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The state of efficiency of use and prospects for restoration of resource potential of agricultural enterprises of the Polissia zone of Ukraine in the post-war period

Abstract. The purpose of this study was to determine the features of the formation and effectiveness of the use of resource potential of agricultural enterprises of the Polissia zone of Ukraine in conditions of wartime transformations. The research methodology was based on the application of descriptive-statistical, structural, dynamic and comparative analysis, as well as the case study method on the example of the enterprises Galeks-Agro and Ritter Bio Agro LLC. The study found that the natural and climatic conditions of Polissia limited the efficiency of resource use: the pH level of soils was 4-5.5, the humus content was 0.8-1.5%, and annual losses were 0.3-0.5 tonnes/hectare. At the same time, an increase in grain crop yields by more than 40% and an increase in production volumes to UAH 258 billion in 2023 were found, which may indicate adaptation. Comparative analysis of enterprises showed significant differences in efficiency: at Galeks-Agro, revenue per hectare was UAH 41,780, profit – UAH 8,887, labour productivity – 1,530,392 UAH/employee, integral indicator – 0.75. At Ritter Bio Agro LLC, revenue per hectare was UAH 2,902, profit per hectare was UAH 631, labour productivity – UAH 196,927 per employee, integral indicator of efficiency – 0.25. At the same time, close profitability values (21.27% and 21.73%) indicate similar cost efficiency, while differences in overall results are due to the scale and intensity of resource use. In the post-war period, increasing the efficiency of resource potential use is associated with optimising land use, modernising the material and technical base, developing processing, diversifying production, and improving logistics and export activities. The practical significance of the study lies in the possibility of using the obtained results and substantiated approaches to increase the efficiency of resource potential use and forming management decisions regarding the restoration of agricultural enterprises in the post-war period

Keywords: productivity; land use; productivity; diversification; digitalisation; profitability

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INTRODUCTION

The functioning of agricultural enterprises in the Polissia zone of Ukraine in the conditions of military transformations is accompanied by a disruption of the processes of formation and resource potential use, which manifested itself in the loss of part of production resources, a decrease in the efficiency of land use and limited access to material, technical and financial resources. A full-scale war led to the destruction of infrastructure, loss of equipment, mining of agricultural lands and disruption of logistics chains, which directly affected the effectiveness of agricultural production. Violation of the effectiveness of the functioning of agricultural enterprises necessitates a review of approaches to the formation and use of the production and financial capabilities in the context of innovative transformations, which are accompanied by the influence of external and internal factors. The study by N.M. Sulima *et al.* (2024) found that agricultural enterprises concentrate a significant share of land, labour and financial resources, which determines the role in the formation of production potential. Increasing the efficiency is associated with the introduction of innovative technologies, the development of human capital, diversification of activities and the use of various sources of financing, which allows adapting to changes in the economic environment. The activities of small and medium-sized agricultural enterprises, as established by N.O. Avercheva & H.V. Kozak (2024), are accompanied by a decrease in the level of profitability, a decrease in employment and an increase in dependence on external sources of financing. A significant part of economic entities is on the verge of financial sustainability, and the restoration of the functioning in the post-war period requires improving management processes, implementing performance assessment systems and attracting state and international support.

The complexity of the processes of combining and using production factors in agricultural enterprises in the context of the transformation of the economic environment necessitates the clarification of the essence and structure of the resource capabilities. The resource potential of agricultural enterprises in the study of S.V. Stepanenko (2022) considered it as a complex system of interconnected elements, including land, capital, and labour with the further detailing in accordance with the peculiarities of the functioning of agricultural production. The author also proved that the efficiency of resource use is determined not only by the volume, but also by the proportionality and balance of the combination, with a special role played by intellectual and image capital, as well as the transformation of land relations and the growth of the importance of human capital in the conditions of innovative development. The agricultural sector of Ukraine, as established by I.V. Tomashuk & R.O. Horobchuk (2024), has significant potential, formed at the expense of natural resources, labour supply, infrastructure and technological capabilities. Its implementation is limited by an insufficient level of modernisation, investment difficulties and social challenges, in particular the ageing of the population in rural areas. The authors argued that increasing efficiency is possible through the introduction of innovative technologies, the development of cooperation, the digitalisation of production, and the expansion of processing, which will contribute to the growth of added value and the competitiveness of products.

Disruption of agricultural land use processes due to military actions, accompanied by a decrease in cultivated areas, deterioration of soil quality characteristics and complication of production and logistics processes, necessitates a rethinking of organisational and economic approaches to land use. The study found that military aggression caused significant losses of land resources due to mining, occupation and pollution, which, as noted by O.M. Dyachynska (2025), led to a reduction in sown areas and a decrease in yields. The researcher also substantiated that in conditions of limited access to resources and disruption of logistical connections, agricultural enterprises are forced to adapt the production structure, reduce costly crops and review approaches to the use of land resources, and also identified areas of state support, investment support and land use optimisation for the restoration of production processes in the post-war period. A. Shevchenko *et al.* (2025), in the study, determined that the resource potential of

agricultural enterprises includes land, material and technical, financial and human components that form the possibilities of the development and adaptation to changes in the economic environment. The authors also substantiated that innovative diversification of activities, in particular the introduction of niche crops, the development of new areas of production and the use of modern technologies, contributes to increasing financial stability, reducing risks and ensuring the stability of the functioning of agricultural enterprises in the post-war period.

Deterioration of the conditions for providing agricultural production with material and technical, financial and labour resources in conditions of economic instability is accompanied by a decrease in productivity and a complication of the processes of reproducing production capabilities. In the study of M.P. Martyniuk (2024), the resource availability of agriculture was characterised by significant limitations caused by the destruction of infrastructure, disruption of logistical connections, loss of part of the land and limited access to financing, which negatively affected the efficiency of the functioning of enterprises. The author also argued that increased efficiency is possible through the introduction of innovative technologies, in particular precision agriculture, production automation and digital solutions, as well as through diversification of financing sources, development of environmentally friendly practices and staff training. At the same time, R.M. Soloshenko (2023) found that the war caused complex negative consequences, in particular the destruction of logistics and production infrastructure, loss of up to 30% of agricultural land, shortage of financial resources and reduction of production by 30-40% compared to the pre-war period. The author also argued that recovery is possible on the basis of an integrated approach, which involves the reconstruction of infrastructure, modernisation of irrigation systems, attraction of international investments, state financial support, implementation of digital and agro-technological solutions, as well as the development of human capital and diversification of export markets.

Meanwhile, the issues of assessing the efficiency of resource use in a regional context remain insufficiently addressed, and there are no comprehensive approaches to restoring production potential, taking into account territorial conditions and the consequences of war-related impact. The purpose of this study was to study the processes of formation and efficiency of use of production resources of agricultural enterprises of the Polissia zone of Ukraine under the influence of military changes. To achieve this goal, the following tasks were defined: to analyse the composition and structure of resource endowment of agricultural enterprises of the Polissia zone of Ukraine, taking into account natural and climatic conditions and military changes; to assess the effectiveness of use of production resources; to substantiate the directions of restoration and improvement of the effectiveness of use of resources of agricultural enterprises in the post-war period.

MATERIALS AND METHODS

The study was empirical in nature and covered the time period of 2021-2025, which was due to the need to simultaneously take into account the pre-war state of the agricultural sector, the sharp transformation of the resource base as a result of full-scale military operations in 2022 and the stage of gradual restoration in 2023-2025, which made it possible to trace the dynamics of changes in the use of the resource potential of agricultural enterprises. The object of the study was agricultural enterprises of the Polissia zone of Ukraine and the resource potential, which was formed under the influence of natural and climatic, economic and military factors. The Polissia zone was considered as a spatial environment for the functioning of enterprises, which determined the specifics of resource use. To clarify the territorial boundaries of the study, the method of regional and spatial analysis was used, which made it possible to outline the composition of the relevant regions (Resolution of the Cabinet of Ministers of Ukraine No. 2068, 1998) and take into account the natural and geographical features. To identify the factors that affected the efficiency of resource potential use of agricultural enterprises in the Polissia zone of Ukraine, the study used a descriptive-analytical method. Using this method, the characteristics of the soil cover were

analysed, in particular, soil acidity (Soil fertility models..., 2022; Soil pH and..., 2025), as well as the humus content and its dynamics (One of the biggest..., 2018). Special attention was paid to the peculiarities of the structure of agricultural production and its transformation (Zosymchuk, 2022). The obtained data were used to identify natural, climatic and resource factors that determined the conditions for using the resource potential of agricultural enterprises in the region (Nechyporenko *et al.*, 2025).

Within the framework of the study of the resource potential of agricultural enterprises of the Polissia zone of Ukraine, the case study method was applied on the example of the enterprises Galeks-Agro (n.d.) and Ritter Bio Agro LLC (n.d.). The choice of these enterprises was due to the need to compare different models of production organisation within the same natural and climatic zone. The study of the enterprise Galeks-Agro was carried out using structural and descriptive-analytical methods to characterise the components of the resource potential, in particular land, biological, material, and technical and innovative resources, as well as determining the features of the combination in the production process. The assessment of the organisational and production model and the level of integration was carried out using a functional-structural approach, which made it possible to analyse the relationships between crop production, livestock farming and processing. The study of innovative and environmental components of the resource potential was based on the analysis of the enterprise's compliance with international standards of organic production: Regulation (EU) 2018/848 (2018), Bio Suisse (2023). Additionally, for a generalised assessment of the efficiency of resource use, elements of financial analysis were used based on the reporting of Galeks-Agro (n.d.), which allowed correlating the structure of resource availability with the results of economic activity.

The study of Ritter Bio Agro LLC (n.d.) was conducted using a similar methodological approach, taking into account the specifics of its production model. The characteristics of land resources and production specialisation were carried out using structural and descriptive-analytical methods to determine the structure of crops and the features of the use of land potential in organic production: Regulation (EU) 2018/848 (2018), Ritter Bio Agro LLC. Information on the organic orientation of the enterprise's activities was taken into account based on the availability of relevant organic production certificates, in particular Organic Standard (n.d.), Naturland (n.d.) and Bio Suisse (2023). The assessment of the material and technical support and production model was carried out using a functional-structural approach based on information on the enterprise's activities. Additionally, elements of financial analysis were used based on open reporting data, which allowed correlating resource support with the results of economic activity.

To generalise approaches to resource potential use, a comparative method was applied by comparing the activities of Ritter Bio Agro LLC (n.d.) and Galeks-Agro (n.d.) according to the following indicators: revenue per hectare, UAH/ha, profit per hectare, UAH/ha, profitability, %, revenue per 1 employee, UAH, integral efficiency indicator. The calculation of revenue per hectare was carried out according to the formula (1):

$$D_1 = \frac{D}{S}, \quad (1)$$

where D – net revenue from sales of products, UAH; S – the area of agricultural land, ha.

This indicator was used to assess the economic return on land resources and allowed comparison of the efficiency of enterprises. The calculation of profit per hectare was carried out according to the formula (2):

$$P_1 = \frac{P}{S}, \quad (2)$$

where P – net profit, UAH.

The indicator characterised the efficiency of land resource use taking into account costs and reflected the level of financial result formation per unit of area. The level of profitability was determined as (3):

$$R = \frac{P}{D} \times 100\%. \quad (3)$$

This indicator enabled assessing the efficiency of enterprise costs and determining the

ratio of profit received to the volume of products sold. The calculation of labour productivity (revenue per employee) was carried out according to the formula (4):

$$L = \frac{D}{N}, \quad (4)$$

where N – the average number of employees, people.

The indicator was used to assess the efficiency of using labour resources and reflected the volume of products created per employee. In order to ensure the comparability of indicators that have different units of measurement, the normalisation was applied using the minimax method (5):

$$(x - x_{min})/(x_{max} - x_{min}). \quad (5)$$

Normalisation made it possible to bring heterogeneous indicators to a single scale and provided the possibility of the further generalisation. The integral indicator of the efficiency of using resource potential was determined as the arithmetic mean of the normalised indicators (6):

$$I = (x_1 + x_2 + x_3 + x_4)/4. \quad (6)$$

The use of the integral indicator allowed for the aggregation of partial indicators of efficiency and the formation of a generalised assessment of the level of use of the resource potential of enterprises. Based on the generalisation of the obtained results, directions for the restoration and improvement of the efficiency of resource use in the post-war period were formed using the method of generalisation and systematisation, which provided a justification for approaches to increasing the operational efficiency of agricultural enterprises, taking into account the identified trends and limitations.

RESULTS AND DISCUSSION

The state and dynamics of agricultural production development in the Polissia zone of Ukraine

The Polissia zone of Ukraine covers the northern and partly western regions of the country and is characterised by the predominance of sod-podzolic soils of sandy and sandy loam mechanical composition, as well as a significant share of waterlogged and swampy lands. It includes the territories of Volyn, Rivne, Zhytomyr, Kyiv, Chernihiv, Sumy, Lviv, Ternopil and Khmelnytsky regions (Resolution of the Cabinet of Ministers of Ukraine No. 2068, 1998). The total area of the zone is over 113 thousand km² (about 20% of the territory of Ukraine), and in some regions, in particular the Rivne region, the share of Polissia territories exceeds 73% (about 1.5 million hectares). The natural environment of the region is characterised by an excess water balance: the average annual rainfall is 600-650 mm (in some areas over 700 mm) with evaporation of 400-450 mm. The temperature regime ranges from -4.5...-8°C in winter to +17...+19°C in summer, and the duration of the frost-free period is 160-180 days. The functioning of agricultural enterprises in the Polissia zone of Ukraine is determined by specific natural resource conditions that directly affect the efficiency of resource potential use. One of the keys limiting factors is the properties of soils characterised by high acidity and low natural fertility. The predominance of sod-podzolic soils with a pH level of 4-5.5 causes the formation of an acidic environment, which leads to the accumulation of toxic forms of aluminium, inhibition of the development of the plant root system and a decrease in the availability of nutrients (Soil pH and..., 2025). As a result, the efficiency of fertiliser use decreases by 20-40%, which increases production costs and reduces resource efficiency (Soil fertility models..., 2022).

The natural and climatic conditions of Polissia also determine the structure of agricultural production and the choice of economically viable crops. The most adapted are grain and leguminous crops (winter wheat, rye, triticale, maize), as well as crops traditional for the region – potatoes, flax, buckwheat, and fodder grasses. Under conditions of proper land reclamation and technological support, individual crops can provide a high level of yield, in particular maize – up to 10-12 t/ha. At the same time, the structure of production is gradually transforming from traditional specialisation to a more diversified model, which includes the expansion of areas under soybeans, rapeseed, and sunflower (Zosymchuk, 2022). Along with

natural limitations, the development of agricultural production is affected by the processes of resource base degradation. One of the characteristic features of the soils of the Polissia zone is the low humus content, which in light mineral soils is mostly 0.8-1.5%. Under conditions of intensive land use, annual humus losses due to mineralisation are estimated at 0.3-0.5 t/ha, which requires the compensation to maintain the initial level of soil fertility (One of the biggest..., 2018). These processes, combined with erosion phenomena and land drainage, lead to a decrease in the productive potential of agricultural landscapes.

Despite the above limitations, the region was experiencing positive dynamics in the development of agricultural production. Over the last decades, the yield of major agricultural crops increased, which is associated with the introduction of modern technologies, the use of new varieties and the development of land reclamation. In particular, the yield of grain crops increased by more than 40%, which was accompanied by an increase in production indicators despite existing natural limitations. At the same time, the increase in production volumes was accompanied by a change in the structure of crops and the expansion of the use of more productive crops. The dynamics of production was growing: the volume of agricultural production increased to UAH 258 billion in 2023, with the share of the Polissia zone accounting for about 10% of the total production in Ukraine, with a high specialisation in the production of individual crops, in particular oats and buckwheat. At the same time, despite the soil degradation processes, the region maintains a tendency to maintain the achieved levels of yield, which may be associated with the adaptation of agricultural production to existing resource constraints (Nechyporenko *et al*., 2025). Thus, agricultural production in the Polissia zone operates under conditions of a combination of natural constraints and gradual technological adaptation. The specifics of soil and climatic conditions, the degradation of the resource base and the transformation of the production structure determine the features of the formation of the resource potential of agricultural enterprises and necessitate the need to increase the efficiency of its use through the introduction of adaptive technologies, diversification of production and optimisation of land use.

Assessment of the efficiency of resource use of agricultural enterprises of the Polissia zone of Ukraine

The agricultural enterprise Galeks-Agro (n.d.) is an example of the formation and effective resource potential use in the conditions of the Polissia zone of Ukraine, based on the model of vertically integrated production. The enterprise functions as a comprehensive system that covers all stages of agricultural production – from the cultivation of organic crop and livestock products to the processing and sale to the end consumer on the principle of "from field to table". Such an organisation of activities ensures the closure of the production cycle, an increase in the level of added value and more efficient use of available resources. The enterprise's land resources constitute over 10 thousand hectares of agricultural land certified as organic. Production is carried out in the conditions of the Polissia zone, which is characterised by less fertile soils and increased humidity, which necessitates the adaptation of agricultural technologies. The specialisation of crop production is represented by the cultivation of grain and leguminous crops, in particular wheat (including spelt), rye, barley, oats, buckwheat, millet, maize, soybeans, as well as legumes (peas, beans, vetch). Fodder crops provide the internal needs of livestock farming, which indicates a rational combination of industries and the closure of resource flows. The livestock sector is represented by the breeding of Simmental cattle of the meat and dairy production. The total livestock population is about 4.7 thousand heads, of which approximately 1.7 thousand are dairy cows. The average annual productivity is about 7,000 litres of milk per cow, which corresponds to a high level of efficiency in the use of biological resources. The development of livestock farming is ensured by the presence of modern dairy complexes operating according to European standards, as well as its own feed base formed at the expense of crop production. The material and technical base of the enterprise includes production infrastructure that ensures

the implementation of basic technological processes in crop and livestock farming, in particular soil cultivation, sowing, harvesting and animal husbandry. It includes dairy farms, fattening complexes, an elevator with a capacity of about 12 thousand tonnes of storage, as well as processing enterprises. The presence of its own infrastructure ensures the possibility of implementing a full production cycle and reducing losses at individual stages of production.

A feature of the resource potential of Galeks-Agro (n.d.) is the development of processing, which allows transforming raw materials into products with high added value. The enterprise has its own dairy plant with a capacity of up to 30 tonnes per day, which produces over 120 types of organic dairy products, including the production of organic beef and pork, as well as a wide range of processed products, in particular sausage products (boiled, semi-smoked, raw smoked), sausage products, thick sausages, meat pâtés and lard products. Additionally, grain crops are processed into flour, cereals and other products, which indicates a deep integration of production processes and effective use of the raw material base. The enterprise's resource potential includes innovative and environmental elements that are implemented through organic production and the corresponding certification system. All products of the enterprise are certified in accordance with international standards of organic production: Regulation (EU) 2018/848 (2018), Bio Suisse (2023), which confirms compliance with environmental requirements and increases the competitiveness of products. The organic management model involves the rational use of land resources, preservation of soil fertility and minimisation of negative impact on the environment.

The economic results of the Galeks-Agro enterprise (n.d.) can be characterised using generalised financial indicators. In particular, in 2025, net revenue from sales of products amounted to UAH 417.8 million, and net profit – UAH 88.9 million, which exceeds the indicators of the same period of the previous year. The enterprise is partially focused on foreign markets, exporting organic products, in particular grain, cereals and flour. About 30% of the products produced are sold outside Ukraine, while the rest is used for internal processing and ensuring the production cycle. The main export destinations are the countries of the European Union (in particular, Germany, Switzerland, Italy, the Netherlands, the Czech Republic), as well as the USA and Canada, which indicates the integration of the enterprise into the international markets of organic products. Thus, the resource potential of Galeks-Agro is formed on the basis of a combination of land, material and technical, biological and innovative resources that operate within a vertically integrated production system. The state of efficiency of its use is characterised by ensuring a closed production cycle, a rational combination of crop and livestock industries, as well as the development of its own processing, which contributes to increasing the return on resources and reducing losses at individual stages of production. Additionally, the effectiveness of the resource potential use is manifested in the stable dynamics of production indicators, in particular livestock productivity and volumes of raw material processing, which reflects the adaptation of the enterprise to the natural and climatic conditions of the Polissia zone.

Ritter Bio Agro LLC (n.d.) is an agricultural enterprise operating within the Polissia zone of Ukraine (Rivne region, Goshchansky district) and specialising in organic crop production with an orientation towards external markets. The production activity of the enterprise is based on the use of land resources, which form the basis of its resource potential, and is characterised by the absence of a livestock direction, which determines a clear industry specialisation. The enterprise's land bank consists of about 3.8 thousand hectares of agricultural land located within the Rivne region. A significant part of the land (approximately 3.2 thousand hectares) is certified as organic, while about 600 hectares are in the transition period to organic production. This structure of land resources indicates the gradual expansion of the organic segment and the transformation of traditional agriculture in accordance with environmental requirements. The production specialisation of the enterprise is focused on growing grain, leguminous and oil crops. The basis of the sown areas is formed by wheat, maize, rye and buckwheat, which are

the basic crops for organic production in the conditions of Polissia. In addition, soybeans are grown as a representative of leguminous crops, as well as oil crops – sunflower and rapeseed. The structure of the enterprise's production includes niche and industrial crops, in particular buckwheat as an export-oriented organic product, as well as sugar beets, the cultivation of which in the organic segment is a relatively new direction for Ukraine. The crop structure is characterised by the dominance of grain crops with the inclusion of oil and niche crops in the crop rotation, which ensures compliance with the principles of organic farming. Organic production is a key component of the enterprise's resource potential. The company was operating in this segment since its foundation (2013) and is certified in accordance with international standards, in particular Organic Standard (n.d.), Naturland (n.d.) and Bio Suisse (2023). Products sold as organic are produced in compliance with the established requirements, which ensures access to external markets, primarily the countries of the European Union.

The material and technical base of the enterprise is formed in accordance with the scale of its activities and includes modern agricultural machinery necessary for soil cultivation, sowing and harvesting. Although open sources do not contain detailed information on specific technologies of precision agriculture, the scale of production and export orientation of the enterprise are consistent with the use of modern technological solutions, which is indirectly confirmed by the need for products to comply with the requirements of international quality standards and certification, in particular Regulation (EU) 2018/848 (2018), ISO 22000:2019 (2019), HACCP (2022). Infrastructure includes warehouses for storing products, while information on the availability of own elevator capacities in open sources is not detailed, which may indicate partial use of leased logistics infrastructure. Assessment of the effectiveness of the resource potential use can be partially illustrated by generalised financial indicators. In particular, in 2025, the company's revenue was about UAH 58 million, while a negative financial result was recorded (loss of more than UAH 10 million), which is accompanied by a decrease in profitability to -18.25%. At the same time, in the previous period (2024), the enterprise demonstrated positive financial results (profit of UAH 27.8 million, profitability of 23.87%), which indicates the variability of the efficiency of resource use depending on market and production conditions. Thus, the resource potential of Ritter Bio Agro LLC is formed mainly at the expense of land and material and technical resources with the dominance of the crop production specialisation and the lack of integration with livestock breeding and processing. The state of its use efficiency is characterised by an orientation towards organic production and export of products, a gradual expansion of certified areas, as well as the dependence of efficiency on external market conditions and crop structure. In order to assess the efficiency of the resource potential use of agricultural enterprises of the Polissia zone, a comparative analysis of the activities of Galeks-Agro and Ritter Bio Agro LLC was conducted using a system of relative indicators characterising the effectiveness of the use of land and labour resources. The results of the calculations are given in Table 1.

Table 1. Comparative assessment of the efficiency of using the resource potential of agricultural enterprises of the Polissia zone

Indicator	Galeks-Agro	Ritter Bio Agro LLC
Revenue per hectare, UAH/ha	41,780	2,902
Profit per hectare, UAH/ha	8,887	631
Profitability, %	21.27	21.73
Revenue per employee, UAH	1,530,392	196,927
Integral efficiency indicator	0.75	0.25

Source: calculated by the author based on Galeks-Agro (n.d.), Ritter Bio Agro LLC (n.d.)

Analysis of the indicators calculated in Table 1 according to formulas (1-6) enabled revealing differences in the effectiveness of using the resource potential of the studied enterprises. In particular, Galeks-Agro demonstrates significantly higher values of revenue and profit per hectare, UAH/ha, which indicates a more intensive use of land resources and a higher level of the economic return. Additionally, the enterprise is characterised by significantly higher labour productivity, which reflects a more efficient use of labour resources and a higher level of organisation of production processes. At the same time, the level of profitability of both enterprises is comparable (21.27% in Galeks-Agro and 21.73% in Ritter Bio Agro), which indicates a relatively close cost efficiency per unit of revenue received. This means that in terms of cost profitability, both enterprises operate in similar economic conditions, despite differences in the scale of activity and the level of resource availability. The value of the integral indicator for this enterprise is 0.75, while for Ritter Bio Agro it is 0.25, which indicates a higher level of generalised efficiency of resource potential use. The results obtained can be explained by differences in the scale of production, the level of diversification of activities and the availability of processing capacities. In particular, the integrated structure of Galeks-Agro, which combines crop production, livestock farming and processing, creates the prerequisites for the formation of added value and more efficient use of resources. In contrast, Ritter Bio Agro functions mainly as a producer of raw materials, which limits the possibilities of increasing the economic return on resource potential.

The analysis of the resource potential of agricultural enterprises in this study was formed taking into account military transformations, which determined its focus on identifying the features of resource use at the enterprise level and determining the possibilities of the restoration and adaptation to changed operating conditions. In this context, a comparison with H. Luo *et al.* (2025) reflects a difference in approaches to the interpretation of resources: if in this study the main attention is paid to the use under conditions of limitations and the need for restoration, then in the work by H. Luo *et al*., resources are considered as a factor in the formation of economic value within the framework of rural development policy. Common to both approaches is the orientation towards increasing the efficiency of resource use, but the difference lies in the focus of the study. Further comparison with S. Seifert *et al.* (2024) makes it possible to expand the understanding of the efficiency of resource use from the enterprise level to the level of agrolandscapes. In this study, the emphasis is on the analysis of production systems of specific enterprises and the ability to adapt to changes, while S. Seifert *et al.* investigate eco-efficiency within broader spatial systems using quantitative approaches. Thus, the difference lies in the scale of analysis and the level of generalisation of results.

Comparison with K.P. Pawłowski & G. Sołtysiak (2024) demonstrates a different nature of resource use constraints. In this study, these constraints are associated with wartime conditions and the transformation of the resource base, while in the aforementioned study, such constraints are associated with environmental policy and regulatory requirements. At the same time, both approaches combine the need to adapt agricultural production and find ways to increase resource efficiency. Comparison with Y. Yuan *et al.* (2025) makes it possible to shift the emphasis towards internal factors of increasing efficiency. In this study, attention is focused on the organisational features of resource use and various production models, in particular vertically integrated and specialised, while Y. Yuan *et al.* consider digitalisation as a key tool for increasing efficiency. The approach of considering resources as the basis for enterprise performance remains common.

Another approach is presented in the study by P.K. Sarangi *et al.* (2024), where resources are considered in the context of the reuse and the formation of closed production cycles. In this study, attention is focused on combining existing resources and increasing the efficiency of the use within enterprises, which differs from the approach focused on circularity. A comparison with C.J. Watson *et al.* (2024) summarises different approaches to resource analysis. While in this study the analysis is carried out at the level of individual enterprises and the

production models, C.J. Watson *et al.* consider the use of resources in a broader interdisciplinary context. Thus, the results of the study complement existing scientific approaches, specifying the features of the resource potential use at the level of agricultural enterprises of the Polissia zone and the adaptation to changed operating conditions. Thus, the analysis of the activities of the studied enterprises shows that the efficiency of the resource potential use in the conditions of the Polissia zone is largely determined by the model of production organisation. The vertically integrated Galeks-Agro model ensures a more complete and balanced use of land, biological and material and technical resources by combining industries and developing processing. In contrast, the specialised model of Ritter Bio Agro is characterised by an orientation towards organic crop production and external markets, which makes the effectiveness dependent on market conditions. The results obtained confirm that increasing the efficiency of resource potential use is associated not only with the volume of resources, but also with the level of the integration, the structure of production and the development of processing activities.

Directions of restoration and improvement of efficiency of use of resources in the post-war period

The conducted research enabled establishing that the formation and resource potential use of agricultural enterprises of the Polissia zone of Ukraine during the war period took place in conditions of significant limitations associated with the reduction of the resource base, the complication of production processes, the disruption of logistical connections and the increase in the risks of economic activity. The identified features of the functioning of the enterprises Galeks-Agro and Ritter Bio Agro indicate a different level of resistance to external influences, which determines a differentiated approach to determining directions of restoration and improvement of efficiency of use of resources in the post-war period. One of the directions is the restoration and optimisation of the use of land resources. In the conditions of the Polissia zone, where soils are characterised by increased acidity, low fertility and excessive humidity, increasing the efficiency of land use is associated with the introduction of adapted cultivation technologies, improving the agrochemical condition of soils and rationalising the structure of crops. For enterprises operating in the organic production segment, it is important to expand the area of certified land and complete the transition period for some land, which allows for an increase in the level of use of land potential and ensure the stability of production. The second direction is the development of the material and technical base and the modernisation of the production infrastructure. It was established that under the conditions of war-related impact, some enterprises suffered losses of equipment and restrictions in access to resources, which negatively affected the efficiency of production processes. In the post-war period, the renewal of the technical fleet, the introduction of modern technologies for soil cultivation, sowing and harvesting, as well as the development of warehouse and logistics infrastructure are relevant. For enterprises with a vertically integrated structure, such as Galeks-Agro, this also involves the support and modernisation of processing capacities, which ensure the formation of added value within the enterprise.

Increasing the efficiency of the use of labour resources and adapting production to weather conditions is one of the directions of recovery in the post-war period. A study of the activities of agricultural enterprises in the Zhytomyr region confirms the presence of practical limitations in the use of resource potential. In particular, during the harvesting process, difficulties are noted associated with adverse weather conditions, in particular excessive rainfall, which complicates field work. At the same time, one of the production factors is labour resources, the shortage of which significantly limits the efficiency of land potential use. The shortage of workers in combination with wartime conditions complicates the implementation of production operations and reduces the effectiveness of agricultural activities. In the post-war period, increasing the efficiency of labour potential use is associated with the automation of production processes, the introduction of digital management technologies and an increase in the level of mechanisation (RuportZT, 2023).

The next direction is the development of processing and increasing the level of integration of production. The analysis showed that vertically integrated enterprises have a higher level of efficiency in the resource potential use due to a closed production cycle and the formation of added value. In the post-war period, the development of processing infrastructure, in particular the production of dairy, meat and grain products, allows reducing dependence on external markets, increasing profitability and ensuring a more complete use of the raw material base. For specialised enterprises in the crop sector, the gradual expansion of participation in value-added chains is relevant, including through cooperation or partnership. Diversification of production and development of niche crops is one of the areas of recovery in the post-war period. In the production structure of enterprises in the Polissia zone, along with traditional crops, niche and technical crops are represented, which provide for the expansion of the possibilities of using land resources and sales markets. The development of such production helps reduce the risks associated with fluctuations in yields and price conditions.

A separate area is increasing the efficiency of resource use through the development of export activities and logistics. Enterprises focused on external markets face significant logistical constraints and dependence on a limited number of sales markets. In particular, about 60% of exporters of organic products experience difficulties in transportation, especially at border crossings, and 45% of enterprises depend on 2-3 main markets, which increases the risks of the activities. Additionally, 29% of producers noted increased competition in international markets, and 28% – increased requirements for product quality. In these conditions, increasing the efficiency of resource potential use is associated with the optimisation of logistics chains, diversification of sales markets, as well as improving product quality in accordance with international standards (The main challenges..., 2025). Increasing the efficiency of resource potential use takes into account the implementation of innovative and environmental approaches. The development of organic production, compliance with international quality standards and the use of modern technologies contribute to increasing the competitiveness of products and the efficiency of resource use. In the post-war period, the innovative transformation of the agricultural sector is one of the key factors in its restoration and development. Thus, increasing the efficiency of using the resource potential of agricultural enterprises in the Polissia zone in the post-war period is associated with the comprehensive implementation of measures covering the restoration of land resources, modernisation of the material and technical base, development of labour potential, adaptation of production to natural and climatic conditions, expansion of processing, diversification of activities and improvement of logistics. This creates the prerequisites for increasing the efficiency of resource use and ensuring sustainable development of the agricultural sector.

The analysis of the resource potential of agricultural enterprises in this study was formed under the influence of war losses, which determined its focus on restoring production capabilities and adapting to the limitations of the resource base. In this context, a comparison with the work by Y. Li *et al.* (2024) made it possible to expand the vision of efficiency factors: if in this study the restoration of resources remained key, then Y. Li *et al.* associated increased efficiency with technological innovations and the diffusion through patent activity. Thus, both approaches overlapped in the systemic understanding of agricultural production, but diverged in determining the sources of its development. This difference in the interpretation of resources was even more pronounced when compared with the work by S. Wunder *et al.* (2025), where resources were interpreted as natural capital that can be included in market mechanisms through biodiversity credits. If this study was about restoring the production potential of enterprises, then in the work by S. Wunder *et al.*, the emphasis shifted to the economic assessment and preservation of natural systems. The common orientation remained the efficiency of resource use, but the tools for achieving it differed significantly.

Further comparison with L. Biagini *et al.* (2026) logically transferred the analysis to the plane of resource interaction. In this study,

efficiency was considered as the restoration of lost opportunities, while L. Biagini *et al.* analysed it through the relationships between food, water, energy and environmental components, identifying trade-offs between these components. This means a transition from a regenerative logic to assessing the balance of the resource system. Another perspective was presented in the study by M.R. Marcone (2025), where efficiency was formed not only at the level of enterprise resources, but also through interaction within supply chains. While this study focused on internal constraints and the overcoming, M.R. Marcone considered interorganisational connections as a factor in the transformation of the agricultural sector. Thus, the systematic nature of the analysis was maintained, but the level of its implementation changed. Comparison with A. Muska *et al.* (2025) made it possible to expand the scope of the study to the inter-country level. While this study assessed the resource potential of enterprises in a specific region, A. Muska *et al.* analysed the "green competitiveness" of EU countries based on integrated environmental indicators. This emphasised a common focus on resource efficiency, but demonstrated different levels of generalisation and methodological approaches. Comparison with A. Serrano *et al.* (2024) made it possible to summarise the difference between approaches to changes in the resource base. While this study focused on its reduction and restoration due to war-related impact, A. Serrano *et al.* analysed the opposite process – the expansion and intensification of resource use through the development of irrigation, which formed regional specialisation and production growth.

The disruption of the functioning of agricultural enterprises in this study was associated with military losses of resources, which determined its focus on the analysis of internal resource potential and opportunities for the restoration of production. In this context, a comparison with J. Du *et al.* (2024) demonstrated a shift in focus from internal transformations to external economic processes: the authors studied the efficiency and potential of China's agricultural exports using econometric models. Despite the difference in objects, both approaches combined multifactor analysis and took into account the structural heterogeneity of the agricultural sector, although methodologically both approaches were implemented through different tools – from structural analysis to modelling of trade flows. Further comparison with the study by M.-L. Huang *et al.* (2025) made it possible to trace the transition from problems of restoration to assessing the efficiency of resource use in a broader systemic dimension. If in this study resource losses determined the logic of adaptation of agricultural production, then in the work by M.-L. Huang *et al.*, the efficiency was analysed through the concept of "food – energy – water" using quantitative models, which reflected a different level of generalisation and different research tools.

This difference in approaches was even more clearly manifested when compared with Y. Chen *et al.* (2024), where the agricultural sector was considered as a system of sustainable development through the Driver – Pressure – State – Impact – Response model. While this study focused on the restoration of the resource base after losses, Y. Chen *et al.* in the study assessed the state and dynamics of sustainability based on an indicator approach. Both studies combined a systemic vision of agricultural production, but the analytical goals differed: restoration versus sustainability assessment. A logical continuation of this line of comparison was the analysis of A. Saxena *et al.* (2024), where the emphasis was shifted to the technological transformation of the agricultural sector. In contrast to this study, which described adaptation to resource constraints, A. Saxena *et al.* considered tools for increasing efficiency through digital technologies and the Internet of Things. At the same time, the common focus remained on optimising resource use, although the context of the application differed significantly. A similar trend was observed in the study by C. Che *et al.* (2024), where digitalisation was considered as a factor in increasing agricultural eco-efficiency. While in this study, efficiency was limited to military losses and degradation of the resource base, C. Che *et al.* analysed the positive impact of the development of the digital economy using econometric models. Thus, the common focus on efficiency was combined with

a different economic environment of operation. Comparing this study with the work of B. Liao *et al.* (2025) made it possible to expand the context to the level of integration of energy and agriculture. In this case, the studies were close in terms of the systemic approach and consideration of resource relationships, but differed in the focus: this study focused on restoring production potential, while the work by B. Liao *et al.* – on the development of "PV+" models and increasing the efficiency of land use in the context of energy transition.

During the war period, the functioning of agricultural enterprises in the Polissia zone was accompanied by a limitation of the resource base, the complication of production processes and the disruption of logistical connections, which affected the efficiency of resource potential use. The study showed that the adaptation of enterprises occurred through changes in organisational and production models, the development of the material and technical base, the improvement of logistics and the expansion of processing activities. It was established that the impact of war factors was differentiated: for vertically integrated enterprises this was manifested in the transformation of the production structure and the maintenance of a closed cycle, while for specialised enterprises – in increased dependence on external markets and logistical restrictions. In the post-war period, increasing the efficiency of resource use is associated with the restoration and optimisation of land use, modernisation of the material and technical base, development of processing, diversification of production, improvement of logistics, and the implementation of innovative and digital solutions.

CONCLUSIONS

The study showed that the efficiency of using the resource potential of agricultural enterprises of the Polissia zone of Ukraine in 2021-2025 was formed under the influence of natural and climatic constraints and military transformations, which led to changes in the structure of production, resource supply and financial results. In particular, the functioning of enterprises in the region takes place in conditions of low natural fertility of soils, characterised by increased acidity (pH 4-5.5), low humus content (0.8-1.5%) and its annual losses at the level of 0.3-0.5 t/ha, which limits the efficiency of using land resources and requires additional costs to maintain the productivity. Despite these limitations, positive dynamics of agricultural production are observed in the region. In particular, the yield of grain crops increased by more than 40%, and production volumes increased to UAH 258 billion in 2023, which indicates the adaptation of the agricultural sector to existing resource constraints and a gradual increase in the efficiency of using resource potential.

At the enterprise level, it was found that the efficiency of resource potential use significantly depends on the production organisation model. In particular, Galeks-Agro, which cultivates over 10 thousand hectares of land, demonstrates higher efficiency indicators: revenue is UAH 417.8 million, net profit is UAH 88.9 million, which corresponds to UAH 41,780 of revenue and UAH 8,887 of profit per hectare, UAH/ha. Labour productivity is UAH 1,530,392 per employee. At the same time, Ritter Bio Agro LLC with a land bank of 3.8 thousand hectares is characterised by significantly lower indicators of resource use intensity: revenue per 1 ha is UAH 2,902, profit is UAH 631, and labour productivity is UAH 196,927 per employee. Calculation of the integral indicator of resource potential use efficiency confirmed these differences: its value is 0.75 for Galeks-Agro and 0.25 for Ritter Bio Agro. This indicates a higher level of generalised efficiency of resource use in enterprises with a vertically integrated production model. At the same time, a comparable level of profitability (21.27% and 21.73%, respectively) indicates a similar cost efficiency, which indicates the influence of external market conditions on the results of enterprises. The generalisation of the results shows that increasing the efficiency of resource potential use in the conditions of the Polissia zone is associated not only with the volume of resources, but also with the level of the integration, diversification of production and development of processing. In the post-war period, the key areas are land use optimisation, modernisation of the material and technical base, development of logistics and export diversification, which creates the prerequisites for

increasing the effectiveness of the functioning of agricultural enterprises.

The limitation of the study is the limited access to complete and representative statistical data in a regional context, which is due to war conditions and partial loss of information on the functioning of agricultural enterprises. Prospects for further research are related to expanding the analytical base through the use of micro-level data from enterprises, as well as the use of economic and mathematical modelling to assess the efficiency of resource use and predict scenarios for the recovery of the agricultural sector.

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Стан ефективності використання та перспективи відновлення ресурсного потенціалу аграрних підприємств Поліської зони України у післявоєнний період

Анотація. Метою даного дослідження було визначення особливостей формування та результативності використання ресурсного потенціалу аграрних підприємств Поліської зони України в умовах воєнних трансформацій. Методологія дослідження ґрунтувалася на застосуванні описово-статистичного, структурного, динамічного та порівняльного аналізу, а також методу кейс-стаді на прикладі підприємств Galeks-Agro та Товариство з обмеженою відповідальністю «Ріттер Біо Агро». У результаті дослідження встановлено, що природно-кліматичні умови Полісся обмежували ефективність використання ресурсів: рівень pH ґрунтів становив 4-5,5, вміст гумусу – 0,8-1,5 %, а щорічні втрати – 0,3-0,5 тонн/гектар. Водночас виявлено зростання урожайності зернових культур більш ніж на 40 % та збільшення обсягів виробництва до 258 млрд грн у 2023 році, що може свідчити про адаптацію. Порівняльний аналіз підприємств показав суттєві відмінності в ефективності: у Galeks-Agro дохід на 1 гектар становив 41 780 грн, прибуток – 8887 грн, продуктивність праці – 1 530 392 грн/працівника, інтегральний показник – 0,75. У ТОВ «Ріттер Біо Агро» дохід на 1 гектар становив 2902 грн, прибуток на 1 га – 631 грн, продуктивність праці – 196 927 грн на одного працівника, інтегральний показник ефективності – 0,25. Водночас близькі значення рентабельності (21,27 % та 21,73 %) свідчать про подібну ефективність витрат, тоді як відмінності в загальних результатах зумовлені масштабами та інтенсивністю використання ресурсів. У післявоєнний період підвищення результативності використання ресурсного потенціалу пов'язується з оптимізацією землекористування, модернізацією матеріально-технічної бази, розвитком переробки, диверсифікацією виробництва та удосконаленням логістики й експортної діяльності. Практичне значення дослідження полягає в можливості використання отриманих результатів і обґрунтованих підходів для підвищення ефективності використання ресурсного потенціалу та формування управлінських рішень щодо відновлення діяльності аграрних підприємств у післявоєнний період

Ключові слова: продуктивність; землекористування; врожайність; диверсифікація; цифровізація; рентабельність