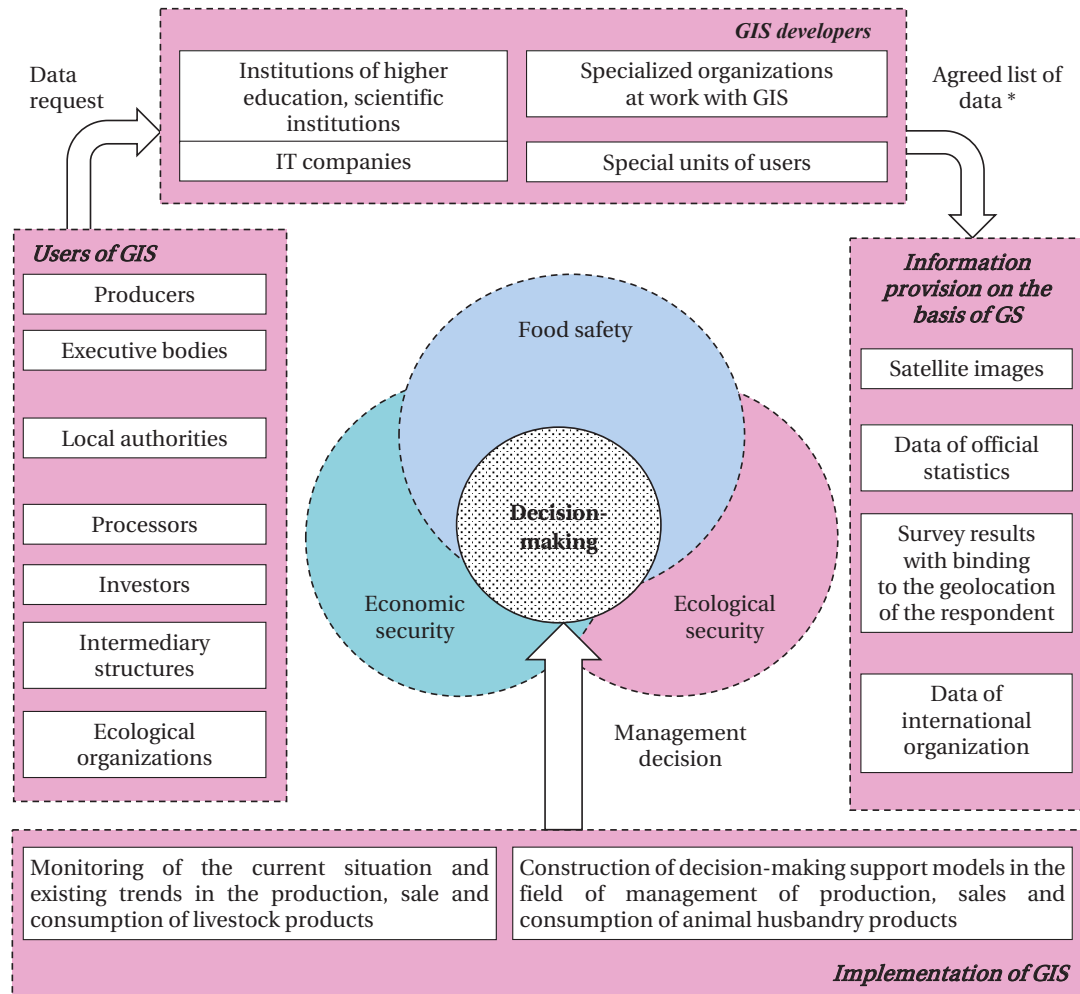


Figure 9. The concept of GIS implementation in the system of institutional support for the development of the livestock industry and the markets of relevant products

Note: * – list of indicators, visualization form, priority sources of information, update period, etc

Source: author's development

The application of geoinformation systems and technologies in the system of institutional support for the development of the livestock industry and the markets of relevant products involves the creation of an integrated and effective infrastructure aimed at supporting various aspects of these industries. Thus, such a system can provide more accurate, efficient and sustainable management of these areas, ensuring the growth of product quality, economic stability and sustainability of development.

► Discussion

Thus, A.O. Polovynkina & S.O. Solntsev (2020), who noted that digital transformation of business processes of enterprises is a market necessity in the era of the information society, as one of the key trends, focused their attention on researching the problem of digitalization of enterprises in the era of information society and digital economy. Digitalization is also making the livestock sector more attractive to investors. Researchers point out that digital innovation can help increase production efficiency, reduce risk and improve results. Investors, in turn, are more inclined

to invest in an industry that uses advanced technologies that can provide stable and high profits.

T. Lazorenko & I. Sholom (2020) argued: "... all market participants will have to change much faster in terms of digital transformation than is happening today. ... Enterprises that follow the latest trends in the field of digital innovations and are ready to implement them, are able to adapt to more flexible business processes, have a fairly large potential for success". The definition by B.S. Teteriatnyk (2018) is more general and marketing oriented, digitalization is defined as the process of applying information and communication technologies by economic entities to achieve the goal of economic activity, based on the capabilities of the modern IT industry, aimed at changing existing economic relations through their digitization; a set of acts of implementation of digitized objects to achieve the goals of economic activity, considered in their unity and related to the formation of a new form of economic relations – digital. Additional processing and analysis of data collected using sensors and IoT technologies is proving to be very useful. Researchers emphasize that such processing can help in detecting deviations in

the health of animals or even prevent the possibility of diseases. Thus, digital technologies make it possible to carry out individual monitoring and provide timely medical interventions, which affects the general condition of animals and, accordingly, the quality of their products.

According to N. Boltyanska *et al.* (2021), digital technologies in animal husbandry make it possible to implement a system of feeding, milking, product quality control, remote control of production processes in real time, as well as to ensure constant collection, analysis, and use of information for compliance with safe measures and careful attitude to the environment. Deserves attention and position I. Lozynska *et al.* (2021), who noted that the widespread adoption of digitalization, with the help of the necessary tools and leverage, will enable decision-making to improve milk quality, herd management, increase cow productivity and production profitability, outlining an overall synergistic effect. Researchers emphasize that such processing can help in detecting deviations in the health of animals or even prevent the possibility of diseases. Thus, digital technologies make it possible to carry out individual monitoring and provide timely medical interventions, which affects the general condition of animals and, accordingly, the quality of their products.

Researchers A. Valiyev *et al.* (2022) systematized and substantiated the factors of the implementation of digitalization to ensure the innovative development of agriculture in Azerbaijan, and based on the survey, the key factors and barriers to the digitalization of agriculture were substantiated, namely: the lack of regulation of legislative processes in this field and the level of cybersecurity and the cost of implementation and use digital technologies. The author also determined the levels of development of digitalization of the country's agricultural sector and substantiated the influence of digitalization factors on the innovative development of agricultural enterprises. As noted by R. Abbasi *et al.* (2022), digital transformation paves the way for the introduction of modern methods of farming and overcoming food security problems.

Scientists J. Kieti *et al.* (2022) defined digital services for agriculture as "a solution that uses digital equipment and devices such as mobile phones, computers, satellites, and sensors to solve problems in agriculture". D. Kos & S. Kloppenburg (2019) argue that digitalization will enable hyper-transparency, changing the roles of stakeholders and expanding the boundaries of global value chains in ways that increase inclusivity for smallholder farmers. Therefore, in order to ensure the systematicity of the digitalization process of the livestock industry, potentially promising types of information technologies for implementation in the production and distribution of livestock products are systematized in terms of the main operational business processes of agricultural producers. In particular, within the framework of resource provision, technologies for determining actual and potential resource needs, selecting potential suppliers, and organizing purchase and sale operations are priorities. Within the scope of production work, it is advisable to use technologies for monitoring the state of farm animals, optimizing the diet and veterinary measures, forecasting the state of the animal, disease outbreaks, and livestock productivity. As for the sale of livestock products, the

development and active use of online platforms for the sale of livestock products, electronic document management services, etc., is promising.

Thus, digitalization should be considered as one of the key tools for revitalizing the development of the livestock industry and increasing the level of efficiency in the production and sale of livestock products. The key issue of ensuring the process of digitalization of business entities is the use of exclusively digital data in business processes. Only under this condition is it possible to implement modern technologies in the economic process of producers of animal husbandry products. In addition, in order to reduce production risks and make adequate management decisions, at all stages of the production process it is important to ensure continuous monitoring of factors affecting the productivity of farm animals and the efficiency of production of livestock products. The solution of part of the management tasks, which lie in the plane of decision-making regarding the optimization of the locations of the capacity of participants in the livestock products market, taking into account the available resources and infrastructure facilities, is solved on the basis of the application of geo-information systems and technologies, which, in addition to attributive data, make it possible to collect, visualize process spatial data.

► Conclusions

Therefore, one of the key directions of information provision on the basis of global digitalization is the application of geoinformation systems and technologies in the economic activity of producers of livestock products. In particular, the expediency of creating geo-informational portals with a targeted direction on information provision of the development processes of the animal husbandry industry, which has a number of significant advantages, namely: free 24-hour access to data; easy-to-understand format; possibility of spatial analysis; use for natural resource management; decision-making support in the grazing planning process; the possibility of monitoring the condition and development of vegetation within pastures; infrastructure planning; identification and continuous monitoring of regions with potentially increased demand for livestock products, in order to plan the infrastructure of sales markets; preservation of the environment. The proposed concept of implementation of geoinformation systems and technologies in the process of ensuring the development of the livestock industry and the markets of relevant products takes into account the information needs of all groups of potential users and aims to ensure the food security of the country.

In all the listed tasks, which are solved on the basis of GIS, one of the main stages is the collection of the most reliable and up-to-date data. In view of the above, in many cases the use of official statistics is problematic due to the length of the update, the incompleteness of the data by region, and, in some cases, the inaccuracy of the information. That is why, at the stage of coordination of key parameters of the geoinformation system within the framework of solving a specific problem, it is necessary to establish which data sources are a priority for the user. Currently, a significant part of data for GIS-based information support is accumulated from satellite images, which

are characterized by objectivity and relative promptness of updating. Considering the fact that for both collection and processing of GIS data, unique maps are usually created at the request of the user, one of the main types of developers should be agricultural universities and scientific institutions. This is explained by the fact that scientists who work with GIS and technologies, firstly, are often specialists in a certain field of agricultural science and, secondly, are part of an extensive informal network of researchers of the university/region/state, which, including, specialize in issues of production, distribution, and consumption of livestock products.

Prospects for further research should be a thorough analysis of the economic efficiency of the introduction of digital technologies in the field of animal husbandry,

namely the effectiveness of the use of GIS and their impact on the development process of the animal husbandry industry and the markets of the corresponding products and confirmation of their significance. Of scientific interest for future research is an in-depth study of the issues of digitalization implementation, which regulates the activation of innovative development of the livestock industry, with a similar base of key European countries and partner countries from other regions of the world.

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► Conflict of Interest

None.

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Діджиталізація як інструмент активізації галузі тваринництва

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► **Анотація.** Діджиталізацію економіки країни наразі слід розглядати як невід'ємну передумову її розвитку, активізація якої є необхідною на всіх рівнях від державного до рівня окремої особи-громадянина. В аграрному секторі впровадження діджитал-інструментів і технологій є необхідним з огляду на їх значний потенціал у контексті збільшення продуктивності ресурсів та підвищення рівня конкурентоспроможності продукції, виробників, галузей і держави у цілому. Особливо нестачу електронних цифрових послуг відчуває галузь тваринництва в Україні. Мета статті – обґрунтувати важливість застосування діджиталізації для інноваційного розвитку галузі тваринництва. У процесі дослідження використовувалися такі методи наукового пізнання: теоретичного узагальнення, аналізу та синтезу, аналізу даних, економіко-статистичний, графічний, кореляційно-регресійний, картографічний та абстрактно-логічний. Було узагальнено основні інструменти діджиталізації процесу ресурсного забезпечення виробників продукції тваринництва. Систематизовано пріоритетні типи інформаційних технологій у рамках діджиталізації бізнес-процесів виробників продукції тваринництва залежно від сфери застосування, основними з яких є інформаційні системи визначення фактичних і потенційних потреб у ресурсах, підбору потенційних постачальників та організації операцій купівлі-продажу (сфера ресурсного забезпечення); технології моніторингу стану сільськогосподарських тварин, оптимізації раціону та ветеринарних заходів, прогнозування стану тварини, спалахів хвороб, продуктивності поголів'я (виробництва); онлайн платформи для продажу продукції тваринництва, сервіси електронного документообігу тощо (збут продукції). Обґрунтовано напрями використання геоінформаційних систем і технологій з метою забезпечення розвитку галузі тваринництва, які передбачають урахування інформаційних потреб потенційних користувачів (зокрема, виробників продукції тваринництва, інвесторів та/або кредиторів, органів виконавчої влади, споживачів) та їх забезпечення точними, неупередженими, оперативними даними, необхідними для прийняття управлінських рішень. Тому, діджиталізацію слід розглядати як один із перспективних інструментів активізації розвитку тваринництва та підвищення ефективності виробництва і реалізації тваринницької продукції. Практична цінність роботи полягає у розвитку систематизації пріоритетних типів інформаційних технологій у рамках діджиталізації бізнес-процесів виробництва продукції тваринництва

► **Ключові слова:** геоінформаційні системи; інформаційне забезпечення; ринок; цифровізація



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Diversification of entrepreneurial activities in the agricultural sector of Ukraine's economy in the post-war period

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► **Abstract.** In the context of modern development of agricultural producers, assessing the level of their activity efficiency and searching for an appropriate strategy for further development is essential. The aim of the article was to formulate a concept of sustainable development for agricultural producers based on identifying the most viable development strategy. The article's methodological framework included the following methods of scientific inquiry: descriptive method, measurement and comparison methods, economic-mathematical modelling, induction, deduction, analysis and synthesis, system-structural analysis. The essence of diversification of activities in the agricultural sector was examined and revealed, defining their role in forming sustainable development. To achieve this, theoretical concepts of Ukrainian and foreign scholars, as well as the categories of "diversification" and "sustainable development," were synthesized. Subsequently, an analysis and forecast of land use by agricultural enterprises were conducted. The dynamics of changes in the structure of cultivated areas from 1991 to 2021 were determined, as this period marked the implementation of agricultural reform aimed at finding effective agricultural product producers. Changes in the magnitude of costs for primary resources in farm enterprises of the Kyiv region on the eve of the war were defined, and the economic efficiency of cultivating major agricultural crops was analysed. Based on established data, a development strategy was modelled for an average farm in the Forest-Steppe zone of Ukraine, considering the concept of diversification through the implementation and development of animal husbandry. Furthermore, directions for further development of agricultural entities were substantiated by deepening the diversification of activities through optimizing cultivated areas. The research outcomes could be considered in shaping the development strategy of entrepreneurial structures and evaluating their impact on sustainable development in the post-war period

► **Keywords:** strategy production; sustainable development; forecast; economic efficiency

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► Introduction

Diversification, in the context of increased competition, plays a crucial role in forming an effective entrepreneurial strategy. In general terms, diversification of activities is seen as a strategy where a company expands its business operations by adding new directions or products to its core activities. This can be achieved through internal development, acquiring other companies, or creating joint ventures with partners. Diversification of activities allows companies to reduce risks associated with market changes, competition, and technological shifts. It also enables companies to enter new markets and enhance their competitiveness. In the agricultural sector of the economy, diversification, based on optimizing production structure, helps mitigate the impact of price fluctuations.

These fundamental principles have been substantiated and further developed in the works of both past and contemporary scholars. For instance, S. Balyuk & A. Kucher (2018), P. De Andrés *et al.* (2017) have highlighted the role of diversification strategies in utilizing financial resources. They explored how the choice of strategy influences a company's value. A. N. Kariuki *et al.* (2018) consider diversification as a tool to expand the range of value-added dairy products. Their findings show that access to markets for diversified products positively impacted the performance of dairy industry enterprises in the studied region. Research by O. Varchenko *et al.* (2019), D. Beillouin *et al.* (2019) assess the production and ecological benefits of diversifying activities in farms specialized in plant-based production. Meanwhile, N. K. Nigam & C. P. Gupta (2020) investigate the feasibility of diversification, studying its impact on various aspects of a firm's activities, including financial performance and time analysis. Ukrainian scholar O. M. Zgurska (2018) extended research in the context of crisis situations, emphasizing diversification as a tool to address inefficiencies and uncertainties in the external environment.

Economic activities are often categorized into production and financial sectors. In the financial sector, diversification involves allocating investments across different assets to reduce the risk of losses. The more diverse the assets in a portfolio, the less impact a decrease in the price of one asset has on the overall income. Diversification can encompass different asset classes such as stocks, bonds, real estate, gold, and other resources. It helps decrease risks and increase stability in an investment portfolio. On the other hand, production diversification is a strategy in which a company expands its production range by adding new categories of goods or services to its core products. This can be achieved through internal development, acquiring other companies, or creating joint ventures with partners.

Production diversification enables companies to expand their market presence, enter new market segments, and enhance competitiveness. It also allows companies to reduce risks associated with market changes and competition. However, the war in Ukraine has posed numerous challenges to the country's economy, affecting business operations and industry development. Agricultural production is one of the sectors heavily affected by the conflict. A crucial precondition for post-war entrepreneurial development in the agricultural sector is the establishment of market conditions that ensure the growth

of value-added and profitability for producers through diversification of their activities. The aim of the article was to scientifically generalize theoretical concepts of diversification of agricultural producers' activities and, based on this, further develop practical recommendations for identifying promising development directions in accordance with the concept of sustainable development in the post-war period.

► Materials and Methods

The basis of the conducted research was an informational foundation, which encompassed not only statistical data characterizing the economic activities of agricultural enterprises in Ukraine, but also aggregated statistical reports provided by the State Statistics Committee of Ukraine. This comprehensive information served as the foundation for studying and analysing various aspects of rural development, enabling a deeper and more objective understanding of the industry's state and its development trends (Agriculture of Ukraine..., 2022; Global and domestic..., 2022).

The research process went through several stages. In the first stage, using descriptive and systemic-structural methods, the generalization, and analysis of theoretical principles of diversification of activities by agricultural producers were carried out. Based on these principles, priority directions of diversification in the post-war period were identified. To substantiate these theoretical positions, in the second stage, using measurement and comparison methods at the empirical level, the land use structure from 1991 to 2021 was analysed, as well as changes in the structure of cultivated areas in Ukraine. This period was chosen due to Ukraine's independence and the initiation of agrarian reform aimed at finding efficient producers of agricultural products. Data for the year 2022 cannot fully reflect the state of economic development, as it is hindered by the full-scale war on Ukrainian territory. Also, not all the data for 2022 and 2023 has been published yet.

In the third stage of the research, for the purpose of forecasting the development of agricultural producers, relevant data for the year 2022 were used. Taking into account the analysis of changes in land ownership, a predictive model was constructed that allows calculating the average size of farm households by 2030. The equation of the model is as follows:

$$y = 64,409 \ln(x) + 15,055. \quad (1)$$

The mentioned model allows for a maximum consideration of trends in land ownership changes among the studied economic entities. The obtained data were used in the construction of an economic-mathematical model. The next important step in the research was the comparison of the economic efficiency of production activities of farm households in the pre-war and subsequent marketing years. This comparison enabled the determination of key resources and their impact on the increase of production costs. This stage of the work was conducted using methods of induction, deduction, analysis, and synthesis.

The obtained analytical data served as the basis for forecasting the development of agrarian producers through the diversification of their activities, specifically through the involvement and development of the livestock sector.

To formulate this forecast, an economic-mathematical model was developed using an economic-mathematical modelling method. This model projects the production structure based on scientifically grounded approaches to crop rotation and considering livestock development (Ilchuk *et al.*, 2019).

The objective function for optimizing production systems is as follows:

$$F_{\max} = \sum_{k=1}^n v_k s_k + \sum_{t=1}^m v_t p_t, \quad (2)$$

where F_{\max} – is income; k – the type of crop ($g = 1, 2, \dots, n$); t – the type of animal ($a = 1, 2, \dots, m$); s_k – the cultivated area

of the g -th crop; p_t – is the livestock population of the a -th animal type; v_k – is the income per unit of area for the j -th crop; v_t – the income per head for the k -th type of animal.

► Results and Discussion

Continuing the scientific and practical work of colleagues, it is necessary to consider and further develop the following key principles of agricultural product diversification, taking into account the balance between cultivating high-margin crops without disrupting crop rotation patterns, revitalizing the livestock sector, and promoting the development of farm households as the foundation for sustainable post-war development (Fig. 1).

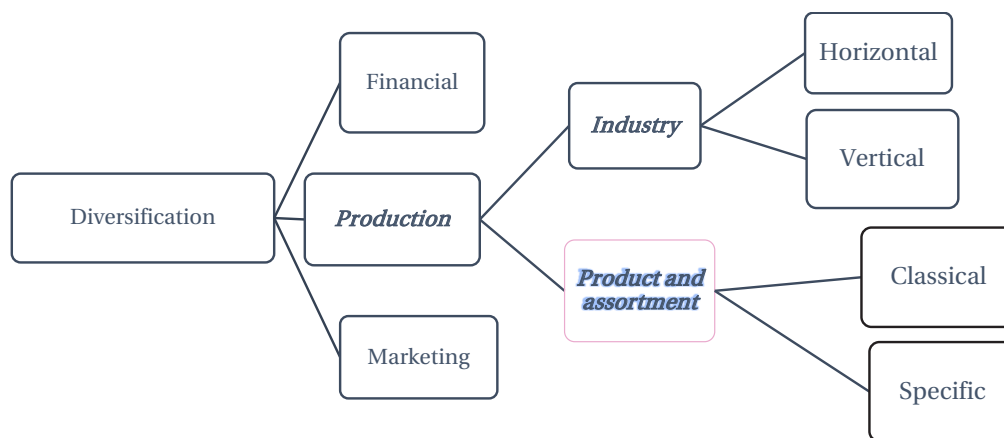


Figure 1. Types of diversification of agricultural producers

Source: summarized and supplemented by the authors on the basis of developed theoretical sources M.M. Ilchuk *et al.* (2016); I.V. Svinous *et al.* (2018)

The diversification of activities among agricultural producers is driven by objective factors within a market economy. It allows for the reduction of the impact of price fluctuations on production, thereby stabilizing the income generated. Diversification also activates potential sources of internal growth and enhances production efficiency. Depending on market conditions, the goals of diversification can vary (Fig. 1). This multifunctionality underscores the practicality of using diversification as a foundation for shaping the development strategy of agricultural producers. In stable market conditions, the theory of production diversification has focused on investigating industry-specific forms of implementation. However, the development of the economy amidst military activities and the post-war period increases the significance of considering and developing the theoretical aspects of production diversification based on product-assortment forms of implementation. The choice of this strategy is justified by its lower investment requirements compared to other strategic forms-horizontal and vertical.

Diversification is regarded as a process that occurs throughout the entire lifecycle of agricultural enterprises, encompassing all its aspects. The economic context of this process involves initiating any activity that generates income, but does not encompass all aspects of the economy (Ilchuk *et al.*, 2016). Therefore, diversification for agricultural producers serves as a tool that maximizes the utilization of internal enterprise potential to achieve profitability. Diversification is believed to preserve the

competitiveness of the enterprise, foster the development of strong market resilience, and eventually channel capital toward more profitable entrepreneurial ventures (Marshallok *et al.*, 2021).

The foundation of diversification must be based on the concept of sustainable development, which aims to move away from the idea of stimulating consumption growth. This concept was initially introduced at the United Nations conferences in Stockholm (1972) and Rio de Janeiro (1992). According to its basic principles, the concept of sustainable development envisions societal growth where economic and social benefits are determined by the ecosystems' capacity for self-renewal. Solving this issue lies in the rational balance between socio-economic development and the rational use of natural resources. This balance should ensure environmental safety while effectively using available resources, all while promoting improved quality of life and well-being for the population. In Ukraine, the implementation of the concept of sustainable development is significantly complicated due to ongoing military actions. Undoubtedly, this situation has a significant impact on the understanding of the state and prospects of sustainable development, underscoring the importance of comprehending diversification in shaping the development strategy of agricultural producers in the post-war period. Agriculture has been one of the sectors most affected. When looking at this issue through the lens of ecological, social, and economic societal development, attention should be drawn to the following problematic aspects.

Firstly, ecology: it has been identified that a considerable area requires demining and proper reclamation. Among land resources, black soils have suffered the most. According to experts from the National Scientific Center "Institute of Soil Science and Agrochemistry named after O.N. Sokolovsky", as of May 2022, the most significant areas affected by combat actions are characterized by the following primary soil types: ordinary chernozems (50.1 thousand square kilometres), soddy and soddy-podzolic soils (29.4 thousand square kilometres), southern chernozems (16.2 thousand square kilometres), and dark chestnut soils (9.6 thousand square kilometres) (Balyuk & Kucher, 2018). Over a short period, significant land areas in the south and east of Ukraine have been taken out of circulation, and the material and technical base has been damaged or destroyed, resulting in reduced livestock populations.

Secondly, social development: the structure, quantity, and employment of the population have significantly changed due to the military actions. The involvement of able-bodied male population, internal migration, and the departure of women and children abroad exacerbate the issues of sustainable development in the post-war period. The incapacity of enterprises in the occupied territories or in regions close to conflict zones, the loss, or damage to business assets, disruptions in logistics including port closures, have led to a sharp increase in unemployment. According to preliminary data, in July, unemployment reached 35%, nearly four times higher than the end of 2021 (9.8%). This is due to the complete or partial closure of enterprises and the loss or wear of production facilities. Considering inflation at 26% and the devaluation of the hryvnia, real wages have decreased by over 40% (The unemployment rate..., 2022).

Thirdly, the economic sphere: military actions have impacted the volume of commodity production. The production of agricultural products, especially crops, has significantly decreased, and the country's export opportunities have deteriorated. The situation further complicated after the start of the maritime blockade of the ports of Odesa and Mykolaiv. The logistical capacities of the Ukrainian Danube Shipping Company, railways, and road

transport are insufficient to facilitate proper agricultural product circulation. As a result, demand has plummeted, and prices for agricultural products, especially grains, have dropped. The conclusion of a grain agreement improved the overall situation, but numerous farmers in the south incurred significant losses. According to unofficial data, up to 30% of micro-agricultural enterprises did not even plant winter grains, as the absence of early spring technological measures and low market prices, ranging from 1600 to 2500 hryvnias per ton, did not allow for profitable margins (Splodytel *et al.*, 2023).

When considering the factors leading to economic decline and the opportunities for managing this process, it's worth noting that the situation with grain crops was anticipated. An export-oriented grain industry had been producing three times more than domestic consumption in recent years (Grain market..., 2022). While excess production was directed towards exports, the sector became a crucial source of currency inflow to the budget. However, the pursuit of profit and the lack of an effective national security policy jeopardize not only income volumes to the budget, such as taxes and contributions, but also the possibility of sustainable development of rural territories and the well-being of tens of thousands of farm enterprises and hundreds of thousands of citizens associated with this sphere.

It can be argued that this situation is the consequence of the absence of a unified, comprehensive concept for the development of the agricultural sector. The lack of control over the formation of market relations resulted in significant sectoral imbalances when forming new principles of management after Ukraine's independence. Therefore, it's important to understand the historical development of Ukraine's agricultural sector, its current level of development, and its place in global agriculture. This analysis is crucial for shaping the development strategy of the agricultural sector both in the post-war period and overall, in the formulation of a sustainable development concept. Based on these considerations, a rapid analysis of the conditions of operations in the agricultural sector of the economy was conducted (Fig. 2).

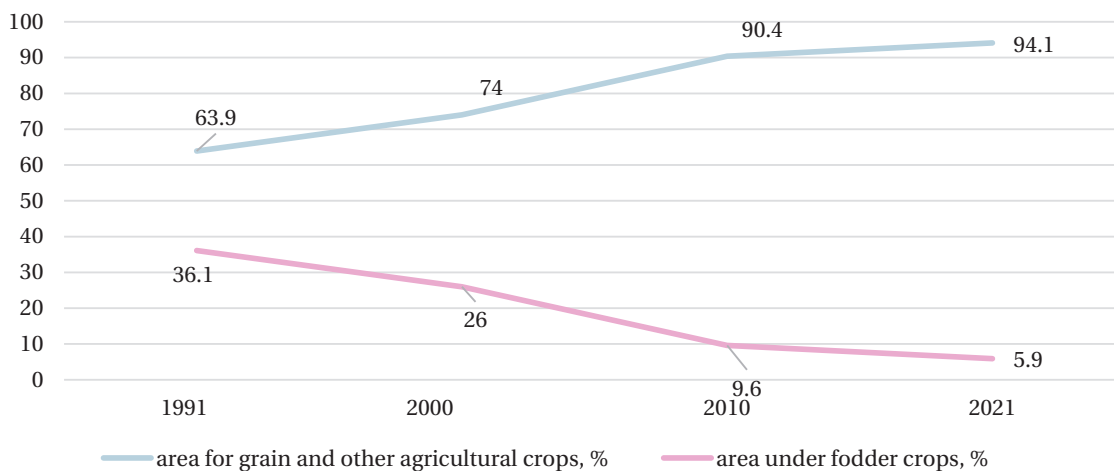


Figure 2. Dynamics of the structure of land use by agricultural producers

Source: summarized on the basis of statistical reporting data Agriculture of Ukraine for 2021 (2022)

In Figure 2, the dynamics of the distribution of agricultural land between grain and forage crops are depicted. Grains are the primary group of crops, while forage crops serve as the main raw material base for the livestock industry. The analysis revealed that during the initial stages of market relations, low agricultural productivity, disruptions in established economic connections, lack of credit and material support negatively affected the economic efficiency of agricultural producers' activities and compelled them to seek ways to navigate the complex situation.

As a result, there was a reduction in livestock farming. This is because managing the livestock industry is more labor-intensive and requires larger investments in fixed assets compared to the crop sector. Bringing livestock to a more productive level demanded disproportionate investments and efforts. These mentioned factors, along with low product prices, became the main influencers behind the reduction in livestock and poultry populations. Consequently, this led to a decrease in the area under forage crops and became one of the factors influencing changes in crop rotation structures (Fig. 3).

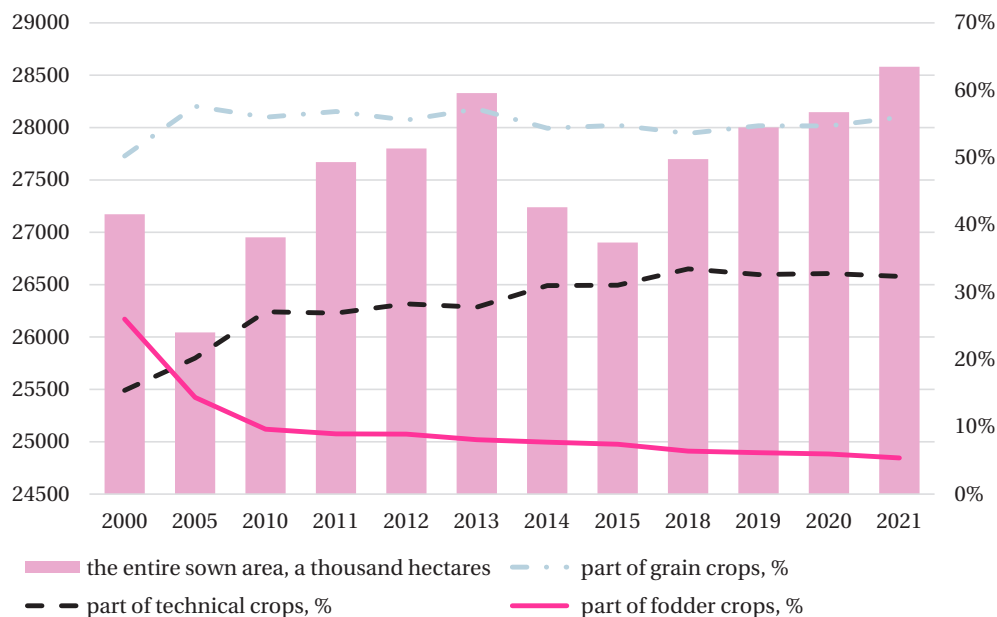


Figure 3. Dynamics of the structure of cultivated areas and its change

Source: summarized on the basis of statistical reporting data Agriculture of Ukraine for 2021 (2022)

Analysing the dynamics of sown areas during the researched period, it's worth noting that the total sown area increased. The significant reduction in 2014 and 2015 is directly linked to the withdrawal of agricultural land from cultivation in the Donetsk and Luhansk regions due to military actions and the annexation of the Crimean Peninsula. However, during the subsequent period, a clear trend of increasing the area under cultivation of agricultural crops was restored. This was primarily achieved through the reduction in areas under forage crops. By the beginning of 2022, Ukraine was able to compensate for the loss of sown areas and partially restore the export opportunities of the agricultural sector. Agricultural producers, including farmers, regained the ability to sell their products at global market prices, and the country was able to fill its budget through external economic activity and currency inflows.

The analysis of agricultural production in Ukraine's agricultural sector indicates that from 2000 to 2020, the production of cereals and legumes consistently increased. Technological improvements in production and the expansion of cultivated areas for crops resulted in a more than twofold increase in grain production over the course of a decade. The production of some oilseed crops, especially sunflower, rapeseed, and soybeans, also increased

(Soybeans in crop..., 2020; Global and domestic..., 2022). However, the low demand for livestock products, combined with a generally low technological level of production processes, influenced the sector's development. Livestock populations, productivity, and consequently, the volume of product output, decreased. Consequently, the overall decrease in livestock affected the reduction of areas under forage crops (Kravchuk et al., 2021).

Structural changes in the industry occurred concurrently with land privatization. These measures allowed peasants to obtain land shares. New types of entrepreneurial structures formed: large-scale and small-scale agricultural producers. Among these, numerous family farms emerged, with 48 860 farms registered as of January 1, 2022 (More than..., 2022). Analysing the development of these economic entities, it's important to highlight the following characteristics: Firstly, family farms comprise around 80% of the total number of agricultural businesses. Secondly, these farms hold approximately 22% of arable land. Thirdly, 80% of family farms own less than 500 hectares of land, with an average farm size of 131 hectares. Therefore, given the quantity of family farms, the changing dynamics of their sizes, and their impact on rural development, it's prudent to emphasize an analysis of their status and prospects (Varchenko et al., 2019).

In Ukraine's agricultural sector, the specialization of family farms is largely driven by the specialization of large-scale agricultural producers, namely agro-holdings.

As a result, the situation that unfolded in 2022 had a negative impact on all market participants. Over a short period, prices for essential resources underwent changes (Fig. 4).

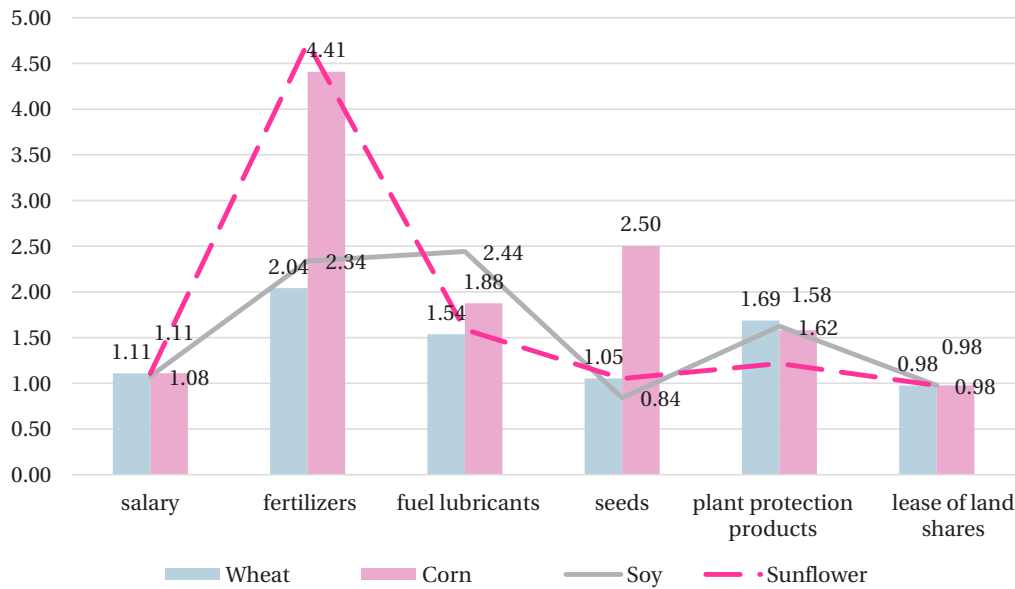


Figure 4. Changes in costs of basic resources in farms of the Kyiv region for the 2021/2022 marketing year
Source: summarized on the basis of statistical data on Agriculture of Ukraine for 2021 (2022)

The sowing campaign of 2022 took place against the backdrop of a sharp increase in prices for essential resources such as fuel, lubricants, fertilizers, seeds, and plant protection products. There was a significant reduction in the supply of these key resources in the market, coinciding with the breakdown of financial and trade credit relationships, a rapid devaluation of the hryvnia (the Ukrainian currency), and a decrease in demand for agricultural products. All of these factors had a negative impact on the economic efficiency of agricultural producers. For instance, when analysing the activities of farms in the Forest-Steppe zone of the Kyiv region, it was observed a considerable increase in the cost of production. The main contributing factors were expenses related to fertilizers,

fuel and lubricants, seeds, and plant protection products. Meanwhile, the increase in labour costs and rental payments for land remained relatively unchanged.

Comparing with the previous year, Table 1 allows drawing the conclusion that the war has impacted the profitability of cultivating main crops. The profitability of cultivating main crops has significantly decreased, and growing cereals has become unprofitable altogether. For example, the loss in wheat cultivation amounted to -10.8%, and for corn, it was -44.5%. Moreover, the marginal profit per hectare of corn turned out to be negative at -10 521.1 hryvnias, indicating the impracticality of producing this type of grain in the short term (Potaeva, 2022).

Table 1. Efficiency of cultivation of the main agricultural crops

Indexes	Wheat		Corn		Soy		Sunflower	
	2021	2022	2021	2022	2021	2022	2021	2022
Productivity, t/ha	4.61	4.12	8.01	5.35	2.68	2.36	2.52	2.19
Fixed costs per 1 ha, hryvnias	4 909.1	6 011.6	4 898.3	6 010.7	4 901.9	6 016.4	4 893.4	6 004.1
Variable costs per 1 ha, UAH	12 637.5	12 472.6	18 609.9	31 118.6	11 935.2	17 691.3	10 633.1	12 108.1
Marginal income, UAH/ha	26 639.7	4 007.4	41 625.3	-10 521.1	32 284.8	9 507.3	36 541.3	12 529.4
Profitability (loss) of production, %	123.8	-10.8	156.2	-44.5	162.6	14.7	203.8	36.0

Source: summarized on the basis of statistical data on Agriculture of Ukraine for 2021 (2022)

The situation that has unfolded in the agricultural sector of the country requires new approaches to organizing the production activities of agricultural production. In this situation, the necessity of implementing a diversification

strategy arises, which would ensure the sustainable development of the industry, both economically and ecologically. Diversification can be used to reduce operational risk, achieve increased financial synergy, stabilize income,

enhance credit opportunities, and promote growth or change in the company's profile. When considering diversification of agricultural production, it is worthwhile to explore the possibility of increasing the acreage under soybean cultivation. Soybeans are a valuable agricultural crop that serves as both a food and feed crop, enhancing its utilization possibilities. Notably, soybean products are considered an alternative source of nutrition and absorption for people who cannot tolerate conventional dairy proteins. This explains the growing demand for soy-based products among the population. Soybeans belong to one of the most widely cultivated agricultural crops globally, and the global trade market for soybeans has increased to nearly 50-55 million tons over the past two decades (Soybeans in crop..., 2020).

Soybeans are also valuable as a preceding crop in crop rotation planning. They have the ability to extract hard-to-reach nutrients from lower soil horizons. Subsequently, soybeans leave behind approximately 70-100 kg/ha of available nitrogen, 20-25 kg/ha of phosphorus, and 30-40 kg/ha of potassium in the soil, which contributes to a 15% increase in maize yield (Global and domestic..., 2022). The growing demand for soybeans, coupled with favourable climatic conditions in Ukraine, has led domestic agricultural producers to become leading exporters of soybeans. As a result, the expansion of soybean processing capacities enables national manufacturers to take leadership positions not only in raw material production but also in finished products. Ukraine ranks among the top ten soybean producers globally. According to preliminary data, in 2021/22 MY, Ukraine exported 1.39 million tons of soybeans, which is only 5% lower than the previous season's figure. Key regions for soybean production in Ukraine include the Khmelnytsky, Poltava, Zhytomyr, Kherson, and Kyiv regions. Soybean was almost the only oilseed crop that experienced a slight increase

in monthly export rates during the war period compared to the previous period. For instance, from March to August 2022, soybean exports reached 507 thousand tons, exceeding the figure of the same period in 2020/21 MY by 65%. The main importers of soybeans are the EU and Turkey (Kazakova & Kondratyuk, 2015; Rozhko, 2022).

When planning the profitability of soybean cultivation, it is crucial to consider pricing dynamics. The internal market experiences low price fluctuations due to both internal and external high demand for this crop. However, the range of price fluctuations within \$400-\$650 per ton is quite noticeable for Ukrainian farmers and does not strategically solve the problem of decreasing soybean prices due to logistics issues. The analysis of operating entities revealed that as of 2020, the average farm size in the Forest-Steppe zone was around 181 hectares. It was also observed that the trend of farm size growth continued over the studied period. For instance, if the average farm size was 22.6 hectares in 1995, it increased to 56 hectares in 2000 and 103 hectares in 2010. Correspondingly, the specialization of agricultural producers also changed. Over the last period, farms specialized in producing spring cereals, maize for grain, sunflower seeds, and soybeans. Approximately 55% of the area was dedicated to grain crops, including maize for grain, while nearly 30% was allocated to sunflower, and slightly over 12% to soybeans. On average, 2 workers were engaged in the production activities (Development of regional..., 2020).

To determine the level of land utilization, an appropriate statistical model was used based on formula (1). As of 2023, farmers cultivate about 21% of arable land (Table 2). Their share in the total number of agricultural enterprises reaches 80%. Therefore, the development project for farms in the Forest-Steppe zone focuses primarily on state support to increase the utilization of arable land for farm use through internal redistribution.

Table 2. Project for the development of an average-sized farm in the Forest-Steppe Zone

Indexes	Medium farm household			
	2022 (fact)		2030 (project)	
	ha	%	ha	%
In total agricultural land, ha	180.5	100	211	100
<i>Sowing area, hectares</i>	180.5	100	116	55
Crops culture, in total	99.3	55	50	10
including: winter wheat	54.2	30	25	5
corn for grain	24.8	25	21	4.2
Sunflower	50.5	28	20	4
Soy	21.7	12	35	7
Other cultures	10.9	11	15	3
Annual herbs	—	—	50	10
Perennial herbs	—	—	20	4
Haymakers, ha	—	—	25	5
<i>Population of animals, heads</i>	—	x	58	x
Cows, heads	—	x	23	x
The young of the great horned livestock, heads	—	x	35	x

Table 2, Continued

Indexes	Medium farm household			
	2022 (fact)		2030 (project)	
	ha	%	ha	%
Pigs, heads	—	x	100	x

Source: summarized on the basis of statistical data on Agriculture of Ukraine for 2021 (2022)

The next step should involve the revival of the livestock industry. Livestock is crucial primarily in the socio-ecological aspect of sustainable development. It enables the creation of additional permanent job opportunities and serves as a foundation for deepening diversification efforts. Furthermore, this move can help structure cropland, improve crop rotation, and enhance the application of organic fertilizers. In combination, this will contribute to strengthening the country's food security, preserving natural soil fertility, and restoring the export potential of livestock products (The state plans..., 2020). For modeling the diversification project of farm operations, an economic-mathematical model was developed. It forecasts

the production structure of the enterprise based on scientifically grounded approaches to forming crop rotations and developing livestock – expressed in formula (2).

According to the developed diversification project, by reducing the area under cereals and correspondingly increasing the area under soybeans and fodder crops, the structure of agricultural land use will change (Table 3). Additionally, it's important to maintain an unchanged proportion of livestock in agricultural production calculations. Such an approach is necessary to overcome the negative processes occurring in this industry, stabilize the situation, and eventually lead the sector to high profitability.

Table 3. Results of the implementation of the project of diversification of medium-sized farms in the Kyiv region for the long term

Indicator	A medium-sized farm		
	In fact, 2022	Forecast for 2030	Forecast to fact index
Area of agricultural land, ha	180.5	211.0	1.2
Number of industries	1	2	2.0
Number of types of products, pcs	4	6	1.5
Production of gross products, thousand hryvnias. total*	4 033.6	11 098.8	2.8
including plant products	4 033.6	5 348.7	1.3
livestock products	—	5 750.0	h
Employed in agriculture, persons of all	2	7	3.5
including plant products	2	2	1.0
livestock products	—	5	x
Need for investments, only thousand hryvnias	x	4 797.50	x
including: plant growing	x	657.5	x
animal husbandry	x	4140	x
Subsidy, thousand UAH	x	115.0	x
Total return on investment, years (RI)	x	1.7	x
Including animal husbandry	x	2.7	x

Source: summarized on the basis of statistical data on Agriculture of Ukraine for 2021 (2022)

The results of calculations indicate the possibility of achieving maximum crop yields, animal productivity, and product quality, which will contribute to increasing production volumes. Optimization of crop area structures and livestock feeding regimes, coupled with mechanisms of state support in the form of subsidies, should expedite investment returns. It should be noted that the combination of crop production and livestock farming should positively impact the ecological and social components of sustainable development. These measures are expected to promote the sustainable development of the agricultural sector and accelerate the country's economic recovery in the post-war period. The obtained results align and complement the conclusions reached by

N.K. Nigam & C.P. Gupta (2020) regarding the overall feasibility of diversification. Similarities can also be drawn with findings from D. Beillouin *et al.* (2019), particularly in terms of the potential for additional benefits from diversification. Agreement can be found with the conclusions of A.N. Kariuki *et al.* (2018), who viewed diversification as a means to expand the product range, and with E. Jahanshahi *et al.* (2023) regarding the positive impact of diversification on the ecosystem, sustainable development, and food security. However, it's important to note that focusing solely on the financial component, as highlighted by PDe Andrés *et al.* (2017), doesn't fully encompass the category in terms of its influence on the social and environmental aspects of business development.

Additionally, considerable attention has been devoted to the study of diversification and sustainable development by foreign authors. Research conducted in the mid-20th century and relevant in 2023 includes the works of H.I. Ansoff (2007) and A.D. Chandler (1990), where the concept of “diversification” started to be viewed through the prism of corporate development strategy. Notably, these studies focused on large corporations, each with unique development characteristics. H.I. Ansoff (2007) regarded diversification as an extreme option for business development, as entering new markets with new products is a complex and costly approach. Subsequently, M.E. Porter (1987) further developed and refined the ideas laid out by previous authors. Porter defines “diversification” as one of three main universal strategies, involving the creation of a product or service with unique properties that essentially coincides with characteristics proposed earlier. These foundational understandings of “diversification” are important for its ongoing scientific exploration. J. Claire *et al.* (2021) advanced the concept of diversification in agriculture. They concluded that in terms of the potential to generate additional income, farms are not making sufficient use of diversification mechanisms. The activities considered by the authors include agro-tourism, professional services, and primary processing.

Similar conclusions were reached somewhat earlier by a group of domestic researchers, including M.M. Ilchuk *et al.* (2016). Their findings established that creating and activating existing service cooperatives and developing agritourism are important directions for expanding diversification. The theoretical portion of their work concluded that diversification in the agricultural sector is a positive process of expanding the assortment of products, goods, and services. It allows enterprises to utilize existing material resources, land, and labour more effectively, thereby reducing production seasonality, increasing employment, and generating additional income through timely and well-thought-out industry manoeuvring. Furthermore, Ukrainian researchers continued this line of study, including O.M. Zgurska (2018). Her research extended beyond the agricultural sector. She viewed diversification as a tool to overcome crises characterized by inefficient enterprise functioning and increasing uncertainty in the external environment. This conclusion is applicable to agricultural sector enterprises as well.

► Conclusions

Therefore, the development of the agricultural sector in the post-war period lies in the realm of diversification of production activities of agricultural enterprises. The increase in the cost of essential resources has led to higher production costs, while the decrease in product prices has

affected both short-term and long-term periods. Additionally, the low level of diversification in the agricultural sector has impacted the financial results of agricultural producers in 2022 – the cultivation of certain grains became unprofitable. For instance, wheat production incurred a loss of 10%, and maize production suffered a loss of 44.5%.

It should be considered that the primary strategic directions for the development of the agricultural sector in the post-war period lie in diversification of entrepreneurial activities. Moving away from grain specialization, developing animal husbandry, and expanding cultivated areas for soybean cultivation are intended to stabilize the profitability of agricultural activities, ensure sustainable rural development, and consequently improve the living standards of rural residents during the post-war period. Trends of increasing land ownership and land use provide grounds to expect the average size of a farm to grow to 211 hectares by 2030. Considering these trends, it's advisable to implement appropriate state regulatory measures that facilitate the development of animal husbandry. The feasibility of such a project is projected within three years. This project will help mitigate risks from market fluctuations and, from an ecological and social perspective, reduce land degradation, optimize land use, and create additional jobs. In general, the projection is to allocate 45% of agricultural land to fodder crops and increase employment by 3.5 times.

It has been determined that diversification of activities can also have negative consequences, such as increased managerial complexity, costs associated with developing new directions, and the potential to lose focus on core activities. Therefore, prior to implementing a diversification strategy, companies should thoroughly analyse their capabilities and risks. The deepening of theoretical concepts regarding the diversification of activities for agricultural producers has been discussed. An optimization model for the development strategy of agricultural producers based on the development of animal husbandry has been proposed. Furthermore, it's advisable to consider further research into the category of “diversification of activities” in the context of household activities in Ukraine; determining the level of economic efficiency of agricultural activities in the post-war period; investigating strategic development directions for the agricultural sector in the context of supporting key economic entities; identifying strategic directions for the development of animal husbandry and several other aspects.

► Acknowledgements

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► Conflict of Interest

None.

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Диверсифікація підприємницької діяльності в аграрному секторі економіки України у повоєнний період

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► **Анотація.** В контексті сучасного розвитку аграрних товаровиробників, актуальною є оцінка рівня їх ефективності діяльності та пошуку відповідної стратегії подальшого розвитку. Мета статті полягала у формуванні концепції сталого розвитку аграрних товаровиробників на основі пошуку найдоцільнішої стратегії розвитку. Методологічною базою статті стали наступні методи наукового пізнання: описовий метод, методи вимірювання та порівняння, метод економіко-математичного моделювання, індукції, дедукції, аналізу та синтезу, системно-структурний. Розглянуто та розкрито сутність диверсифікації діяльності підприємств аграрної сфери та визначено їх роль у формуванні сталого розвитку. З цією метою здійснено узагальнення теоретичних положень, українських та зарубіжних науковців, категорій «диверсифікація» та «сталий розвиток». В подальшому проведено аналіз та здійснено прогноз землекористування сільськогосподарських підприємств. Встановлено динаміку зміни структури посівних площ в період з 1991 по 2021 роки, оскільки в саме в цей період починається реалізовуватись аграрна реформа, яка спрямована на пошук ефективного товаровиробника сільськогосподарської продукції. Визначено, як змінювалася величина витрат на основні ресурси у фермерських господарствах Київської області на передодні початку війни та проаналізовано економічну ефективність вирощування основних сільськогосподарських культур. На основі встановлених даних, змодельована стратегія розвитку середньостатистичного фермерського господарства Лісостепової зони України, яка враховує концепцію диверсифікації діяльності на основі впровадження та розвитку галузі тваринництва. Також, обґрунтовано напрями подальшого розвитку аграрних формувань через поглиблення диверсифікації діяльності на основі оптимізації посівних площ. Результати дослідження можуть бути враховані при формуванні стратегії розвитку підприємницьких структур та оцінці їх впливу на сталий розвиток у повоєнний період

► **Ключові слова:** стратегія; виробництво; сталий розвиток; прогноз; економічна ефективність



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Agricultural land turnover in Ukraine: New challenges and new opportunities

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► **Abstract.** The experience of the market turnover of agricultural land in Ukraine has shown that untimely and insufficiently comprehensive analysis of the functioning of the land market can lead to incorrect conclusions and limit the understanding of its dynamics and impact on the country's economic situation. The purpose of the study was to identify the main trends and indicators of the market turnover of agricultural land in Ukraine by analysing land ownership transactions. The methodological tools of the problem under study were general scientific and special methods, as well as the method of comparison and abstract and logical methods. The main results of the study are a cost and quantitative assessment of transactions of sale and purchase of ownership rights to agricultural land in Ukraine, which makes it possible to identify the main trends in the land market. Certain provisions can be used to formulate strategies for the development of land relations in Ukraine. The number and share of transactions involving the sale and purchase of ownership rights to agricultural land in the overall structure of transactions is determined. The area of land ownership rights to which were alienated through sale and purchase is determined. The author calculates the value of agricultural land depending on its remoteness from a settlement, regional location and designated purpose. Fluctuations in the value of arable land depending on their territorial location and in the overall dynamics by month are determined. The level of activity of agricultural land market participants in the country as a whole and by regions is determined. The results and trends in the market turnover of agricultural land in the territories where military operations were or are ongoing are investigated. The main key indicators of the market turnover of agricultural land are determined. Forecasts of the value of arable land in Ukraine by the end of 2023 are formed. The discrepancy between the Ukrainian model of agricultural land market turnover and the models operating in the European Union has been established. The results of the study can be used to develop ways to reorient the market turnover of agricultural land to the European principles of functioning aimed at the development of family farming as a fundamental goal of Ukraine's agricultural policy

► **Keywords:** market turnover; agricultural land; transactions; market; value; property

► Introduction

A key element of the efficient functioning of the agricultural sector in any country is the effective distribution and use of agricultural land. As of 2023, there is no country on the world map with a developed and efficient agriculture where the market turnover of agricultural land would not be regulated by the state. Countries regulate the market turnover of land based on their national interests by

applying a number of individual regulatory mechanisms and instruments combined into one general concept.

The agricultural land market has been fully operational in Ukraine for two years. However, the results of the land market functioning are not properly analysed: the analysis of indicators is carried out without taking into account value fluctuations, which affects the objectivity of

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the final conclusions; the structure of transactions on the transfer of ownership of land plots remains undisclosed; trends in value and quantity indicators depending on the location of land and its intended use remain unexplored. Transactions for the sale and purchase of property rights in the context of certain types of land have not been studied. The impact of the martial law on the land market is also not sufficiently studied, and the main goal of launching an agricultural land market has not been achieved. All this makes it impossible to form a correct and comprehensive vision of the results and provokes incorrect conclusions and forecasts regarding the functioning of the agricultural land market in Ukraine. The market turnover of agricultural land is in the scientific field of view of leading Ukrainian researchers.

The results of the work of O. Khodakivska & O. Mohylnyi (2019) are relevant, which refute the inflated expectations from the introduction of unregulated market turnover of agricultural land in Ukraine. The “village-preserving model” of the market turnover of agricultural land was outlined and studied by Y. Hadzalo & V. Zhuk (2015). The researchers identified and singled out a scenario of building market relations in the land market, according to which the main goal of the market is to preserve and develop the countryside. The study of the prerequisites for the introduction of the agricultural land market in Ukraine is devoted to the work of O. Shulha (2021), where the scientist substantiates the need for institutions, macroeconomic conditions and the stages of market introduction.

The main disadvantages of the market turnover of agricultural land, which impede the attraction of investments in agriculture in Ukraine, are highlighted in the scientific works of V. Andreeva (2020). N. Stupen *et al.* (2019) studied the conditions for the introduction of market turnover of agricultural land in Ukraine, highlighting the fundamental aspects: state control and institutional support. Given the significant achievements of Ukrainian and foreign scholars on the market turnover of agricultural land, such aspects of land turnover in Ukraine as the dynamics of value and quantitative indicators in the market, as well as the impact of the war in Ukraine on the trends in alienation of ownership of agricultural land through their sale and purchase, need to be covered more widely, which justifies the relevance of the results presented.

The purpose of the study was to determine the results of the functioning of the market turnover of agricultural land in Ukraine. The task of the study is to comprehensively study the transactions of sale and purchase of ownership rights to agricultural land plots concluded in Ukraine between 01.07.2021 and 31.12.2022 to identify the main trends and evaluate the results.

► Materials and Methods

The work was carried out by applying general scientific, economic and statistical research methods. In particular, the analytical and statistical methods were used to determine the number of land sale and purchase transactions, their area, and structure by region, the dynamics of land sale and purchase transactions by month, the number of agricultural land sale and purchase transactions by location, the dynamics of agricultural land and arable land value, in particular by region and location.

The comparative method was used to compare the value of land and its regulatory monetary valuation; compare the value of sale and purchase transactions by location; compare the value of sale and purchase transactions by region of land location, compare the value of land in accordance with its intended use; compare the value of land depending on its location and region. The grouping method was used to separate the data from the total array, depending on the type of land. The analytical and statistical methods of arithmetic mean and median were used to calculate the obtained value and quantitative indicators. The arithmetic mean was calculated using the classical formula:

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{\sum x}{n}, \quad (1)$$

where $x_1 \dots x_n$ – is the volume of the feature; n – is the size of the population.

The median of the studied indicators was calculated using the following formula:

$$M_e = x_{M_e} + i_{M_e} \frac{\frac{\sum f}{2} - S_{M_e-1}}{f_{M_e}}, \quad (2)$$

where x_{M_e} – is the lower boundary of the median interval; i_{M_e} – is the width of the median interval; $\frac{\sum f}{2}$ – is the number of all values divided by 2; S_{M_e-1} – is the accumulated frequency of the pre-median interval; f_{M_e} – is the number of observations in the median interval.

In order to determine the forecast of arable land value, we used the regression analysis method according to the following formula:

$$\hat{y} = a + bx, \quad (3)$$

where \hat{y} – is the expected value of y for a given value of x ; x – is the independent variable; a – is the segment on the y -axis for a straight line; b – is the slope of the straight line.

By using the abstract and logical method to analyse and study the problems of the agricultural land market, the main structural shortcomings of this market were revealed and ways to overcome them were identified. This method, using logical concepts and abstract models, helped to identify the main systemic problems. The graphical method was used as a tool for visualizing complex data and research results. In particular, it helped to show the geographical distribution of alienated agricultural land, noting differences in the volume and nature of such transactions between different regions. The graphs also showed variations in land values depending on their location, making it possible to identify areas with high and low market prices for land. Additionally, the graphical representations were used to analyse the dynamics of changes in arable land values and their relationship to changes in market conditions.

The main information base for the calculations was the open data of land relations monitoring (starting from 01.07.2021) of the State Service of Ukraine for Geodesy, Cartography, and Cadastre (Monitoring of land relations, 2023). The combination of abstract and logical and graphical methods allowed for a deeper understanding of the problems of the agricultural land market, clarifying their relationship and visualizing complex data, which contributes to the development of more effective strategies for managing this market.

► Results

Since 1 July 2021, in accordance with the Law of Ukraine No. 552-IX “On Making Changes to Certain Legislative Acts of Ukraine Regarding the Terms of Circulation of Agricultural Land” (2020), agricultural land has been brought into the market. Despite the full functioning of the land market

and the right to dispose of land shares, their owners are in no hurry to alienate their land plots. The share of agricultural land sales and purchases in 2021-2022 was 26% of the total number of land transactions. The vast majority of transactions involving the transfer of ownership of agricultural land were related to inheritance (68%) (Table 1).

Table 1. Structure of agreements regarding the transfer of ownership rights to land plots in rural areas and urban areas appointment in Ukraine for 2021-2022

Type of agreement	Number of transactions, units	Share, %
A certificate of inheritance	308 761	68.4
Contract of sale	117 031	25.9
Deed of Gift	24 787	5.5
Mine contract	866	0.19
Lifetime maintenance contract	80	0.02
Total number of transactions	451 525.0	100.00

Source: monitoring of land relations (2023)

During 2021-2022, 266.6 thousand hectares of agricultural land were alienated in Ukraine through sales and purchases, which is 0.6% of all agricultural land. The ownership rights to the land shares were sold through 117 thousand purchase and sale transactions. The largest

area of agricultural land, the ownership rights to which were sold through sale and purchase, was recorded in the Kharkiv region – 34.2 thousand hectares. This region is also the leader in terms of the number of sale and purchase transactions – 9.9 thousand transactions (Table 2).

Table 2. Expropriated area and number of land purchase and sale agreements in rural areas appointment by region for 2021-2022*

Region	Alienated area		Number of transactions purchase/sale
	Ha	share of the total area of all agricultural land in the region, %	
Kharkivska	34 203	1.4	9 861
Dnipropetrovsk	22 862	0.9	5 826
Poltava	22 328	1.0	8 927
Kirovohradsk	19 919	1.0	6 238
Kherson	17 699	0.9	4 201
Vinnytsia	17 127	0.9	9 395
Khmelnitskyi	15 686	1.0	8 515
Sumy	14 517	0.9	8 469
Mykolayivska	12 681	0.6	3 494
Kyivska	11 439	0.7	8 033
Chernihivska	10 946	0.5	5 501
Zaporizhzhia	9 740	0.4	2 673
Zhytomyr	8 095	0.5	4 749
Odesa	7 843	0.3	2 854
Cherkasy	6 910	0.5	4 121
Volynsk	6 587	0.6	4 767
Donetsk	6 155	0.3	1 616
Luhansk	5 851	0.3	1 229

Table 2, Continued

Region	Alienated area		Number of transactions purchase/sale
	Ha	share of the total area of all agricultural land in the region, %	
Ternopil	4 827	0.5	3 350
Lviv	3 226	0.3	3 486
Rivne	2 232	0.2	2 383
Chernivtsi	2 067	0.4	2 393
Zakarpattia	1 997	0.4	2 088
Ivano-Frankivsk	1 274	0.2	2 682
Across Ukraine	266 556	0.6	117 031

Note: * – structured by area from the largest to the smallest indicator

Source: monitoring of land relations (2023)

In turn, the smallest area was sold in the Ivano-Frankivsk region – 1.3 thousand hectares. However, the lowest number of sale and purchase transactions was recorded in Luhansk region – 1.2 thousand hectares and Donetsk region – 1.6 thousand hectares. It is worth noting the trend observed in the western regions of Ukraine, namely, the total number of sale and purchase transactions exceeds

the area of land sold and purchased, which indicates the sale of small (up to 1 hectare) land shares. Analysing the market turnover of agricultural land, it can be noted that the largest areas of land, the rights to which were sold, are observed in the north-eastern and central regions of Ukraine, while in the southern and western regions this figure is much lower (Fig. 1).

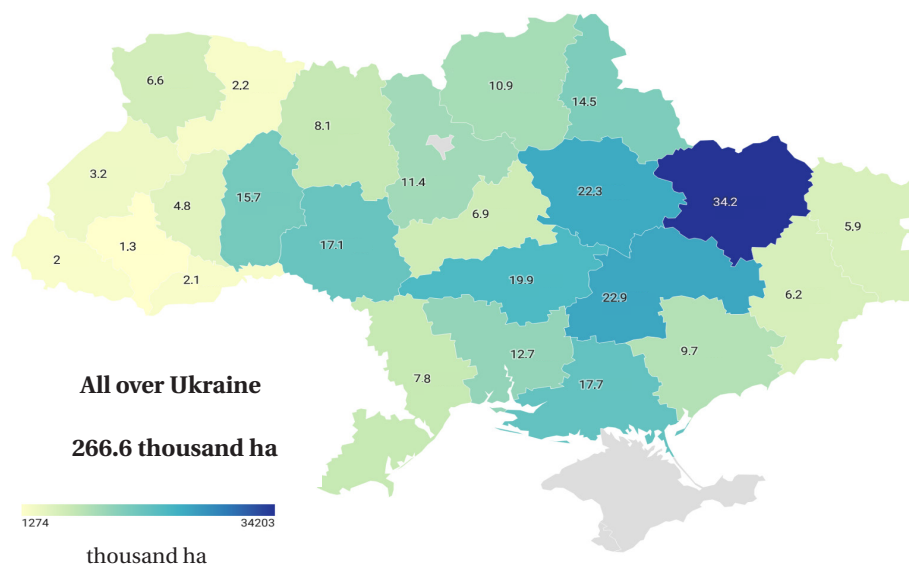


Figure 1. Alienated area of agricultural land under sale and purchase agreements by regions in 2021-2022

Source: monitoring of land relations (2023)

The location of land is a factor that determines not only its current use but also its future. A land plot located near a city will potentially have a higher value than a similar land plot located in rural areas or outside a settlement. Studies of the value of agricultural land, depending on the location of the land plot, largely confirm this statement. The value of agricultural land in Ukraine, depending on the location of the land plot, is as follows: 64 thousand UAH/ha – within the city; 45.2 thousand UAH/ha – within the village; 29.2 thousand UAH/ha – outside the settlement.

It should be noted that this trend does not always hold true at the regional level. For example, in Volyn region, the

value of land within the city limits is UAH 17.1 thousand per hectare, outside the city 22.8 thousand per hectare, and within the village 39.1 thousand per hectare (Fig. 2). Among the regions where the cost of land within villages is higher than the cost of land within cities are: Vinnytsia, Volyn, Zhytomyr, Lviv, Mykolaiv, and Odesa regions. There were also regions where the value of land outside settlements exceeds the value of land within villages: Kirovohrad, Luhansk, Kharkiv, and Kherson. The highest value of agricultural land within the city limits is in the Kyiv region – 103.5 thousand UAH/ha, while the lowest value is in the Mykolaiv region – 15.3 thousand UAH/ha.

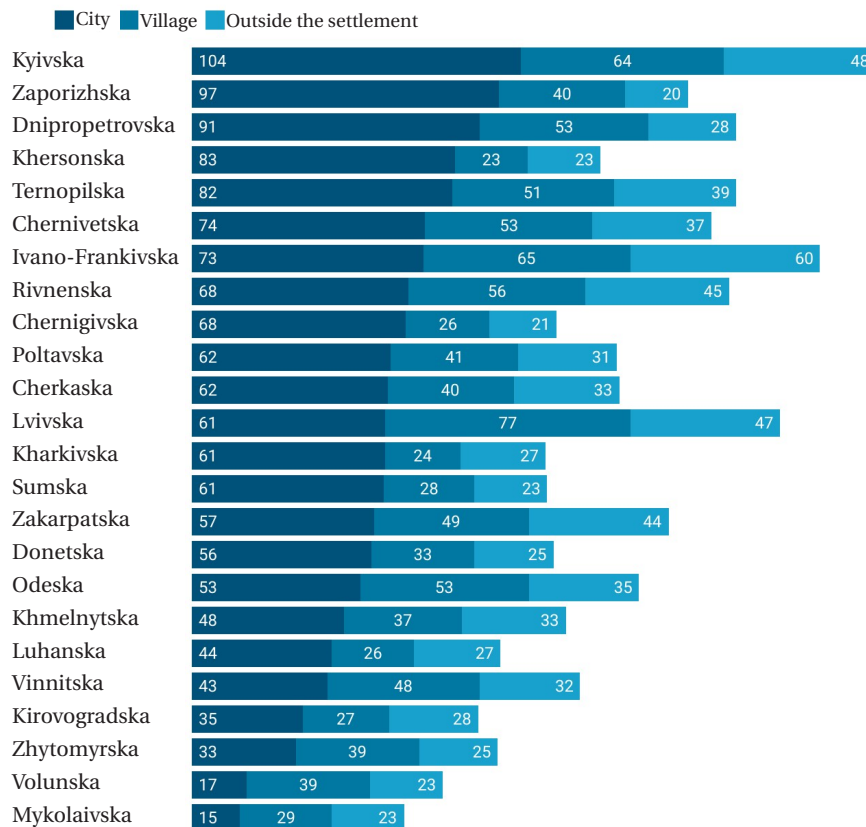


Figure 2. The cost of agricultural land, depending on the location, by region in 2021-2022, thousand UAH/ha
Source: monitoring of land relations (2023)

The value of agricultural land located within villages is highest in the Lviv region – 76.9 thousand UAH/ha, while the lowest value is 22.7 thousand UAH/ha in the Kherson region. For the purpose of a deeper study of the value of agricultural land, the value of land in Ukraine was determined depending on its intended use: 26.4 thousand UAH/ha – agricultural land; 27.9 thousand UAH/ha – farm; 33.6 thousand UAH/ha – commercial agricultural production; 85.8 thousand UAH/ha –

subsidiary farming; 273.6 thousand UAH/ha – individual gardening; 671.2 thousand UAH/ha – collective gardening.

Monitoring of the value of agricultural land, depending on its intended purpose, by region showed that the highest value of land used for commercial agricultural production is in the Ivano-Frankivsk region – 43.4 thousand UAH/ha, and the lowest value is in the Kherson region – 24.4 thousand UAH/ha (Table 3).

Table 3. The cost of rural land assignment, depending on the target assignment by region for 2021-2022

Region	The cost of rural land destination, thousand hryvnias/ha					
	Commercial agricultural production	Farming households	Individual agricultural household	Subs. village household	Ind. gardens	Number of gardens
Vinnitsia	32.2	39.1	22	101.9	453.6	751.2
Volynsk	33.7	27.9	20.7	14.1	301.9	500
Dnipropetrovsk	30.2	28.1	23	731	13.3	241.7
Donetsk	29.9	15.4	17.3	550.2	12.1	219
Zhytomyr	28.2	30.8	17.2	29	135	223.6
Zakarpattia	34.1	12.1	48	150.5	87.7	145.2
Zaporizhzhia	25.7	20.7	13.5	429.2	526.4	789.5
Ivano-Frankivsk	43.4	15.3	89.6	280.8	1 090.8	1 230.2
Kyivska	39.3	42.8	114.8	108	613.9	1 016.7
Kirovohrad	32.7	29.1	27.2	3 149.2	29.3	69.1
Luhansk	29.8	30.5	19.8	627.9	13.8	249.9
Lviv	31.5	25.9	142.7	447.1	620.1	699.3

Table 3, Continued

Region	The cost of rural land destination, thousand hryvnias/ha					
	Commercial agricultural production	Farming households	Individual agricultural household	Subs. village household	Ind. gardens	Number of gardens
Mykolayiv	29	23.7	13.7	19.8	175.5	414.5
Odesa	33.1	25.4	35.3	51	787.4	1 859.4
Poltava	36.1	34.8	25.3	65.8	175.5	352.6
Rivne	26.7	93.5	27	352.1	100	165.6
Sumy	25	23.7	15.6	117.4	114.1	229.1
Ternopil	32.9	33.4	53.2	160.8	880.2	992.6
Kharkiv	33.3	34.4	10	3 631.9	111.2	223.3
Kherson	24.4	18.5	16.6	113.3	170.7	256
Khmelnyskiy	33.8	34.3	29.2	88.2	136.2	257
Cherkasy	37	32.8	37.4	29.9	48.5	114.5
Chernivtsi	33.5	29.5	58.2	161.3	132.8	149.8
Chernihiv	24.6	20.9	14	105.6	250	502.1
Across Ukraine	33.6	27.9	26.4	85.8	273.6	671.2

Source: monitoring of land relations (2023)

Agricultural land used for farming has the highest value of 93.5 thousand UAH/ha in the Rivne region, while in Zakarpattia region it is worth 12.1 thousand UAH/ha, which is the lowest in Ukraine. The most expensive agricultural land, depending on its intended use, is the land used for arable farming in Kharkiv region – UAH 3.6 million/ha. In turn, the land used for private farming has the lowest value – 10 thousand UAH/ha in Kharkiv region.

The value of agricultural land in Ukraine for the period under review is UAH 30.3 thousand per hectare, which

exceeds the normative monetary value (hereinafter – NMV) by 18%. The study of the dynamics of agricultural land value in 2021-2022 by months shows fluctuations in value. In almost 18 months of market operation, the value of agricultural land has increased by UAH 14 thousand, from a minimum of UAH 26 thousand per hectare to UAH 40 thousand per hectare. However, it should be noted that this growth is not linear, and the maximum value was recorded only in November 2022, while in December 2022 the value decreased by UAH 5 thousand (Fig. 3).

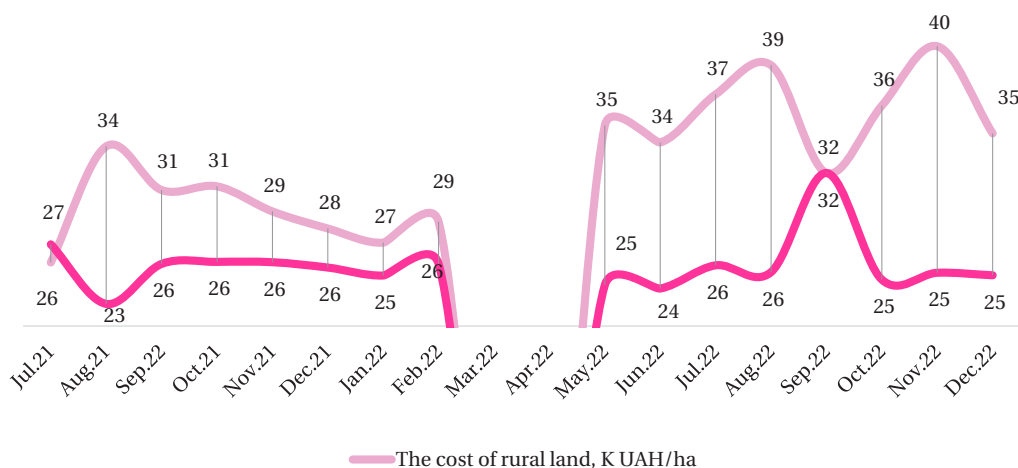


Figure 3. Dynamics of agricultural land value in Ukraine in 2021-2022, thousand UAH/ha

Source: monitoring of land relations (2023)

When studying the dynamics of agricultural land values, one should pay attention to the value indicator in comparison with the indicator of the NMV of land in the first month of the market's operation. In July 2021, it was recorded that in Ukraine, the NMV was UAH 27 thousand per hectare, while the land value was UAH 26 thousand per hectare, i.e. the NMV was UAH 1 thousand higher than the value of agricultural land, which contradicts the

legislation in terms of the provision of the Law of Ukraine No. 552-IX "On Amendments to Certain Legislative Acts of Ukraine on the Terms of Turnover of Agricultural Land" (2020), which stipulates that the sale price of agricultural land may not be less than their normative monetary value. In addition, it was recorded that in September 2022, the value of agricultural land and NMV had the same indicators of UAH 32 thousand per hectare, i.e., the value of land

decreased to the lowest possible level. The dynamics of agricultural land value over the study period shows that

a significant increase in land value occurred mainly in the western regions of Ukraine (Fig. 4).

	2021						2022									
	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Vinnitska	25	34	36	40	23	29	27	23	19	67	43	35	49	30	55	32
Volhynska	21	27	23	25	19	23	21	22	39	28	20	23	25	46	39	17
Dnipropetrovska	19	32	28	28	20	29	29	29	61	29	31	29	33	41	31	28
Donetska	19	14	34	25	20	26	29	27	0	0	0	20	0	2	2	24
Zhytomyrska	25	28	26	32	15	24	28	21	40	22	72	89	47	21	22	71
Zakarpatska	33	46	49	35	51	39	45	48	31	69	51	46	37	115	45	41
Zaporizhska	15	50	29	25	15	23	19	25	20	18	18	32	11	1	7	29
Ivano-Frankivska	45	76	57	57	44	72	66	76	62	107	92	53	48	94	79	114
Kyivska	48	51	52	52	41	69	56	64	132	97	72	60	106	38	74	67
Kirovogradska	21	29	28	27	23	30	31	30	49	34	33	15	27	33	35	36
Luhanska	23	27	29	29	29	25	27	30	0	0	0	0	0	0	0	0
Lvivska	39	49	44	42	17	60	98	77	100	54	92	115	67	84	113	98
Mykolaivska	14	22	20	22	21	31	28	17	32	33	31	24	19	30	27	27
Odeska	41	39	39	39	38	45	35	35	27	46	33	42	33	33	32	32
Poltavska	23	33	32	31	38	41	28	28	29	31	40	41	32	36	43	32
Odeska	34	65	56	53	15	85	27	30	100	26	52	18	23	56	21	20
Sumska	22	24	22	25	13	35	14	17	25	12	29	27	20	135	30	10
Ternopil'ska	28	37	35	41	44	65	43	36	81	41	37	73	31	45	31	47
Kharkivska	18	33	29	30	25	35	24	33	0	28	35	12	9	0	35	32
Khersonska	15	24	23	21	33	26	23	22	0	0	0	0	0	0	0	0
Khmelnitska	30	36	35	37	25	52	31	28	28	34	28	29	22	24	39	31
Cherkaska	27	37	36	38	15	84	26	36	40	38	39	36	40	41	39	38
Chernivetska	33	57	53	48	29	144	28	36	29	35	26	30	30	45	40	42
Chernigivska	13	26	21	21	10	48	16	22	4	12	15	10	32	28	8	14

Figure 4. The cost of agricultural land in the regions of Ukraine by months in 2021-2022

Source: monitoring of land relations (2023)

The market value of land in some regions of Ukraine has increased since May 2022, after the outbreak of war and two months of non-functioning of the land market. However, Kherson and Luhansk oblasts are the only ones where the land market has been suspended since May

2022 and no land sales have taken place. The value of arable land in Ukraine for the period under study is 32.2 thousand UAH/ha, which is 13% higher than the NMV. A study of arable land values by regions shows that the highest values are in the western regions of Ukraine (Fig. 5).

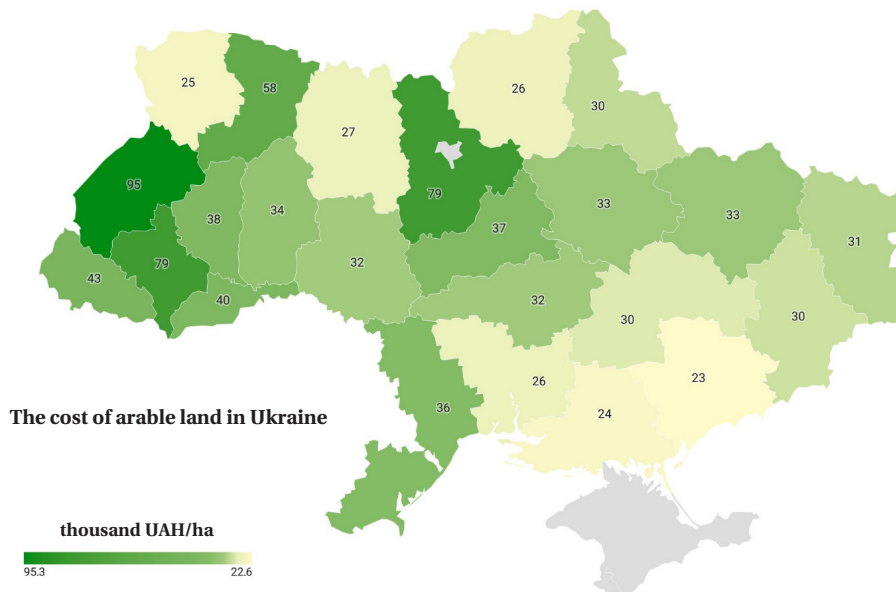


Figure 5. Cost of arable land by regions of Ukraine in 2021-2022, thousand UAH/ha

Source: monitoring of land relations (2023)

The regions with the highest arable land values in Ukraine are: Lviv – 95 thousand UAH/ha; Ivano-Frankivsk – 79 thousand UAH/ha; Rivne – 58 thousand UAH/ha; Zakarpattia – 43 thousand UAH/ha; Chernivtsi – 40 thousand UAH/ha and Kyiv – 79 thousand UAH/ha. The lowest cost of arable land is mainly in the southern regions of Ukraine: Zaporizhzhia – 23 thousand UAH/ha; Kherson – 24 thousand UAH/ha; Mykolaiv – 26 thousand UAH/ha; and Dnipro – 30 thousand UAH/ha. If look at the ratio of arable land value to the area alienated through sale and purchase, it is possible to see that with the highest arable land value of UAH 95.3 thousand per hectare in the Lviv region, only 3.2 thousand hectares were sold. At the same time, with the sold area of 34.2 thousand hectares in the Kharkiv region, the cost of arable land was 32.5 thousand UAH/ha.

On 24 February 2022, Ukraine experienced a full-scale military aggression that changed the lives of Ukrainians. These changes affected everything, including the market turnover of agricultural land. Monitoring of transactions related to the sale and purchase of ownership of agricultural land revealed that the activities of the State Land Cadastre of Ukraine were suspended for 76 days from

24.02.2022 to 06.05.2022, no transactions on the transfer of ownership of agricultural land were carried out, and the land market reopened on 6 May 2022 (Monitoring of land relations, 2023). With the reopening of the land market, the number of sale and purchase transactions decreased significantly: while in February, 15 000 agricultural land sales transactions were registered, in May, only 438 transactions were registered, a 96% decrease. At the same time, the area of land transferred into ownership through sale and purchase agreements also declined sharply: 28 000 hectares in February compared to 726 hectares in May, a 97% decrease (Monitoring of land relations, 2023).

Given the significant decline in agricultural land sales at the beginning of the war, their value has increased: in February 2022, the value of agricultural land was 28 thousand UAH/ha, while in May it was 35 thousand UAH/ha, an increase of 22%. From 24.02.2022 to 01.04.2023, the cost of arable land in Ukraine was recorded at 37 thousand UAH/ha. The highest price is observed in the western part of the country: Zakarpattia region – 46 thousand UAH/ha; Ivano-Frankivsk region – 75 thousand UAH/ha; Lviv region – 92 thousand UAH/ha (Fig. 6).

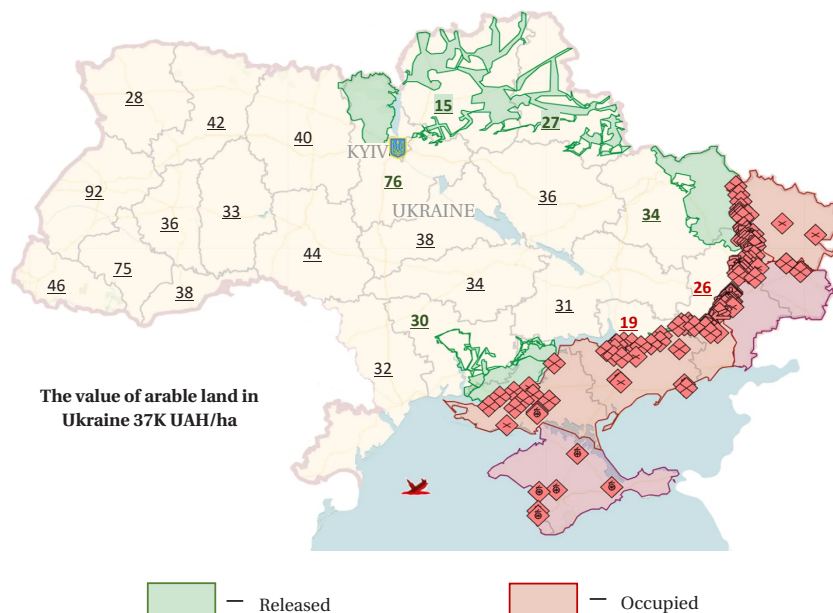


Figure 6. The cost of arable land by regions of Ukraine for 24.02.2022-01.04.2023, thousand UAH/ha
Source: monitoring of land relations (2023); DeepStateMAP (n.d.)

Due to the hostilities, the purchase/sale of agricultural land was resumed almost throughout the country, except for Kherson and Luhansk regions (no transactions were recorded in these regions during 24.02.2022-01.04.2023).

The study of the value of arable land in the regions where active hostilities took place showed that in some areas, the value of arable land did not decrease, but rather increased (Table 4).

Table 4. The value of arable land in areas where active hostilities were conducted

Region	The value of arable land 07/01/2021-02/24/2022, thousand hryvnias/ha	The value of arable land 24.02.2023-01.04.2023, thousand hryvnias/ha	Value ratio (+; -)
Kyivska	50.8	76	25.2
Kharkiv	31.2	34	2.8
Sumy	31.1	27	-4.1
Luhansk	30.1	h	h
Donetsk	29.1	26	-3.1

Table 4, Continued

Region	The value of arable land 07/01/2021-02/24/2022, thousand hryvnias/ha	The value of arable land 24.02.2023-01.04.2023, thousand hryvnias/ha	Value ratio (+; -)
Chernihiv	27.1	15	-12.1
Zaporizhzhia	24.8	19	-5.8
Kherson	24.0	h	h
Mykolaiv	23.3	30	6.7
Across Ukraine	33	37	4

Source: monitoring of land relations (2023)

The Kyiv region tops the list of conflict-affected regions in terms of arable land value. During the war, the value of arable land in the region increased to UAH 76 000/hectare, or by 33%. The most significant decrease in the value of arable land was recorded in the Chernihiv region (-80%), where the value of arable land amounted to UAH 15 000/hectare. In addition to these regions, the value of arable land decreased by 10% in Donetsk region, by 13% in Sumy region, and by 25% in Zaporizhzhia region. Comparing the general price changes for arable land in Ukraine between the pre-war and post-war periods, the downward trend in price is observed only in regions where hostilities have been/continue. In total, since the beginning of the war, the value of arable land in Ukraine has increased by 11%, reaching UAH 37 000/hectare. A study of transactions for the purchase/sale of agricultural land ownership rights in Ukraine shows that landowners are in

no hurry to sell their land. If in the pre-war period land purchase and sale contracts accounted for 30% of the total structure, then as of February 24, 2021, their share decreased by 4% and is at the level of 26%.

According to the study of agreements for the sale of agricultural land in Ukraine, after February 24, 2022, market agreements for the sale of land decreased by 96%. Luhansk and Kherson regions are the only regions where market operations were suspended at the beginning of the war and are currently not functioning. The value of arable land decreased by an average of 10% in most conflict-affected regions, while it increased by 11% in Ukraine as a whole. The study of the dynamics of the value of arable land gives reasons to claim that the highest value was recorded in November 2022, at the level of UAH 40 000/ha. In turn, the lowest value of arable land was at the beginning of the launch of the land market, in July 2021 – 25.8 thousand UAH/ha (Fig. 7).

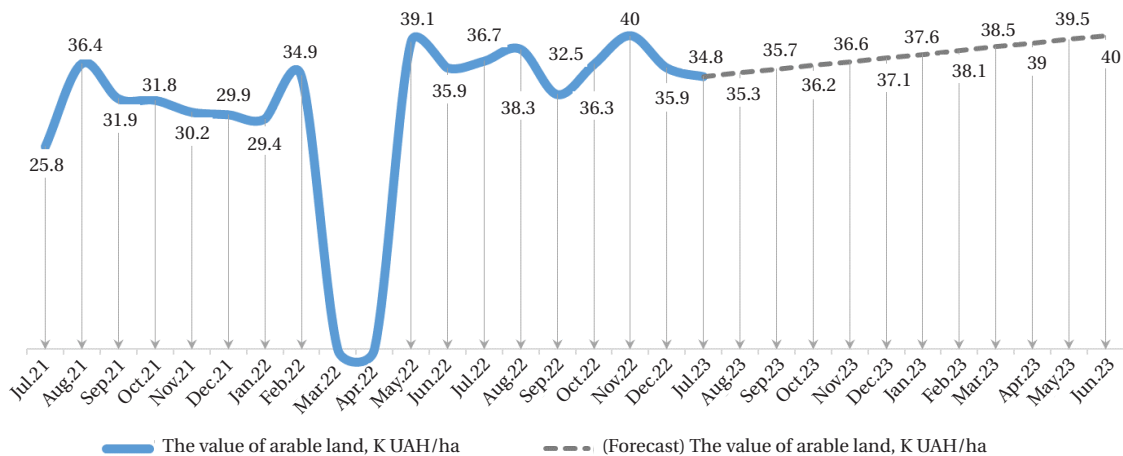


Figure 7. Dynamics of the value of arable land in Ukraine for 2021-2022, thousand UAH/ha

Source: monitoring of land relations (2023)

For March and April 2022, there are no value data on the market circulation of land, as sales agreements did not take place, as a result of the beginning of the war in Ukraine and non-working registers. To determine the forecast data of the cost of buying/selling arable land, the method of regression

analysis was used, according to the calculations of which, the value of arable land should increase during 2023, but the increase is not significant and is forecasted to a maximum of UAH 40 000/ha. The key indicators of the market circulation of agricultural land are presented in the Table 5.

Table 5. Key indicators of market turnover of agricultural land in Ukraine for 2021-2022

The cost of rural land appointment	30.3 thousand/ha
in particular: arable	32.2 thousand/ha
fallow	20.6 thousand/ha

Table 5, Continued

haymakers	13.5 thousand UAH/ha
pastures	11.6 thousand UAH/ha
The cost of rural land destination depending on their location (within):	
city	UAH 64 000/ ha
village	45.2 thousand/ha
outside the settlement	29.2 thousand/ha
The cost of the land plot in the village of appointment, depending on the intended purpose:	
Commodity agricultural production	UAH 33.6 thousand/ha
Farming	UAH 27.9 thousand/ha
Personal peasant economy	UAH 26.4 thousand/ha
Subsidiary peasant economy	UAH 85.8 thousand/ha
Individual gardening	UAH 273.6 thousand/ha
Collective gardening	UAH 671.2 thousand/ha
The number of concluded purchase and sale agreements, total	117 thousand
Area of registered purchase and sale agreements, total	267.6 thousand ha

Source: monitoring of land relations (2023)

The study of the functioning of the market circulation of agricultural lands shows that currently the market does not bring a positive effect, changes, or promotion of the development of the agricultural industry. There is a clear understanding that the market has achieved its main goal – it functions on the market's advice, because it does not solve any short-term, long-term or strategic problems of the agrarian industry. So far, the only thing the market has brought is the right to buy or alienate agricultural land.

► Discussion

The issue of market turnover of agricultural land is also the subject of research by foreign experts. A group of researchers from Poland, including M. Dacko *et al.* (2021), in their studies consider the dependence of the market value of agricultural land on changes in such features of the land plot as its area, shape, and access to public roads.

M. Rasva & E. Jürgenson (2022) found that the market turnover of agricultural land in Estonia requires stricter state regulation to overcome the concentration of agricultural land in “one hand”, which has a negative impact on the development of rural communities. Scientists have determined that one of the main ways to combat this phenomenon is to set a limit on the amount of land in possession. P. Prochazka *et al.* (2023) identified urbanization, rents, and subsidies as the main determinants of agricultural land price fluctuations. Short-term fluctuations in land prices are explained using an error correction model. The authors identify the impact of urbanization as the most important variable in the short-run of agricultural land prices in the Czech Republic. H. Kryszk *et al.* (2022) studied the role of the state in regulating the market turnover of agricultural land. In particular, the legal provisions aimed at limiting the purchase of land by the National Centre for Agricultural Support (NCAS) through the application of the pre-emptive right to purchase land in Poland (Kilnitska *et al.*, 2020).

A group of Slovak researchers consisting of J. Lazíková *et al.* (2021) analyse the functioning of agricultural land

markets in terms of the sustainability of agricultural production based on the correlation between land price and soil quality. The authors argue that land with low fertility tends to be sold at higher prices than land with good soil quality, leading to the risk of investors buying land for non-agricultural purposes and the risk of agriculture being displaced from certain areas. W.K. Korthals Altes (2023) extensively discusses the issue of new farmers' access to land on the market. The researcher analysed the European agricultural sector to determine the impact of its modernization on the farmland market and the difficulty of access to land for new entrants. The researcher concluded that the common European agricultural policy is in many ways an obstacle rather than an enabler to providing access to land for new farmers (Shyian & Kotelnikova, 2019).

J. Loughrey *et al.* (2019) draw attention to the lack of comprehensive statistics on the functioning of agricultural land markets in the EU and the impact of this factor on agricultural production. M. Kionka *et al.* (2021) conducted a study of the liquidity parameters of agricultural land markets and the relationship between liquidity and land prices. B. Britos *et al.* (2022) investigate the impact of farmland market imperfections on the allocation of land among different farmers and on overall agricultural productivity, holding other factors constant. C. Chen *et al.* (2022) assessed the impact of the land market on resource allocation and productivity in agriculture.

M. Gorgan & M. Hartvigsen (2022) provided an overview of the level of development of agricultural land markets in Eastern Europe and Central Asia, analysed and systematized the main constraints to the development of these markets, and proposed solutions to the identified problems. P. Bórawski *et al.* (2019) presented the results of a study on fluctuations in agricultural land prices in selected voivodeships of Poland in comparison with land prices in the EU countries for 1992-2016. M. Vijayabaskar & A. Menon (2018) in their study reveal the problem of buying up agricultural land by non-agricultural entities for the purpose of further resale at a higher price.

S. Zrobek *et al.* (2020) tested a universal methodological approach to calculating the value of agricultural land based on “fuzzy logic”. According to the researchers, this method is the most appropriate for emerging market models. The research of scientists on the market turnover of agricultural land is multifaceted and diverse. The practice of land market functioning in Ukraine is only being formed, so Ukraine should use the already existing positive experience of other countries to avoid negative phenomena. There are no studies of the functioning of the agricultural land market during the war in the scientific literature and works of scholars. Ukraine has become the country that demonstrates such experience. The market for agricultural land in the areas where military operations are ongoing or have been conducted raises many new questions, the answers to which will be provided later.

Analysing the research of foreign scientists (mainly EU countries) on the problems of functioning of the market turnover of agricultural land, it should be noted that the outlined range of issues under study helps to form an understanding of models and mechanisms for implementing the functioning of the land market. All this leads to the fact that foreign models of the land market are fundamentally different from the Ukrainian model. Moreover, the market turnover of agricultural land in Ukraine does not have such market elements as a “state land agency”, and such a mechanism of land redistribution as “pre-emptive right” needs to be significantly improved. Whereas in other countries the main purpose of this mechanism is to distribute land in favour of farmers and persons willing to engage in agricultural production, in Ukraine this mechanism is aimed at selling ownership rights to a land plot to the highest bidder.

At the current stage of Ukraine’s development, there is an unusual and conflict-prone situation. Despite the country’s focus on European development, including reform of land relations, the positive experience of the European Union is not being properly used and ignored. The process of building a European model of land relations in Ukraine is limited to declarative statements and has no concrete practical implementation.

► Conclusions

In 2021-2022, the share of sale and purchase transactions in the total structure of land ownership transfers was 26%. The total area of agricultural land, the ownership of which was transferred through sale and purchase agreements, is 267.6 thousand hectares or 0.6% of the total land area. There were no massive sales or purchases of land. The value of agricultural land in 2021-2022 is UAH 30.3 thousand per hectare and has a tendency to increase, but this

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increase is not significant. It was determined that the value of these lands exceeds the NMV by 18%. There are cases when the value of land intended for agricultural activities, the ownership rights to which are sold, is lower, equal to or almost equal to the NMV. Agricultural land has the highest value in urban areas, and the lowest value outside urban areas. After the full-scale military aggression, activity on the land market in Ukraine decreased by 96%. The hostilities on the territory of our country forced the suspension of purchase and sale transactions on the land market, but two months later the market continued to operate, taking into account the military situation in the regions. Kherson and Luhansk regions remained the only regions where market operations were suspended at the beginning of the war and did not resume until 01.04.2023.

An analysis of the dynamics of arable land prices in Ukraine before and after the war shows a decline in prices only in the regions where active hostilities took place. The value of arable land in Ukraine has increased to UAH 37 thousand per hectare or 11% since 24.02.2021. Landowners are in no hurry to sell their land. Before the war, land sale and purchase agreements accounted for 30% of the total, and as of 24.02.2021, their share is 26% (down 4%). The market turnover of agricultural land in Ukraine should be a tool aimed at strengthening and developing the agricultural sector, which requires the market to have a clearly defined, legally enshrined purpose for its functioning. For example, the goal of land market turnover may be the development of family farming, as is the case in all EU countries (Strapchuk & Mykolenko, 2022).

The scientific novelty of the work is formed by the results of the study, namely, the analysis of the market turnover of agricultural land through the study of land ownership transactions, including under martial law in Ukraine. The prospect of further research is to determine the efficiency of the market turnover of agricultural land, the compliance of the Ukrainian market model with the models of the European Union and the achievement of the main objectives of land reform.

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► Conflict of Interest

None.

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Обіг земель сільськогосподарського призначення в Україні: нові виклики та нові можливості

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► **Анотація.** Досвід ринкового обігу земель сільськогосподарського призначення в Україні показав, що несвоєчасний та недостатньо комплексний аналіз функціонування ринку землі може спричинити неправильні висновки та обмежити розуміння його динаміки та впливу на господарську ситуацію країни. Метою роботи було визначення основних тенденцій та показників ринкового обігу земель сільськогосподарського призначення в Україні шляхом дослідження угод купівлі-продажу прав власності на землі. Методичним інструментарієм досліджуваної проблеми стали загальнонаукові та спеціальні методи, а також метод порівняння та абстрактно-логічний. Основними результатами дослідження є вартісна та кількісна оцінка угод купівлі-продажу прав власності на землі сільськогосподарського призначення в Україні, що дає змогу визначити основні тенденції на земельному ринку. Окремі положення можна використати для формулювання стратегій розвитку земельних відносин в Україні. Встановлено кількість та частку угод купівлі-продажу прав власності на землі сільськогосподарського призначення в загальній структурі трансакцій. Визначено площі земель права власності на які були відчужені через купівлю-продаж. Розраховано вартість земель сільськогосподарського призначення залежно від їх віддаленості від населеного пункту, регіонального розташування та цільового призначення. Встановлено коливання вартості орних земель залежно від їх територіального розміщення та у загальній динаміці по місяцях. Визначено рівень активності суб'єктів ринкового обігу земель сільськогосподарського призначення загалом по країні та в розрізі областей. Досліджено результати та тенденції ринкового обігу земель сільськогосподарського призначення на територіях де велись чи ведуться бойові дії. Визначені основні ключові показники ринкового обігу земель сільськогосподарського призначення. Сформовано прогнозні дані вартості ріллі в Україні до кінця 2023 року. Встановлено невідповідність української моделі ринкового обігу земель сільськогосподарського призначення моделям, які функціонують в країнах Європейського Союзу. Результати дослідження можуть бути використанні для опрацюванні шляхів переорієнтації ринкового обігу земель сільськогосподарського призначення на Європейські засади функціонування, націленого на розвиток сімейного фермерства, як основоположної засадничої цілі аграрної політики України

► **Ключові слова:** ринковий обіг; сільськогосподарські угіддя; угоди; ринок; вартість; власність



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Monitoring and evaluation of the efficiency of rural development of the united territorial communities of the Vinnytsia region

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► **Abstract.** Balanced development and interaction of types of economic activity form the economic potential of the region and help fill budgets. Improvement of the methodology of diagnostics of the economy of rural development taking into account natural, economic, demographic, social and recreational features is urgent. The purpose of the study was to improve and develop a methodological toolkit for assessing the effectiveness of rural development on the example of united territorial communities of the Vinnytsia region. A number of methods were used in the research process: abstract-logical, comparative analysis, tabular, statistical, calculation-constructive. According to key economic parameters, such as the pace of the Supreme Council of Justice and the volume of production per person, the Vinnytsia region is marked by a relative trend of anticipatory regional development, and the agriculture of the region in 2017-2021 retains priority positions in the structure of the agro-industrial complex of Ukraine. Analytical monitoring of the positive dynamics of the majority of economic indicators of rural development of the united territorial communities of the Vinnytsia region contributed to the growth of the partial index of the economic component. During 2017-2021, this aggregate indicator increased from 411 to 427 points, or almost 4%. It was established that the partial index of social efficiency of rural development of the united territorial communities of the region decreased by 2.4% (from 107.4 in 2017 to 104.8 points in 2021). The highest value of the index of social efficiency of rural development of united territorial communities was reached in 2017 (107.4), and the lowest in 2020 – 104.0. Calculation partial index environmental efficiency of rural development established a growth of 7.3% (from 17.2 in 2017 to 18.5 in 2021). The calculation and analytical measurement of the aggregate integral indicator of the effectiveness of rural development of the united territorial communities revealed a slight growth trend – from 91.2 in 2017 to 93.9 points in 2021, which does not exceed 3%. The practical significance of the conducted research is determined by the improvement of the toolkit and the development of a methodical algorithm for determining the integral indicator of the effectiveness of rural development of united territorial communities, which can be useful in the regional management practice of organizing monitoring and developing directions for the development of rural areas

► **Keywords:** development of rural areas; integral indicator; economic efficiency index; social efficiency index; ecological efficiency index

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► Introduction

Development of the region as a regional and territorial socio-economic system involves effective use of available resource potential in the process of economic, production, social, scientific and technical and other types of activity. Successful implementation of the decentralization policy, substantiation of the conceptual bases for the development of strategic directions for increasing the level of rural development, requires an objective assessment of phenomena and processes occurring in rural areas. Monitoring the development of rural areas is a mandatory prerequisite for regulating processes related to the development of agriculture, the territories of rural settlements and united territorial communities. This monitoring involves the study of the current state and effective use of the resource potential of the territories, as well as their human and social capital.

The process of analysing the level of socio-economic development for rural areas includes successive stages, including the definition of assessment criteria, the selection of indicators (indicators) and assessment methods, the assessment itself and the analysis of the results. However, there is currently no universal algorithm for the formation of indicators of the effectiveness of rural development on the basis of the balanced functioning of territorial units. There are recommendations that contribute to the creation of a set of indicators for a specific project, plan, program, or strategy. Among foreign scientists, Ya. Liu *et al.* (2022), who investigated the problems of substantiation and construction of a set of scientifically based evaluation indices for evaluating the effectiveness of the rural revitalization strategy in China. The authors proposed an index evaluation system for evaluating the effectiveness of village revitalization implementation and influencing factors from two points of view: material and spiritual life.

The problem of adaptation and evaluation of the effectiveness of the implementation of the Japanese model "One Village, One Product" (OVOP) in Vietnam was solved in their studies by L.H. Thanh *et al.* (2018). The authors proved that this model creates employment opportunities and increased employment and increased welfare of the rural population. The problems of rural development related to the mechanisms of land use and regulation of the agricultural land market in Germany were solved in their studies by D. Kirschke *et al.* (2021). The authors proved that the increase in land prices, the deterioration of ecological indicators, the structure of land use, as well as the dynamics of international prices for agricultural products are key factors affecting the level of rural development of territories.

Researcher O.V. Dovgal (2019) noted that the demographic state is the most important indicator of the development of rural areas. The authors believe that the main characteristic and prerequisite of rural development is the dynamics of relevant economic indicators. It is worth agreeing with Ya. Liu *et al.* (2022) that in the process of promoting the sustainable development of villages, it is necessary to single out the characteristics of rural development and increase the effectiveness of the implementation of rural revitalization strategies on both the material and spiritual levels. J.A. Pérez-Méndez *et al.* (2019) evaluated the impact of government subsidies on the level of rural development and the efficiency of agricultural enterprises in Spain. The results of the study showed that

subsidies have a positive effect on the technical progress of agricultural companies, and the resulting effect is materialized in the form of an increase in technical efficiency. At the same time, research focuses on substantiating the methodological aspects of assessing the effectiveness of the development of rural areas without taking into account the influence of transformational factors of the decentralization process. Many approaches to structuring, quantitative selection and mathematical substantiation of the calculation of the aggregate efficiency indicator are presented, in which attention is focused on individual factors of the development of rural areas, without updating the mechanism of rural development itself. In view of this, the existing developments require additional substantiation, clarification, and adaptation to modern conditions of the transformation processes taking place in the united territorial communities of Vinnytsia.

The purpose of the study was to measure the dynamics of the integral indicator of the effectiveness of rural development of united territorial communities on the example of the Vinnytsia region. In order to realize the set goal, it is necessary to complete the following tasks:

- carry out a comparative characterization of the dynamics of socio-economic development indicators of Ukraine and Vinnytsia region;
- to justify the toolkit for calculating the integral indicator of the efficiency of rural development of united territorial communities (UTC or ATG);
- to assess the dynamics of the level of efficiency of rural development using the method of calculating the aggregate indicator.

► Materials and Methods

A number of methods of scientific knowledge were used in the research process. Abstract-logical method – for formulating conclusions. The comparative analysis was used to compare the dynamics of the set of socio-economic development indicators of the Vinnytsia region with the corresponding indicators on average across Ukraine. According to the tabular method, the obtained results of the study are visually depicted. A statistical method was used to determine the variation of agricultural production indicators in Ukraine and the Vinnytsia region by category of farms. The computational and constructive method was used to analyse and compare the dynamics of natural indicators of agricultural production in Ukraine and the Vinnytsia region.

Calculation of the integral indicator of the efficiency of rural development of the united territorial communities of the Vinnytsia region, carried out according to the following algorithm:

- substantiation of the structural components of the integral index of assessment of rural development of UTC;
- calculation of individual indicators of state and development;
- construction of indices by separate blocks of indicators;
- construction of an integral index.

The partial index of the economic efficiency of rural development of the UTC is calculated based on 30 indicators that comprehensively characterize the effectiveness of the functioning of economic entities in agriculture, the

effectiveness of improving the investment climate, and the dynamics of household incomes

$$IR_{econ.t} = \sqrt[30]{\prod_{i=1}^{30} e_n}, \quad (1)$$

where $IR_{econ.t}$ – is the partial index of economic effectiveness of rural development in ATGs; e_1 – total land area, thousand hectares; e_2 – area of agricultural land, thousand hectares; e_3 – level of land development for agricultural purposes, %; e_4 – level of plowed area for agricultural land, %; e_5 – availability of agricultural land per rural resident, hectares per person; e_6 – number of agricultural enterprises per 10 000 population, units; e_7 – proportion of small enterprises, %; e_8 – number of economic entities in agriculture, forestry, and fishery activities, units; e_9 – proportion of economic entities in agriculture, forestry, and fishery activities in the total number, %; e_{10} – profitability level of agricultural, forestry, and fishery enterprises, % (e_{10}); e_{11} – proportion of employed population in agriculture, forestry, and fishery activities, %; e_{12} – average monthly nominal wage of permanent employees in agriculture, UAH; e_{13} – production of agricultural products, million UAH (at 2016 prices); e_{14} – proportion of agricultural production by household farms in total production, %; e_{15} – proportion of crop production, %; e_{16} – proportion of livestock production, %; e_{17} – e_{25} – production of various agricultural products per person (kg); e_{26} – volume of agricultural products sold by agricultural producers, million UAH; e_{27} – financial results from ordinary activities before taxation: profit; e_{28} – loss; e_{29} – volume of capital investments in agriculture, million UAH; e_{30} – proportion of capital investments in agriculture, hunting, and related services in total capital investments, %.

The partial index of social effectiveness of rural development in ATGs is calculated using 39 indicators that diagnose structural shifts in the rural population, the current dynamics of housing supply, characteristics of household living conditions, changes in the state of social infrastructure elements.

$$IR_{soc.t} = \sqrt[39]{\prod_{i=1}^{39} s_n}, \quad (2)$$

where $IR_{soc.t}$ – is the partial index of social effectiveness of rural development in ATGs; s_1 – total population of ATGs, thousand people; s_2 – proportion of rural population, %; s_3 – number of rural residents per rural settlement, on average individuals; s_4 – overall increase (-) or decrease of rural population, per 1000 people; s_5 – total fertility rate per 1 woman; s_6 – rural population birth rate, individuals; s_7 – rural population mortality rate; s_8 – economically active rural population aged 15-70, thousand people; s_9 – economically inactive rural population aged 15-70, thousand people; s_{10} – level of economic activity, %; s_{11} – employment rate, %; s_{12} – unemployment rate, %; s_{13} – number of registered marriages, units; s_{14} – per 1000 population; s_{15} – number of registered divorces, units; s_{16} – per 1000 population; s_{17} – ratio of marriages to divorces; s_{18} – coverage of preschool education for children, %; s_{19} – in urban settlements; s_{20} – in rural areas; s_{21} – coverage of children in educational institutions per 100 available spots, %; s_{22} – in urban settlements; s_{23} – in rural areas; s_{24} – s_{27} – number of individuals enrolled in educational institutions of different levels (at the beginning of the academic year, thousand); s_{28} – number of libraries

in rural areas, units; s_{29} – number of club establishments in rural areas, units; s_{30} – number of hospital beds, units; s_{31} – consumer price index; s_{32} – total household resources in rural areas, on average per month per household; s_{33} – value of consumed products obtained from personal subsidiary farms in rural areas, %; s_{34} – housing space per person, square meters; s_{35} – proportion of equipped flats with water supply in residential and non-residential buildings in rural areas; s_{36} – with hot water supply; s_{37} – with sewage system; s_{38} – with central heating; s_{39} – with natural gas.

The index of ecological effectiveness of rural development in ATGs is calculated using 7 indicators that characterize positive or negative changes in air and overall environmental pollution, waste management situation, monitoring of deforestation and forest resource restoration, investment in environmental protection.

$$IR_{ecol.t} = \sqrt[7]{\prod_{i=1}^7 ek_n}, \quad (3)$$

where $IR_{ecol.t}$ – is the partial index of ecological effectiveness of rural development in ATGs; ek_1 – emissions of pollutants into the atmosphere from stationary sources of pollution from agricultural, forestry, and fishery activities, thousand tons (their proportion in the overall emissions structure), %; ek_2 – emissions of carbon dioxide into the atmosphere from stationary sources of pollution from agricultural, forestry, and fishery activities, thousand tons. Their proportion in the emissions structure, %; ek_3 – proportion of reforested area to deforested area, %; ek_4 – proportion of capital investments in environmental protection from agricultural activities to total capital investments, %; ek_5 – proportion of current investments in environmental protection from agricultural activities to total capital investments, %; ek_6 – proportion of area fertilized with organic fertilizers, %; ek_7 – proportion of area fertilized with mineral fertilizers, %.

The integral index of effectiveness of rural development in ATGs can be determined as the cube root of the product of three partial indices: economic, social, and ecological, and analyse the obtained dynamics during the studied period.

$$IR_{tot.t} = \sqrt[3]{IR_{econ.t} \cdot IR_{soc.t} \cdot IR_{ecol.t}}, \quad (4)$$

where $IR_{tot.t}$ – is the general index of effectiveness of rural development of the ATG in the year, t.

► Results and Discussion

Before the administrative-territorial reform of 2020, the Vinnytsia region had 27 districts, 6 cities of regional importance, 12 cities of regional importance, 29 urban-type settlements, 1,328 rural settlements, and 46 united territorial communities. According to the official website of the Vinnytsia Regional Council (2023), as of 2023, the Vinnytsia Region has 6 districts, 63 territorial communities. Rural areas occupy an important place in the economy of Vinnytsia, after all, in them, lives about half of the entire population of the region. It is worth noting that rural development of the territory of any region in Ukraine, firstly, it is mediated by the level of development of its agricultural sector, the dynamics of support of the state and united territorial communities of this process. A comparison of the dynamics of a

set of statistical indicators of the socio-economic development of the Vinnytsia region with the corresponding indicators of development on average across Ukraine revealed that in a number of indicators the region lags behind the average Ukraine indicator. However, a relative tendency of anticipatory regional development has been established by key economic parameters.

Thus, published data on the growth rate of the gross regional product (GRP) of the region for the period 2017-

2021 is 88.0%, which is 5.3% higher than the overall Ukrainian value, and its regional share is stable at 3.2% (Table 1). If we pay attention to the volume of GRP produced per person, the rate of growth of this indicator in the Vinnytsia region is almost 10% ahead of the all-Ukrainian rate. Thus, during the analysed period, this indicator in the region increased almost 2 times (from 58.3 to 114.2 thousand UAH), and its ratio with the average value for Ukraine increased from 83.1 to 86.7%.

Table 1. The main ones Indexes socio-economic development of Ukraine and Vinnytsia region in 2017-2021 year

Indicator	Units of measuring	Region	Year					2021 to 2017, %
			2017	2018	2019	2020	2021	
GRP	billion UAH	Ukraine	2 983.9	3 560.6	3 978.4	4 222.0	5 450.8	182.7
		Vinnytsia region	92.3	111.5	129.1	135.9	173.5	188.0
	The share of GRP of Vinnytsia region in GDP of Ukraine, %	3.09	3.13	3.25	3.22	3.18	—	
GRP for one a person	UAH	Ukraine	70 170	84 228	94 633	101 138	131 734	187.7
		Vinnytsia region	58 296	71 098	83 133	88 380	114 218	195.9
	Vinnytsia region in comparison with all-Ukrainian value, %	83.1	84.4	87.8	87.4	86.7	—	
People	thousands of people	Ukraine	42 584.5	42 386.4	42 153.2	41 902.4	41 588.4	97.7
		Vinnytsia region	1 590.4	1 575.8	1 560.4	1 545.4	1 529.1	96.1
	Fraction of people in Vinnytsia region in total amount of people of Ukraine, %	3.73	3.72	3.70	3.69	3.68	—	
Number of employed	thousands of people	Ukraine	16 156.4	16 360.9	16 578.3	15 915.3	15 610.0	96.6
		Vinnytsia region	640.9	652.7	660.7	634.9	621.0	96.9
Number of subjects of housing	thousands of units Vinnytsia region	Ukraine	1 805.1	1 839.7	1 941.7	1 973.7	1 956.3	108.4
		68.9	68.6	70.2	69.8	101.3	—	
	Share of EDROU subjects Vinnytsia region in general Numbers of subjects EDROU, %	3.82	3.73	3.62	3.55	3.57	—	
Number of enterprises on 1 thousand of existing people	units	Ukraine	42.4	43.4	46.1	47.1	47.0	111.0
		Vinnytsia region	43.3	43.6	45.0	45.3	45.4	104.7
Specific weight of hired employees of enterprises	in % to total number of employed workers	Ukraine	81.1	81.8	81.1	81.5	81.4	0.3
		Vinnytsia region	73.4	76.2	77.0	77.0	76.3	2.9
Medium-monthly salary pay	UAH	Ukraine	7 104	8 865	10 497	11 591	14 014	197.3
		Vinnytsia region	6 121	7 801	9 299	10 297	12 488	204.0
	Vinnytsia region in comparison with all-Ukrainian meaning %	86.2	88.0	88.6	88.8	89.1	—	
Arrears with payment of wages	million hryvnias	Ukraine	2 368.4	2 645.1	3 034.4	3 136.7	3 207.1	135.4
		Vinnytsia region	12.2	10.8	15.4	18.4	36.4	298.4
	The specific gravity of the Vinnytsia region in the all-Ukrainian sense, %	0.52	0.41	0.51	0.59	1.13	—	
Level of unemployment (methodology of ILO)	%	Ukraine	9.9	9.1	8.6	9.9	10.3	104.0.
		Vinnytsia region	11.0	10.2	9.7	11.0	11.4	101.8
Volumes of implemented industrial products	thousand hryvnias for one a person	Ukraine	61.7	71.8	71.6	77.2	112.5	182.5
		Vinnytsia region	38.1	44.0	50.3	55.5	58.7	154.1
Volumes of gross products of rural economy	thousand UAH on one a person	Ukraine	5.9	6.4	16.2	14.7	17.2	291.5
		Vinnytsia region	12.9	14.4	36.8	31.7	39.1	303.1
Profit/loss of enterprises before taxation	thousand hryvnias for one a person	Ukraine	1.6	1.7	2.2	1.9	5.7	356.0
		Vinnytsia region	3.7	3.4	2.4	2.0	5.4	145.7

Table 1, Continued

Indicator	Units of measuring	Region	Year					2021 to 2017, %
			2017	2018	2019	2020	2021	
Amount of capital investments on one a person	UAH	Ukraine	10 598	13 746.4	14 907	10 030	12 719	120.0
		Vinnitsia region	7 451.8	11 291.7	10 172.5	6 463.7	9 157.8	122.9
	Vinnitsia region in comparison with all-Ukrainian value	0.70	0.82	0.68	0.64	0.72	—	
including by funds of state and local budgets	% to general sum	Ukraine	12.7	12.6	14.0	19.1	17.6	+4.9
		Vinnitsia region	16.8	11.2	17.7	12.4	17.6	+0.8
Coefficient of coverage of imports by exports		Ukraine	0.88	0.83	0.83	0.92	0.94	106.9
		Vinnitsia region	3.00	2.44	2.67	2.53	1.86	61.9
Budget revenues on one person	UAH	Ukraine	4 727	5 844.2	6 914	7 468.8	9 003.6	190.5
		Vinnitsia region	4 543.6	5 573.4	6 550.3	7 093.9	8 627.4	189.9
	Vinnitsia region in comparison with all-Ukrainian value	0.96	0.95	0.95	0.95	0.96	—	
Expenses for oneperson	UAH	Ukraine	6 170.2	7 611.1	8 938.2	9 537	11 724.4	190.0
		Vinnitsia region	5 424.5	6 675.8	8 155.7	8 720.3	10 301.4	189.9
	Vinnitsia region in comparison with all-Ukrainian value	0.88	0.88	0.91	0.91	0.79	—	
Expenses on education for one person	UAH	Ukraine	1 860	2 076	2 664	2 688	3 252	174.8
		Vinnitsia region	2 220	1 680	2 412	2 218	3 540	159.5
	Vinnitsia region in comparison with all-Ukrainian value	1.19	0.81	0.91	0.83	1.09	—	
Expenses on protection health on one person	UAH	Ukraine	3 048	4 116	4 356	5 136	6 365	208.8
		Vinnitsia region	3 019	3 864	4 352	5 208	6 348	210.3
	Vinnitsia region in comparison with all-Ukrainian value	0.99	0.94	1.00 a.m	1.01	1.00 a.m	—	

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnitsia region (2023)

For the period 2017-2021, the growth rates of the number of economic entities and enterprises per 1 000 people of the existing population in Vinnitsia region were lower than the average indicators for Ukraine – 101.3% and 104.7%, respectively. The ratio of the average monthly salary in comparison with the average Ukrainian value increased from 86.2% (2017) to 89.1% (2021), and the absolute amount increased more than 2 times, to 12 488 UAH. The arrears for the payment of wages in the oblast increased almost threefold during this period, and the share of the oblast in the total arrears increased from 0.52% to 1.13%. The unemployment rate in the region rose to 11.4%, which is 1.1 percentage points higher than the average Ukrainian level. The indicator of the volume of industrial products sold per person in the region is half the average level in the country. However, the volume of agricultural products in the region exceeds the average Ukrainian level by more than two times (39.1 thousand UAH compared to 17.2 thousand UAH). The profitability of agricultural enterprises in Vinnitsia corresponds to the national average – UAH 5.4 thousand per person.

The volume of capital investments per person in the region lags behind the national indicator by almost a third – UAH 9 158 compared to UAH 12 719 on average in Ukraine. However, the growth of this indicator in the region during the analysed period (122.9%) exceeds the similar indicator in Ukraine by almost 3%. Budgetary income per person in the region grew at a slower rate than the average for

Ukraine – by 89.9% (from UAH 4.5 thousand in 2017 to UAH 8.6 thousand in 2021). The amount of expenditures per person in the region at the end of 2021 is 21% behind the national indicator – 10.3 thousand UAH compared to 11.7 thousand UAH. The amount of expenditures on health care in the region corresponds to the Ukrainian indicator – UAH 6 348, and on education it exceeds it by 9% – UAH 3 540 per person compared to UAH 3 252 in Ukraine.

The start of a full-scale war with Russia led to a sharp decline in economic activity, both in Ukraine as a whole and in economic entities of Vinnitsia. Physical destruction, a very high level of uncertainty and risks, deformation and disruption of logistical and production ties, significant migration of the population have an extremely negative impact on the indicators of socio-economic development of the united territorial communities of the region.

It is worth stating that the agriculture of the Vinnitsia region maintains a priority position in the structure of the agro-industrial complex of Ukraine. There are 4 283 economic entities operating in the industry, of which 841 are agricultural enterprises, 1 893 are farms. The number of personal peasant farms in the region is 274.4 thousand (Official website of..., 2023). In the agriculture of Vinnitsia region, 2012.0 thousand ha of agricultural land is used (1 730.5 ha – arable land, 48.0 thousand ha – perennial plantations, 48.8 thousand ha – hayfields, 183.9 thousand ha – pastures). The region ranks 9th among the regions of Ukraine in terms of agricultural land. Almost 50% of which are chernozems.

According to the results of 2021, the agricultural sector of the region confidently took first place in terms of the following indicators:

- production of agricultural products;
- production of agricultural products per person;
- production (sale) of meat;
- number of poultry;
- production of grain crops, sugar beets and fruit and berry products.

In terms of milk production and the number of cows, Vinnytsia ranked second. However, during 2017-2021, the number of cattle in all categories of farms in the region

decreased by 40% (from 308.8 to 185.6 thousand heads). The number of pigs decreased by almost half – from 351.3 to 203 thousand heads. However, a significant increase (by almost 40%) was recorded in the poultry industry, where the population grew from 27.6 to 38.1 million heads during the analysed period.

During 2017-2021, the growth rate of agricultural production by farms of all categories amounted to 116.4%, which exceeds the similar indicator in Ukraine as a whole by 1.6% (Table 2). The specific weight of the Vinnytsia region in the production of agricultural products ranges from 7.96 to 8.42%.

Table 2. Agricultural production of Ukraine and Vinnytsia region by farm category, 2017-2021, billion UAH (at constant 2016 prices)

Name of indicators	2017		2018		2019		2020		2021		2021 to 2017, %	
	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region
Farms of all categories												
Agricultural products	620.5	51.1	671.3	56.5	681.0	57.2	612.1	48.7	712.6	59.5	114.8	116.4
specific weight, %	8.24		8.42		8.40		7.96		8.35		0.11	
Product of crop production	480.2	36.8	529.3	41.7	538.7	39.4	473.4	30.8	580.3	42.0	120.8	114.1
specific weight, %	7.66		7.88		7.31		6.51		7.24		-0.43	
Product of animal husbandry	140.3	14.3	141.9	14.8	142.3	17.7	138.7	17.8	132.3	17.4	94.3	121.7
specific weight, %	10.19		10.43		12.44		12.83		13.15		2.96	
Agricultural enterprises												
Rural products	391.0	35.2	438.0	40.9	449.8	42.4	395.7	35.2	484.1	45.4	123.8	129.0
specific weight, %	9.00		9.34		9.43		8.90		9.38		0.38	
Products of crop production	323.7	25.9	367.7	30.8	376.8	29.1	323.2	21.5	413.0	31.8	127.6	122.8
specific weight, %	8.00		8.38		7.72		6.65		7.70		-0.30	
Product of animal husbandry	67.3	9.3	70.3	10.0	73.0	13.3	72.5	13.6	71.1	13.7	105.6	147.3
specific weight, %	13.82		14.22		18.22		18.76		19.27		5.45	
Households												
Rural products	229.5	15.9	233.3	15.6	231.2	14.8	216.4	13.5	228.5	14.1	99.6	88.7
specific weight, %	6.93		6.69		6.40		6.24		6.17		-0.76	
Product of crop production	156.4	10.9	161.7	10.9	161.9	10.3	150.2	9.3	167.3	10.3	107.0	94.5
specific weight, %	6.97		6.74		6.36		6.19		6.16		-0.81	
Product of animal husbandry	73	5	71.6	4.7	69.3	4.4	66.2	4.2	61.2	3.8	83.8	76.0
specific weight, %	6.85		6.56		6.35		6.34		6.21		-0.64	

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnytsia region (2023)

Analysing the data in Table 2, an important result is the fact that the growth rates of crop production and livestock production significantly exceeded the indicators of agricultural enterprises in comparison with other farms. The analysed information confirms the important role of agricultural enterprises in increasing production volumes and maintaining stability in the production of crop and

livestock products. However, it is worth noting that the rate of decline in agricultural production in the households of the region is ahead of the national level. This aspect may require attention and further analysis to ensure the sustainable development of the agricultural sector in the region.

Regarding the dynamics of natural indicators of regional crop production, the production of grain and

leguminous crops for the period 2017-2021 increased by a third – from 4.89 to 6.54 million tons, and the specific weight in the all-Ukrainian production decreased slightly from 7.9 to 7.6% (Table 3).

Table 3. Dynamics of agricultural production in Ukraine and Vinnytsia region, 2017-2021 million tons

Product type	2017		2018		2019		2020		2021		2021 to 2017, %	
	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region	Ukraine	Vinnytsia region
Cereal and leguminous crops	61.92	4.89	70.06	5.91	75.14	5.94	64.93	4.02	86.01	6.54	138.9	133.7
specific weight, %	7.90		8.44		7.90		6.18		7.60		-0.30	
wheat	26.16	1.74	24.61	1.67	28.33	1.83	24.88	1.35	32.15	1.77	122.9	101.7
barley	8.28	0.47	7.35	0.39	8.92	0.49	7.64	0.35	9.44	0.43	113.9	92.3
corn	24.67	2.55	35.80	3.75	35.88	3.57	30.29	2.28	42.11	4.28	170.7	167.5
Sunflower	12.24	0.73	14.17	0.81	15.25	0.85	13.11	0.77	16.39	0.98	134.0	135.7
specific weight, %	5.93		5.70		5.55		5.90		6.01		0.08	
Factory sugar beet	14.88	2.83	13.32	3.15	9.66	1.95	8.63	2.00 a.m	10.35	2.31	69.6	81.4
specific weight, %	19.05		23.65		20.20		23.20		22.28		3.23	
Potato	22.21	1.88	22.50	1.91	20.27	1.83	208.38	1.91	21.36	1.60	96.2	84.6
specific weight, %	8.49		8.48		9.01		0.92		7.47		-1.02	
Vegetable crops	9.29	0.48	9.44	0.46	9.69	0.46	9.65	0.43	9.94	0.50	107.0	104.1
specific weight, %	5.20		4.89		4.70		4.45		5.06		-0.14	
Fruits and berries	2.05	0.23	2.57	0.33	2.12	0.23	2.02	0.22	2.24	0.27	109.1	115.9
specific weight, %	11.40		12.92		11.08		10.82		12.12		0.72	
Meat	3.21	0.32	3.37	0.35	3.45	0.46	3.41	0.47	3.33	0.47	103.9	147.2
specific weight, %	9.97		10.43		13.32		13.86		14.14		4.18	
Milk	10.28	0.85	10.06	0.82	9.66	0.76	9.26	0.73	8.71	0.69	84.8	80.6
specific weight, %	8.28		8.20		7.90		7.88		7.87		-0.41	
Eggs, billion pcs	15.51	0.95	16.13	0.92	16.68	0.93	16.17	0.87	14.07	0.71	90.7	74.9
specific weight, %	6.10		5.69		5.60		5.37		5.04		-1.06	
Honey, thousand tons	66.2	4.20	71.3	4.39	69.9	3.91	68.0	3.73	68.6	3.87	103.6	92.1
specific weight, %	6.34		6.16		5.59		5.49		5.64		-0.70	

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnytsia region (2023)

Among grain crops, the highest production growth rates were recorded for corn – 167.5% (from 2.55 to 4.28 million tons). The production of sunflower by farms in the Vinnytsia region increased by 135.7%, fruits and berries – by 115.9%, vegetable crops – by 104.1%, wheat – by 101.7%. As already mentioned, in 2021, Vinnytsia took first place among the regions of Ukraine in terms of meat production. Thus, the farms of the region produced 0.47 million tons of meat, which is 147.2% more than the level of 2017, and the specific weight in the total production in the country increased from 9.97% in 2017 to 14.14% in 2021. According to other types of agricultural products, a decrease in production was recorded. Thus, the largest drop (by almost 25%) was experienced by the production of eggs – from 950 to 710 million units. the production of milk decreased by 19.4%, sugar beets – by 18.6%, potatoes – by 15.4%.

In the course of the study, a partial and integral index of the state and development of rural areas was calculated. As separate blocks of indicators, attention is focused on

economic, social and environmental components. Thus, for the analysed period, a relative improvement of the following economic indicators of rural development of the ATG oblast was established:

- the volume of products sold by agricultural producers (increase from UAH 31.6 to 39.2 billion);
- the volume of agricultural production (at 2016 prices) (increased from UAH 51.1 to 59.4 billion);
- increase in profit from ordinary activities before taxation (from UAH 6 275.4 to UAH 7 010.7 million);
- the average monthly nominal salary of full-time employees in agriculture (increase from UAH 6 499 in 2017 to UAH 11 910 in 2021), or by 83.3%;
- growth of production per person of such types of products as: meat (by 51.5%), sunflower (by 39.7%), cereals and legumes (by 37.7%), fruits and berries (by 19.6%), vegetables (by 7.5%);
- growth of the share of the employed population in agriculture from 31.2% to 31.6% (Table 4).

Table 4. Dynamics of economic indicators of rural development of the ATG of the Vinnytsia region, 2017-2021

Name of indicators	2017	2018	2019	2020	2021	2021 to 2017, %
Total land area, thousand hectares	2 649.2	2 649.2	2 649.2	2 649.2	2 649.2	100.0
Area of agricultural land, thousand hectares	2 014.2	2 012.0	2 012.0	2 012.0	2 012.0	99.9
The level of agricultural land development, %	76.0	75.9	75.9	75.9	75.9	99.9
The level of plowing of agricultural land, %	65.1	65.1	65.1	65.1	65.1	100.0
Availability of agricultural land, ha per village resident	2.68	2.72	2.76	2.81	2.74	102.2
The number of agricultural enterprises per 10 000 people of the existing population, units.	58	62	66	63	58	100.0
Share of small enterprises, %	94.8	94.4	94.0	94.0	95.2	100.4
Number of economic entities in agriculture, forestry and fisheries, units	4 535	4 432	4 406	4 286	4 093	90.3
The share of economic entities in agriculture, forestry, and fisheries in the total number, %	6.6	6.4	6.3	6.1	6.1	92.4
The level of profitability of agricultural, forestry and fishing enterprises, %	25.8	19.8	10.5	16.4	17.5	0.0
The share of the employed population in agriculture, forestry and fisheries, %	31.2	31.8	32.9	34.1	31.6	101.3
Average monthly nominal salary of full-time employees in agriculture, hryvnias	6 499	8 317	10 203	10 699	11 910	183.3
Production of agricultural products, million hryvnias (at 2016 prices)	51 111.3	56 520.9	57 168.9	48 688.6	59 448.8	116.3
Share of production of agricultural products by households, %	31.1	27.7	25.8	27.8	23.7	76.2
Share of crop production, %	72.0	73.8	68.0	63.3	70.7	98.2
Share of livestock products, %	28.0	26.2	31.0	36.7	29.3	104.6
Production of agricultural products, per person (kg)						
Cereal and leguminous crops	3 088	3 770	3 823	2 612	4 252	137.7
Factory sugar beet	1 790	2 008	1 256	1 302	1 498	83.7
Sunflower	458	515	545	503	640	139.7
Potato	1 191	1 217	1 176	1 241	1 037	87.1
Vegetable crops	305	294	293	280	328	107.5
Fruit and berry crops	148	212	151	143	177	119.6
Meat (in slaughter mass)	202	224	296	307	306	151.5
Milk	538	526	492	475	446	82.9
Eggs, pc.	597	585	601	565	461	77.2
The volume of products sold by agricultural producers, million hryvnias	31 595.6	36 283.5	38 753.1	36 152.8	39 209.7	124.1
Financial results from ordinary activities before taxation:						
profit	5 860.4	5 394.0	3 734.7	3 040.8	5 534.8	94.4
loss	6 275.4	6 299.3	4 315.2	4 792.4	7 010.7	111.7
volumes of capital investments in agriculture, million, hryvnias	415.0	905.3	580.5	1 751.6	1 475.8	355.6
Volumes of capital investments in agriculture, million, hryvnias	4 627	4 803	3 982	2 986	3 140	67.9
The share of capital investments in agriculture, hunting, and the provision of related services to the total volume, %	38.9	26.8	25.1	21.8	22.4	57.6
Partial index of economic efficiency of rural development of ATG	410.9	428.2	396.7	403.0	426.8	103.9

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnytsia region (2023)

According to other indicators of the economic bloc, a gradual decline is observed. Thus, the number of economic entities in agriculture during 2017-2021 decreased by 10% (from 4 535 to 4 093 units), and their share in the total number decreased from 6.6 to 6.1%. It was established that the share of agricultural production by households decreased from 31.1% in 2017 to 23.7% in 2021. Despite a significant improvement in the rating of Vinnytsia according to the capital investment index in 2021, the amount of capital investment in agriculture over the last five years decreased by a third – from UAH 4.627 million in 2017 to UAH 3.140 million in 2021. At the same time, the share of capital investments in the region's agrarian economy in the total volume decreased by 16.5%.

The practical approbation of the methodological toolkit for measuring and diagnosing the level of efficiency of rural development of the Vinnytsia Oblast ATG made it

possible to determine relatively positive dynamics of the partial index of the economic component. Thus, during 2017-2021, this aggregate indicator grew by 3.9% (from 410.9 in 2017 to 426.8 in 2021). The highest value of the index of economic efficiency of rural development of the ATG was recorded in 2018 (428.2), and the lowest in 2019 – 396.7. During 2017-2021, there is a gradual (on average by 1% per year (by 15-16 thousand people)) decrease in the total population of the ATG oblast. During the analysed period, this indicator decreased by 61.3 thousand people. The average indicator of the number of rural population in population per settlement decreased from 535 in 2017 to 503 in 2021. The total birth rate in the village decreased by 16.2%, and the death rate increased by 10.5% (Table 5). At the same time, a stable trend in the number of active population was established in villages aged 15-17 years – from 336.9 thousand in 2017 to 338.4 thousand people in 2021.

Table 5. Dynamics of social indicators of rural development of the ATG of Vinnytsia region, 2017-2021

Name of indicators	2017	2018	2019	2020	2021	2021 to 2017, %
Total population of ATG, thousands of people	1 590.4	1 575.8	1 560.4	1 545.4	1 529.1	96.1
Share of the rural population, %	49.1	48.8	48.6	48.3	47.9	97.6
Number of rural populations based on one rural settlement, on average persons	535	528	521	512	503	94.0
Total increase, reduction (-) of rural population, per 1,000 people	-8 067	-8 902	-9 120	-9 239	-11 300	140.1
Total fertility rate per woman	1 355	1 262	1 205	1 203	1 135	83.8
The birth rate of the rural population, persons	6 741	5 989	5 545	5 448	5 251	77.9
Mortality rate of the rural population	19.1	19.5	19.5	19.9	21.1	110.5
Economically active rural population aged 15-70, thousand people	336.9	338.8	340.1	343.7	338.4	100.4
Economically inactive rural population aged 15-70, thousand people	211.9	204.6	198.5	187.7	184.0	86.8
Level of economic activity, %	43.2	44.0	44.8	46.0	45.8	106.0
Employment rate, %	55.9	57.0	57.8	58.2	58.7	105.0
Unemployment rate, %	8.9	8.6	8.5	10.0	9.4	105.6
Number of registered marriages, unit	9 527	8 904	9 361	6 319	8 104	85.1
Per 1000 of the existing population	6.0	5.7	6.0	4.1	5.3	88.3
The number of registered divorces	5 445	6 244	5 617	4 840	5 046	92.7
Per 1000 of the available population	3.4	4.0	3.6	3.1	3.3	97.1
The ratio of the number of marriages and divorces	1.7	1.4	1.7	1.3	1.6	94.1
Enrolment of children in preschool educational institutions, % of the number of children of the appropriate age	67	69	71	72	70	104.5
In urban settlements	86	88	93	95	94	109.3
In the countryside	47	48	48	49	46	97.9
Coverage of children in institutions based on 100 places, %	111	110	104	101	94	84.7
In urban settlements	135	135	126	122	116	85.9
In the countryside	84	82	78	76	67	79.8
The number of people who studied in educational institutions (at the beginning of the academic year, thousands)	215.9	219.1	218.2	226.3	211.4	97.9
In secondary education institutions	157.5	161.8	164.9	166.9	166.4	105.7
In institutions of professional and technical education	13.5	12.7	11.9	11.7	12.2	90.4
In institutions of higher education	44.9	44.6	41.4	39.3	32.8	73.1

Table 5, Continued

Name of indicators	2017	2018	2019	2020	2021	2021 to 2017, %
Number of libraries in the countryside	826	825	823	819	816	98.8
Number of club establishments, units in the countryside	1018	1016	997	1017	985	96.8
Number of hospital beds, unit	10 935	10 822	10 566	10 261	9 769	89.3
Consumer price index	113.0	109.0	102.4	102.9	108.7	96.2
Aggregate resources of households in rural areas, on average per month per household	7 752.2	8 195.0	11 551.9	11 603.6	12 673.7	163.5
The cost of consumed products obtained from personal subsidiary farms in rural areas, %	10.5	10.5	8.3	8.3	8.2	78.1
Availability of living space, sq. m per person	35.2	35.7	36.3	37.0	37.3	106.0
Specific weight of equipped flats in residential buildings and non-residential buildings in rural areas, % with water supply	21.4	22.5	23.2	23.8	24.1	112.6
hot water supply	12.0	12.1	12.4	12.4	12.6	105.0
sewage	18.7	19.3	20.0	20.3	20.3	108.6
central heating	41.5	42.3	42.3	42.4	42.2	101.7
natural gas	81.3	81.5	82.2	82.2	82.0	100.9
Partial index of social efficiency of rural development of the ATG	107.4	107.0	106.9	104.0	104.8	97.6

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnytsia region (2023)

In turn, the economically inactive rural population of Vinnytsia region experienced a significant decrease – from 211.9 thousand people in 2017 to 184 thousand in 2021. Accordingly, the level of economic activity in the village during the analysed period increased from 43.2 to 45.8%, the level of employment increased by 5.0%. Regarding the assessment of the state and dynamics of the social infrastructure, we note that it is the qualitative dynamics of its components that largely mediate and contribute to the rural development of the ATG. A developed social infrastructure contributes to the consistent reduction of unnecessary migration and personnel rotation, and also contributes to the formation of stable work groups in existing agricultural structures. During the analysed period, the overall index of coverage of children in the region by preschool education institutions increased from 67 to 70%. However, if in urban settlements this ratio is from 86% to 94%, then in rural areas it even decreased from 47% in 2017 to 46% in 2021. That is, all forms of acquisition preschool education covered only 46 % of rural children

If the total number of people studying in secondary education institutions of the region during the analysed period increased by 5.7% (from 157.5 to 166.4 thousand people), then in rural areas there is a completely negative dynamic. Thus, during 2017-2021, the number of rural institutions of general secondary education decreased by 23% (from 632 to 488). At the same time, the number of students decreased by 6.6% or by 4 190 people. The dynamics of such components of the social infrastructure in the village, such as the presence of hospitals, libraries, and clubs in the Vinnytsia region, is relatively stable. Thus, during 2017-2021, the number of hospital beds in rural areas decreased by 10.7% (from 10 935 to 9 769 units), libraries – by 1.2% (from 826 to 816 units), and club facilities – by 3.2% (from 1 018 up to 985 units).

A fairly positive trend is the comparison of the ratio of the regional consumer price index and the growth dynamics of aggregate household resources in rural areas. Thus, during 2017-2021, the consumer price index decreased in annual terms from 113 to 108.7%, and the average monthly indicator of aggregate resources of households in rural areas per household increased by 63.5% (from UAH 7 752 to UAH 12 674). The condition of the rural housing stock has improved relatively. Provision of living space per rural resident increased from 35.2 to 36.3 m², and the rate of equipment of flats in residential buildings and non-residential buildings in rural areas with water supply increased from 21.4 to 24.1%. The level of gasification of housing in rural areas of the region is 82%.

The dynamics of the partial index of social efficiency of rural development of the ATG were determined and evaluated. During 2017-2021, this aggregate indicator decreased by 2.4% (from 107.4 in 2017 to 104.8 in 2021). The highest value of the index of social efficiency of rural development of the ATG was experienced in 2017 (107.4), and the lowest in 2020 – 104.0. In the course of the study, the index of ecological efficiency of rural development of ATG was calculated based on 7 indicators that allow monitoring the state of the environment – air pollution, the situation with the removal and disposal of waste, as well as the investment policy in the field of environmental protection (Table 6). Calculation partial index of environmental efficiency of rural development of the Vinnytsia Oblast ATG revealed a positive growth rate of 7.3% (from 17.2 in 2017 to 18.5 in 2021).

Based on the determination of the partial indicators of the economic, social and ecological components of the efficiency of rural development, the calculation and analytical measurement of the aggregate integral indicator was carried out (Table 7).

Table 6. Dynamics of ecological indicators of rural development of the ATG of Vinnytsia region, 2017-2021

Name of indicators	2017	2018	2019	2020	2021	2021 to 2017, %
Emissions of polluting substances into atmospheric air from stationary sources of pollution in agriculture, forestry and fisheries, thousand tons. Their share in the total structure of emissions, %	19.9	11.8	15.2	15.9	11.5	57.8
Emissions of carbon dioxin into the atmospheric air from stationary sources of pollution in agriculture, forestry and fisheries, thousand tons. Their share in the structure of emissions, %	4.6	1.6	6.8	6.9	6.3	137.0
The share of forest reproduction areas to the areas of forest cuttings, %	14.9	14.8	10.2	8.9	11.0	73.8
The share of capital investments for environmental protection from agriculture from the total amount of capital investments, %	26.1	29.1	23.1	16.3	45.4	173.9
The share of current investments for environmental protection from agriculture from the total volume of capital investments, %	73.9	70.9	76.9	83.7	54.6	73.9
Share of the area fertilized with organic fertilizers, %	1.8	1.8	3.9	3.5	3.9	216.7
Share of the area fertilized with mineral fertilizers, %	94.5	94.6	94.9	91.9	95.3	100.8
Partial index of environmental efficiency of rural development of ATG	17.2	13.9	18.3	17.1	18.5	107.3

Source: generated and calculated by the author based on the official data website of the State Statistics Service of Ukraine in the Vinnytsia region (2023)

Table 7. Integral indicator of the efficiency of rural development of Vinnytsia Oblast, ATG, 2017-2021

Name of indicators	2017	2018	2019	2020	2021	2021 to 2017, %
Partial index of economic efficiency of rural development of ATG	410.9	428.2	396.7	403.0	426.8	103.9
Partial index of social efficiency of rural development of the ATG	107.4	107.0	106.9	104.0	104.8	97.6
Partial index of environmental efficiency of rural development of ATG	17.2	13.9	18.3	17.1	18.5	107.3
An integral indicator of the efficiency of rural development of the ATG	91.2	86.0	91.9	89.5	93.9	102.9

Source: calculated by the authors

Over the analysed period and the integrated indicator of the regional effectiveness of rural development, the ATG experienced an increase of only 2.9% (from 91.2 in 2017 to 93.9 in 2021, which is the maximum value). The negative impact on the value and dynamics of the integral indicator was caused by structural deformations of the social component itself. Comparing the obtained results with the results of other researchers, the results of A.P. Sava (2018) are important, they are about the fact that the assessment of the level of socio-economic development of rural areas is a set of consecutive operations for establishing criteria, selecting indicators, justifying the methodology and its practical implementation. So, indeed, there is no universal algorithm for the formation of indicators of the effectiveness of rural development. In the course of the study, an algorithm for calculating the integral indicator of the effectiveness of rural development was developed and tested, taking into account the regional specificity of the

functioning of the united territorial communities of the Vinnytsia region (Trusova *et al.*, 2021).

Author M.M. Tymoshenko (2018) tried to justify and develop an analytical-synthesizing scheme for researching the current state of rural areas and their components. Comparing the studies, this article improved the methodical approach to evaluating the effectiveness of rural development, which has the character of a dynamic mechanism and is based on detailed structuring and meaningful filling of the components of the integral indicator of effectiveness. So, for assessing rural development in united territorial communities, various structural systems of indicators and criteria can be applied, as substantiated in the research by N. Mokhort (2018), T.V. Usyuk & L.V. Farion (2018), N.L. Khomyuk & N.V. Pavliukha (2019). According to the authors, the diversity of indicators and criteria can be structured into two groups - diagnostic (monitoring) indicators and criteria of effectiveness and efficiency of development.

Similarly, to the research by O.Yu. Borovska (2017), the study is based on a system of regional diagnosis, encompassing economic, social, and ecological components, structurally detailed with a specific set of indicators and calculation tools proposed. In contrast to V.S. Kravtsiv & I.Z. Storonyanska (2020), who suggested computing a synthetic weighted index using a formula of weighted arithmetic mean, this article employs a mathematical calculation framework involving the n -th root of the product of selected criteria (indicators). S. Hussain *et al.* (2022) delved into the influence of socio-economic factors on the development of rural communities in Pakistan. The authors justified a development support strategy for rural areas centred on implementing infrastructure projects as fundamental tools to enhance the socio-economic conditions of rural populations. The essential distinction between the concepts of “rural territory development” and “rural development” is rooted in the former concentrating on organizational, economic, production, and infrastructure-related components, while the latter focuses on ensuring a dignified level of social security and rural population well-being. Hence, the assessment practice of the effectiveness of implementing the Japanese “One Village, One Product” model, which contributes to rural population employment and well-being, as explored by L.H. Thanh *et al.* (2018), is quite intriguing for further research.

Conclusions drawn by S. Hussain *et al.* (2022) affirm that the practice of implementing public infrastructure projects is the foundation of rural territory development and improving the quality of life. Results from the research by J.A. Pérez-Méndez *et al.* (2019) established a positive impact of government subsidies on the dynamics of rural territory development. An important direction for further investigation would be to examine and justify the mechanisms through which state support instruments for the agricultural sector in Ukraine influence the level of rural community development. Polish researchers A. Pawlik *et al.* (2021) studied the influence of the community’s budget potential and its dependency on state budget allocations on the dynamics of rural development. Indeed, the socio-economic potential of a region, district, or community (of any territorial-administrative entity) is shaped within the respective territory by economic entities and the population. The centrally formulated budget-tax system, represented locally as municipal budgets, plays a key role in this process.

A noteworthy empirical experience is the practical application of selecting indicators relative weights for evaluating the degree of rural area development, as executed by X. Liu *et al.* (2021). An important insight is that by clearly defining rural development criteria, selecting indicators with a certain number of structural components, a combination of methodological approaches can be used to analyse, assess, and visually express the level of development of a specific rural area. Significant results from the research of B. Hennebry & T. Strykiewicz (2020) introduced the “structural strength” index to measure the socio-economic development of rural territories. Analysing models of urban spread and justifying guiding principles for planning rural areas in transitional zones between urban and rural areas in the Turkish Mediterranean city of Antalya, S. Balta & M. Atik (2022) dedicated their research. The authors developed an effective planning tool

based on ecological, spatial, and social characteristics of both rural and urban territories, ensuring the continuity of rural features to support agricultural productivity and protect natural biodiversity (Gutorov, 2021).

Noteworthy is the work of G. Gargano (2021), which focuses on the comparative evolution of policies and methodological approaches for rural area development and local groups in the United Kingdom and Italy. The author examined the effectiveness of EU strategies for rural development, measured how management structure, institutional mechanisms, and economic potential influence the level of rural development across different EU countries. The impact measurement of the LEADER development strategy on its spheres of activity, as well as the efficiency of managing European aid for rural territory development in Spain to enhance economic activity and address demographic and socio-economic challenges in the most depressed municipalities, was the focus of research by G.C. Alonso & N.A. Masot (2020). Ž. Jurjević *et al.* (2021) provided a comparative characterization of levels of development of rural territories in Serbia and the EU based on the determination and measurement of a set of socio-economic indicators. The methodological research framework was built upon the structural justification of the socio-economic efficiency index, created through factor analysis. The authors measured the extent of development lag in rural territories of Serbia compared to other EU regions. The need for implementing strategies capable of directing the available resource potential of rural territories towards accelerating their socio-economic development was justified.

In this study, a toolkit for quantitative-structural substantiation was developed and tested, content components were determined, and a methodological algorithm for determining an integral indicator of the effectiveness of united community rural territory development was created. Structural monitoring was also conducted, and the dynamics of this indicator were studied.

► Conclusions

The process of assessing the level of socio-economic development of rural areas is characterized by a set of sequential operations, starting with the establishment of evaluation criteria, selection of indicators, justification of calculation methodology, and ending with analytical conclusions drawn from the obtained results. To assess the effectiveness of rural development in amalgamated territorial communities (ATGs), there is a variety of indicators and criteria, which are structured into economic, social, and ecological blocks in the context of the study and differentiated analytically into diagnostic indicators (monitoring) and criteria for development effectiveness and performance. The determination of partial indicators for the economic, social, and ecological components of rural development effectiveness allowed for the calculation and analytical measurement of the overall integral indicator, as well as an analysis of its dynamics. Throughout the analysed period, a trend of stability in the achieved level of rural development in the Vinnytsia Oblast’s ATGs was identified, although the growth dynamics proved to be relatively modest, increasing by only 2.9% (from 91.2 in 2017 to 93.9 in 2021). The maximum value of the integral indicator was

reached in 2021. The full-scale invasion by Russia prevents predicting its further positive dynamics.

Among the array of economic indicators, the greatest positive impact on the level of rural development in Vinnytsia's ATGs was caused by: an increase in agricultural production volume by 8.3 billion UAH (or 16.2%), growth in the sales volume of agricultural products by producers by 7.6 billion UAH (or 24.1%), profitability growth by 735.3 million UAH, significant increases in meat, grain, fruit, berry, and vegetable production per capita, an increase in the average monthly salary in rural agriculture, and an increase in the share of the employed population. Overall, the partial index of economic efficiency of rural development in ATGs demonstrated a positive growth trend of 3.9%.

Factor analysis revealed a negative influence of deteriorating social indicators on the overall integral indicator of rural development effectiveness. The decline in the population of the region's ATGs, the decrease in rural population per settlement, and the increase in rural mortality had a particularly negative impact. However, stability and improvement in social infrastructure indicators provide a positive basis for the future development of rural territories. Improvement includes increased access of children to preschool education, betterment of the rural housing stock, and increased gasification of rural dwellings. Regarding the dynamics of the partial index of social effectiveness of rural development in ATGs, a negative decline of 2.4% was observed during the analysed period. On the other hand, the

partial index of ecological effectiveness of rural development in Vinnytsia's ATGs grew at the highest rate, by 7.3%.

The scientific novelty lies in the further development of a methodological approach to assessing rural development effectiveness. This approach is based on a systematic toolkit of quantitative-structural substantiation and content filling of integral indicators for rural development effectiveness in Vinnytsia's ATGs, which creates prerequisites for further research and evaluation of the efficiency of territorial transformations in rural areas within individual ATGs.

The research results provide a practical opportunity to objectively assess and analyse the comparative advantages, challenges, and risks of rural development in the united territorial communities of Vinnytsia Oblast. Identified logical connections between internal and external factors contribute to determining strategic directions for further activation of these communities' development, justifying the dynamics of development effectiveness indices over the considered period, and highlighting the role and significance of objective assessment for the development of united rural communities.

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► Conflict of Interest

None.

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Моніторинг та оцінка ефективності сільського розвитку об'єднаних територіальних громад Вінницької області

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► **Анотація.** Збалансований розвиток та взаємодія видів господарської діяльності формують економічний потенціал регіону і допомагають заповнювати бюджети. Удосконалення методики діагностики економіки сільського розвитку з урахуванням природних, економічних, демографічних, соціальних та рекреаційних особливостей є актуальним. Метою дослідження було удосконалення та опрацювання методичного інструментарію оцінки ефективності сільського розвитку на прикладі об'єднаних територіальних громад Вінницької області. У процесі дослідження використано ряд методів: абстрактно-логічний, порівняльного аналізу, табличний, статистичний, розрахунково-конструктивний. За ключовими економічними параметрами, такими як темпи Вища рада правосуддя та обсяг виробництва на особу, Вінницька область відзначається відносною тенденцією випереджального регіонального розвитку, а сільське господарство області 2017-2021 рр. зберігає пріоритетні позиції в структурі агропромислового комплексу України. Аналітичний моніторинг позитивної динаміки переважної сукупності економічних індикаторів сільського розвитку об'єднаних територіальних громад Вінницької області сприяв зростанню часткового індексу економічної складової. Протягом 2017-2021 рр. даний сукупний показник збільшився від 411 до 427 пунктів або майже на 4%. Встановлено, що частковий індекс соціальної ефективності сільського розвитку об'єднаних територіальних громад області знизився на 2.4% (від 107.4 у 2017 р. до 104.8 пунктів у 2021 р.). Найвищого значення індекс соціальної ефективності сільського розвитку об'єднаних територіальних громад зазнав у 2017 р. (107.4), а найнижчого – у 2020 р. – 104.0. Розрахунок часткового індексу екологічної ефективності сільського розвитку встановив зростання на 7.3% (від 17.2 у 2017 р. до 18.5 у 2021 р.). Розрахунок та аналітичне вимірювання сукупного інтегрального показника ефективності сільського розвитку об'єднаних територіальних громад виявив тенденцію незначного зростання – від 91.2 у 2017 р. до 93.9 пунктів у 2021 р., що не перевищує 3%. Практична значущість проведеного дослідження визначається удосконаленням інструментарію та розробкою методичного алгоритму визначення інтегрального показника ефективності сільського розвитку об'єднаних територіальних громад, що може бути корисним в регіональній управлінській практиці організації моніторингу та розробки напрямів розвитку сільських територій

► **Ключові слова:** розвиток сільських територій; інтегральний показник; індекс економічної ефективності; індекс соціальної ефективності; індекс екологічної ефективності

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