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## Assessment of the impact of the Russian-Ukrainian war on the agrarian potential in Kherson region

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► **Abstract.** The relevance of the study lies in the need to assess the impact of the Russian-Ukrainian war on the agrarian potential of the Kherson region due to significant economic and ecological losses, in particular, the destruction and contamination of soils, which requires urgent monitoring of their quality and restoration of fertility to restore the agrarian sphere of the region. The assessment of the impact of the Russian-Ukrainian war on the agrarian potential of the Kherson region and the determination of the prospects for its post-war recovery were chosen as the purpose of this work. The research was carried out using general scientific and special methods of studying phenomena and processes: analysis and synthesis, system analysis, method of analogy and modelling, system analysis, methods of information collection and processing. Data from the NASA FIRMS databases, Sentinel-2 satellite images, as well as images of fires from the Giovanni resource were used as an information base for the analysis. Additionally, tracking results of MODIS, VIIRS and VIIRS 2 Suomi satellites are involved. A mutual correlation of the yield of agricultural crops and the Agricultural Stress Index was carried out, which proves the absence of a serious impact of drought on the yield of agricultural crops in the Kherson region, except for the driest years. The dependence between the yield of grain and

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leguminous crops and the application of fertilisers and pesticide treatment was established through the use of the mutual correlation function. A model of the influence of the application of mineral fertilisers and pesticides was built using the Cobb-Douglas econometric function, which allows predicting the optimal conditions for the introduction of agricultural production. Conclusions, proposals and practical recommendations will be useful in the development of relevant programs and measures aimed at the post-war restoration of agricultural soil and the general development of the country's agricultural production

► **Keywords:** agricultural production; yield; soil quality; fertilisers and pesticides; Agricultural Stress Index; mutual correlation function; Cobb-Douglas function

### ► Introduction

The consequences of hostilities and the temporary occupation of Ukrainian territories by Russian invaders are unprecedented in scale and impact on the future development of the country's economy. The deterioration of the economic and ecological state of the country, the socio-economic living conditions of the population and the demographic crisis in the conditions of a prolonged war have a further negative trend. The war has affected all spheres of life, with problems in each area reinforcing each other and requiring a comprehensive solution both in the current time and the post-war period. This necessitates an appropriate comprehensive interdisciplinary study of these consequences.

O. Menshov *et al.* (2021) found that during the years of Ukraine's independence, agricultural production played a significant role in its economy. Moreover, the share of the primary sector of the economy, to which agriculture belongs, increased to 20% during this time, which exceeds the corresponding world average by almost 4 times. From 1991 to 2024, there was a structural reversal from the industrial-agrarian economy of the pre-reform period to an agrarian-industrial one with the raw material exploitation of human, natural and economic resources by local and foreign companies (Mohylnyi, 2024). Since agricultural production plays a leading role in the national economy of Ukraine, its losses from military aggression have become the most tangible. Due to its specific features, agriculture has always been and remains the most vulnerable to social unrest, natural disasters, various extraordinary events, catastrophes, etc. The main reason for this, according to Y. Hadzalo (2023), is the nature of the main means of production of the industry – land, agricultural land, with the loss of which agricultural activity, as well as the existence of the peasant himself, becomes impossible.

The effectiveness of the development of the agricultural sector manoeuvres in a two-vector coordinate system: agricultural production and socio-economic conditions for the development of rural areas (Mamchur & Studinska, 2023). The determining factors of the efficiency of the development of agricultural production according to the first vector are, first of all, the quality of the fertile soil, the level of knowledge-intensiveness of production, its technological and technical innovation, the availability of resources (financial, energy, chemical, organic, human). Most of the listed factors are within the competence of state and local authorities and require appropriate decisions, the development of a strategy, programs for its implementation, and significant investments. The need for the development of rural areas is caused by the significant polarisation of the socio-economic living conditions of the population in rural and urban areas, which has led

to the disappearance of several hundred villages over the years of independence and a shortage of workforce in agricultural production, which is exacerbated by military migration. The war destroyed the pre-war model of the Ukrainian economy, exacerbated internal contradictions and confirmed the general inefficiency, and increased the degradation of the raw material sector in the agricultural; farmers have lost incentives to produce raw materials and reduce crops (Studinska, 2023).

The minimum calculation of environmental damage for the year of the war, carried out by the Ecocide: 10 environmental consequences of Russia's war against Ukraine (2023), is 441 billion dollars. The destruction of soils and their contamination is considered to be especially serious damage. In Ukraine, 30% of the entire area of the state is mined. Significant destruction of the most fertile black soil occurred in the south and east of Ukraine, including in the Kherson region. According to experts, the territories covered with craters after shelling may be unsuitable for agricultural use due to the large number of chemicals that the ammunition contained, which, after the explosion can remain in the soil for a long time and "migrate", that is, get into groundwater and plants. Products grown on land affected by the fighting may be unsafe for consumption, and almost the only way to avoid danger is to remove the land from agricultural use.

The problem of returning land plots to their normal condition is particularly acute and requires significant financial resources. Thus, according to experts, the average cost of such work is about 1,000 US dollars per hectare, including the cost of surveying, demining, reclamation, chemical (biological) contamination, etc. (Husakov, 2023). The total cost of restoration may exceed the standard monetary valuation of the land. To improve the situation, experts recommend the use of innovative agricultural technologies, such as plantation ploughing, deep melioration loosening, and crop rotation, in particular the cultivation of maize, which may be less sensitive to pollution. Microbiological preparations will help reduce toxic elements, and chemical and organic melioration will contribute to the restoration of soils. Phytoremediation is also effective for cleaning contaminated areas (How to save ..., 2023).

Damaged, destroyed fertile soil requires the development of a list of measures according to a certain algorithm that can restore its natural properties. The restoration of the agricultural sector of Ukraine should begin immediately after the liberation of the territories from occupation, as the consequences of the war are extremely complex and large-scale. It is advisable to begin preparatory work on restoration before the de-occupation of the territories (remotely), with monitoring the condition of the soil

and substantiating a set of measures for the reincarnation of the fertile soil. The purpose of the work is to assess the impact of the Russian invasion on the agricultural potential of the Kherson region and outline the possibilities of its post-war restoration in the future.

### ► Materials and methods

In the process of conducting the research, general scientific (analysis and synthesis, induction and deduction, analytical grouping) and special (abstraction, modelling, forecasting, statistical analysis, Microsoft Excel, etc.) methods of studying phenomena and processes were used. In order to determine the impact of Russian aggression on agricultural production in the Kherson region, data from NASA FIRMS databases, Sentinel-2 satellite images and the Giovanni resource were used. (Fire information for..., n.d.). For the analysis of the number of fires, data from NASA FIRMS databases were used (due to the lack of such data for 2023, additional observation data from MODIS, VIIRS and VIIRS 2 Suomi satellites were used). The study was conducted based on statistical data for the period from 2018 to 2024 (Moderate resolution imaging... n.d.; Visible infrared imaging...n.d.; VIIRS+CrIS..., n.d.). The study of the impact of droughts as a factor in the damage to agricultural areas and the reduction in crop yields was conducted using FAO data, in particular its remote sensing tools and their further analysis using the following indices. The Agricultural Stress Index (ASI) made it possible to indirectly assess and determine the percentage of agricultural land (arable land or natural pastures) within certain areas that are potentially affected by drought (Earth Observation, n.d.). The data are provided in monthly (decadal) and annual (seasonal) sections. The basis for assessing the drought risk areas is the complex data on the normalised difference index (NDVI) and temperature index (BT4), obtained from the AVHRR sensor. Through a series of transformations, the combined series of NDVI and BT4 is transformed into a vegetation health index (VHI), on the basis of which the percentage ASI for a given area is calculated. According to the FAO classification (Earth Observation, n.d.), there are 7 main gradations of ASI. FAO defines the following levels of ASI: <10%, 10-25%, 25-40%, 40-55%, 55-70%, 70-85%, >=85%. The value of the indicator at the level of <10% means that the region or area is almost not experiencing the negative impact of drought. The increase in the value of the indicator indicates an increasing impact of drought on the state of agriculture in the region.

The NDVI index is a normalised relative vegetation index, on the basis of which conclusions are drawn about the development of plant biomass during the growing season. Using the NDVI index, it became possible to assess the "greenness" of the soil cover. NDVI values range from +1 to -1, with high positive values indicating dense and healthy vegetation, and low and/or negative NDVI values indicating poor vegetation conditions or sparse vegetation cover. The NDVI anomaly shows a change in the vegetation condition during a certain current period (decade, month) compared to the long-term average value. Positive changes (in % with a sign +) indicate an improvement in the vegetation condition compared to the average level, and negative (negative) values mean relatively negative changes (in % with a sign "-") was the state and conditions of vegetation.

For the purpose of analysing and identifying common trends in the change of the resulting indicator and factors influencing it, a cross-correlation function was used, which characterises the density of the connection of each element of the dynamic series of values of the dependent (resulting)  $y_t$  and explanatory  $x_t$  variables, shifted relative to each other by a time lag  $\tau$ . The cross-correlation coefficient was determined by the formula (1) (Nakonechnyi, 2004):

$$r_{\tau} = \frac{(n-\tau) \sum_{t=1}^{n-\tau} y_t x_{t-\tau} - \sum_{t=1}^{n-\tau} y_t \sum_{t=1}^{n-\tau} x_{t-\tau}}{\sqrt{[(n-\tau) \sum_{t=1}^{n-\tau} y_t^2 - (\sum_{t=1}^{n-\tau} y_t)^2][(n-\tau) \sum_{t=1}^{n-\tau} x_{t-\tau}^2 - (\sum_{t=1}^{n-\tau} x_{t-\tau})^2]}} \quad (1)$$

where  $y_t$  and  $x_t$  – are the elements of the vector of the dependent (resulting) and explanatory variables, respectively, shifted relative to each other by a time lag  $\tau$ ;  $n$  – is the number of values of the quantity  $r_{\tau}$ .

Considering the existence of relationships between the resulting indicator and the influencing factors, it was determined to be appropriate to use the possibilities of econometric modelling using the Cobb-Douglas function and to build the corresponding regression model and check its reliability using the MS Excel tool in terms of determining the coefficients  $a_0$ ,  $a_1$  and  $a_2$  (Nakonechnyi, 2004).

### ► Results and Discussion

Before the start of the full-scale war, the Kherson region was one of the leaders in the production of grain and sunflower, vegetables, and melon crops. In addition, it was one of the largest exporters of agricultural products in Ukraine. According to the State Statistics Service (Agriculture, forestry, and..., n.d.), about a third of the population of the Kherson region in pre-war times was traditionally employed in agriculture, forestry and fisheries as of 1 January, 2022, the situation has changed significantly. Restoring the region's former potential requires a detailed analysis of the situation and determining the directions of its restoration and further development in the post-war period.

Before the beginning of the Russian aggression in the Kherson region, the agro-industrial complex (AIC) was the leading sector of the regional economy and the sphere that provided a large number of jobs and formed the export potential of the region. In the Kherson region, 2,469 AIC business entities operated, including 1,941 farms, 528 agricultural enterprises, of which 25 were agricultural production cooperatives, and 66 were agricultural service cooperatives. Agricultural land as of 01.01.2022 amounted to 1,969.5 thousand hectares, including arable land – 1,777.9 thousand hectares, 26.6 thousand hectares – perennial plantations, 10.4 thousand hectares – hayfields, 155.7 thousand hectares – pastures (Economic Statistics / Economic..., n.d.). In the arid climate, the presence of a drip irrigation system was important for the region. Of the total amount of agricultural land, 427 thousand hectares or 24% were irrigated, 43.5 thousand hectares had drip irrigation. In terms of ploughing, the territory had indicators higher than the average in Ukraine, namely 62.7%, which is higher than the average level in the country, which is 53.9%. The ploughing of agricultural land was 87.9%. As for crop production, in the structure of agricultural production, the region occupied almost 87%, but compared to 2017, it decreased by 5.2%. As for comparative estimates

of the area occupied by agricultural crops, 5.1% of the area available in Ukraine was occupied by grain crops in the region, 5.3% – by sunflowers and 32.3% – by vegetables. Regarding grain and leguminous crops, in 2021 (a record year for the Kherson region), the harvest was harvested from an area of 812.8 thousand hectares, which is 5.7% of the total area in Ukraine (15,948.4 thousand hectares). The volume of the harvested crop in the Kherson region was 3,528.8 thousand tons, which is 4.1% of the total in the country (86,010.4 thousand tons). Industrial crops in the Kherson region in 2021 were harvested from an area of 636.5 thousand hectares, which is 5.9% of 536.5 thousand hectares in Ukraine. The volume of the harvested crop in the region was 5.3% of the total in Ukraine (1,208.6 thousand tons and 22,896.9 thousand tons, respectively). If we compare the indicators of irrigated land for grain and

leguminous crops, then in total in Ukraine in 2021 their area amounted to 200.6 thousand hectares, of which in Kherson region – 115.8 thousand hectares (57.7%). As for the volume of harvested crops, in total in Ukraine in 2021 there were 14,316.2 thousand tons, of which 56.1% or 8,028.4 thousand tons – in Kherson region (Agriculture, forestry and..., n.d.; Economic Statistics / Economic..., n.d.).

With the beginning of the war, the situation changed dramatically, most of the region was occupied. The above analysis of the main indicators of agricultural production will help determine the impact of the war on the state of crop production in the Kherson region. Table 1 shows the dynamics of the sown areas of winter crops for grain and green fodder, and grain and leguminous crops for grain for harvest as of 1 December of the following year:

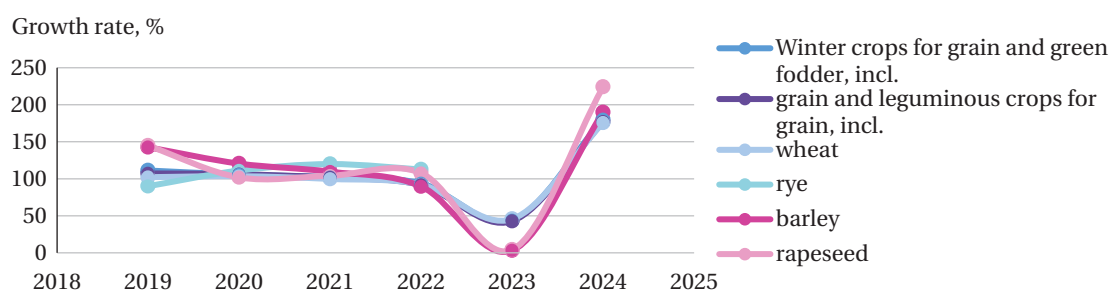
**Table 1.** Sown area of winter crops and green fodder in the Kherson region for the harvest on December 1 of the following year, thousand hectares

	2019	2020	2021	2022	2023	2024
Winter crops for grain and green fodder, incl.:	660,624	698,449	712,223	668,106	29,328.9	52,800
grain and leguminous crops for grain, incl.:	568,735	603,527	613,231	562,604	24,186.5	42,831
wheat	478,886	495,568	494,758	455,905	20,824.7	36,589
rye	1,493	1,659	1,990	2,238	-	-
barley	88,320	106,300	116,483	104,460	0.3285	6,232
canola	89,465	91,172	94,898	102,230	0.44328	9,700

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics/Economic Activity/Agriculture, Forestry, and Fishing/Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The information provided indicates noticeable negative changes due to the occupation of the Kherson region. However, the de-occupation of part of the territory, 26.4% of which was agricultural land, at the beginning of 2023 slightly improved the situation, due to which the level of reduction in sown areas was more

than 50%. The situation has significantly improved by the beginning of 2024, as part of the territories will be additionally demined. Figure 1 shows the chain growth rates of sown areas of winter crops for grain and green fodder and grain and leguminous crops for grain during 2018-2025:



**Figure 1.** Chain growth rates of sown areas of winter crops for grain and green fodder and grain and leguminous crops for grain during 2018-2023, %

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The area of agricultural land in the territory of the de-occupied Kherson region as of the beginning of 2023 was 520 thousand hectares, of which more than 10% (56.4 thousand hectares) has already been officially demined. But farmers also carried out demining on their own; the share of such lands was also approximately 10%. The total area of demined lands is only approximately

25% of the pre-war level of agricultural land in the region. As of 01.01.2024, part of the region, which is located in a 20-kilometer zone of active hostilities, is not subject to demining; therefore, agricultural lands cannot be used. This is the territory of four communities of the Kherson district of the region: Kherson; Bilozersk; partly Stanislavsk and Darivsk.

In 2023, more than 60 thousand hectares of land were sown in the Kherson region, including: grain group – 23.5 thousand hectares, 35.7 thousand hectares – industrial crops, of which 31.7 thousand hectares – sunflower. It is quite clear that such a structure of the distribution of sown areas between crops cannot be considered rational, since most of it was given to industrial crops in general and to sunflower, in particular. The reason is that farmers were unable to sow the planned

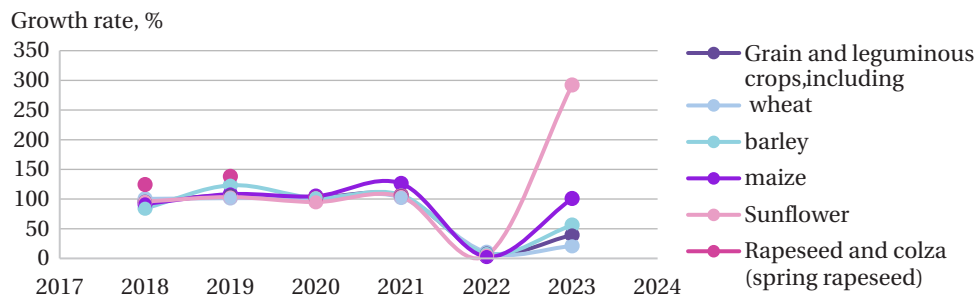
areas with spring crops in time due to land clearance, and were forced to sow the land with sunflower later than the established deadlines. Let us analyse the yields of the main crops of the Kherson region in dynamics through the area of harvested crops (Table 2) and the productivity of these crops (Table 3).

Based on the data in Table 2, we will construct a diagram (Fig. 2) that visualises changes in the areas where the crop was harvested from 2018 to 2024.

**Table 2.** Dynamics of harvested crop areas in Kherson region, thousand hectares

	2017	2018	2019	2020	2021	2022	2023
Grain and leguminous crops, including	738.6	710,179.9	756,820	776,960	813,852	45,516	18,629
wheat	470.4	471,587.2	482,959	491,731	503,662	33,366	7,172
barley	185.8	156,803.1	193,164	196,321	209,753	9,845	5,867
maize	45.0	41,278.8	44,717	46,862	59,036	1,114	1,211
Sunflower	356.6	341.70	353,038	335,344	348,884	11,671	35,073
Rapeseed and colza (spring rapeseed)	51.1	63,308.3	87,388	89,666	95,340	11.5	3,092

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)



**Figure 2.** Chain growth rate of harvested crop areas in the Kherson region, %

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

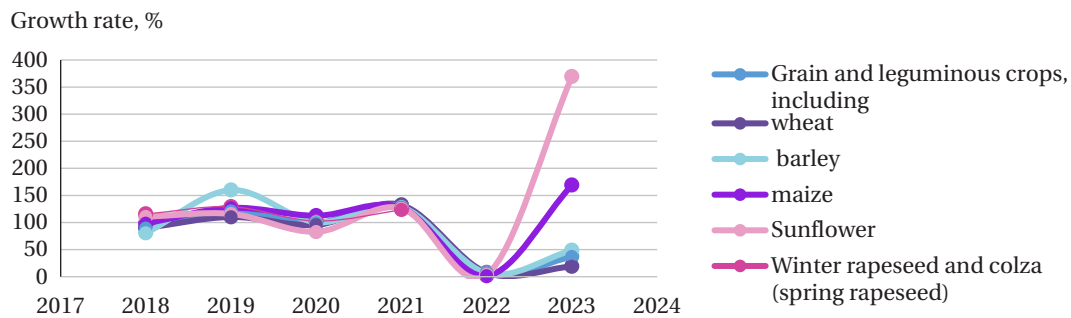
The reasons for the decrease in the area of most harvested crops in the Kherson region in 2023 and the increase in the area of sunflower, the chain growth rates of which are presented in Figure 2, are given above.

Based on the data in Table 3, we will construct a diagram (Fig. 3) that visualises the dynamics of changes in the gross harvest of the main crops in the Kherson region.

**Table 3.** Dynamics of gross harvest of main crops in Kherson region, thousand tons

	2017	2018	2019	2020	2021	2022	2023
Grain and leguminous crops, including	2,545.44	2,267.69844	2,739.7140	2,719.9474	3,528.7674	145,387.3	55,351.0
wheat	1,652.9	1,486.95973	1,640.7722	1,567.7918	2,073.3675	105,436.1	20,551.0
barley	488.41	393,712.84	629,250.6	632,753.2	813,010.9	32,427.5	16,640.7
maize	298.11	292,968.33	372,446.2	419,066.3	533,283.0	6,391.4	11,759.6
Sunflower	499.2	552,836.01	641,154.2	531,556.8	672,591.5	16,095.5	60,536.3
Winter rapeseed and colza (spring rapeseed)	128.63	148,882.61	192,308.5	197,214.9	243,994.2	21.7	4.9107

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)



**Figure 3.** Chain growth rates of gross harvest of main crops in Kherson region, %

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The data presented in Figure 3 indicate that in 2023, only 5% of the pre-war harvest was collected in the de-occupied right-bank part of the Kherson region. The grain harvest in the region amounted to about 55 thousand tons from 22 thousand hectares, rapeseed – 4.9 thousand tons

from 2.7 thousand hectares. In 2022, due to fires caused by shelling, it was not possible to collect a significant part of the harvest. Let us analyse the yield of the main crops of the Kherson region in dynamics, the data of which are presented in Table 4.

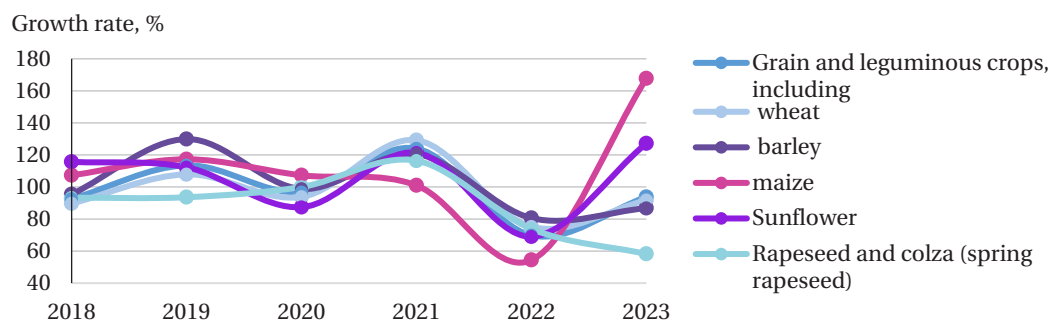
**Table 4.** Yield in Kherson region, tons/hectare

	2017	2018	2019	2020	2021	2022	2023
Grain and leguminous crops, including	3.45	3.19	3.62	3.5	4.34	3.19	2.97
Wheat	3.51	3.15	3.40	3.90	4.12	3.16	2.87
Barley	2.63	2.51	3.26	3.22	3.88	3.29	2.83
Maize	6.62	7.10	8.33	8.94	9.03	5.74	9.71
Sunflower	1.41	1.62	1.82	1.59	1.93	1.38	1.73
Rapeseed and colza (spring rapeseed)	2.52	2.35	2.20	2.20	2.56	1.89	1.59

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics/Economic Activity/Agriculture, Forestry, and Fishing/Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The data in Table 4 indicate some fluctuations in yields in different years, but a significant decrease in yields in 2023 for wheat, barley and rapeseed. From the data in Table 4, it is noticeable that corn yield increases. We visualise the chain growth rates of crop yields in the Kherson region in dynamics in Figure 4. The data presented in Figure 4 indicate that during 2018-2023, the yield of grains and legumes in the Kherson region increased and was a record in recent years on the eve

of the war in 2021. A similar trend is observed for industrial crops (sunflower and rapeseed). In the first year of the war, yields decreased significantly, which is explained by the fact that, firstly, part of the crop crops were damaged by hostilities; secondly, the rest of the crops ended up in mined areas and their processing was impossible; Thirdly, the de-occupied territory is under shelling, which also interferes with the normal conduct of agricultural work.

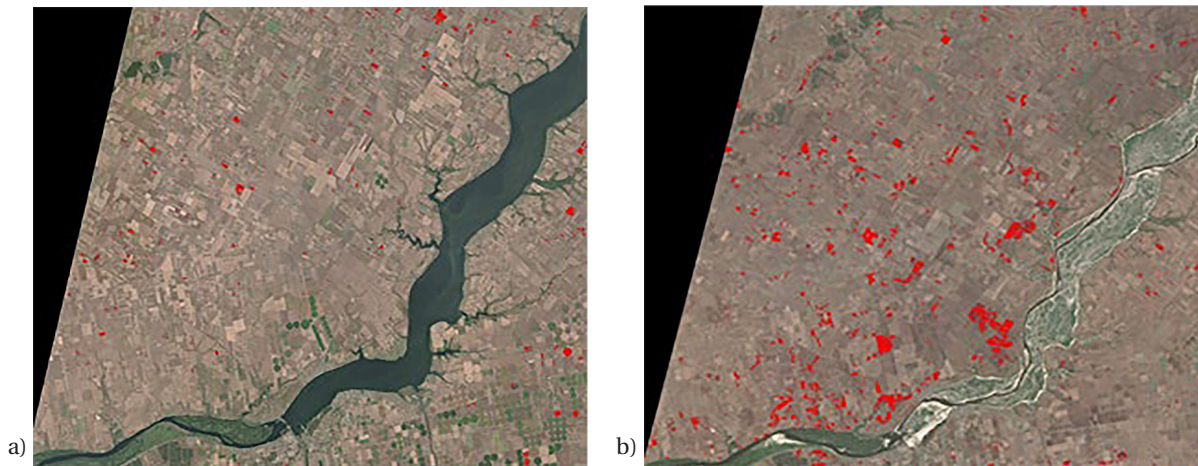


**Figure 4.** Chain growth rates of yields of main crops in the Kherson region, %

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics/Economic Activity/Agriculture, Forestry, and Fishing/Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The decrease in yield was not so much due to weather conditions and the impossibility of irrigating farmland due to the destruction of the Kakhovka reservoir, but as a result of the negative impact of the war and the consequences of hostilities on the territory. In order to assess the impact of Russian aggression on agriculture in the Kherson region, namely its Right-Bank part (Beryslav and Kherson districts), NASA FIRMS data, Sentinel-2 satellite images, and the Giovanni resource were used, which are presented in Figure 5 as of September 2021 (before the war) and September 2023. The number of fires in the specified periods before the war and during the war increased

significantly. It is quite clear that a small number of fires are observed in September, but their number became much larger during the war due to the constant shelling of territories and their consequences – the occurrence of fires. To analyse the number of fires in the specified territories, data from NASA FIRMS databases were used for the period from January 1, 2020 to December 31, 2022. Data for 2023 were not analysed due to their closed access. The analysis was carried out based on observation data from MODIS, VIIRS and VIIRS 2 Suomi satellites. The results of these observations on the number of fires in 2020-2022 are presented in Table 5:



**Figure 5.** Sentinel-2 satellite space images for September 2021 (a) and September 2023 (b) with the Burned Area Detection filter

**Source:** provided by Fire information for resource management system (n.d.)

**Table 5.** Dynamics of the number of fires on the Right Bank of the Kherson region

	2020	2021	2022	2020	2021	2022	2020	2021	2022
	VIIRS			MODIS			VIIRS 2		
January	116	40	53	3	0	0	104	34	53
February	125	49	188	8	0	41	91	47	202
March	478	210	442	138	27	151	555	239	405
April	518	277	179	64	30	13	520	292	191
May	243	360	335	2	7	19	242	432	320
June	498	404	645	19	9	68	481	409	640
July	1,457	1,183	1,919	253	122	504	1,398	1,121	2,179
August	1,180	1,479	752	129	277	133	1,227	1,480	787
September	732	632	183	72	69	40	714	671	153
October	306	608	254	40	131	23	314	681	226
November	76	190	66	6	12	2	61	212	73
December	41	20	30	1	0	0	39	17	24

**Source:** built by the authors for Fire information for resource management system (n.d.)

The statistics presented in Table 5 show that the data obtained from different satellites differ, in particular, the MODIS satellite does not reflect most of the fires recorded by other satellites. An increase in the number of fires at the beginning of hostilities in February 2022, compared to 2020 and 2021, was recorded by almost 1.5 times. The next increase in the number of fires was recorded in June and July 2022, which can be explained by two reasons. First,

the seasonal characteristics of agricultural production in the South of Ukraine (due to the heat). Second, the beginning of the counter-offensive operation in the South of Ukraine. In August – September 2022, the number of fires was almost 2 times lower compared to the same period in 2020-2021. This can be explained by the fact that after the end of the harvest season, stubble burning took place in agricultural fields. But given that much less grain

was sown than in the pre-war years, the amount of burnt stubble, and consequently the number of fires, was much smaller. In addition, there was a general reduction in agricultural land due to the impossibility of cultivating it due to active hostilities in the Kherson region.

In order to determine the area of agricultural lands affected by fires in the Right-Bank (unoccupied) part of the Kherson region, the EO Browser tool and Sentinel-2 satellite images (for the period from January 2020 to December 2023) and the Burned Area Detection script were used. The resolution of the downloaded images was 2,500×1,189 pixels in the WGS 84 coordinate system (EPSG: 4326). Further analysis of the obtained images was carried out using the QGIS program using the Raster layer unique values report tool. The results obtained in pixels were converted into square meters, taking into account the number of square

meters in one pixel, their resolution and coordinate system. The final result, namely the area of areas affected by fires, is given in Table 6.

During February 2022 and 2023, an increase in the number of areas affected by fires was recorded compared to the corresponding period in 2020 and 2021, which can be explained by the beginning of a full-scale war and the conduct of active hostilities in this territory. A complete correlation was established between the areas affected by fires in July – September 2022 and the recorded number of fires according to NASA FIRMS data. At the same time, the affected area in June 2022 is insignificant, despite the number of recorded fires, which is explained by the nature of the shelling, namely the emergence of point sources of ignition as a result of artillery shelling of Russian equipment by the Defence Forces of Ukraine.

**Table 6.** Dynamics of the average area of fire-affected areas on the right bank of the Kherson region, km<sup>2</sup>

	2020	2021	2022	2023
January	278,839	6,693	no data*	no data
February	0.347	6,039	1,052.576	219,986
March	428,547	1,376.97	1,417.2267	561,906
April	410.27	111,588	433,633	16.28
May	226,361	632,256	199,511	3.37
June	1,283	9,685	11,952	36,872
July	119,301	0.599	247,082	19.83
August	494,375	161,061	62,655	267,234
September	197,615	142,829	76.54	320,557
October	52,327	421,824	196.65	759.75
November	698,882	1,055.34	636,772	652,282
December	no data	no data	no data	no data

**Note:** \* – the picture for this period is not available due to high cloud cover

**Source:** built by the authors for Fire information for resource management system (n.d.)

During August – October 2023, a different damage to areas compared to previous years was established, which is explained by the shelling of the Right-Bank part of the Kherson region (unoccupied) by the armed forces of the Russian Federation with artillery weapons and aerial bombs. In order to confirm the conclusions made that the main factor influencing the decrease in the efficiency of agricultural production in the region (in its controlled part) is precisely military operations, we additionally conducted studies of the impact of droughts as a factor affecting agricultural areas and

reducing crop yields. For this purpose, FAO data were used, in particular its remote sensing tools and further analysis using the ASI, NDVI and NDVI anomalies indices. According to FAO data, the beginning of the season on the Right-Bank Kherson region occurs from March to April; the seasonal maximum is observed from May to June; the end of the season in most territories of the Right-Bank Kherson region occurs from July to August. Corresponding changes to the ASI index were made for the period from June 2021 to June 2024, decade by decade and presented in Table 7:

**Table 7.** Seasonal decadal dynamics of the ASI Index

Year	Month	Indicator ASI, %		
		The first decade	Second decade	Third decade
2021	June	<10	<10	<10
	July	<10	<10	<10
	August	<10	<10	<10
2022	March	–	–	25-40
	April	25-40	<10	10-25
	May	<10	<10	<10
	June	<10	<10	<10
	July	<10	<10	<10
	August	<10	–	–

Table 7, Continued

Year	Month	Indicator ASI, %		
		The first decade	Second decade	Third decade
2023	March	–	–	<10
	April	<10	<10	<10
	May	<10	<10	<10
	June	<10	<10	<10
	July	<10	<10	<10
	August	<10	–	–
2024	March	–	–	10-25
	April	10-25	25-40	10-25
	May	<10	<10	<10
	June	<10	<10	There are no data

**Note:** \* the sign “–” corresponds to the meaning that the agricultural season has not started or has already ended

**Source:** built by the authors for Earth Observation (n.d.)

Based on the analysis of FAO data, in particular the use of remote sensing tools and their further analysis using the average monthly anomaly index NDVI, the following results were obtained for the period from June 2021 to May 2024, which are presented in Table 8.

From the data in Table 8, it can be seen that during the study period from 2021 to 2024, the average annual

ASI indicator did not exceed 10%. Accordingly, drought cannot be considered a factor of significant impact on the reduction in crop productivity on the Right Bank of the Kherson region during the study period. Let us compare the ASI indicators and the yield of grain and leguminous crops in the Kherson region during 1995-2023 (Table 9).

Table 8. Dynamics of the average monthly NDVI anomaly index

Year	Month	Average anomaly rate NDVI, %
2021	June	10-25
	July	>10
	August	<-10-0
	September	<-10
	October	<-10
	November	<-10
	December	<-25
2022	January	>10
	February	>25
	March	>25
	April	>10
	May	>10
	June	>10
	July	>10
	August	0
	September	>25
	October	>25
	November	>10
	December	>10
2023	January	>10
	February	>50
	March	>50
	April	>25
	May	>10
	June	>10
	July	>25
	August	>10
	September	<-10
	October	<-25
	November	>10
	December	<-25

Table 8, Continued

Year	Month	Average anomaly rate NDVI, %
2024	January	<-25
	February	>25
	March	>25
	April	>25
	May	>10

Source: built by the authors for Earth Observation (n.d.)

Table 9. Average annual ASI index and corresponding yields of grain and legume crops in Kherson region

Year	Indicator ASI, %	Yield, quintals /hectare	Year	Indicator ASI, %	Yield, quintals /hectare
1995	<10	24.6	2010	<10	22.1
1996	<b>25-40</b>	<b>15.7</b>	2011	<10	32.4
1997	<10	27.4	2012	<b>40-55</b>	<b>18.2</b>
1998	<10	21.2	2013	<b>10-25</b>	<b>22.2</b>
1999	<10	20.6	2014	<10	28.3
2000	<10	17.2	2015	<10	33.6
2001	<10	26.5	2016	<10	34.1
2002	<10	21.8	2017	<10	34.5
2003	<b>55-70</b>	<b>8.9</b>	2018	<10	31.9
2004	<10	26.3	2019	<10	36.2
2005	<10	22.1	2020	<10	35.0
2006	<10	22.8	2021	<10	43.4
2007	<b>70-85</b>	<b>16.0</b>	2022	<10	31.9
2008	<10	32.9	2023	<10	29.7
2009	<10	23.9	2024	The year continues	

Source: built by the authors for Agriculture, forestry and fisheries (n.d.); Earth Observation (n.d.)

The data in Table 9 demonstrate the periodic impact of drought on crop yields (data in bold). The ASI for Kherson region and its Right Bank in particular did not exceed 10% for most years and months, with minor exceptions in 1996, 2003, 2007, 2012 and 2013. For example, the 2007 drought, which led to significant losses in agriculture, corresponded to a value of 70-85% in terms of the ASI for Kherson region. Over the past 10 years, no significant impact of drought has been observed. A certain decrease in average yields was indeed observed in 2023, but the exceptions were maize and sunflower (Table 4). Therefore, there is every reason to expect positive results in terms of increasing crop yields due to the restoration of irrigation. For 2024 planned restoration of irrigation of over 3 thousand hectares of land (in three communities) through the use of the Ingulets irrigation system, which requires restoration, since enemy positions were established in its canals during the hostilities in the Right-Bank Kherson region.

The next important factor that can increase the yield of agricultural crops is the use of agro-technological measures, including the application of fertilisers. The problem of reducing soil fertility in the Kherson region arose long before the war. A negative balance of humus with a simultaneous decrease in the content of nutrients in it, significant decalcification of soils, increased acidity, a noticeable deterioration in physical and physical and chemical indicators have always been inherent in the soils of the Kherson region. In addition to this, erosion processes and deflation, which lead to the loss of humus, nitrogen, phosphorus, potassium and other substances, reduce their content in the soil, which negatively affects

their balance. The effects of the war on soils have been added to these negative trends. For shelling of the territories of the Right-Bank part of the Kherson region, the Russian armed forces use artillery shells, mines, shells for multiple launch rocket systems of various sizes, ballistic and cruise missiles. Regional territories are contaminated with various types of munitions, including anti-personnel and anti-tank mines (both direct-laying and remotely detonated), booby-trapped mines (based on hand grenades and grenade launcher shells), and cluster munitions. Such anthropogenic impact on soils necessitates the search for solutions and opportunities to preserve and increase the fertility of agricultural lands.

It is traditional to use mineral fertilisers and plant protection products (pesticides) at the beginning of the agricultural season. The use of pesticides is practically an integral part of modern crop growing technologies, since they are a means of combating weeds, pests and plant diseases, which helps to maintain a high yield. However, along with this, pesticides accumulate in the soil, leading to disruptions in the normal cycles of the biological circulation of substances. They suppress the biological activity of soils, destroy beneficial microorganisms. Mineral fertilisers should also be used with caution in agricultural production. Yes, indeed, their use significantly increases the yield of agricultural plants, and, taking into account the specifics of the soils of the Kherson region, their use gives positive results. But it should be remembered that an excessive number of mineral fertilisers can lead to disruption of soil processes, namely the optimal reaction of the soil solution, which will complicate the assimilation of

nutrients from the soil and applied fertilisers. In this context, organic fertilisers are more useful, the result of which is the improvement of soil quality and an increase in yield. However, the effectiveness of mineral fertilisers in increasing yield is significantly higher than organic ones. In order

to determine the impact of agro-technological measures on the yield of grain and leguminous crops in the Kherson region, the impact of the application of mineral, organic fertilisers and pesticides on the yield level before and during military operations was studied (Table 10):

**Table 10.** Fertilisers application and pesticide treatment per 1 ha in Kherson region (Grain and legume crops), kg

	2018	2019	2020	2021	2022	2023
Area under grain and leguminous crops, thousand hectares	710.1799	756.820	776.960	813.852	45.516	18.629
Area treated with mineral fertilisers, thousand hectares	327.941	353.109	394.447	419.687	38.265	11.137
Amount of applied mineral fertilisers per 1 ha, kg	105	104	168	121	94	46
Area treated with organic fertilisers, thousand hectares	16.899	11.513	16.315	42.773	There are no data	There are no data
Number of organic fertilisers applied per 1 ha, kg	3,110	6,681	2,064	1,176	There are no data	There are no data
Area treated with pesticides, thousand hectares	308.293	339.024	384.360	411.320	23.779	11.319
Number of pesticides applied per 1 ha, kg	0.767	0.870	0.744	0.951	0.534	0.491

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

The data in Table 10 prove the fact of an increase in the areas on which fertilisers are applied and treated with pesticides. The volume of mineral and organic fertilisers applied per 1 ha increased until 2020, which was the reason for the increase in the yield of grain and legume crops in 2021. In 2021, the number of fertilisers applied per 1 ha, except for pesticides, decreased. Since the beginning of the war, the volume of fertilisers applied to

the soil has decreased due to the reduction of land under cultivation, the reduction in the number of agricultural machineries for applying fertilisers, and the financial capabilities of farmers. Since fertiliser application is a traditional agro-technological measure to increase the yield of agricultural plants, an analysis of the impact of these measures on the yield of grain and legume crops over 15 years was conducted (Table 11).

**Table 11.** Dynamics of yield, fertiliser application and pesticide treatment per 1 ha in Kherson region

Year	Yield of grain and leguminous crops, tons per 1 hectare of harvested area	Application of mineral fertilisers, kg/ha	Application of organic fertilisers, tons/hectare	Pesticide treatment, kg/hectare
2009	2.39	35	0	н/д*
2010	2.21	43	0	н/д
2011	3.24	49	0	н/д
2012	1.82	44	0	н/д
2013	2.22	42	0	н/д
2014	2.83	40	0	н/д
2015	3.36	36	0	н/д
2016	3.41	58	0	н/д
2017	3.45	72	0	н/д
2018	3.19	105	3.110	0.767
2019	3.62	104	6.681	0.870
2020	3.50	168	2.064	0.744
2021	4.34	129	1.178	0.951
2022	3.19	95	–	0.534
2023	2.97	46	–	0.491

**Note:** pesticide treatment data began to be collected starting in 2018

**Source:** built by the authors for Agriculture, forestry and fisheries (n.d.); Economic Statistics / Economic Activity / Agriculture, Forestry, and Fishing / Agriculture (n.d.); Main Statistical Office in the Kherson Region (n.d.)

Organic fertilisers began to be used only in 2018 in fairly small amounts. Increasing their application volumes simultaneously with a corresponding increase in the volume of mineral fertilisers can be considered measures that may have a positive impact on the yield of grain and leguminous crops in the future. There is reason to

believe that a significant increase in the volume of mineral fertiliser application to 168 kg/hectare in 2020 and 129 kg/hectare in 2021 led to a record harvest in 2021. In addition, in 2019-2020, the application of organic fertilisers was simultaneously increased, and in 2021, the volume of pesticide treatment was also increased.

Based on the data presented in Table 10, an analysis was conducted of the presence of common trends in the yield of grain and legume crops and the application of mineral, organic fertilisers and pesticide treatment using the mutual correlation function (1).

Accordingly, three models were constructed: in the first, the resulting variable is the yield of grain and legume crops, and the influencing factor is the amount of mineral fertiliser application (kg/hectare); in the second model, the resulting variable is the yield of grain and legume crops, the influencing factor is the application of organic fertilisers (tons/hectare); in the third model, the resulting variable is the yield of grain and legume crops, the influencing factor is pesticide treatment (kg/hectare).

For the first model, the correlation coefficient was 1.0, which indicates a significant impact of mineral fertiliser application on yield. In the second model, the maximum value of the correlation coefficient reached 0.5912, but there were negative values, which indicate a low level of correlation. As for the third model, the maximum value of the correlation coefficient was 0.7256, which indicates a closer relationship than in the previous model. The results obtained correspond to the situation described above regarding the specifics of the impact of fertilisers and pesticide treatment on the level of yield. In the Kherson region, the influential factor is precisely mineral fertilisers and pesticide treatment, not organic fertilisers. To some extent, this can be explained by the specifics of the region's soils, but there are grounds for risks regarding excessive application of mineral fertilisers against the background of underestimation of the potential of organic fertilisers and the presence of fewer possible negative consequences from their use.

Taking into account the existence of interrelationships, econometric modelling was carried out using the Cobb-Douglas function and a regression model was constructed, in which the resulting indicator is crop yield, and the influencing factors are the amounts of mineral fertiliser application and pesticide treatment. To determine the coefficients  $a_0$ ,  $a_1$  and  $a_2$  were used MS Excel. As a result, we obtained the following data: coefficient values  $a_2 = 1.0496399$ ,  $a_1 = 1.002898$ ,  $a_0 = 5.7316155$ ; standard errors of these coefficients 0.0275036; 0.0167969 i 0.1418608 accordingly; coefficient of determination  $R^2 = 0.708326$ ; F-criterion value = 4.04166.

Received the model:  $\ln Y = 5.731616 + 1.002898 \ln K + 1.049639 \ln L$ . So, the Cobb-Douglas function has the form:

$$Y = 308.46722 \times K^{1.002898} \times L^{1.049639}, \quad (1)$$

where  $K$  – amounts of mineral fertilisers applied (in g/hectare);  $L$  – amounts of pesticides applied (in g/hectare);  $y$  – yield of grain and legume crops (kg/hectare).

The tabular value for the t-criterion = 0.277 (at  $\alpha = 0, 20$ ), that is, only one experimental value: 2.9967; more than the tabular value, the others are 0.1854 and 2.1433. Therefore, there are grounds for concluding that the correlation coefficients regarding the density of the relationship between the dependent and explanatory variables in the proposed model are, but incomplete. Let's consider another version of the model and build a regression model in which is taken into account only the effect of mineral

fertiliser application on yield. Let's build and consider a model of the form:

$$\ln Y = \ln a_0 + a_1 \ln K. \quad (2)$$

To determine the coefficients  $a_0$  and  $a_1$  it will be used the capabilities of MS Excel. As a result, we will obtain the following data: coefficients  $a_1 = 1.0913$ ,  $a_0 = 2.3598$ ; standard errors of these coefficients are 0.0291; 0.1215, respectively; coefficient of determination  $R^2 = 0.4228$ ; value of F-criterion = 9.5229; significance 0.008676. So, there is a model:  $\ln Y = 2.3598 + 1.0913 \ln K$ . Moving on to the Cobb-Douglas function, it is:  $Y = 10.5891 \times K^{1.0913}$ .

Let's assess the significance of the proposed model.  $F_{\text{table}} = 6.94$  at a significance level of  $\alpha = 0,05$  (probability 0.95, for degrees of freedom  $m - 1 = 2 - 1 = 1$  and  $n - m = 15 - 2 = 13$ ). Thus,  $F_{\text{fact}} (9.5229) > F_{\text{table}} (6.94)$ , which means that the corresponding econometric model is statistically significant, i.e. the hypothesis that the quantitative assessment of the relationship between the dependent variable (yield) and the explanatory variable (mineral fertilisers) in the model is significant with a probability of 0.95 is confirmed.

Let's check the significance of the correlation coefficient. The tabular value for the t-criterion = 3.012 (at  $\alpha = 0, 95$ ), the experimental values: 5.4902; 3.0861 are greater than the tabular value, which allows us to conclude that the correlation coefficients, which characterise the density of the relationship between the dependent (yield of grain and legume crops) and the explanatory variable (volume of mineral fertiliser application) in the proposed model, are reliable with a probability of 0.95. Thus, the proposed Cobb-Douglas function in this case is correct and the model is significant and can be used to model an effective system of sustainable land use.

As a result of the war, there was a noticeable decrease in profits from grain export operations. Thus, the total profit from exports in 2022 was only 13.8% of the same Figure for 2021. In 2023, the situation deteriorated further: the total profit from exports was only 5.2% of the corresponding Figure for 2021. This indicates that the war is hindering the realisation of the region's agricultural potential for export. (Agriculture, forestry and ..., n.d.).

Pre-war statistical data of the Kherson region indicate that the total area of agricultural land with fertile lands was 1,968.4 thousand hectares, including 1,770 thousand hectares of arable land. According to the Kherson Regional State Administration, 1,396 hectares of agricultural land are located on the left-bank (occupied) part of the region. On the territory where 515 thousand hectares, or 36.9% of the land area, are cultivated. That is, 881 thousand hectares of land, or 63.1%, are not cultivated due to the war (Economic Statistics / Economic..., n.d.). According to the information of the occupiers, the quality of the grain stolen by them is only 40% of the standards for food wheat, which can be the result of both agro-technological measures and the use of grain varieties resistant to arid climate. In 2022, the enemy exported all the grain stored in elevators from the occupied territories. The problems of spring sowing did not concern him. Therefore, one could only count on the harvest of winter varieties. Spring sowing practically did not take place, or the remains of low-quality grain were sown. In June 2023, after the destruction of

the Kakhovka reservoir, the water of which was actively used in the irrigation system of the left-bank Kherson region, the problems of flooding of agricultural lands and the impossibility of irrigating the lands were added. As a result, part of the lands was not cultivated, which created additional consequences that will need to be overcome after the de-occupation of the Left-Bank Kherson region.

As part of improving the situation in the Right-Bank Kherson region, measures to support farmers have already been approved, and a number of relevant programs are planned for 2024. In particular, agricultural producers from de-occupied and war-affected territories who cultivate up to 120 hectares will be able to receive eight thousand UAH in non-refundable aid for each hectare. Farmers who keep from three to 100 cows will receive seven thousand UAH for each animal, and those who raise up to 500 sheep and goats will also be entitled to appropriate financial support (State support programs..., 2024). Such measures will help increase the productivity of agricultural production. Restoring the pre-war level of agricultural production and productivity is a more complex task that will require a significant amount of investment. Farmers can count on partial compensation for losses, the amount of which is still being calculated today.

Given Ukraine's strategic goal of becoming a member of the European Union, it is essential to take into account the aspect of its sustainable development in the issues of economic recovery from the consequences of the Russian-Ukrainian war. Especially since Ukraine has officially supported a number of international decisions on sustainable development, such as the "Agenda for the 21<sup>st</sup> Century" (Agenda for the..., 1992). In this regard, the study by I. Aliksieienko *et al.* (2023) on the sustainable development of territories in the post-war period deserves attention, in which Ukrainian scientists substantiated the need to transform the conceptual principles of sustainable development of territories in the period of post-war ecological restoration of states. Using the example of post-war ecological restoration in Bosnia and Herzegovina, researchers have proven that sustainable development goals are effective vectors for improving the state of the environment during the period of post-war ecological restoration. A study of the European and Japanese experience of restoration after military conflicts made it possible to propose acceptable approaches to the reconstruction of Ukraine. The survey helped to determine the start dates and priorities for the restoration of these territories. Based on these data, a concept of sustainable development of territories was formulated, represented by its post-war cognitive model. We fully share the need to take into account the goals of sustainable development in the post-war restoration of Ukraine, including the fertile layer of agricultural land, since Ukraine joined the world community in achieving these goals in 2017 (Martynovych *et al.*, 2023).

In the context of sustainable development of the world economy, it is useful to study the well-known models of landscape restoration ecology, carried out by J. Aronson *et al.* (2017), who argue that in the presence of large-scale damage, it is important to consider both ecological restoration and ecological rehabilitation only as two different components in the "family" of restoration measures that should be deployed, including changed agricultural

management practices to ensure continued human activity and more environmentally safe and sustainable land use. Scientists presented a new model for planning, monitoring and evaluation, expansion and application of restoration measures in new areas, which contributed to the formation of the author's approach to the study. O. Tur (2022) identi

The destruction of agricultural soils during the war is one of the current issues being studied by Ukrainian scientists, since the myth of significant reserves of the best black soil in the world has been debunked. Ukrainian black soil has been destroyed over the past century by extensive agricultural practices, crop rotation violations, and during the war by mechanical, physical, and chemical influences. Thus, in samples taken in areas of combat operations, the content of heavy metals exceeded background values by 15-30 times. Just one shelling by the Grad multiple launch rocket system makes it impossible to conduct agricultural activities for about five years (Mohylnyi, 2024). The fundamentality of the study and the validity of the conclusions of O. Mohylnyi (2024) proved the severity of the existing problem of the loss of the quality of the fertile layer of agricultural land, including from the military aggression of the Russian Federation, which became the leitmotif of this work.

As a result of the shelling with "Grads", the soil is deformed in all directions of the shock wave, and as a result of the burning, explosion and detonation of ammunition, various by-products are formed, most of which are toxic and dangerous, including, in particular, heavy metals. Under such conditions, the primary accumulation of pollutants occurs in the soil with subsequent redistribution both in the soil itself and their transfer to other environments – surface and groundwater, vegetation and living organisms (Presentation at the..., 2023). The authors logically focused on finding effective measures to control the technogenic load on soils and propose eco-technological optimisation of the control and restoration of soil fertility of agricultural lands during the period of high risk of their rehabilitation through the use of bee pollen produced by bees from white marigold pollen as a bioindicator for monitoring the content of toxicants in soils as a source of soil fertility restoration (Presentation at the..., 2023). Soil microbiocenosis as a functional component that determines the reduction process, humus formation, intensification of enzymatic activity, soil respiration, and contributes to an increase in the quantitative composition of amino acids has become the subject of research by scientists at the Institute of Agroecology and Environmental Management of the National Academy of Agrarian Sciences of Ukraine (Presentation at the..., 2023). A valuable contribution of the study was the focus of scientists' attention on the need to diversify control measures and restore soil fertility, which contributed to the definition and detailing of mathematical methods for assessing the impact of the Russian-Ukrainian war in a particular region.

The issue of methods for monitoring damaged agricultural soils affected by the war is also in the focus of Ukrainian and foreign scientists. In particular, researchers at the Scientific Centre for Aerospace Research of the National Academy of Sciences of Ukraine have proposed a method for mapping minefields using centimetre resolution images from a helicopter-type unmanned aerial

vehicle (UAV) equipped with a multispectral camera and a thermal infrared camera. The new remote method for obtaining minefield maps involves the following procedures: mission planning and aerial photography, aerial photo processing, digital image mosaic production, smoothing and pixel-by-pixel classification, decision-making and documentation (Popov *et al.*, 2022). Remote sensing of land plots for identifying war-affected territories is also proposed by independent researcher A. Shmurak (Presentation at the..., 2023). The ability to remotely monitor affected agricultural land plots helped to select the correct information sources for further analysis.

Considerable attention is paid by scientists to the analysis of existing methods for assessing damage from chemical soil pollution. In particular, a group of Ukrainian researchers calculated the amount of damage from soil pollution in accordance with the Methodology proposed by the Ministry of Environmental Protection and Natural Resources of Ukraine dated 04.04.2022 No. 167 (Order of the Ministry No. 167..., 2022). According to the calculations, the amount of damage to 1 ha of arable land contaminated with petroleum products will be 506 thousand UAH/ha in 2023, while the norm for the Kyiv region as of December 18, 2023 is 2,362 thousand UAH/ha, which is 4.66 times more. That is, in the proposed Methodology of the Ministry of Environmental Protection of Ukraine, the final results of the amount of damage are underestimated (Tretyak *et al.*, 2024). Such conclusions are of great importance for calculating the total environmental, and economic damage from the war in terms of assessing the amount of reparations that will be presented by the Russian Federation after the Victory. The authors propose an approach based on the theory of the replacement value of assessing the damage caused to land resources that suffered as a result of military actions in the territories of regions, and for territorial communities. In the authors' opinion, the task of scientifically substantiated development, and adoption of relevant regulatory, and methodological documents remains relevant (Tretyak *et al.*, 2024).

An important issue for the restoration of war-affected soils is the search for effective, and cheap methods for their study, in particular, a team of Ukrainian scientists proposed a magnetic method for assessing processes in the soil, and minimising risks associated with improper farming, which was practically applied on a plot of agricultural land in the Kharkiv region (Menshov *et al.*, 2023). Another method – field, agronullometric analysis is used to study soil quality by scientists of the National Scientific Centre “Institute of Soil Science and Agro chemistry named after O.N. Sokolovsky” – I. Plisko *et al.* (2023). The use of various methods for soil assessment confirmed the need for interdisciplinary research that can optimise monitoring results, and determine future methods for managing agricultural territories.

T. Hanson (2018) analyses the relationship between armed conflict, and biodiversity, and considers it using the time frame of the ecology of war, which defines war as an ongoing process of three overlapping stages: preparation, war (armed conflict), and post-war activities. The researcher draws attention to the need to raise awareness of the conservation of biodiversity in military lands, the potential of scientific, and conservation activities to

mitigate the negative impact on biodiversity in combat zones, as well as the importance of the post-war period for incorporating biodiversity priorities into reconstruction and recovery efforts, which correlates with our position on the current, and post-war recovery of war-affected territories. The importance of this issue is emphasised by another group of scientists (Hryhorczuk *et al.*, 2024), who draw attention to the fact that in addition to the huge human losses, Russia's war against Ukraine has a devastating impact on the natural, and anthropogenic environment, and a just peace requires their reconstruction, and restoration, which stimulates research into the environmental consequences of the war in order to take more effective measures to protect the environment. The conclusions of the scientists emphasised the importance of maintaining the biodiversity of the natural environment, and formed confidence in the need for permanent monitoring in rural areas that were occupied, suffered from shelling, or are under occupation (Tkachenko, 2024).

Valuable for this study is the ability to compare its results with similar ones. Such work is the dissertation study by G. Gibson (2012), in which the author assessed changes in cultivated agricultural areas in Iraq using satellite remote sensing during, and as a result of the war. The author's conclusions regarding the reasons for the reduction in the area sown for grain crops during, and after the war are interesting. Unlike the impact of the Russian-Ukrainian war on agricultural lands, in Iran the reduction in the area sown did not occur due to the contamination of the fertile layer or its destruction, but due to purely political motives, and levers. Thus, in the author's opinion, economic sanctions against the country affected the reduction in the area sown, and agricultural production more than military actions.

Reclamation as an artificial restoration of soil fertility, and vegetation cover after man-made disturbance of the fertile layer, which includes the consequences of war, is considered by scientists as one of the first, and primitive, and therefore debatable, methods of restoring soil quality. Thus, L. Campbell *et al.* (2019) consider it possible to apply passive reclamation to the ecosystem of estuaries, which are degraded due to anthropogenic development, which leads to a decrease in the suitability of the habitat for biological communities. A team of Spanish scientists: J.D. Peco *et al.* (2021) emphasise that traditional reclamation methods are expensive, labour-intensive, and therefore cannot be used on a large scale. However, over the past 20 years (from 2000 to 2021), plant technologies, according to the authors; have gained recognition as an environmentally friendly alternative. Plants can be used for phytoextraction, Phyto stabilisation, and Phyto evaporation. The authors consider it necessary to use these Phytoremediation methods for the restoration of contaminated soils, paying special attention to the selection of appropriate plants in each specific case. The conclusions of the scientists are valuable for the management of rural areas, as they exclude the reclamation of land, the volumes of which in the affected areas are quite large, and offer a list of alternative restoration methods that may be appropriate in the conditions of restoration of Ukrainian lands.

The institutional aspect of the problem of current and post-war restoration of war-affected territories is also of

great importance, which is why a number of scientists pay attention to it. In particular, R. Tytykalo *et al.* (2022), studying the environment of Ukraine destroyed as a result of military actions, came to a logical conclusion about the important role of local governments in the most operational, and differentiated response to all problems arising in the affected territories, since the problem of environmental restoration is complex, and therefore requires coordination of the efforts of all community entities, and their active participation in this important matter. At the same time, the authors emphasise that an important aspect is the establishment of properly coordinated interaction between state authorities, and local governments, taking into account the principle of subsidiarity. The integration of interdisciplinary efforts of scientists, practicing farmers, state administration bodies, and local governments will help to detail the problem even during the war, determine a list of priority actions for the liberated territories, and optimise processes for the future.

### ► Conclusions

Before the start of the full-scale Russian-Ukrainian war, the Kherson region was among the leaders in the production of grain, legumes, and sunflowers. The war caused a reduction in the cultivated area by more than 50%. The irrational structure of the cultivated area is also a result of the war – sunflower occupies the majority of the sown area of the Kherson region. Significant crop losses in the unoccupied territory occurred due to fires caused by shelling. The conduct of hostilities in the controlled territories of the Kherson region affected the reduction of wheat and barley yields, while the yield of maize significantly increased due to the use of the optimal structure of applied organic, inorganic fertilisers and pesticides.

Studies of the impact of droughts on crop production in the Kherson region using ASI, NDVI, and NDVI anomalies

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show that droughts are not a critical factor affecting crop productivity. Restoring irrigation of territories through the use of the Ingulets irrigation system will improve the situation. Analysis of the impact of agro-technological measures on the level of crop yields proves that the application of mineral fertilisers and pesticide treatment has a significant impact on the yield of grain and leguminous crops in the region, while the importance of the use of organic fertilisers' remains underestimated. The use of an econometric model based on the Cobb-Douglas function will facilitate management decisions regarding fertiliser application and pesticide treatment, and will contribute to increasing yields while minimising the risks of negative consequences from their use. A scientific approach to land use becomes particularly important in wartime, when the traditional negative factors that reduce the quality of the fertile soil layer are combined with the impact of substances that enter the soil as a result of shelling.

The practical benefit of the work lies in the possibility of applying an integrated approach to monitoring and assessing the quality of agricultural land not only in war-affected areas, but also for permanent monitoring of land quality to make optimal management decisions regarding its effective use. Since the study is regional in nature, the proposed method can be adapted and applied to other areas in future studies. Further work may focus on expanding the geography of research, introducing new soil quality indicators, and improving the monitoring system to increase the efficiency of land management in the face of climate and economic change.

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### ► Conflict of interest

The authors of this study declare no conflict of interest.

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## Оцінка впливу російсько-української війни на аграрний потенціал Херсонської області

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► **Анотація.** Актуальність дослідження полягає у необхідності оцінки впливу російсько-української війни на аграрний потенціал Херсонської області через значні економічні та екологічні збитки, зокрема, знищення і забруднення ґрунтів, що потребує термінового моніторингу їх якості та відновлення родючості для відновлення аграрної сфери регіону. Оцінка впливу російсько-української війни на аграрний потенціал Херсонської області та визначення перспектив його повоєнного відновлення були обрані за мету даної роботи. Дослідження здійснено з використанням загальнонаукових та спеціальних методів вивчення явищ і процесів: аналізу та синтезу, системний аналіз, метод аналогії і моделювання, системний аналіз, методи збору та обробки інформації. У якості інформаційної бази для аналізу використані дані баз NASA FIRMS, супутникові знімки Sentinel-2, а також знімки пожеж з ресурсу Giovanni. Додатково залучені результати відстеження супутників MODIS, VIIRS та VIIRS 2 Suomi. Здійснена взаємна кореляція врожайності сільськогосподарських культур та індексу Agricultural Stress Index, що доводить відсутність серйозного впливу посухи на врожайність сільськогосподарських культур Херсонської області за виключенням найбільш посушливих років. Встановлено залежність між врожайністю зернових, зернобобових культур та внесенням добрив і обробленням пестицидами через використання функції взаємної кореляції. Побудовано модель впливу внесення мінеральних добрив та пестицидів з використанням економетричної функції Кобба-Дугласа, що дозволяє прогнозувати оптимальні умови введення сільськогосподарського виробництва. Висновки, пропозиції та практичні рекомендації будуть корисними у розробці відповідних програм та заходів, спрямованих на повоєнне відновлення сільськогосподарського ґрунту та загальний розвиток аграрного виробництва країни

► **Ключові слова:** аграрне виробництво; врожайність; якість ґрунту; добрива та пестициди; індекс Agricultural Stress Index; функція взаємної кореляції; функція Кобба-Дугласа



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## Import of agri-food products to Ukraine

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► **Abstract.** Ukraine's foreign trade in agri-food products continues to develop despite the full-scale war. While the blocking of seaports at the beginning of the Russian invasion had an equally negative impact on exports and imports of Ukrainian food, it is now possible to speak of the stabilization of agricultural purchases abroad. The purpose of the article is to examine the current state of imports of agri-food products to Ukraine, including the most significant changes in its commodity and geographical structure that have occurred since 2022. The methods used were theoretical generalization, historical and logical, analysis and synthesis, comparative evaluation, statistical, expert evaluation, graphical and tabular. The dynamics of agricultural imports to Ukraine in 2013-2023 is presented, with the periods of recessions and growth highlighted. The article determines the share of food products in total imports, examines the situation with the balance of foreign trade by subgroups, analyses the geographical and commodity structure of foreign purchases with details on fruits and berries, fish and seafood, and beverages, pays special attention to imports from the European Union, classifies certain commodity items based on their impact on the domestic food market, and assesses future trends in agri-food imports to Ukraine based on primary data for 2024. The provisions of the article are aimed at identifying the specific features of imports of agricultural raw materials and foodstuffs to Ukraine and informing specialized Ukrainian companies and relevant public authorities about possible prospects for the development of foreign procurement based on the monitoring of relevant data

► **Keywords:** procurement; agricultural products; commodity groups; supplier countries; trends; problems; prospects

### ► Introduction

Ukraine is increasingly integrating into the global economy as a supplier and buyer of food on the world agricultural market. While Ukraine's exports have a distinct commodity structure dominated by a few items of mainly raw materials, its imports include a variety of food groups. In the third year of the full-scale war, the typical characteristics of purchases from abroad are generally observed, but new features are emerging due to drastic changes in the business environment of the entire agri-food sector.

Since 2022, Ukraine's imports of agricultural raw materials and food products have become even more dependent on supplies from the European Union, which have been crucial for fully meeting existing consumer needs, as discussed in monographs by Ukrainian scientists, in

particular O. Kozak *et al.* (2023), which comprehensively highlight its indicators and dynamics. The usual situation in Ukraine's foreign trade, including the food component, has been absent for the third year in a row, and has been replaced by permanent uncertainty and high risks resulting from the Russian-Ukrainian war (Shumska *et al.*, 2023). One of the measures taken by the Ukrainian government to respond to the new challenges was the introduction of food security monitoring, controlling the balances of all major food products, and providing support to sectoral producers (Polukhina, 2022).

Analysing the domestic food market of our country, the US Department of Agriculture draws attention to the peculiarities of its functioning during a full-scale war, the

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ability to recover even in conditions of constant force majeure, the need to take into account the reduced purchasing power of the population and the possibility of supplying food from premium segments, the demand for which continues to grow (Ukraine: Exporter Guide..., 2024). At the same time, professional international organizations make forecasts in their forward-looking reports on imports of major food groups to Ukraine for the next ten years, taking into account, firstly, the average procurement figures for the last three years (OECD and Food and..., 2024).

Of course, long-term forecasts or assumptions about the development of agricultural imports can serve as a guide for specialized procurement companies and potential suppliers from abroad. However, as recent experience has shown, in the current environment, the parameters of Ukraine's domestic market and the objective ability to fully exploit the potential of foreign trade change too quickly, so its value and quantity sometimes vary greatly within a few months of a single year, reducing the reliability of any forecasts.

Despite constant monitoring, the import of agri-food products to Ukraine requires a deeper study, as it is currently being formed not only under the influence of internal and external factors, but also in the realities of a full-scale war. The purpose of the article was to analyse the dynamics and structure of food supplies to Ukraine, taking into account the objective need and market conditions of the domestic food market. The study of imports of agri-food products to Ukraine should be based on a systematic assessment of its historically formed trends and new features that have emerged as a result of significant changes in the economic environment in recent years. For the overall optimization of the domestic food market, it is necessary to balance the relationship between foreign trade, production and consumption through self-regulation and state support of the most vulnerable sectors, as indicated in this article.

### ► Materials and methods

A set of relevant methods was applied in the course of the study of imports of agri-food products to Ukraine. Thus, the method of theoretical generalization was used to identify the necessary prerequisites for buying food from abroad, including due to the absence or limited alternatives from domestic agricultural production, as well as to classify the main types of imports actually carried out by Ukraine. The method of analysis and synthesis was used to characterize the commodity and geographical structure of Ukraine's agrarian imports, with a focus on key product groups. The method of comparative assessment helped to identify differences between total food supplies from abroad and those made by the EU countries alone. The historical method was used to describe the dynamics of agricultural imports from 2013 to 2024, along with the calculation of its share in the total value of foreign supplies for the analysed period. The method of forecast estimates served as a transition from past and current results to predictions of fundamental trends in Ukraine's food imports in the near future. Graphical and tabular methods were implemented to ensure optimal visualization of statistical and analytical data.

The structure of the article includes three main stages, which are presented sequentially. Stage 1 is a general

description of the value of imports of agri-food products to Ukraine, including dynamics, share in total commodity purchases, and the balance of groups 1-24 of the Ukrainian Classification of Goods for Foreign Economic Activity (UCGFEA). The 2<sup>nd</sup> stage is the analysis of the commodity and geographical structure of agricultural imports. The 3<sup>rd</sup> stage is the identification the specifics of imports of agri-food products to Ukraine, its division into the most typical types, and assumptions about its development in the short term. The study was conducted to identify current trends in Ukraine's purchases of food abroad, to separate objectively necessary imports from those that can be met by domestic production, and to analyse the food market in our country in the context of demand for imported goods.

The information base for this research is made on publications by Ukrainian and foreign scholars, statistical data from the State Statistics Service of Ukraine (Official website of the..., n.d.), information materials of the Food and Agriculture Organization of the United Nations (Crops and livestock..., n.d.), and the International Trade Centre (List of products..., n.d.). Data from the European Commission (Monitoring EU agri-food trade..., 2024), the Foreign Service of the US Department of Agriculture (Ukraine: Exporter Guide..., 2024), and the author's own developments, observations, and conclusions were also used.

### ► Results and Discussion

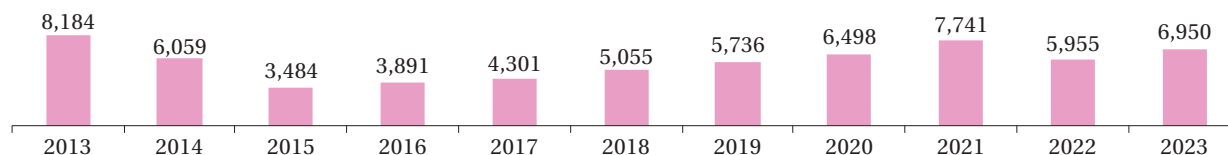
Traditionally inferior in terms of the total value of exports, food imports to Ukraine have their own peculiarities, which are increasingly determined by the country's socio-economic situation and domestic market conditions (hryvnia exchange rate against foreign currencies, purchasing power of the population, activity of companies specializing in purchasing agricultural products on the international market, etc.), while being less affected by changes in the global agricultural sector.

During the analysed period (2013-2023), imports of agri-food products demonstrated many interesting statistical features. In 2013, its total value was the highest since independence, exceeding USD 8 billion. For the next two years, due to economic problems caused by the annexation of Crimea and the hostilities in Donbas, agricultural imports declined significantly (to almost USD 3.5 billion in 2015), but then grew steadily until 2021, reaching USD 7.8 billion. However, the full-scale Russian invasion led to a forced curtailment of foreign trade, which resulted in a 23% decline in food imports in 2022 (Official website of the..., n.d.). However, last year, the decline was overcome, replaced by an increase of USD 1 billion, so that Ukraine's agricultural imports amounted to almost USD 7 billion, becoming the fourth largest in history (Fig. 1).

The share of agri-food products in Ukraine's total imports is usually within 10%. Since 2013, its highest figure was 12% in 2020, and the lowest was recorded in 2017 – 8.7%. As of now, the situation remains unchanged: in 2022, agricultural products accounted for 10% of Ukraine's imports, and in 2023 – 11% (Official website of the..., n.d.). Another important point is the situation with the foreign agricultural trade balance, or rather, its ambiguity. The overall balance of foreign trade is positive, with exports significantly exceeding imports (by USD 14,899 million in 2023), but the result is already the opposite for most commodity subgroups.

This is explained by the high concentration of Ukraine's agri-food exports, where grains, oilseeds, oils, processing residues, and poultry meat account for almost 90% of its value, while the remaining items are characterized by very small amounts of foreign sales (Kovalenko *et al.*, 2024). As a result, last year the balance was negative in subgroups 01, 03, 05, 06, 07, 08, 09, 13, 16, 18, 20, 21, 22, 24 (Kryvenko *et*

*al.*, 2023). In addition, the ratio of exports to imports for many traditional products for the domestic agriculture and food industry remains negative for Ukraine – live poultry, pork, lard, some vegetables (tomatoes, cucumbers, onions, cabbage), fruits (grapes, pears, apricots, peaches, plums), cheeses, seed sunflower, and fruit and berry seedlings (statistics and registers, n.d.; Ihor Vishtak: Ukraine..., 2024).



**Figure 1.** Dynamics of imports of agri-food products to Ukraine, USD million

**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

The geographical structure of Ukraine's food purchases is shaped by a pronounced focus on the European Union, which accounts for more than half of the value of imports. In 2023, the European Union supplied agricultural raw materials and finished food products to our country worth USD 3,680 million, or almost 53%. Imports of food from other parts of the world were significantly lower: from Asia they amounted to USD 1,365 million (19.6%), Latin America – USD 511 million (7.4%), and Africa – USD 326 million (4.7%). Thus, these four regions accounted for almost 85% of Ukraine's agricultural imports (Statistics and registers, n.d.; Official website of the..., n.d.). Poland was traditionally the main supplier of agri-food products to Ukraine last year, with sales worth

USD 950 million. The top ten partners in agricultural imports also included: Turkey – \$627 million, Germany – \$534 million, Italy – \$337 million, Norway – \$304 million, France – \$282 million, the Netherlands – \$278 million, the United States – \$252 million, Spain – \$233 million, and China – \$216 million (Official website of the..., n.d.). The overall structure of Ukraine's external purchases of agri-food products has a significant feature: the largest volumes by value are not raw materials, but ready food products (subgroups 16-24 of UCGFEA). The year 2023 was no exception, as they accounted for about 47% of Ukraine's agricultural imports. At the same time, oils and fats accounted for the smallest share of supplies, within 4% (Table 1).

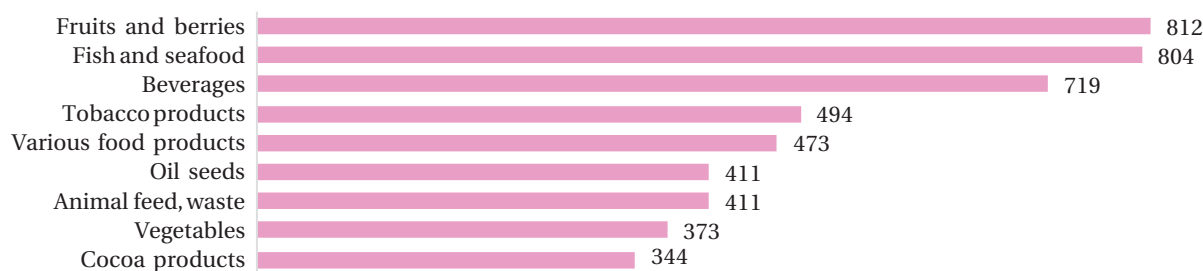
**Table 1.** Commodity structure of agricultural imports to Ukraine, mln USD

	2015	2020	2021	2022	2023
Products of animal origin	548	1,258	1,592	1,176	1,342
Products of plant origin	1,146	1,989	2,130	1,928	2,113
Fats and oils	182	280	444	294	247
Ready-to-eat food products	1,608	2,971	3,576	2,558	3,252

**Source:** compiled by the authors on the basis of the Official website of the State Statistics Service of Ukraine (n.d.)

Last year, despite the war, fruit and berry products remained the main commodity groups in our agricultural imports, with the value of purchases totalling USD 812 million, along with fish and seafood (USD 804 million), alcoholic and non-alcoholic beverages (USD 719 million).

Also, significant in value terms were Ukraine's purchases of tobacco products, various food products, oilseeds, animal feed, processing industry waste, vegetables, and cocoa products. Together, they accounted for 70% of imports of agri-food products in monetary terms (Fig. 2).



**Figure 2.** Commodity structure of imports of agricultural products to Ukraine (2023), USD million

**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

At the same time, our importers spent the most on purchases of animal feed, frozen fish, spirits, tobacco products for direct use, citrus fruits, sunflower seeds, coffee, bananas, cheese, fresh and chilled fish (Table 2).

**Table 2.** Products with the highest value of imports to Ukraine (2023), USD million

Products for animal feeding	387
Frozen fish	386
Ethyl alcohol, < 80 vol. %	330
Reconstituted tobacco and its substitutes	278
Citrus fruits	276
Sunflower seeds	232
Coffee	218
Bananas	202
Cheeses	201
Fresh or chilled fish	199

**Source:** compiled by the authors based on Statistics and registers (n.d.)

The total volume of imported fruit and berry products last year was 706 thousand tonnes, mainly including 271 thousand tonnes of various citrus fruits and 201 thousand tonnes of bananas. Smaller quantities were imported of stone fruits (46 thousand tonnes), grapes (41 thousand tonnes), watermelons and melons (30 thousand tonnes), and other exotic fruits and nuts.

In 2023, the leading suppliers of fruit to Ukraine were Turkey, Ecuador, Greece, Costa Rica, Spain, and Colombia (Table 3). It is worth noting that Turkey traditionally specializes in the sale of citrus fruits, while Latin America supplies bananas. These six countries accounted for about 64% of Ukraine's imports of fruit and berry products in monetary terms.

**Table 3.** Imports of fruits and berries to Ukraine in 2023

Country	Volume, thousand tonnes	Value, USD million
Turkey	218	226
Ecuador	115	115
Greece	49	56
Costa Rica	40	43
Spain	28	39
Colombia	33	38

**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

In 2023, purchases of fish and seafood abroad totalled almost 300 thousand tonnes (including 214 thousand tonnes of frozen fish, 37 thousand tonnes of fish fillets, 25 thousand tonnes of fresh and chilled fish, and

13 thousand tonnes of crustaceans). The largest purchases in this group were made from Norway, Iceland, the United States of America, the United Kingdom, Spain, Ecuador, and Canada (Table 4), with a combined share of 71%.

**Table 4.** Imports of fish and crustaceans to Ukraine in 2023

Country	Volume, thousand tonnes	Value, USD million
Norway	70	295
Iceland	61	108
USA	23	68
United Kingdom	12	26
Spain	10	25
Ecuador	5	24
Canada	9	24

**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Imports of alcoholic and non-alcoholic beverages exceeded 370 thousand tonnes. It included sweet and mineral waters (138 thousand tonnes), beer (65 thousand tonnes), grape wines (62 thousand tonnes), and beverages

with an alcohol content of less than 80 vol. % (92 thousand tonnes). Italy, the United Kingdom, Poland, Georgia, Germany, and France as the main suppliers had a total share of 57% last year (Table 5).

**Table 5.** Imports of beverages to Ukraine in 2023

Country	Volume, thousand tonnes	Value, USD million
Italy	41	110
United Kingdom	21	106
Poland	70	58
Georgia	44	56
Germany	25	41
France	10	39

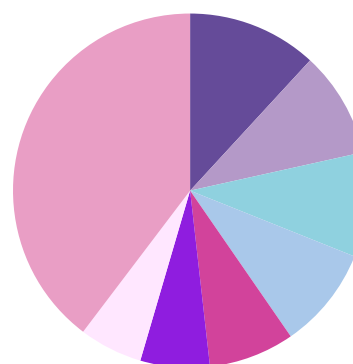
**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Among other key commodity groups in imports, the authors of this study would like to mention purchases of oilseeds in the amount of over 86 thousand tonnes, where the largest volumes were sunflower seeds (30 thousand tonnes) and rapeseed (20 thousand tonnes), as well as peanuts (22 thousand tonnes). In addition, 197 thousand tonnes of animal feed were imported, which formed the absolute majority in the structure of the residues and waste group (List of products..., n.d.). Since 2022, as a result of the occupation and hostilities in the south of Ukraine, in particular in Kherson, Mykolaiv, and Zaporizhzhia regions, there has been a shortage of vegetables for the domestic market, which was compensated for by imports. In 2023, there was still a high dependence on purchases of this group of products from outside Ukraine. Thus, the total imports of vegetables amounted to 338 thousand tonnes, with the main commodity items being tomatoes (95 thousand tonnes), onions and garlic (76 thousand tonnes), carrots and other root vegetables (32 thousand tonnes), cabbage (30 thousand tonnes), and cucumbers (29 thousand tonnes).

Objectively, there is no alternative to importing cocoa products, coffee, tea, and spices from abroad. Last year, Ukraine imported 73,000 tonnes of cocoa products (mostly chocolate, cocoa paste, powder and butter), 45,000 tonnes of coffee, 12,000 tonnes of tea, and over 4,000 tonnes of black pepper (Official website of the..., n.d.). Regarding imports of agri-food products from the European Union as our key supplier, it is worth noting that its dynamics are very similar to the general trend. The continuous increase for six years (2016-2021) stopped in 2022, when the value of supplies from the countries of this regional grouping decreased by 17% to USD 3,376 million. However, 2023 again brought an increase in purchases by Ukrainian importers by \$300 million, which totalled \$3,680 million. The authors of this study mention a certain stabilization of the logistics of food supplies to Ukraine from the EU (Official website of the..., n.d.). According to the European Commission, in 2023, the EU's agricultural exports to Ukraine amounted to €3,455 million, and our market was the fourteenth largest in terms of sales value in the geographical structure of the neighbouring country's sales (Monitoring EU agri-food trade..., 2024).

Last year, the largest expenditures of Ukrainian importers of food products originating in the EU countries were in the groups of beverages (primarily wines, spirits, beer, sweet waters), tobacco products (mainly e-cigarette kits), residues and waste from the processing industry (in fact, in the form of animal feed), various food products (mainly extracts and concentrates of tea and coffee,

sauces, etc.), dairy products, eggs (mainly cheese), prepared grain products (including bakery confectionery, malt extracts and flour products), cocoa products (mainly chocolate), which together accounted for exactly 60% (Fig. 3). It is noteworthy that, in contrast to the general structure of our agricultural imports, the main supplies from the European Union do not include fruits and berries, along with fish and crustaceans, but are instead supplemented by dairy and grain processing.



■ Beverages; 436
■ Tobacco products; 356
■ Residues and waste; 351
■ Various food products; 343
■ Dairy products, eggs, honey; 288
■ Ready-made grain products; 233
■ Cocoa products; 213
■ Other; 1,460

**Figure 3.** Commodity structure of imports of agricultural products to Ukraine from the EU in 2023, USD million

**Source:** compiled by the authors based on Statistics and registers (n.d.); Official website of the State Statistics Service of Ukraine (n.d.)

Ukraine is not among the largest food importers in the world, in particular, before the full-scale war, in 2021, being in 49th place in this ranking (Crops and livestock..., n.d.). However, for some items, Ukraine is still among the top 25 buyers in terms of quantitative volumes, namely in the segments of citrus fruits, bananas, tomatoes, cucumbers, frozen fish, tobacco-containing products for electric heating, and spirits (List of products..., n.d.). The first half of 2024 was a continuation of the main trends in agricultural imports to Ukraine that emerged in the previous year (Statistics and registers, n.d.). The total value of imported agricultural goods was USD 3,738 million, which is 8% more than in January-June last year. Specialised importing

companies continue to spend the most on fish and seafood (USD 441 million), fruits and berries (USD 413 million), and various beverages (USD 364 million). The geography of supplies from abroad is traditionally based on the European Union, where food worth USD 1,956 million was purchased. Purchases from Asia (USD 759 million) also stand out, significantly exceeding those from Latin America and Africa. Poland (\$436 million), Turkey (\$334 million) and Germany (\$318 million) are the top countries from which the largest supplies of agricultural products are made.

Summing up the above statistics for the period under review, it is necessary to pay attention to the characteristic features of agricultural imports to Ukraine. It has demonstrated a generally high unpredictability, which is only getting stronger over time. In 2014-2015, its value decreased by more than 2 times after the peak in 2013, while the decline in exports was not as significant. During the height of the coronavirus pandemic and related international trade restrictions in 2020, our exports of agricultural products and food essentially stopped growing, while sectoral imports continued to grow. Having adapted to these new conditions, imports grew significantly in sync with exports the following year. The absolute consequence of force majeure in the form of a complete blockade of seaports and a temporary collapse of the entire logistics system was a drop in incoming and outgoing food trade flows in 2022. Another difference between imports and exports was in 2023 in the form of a rapid increase in imports amid a slowdown in the ongoing decline in agricultural exports.

It is absolutely clear that the global economy and Ukraine as an integral part of it are facing systemic organisational imbalances, including one of the most significant problems caused by massive population migration due to ongoing military operations (Chernobay & Malibroda, 2024). When there are large-scale military confrontations involving key players in the global food market, as in Ukraine, agribusinesses are generally forced to adapt, but global food security becomes vulnerable, primarily reflected in rising food prices (Kutsmus *et al.*, 2024). As the social and political circumstances in Europe are still too unstable to affect the economic environment, the ongoing transition period for Ukraine is likely to drag on for a longer time (Dalampira & Nastis, 2020).

Since 2022, under martial law, the Ukrainian agricultural market has been facing new challenges and problems, so it is advisable to apply additional measures of state sectoral policy that will help stabilise it over a certain period of time (Boiko, 2022). Dramatic changes in the socio-economic sphere against the background of accelerating integration processes require appropriate structural transformations for the agri-food sector (Lupenko *et al.*, 2022). Researchers rightly believe that the development of the sector will be supported by improved investment potential, digitalization, and further international integration.

Even in the face of extremely difficult challenges, sectoral enterprises should try to implement modernization measures within the framework of planned strategic initiatives, including integration into the European Union (Yatsenko *et al.*, 2024). In this context, the long-term Strategy for the Development of Agriculture and Rural Areas until 2030 should be as consistent as possible with the EU's Common Agricultural Policy (Popova, 2024). The

process of food imports is directly related to a group of risks – supply, demand, production, management, operational, logistics, infrastructure, political, regulatory and financial. To minimize their negative impact or avoid them altogether, it is necessary to properly assess and group risks by the degree of impact (Barauskaitė & Jurevičienė, 2021). At the same time, in many cases, the interpretation of the ranking of unfavourable factors can differ significantly, as well as the ways to solve them.

C. Tortajada & F. González-Gómez (2022) argue that international agricultural trade is closely linked to the environment. Its development and increase in volumes are currently occurring mainly at the expense of developing countries. However, the increase in production has had a negative impact on the environment. The Russian aggression has further exacerbated this problem for Ukraine, so the environmental component is becoming increasingly important. While climate change may reduce productivity and yields, it may also open up new supply chains as a result of global warming, which may expand traditional maritime routes (Martínez-Martínez *et al.*, 2023). It should be agreed that any improvement in logistics routes is critical for companies specializing in foreign trade.

Given the commodity mix of Ukraine's purchases of agri-food products from abroad and the conditions of their implementation, four typical types of imports can be distinguished: 1. *Critical* – products that, for objective reasons, cannot be produced due to the lack of traditions, experience, natural and climatic conditions for their cultivation, growing, and the inability to satisfy even a small share of the domestic market needs (sea fish, various types of crustaceans, molluscs; exotic fruits of tropical and subtropical latitudes, for example, according to official statistics, more than 62 thousand tonnes of oranges last year, as well as tangerines, lemons, kiwi, persimmons; coffee, tea, cocoa, spices, and palm oil). A characteristic feature of this type of imports is their urgent need for the domestic food market, as the demand for them is stable and established, so there is a real need for their constant purchases. 2. *Market-driven* – products that have historically been produced in Ukraine and were quite well-developed, but over time have suffered a decline, reorientation and lost their positions in the domestic market (breeding animals; seedlings of fruit and berry crops; certain types of meat and offal, including more than 24 thousand tonnes of lard and fat in 2023; oilseeds and grains). This includes all goods without which the normal functioning of the food market is impossible, so their supply must be ensured. 3. *Point* – represented by analogue goods that are produced in the country, sometimes in sufficient quantities to meet demand throughout the calendar year, but are regularly imported due to better consumer quality, price advantages, and seasonal demand (fruits and vegetables typical of Ukraine's natural and climatic conditions, various cheeses – about 34 thousand tonnes last year). The peculiarity of this group is that it does not have a critical impact on food security, and supplies from abroad are almost always a response to the special needs of a certain circle of consumers who are willing to pay higher costs for a particular product, including those imported from another country. 4. *Unpredictable* – any agri-food product from the rest of the product groups for which there is a sudden rush or

unexpected shortage (buckwheat, ginger, etc.). This type of imports appears spontaneously or may be absent for a long time, often characterized by even single cases. However, its occurrence is almost never predicted in advance, so it is accompanied by a sharp increase in selling prices for goods that have to be imported on an emergency basis.

It is an objective fact that the consumption of most basic food groups by the population of Ukraine remains insufficient (Kvasha *et al.*, 2024). The ongoing full-scale war and the resulting decline in household incomes significantly worsen the availability of the food basket. In order to assess possible imports, the list of classified types will be used to determine the current and future characteristics of the Ukrainian food market related to the overall state of the economy (Hrubá *et al.*, 2021). In the structure of Ukraine's foreign agricultural trade, imports develop according to their own patterns, which distinguish them from exports. The indicators of food purchases by Ukrainian companies from abroad are the objective needs of the domestic market based on the purchasing power of the population (Semenda *et al.*, 2022). At the same time, the fluctuations recorded in previous years were caused by systemic changes in the economic environment, which were quickly restored after a sharp deterioration. Imported products are of secondary importance for the food supply of the Ukrainian population, mostly only supplementing the supply in non-core segments.

However, regardless of the circumstances, it is worth increasing the number of bilateral and multilateral trade agreements that directly improve mutual food trade performance, especially when there is a need and clear economic benefits of imports (Newman *et al.*, 2023). For Ukraine, in the current highly challenging circumstances, it is vital to build resilience of its agri-food system to shocks and crises, which is achieved by adhering to three main principles: preparedness for disruptions, implementation of a multifaceted and cross-sectoral approach to multiple risks, and consideration of different issues and policy components (Pohorielova, 2024). In any case, the long-term perspective for the development of Ukraine's economy and agri-food sector in the post-war period will involve reconstruction with the direct interest of foreign partners, among which large multinational companies will play a key role (Bilyk *et al.*, 2023). The situation with imports of food and agricultural raw materials will remain potentially dynamic and correlated with logistical problems until the end of the war, but periodic trade restrictions by some European countries cannot be ruled out (Ukraine: Exporter Guide..., 2024; This game can be played..., 2024). Nevertheless, quantitative limits on Ukrainian agricultural exports to the EU are foreseen for the next year, 2025.

Thus, agricultural imports to Ukraine continue to play an important role in terms of the adequacy of the assortment of the domestic food market. Its quantitative and value indicators for key groups are closely interrelated,

depending on the stability of the economy. In the current environment, purchases of raw materials and ready-to-eat products of foreign origin are subject to many risks and force majeure circumstances, but still in the required volumes.

### ► Conclusions

Ukraine's imports of agri-food products are significantly inferior to sectoral exports, but have many of their own characteristics, which have been repeatedly confirmed over the period 2013-2023. In the absence of structural shocks in social and political life, imports have consistently shown a clear positive trend. However, in 2020-2021, the presence of severe and prolonged restrictions on foreign trade related to the coronavirus pandemic did not prevent its continued growth. In addition to alternating ups and downs due to shock events for the entire economy, its value exceeds exports in most groups 1-24 of UCGFEA, the vast majority of the structure is occupied by prepared foods, the European Union remains the main regional supplier, and Poland has been the largest supplier by value for several years. However, food purchases in Asia, Latin America and Africa also have a distinctive pattern. The available value indicators of aggregate agricultural imports give grounds to classify Ukraine as a significant participant in the global market, which meets the vast majority of its food market needs on its own. Traditionally, the largest expenditures of specialized Ukrainian importers are on fish and seafood, along with fruits and berries, and various beverages. Since the start of the full-scale war, vegetables have been added to the list of major food imports. The domestic food market for coffee, tea, cocoa and some other products is practically dependent on imports. All food imports can be divided into four groups of different sizes, ranging from the clearly foreseen to the completely unexpected. Given the trends of recent years and the situation as of the first half of this year, 2024, there are signs of stabilization of imports, which in the short term have the potential for moderate growth while maintaining the foundation of the existing economic situation in Ukraine. It will be determined by the further adaptation of businesses focused on foreign economic activity to operate in conditions of force majeure and constantly high risks.

Promising further research on the import of agricultural products to Ukraine should include determining the approximate share of foreign goods in the domestic food market and the possibility of developing domestic production of those segments or individual items that can quickly replace currently imported ones while maintaining an optimal balance by use.

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### ► Conflict of interest

None.

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## Імпорт агропродовольчої продукції в Україну

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► **Анотація.** Зовнішня торгівля України агропродовольчою продукцією продовжує розвиватись, незважаючи на повномасштабну війну. Якщо блокування морських портів на початку російського вторгнення однаково негативно впливало на експорт та імпорт українського продовольства, то в даний час можна говорити про стабілізацію саме закупівель сільськогосподарських товарів за кордоном. Метою статті було розглянути актуальний стан імпорту агропродовольчої продукції в Україну, включаючи найсуттєвіші зміни в його товарній і географічній структурі, які відбулись з 2022 року. Було використано методи теоретичного узагальнення, історико-логічний, аналізу і синтезу, порівняльної оцінки, статистичний, експертних оцінок, графічний і табличний. Наведено динаміку аграрного імпорту в Україну за 2013-2023 роки з виділенням періодів спадів і підйомів. Визначено частку продовольчої продукції в загальному імпорті, розглянуто ситуацію з сальдо зовнішньої торгівлі в розрізі підгруп, проаналізовано географічну й товарну структуру закордонних закупівель з деталізацією по плодах та ягодах, рибі і морепродуктах, напоях, окрему увагу приділено імпорту з Європейського Союзу, класифіковано окремі товарні позиції на основі їх впливу на внутрішній продовольчий ринок, здійснено оцінку майбутніх тенденцій агропродовольчого імпорту в Україну, базуючись на первинних даних 2024 року. Положення статті спрямовані на визначення характерних особливостей імпортних поставок сільськогосподарської сировини і продуктів харчування в Україну та інформування спеціалізованих українських компаній і відповідних органів державної влади щодо можливих перспектив розвитку закордонних закупівель, виходячи з моніторингу актуальних даних

► **Ключові слова:** закупівлі; сільськогосподарська продукція; товарні групи; країни-постачальники; тенденції; проблеми; перспективи



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## The role of labour resources in the development of food self-sufficiency of territorial communities of the Mykolaiv Oblast

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► **Abstract.** The purpose of the study was to investigate the influence of labour resources on the efficiency of agricultural production and ensuring food self-sufficiency of territorial communities of the Mykolaiv Oblast. The methodology was based on the results of a survey among respondents working in the agricultural sector. Statistical data were used to assess the impact of labour resources on production activities. The study showed that 70% of respondents consider labour resources extremely important for ensuring their production activities. This highlights the importance of human capital in contemporary business environment. Among the main factors affecting productivity, 45% of respondents noted the role of technologies that automate processes and increase production efficiency. In addition, 30% of respondents indicated the qualifications of employees, which indicates the need for constant training and development of personnel to achieve high results. Another 25% of respondents indicated working conditions that include both physical and psychological aspects of the work environment. This indicates that the development of labour resources is directly related to improving the efficiency of agricultural production, since investment in people and their training can significantly affect the overall success of enterprises in this area. The results of the study confirmed the

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importance of investing in labour resources and their development in achieving food self-sufficiency. Improving the skills of employees and technological working conditions can significantly increase the productivity of the agricultural sector. This study is of practical importance for local self-government bodies and agricultural producers seeking to improve the efficiency of their activities

► **Keywords:** labour force; agriculture; economy; production efficiency; society

### ► Introduction

The modern agricultural sector of Ukraine faces numerous challenges, including a significant problem of ensuring food self-sufficiency of territorial communities. In the context of globalisation and climate change, labour efficiency is becoming critical to improving agricultural productivity. There is a need for a detailed analysis of the contribution of labour resources to the development of food security, which led to this study. The study of the problem of labour resources in agriculture has been considered by many researchers. K. Donovan & T. Schoellman (2023) emphasised the importance of labour resources in the labour market in the process of structural changes affecting economic development. They found that these resources can slow down the transition of labour between sectors, making it difficult to optimise work.

The challenges in the development of the agricultural sector in Indonesia was analysed by N. Ngadi *et al.* (2023), in particular, youth migration and an ageing labour force. They noted that these factors negatively affect the productivity and sustainable development of agriculture. However, research gaps relate to the lack of strategies that could adapt the agricultural sector to these demographic changes, which requires further study. In turn, M. Etxezarreta (2023) reviewed the transformation of the labour system and work processes in the context of rapid modernisation of agriculture in Spain. The researcher focused on the need to adapt to new technologies and changes in the socio-economic context, which creates new challenges for employees. Research shortcomings relate to the lack of analysis of the impact of these changes on different social groups, and the lack of comprehensive strategies to support the workforce in the face of rapid transformation.

N. Hii & E. Lau (2024) examined the impact of the quality of education in the labour market on economic development and value added in the agricultural sector of Malaysia. Researchers have found that a high level of education in the labour force contributes to increased productivity and competitiveness in agriculture. However, there is a gap in understanding how educational programmes can be adapted to the specific needs of the agricultural sector, which requires further study. T. Dinkelman *et al.* (2024) analysed the relationship between labour migration, capital investment, and the structure of rural labour markets. The paper highlighted that migration can have a positive impact on rural capitalisation, but it also poses challenges for local economies. However, the study did not sufficiently examine the social consequences of migration for families and communities, which requires a more in-depth analysis.

The labour substitution in the agricultural sector of Indonesia, in particular, in the context of the expansion of oil palm plantations, was investigated by C. Kubitzka *et al.* (2024). Researchers have found that this expansion leads to significant changes in the labour market, in

particular, to the loss of jobs in traditional agriculture. P. Maulidar *et al.* (2024) examined the impact of agriculture, economic growth, capital, and labour on CO<sub>2</sub> emissions in Indonesia. It was found that the agricultural sector is a significant factor influencing the environmental situation, emphasising the need to integrate sustainable development into agricultural policy. However, research gaps relate to the lack of study of specific measures that could reduce emissions in the context of agricultural transformation, which requires additional analysis.

F. Sarie & I. Harsono (2024) investigated the impact of pesticide use, labour availability, and agricultural technologies on the efficiency of vegetable growing in Central Java. They found that the right combination of these factors can significantly improve performance. In contrast, P. Maitra & A. Tagat (2024) examined the response of labour supply to rain shocks. Changes in precipitation have been found to significantly affect the availability of labour in the agricultural sector, which can lead to instability in agricultural production. U. Pirnazarovna (2024) emphasised the importance of labour resources as an integral component of economic development. The study focused on the importance of efficient use of labour resources to increase productivity and sustainable growth. However, gaps in the literature relate to the lack of analysis of specific human resource management strategies in various sectors of the economy, which requires further study.

The current state of research demonstrates the lack of empirical data on the relationship between employee qualifications and production efficiency. Research is usually limited to general conclusions, without a detailed analysis of specific examples of territorial communities. This highlights the need for an in-depth study of the topic. Thus, the main purpose of this study was to assess the contribution of labour resources to the development of food self-sufficiency of territorial communities of the Mykolaiv Oblast. In the course of the study, the following tasks were formulated: to analyse the impact of labour resources on the efficiency of agricultural production in the communities of the Mykolaiv Oblast; to investigate the level of qualification of employees of the agricultural sector and identify gaps in knowledge and skills; to assess the impact of automation and modern technologies on labour productivity in agriculture.

### ► Materials and methods

The study was conducted from January to June 2024 in the territorial communities of the Mykolaiv Oblast, in particular in the Kryvozerska, Pervomaiska, and Arbusynska territorial communities. The study analysed labour resources and their employment in the agricultural sector, and the impact of local initiatives on the development of agriculture. In addition, data were collected on the available resources, infrastructure, and potential for agro-industrial

development in these communities. The survey was conducted on the territory of Kryvoozerska, Pervomaiska, and Arbusynska territorial communities.

150 respondents took part in the survey, including representatives of various professions, such as farmers, agronomists, and employees of agricultural enterprises. The survey was conducted anonymously in a group form and in person, which provided direct communication with respondents. The questionnaire covered such aspects as the introduction of new technologies, the assessment of employees' qualifications, and their contribution to the overall production process. Among the main questions that were asked to respondents, the following can be highlighted: "What are the main factors that affect the productivity of your enterprise?" and "How do you assess the impact of labour resources on your production activities?". The average age of participants was 42 years, and the distribution by age group was the following: 25-34 years – 30%, 35-44 years – 40%, 45-54 years – 20%, 55-60 years – 10%. The group consisted of both men and women, with 60% of respondents being men and 40% being women, which contributed to greater representativeness of the sample.

The sample was based on clear criteria, which included at least 3 years of experience in agriculture. This allowed attracting respondents who have a sufficient level of knowledge and practical skills in this area. It is important to note that the sample was random, which significantly reduced the risk of bias in the study results and provided a more objective assessment of the data obtained. Thus, the results of the study can be considered reliable and applicable for further analysis in the agricultural sector.

These questions helped to gain a deeper understanding of which elements, such as the level of training of employees, technological equipment, labour organisation, and other factors, most affect the productivity of agricultural enterprises. The analysis of the answers to these questions provides an opportunity to determine key trends and problems in the field of labour resource management, and identify ways to optimise production pro-

cesses and improve the overall efficiency of agriculture. When conducting the survey, ethical standards for working with people were observed, in particular, informed choice of respondents and anonymity of their responses were ensured (Order of the era, 2005).

Computers (South Korea) and specialised statistical analysis software such as SPSS and Excel were used to collect and process the data. This facilitated the initial data processing and a detailed analysis of the results obtained. The following formulas were used for data analysis:

1. Average performance (1):

$$P = \frac{V}{N}, \quad (1)$$

where P – productivity; V – volume of production; N – number of employees.

2. Efficiency of using labour resources (2):

$$E = \frac{O}{R}, \quad (2)$$

where E – efficiency; O – production results; R – total labour costs.

The obtained data were analysed using correlation and regression analysis, which helped to identify the relationship between the qualifications of employees and the results of agricultural production. The analysis showed that the high level of qualification of employees has a positive impact on the food self-sufficiency of communities. The data show that communities with more skilled workers show higher production efficiency. In particular, it was observed that enterprises with highly qualified employees were characterised by greater productivity and stability in production. Thus, the study allowed assessing the importance of labour resources for the development of food self-sufficiency on the example of these communities, which emphasises the importance of investment in the training and development of workers in agriculture.

## ► Results

Table 1 shows the results of a survey that was conducted among respondents working in territorial communities of the Mykolaiv Oblast.

**Table 1.** Survey results

Question	Responses (%)	Number of respondents
What are the main factors that affect performance?	Technology (45%)	67
	Qualification (30%)	45
	Working conditions (25%)	38
How do you rate the impact of labour resources on your production activities?	Positive (70%)	105
	Neutral (20%)	30
	Negative (10%)	15
What are the qualifications of your employees?	High (50%)	75
	Average (35%)	53
	Low (15%)	22
Have new technologies been introduced at the enterprise?	Yes (60%)	90
	No (40%)	60

**Source:** compiled by the authors

Table 2 shows the composition of respondents by profession who participated in the study. This information is extremely important for a deeper understanding of the context of the results obtained, since different professions can have significantly different views on the role of labour

resources in agricultural production. In particular, among the respondents were farmers, agronomists, and employees of agricultural enterprises, which provided a variety of opinions, experiences, and approaches to human resource management.

**Table 2.** Composition of respondents by profession

Profession	Number	Percentage
Farmers	75	50%
Agronomists	38	25%
Employees of agricultural enterprises	20	13%
Technical specialists	10	7%
Others (not related to the agricultural sector)	7	5%
Total	150	100%

**Source:** compiled by the authors

This diversity of participants allows the study to get a more comprehensive picture of the efficiency of using labour resources in the agricultural sector and to identify possible problems and development prospects. Farmers, as direct producers, can share their practical problems, while agronomists who focus on scientific aspects can provide valuable recommendations for optimising processes. Agricultural workers, in turn, can express their opinions on working conditions and motivation, which are also important for a general understanding of the problem. Among the respondents who participated in the study, 70% had a higher education, which indicates a high level of qualification and knowledge of the participants. 20% of respondents received secondary special education, which also indicates that they have practical skills necessary to work in various fields. Only 10% of the respondents had a general education, which may indicate a diverse socio-economic background of the participants.

The study revealed a significant impact of labour resources on the productivity of agricultural enterprises in territorial communities of the Mykolaiv Oblast. Efficient use of labour resources directly affects production volumes, product quality, and competitiveness of

enterprises, which is critical for ensuring food security in the regions. The data collected shows that communities with more skilled workers show higher productivity rates. Respondents stressed that professional training and experience of employees have a positive impact on production efficiency, which confirms the importance of skills in working with new technologies. High productivity not only improves the financial results of enterprises, but also contributes to the development of the local economy, creating new jobs.

In the face of global challenges such as climate change and economic crises, efficient use of labour resources is becoming critical to the stability of the agricultural sector (Ismayilzada *et al.*, 2023). Adapting to new technologies and investing in employee training can be key factors in achieving sustainability in an unstable environment. Thus, the improvement of living conditions of the population and the socio-economic development of territories depend on the effectiveness of labour resource management in the agricultural sector (Table 3). This highlights the importance of an integrated approach to analysing and optimising the use of labour resources to ensure food self-sufficiency and the development of territorial communities.

**Table 3.** Productivity of agricultural enterprises in territorial communities (for the period from January to June 2024)

Community	Average productivity (kg/ha)	Number of qualified employees (%)
Kryvozerska	1,200	75
Pervomaiska	1,100	70
Arbuzynska	1,000	65

**Source:** compiled by the authors

The analysis showed that the level of qualification of employees directly correlates with production efficiency, which is critical for the economic development of regions. Improvement of the professional skills of workers can lead to a significant increase in the efficiency of the agricultural sector, increasing its competitiveness in the domestic and international markets. In the Kryvozerska community, where 75% of employees have a high level of qualification, the average productivity of agricultural land reached 1,200 kg/ha. This indicates the successful introduction of modern technologies, such as process automation and precision farming. In contrast, in the Arbuzynska community, only 65% of employees have the necessary skills, which led to a decrease in productivity of up to 1,000 kg/ha. This highlights the importance of investing in training, as insufficient skills of employees negatively affect production performance.

Pervomaiska community demonstrates Intermediate results: 70% of its employees have a high level of qualification, and the average productivity is 1,100 kg/ha. However, to achieve better results, it is necessary to focus on investing in training and upgrading production processes. This analysis confirms the importance of improving the skills of employees and introducing new technologies to achieve stable economic growth in the regions. The right combination of highly qualified labour resources with modern technological solutions is key to achieving maximum results in agriculture (Lopatynskiy *et al.*, 2023). When employees have the opportunity to use the latest technologies and equipment, it allows them to work more efficiently and with fewer errors. Along with this, technologies become less effective without qualified personnel who can properly configure and use them.

Investment in technological innovations not only increases productivity, but also contributes to the sustainable development of the agricultural sector as a whole (Strapchuk & Mykolenko, 2022). They allow businesses to adapt to changing market conditions and

climate, increasing their competitiveness. For example, in communities where field monitoring drones are implemented, productivity has increased by 20% and product quality has improved by 15% due to accurate crop monitoring (Table 4).

**Table 4.** Impact of technology on productivity

Community	Implemented technologies	Productivity up to (kg/ha)	Productivity after (kg/ha)	Productivity growth (%)	Product quality improvement (%)
Kryvoozerska	Field monitoring drones	1,000	1,200	20%	15%
Pervomaiska	Automated irrigation systems	880	1,100	25%	10%
Arbuzynska	Yield forecasting programmes	850	980	15%	12%

**Source:** compiled by the authors

The study also found that local initiatives, such as training and consultation programmes for farmers, significantly improve the skills of workers in the agricultural sector. Such programmes, implemented at the level of territorial communities, create a platform for sharing knowledge and experience. For example, farmers who participated in the programmes learned how to use automated irrigation systems, which allowed them to reduce water consumption by 30% and increase yields by 25%. Participation in training programmes allowed farmers to learn new environmental practices that reduce the use of chemical fertilisers and preserve soil fertility. It is important that these programmes also help farmers to master effective natural resource management strategies, such as crop rotation planning and soil monitoring. These results show that the development of local initiatives aimed at improving skills can significantly enhance agricultural efficiency. Programmes can include seminars, workshops, and practical training based on successful enterprises, which increases farmers' confidence in decision-making.

It is worth noting that investment in education and training leads to an increase in employment and income, which has a positive impact on the social structure of communities. It also helps to keep young people in rural areas by reducing migration to cities. Thus, the development of local initiatives is a key factor for achieving food self-sufficiency and sustainable economic development of territorial communities. By investing in educational programmes and supporting initiatives, communities can

create a solid foundation for the future, basing it on innovation, sustainability, and social cohesion (Nazarova *et al.*, 2024). Thus, the results of the study confirm that labour resources are a key factor in the development of food self-sufficiency of territorial communities. The high level of skills of workers, the use of new technologies and support for local initiatives contribute to improving agricultural productivity. These conclusions can serve as a basis for further research and practical recommendations on the development of the agricultural sector in Ukraine. The study revealed a significant impact of labour resources on the productivity of agricultural enterprises in territorial communities of the Mykolaiv Oblast. The data collected shows that communities with more skilled workers show higher productivity, which is crucial for ensuring food self-sufficiency.

The efficiency of using labour resources is a critical indicator for assessing the productivity of agricultural enterprises. The study analysed various aspects that affect this efficiency, in particular, the organisation of work, technological equipment, and total labour costs. The efficiency measurement helps to identify the potential for improvement in the agricultural sector. The study showed that enterprises that actively implement new technologies and organisational changes have a higher level of efficiency. For example, at the enterprises of the Kryvoozerska community, where training programmes for employees were implemented, the efficiency of using labour resources increased by 15% compared to previous year (Table 5).

**Table 5.** Efficiency of labour resources use in different communities (for the period from January to June 2024)

Community	Production results (O)	Total labour costs (R)	Efficiency (E)
Kryvoozerska	1,800	1,000	1.8
Pervomaiska	1,500	1,200	1.25
Arbuzynska	1,300	1,100	1.18

**Source:** compiled by the authors

The study also identified several key factors that affect the efficiency of using labour resources: employee qualifications – a high level of training of employees contributes to more efficient performance of tasks. Respondents noted that highly qualified employees learn new technologies and working methods faster. Technological equipment – the use of modern agricultural machinery and equipment allows reducing labour costs

and increasing productivity. For example, Process Automation has reduced the need for manual labour, which, in turn, has improved efficiency. Labour organisation – clear organisation of work processes and proper time management also have a positive impact on efficiency. Enterprises that have implemented time planning systems have noted a reduction in employee downtime and an increase in overall productivity.

Correlation analysis conducted as part of this study revealed a significant positive correlation between the skill level of employees and production results, which is confirmed by the correlation coefficient, which is 0.75. This indicates that professional development of employees has a direct impact on the efficiency of production processes. In addition, regression analysis, which was also performed, confirmed this trend, indicating

that a 10% increase in employee skills can lead to an 8% increase in productivity. These results, presented in Table 6, highlight the importance of investing in staff training and development to improve overall enterprise efficiency. Thus, organisations that strive to achieve high results in their activities should focus on improving the skills of their employees as one of the key success factors.

**Table 6.** Results of correlation analysis

Variable	Correlation coefficient
Employee qualifications	0.75
Introduction of new technologies	0.6
Labour organisation	0.5

**Source:** compiled by the authors

Thus, the results of the analysis clearly confirm that the efficiency of using labour resources is a key factor that directly affects the increase in agricultural productivity. Improving the skills of employees, which includes both theoretical training and practical training, and the introduction of new technologies, such as process automation and the use of modern agronomic practices, can significantly improve production results. In addition, organisational changes that involve optimising workflows and effectively managing teams also play an important role in improving overall productivity. These factors highlight the extreme importance of strategic investments in training and human resource development. Such investments not only contribute to improving the professional competence of employees, but also ensure sustainable development and food self-sufficiency of territorial communities. In turn, this can lead to an improvement in the economic situation of the regions, an improvement in the quality of life of the population and ensuring food security at a broader level.

Local initiatives play a key role in the development of agriculture in territorial communities, as they create a favourable environment for the introduction of new ideas and technologies (Mero *et al.*, 2023). These initiatives not only stimulate innovation, but also help to unite the efforts of local farmers, agricultural organisations and government agencies, which, in turn, ensures more efficient use of resources and optimisation of production processes. The study found that successful local programmes not only significantly improve the skills of workers, but also provide access to new technologies that can significantly improve agricultural productivity. In addition, such initiatives contribute to the development of cooperation between various participants in the agricultural sector, which allows the exchange of experience, knowledge and best practices. This, in turn, leads to an increase in the competitiveness of local producers in the market and an improvement in the quality of products, which is an important factor for the sustainable development of rural areas.

Training programmes were used among local initiatives. These programmes cover a wide range of courses, seminars and master classes aimed at improving the professional skills of employees in various industries. Such training events are organised by both local agricultural universities and private educational institutions, which

provides access to modern knowledge and practices. For example, the Pervomaiska community implemented a programme to train agronomists in new methods of growing crops, which included theoretical classes and practical trainings in the fields, which allowed participants to gain theoretical knowledge and practical experience in implementing innovative agronomic technologies. Within the framework of this programme, 10 seminars and 5 practical trainings were held in the fields. Participants received certificates confirming their qualifications and based on new knowledge, agronomists increased their yields by 15% in the following season.

Agricultural cooperatives play an important role in the development of agriculture, as they help pool farmers' resources to jointly purchase equipment, seeds, fertilisers, and other necessary resources (Shahini *et al.*, 2022). This, in turn, helps to reduce costs, increase production efficiency and provide more favourable conditions for all participants of the cooperative. For example, in the Kryvozerska community, due to the activities of agricultural cooperatives, farmers were able to reduce the cost of purchasing fertilisers by 20%, which significantly increased their profitability and allowed them to invest the saved funds in the development of their own farms. A cooperative was also created, bringing together 30 farmers who jointly purchased fertilisers and seeds. This reduced the cost of purchasing fertilisers by 20%, which significantly increased the profitability of farms. The funds saved due to the cooperative were reinvested in new equipment, which made it possible to automate production processes.

Local organisations actively promote the introduction of new technologies in production, which is an important step towards modernising the agricultural sector. For example, the Arbuzynska community implemented a project to introduce automated irrigation systems, which included the installation of 50 automatic irrigation systems on farmland, and trainings for farmers on the effective use of new technologies. As a result, yields increased by 25%, while water consumption decreased by 30%. The project became an example of successful use of innovative solutions, which helped to increase the competitiveness of local producers in the market.

A study conducted as part of an assessment of the effectiveness of training programmes showed that active

participation of employees in such programmes significantly improves their professional skills and competencies. In particular, during the survey, 80% of respondents from the Pervomaiska community took various advanced training courses, namely agronomy courses – focused on new methods of growing crops and managing agricultural land. Seminars on ecological farming – devoted to strategies to reduce the use of chemical fertilisers and the introduction of organic farming methods. Trainings on the use of the latest technologies, for example, training in working with drones for field monitoring and automated irrigation systems and financial management courses that covered the basics of accounting and budget

management in agriculture. These programmes have helped farmers to improve their skills, implement innovative practices, and significantly improve the productivity of their farms.

After the courses, they noted that their productivity in enterprises has increased. This indicates a positive impact of training on the overall level of work efficiency. Table 7 provides detailed survey results that illustrate the impact of training on employee qualifications, including various aspects such as improving professional knowledge, developing management skills, and improving teamwork. These data indicate that investment in training is important for ensuring the competitiveness of enterprises.

**Table 7.** Survey results on the impact of training on qualifications

Community	Percentage of employees who have been trained	Impact on efficiency (%)
Kryvozerska	70%	+30%
Pervomaiska	80%	+25%
Arbuzynska	60%	+15%

**Source:** compiled by the authors

Cooperatives, as a form of organisation, play an important role in farmers' lives, as they allow them to pool resources, which helps to reduce production costs. A study conducted in this area found that farmers working in cooperatives spend 20% less on purchasing seeds and fertilisers compared to those who are not members of cooperatives. This significant cost reduction opens up opportunities for farmers to focus on other important aspects of their business development, such as improving processing technologies, expanding their product range, and marketing. The introduction of new technologies through local initiatives also has a significant impact on improving agricultural productivity. For example, in the Arbuzynska community, crop yields increased by 25% due to automated irrigation systems. This was made possible by the active support of local organisations that provided farmers with the necessary equipment and training to effectively use new technologies. Such initiatives not only increase yields, but also help to reduce resource costs, as automation allows optimising irrigation and crop management processes.

Thus, the results of the conducted research confirm that local initiatives have a significant positive impact on the development of agriculture in territorial communities. Improving the skills of farmers, saving resources, and introducing new technologies contribute not only to increasing productivity, but also to improving the overall self-sufficiency of communities. These findings highlight the need to continue and expand such initiatives to achieve sustainable agricultural development and improve the quality of life of rural residents. It is important that public and private structures support these processes, because only through joint efforts can significant results be achieved in the development of agriculture.

### ► Discussion

The results of this study highlight the critical role of labour resources in ensuring food self-sufficiency of territorial communities, which is an important component of sustainable development. They support the findings of E. Antriyandarti *et al.* (2024), which emphasised the

importance of women's role in food security in the face of climate change. Women, as key participants in the agricultural sector, not only ensure food production, but also play an important role in transforming agricultural practices to meet new environmental challenges (Shyian *et al.*, 2023).

This connection was also supported by S. Baysan *et al.* (2024), who indicated agricultural wages and their impact on the development of rural communities. A high level of wages contributes to the attraction and retention of qualified personnel in agriculture, which, in turn, has a positive impact on the productivity and stability of rural economies. However, this study showed that in addition to gender aspects, socio-economic factors also play an important role, which were not emphasised by other researchers. In particular, the study by R. Ardana *et al.* (2024) considered traditional agricultural systems, but did not address the current challenges that these systems face in the context of globalisation and climate change. This indicates the need to integrate different approaches in further research to better understand agricultural challenges and develop effective strategies to overcome them.

The results of the study are also consistent with the findings of Y. Pan *et al.* (2024), which emphasised that farmers' entrepreneurship plays an important role in the development of agriculture and the economy. This confirms the idea of an innovative approach to agricultural development, which has been emphasised in many modern studies. In particular, such entrepreneurial initiatives not only increase productivity, but also stimulate the socio-economic development of rural areas, creating new jobs and ensuring the sustainability of local communities. In addition, the findings relate to the transformation of labour relations in the context of post-capitalism, which was analysed by G. Raj *et al.* (2024). This opens up new horizons for research aimed at studying alternative models of labour organisation in agriculture. In the face of rapid changes in the global economy and social environment, it is important to explore how new forms of cooperation and labour organisation can affect the productivity and well-being of workers in the agricultural sector.

Research conducted by E. Ammar *et al.* (2024), on digital agriculture, is also an important context for analysis, as it points to new technological approaches that can improve the efficiency of agricultural production. The introduction of digital technologies, such as data management systems, process automation, and the use of drones, can significantly optimise production processes, reducing costs and improving product quality (Zadorozhniuk, 2023). These innovations not only transform conventional farming practices, but also open up new opportunities for sustainable rural development in a global context.

The study by A. Chandio *et al.* (2024) on the relationship between energy, climate and agriculture highlights the need to integrate environmental aspects into agricultural policy. This study not only highlights the importance of the relationship between energy resources, climate change, and agricultural production, but also highlights the need to develop comprehensive strategies that consider these factors. Further research in this area is critical to achieving sustainable development, as it will help to understand how to optimise the use of natural resources, reduce the negative impact on the environment, and ensure food security for future generations.

The results of this study also correspond to the findings of D. Siregar *et al.* (2024), who pointed out the importance of choosing the appropriate leadership style to support sustainable agriculture. This aspect is extremely important, as the right leadership style can significantly affect the implementation of environmental sustainability strategies. Leaders who understand the needs and challenges facing the agricultural sector can more effectively implement innovative solutions that contribute to the conservation of natural resources and reduce the negative impact on the environment (Parkhomets *et al.*, 2023). The study by R. Kumar *et al.* (2024) highlighted the role of data analytics in agriculture, which can be useful for improving decision-making processes. The use of data analytics allows farmers to gain valuable information about production efficiency, cost optimisation, and risk management. This highlights the potential of modern technologies to improve the efficiency of the agricultural sector, which can lead to significant economic benefits and improved productivity.

In addition, X. Yu *et al.* (2024) highlighted the need to increase productivity as a strategy to promote green economic growth. This concept is extremely relevant in the face of global challenges related to climate change and the decline of natural resources. Increasing labour productivity in agriculture can ensure more efficient use of resources, which, in turn, will contribute to the sustainable development of the agricultural sector and maintain environmental balance (Penkova & Kharenko, 2023). Thus, the results of the study not only complement existing theories, but also open up new prospects for further research. This can serve as a basis for developing new strategies and initiatives that will promote sustainable agricultural development, integrate innovative technologies, and improve management practices in this important area.

Interaction between universities and businesses was considered by T. Nguyen (2024), emphasising the importance of human resource development in the context of the digital economy. This cooperation can be key for

training specialists who can introduce innovations in the agricultural sector, which, in turn, will contribute to improving the competitiveness and efficiency of production. In the context of the rapid development of technologies that are changing conventional processes, it is important that educational programmes meet the current requirements of the labour market, which would allow students to gain practical skills and knowledge necessary for a successful career (Novykova *et al.*, 2022).

M. Dubofsky & J. McCartin (2024) provided a historical context for the role of labour in shaping the economy, providing a deeper understanding of how historical factors influence current agricultural practices. This analysis helped to identify which long-established labour models can be adapted to new conditions, and what new approaches can be introduced to improve productivity and sustainable development of the agricultural sector. The study by R. Feng *et al.* (2024) analysed the impact of digital finance on labour demand in industrial enterprises, which can be useful for predicting the need for qualified personnel in the agricultural sector. This aspect is particularly important because the introduction of digital technologies in financial processes can significantly change the structure of labour demand, requiring new skills and knowledge from employees.

Consequently, the results obtained are integrated into a broader context, which helps to identify new areas for further development in this line. They open up opportunities for creating new educational programmes, adapting existing courses to modern market requirements, and for developing partnerships between academic institutions and businesses, which will help to improve the quality of training specialists in the field of agricultural technologies. The study by P. Chakraborty *et al.* (2024) focused on the impact of import competition and the role of contract labour, which is critical for understanding the dynamics of the labour market in the agricultural sector. The researchers note that the growth of import competition can significantly change working conditions, and affect the development of prices for agricultural products. This may indicate the need to adapt policies to support labour formalisation, which, in turn, will help to improve the socio-economic situation of workers and increase their legal protection.

O. Yahyoyevna & Z. Tatulovna (2024) emphasised the importance of economic stability, which is a major factor for ensuring the sustainable development of agricultural production, especially in the face of external challenges such as fluctuations in commodity prices, climate change, and global economic crises. The researchers emphasise the need to develop strategies that would support the stability of the agricultural sector, in particular, through investment in innovation and technology. The study by A. Karim & F. Said (2024) on the transformation of Malaysia's economy from resource-oriented to global pointed out how countries can use the agricultural sector to achieve competitiveness on the world stage. The researchers emphasise the importance of integrating agricultural production into global supply chains, which allows countries not only to increase their economic efficiency, but also to ensure food security. These results help to identify new areas for further research, in particular, in the context

of adapting strategies to global economic changes, which may include an analysis of the impact of technological innovations on the agricultural sector, and the study of social aspects related to changes in the labour market.

A study conducted by A. Kuzior *et al.* (2023) emphasised the critical importance of informatisation of innovative technologies for ensuring the stability of macroeconomic trends in a circular economy. This paper indicated that the integration of modern technologies can significantly affect the efficiency of agricultural production, which, in turn, will contribute to increasing productivity and sustainable development of the agricultural sector. B. Nosiroy and D. Fakhridinova (2023) proposed a number of strategies that can be effectively implemented to reduce product costs in agricultural clusters operating within the digital economy. The implementation of these strategies can significantly increase the competitiveness of local producers, providing them with the opportunity to reduce prices for their products and at the same time maintain high quality.

A. Luthin *et al.* (2023) assessed the social impacts resulting from the transition to a circular economy. They emphasised the importance of social aspects in the process of planning agricultural strategies, emphasising that the successful implementation of such strategies should consider not only the economic, but also the social needs and interests of local communities. The study by J. Rosak-Szyrocka *et al.* (2024) addressed quality management and value creation in the context of the digital economy. This paper opens up new horizons for integrating innovation into the agricultural sector, offering new approaches to resource management and improving production efficiency. Therefore, the results indicate the need to further study the synergy between technological innovation and economic efficiency in the agricultural sector. This will not only improve production indicators, but also contribute to the sustainable development of the agricultural sector as a whole.

### ► Conclusions

During the study, the key role of labour resources in ensuring food self-sufficiency of territorial communities of the Mykolaiv Oblast was determined. In particular,

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70% of respondents noted the importance of labour resources for increasing productivity in the agricultural sector. The main factors affecting efficiency were identified as technological innovation (45%), employee qualifications (30%), and working conditions (25%). The importance of technological innovation underscores the need for continuous implementation of new methods, such as process automation and the use of drones to monitor fields, which allows agricultural producers to optimise resources. Respondents also noted that investing in the skills of employees not only increases their productivity, but also contributes to the growth of the moral climate in enterprises, which, in turn, reduces staff turnover. These results highlight the need for a systematic approach to the development of labour resources in the agricultural sector.

It is recommended to organise advanced training courses for employees of the agricultural sector, which can significantly increase their productivity. It is also important to create more comfortable and safe working conditions for attracting and retaining personnel. In addition, it is necessary to actively introduce new technologies in agricultural production, which will increase the efficiency of using labour resources. The study has certain limitations, in particular, a limited number of respondents, which can significantly affect the generalisation of the results obtained. This may lead to insufficient representation of the data, which should be considered when interpreting the results. In addition, the focus on the Mykolaiv Oblast may not consider the specifics of other regions of Ukraine that have their own unique economic, social, and cultural characteristics. Further research may focus on investigating the impact of various models of human resource management on the productivity of the agricultural sector, which is extremely relevant in the context of modern challenges faced by the agricultural economy.

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### ► Conflict of interest

The authors of this study declare no conflict of interest.

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## Роль трудових ресурсів у формуванні продовольчої самодостатності територіальних громад Миколаївської області

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► **Анотація.** Метою дослідження було вивчення впливу трудових ресурсів на ефективність аграрного виробництва та забезпечення продовольчої самодостатності територіальних громад Миколаївської області. Методологія базувалась на результатах анкетування серед респондентів, що працюють у сільськогосподарському секторі. Використовувались статистичні дані для оцінки впливу трудових ресурсів на виробничу діяльність. Дослідження показало, що 70 % респондентів вважають трудові ресурси надзвичайно важливими для забезпечення їх виробничої діяльності. Це підкреслює значущість людського капіталу в сучасному бізнес-середовищі. Серед основних факторів, що впливають на продуктивність, 45 % респондентів зазначили роль технологій, які забезпечують автоматизацію процесів і підвищують ефективність виробництва. Крім того, 30 % респондентів вказали на кваліфікацію працівників, що свідчить про необхідність постійного навчання та розвитку кадрів для досягнення високих результатів. Ще 25 % респондентів вказали на умови праці, що включає в себе як фізичні, так і психологічні аспекти робочого середовища. Це свідчить про те, що розвиток трудових ресурсів безпосередньо пов'язаний із підвищенням ефективності агровиробництва, оскільки інвестиції в людей і їхнє навчання можуть суттєво вплинути на загальний успіх підприємств у цій сфері. Результати дослідження підтверджували важливість інвестицій у трудові ресурси та їх розвиток для досягнення продовольчої самодостатності. Поліпшення кваліфікації працівників і технологічних умов роботи можуть суттєво підвищити продуктивність аграрного сектора. Це дослідження має практичне значення для органів місцевого самоврядування та агровиробників, що прагнуть підвищити ефективність своєї діяльності

► **Ключові слова:** робоча сила; сільське господарство; економіка; ефективність виробництва; суспільство



UDC 332.12

## Strategies for regional disproportion management to restore economic security in the Ukrainian agricultural sector

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► **Abstract.** The study aimed to identify key threats to the Ukrainian agricultural sector in the context of the war and to develop proposals for overcoming them through effective governance, government support and infrastructure investment. The study was conducted based on an analysis of socio-economic indicators of different regions of Ukraine with a focus on the agricultural sector. The data collection covered the period from 2022 to 2023 and included indicators of unemployment, investment activity, agricultural sector productivity, and the effectiveness of government support programmes. A comparative analysis was conducted between the regions affected by the hostilities and more stable regions, and the impact of infrastructure investment on economic stability was also investigated. The study determined that the Ukrainian agricultural sector has been severely affected by the hostilities, leading to increased unemployment, reduced investment and widening economic gaps between regions. The highest losses were observed in regions bordering the conflict zone, such as Kharkiv and Dnipro regions. In these regions, investment activity has completely stopped, which has significantly reduced the productivity of the agricultural sector. At the same time, regions with more developed infrastructure performed better due to access to markets and financing. The study also demonstrated that state support had an uneven impact on different regions, with the

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most affected regions receiving insufficient support. The study results highlighted the importance of infrastructure investment and comprehensive state support to overcome regional disparities in Ukraine's agricultural sector and stabilise the economic situation in the face of the ongoing conflict

► **Keywords:** spatial inequality; stabilisation measures; balanced growth; resource potential; agricultural innovation

### ► Introduction

In Ukraine, regional disparities have become a substantial issue in socio-economic development, making it difficult to implement strategies to ensure sustainable growth. This phenomenon caused profound economic and social consequences, which, in turn, threatened the financial and economic security of the state. The research relevance is determined by several factors. Firstly, the Ukrainian economy has long been negatively affected by external and internal challenges, including military aggression, political instability and socio-economic difficulties. The regions that suffered the greatest losses from the conflict have faced difficulties in economic recovery, which has exacerbated regional disparities (Ivanov *et al.*, 2020). For example, the affected regions demonstrated significantly lower development indicators. Second, regional development disparities were complex and required a comprehensive approach to their analysis, as various factors, such as economic, social and political, influenced their development.

The importance of the topic is determined by the need to implement effective government strategies to overcome regional disparities, through investments in infrastructure, education, training and support for local initiatives. It is necessary to address the experience of European countries in the field of decentralisation and regional governance, accounting for the specifics of Ukrainian realities. The study identified key aspects of regional development and proposed practical solutions to improve national economic security, which is relevant in the face of current challenges. Determination of regional disparities is an important step towards sustainable development and improving the quality of life in all regions of Ukraine.

The main problem of the study was the low level of Ukrainian economic security due to its vulnerability to external threats and dependence on international financial institutions. L. Mohilevskyi *et al.* (2021) proposed a method for determining an integral indicator of economic security, which can be used to assess the economic situation and identify problem areas. However, the study does not cover adaptive mechanisms of economic policy to respond quickly to challenges. The study covered the impact of the war on Ukraine's agricultural sector, including the destruction of land and the blockade of exports. Considerable attention was devoted to losses and the necessary investments to restore the industry. A.A. Román (2024) emphasised that recovery requires large financial resources and demining, which is a key challenge for land reclamation.

The study addressed the economic recovery and the exacerbation of regional inequalities due to the war. A. Kochnev *et al.* (2024) emphasised the importance of Ukrainian integration into European economic chains as a means of reducing disparities. However, the problem of uneven use of resources due to differences in administrative capacity remained. The study focused on economic imbalances and risks of regional development. I. Storonyanska *et al.* (2023) emphasised that regional development

depended on an agricultural orientation, which exacerbated disparities and instability. The gap concerned insufficient research on the long-term effects of economic orientation. The study addressed the challenges of the agricultural sector in the context of globalisation. I. Koshkaldá *et al.* (2023) studied the impact of global changes on agriculture and the need to create an economic security strategy for stability and development. The gap was the insufficient analysis of the adaptation of the agricultural sector to global challenges.

The study raised the issue of crisis dynamics of regional disparities. O. Shevchenko *et al.* (2023) developed disaster forecasting models, although gaps in the study of their adaptation to changing external factors were present. The problem of regional disparities in Ukraine is relevant due to the impact of military operations on the country's socio-economic development. D. Rupp (2023) emphasised that the war increased disparities between regions due to different levels of infrastructure development and economic activity. The results of these studies showed that the regions most affected by the conflict showed a decline in economic performance, while other regions were able to maintain some stability due to better infrastructure. Gaps in the research include the lack of strategies to effectively rebuild the economies of the affected regions and invest in their infrastructure.

The problem of regional disparities in the agricultural sector of Ukraine is relevant due to the impact of military operations on the country's economic security. Research on this topic was conducted by such authors as O. Hnatkovich *et al.* (2023), who studied modern approaches to managing Ukraine's regional development in the context of the European experience of decentralisation and governance. They noted the imperfection of the existing system of regional governance, which leads to a decrease in the effectiveness of public policy at the regional level. Gaps that require further research include the development of new approaches to financial support for regions and the adaptation of European experience to Ukrainian conditions.

The study aimed to develop ways to overcome the disparities with a focus on ensuring socio-economic stability and improving the living conditions of the population. The main objectives were to analyse the reasons for these differences (economic, military, political, social, geographical), their impact on the national financial and economic security, and to develop recommendations for investments in infrastructure, education, agriculture and other key sectors to reduce regional imbalances and ensure sustainable development.

### ► Materials and methods

A comprehensive approach was used in this study, consisting of several stages of analysis and the use of various methodological tools to examine strategies for managing regional disparities in Ukraine. The study was conducted

over two years, from 2022 to 2023, in different regions, including Kyiv, Kharkiv, Lviv, Odesa, and Dnipro oblasts. The choice of these regions was based on their strategic importance for Ukrainian economic security and differences in socio-economic conditions. Kyiv region represents the capital region, which is the administrative and economic centre of the country. Kharkiv and Dnipro regions were heavily affected by the hostilities and the destruction of infrastructure, making them key to studying the agricultural sector in wartime. Lviv and Odesa regions remained stable yet are crucial for agriculture and exports due to their logistical capabilities. This can be used to compare the effects of the war in different regions and develop comprehensive recommendations to overcome regional disparities.

The first stage of the research was to collect data from official sources. The main source of information was the State Statistics Service of Ukraine (n.d.). The data collected included gross domestic product (GDP), unemployment, income, social conditions, investment, and other important socio-economic characteristics (Minfin, 2024a; 2024b; 2024c). This stage provided the basic framework for further analysis of regional disparities and allowed for the identification of key challenges faced by different regions. The second stage was a comparative analysis of socio-economic indicators between the selected regions. Statistical analysis methods were used for this analysis. Software tools included Excel for analysing the collected data. The focus was on employment, investment in the agricultural sector, farm productivity and changes in economic activity in different regions. The collected data were compared with each other, which identified regional disparities and general trends.

The third stage of the study assessed the impact of investment in the regions, including an analysis of how investment flows changed before and after the war. The study determined that investment activity in the affected regions declined significantly, which led to a decline in agricultural productivity and an increase in unemployment. Methods of state investment programmes in restoring the agricultural economy in the regions were addressed (Ministry of Economy of Ukraine, 2023; Poltavazernoproduct develops irrigation..., 2024). One of the key stages of the study was to assess the effectiveness of state support for the agricultural sector. The mechanisms of state aid to small and medium-sized farms, as well as programmes aimed at restoring the infrastructure of the agricultural sector in the most affected regions, were studied. For this purpose, data on the number of subsidies, soft loans and other measures aimed at supporting the agricultural sector in the context of military operations were used. The study found significant differences in the levels of support across regions, which led to an uneven distribution of resources. Moreover, in the regions that suffered the greatest losses due to the hostilities, government programmes were less effective, which requires a review of existing policies. At the final stage, the main challenges faced by farmers and other agricultural market participants in the context of the war were assessed. Particular attention was devoted to the analysis of the impact of hostilities on access to markets, transport infrastructure and opportunities for agricultural business development.

## ► Results

GDP is the main indicator of economic activity in a region. Studies show that there are significant differences in GDP levels between regions in Ukraine. For example, the Kyiv region has the highest GDP per capita, amounting to UAH 431,616 in 2021, due to the development of high technology and infrastructure (State Statistics Service..., n.d.). At the same time, regions such as Dnipro and Odesa regions have significantly lower figures, indicating insufficient economic activity and the need for additional investment. According to the study by A.S. Poltorak *et al.* (2023), regions with active infrastructure development, such as the Odesa region, demonstrate positive economic growth dynamics. The main factor affecting social stability is the unemployment rate. The unemployment rate in Ukraine varies from region to region. For instance, the unemployment rate is expected to reach 40% in the Kharkiv region in 2024, which is a worrying sign for the social development of the region (Davydova, 2023). Social tensions, increased crime, and out-migration are on the rise due to high unemployment. Notably, low living standards are often observed in areas with high unemployment, which underscores the need for employment support programmes.

The standard of living in the regions is determined by the income of the population. Regions with the highest investment in the economy, such as Kyiv and Kharkiv regions, have higher average per capita incomes, according to the Ministry of Economy of Ukraine. The average monthly income in the Kyiv region in 2024 is approximately UAH 21,000 (Tupalska, 2024), while in the Kharkiv region, it is only about UAH 15,000 (Svilenok, 2024). This indicates a significant inequality in economic development between the regions. Access to social services, such as education and healthcare, also affects the overall level of development in a region (Zotaj *et al.*, 2024). Higher levels of access to high-quality social services are observed in regions with better infrastructure and high economic development. Studies show that the quality of education and healthcare services is better in regions with higher income levels. This underscores the importance of investing in social infrastructure to improve the overall standard of living. Thus, the analysis of socio-economic metrics shows that regional disparities in Ukraine are a significant issue that requires a comprehensive approach to address. These metrics can be used to identify the strengths and weaknesses of the regional economy, which is important for the development of public policies. The collected data and findings can be used to develop plans aimed at improving social stability and economic security in Ukraine.

Ukrainian overall stability depends on domestic economic security. Ensuring economic security is a priority for the government and society in the face of current challenges, such as military conflicts, globalisation and internal problems. This means the ability of the state to continue to develop, preserve its independence and protect its national interests from threats from external and internal sources. Military conflict is a major threat to economic security, as it directly affects economic activity, investment and consumer sentiment (Shahini *et al.*, 2022). War destroys infrastructure, disrupts businesses, and reduces the number of jobs, leading to unemployment and social tensions. Economic dependence on external partners is

another significant threat. Reducing dependence on imported goods, in particular energy, is essential for Ukraine, as this could negatively affect economic stability in the event of changes in global prices. Various metrics are used

to assess economic security in Ukraine. GDP, unemployment and inflation are important (Table 1). These indicators help determine the state of the national economy and its ability to respond to challenges.

**Table 1.** Key indicators of economic security of Ukraine 2023

Value	Value
GDP (million UAH)	5.518062
Unemployment rate (%)	10
Inflation (%)	12

**Source:** Minfin (2024a; 2024b; 2024c)

This table demonstrates that the national GDP remains stable, but unemployment and inflation need to be urgently controlled. High unemployment can lead to social problems, while inflation reduces the purchasing power of the population, which negatively affects the overall economic situation. To improve economic security, Ukraine needs to develop comprehensive strategies. It is necessary to address a variety of approaches that can significantly impact the stability of the economy. These include the active introduction of innovative technologies that can increase productivity and reduce costs in key industries. It is also necessary to create a favourable investment climate that will attract capital for the development of strategically important sectors.

Effective management of natural resources and energy efficiency should also be priorities. Ukraine should invest in green development, which will not only reduce dependence on imported energy but also create new jobs in environmentally friendly industries. Training and retraining programmes will contribute to the development of human capital, which is necessary to meet the needs of the labour market in a rapidly changing environment. Table 2 demonstrates key recommendations for improving Ukrainian economic security. To ensure sustainable development and increase economic stability, several measures need to be taken to diversify the economy, support small businesses, invest in infrastructure and develop human capital.

**Table 2.** Recommendations for improving economic security

Recommendation	Description
Diversification of the economy	Stimulation of the development of new sectors, such as green energy, IT, and agriculture
Small enterprise support	Providing financial support, including loans and consulting programmes
Investments in infrastructure	Modernising transport and energy infrastructure to improve economic efficiency
Human capital development	Investing in education, training and retraining to improve the skills of the workforce

**Source:** K. Miyamoto & E. Chiofalo (2017)

Diversification of the economy is an important step to reduce dependence on single sectors. This can be achieved by stimulating innovative industries, such as green energy, information technology and agricultural exports, through tax incentives and government support for start-ups and investors. Support for small businesses should include expanding access to finance through government lending programmes and advisory services. Establishing business incubators in the regions could stimulate local entrepreneurship and help create new jobs. Investments in infrastructure are a key factor in improving economic efficiency. Transport and energy infrastructure needs to be modernised to improve logistics and ensure energy sustainability. This, in turn, will help reduce energy costs and improve overall economic productivity.

Human capital development is another important component of economic security. Investments in education and training, including retraining programmes for adults, will help to improve the skills of the workforce, which is essential for the development of new technologies and innovative industries. Thus, to ensure Ukrainian economic security, it is necessary to take specific measures to diversify the economy, support small businesses, invest in infrastructure and develop human capital. These actions will ensure the national stable development, improve living standards and reduce the impact of external and internal challenges on the economy. Other important economic factors include international trade and investment, which may also be at risk due to political instability. Table 3 demonstrates the main indicators of the impact of energy prices on the Ukrainian economy.

**Table 3.** Impact of energy prices on the Ukrainian economy in 2023

Value	Values before changes	Value after changes	Percentage change (%)
Gas price (UAH per 1000 m <sup>3</sup> )	7.000	9.000	+28.57
Oil price (UAH per barrel)	4.000	6.500	62.5
Inflation (%)	10	12	+20

**References:** Ministry of Economy of Ukraine (2024a)

This table shows that rising energy prices have a direct impact on inflation in Ukraine. Higher energy prices lead to higher production costs, which affects consumer prices. The political situation in the international arena also has a crucial impact on Ukrainian economic security.

Conflicts in neighbouring countries can lead to increased tensions with trading partners. Diplomatic sanctions and political instability can significantly limit business opportunities. Table 4 shows the main political factors affecting Ukraine's economic security.

**Table 4.** The impact of political factors on Ukrainian economic security 2023

Factor	Description	Potential impact
Sanctions	Import/export restrictions	Decrease in trade volume
Political instability	Conflicts in the region	Reduced investment
Foreign policy	Diplomatic relations	Impact on economic cooperation

**Source:** National Institute for Strategic Studies (2023)

The table highlights that political factors can have a significant negative impact on Ukrainian economic security. Sanctions could lead to a decrease in foreign trade, which would affect the overall economic situation. Social aspects, such as living standards, employment and access to education, also affect economic security. Social tensions caused by high unemployment or poverty can lead to protests and instability (De La Llave *et al.*, 2022). Environmental factors, such as climate change and natural disasters, can affect agriculture and the overall economy. For instance, droughts or floods can reduce yields, which can negatively affect food security. A.S. Poltorak *et al.* (2023) noted that integration into global economic processes and adaptation to new conditions are critical to strengthening a country's economic security. Developing strategies that incorporate global challenges can ensure sustainable development and economic stability.

Thus, the impact of global factors on Ukrainian economic security is multifaceted and complex. Economic, political, social and environmental factors interact with each other, creating both threats and opportunities for development. To ensure its economic security, Ukraine needs to adapt its strategies to the changing conditions of the global economy, invest in infrastructure, support small and medium-sized businesses, and work to improve social conditions. This will help reduce the national vulnerability to external threats and ensure sustainable development in the face of current challenges.

The restoration of Ukrainian economic security depends on the elimination of regional imbalances in the agricultural sector. Food security, employment, and social stability are ensured by the agricultural sector, which makes up a significant part of the economy (Biyashev *et al.*, 2024). However, the social, economic and environmental disparities that exist in different regions pose significant obstacles to the development of this sector. The existing disparities in economic performance between Kyiv, Kharkiv, Lviv, Odesa and Dnipro regions need to be addressed immediately, as they could lead to social tensions, increased poverty and out-migration. The main strategies for managing regional disparities include support for small and medium-sized farms, investment in infrastructure, diversification of production, and the implementation of environmental initiatives.

As they make up a significant part of agricultural production, contributing to food security, employment and rural development, support for small and medium-sized farms is vital for the development of the Ukrainian

agricultural sector. Financial resources, educational programmes, advisory services and infrastructure can be part of strategies to support small and medium-sized farms. Access to finance is an important part of supporting small and medium-sized farms. This includes providing preferential terms for obtaining financing, as well as grants and loans. Many programmes in Ukraine help small and medium-sized enterprises. For instance, farmers can obtain funds to purchase seeds, machinery and other inputs for their farms through microcredit programmes. Programmes such as "Gardening" or "Livestock" can provide interest-free loans for certain activities, which helps to develop the industry (Ukraine Plan 2024-2027, 2024).

Farmer training is an important aspect of supporting small and medium-sized farms. Education and training can have a significant impact on the productivity and efficiency of farmers. Training programmes are being implemented in Ukraine that cover agronomic practices, management skills and the use of modern technologies. These programmes can be provided by agricultural universities, farmers' associations and government agencies. Small and medium-sized farms participating in the "eRobota" ("digital job") programme are substantial in Ukrainian economy by receiving grant support for the development of processing enterprises. In 2023, these enterprises contributed more than 1 billion UAH in taxes to the budget, which demonstrates their importance to the economy. In total, since the launch of the New Level grant programme for processing enterprises, 633 enterprises have received grant support totalling UAH 3.2 billion. Deputy Minister of Economy of Ukraine Nadiia Bihun noted that Ukrainian businesses are beginning to actively use external financing and government instruments for their development. This is a crucial practice that has already been successfully applied in the European Union. Grant programmes not only support business but also stimulate economic development in general, as they create new jobs and contribute to the growth of value-added production. Among the grant applicants, 77% are legal entities, 17% are individual entrepreneurs, and 5% are individuals. Businesses mostly use the grants to purchase equipment (78%), as well as to put it into operation (12%) and to deliver equipment (9%). This approach is extremely effective, as one invested hryvnia generates about 20 hryvnias in output, which confirms the high profitability of such investments (Ministry of Economy of Ukraine, 2024b).

Advisory services are another important element of support. Farmers can receive advice on crop selection,

tillage techniques, product marketing and management practices. These services can be provided by specialists from agricultural universities, research institutes or private consultants. Access to such services can help farmers make more informed decisions and improve their performance. Infrastructure development is also a relevant factor in supporting small and medium-sized farms. Investments in roads, warehouses, irrigation systems and other infrastructure can significantly improve the environment for agribusiness. Modernising the road network reduces the cost of transporting products and improves access to markets. It is also necessary to create cooperatives that can pool farmers' resources to share machinery and market products.

Farmers should actively participate in government programmes for the development of the agricultural sector. This may include participation in grant competitions that provide funding for innovative projects or in sustainability support programmes that offer resources for the implementation of environmentally friendly technologies. Farmers should be aware of the opportunities available and take advantage of them. For instance, Astarta-Kyiv agricultural holding is actively implementing environmental initiatives aimed at reducing its environmental footprint. The main areas of focus include reducing greenhouse gas emissions by 10% by 2025, developing bioenergy using biogas plants, and rational use of natural resources. Astarta (2020) is also committed to the reduction of water and agrochemicals, which contributes to environmentally friendly production and biodiversity conservation.

Overall, support for small and medium-sized farms is vital for the development of the Ukrainian agricultural sector. State support, educational programmes, advisory services and infrastructure development can ensure sustainable development and significantly increase the competitiveness of farmers. Farmers can receive assistance in overcoming current challenges and reducing regional disparities if they have access to financial resources and participate in development programmes. Investments in the infrastructure of Ukraine's agricultural sector are critical to ensuring economic security and sustainable development of the region (Radchenko *et al.*, 2023). In 2023, Ukraine actively worked to attract investment in infrastructure despite the challenges posed by the war. One of the key areas was the creation of a war risk insurance system, which made it much easier for investors to invest in projects in Ukraine. This helped attract 2.9 billion USD in foreign direct investment in the first eight months of the year, which was an unexpected result even for international experts.

Successful examples of investment include Bayer's EUR 60 million plant in the Zhytomyr region and King-span Group's USD 280 million project to build a construction materials plant. In addition, Ukrainian companies

such as Astarta-Kyiv continue to develop, having signed a USD 60 million deal to build a soybean processing plant. Moreover, a new flour milling complex by Volyn-Zernoproduct was launched in the Volyn region (Ministry of Economy of Ukraine, 2023). Investment in transport infrastructure is a priority. Modernising roads, building new transport arteries and improving rail connections can significantly improve logistics processes. For instance, investments in the repair and construction of new roads can shorten delivery times, reduce fuel costs, and improve the overall level of service to farmers (Tupalska, 2024).

The irrigation system is another important piece of infrastructure that is critical for agriculture, especially in the arid regions of Ukraine. Investments in modern irrigation systems not only increase yields but also ensure the sustainability of production in the face of climate change (Zibtsev *et al.*, 2024). For instance, Poltavazernoproduct Investment and Industrial Company Limited Liability Company are actively working on the development of irrigation systems within the Gradyzha Irrigation System in the Poltava region. This association of water users, Hradzka, can provide irrigation for an area of over 8,000 hectares, of which 6,700 hectares are currently under irrigation. Every year, the farmers modernise the irrigation system by replacing old metal pipelines with plastic ones and rebuilding pumping stations. In 2023, the company will grow sugar beet, hybrid corn and soybeans on an area of almost 1,050 hectares under irrigation. The company started implementing drip irrigation in 2015 on an area of 300 hectares, and since then has upgraded 1.5 km of the state canal and launched two pumping stations. Currently, there are 8 sprinklers in operation, operated by 15 hydraulic engineers. To ensure their efficient operation, about 10 km of communications were restored and built over the year (Poltavazernoproduct develops irrigation..., 2024).

Energy infrastructure also requires attention. Investments in energy systems such as electricity grids and renewable energy sources can reduce energy costs for farmers. Wind and solar energy projects are being actively developed in Ukraine, which can provide farmers with cheap and clean energy. This, in turn, reduces production costs and increases the overall competitiveness of the agricultural sector. To implement investment projects in agricultural infrastructure, it is necessary to ensure transparency and accountability in the use of public funds. The State Programme "Agrarian Investments" envisages the attraction of both public and private financing, which can form the basis for the implementation of infrastructure projects in the agricultural sector. Such investments will not only increase the efficiency of agriculture but also create new jobs, which will contribute to the social development of the regions. The volume of investments is shown in Table 5.

**Table 5.** Investment in agricultural infrastructure 2023

Region	Investment volume (million UAH)	Key areas of expenditure
Kyiv region	120	Modernisation of roads
Kharkiv region	90	Water supply
Lviv region	70	Irrigation systems
Odesa region	60	Logistics
Dnipro region	80	Energy networks

Source: World Bank (2023)

Thus, investment in infrastructure is essential for the development of Ukrainian agriculture and overcoming regional disparities. Modern transport, energy and utility infrastructure create the conditions for efficient farming, reducing production costs and providing access to markets. In the face of current challenges, such as climate change and global economic crises, investments in agricultural infrastructure are becoming particularly important for ensuring sustainable development and the economic security of the country. Managing regional disparities in Ukrainian agriculture through social policies is crucial for improving the quality of life and ensuring stability in rural areas. These include measures aimed at improving access to education, healthcare and social support, which are essential for the development of human capital. Access to high-quality education is needed to improve the level of professional skills of the population. Modernisation of rural educational institutions, teacher training and the provision of modern teaching materials can have a significant impact on the quality of education. Youth will be attracted to agriculture through training programmes that meet the needs of the agricultural sector.

The example of the "Faini Gazdy" cooperative association in the Ternopil region demonstrates how cooperation can contribute to the development of local farms. The cooperative unites more than 16 cooperatives, growing berries, honey, medicinal plants and grain. The introduction of the latest technologies, such as shock freezing of berries, allows the cooperative to export its products to European markets. This is an example of how cooperation can reduce costs and increase the competitiveness of small farmers, helping to reduce regional disparities (Panasyuk, 2021). As part of its 2030 healthcare development strategy, Ukraine committed to improving access to healthcare services in rural areas. This includes the creation of mobile medical teams, the development of telemedicine and the strengthening of primary healthcare, which allows patients to receive medical care closer to home. The implementation of preventive programmes and an epidemiological monitoring system is aimed at combating the main diseases affecting the rural population. In addition, the drug reimbursement programme facilitates access to medicines, which helps reduce social inequality (Healthcare system development..., 2022).

KSG Agro has adapted to the new conditions caused by the war by implementing strategic changes in its operations. The company increased its production capacity by 20%, increased the number of pigs by 16% and expanded its supply geography by 23%, including the affected regions such as Kharkiv, Zaporizhzhia and Kherson. This is an example of how agribusinesses can successfully adapt to challenges and maintain economic stability even in difficult conditions (Fairy-tale pork: Serhiy..., 2023). Economic strategies are aimed at increasing the productivity of the agricultural sector and its competitiveness. Diversification of production is an important element in reducing regional disparities. Reducing dependence on certain crops and developing new areas, such as organic farming or medicinal plant production, can increase the resilience of the agricultural sector to market changes. This will allow farmers to adapt to changing conditions and reduce the risks associated with price fluctuations.

The U.S. Agency for International Development's AGRO and AgriLab support programme is also an important tool for improving the efficiency of the agricultural sector. The programme makes precision farming technologies more accessible to small and medium-sized enterprises, helping them to optimise their use of resources and increase yields. This is especially important in times of war when it is necessary to maintain food security and ensure the resilience of the agricultural sector (New support programme..., 2024). Thus, social and economic strategies are interlinked to manage regional disparities in Ukrainian agriculture. Supporting small and medium-sized farms, investing in infrastructure, diversifying production, and improving access to education and healthcare services will increase the sustainability of the agricultural sector, improve living standards, and reduce social and economic inequalities in the regions. This type of strategy requires a careful approach and the active participation of all stakeholders, such as local communities, government agencies and civil society organisations.

Strategies for managing regional disparities should be incorporated into government policy to ensure the sustainable development of Ukraine's agricultural sector. This will require a comprehensive approach, the involvement of all stakeholders and the active participation of civil society in the development and implementation of programmes. Only in such a situation can the existing divisions be overcome and the country's economic security be ensured.

### ► Discussion

The study of regional disparities in Ukrainian agriculture highlights the significant impact of the hostilities on economic security, especially through rising unemployment and declining investment. These factors exacerbate economic imbalances between regions and threaten the stability of the agricultural sector, which requires immediate implementation of government support strategies. Despite some positive assessments of the potential development of farms, particularly small and medium-sized businesses, the real challenges lie in difficulties with financing and insufficient infrastructure. To overcome these challenges, a comprehensive approach is required, including investments in infrastructure, support for local initiatives and regional strategies.

The study of regional disparities in Ukrainian agriculture confirms the significant impact of the war on economic security, including increased unemployment and reduced investment, which is consistent with the findings of O. Dovgal *et al.* (2024). The need for state support for small and medium-sized farms for the stability of the sector is highlighted, which is also emphasised by these authors. However, this study emphasises the serious difficulties with financing, pointing to real challenges for farmers. This situation contrasts with the more optimistic views of other studies. Thus, the results emphasise the importance of a comprehensive approach to addressing regional disparities and identifying barriers that need to be addressed urgently.

The study addressed the issue of regional disparities in Ukraine's agricultural sector and their impact on economic security. Aid for Trade (2024) analyses international support to developing countries through trade cooperation. Both studies emphasise the importance of economic

growth. This study highlighted government strategies and investment in Ukraine's infrastructure, while Aid for Trade discusses global trade and the development of small and medium-sized enterprises. The main difference is in the geographical context: this study focuses on Ukraine, while Aid for Trade looks at global processes. Also, the second study pays attention to the impact of the digital economy and e-commerce, which is not the case in this study.

This study addressed the problem of regional disparities in Ukraine and their impact on the agricultural sector. It emphasises the need for investment in infrastructure to overcome these imbalances and improve the country's economic security. It focuses on the development of government strategies to address economic imbalances, through support for small and medium-sized businesses in the agricultural sector. The second study, conducted under the auspices of the World Bank (2021), examines the economic situation in Uganda after the COVID-19 pandemic. The study highlights the need to implement sustainable agricultural practices and natural resource management to ensure green growth and reduce poverty. The document discusses measures to mitigate the effects of the pandemic, including investments in agricultural development and support for small businesses. Commonalities between the two studies are that they both emphasise the importance of investment in infrastructure and sustainable development approaches. They emphasise the need to address disparities through government strategies that focus on regional development. However, the difference lies in the geographical context and focus: this study focuses on Ukraine's agricultural sector, while the World Bank study covers Uganda's overall economic challenges and approaches to post-pandemic recovery through natural resource management and agriculture.

A. Poltorak *et al.* (2022) studied the processes of improving the monitoring of the state's economic security in the context of global instability. They emphasised the need to modify existing mechanisms due to the impact of hostilities and the COVID-19 pandemic. The authors noted that the economic security of the state includes nine main subsystems, the indicators of which should be revised following current conditions. The main recommendations of the study are to systematically review the weighting of indicators, use objective assessment methods, and update the list of indicators to reflect changes in the structure of the economy and global instability. B. Shiferaw *et al.* (2014) explored the issue of drought vulnerability and ways to increase livelihood resilience in sub-Saharan Africa through technological, institutional and policy solutions. They emphasised that sub-Saharan African economies are particularly vulnerable to climate change, where drought is one of the most serious contributors to hunger and malnutrition in the region. This study shows that the overall impact of drought depends on the ability of a country or region to recover from such events, accounting for social, economic and environmental factors. The researchers reviewed existing drought risk management strategies, including both *ex ante* (preventive measures) and *ex post* (response strategies). They emphasised the need to strengthen technological, policy and institutional measures to minimise the negative effects of drought on the most vulnerable households and regions.

V. Shebanin *et al.* (2023) analysed the impact of closed-loop technologies on the economic security of regions, which is similar to this approach to studying economic security in the agricultural sector. Although the focus of this study is more on socio-economic disparities caused by military operations, both studies emphasise the importance of sustainable regional development through economic and environmental factors. Another common feature is the focus on regional aspects of development, which demonstrates the importance of local economic security in the national context. However, the differences lie in the methodological approaches, for instance, V. Shebanin *et al.* addressed the introduction of closed-loop technologies as a tool for achieving economic sustainability, while this study focuses on analysing the impact of military operations on the socio-economic situation in the regions. Moreover, V. Shebanin *et al.* addressed environmental aspects, while this study focuses on financial and social issues on supporting small and medium-sized farms in the context of war.

The Organisation for Economic Co-operation and Development (2016) analysed food security and nutrition challenges in Cambodia, focusing on the uneven distribution of policy outcomes across different regions of the country. The main challenges include the lack of coordination between different levels of government, limited resources and the capacity of local authorities. Of particular importance is the issue of coordination between national and subnational structures, where there is often a lack of mechanisms for effective interaction. Cambodia also faces economic and natural crises that have a significant impact on food security. For instance, the increase in rice prices in 2008 significantly reduced the purchasing power of the poor, which negatively affected their food security. Notably, Cambodia is in dire need of infrastructure to support the agricultural sector, as well as integrated programmes aimed at improving the welfare of the population.

K. Huk & A. Zeynalov (2022) analysed regional disparities and economic growth in Ukraine, focusing on socio-economic inequalities between regions that have increased significantly in recent decades. This study shared some similarities with the present study, as both examined regional disparities in Ukraine and their impact on the country's economic security. The main factors that the authors of the study focused on were natural resources, industrial and agricultural production, government spending, and migration. However, the difference was in the methodology and focus of the studies. While this study focused on the impact of the war on the agricultural sector and support for small and medium-sized farms, K. Huk and A. Zeynalov emphasised the general economic disparities between the regions of Ukraine, including the impact of natural resource allocation and public investment. In addition, they investigated the impact of uneven development between the capital and other regions, which was not the focus of this study.

The study highlighted that regional disparities in Ukraine's agricultural sector are significantly deepening due to military actions, which negatively affect the country's economic security. Rising unemployment, declining investment, and lack of adequate infrastructure support pose additional challenges to the sector's sustainable

development. The need to urgently implement comprehensive government strategies aimed at supporting small and medium-sized farms is obvious, as they play a key role in ensuring food security and economic recovery. It is also important to improve financial support, which will be the basis for overcoming disparities between regions. Thus, a comprehensive approach that includes investments in infrastructure, state support for farmers and the reduction of economic barriers will stabilise the agricultural sector and improve Ukrainian economic security.

### ► Conclusions

The study of regional disparities in the Ukrainian agricultural sector has confirmed the importance and complexity of the problems faced by this sector in the context of war and economic instability. The study revealed that the war significantly affected Ukrainian agriculture, especially in the regions where hostilities are taking place. Limited production capacities and reduced access to markets have led to an increase in unemployment and a drop in investment activity, creating significant regional disparities. The key challenge is to rebuild infrastructure, which remains critical for the sustainable development of agriculture. To stabilise the situation, the government should focus its efforts on supporting small and medium-sized farms by providing loans and grants, as well as implementing government support programmes. The prospects for the recovery of the agricultural sector lie in attracting international investment, modernising infrastructure and introducing

new technologies, which will help to overcome regional imbalances and restore economic security in Ukraine. Effective management of the agricultural sector is an important element of the country's overall economic development strategy. Overall, the study emphasises the need for urgent and coordinated measures to stabilise Ukraine's agricultural sector and overcome regional imbalances.

The study had several limitations. First, the ongoing hostilities have significantly limited access to some regions, making it difficult to obtain accurate data on the socio-economic situation in these areas. The absence or destruction of infrastructure in many regions made it difficult to access basic information, which may have affected the completeness of the analysis. Secondly, due to the war, official statistics were often incomplete or delayed, which could have affected the accuracy of the assessment of the agricultural sector. Despite these limitations, the study provided important information for developing strategies to address regional disparities. Future research should focus on the long-term economic consequences of the war and the potential for the agricultural sector to recover through international investment and the introduction of innovative technologies.

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### ► Conflict of interest

The authors of this study declare no conflict of interest.

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## Стратегії управління регіональними диспропорціями для відновлення економічної безпеки в аграрному секторі України

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► **Анотація.** Метою дослідження було виявлення ключових загроз для аграрного сектору України в умовах війни та розробка пропозицій для їх подолання через ефективне управління, державну підтримку й інфраструктурні інвестиції. Дослідження проводилося на основі аналізу соціально-економічних показників різних регіонів України з фокусом на аграрний сектор. Збір даних охоплював період з 2022 до 2023 року та включав показники безробіття, інвестиційної активності, продуктивності аграрного сектору та ефективності державних програм підтримки. Було проведено порівняльний аналіз між регіонами, що постраждали від бойових дій, і стабільнішими регіонами, а також досліджено вплив інвестицій в інфраструктуру на економічну стабільність. Дослідження виявило, що аграрний сектор України суттєво постраждав через бойові дії, що призвело до збільшення безробіття, зниження інвестицій і розширення економічних розривів між регіонами. Найбільші втрати спостерігалися в регіонах, що межують із зоною конфлікту, таких як Харківська та Дніпропетровська області. У цих регіонах інвестиційна активність майже повністю припинилася, що суттєво знизило продуктивність аграрного сектору. Водночас, регіони з розвиненішою інфраструктурою демонстрували кращі результати завдяки доступу до ринків і фінансування. Дослідження також показало, що державна підтримка мала нерівномірний вплив на різні регіони, причому найбільш постраждали регіони отримували недостатню підтримку. Результати дослідження підкреслюють важливість інвестицій в інфраструктуру та комплексної державної підтримки для подолання регіональних диспропорцій в аграрному секторі України, а також стабілізації економічної ситуації в умовах тривалого конфлікту

► **Ключові слова:** просторова нерівність; заходи стабілізації; збалансоване зростання; ресурсний потенціал; сільськогосподарські інновації



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## Food security strategies in the context of environmental and economic fluctuations in Ukraine

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► **Abstract.** The study aimed to assess the impact of investments in agricultural technology on the productivity, economic efficiency and profitability of farming enterprises. The emphasis was on analysing yields of the three leading agricultural holdings in Ukraine: Svarog West Group, Stepova and Agroproduct LLC, which operate in different natural and climatic conditions. The methodology involved collecting data for three agricultural seasons (2021-2023), which was used to identify long-term trends and determine the impact of technology investments on key performance indicators of enterprises. A correlation analysis with the calculation of Pearson's coefficients was used to assess the relationship between agricultural technology expenditures and yields. The economic efficiency was calculated based on profitability and resource efficiency, which compared the results between agricultural holdings and identified management features in different conditions. The main results showed that investments in agricultural technology have a positive impact on yields, although their effectiveness depends on the specialisation of the farms and environmental conditions. For Svarog West Group, a strong correlation between investment and yield was determined ( $r = 0.85$ ), which highlights the importance of technological innovation. Agroproduct LLC demonstrated the highest level of profitability (40%), which indicates effective cost management. In turn, Stepova

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achieved the highest efficiency of resource use (0.0056 t/thousand UAH) due to its specialisation in seed production. The results showed that it is necessary to combine technological innovation with adaptation to climate conditions to ensure the long-term efficiency of agricultural production. These findings can be useful for researchers, managers and practitioners involved in agricultural sector development and seeking ways to achieve food security in a changing climate

► **Keywords:** agronomic technologies; profitability; yield; climate change; food security; correlation analysis; agricultural management

### ► Introduction

Agribusiness is a key sector of the Ukrainian economy, ensuring not only domestic food security but also a significant contribution to the global agricultural market. Modern agriculture is at the crossroads of several important challenges, such as rising demand for food, climate change and the need for sustainable resource use. According to a study by S. Kvasha *et al.* (2024), the global population is growing, which requires innovative approaches to increase agricultural productivity and ensure food security. At the same time, many scholars emphasise the need to balance economic efficiency with environmental sustainability (Kushniruk *et al.*, 2021; Kotykova *et al.*, 2022). In this context, the role of large agricultural holdings should be studied and their efficiency assessed in both economic and environmental terms. Various studies already highlighted the impact of agricultural technologies on farm yields and economic efficiency. For instance, M. Haydaroglu and P. Bilgiç (2024) demonstrated that innovations in seed and soil management increase crop productivity by 15-20%. However, L. Yang (2024) noted that investments in technology may be less effective without accounting for climate change. This challenge is particularly relevant for Ukraine, where natural and climatic conditions vary between regions, creating additional risks for agricultural production (Vernooy, 2022).

Despite substantial research, not all aspects of the efficiency of large agricultural holdings were sufficiently covered. Most previous studies focus on either technical productivity or economic performance. To a lesser extent, how different business models respond to external challenges, such as economic crises and climate change, has been studied (Henderson, 2022). In addition, agriculture holdings in the context of sustainable development often lack complexity. The challenge of this study is to determine how investments in agricultural technology and efficient resource management affect the economic stability and productivity of large agricultural holdings. In addition, it is necessary to determine which management models are most effective in the face of economic instability and environmental challenges. The use of modern technologies not only increases yields but also contributes to economic profitability, if they are adapted to local climatic conditions (Bulgakov *et al.*, 2019). The study of this topic will help identify the best approaches to agricultural business management and develop recommendations for increasing the productivity and sustainability of agricultural enterprises.

In this regard, a study of Ukrainian agricultural holdings, which have different specialisations and operate in different regional climates, is particularly important for determining what strategies can ensure long-term food security. Thus, the research relevance is determined by several factors. The first is the growing role of agriculture

holdings in the structure of Ukrainian agriculture. In recent years, large agricultural enterprises have become key players in the market, controlling a significant portion of grain and oilseed production (European Commission, 2023). Second, global climate change is creating new risks for the agricultural sector, forcing producers to adapt their technologies and management practices (Ploeg, 2020). Thirdly, despite considerable scientific interest in agricultural technologies, the question of how different management models affect the economic and environmental outcomes of farming remains open (Ohlan & Ohlan, 2022). In this context, it is also necessary to address the current economic and political conditions affecting agribusiness in Ukraine, including rising energy and fertiliser costs, the impact of climate change on agriculture, and the need to adapt to new market conditions. Assessment of profitability, resource efficiency and the impact of agricultural technologies on yields will help to develop practical recommendations for optimising the management of large agricultural enterprises in the face of economic and climate challenges.

The study aimed to analyse the relationship between investments in agricultural technologies and their impact on yields, profitability and resource efficiency of agricultural holdings to identify optimal strategies for managing agricultural enterprises in the context of climate change.

### ► Materials and methods

The selection included 3 leading agricultural holdings from different regions of Ukraine, which differ in terms of natural and climatic conditions. During three agricultural seasons (2021-2023), data on the production performance and financial activities of the three leading agricultural holdings in Ukraine were collected: Svarog West Group, Stepova, and Agroproduct LLC. These companies are in different regions of the country and operate in different natural and climatic conditions, which was used to compare their efficiency and adaptation to environmental and economic changes. The assessment of efficiency and relationships between indicators is carried out using several economic and statistical approaches, including correlation analysis and calculation of key performance indicators.

Svarog West Group specialises in various areas of activity: growing grain, oilseeds and industrial crops, dairy and meat products, growing fruits and berries, own plant for seed production and processing, and storage of products. This agricultural holding is highly diversified, which makes it more resilient to market and climate fluctuations.

Stepova the core business is the development of new corn hybrids and seed production. Narrow specialisation provides a competitive advantage in creating productive varieties but increases dependence on demand for seeds.

Agroproduct LLC: the production of crop and livestock products. The combination of both areas creates a synergy: crop residues are used for animal feed, and organic fertilisers from livestock are returned to the soil.

The following indicators were used to assess the impact of climate change on the operations of agricultural holdings: average annual temperature, precipitation and frequency of extreme weather events in the regions where they are located. This data served as the basis for analysing the impact of climatic conditions on costs, yields and overall economic performance of enterprises. The sources of climate data were state meteorological services that provided data on weather conditions for the study period (2021-2023), as well as satellite observations to verify and refine the indicators. This approach determined not only average annual changes but also specific climate events that could affect the operations of agricultural holdings. The analysis was based on the integration of climate data with the production and financial performance of agricultural holdings. This approach was used to track dependencies and develop recommendations for improving climate change resilience. Pearson's correlation coefficient is effective in assessing the relationship between investment and productivity, as it measures the strength and direction of a linear relationship between two quantitative variables. The correlation coefficient is calculated using the formula (1):

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}}, \quad (1)$$

where  $x_i$  and  $y_i$  – variable values (e.g. yield level and agricultural inputs) for  $i$ -th observation;  $\bar{x}$  and  $\bar{y}$  – average values of variables  $X$  and  $Y$ ;  $n$  – number of observations. Correlation analysis was used to assess, for example, the relationship between yields and investments in agricultural technology, or between changes in climate conditions and farm productivity. It also determined how economic changes, such as rising input prices, affect the operations of agricultural holdings.

Profitability reflects how profitable a farm is by showing how much profit is generated for each hryvnia of costs. This metric is widely used to assess the efficiency of both agricultural holdings and farms (2):

$$R = \frac{P - C}{C} \times 100\%, \quad (2)$$

where  $R$  – profitability;  $P$  – profit;  $C$  – expenses.

The resource efficiency ratio ( $E$ ) shows how many units of output (e.g. tonnes of grain) are produced per unit of input. The higher the  $E$ , the more efficiently the farm uses its resources. It is useful for comparing agricultural holdings and farms with similar inputs (3):

$$E = \frac{\text{Yields}}{\text{Total costs}}, \quad (3)$$

where  $E$  – resource efficiency factor; yields is the volume of output (e.g. tonnes of grain per hectare); Total costs is the total cost of production (fertiliser, fuel, water, wages, etc.).

A higher ratio indicates a rational use of resources and increased productivity. This compares the performance of different businesses at similar costs and identifies which ones are better able to adapt to changes in the market or climate.

## ► Results

Specific investments in agricultural technologies for each agricultural holding were considered, the amounts of these investments, and their impact on yields were determined, and the return on investment based on productivity gains was calculated. The impact of investments in agricultural technologies was reflected in this study based on data for the period 2021-2023. Improving the productivity of agricultural holdings such as Svarog West Group, Stepova and Agroproduct LLC is crucial in ensuring Ukrainian food security. Increased yields result in higher agricultural output, which reduces dependence on imports and ensures stable supply on the domestic market. This situation helps to reduce price fluctuations and increase the availability of food for the population, which is essential for maintaining economic and social stability in the face of crises or climate change.

In the context of Svarog West Group, investments in precision farming systems, including the use of GPS navigation and drones for mapping and field analysis, are proving to be effective, as they significantly improve resource management and yields. This optimised field processing and reduced fertiliser use by 15%, which improved the economic results due to lower costs. The introduction of a system that achieves real-time moisture levels has mitigated unnecessary irrigation, reducing water consumption by 20%. This ensured a stable yield level even in conditions of moisture deficit. The introduction of new biological products to replace some chemical pesticides has reduced the risk of crop loss due to pest resistance and improved yields. The use of GPS navigation and drones reduced the amount of fertiliser and optimise field cultivation, which increased yields by 8% and reduced production costs by 10%. This had a positive impact on profitability, which was reflected in economic indicators (State Statistics Service of Ukraine, 2024).

Spending on splicing ensured optimum moisture level, which further increased yields by 5%, and during dry seasons, which reduced costs by 15%. The use of biological products to protect crops reduced pest losses, increasing yields by 6% and improving profitability, resulting in a 7% reduction in the profitability margin. Investments in agricultural technologies during the study period (2021-2023) totalled approximately (UAH 1,200 thousand). The main expenditures were made on precision farming systems, automated management of agricultural operations and the use of biological products for plant protection. Innovations (precision farming systems and biological products) increased yields by 20%, which resulted in an additional income of (UAH 1,500 thousand) (State Statistics Service of Ukraine, 2024).

In the context of Stepova, investing in the treatment of corn with highly effective products to improve the quality of genetic material, increased yields by 10%. The use of a precision irrigation system equipped with sensors, reduced water and energy consumption by 15%, increasing resource efficiency. Installation of a greenhouse where temperature and humidity can be controlled to reduce the impact of external climatic factors. This extended the growing season and maintained yields even in unstable weather conditions. Specialisation in treatments helped to increase its disease resistance, which increased

yields by 10%. Growing high-quality seed had a positive impact on profitability, which increased by 8% (State Statistics Service of Ukraine, 2024). Saving water and energy through automation has led to a 5% increase in profitability due to lower operating costs and a 7% increase in yield. By stabilising growing conditions, high yields were maintained even in adverse weather conditions. This increased the company's revenues by 12%, especially in a changing climate, while maintaining a stable level of profitability. Investments were approximately (UAH 800 thousand), of which a significant part was spent on the use of innovative treatment technologies, automation of splicing and climate control in greenhouses. This allowed the company to reduce its dependence on climatic factors and improve the quality of its products. Processing technologies and climate control increased yields by 15%, which brought in (UAH 1,100 thousand) in additional income (State Statistics Service of Ukraine, 2024).

In turn, in the context of Agroproduct LLC, investments in equipment for analysing macro- and microelements justification ensured optimal fertiliser rates, which increased yields by 12% and reduced fertiliser costs. Agricultural operations management systems. Implementation of an agricultural operations management system that allows for real-time monitoring of material costs and assessment of the efficiency of each stage of production. This helped optimise production costs and increase profitability. The use of biological pest control products reduced the cost of chemical pesticides by 18% and increased the risk of environmental pollution. Optimisation of fertiliser application through analysis increased yields by 12%, which led to increased economic efficiency by reducing fertiliser costs by 10%. Agricultural operations management systems. These systems helped control costs and

increased productivity by 9%. It also led to a 6% increase in profitability, which reduced unproductive costs. The use of biosecurity has reduced chemical pesticide costs by 18%, which has increased the overall profitability of the company by 4% and reduced environmental costs. The total investment amounted to approximately (UAH 1,000 thousand). The main costs were invested in a feasibility study to optimise fertiliser, the farm management system and the use of biosecurity. These investments have contributed to increased yields and resource efficiency. The feasibility analysis and the farm management system increased yields by 18%, resulting in an additional income of (UAH 1,400 thousand) (State Statistics Service of Ukraine, 2024).

Environmental sustainability is an important component of food security, especially in the face of climate change (Zibtsev *et al.*, 2024). Reducing the use of chemical plant protection products and optimising resource consumption helps preserve ecosystems and improve soil fertility. This has a positive impact on the long-term productivity of agricultural companies such as Svarog West Group, Stepova and Agroproduct LLC. Rational use of resources and implementation of environmentally friendly practices also reduce the negative impact on the environment, which ensures the sustainability of agricultural systems and contributes to the stability of food production. Thus, an environmentally friendly approach to agriculture supports food security and ensures sustainable development in the long term. These three agricultural holdings represent different business models: Svarog West Group with diversified activities, Stepova with specialisation, and Agroproduct LLC as an integrated crop and livestock production system. Table 1 summarises the costs, revenues and profits for the three agricultural holdings over the study period (2021-2023). Average yields are also included for comparison.

**Table 1.** Average expenses and income for 2021-2023 (thousand UAH)

Agricultural holding	Total costs	Income	Profit	Yield (t/ha)
Svarog West Group	1.200	1.500	300	5.2
Stepova	800	1.100	300	4.5
Agroproduct LLC	1.000	1.400	400	5

**Source:** compiled by the authors based on State Statistics Service of Ukraine (2024)

Svarog West Group has the highest costs (UAH 1,200 thousand) but also achieves high revenues (UAH 1,500 thousand) and profit (UAH 300 thousand). Yields of 5.2 t/ha indicate the effective use of agricultural technologies. This is due to the diversification of activities and the use of innovations in crop and livestock production. Stepova incurred the lowest costs (UAH 800 thousand) and relatively low revenues (UAH 1,100 thousand). Despite the smaller scale of its operations, profits remain stable (UAH 300 thousand). Yields of 4.5 t/ha indicate specialisation in seed production and cost efficiency. Agroproduct LLC has balanced expenses (UAH 1,000 thousand) and income (UAH 1,400 thousand), with a profit of UAH 400 thousand. Yields of 5.0 t/ha demonstrate the synergy between crop and livestock production, which allows for efficient use of resources. The analysis demonstrated a positive correlation between investment in agricultural

technology and yields. This confirms that modern technologies are critical in increasing productivity. The impact of investments in agricultural technology on yields depends on a range of factors that can vary significantly between farms. This impact varies depending on the natural and climatic conditions, business strategy and production specialisation of each farm, with business model and specialisation affecting the final results. Pearson's correlation coefficient ( $r$ ) measures the strength and direction of a linear relationship between two variables – in this case, between agricultural technology expenditures and yields. The coefficient ranges from -1 to 1, where:  $r = 1$ : perfect direct correlation (the two variables increase together),  $r = -1$ : perfect inverse correlation (one variable increases and the other decreases),  $r = 0$ : no linear relationship between the variables. Table 2 presents the results of the correlation analysis (Table 2).

**Table 2.** Results of correlation analysis for each agricultural holding

Agricultural holding	Pearson's coefficient (p)	Correlation power
Svarog West Group	0.85	Strong direct correlation
Stepova	0.72	Moderate direct correlation
Agroproduct LLC	0.78	Strong direct correlation

**Source:** compiled by the authors

The correlation coefficients show that agricultural technology plays an important role in increasing yields, but the extent of its impact differs between farms due to different production approaches and conditions.

Svarog West Group:  $R = 0.85$ , a high coefficient, which indicates a strong direct correlation between spending on agricultural technology and yields. Therefore, investments in modern technologies, such as automation and innovative crop protection products, significantly improve results. As the agricultural holding is involved not only in crop production but also in livestock and seed production, technological innovations increase the efficiency of all areas of production.

Stepova.  $R = 0.72$  indicates a moderate direct correlation. Although technology is also of substantial effect, its impact is not as significant as in Svarog West Group. The company's specialisation in corn seed production and breeding partly explains this result, as its main investments are directed at developing new hybrids rather than increasing the yield of the final product.

Agroproduct LLC:  $R = 0.78$ , a positive correlation between expenditure on agricultural technology and yield. The integration of crop and livestock production allows the company to use technology to increase yields and optimise resources. For instance, crop residues are used as feed and organic waste is used as fertiliser, which also affects productivity.

The strong correlation between investment and yields for Svarog West Group and Agroproduct LLC confirms that innovative agricultural technologies are a key factor in the success of these businesses. Svarog West Group can continue to invest in technologies aimed at automating and managing large amounts of data to improve efficiency across the board. Agroproduct LDT can expand its use of agricultural technology to improve integration between crop and livestock production, resulting in even greater productivity and efficiency. Stepova shows a moderate correlation, which confirms the impact of specialisation in seed production on production efficiency. Expenditures on agricultural technology are more focused on breeding than on directly increasing the yield of the final product. Stepova should introduce new technologies to optimise production and increase profitability. The variability of the results shows that, while technology has a significant impact on productivity, natural and climatic conditions and management practices also play an important role. This underscores the importance of adapting business models to specific operating conditions. This correlation analysis confirms that technological investment is a major factor in increasing farm yields and efficiency, but that farm-specific and regional conditions need to be taken into account. Table 3 shows the calculations of profitability for each of the three enterprises based on their costs and profits.

**Table 3.** Profitability calculations

Agricultural holding	Profit (P)	Expenses (C)	Profitability (R, %)
Svarog West Group	300	1,200	25
Stepova	300	800	37.5
Agroproduct LLC	400	1,000	40

**Source:** compiled by the authors based on State Statistics Service of Ukraine (2024)

Agroproduct LLC demonstrated the highest profitability (40%), which indicates efficient use of resources and well-balanced costs. The company combines crop and livestock production, which optimises the use of production waste and reduces overall costs. Despite the high level of technological investment, the company achieves excellent financial performance. Stepova has a profitability of 37.5%, which is also a high level. Specialisation in corn breeding and seed production allows the company to maintain low production costs by focusing on optimising its cost processes. The high profitability is due to cost-effective resource management, although agricultural-technological investments are not as large as those of other agricultural holdings. Svarog West Group has a profitability of 25%. This is lower than other companies due to its more diversified operations: the company is engaged not only in crop production but also in livestock, horticulture and seed production. This diversity requires significant

investments in different areas, which affects the overall costs and reduces profitability. The profitability analysis shows that Agroproduct LLC has the highest resource efficiency (40%). This confirms the importance of integrating different areas of production and using agricultural technologies to increase productivity. Stepova also demonstrates high profitability due to its narrow specialisation and low production costs.

The lower profitability of Svarog West Group (25%) suggests that diversified businesses may have lower short-term financial performance. However, this model ensures sustainability and risk reduction in the long term. Agroproduct LLC should continue to develop integrated production processes and optimise costs to maintain high profitability. Stepova should invest in new breeding technologies and expand the market for its seeds, which could increase profitability. Svarog West Group should address the efficiency gains in certain areas (e.g., livestock

automation) and use cost analysis to identify the most profitable production processes. This analysis highlights the importance of prudent resource management and diversification to achieve sustainable development and economic efficiency in the agricultural sector. Resource

efficiency determines how efficiently a company uses its inputs. It measures how many units of output (in this case, tonnes of grain per hectare) are produced for every thousand hryvnias of total costs. Table 4 shows the results for each of the three agricultural holdings.

**Table 4.** Resource efficiency ratio

Agricultural holding	Yield (t/ha)	Total expenses (thousand UAH)	E (tonnes/thousand UAH)
Svarog West Group	5.2	1.200	0.0043
Stepova	4.5	800	0.0056
Agroproduct LLC	5	1.000	0.005

**Source:** compiled by the authors based on State Statistics Service of Ukraine (2024)

Stepova demonstrated the highest efficiency ratio of 0.0056 t/thousand UAH. This means that the company receives 5.6 kg of grain for every thousand hryvnias of costs. Such a high figure is explained by the specialisation in breeding and seed production, which allows the company to optimise production costs and produce quality products with less investment. Agroproduct LLC has an efficiency ratio of 0.005 tonnes/thousand UAH. This indicates an efficient use of resources, although slightly lower compared to Stepova. The high productivity of this company is ensured by a combination of crop and livestock production, which allows for optimal use of secondary resources (e.g. organic fertilisers). Svarog West Group demonstrated the lowest efficiency ratio of 0.0043 t/thousand UAH. Despite higher yields (5.2 t/ha), the high costs of supporting the various activities (livestock, horticulture, seed production) resulted in lower resource efficiency. This underlines that diversified enterprises may have higher costs due to a wider range of operations. The analysis of the resource efficiency ratio shows that specialised enterprises, such as Stepova, achieve the highest efficiency rates due to their narrow specialisation and cost optimisation. Enterprises engaged in diversified operations (e.g. Svarog West Group) may have a lower ratio due to the higher costs of maintaining different production lines. This analysis confirms that effective resource management is critical to improving productivity and economic efficiency, especially in times of economic change.

The results of the study showed that investments in agricultural technologies and rational resource management have a significant impact on productivity and economic efficiency, as well as the yield of agricultural enterprises. The positive correlation between agricultural technology expenditures and yields demonstrates the importance of innovation in increasing productivity. This is particularly evident for Svarog West Group, where the correlation coefficient of  $R = 0.85$  indicates a strong link between investment and yield growth. Innovations in seed production, the use of modern machinery and the optimisation of agricultural practices have allowed this company to achieve high yields (5.2 t/ha). However, the diversified nature of the business increases costs, which reduces overall economic efficiency. Agroproduct LLC has the highest profitability. This enterprise achieved a profitability of 40%, indicating a high level of cost management and profitability. The combination of crop and livestock production allows for efficient use of resources: organic fertilisers from livestock production reduce chemical costs,

improving soil quality and yields (5 t/ha). The company's profitability demonstrates the optimal use of resources, even in difficult economic conditions. Stepova demonstrates the highest resource efficiency ratio. The efficiency ratio of 0.0056 t/thousand UAH indicates that Stepova uses its investments most rationally. This is attributable to the narrow specialisation in breeding and seed production, which requires lower costs but ensures high-quality products. This approach reduces financial risks and optimises production. This study confirms that the efficiency of agricultural production depends on both the level of technological investment and the ability of enterprises to adapt to changing conditions. High profitability and resource efficiency indicate that enterprises that skilfully combine innovation with good management can achieve significant results. However, to ensure long-term sustainability and food security, strategies need to be developed that consider both economic and environmental factors.

Achieving food security requires a comprehensive strategy that addresses environmental and economic challenges, climate change, and the structural characteristics of the agricultural sector. The main strategic components are state support (direct subsidies, preferential lending to farmers), infrastructure development (logistics, storage facilities, digitalisation of agribusiness), stimulating investment in the latest agricultural technologies, and legislative initiatives to harmonise the regulatory environment. Based on the experience of other countries, such as the Netherlands or Israel, the integration of precision agriculture, irrigation systems and climate change adaptation programmes remains a priority. The experience of other countries in precision agriculture and water management demonstrates significant potential for improving food security. For instance, Israel uses sensor technologies and intelligent water management systems that have reduced water consumption by 50% and increased yields by 25% through optimised irrigation. The Netherlands has successfully applied precision agriculture using the Internet of Things, machine learning, and cloud computing, which has increased yields by 15-20%, reduced losses due to crop diseases and stress, and improved soil fertility management (Ramdinthara & Bala, 2019; Lopushynska *et al.*, 2022).

For Ukraine, the implementation of these approaches through government support programmes is crucial. This includes subsidies for sensor-based soil monitoring systems, the development of research clusters to adapt technologies to local conditions, and the establishment of cooperation with international partners. The development of

training programmes for farmers on the use of new technologies and risk management is also needed. Given the success of other countries, such initiatives could increase yields and reduce dependence on weather conditions in Ukraine. It is necessary to create financial support mechanisms through government guarantees and partnerships with international organisations to attract investment in agriculture. Adaptation to climate change involves developing risk management programmes, such as crop insurance, drought-resistant crops, and water optimisation (Ivanova *et al.*, 2021). Improving logistics can include developing rail transport, modernising ports and ensuring efficient distribution of resources within the country.

The state is central in ensuring food security through financial support, regulatory measures and partnerships with international organisations. One of the most effective mechanisms is the introduction of targeted subsidy programmes for the purchase of modern machinery, sensor systems and software for precision farming (Bulgakov *et al.*, 2017). For instance, similar programmes in Germany provide up to 40% of the cost of innovative agricultural technologies, which has significantly increased yields and reduced environmental impact. In Ukraine, similar subsidies could be targeted at farmers who introduce soil monitoring tools, crop monitoring drones or automated irrigation systems. Financing for small and medium-sized farmers can be provided through concessional lending programmes. For instance, Poland has a programme where farmers receive low-interest loans subsidised by the state. In Ukraine, a similar model could stimulate the development of small farms, which make up a significant part of the agricultural sector (Javed *et al.*, 2022; Bexolli *et al.*, 2023).

Crop insurance is another vital mechanism. The US has a Federal Crop Insurance programme where the government covers up to 60% of the insurance premium. In Ukraine, this is possible through partial compensation of the cost of insurance for farmers who grow strategically important crops such as wheat or corn. Partnerships with international organisations, such as the Food and Agriculture Organisation, the World Bank and the European Union, can provide access to long-term financing grants. For instance, the Food and Agriculture Organisation supports sustainable water use programmes in Southern Africa, while the World Bank finances agricultural innovation through low-interest loans to developing countries (Ncube *et al.*, 2018). In Ukraine, it is advisable to create a trust fund for the development of the agricultural sector, attracting investments from these organisations for the construction of infrastructure, training of farmers and digitalisation of agribusiness. Practical measures for Ukraine should address the specifics of the regions. For instance, in the southern regions, the creation of water supply systems, and in the western regions, the strengthening of organic farming. A programme to train farmers in new technologies and move towards more sustainable production practices is also needed. Overall, a clear strategy that integrates international experience and national priorities is key to achieving food security.

### ► Discussion

The results of this study show that investments in agricultural technology have a positive impact on yields, but

the level of this impact varies between agricultural holdings due to the specifics of their operations and climatic conditions. The highest correlation between agricultural technology expenditures and yields was found for Svarog West Group ( $r=0.85$ ), which correlates with the study by H. Ayeb & R. Bush (2019), who emphasised that innovative technologies in agriculture can increase productivity by 15-20%. This indicates a significant impact of technological innovation on productivity and is consistent with the findings of B. Boulay *et al.* (2020), who emphasised that the effectiveness of technologies varies depending on environmental conditions and needs to be adapted. This emphasises the importance of a flexible approach to technology adoption at enterprises operating in different climatic zones.

The analysis of Stepova Agroholding showed a moderate correlation between agricultural technology expenditures and yields ( $r=0.72$ ). This can be attributed to the specialisation in seed production, where the focus is not on increasing yields but on improving genetic material. Similar conclusions were reached by S. Madsen *et al.* (2020), determining that seed farms have a different productivity focus that affects economic performance. The analysis of the resource efficiency coefficient showed that the highest indicator was for Stepova Agroholding (0.0056 t/thousand UAH). For Agroproduct LLC, the correlation between investment and yield was also high ( $r=0.78$ ), indicating the efficient use of technology to increase productivity. This is consistent with the study by B. Feyisa *et al.* (2024), emphasising that optimal resource management allows for high yields even in conditions of limited access to resources.

The profitability analysis also revealed interesting patterns. The highest profitability was shown by Agroproduct LLC (40%), which indicates effective cost management. This result corresponds to the findings of W. G. Moseley (2013), noting that effective cost management is a key factor in the success of agricultural enterprises, regardless of the level of investment in technology. This may be due to efficient cost management and optimisation of production processes. Other studies, such as M. Babych & A. Kovalenko (2018), who analysed the efficiency of large agricultural holdings, also demonstrated that higher profitability can be achieved through efficient resource management even with high technology costs. O. Kotyková & M. Babych (2021) noted that high levels of investment in agricultural technology do not always lead to a proportional increase in profitability. Stepova's profitability was 37.5%, which highlights the importance of cost optimisation for seed-focused farms. The study by E. Holt Giménez and A. Shattuck (2011) also confirms that reducing costs without sacrificing productivity is an important component of economic resilience in the face of climate change.

The coefficient of resource use efficiency showed that the highest efficiency was in Stepova (0.0056 t/thousand UAH), which indicates the rational use of resources. This correlates with the findings of M. Sommerville *et al.* (2014), who emphasised the importance of efficient use of resources in agriculture, especially in the context of limited financial resources. This can be attributed to the focus on specialised areas, such as corn seed production, which optimises production costs. This is confirmed

by R. Merino (2020), emphasising that enterprises with specialised activities can achieve higher efficiency through resource optimisation, even if their overall productivity is lower than that of diversified farms. For Svarog West Group, this coefficient was lower (0.0043 t/thousand UAH) due to the scale of operations and wider diversification of production. This structure may require higher costs to support different production areas, making it difficult to achieve maximum efficiency.

However, the study also revealed certain limitations. The impact of climate change on productivity remains a significant factor that makes it difficult to predict economic results in the long term (TOP-10 wheat producing..., 2022). This conclusion is supported by J. Essex *et al.* (2014), who noted that farms that are not adapted to climate change lose some of their productivity despite investments in technology. Without proper adaptation, enterprises may lose some of their efficiency, even when using modern technologies. Thus, this study confirms the need for an integrated approach to agricultural holding management. While investments in technology contribute to increased yields and efficiency, success also depends on the ability of enterprises to adapt to climate and economic changes. The optimal combination of innovative technologies, rational use of resources and adaptation strategies is key to the long-term sustainability and success of agricultural enterprises (Kyfyak *et al.*, 2024). Overall, the findings of this study demonstrate the importance of an integrated approach to agricultural holding management. The use of modern technologies does indeed help to increase productivity, but success also depends on the ability of enterprises to adapt their strategies to external challenges (Pietrzyk, 2022). The findings are in line with international research but also point to some unique aspects, such as the importance of specialisation and effective cost management for profitability. The study also showed that climate change remains a significant factor that makes it difficult to predict economic performance in the long term. This underscores the need to develop comprehensive adaptation strategies aimed at increasing the resilience of enterprises to climate challenges.

Thus, the findings of this study indicate that achieving long-term sustainability in the agricultural sector requires a comprehensive management approach that combines investment in technology, resource optimisation and adaptation to changing conditions. This will allow enterprises to use available resources efficiently and achieve sustainable productivity even in the face of climate and economic challenges. The findings of this study confirm the importance of combining effective governance with technological innovation and adaptation strategies as key factors for ensuring food security and the sustainable development of agricultural enterprises. Both economic and environmental factors need to be addressed to ensure food security. In the future, it is

necessary to continue researching the impact of climate change on agricultural production and to develop more flexible management strategies that can ensure stability in a changing environment.

### ► Conclusions

The study was conducted based on three agricultural holdings in Ukraine – Svarog West Group, Stepova and Agro-product LLC and revealed the importance of investing in modern agricultural technologies to increase agricultural productivity. An analysis of data for three agricultural seasons (2021-2023) showed a clear positive correlation between technology spending and yields, confirming the importance of innovative practices as a key factor in ensuring high productivity. In the case of Svarog West Group, the correlation coefficient between investment and yield reached  $r = 0.85$ , indicating a high impact of agricultural technology on the results. This underlines the importance of not only the number of financial expenditures but also their adaptation to the specifics of the crops and natural and climatic conditions in which the company operates.

For the Stepova agricultural holding, which specialises in seed production and breeding, the correlation coefficient was slightly lower ( $r = 0.72$ ), indicating a different nature of the impact of the investment. However, this specialisation contributed to high efficiency in the use of resources with an indicator of 0.0056 t/thousand UAH. This suggests that enterprises that focus on the quality of genetic material can maximise the return on investment. This approach confirms the importance of narrow specialisation in the agricultural sector, which allows to optimise of production costs and increases the efficiency of resource use. In terms of profitability, the highest financial performance was demonstrated by Agroproduct LLC, with a profitability of 40%. This demonstrates effective cost management and strategic use of investments in technology. The study showed that even significant expenditures on agricultural technologies can pay off if resources are managed efficiently and production processes are optimised.

Thus, the results of the study underline the need for a comprehensive approach to agricultural holdings management that addresses both economic and environmental aspects. In addition to investing in technology, enterprises should integrate environmental practices to adapt to climate challenges. The prospect of further research is to investigate the long-term contribution of investments in agricultural technologies to the adaptability of agricultural enterprises to climate change and their economic sustainability.

### ► Acknowledgements

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### ► Conflict of interest

None.

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## Стратегія забезпечення продовольчої безпеки в умовах еколого-економічних коливань в Україні

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► **Анотація.** Метою цього дослідження було оцінити вплив інвестицій в агротехнології на продуктивність, економічну ефективність і рентабельність агропідприємств. Основний акцент зроблено на аналізі показників врожайності, трьох провідних агрохолдингів України: «Сварог Вест Груп», «Степова» та товариство з обмеженою відповідальністю (ТОВ) «Агропродукт, ЛТД», які функціонують у різних природно-кліматичних умовах. Методологія включала збір даних за три сільськогосподарські сезони (2021-2023 роки), що дало змогу виявити довгострокові тенденції та визначити вплив інвестицій у технології на ключові показники діяльності підприємств. Для оцінки взаємозв'язку між витратами на агротехнології та врожайністю було застосовано кореляційний аналіз із розрахунком коефіцієнтів Пірсона. Економічна ефективність розраховувалася на основі показників рентабельності та коефіцієнта ефективності використання ресурсів, що дозволило порівняти результати між агрохолдингами та виявити особливості управління в різних умовах. Основні результати показали, що інвестиції в агротехнології позитивно впливають на врожайність, хоча їх ефективність залежить від спеціалізації підприємств та умов довкілля. Зокрема, для «Сварог Вест Груп» було виявлено сильний зв'язок між інвестиціями та врожайністю ( $r=0.85$ ), що підкреслює важливість технологічних інновацій. ТОВ «Агропродукт, ЛТД» продемонструвало найвищий рівень рентабельності (40%), що свідчить про ефективне управління витратами. У свою чергу, «Степова» досягла найвищої ефективності використання ресурсів (0.0056 т/тис. грн) завдяки спеціалізації на насінництві. Отримані результати свідчать про необхідність поєднання технологічних інновацій із адаптацією до кліматичних умов для забезпечення довгострокової ефективності агровиробництва. Ці висновки можуть бути корисними для науковців, управлінців та практиків, які займаються розвитком агропромислового сектору та шукають способи досягнення продовольчої безпеки в умовах змінного клімату

► **Ключові слова:** агрономічні технології; рентабельність; врожайність; кліматичні зміни; продовольча безпека; кореляційний аналіз; аграрне управління



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## Status and development prospects of agricultural cooperatives in the context of European integration processes

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► **Abstract.** The intensification of agricultural cooperatives is of particular significance in the system of increasing the competitiveness and adaptability of the agricultural sector of the economy, stabilising food security in the context of integration with the European community. The purpose of this study was to substantiate the economic, theoretical, methodological, and social provisions of the functioning of agricultural cooperatives in the context of European integration processes. The study employed general scientific methods of cognition in generalising the trends in the development of cooperation in the pre-war and wartime periods, and the specifics of the regulatory framework; the structural and functional method in determining the indicators that hinder the functioning of agricultural cooperatives; analysis and synthesis in assessing the trends in the development of cooperatives; and analysis in assessing and characterising individual cooperative structures. The study considered the current state, place, and role of agricultural cooperatives in the context of European integration processes in Ukraine's accession to the European community. A systematic analysis

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of the problems and trends in the functioning of agricultural cooperatives in Ukraine during wartime was performed. The theoretical and methodological aspects of the functioning of cooperative entities were considered. The reasons that impede the activation of the cooperative movement in the agrarian sector of the economy at the present stage of development were identified. The study considered the trends in the development of agricultural cooperatives in the European Union and the world. The dynamics of development of agricultural cooperation in Ukraine was assessed and the study identified the negative aspects that should be considered in the organisation and functioning of agricultural cooperatives, depending on the type and activities of the cooperative. The role of international technical assistance and state support in stimulating and strategising the development of agricultural cooperation in Ukraine was determined. The study identified the opportunities and prospects for the development of the cooperative movement and problems of sustainable development of cooperatives through the involvement of private farms in integration processes. The role of cooperatives in the development of social capital and sustainable development of rural areas in the post-war reconstruction of the Ukrainian economy was covered. The information material can be used in the development of programmes for the development of business entities in the agricultural business of the regions

► **Keywords:** cooperation; entrepreneurship; cooperative; business entity; integration associations; social capital; rural areas

### ► Introduction

In the context of European integration and military challenges, agricultural cooperatives are undergoing profound transformational changes caused by the need to adapt to these processes. Practice has shown that small producers, farms, and private households have adapted to the new crisis conditions faster. By uniting in cooperative structures, these business entities receive a synergistic effect from joint activities, considering the increased requirements for the quality characteristics of agricultural products stemming from trade with the EU. Transformation processes are ongoing and require a rethinking of the existing processes related to the further development of agricultural cooperation, caused by martial law and the need to prepare for accession to the European cooperation. Upon investigating the state of implementation of digital marketing tools in agricultural cooperatives, R. Bezus & L. Kriuchko (2022) identified the need to amend regulations, which will help improve the quality of the marketing system for agricultural products of cooperatives. V. Lavruk *et al.* (2022) substantiated the feasibility of establishing service dairy cooperatives to improve milk quality, follow the rules of machine milking, increase the purchase price of milk, and make best use of cows based on self-organisation. H. Kaletnik *et al.* (2022) focused on the need to create energy cooperatives in rural areas, which are an element of achieving sustainable development in rural areas. The researchers concurred that by increasing the added value of products, the profitability of doing business in agriculture increases.

D. Onopriichuk & I. Cherven (2023) focused on the specific features of the development of dairy cooperatives Friesland Campina (Netherlands), Yili and Mengniu (China), Nestle Dairy (Switzerland), Amul (India), Arla Foods (Denmark and Sweden), Saputo (Canada and the USA), specifically, on the establishment of milking, collection, processing, transportation, processing, and sale of dairy products. The researchers explained why milk from private households is not used for industrial production. O. Tomilin & T. Bahalika (2023) covered the principles of cooperation and integration processes, identified the reasons that hinder the development of cooperation, and developed areas for the development of cooperation processes during the post-war economic reconstruction of the country. A. Panteleimonenko & V. Honcharenko (2023)

substantiated that the presence of factors of 'unreadiness' to establish a cooperative may lead business entities to decide that it is inexpedient to establish a service cooperative in agriculture. The researcher fully covered the specific features of the negative components of socio-psychological readiness to establish a cooperative (inertia of agricultural producers; misunderstanding of the benefits of economic mutual assistance; unwillingness to pay for the services of a cooperative; distrust of colleagues in production; resistance to 'collectivist values'; imperfection of tax policy; deformation of the essence of the cooperative idea; unwillingness to take responsibility; lone wolf syndrome; lack of faith in state support, etc.)

O. Hafurova (2024) characterised agricultural cooperatives (operating without the purpose of making a profit) and agricultural cooperatives (operating with the purpose of making a profit). O. Demchenko (2024) focused on the specific features of the impact of cooperation in agriculture on the development of human capital in rural areas; the complexity of legal regulation of cooperatives; and the improvement of information support. Y. Danko & D. Zhyvytskyi (2024) covered the problems of developing dairy clusters as a tool for diversifying the production of business entities. The researchers focused on the need to attract financial resources; stimulate cooperation; build infrastructure; innovative development; state support for clustering; drivers of competitiveness; and diversification of production.

It was found that most of the results of scientific research are aimed at clarifying certain issues of organisation and operation of agricultural cooperatives in general without linking them to modern challenges, which necessitates further investigation into the system of enhancing the formation of cooperative structures and their prospects for the future. The purpose of this study was to assess the current state of development of agricultural cooperatives and the problematic issues in intensifying their functioning strategy in the context of military and European integration challenges.

### ► Materials and methods

The information base of the study included the Law of Ukraine "On Approval of the Model Charter of Agricultural Service Cooperative. Order of the Ministry of Agrarian

Policy and Food of Ukraine” No. 315 (2013). The study also reviewed the Order of the Ministry of Agrarian Policy and Food of Ukraine No. 643 (2013). The analysis covered the Law of Ukraine No. 1087-IV (2003), as well as the Laws of Ukraine No. 1377-IV (2003) and No. 819-IX (2021). Publications of national and international news agencies, including the State Statistics Service of Ukraine, were examined (Official website of the..., n.d.). The study also built on the findings of Ukrainian researchers, as well as researchers from Malaysia, Indonesia, and the Baltic States who investigated the development of agricultural cooperatives in the context of European integration processes (Abu Hasan *et al.*, 2022; Kutsyk *et al.*, 2023). The study also considered the research of O. Hafurova (2024) and other authors. Furthermore, the previous findings of the authors of the present study were considered.

The key theoretical and methodological platform of the study included the provisions of institutional economic theory and structural-functional analysis. Monographic (in synthesising the existing provisions on the organisation and operation of agricultural cooperatives), abstract and logical (in analysing the dynamics and state of organisational and economic support for the development and functioning of integrated structures), statistical (in assessing the performance indicators of agricultural cooperatives) and graphical (in assessing the number of operating cooperatives, those working in cooperatives and the directions of their development) methods, as well as approaches to generalising the findings in characterising the development of some individual agricultural cooperatives and formulating conclusions. Information on the key indicators of agricultural cooperatives’ development as of 01 January 2024 is not yet available, and therefore the data for 2018-2023 were analysed.

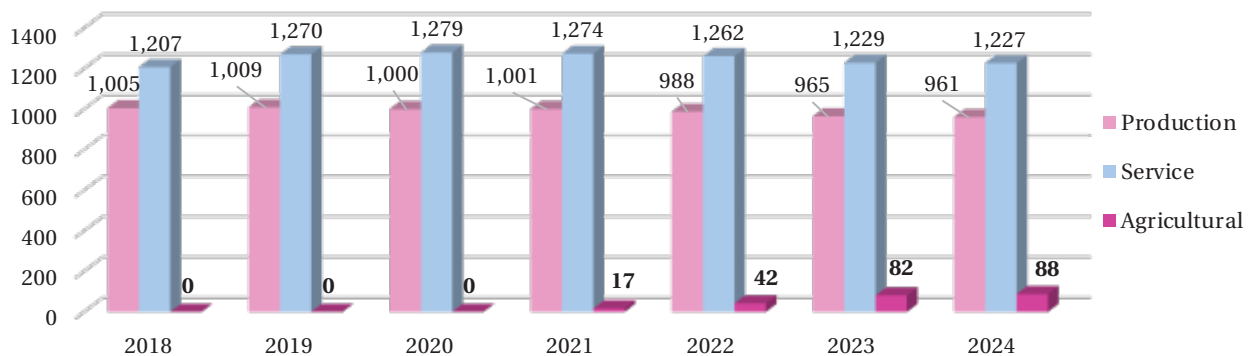
Particular attention was paid to identifying the prospects for the development of cooperatives in the post-war period, including an analysis of international technical aid programmes. The study also considered the impact of external and internal factors on the development of agricultural cooperatives, such as government policy,

military operations, socio-economic changes, and European integration processes. A comparative analysis of the development of cooperatives in different regions of Ukraine and abroad is complemented by an assessment of the effectiveness of international support programmes such as USAID, EU/UNDP, and Canadian government projects. To predict the prospects for the development of cooperatives, dynamics models were used, including a logarithmic function to assess changes in the number of employees, as well as elements of SWOT analysis to identify the strengths and weaknesses of the cooperative movement in Ukraine.

## ► Results

**Development of agricultural service cooperatives.** The study found that the country has considerable potential and natural resources to increase the sustainability and productivity of agricultural production, the competitiveness of quality products, and the development of social capital. Almost a third of people live and work in rural areas, and this share has increased during wartime. The state of agricultural business development is characterised by positive dynamics. Foreign exchange earnings from exports account for about 40%. The agricultural sector accounts for about 13% of gross value added. In the context of military and European integration processes, the problem of organisational and economic support for the development and functioning of integrated structures overall and agricultural cooperation specifically is becoming increasingly important for achieving the Sustainable Development Goals for the period up to 2030 (Malik *et al.*, 2022; Kravchenko *et al.*, 2023).

Through labour, citizens consolidate their efforts to conduct business together. Therefore, labour is the foundation of cooperation, which reflects the essence of the ideology of production organisation, from the implementation of which society receives certain results (Malik, 2019). The development of agricultural cooperatives has a minimal effect on the functioning of the agricultural sector of the economy. The number of agricultural cooperatives is changing (Fig. 1).



**Figure 1.** Number of agricultural cooperatives as of 1 January of each year

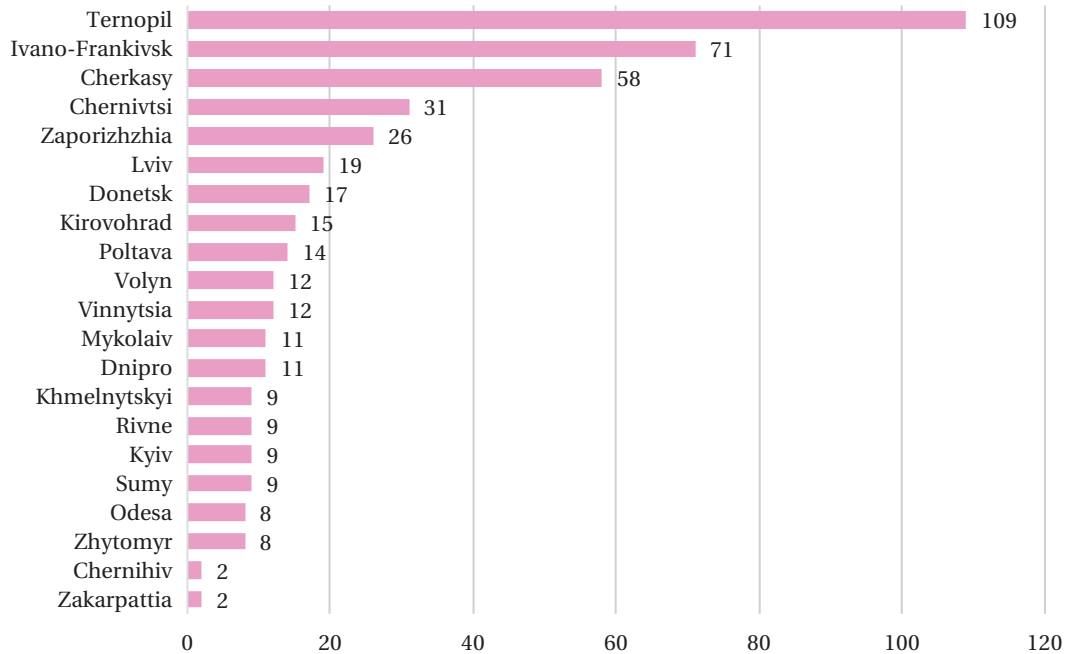
**Source:** Official website of the State Statistics Service of Ukraine (n.d.)

Services provided by agricultural cooperatives as business entities do not exceed 1%. It was found that the number of members of agricultural service cooperatives is about 28 thsd people, which is 0.25% of the country's farmers. As of 01 January 2024, agricultural cooperatives

accounted for only 8.40% of the total number of cooperatives in the country. There are 1,227 registered agricultural cooperatives. However, only 735 business entities with a 1% share of the agricultural market are active. The existing agricultural cooperatives are structured by

specialisation: grain, land cultivation, meat, dairy, harvesting, fruit and vegetable, etc. The largest number of cooperatives are dairy, land cultivation, and harvesting. The distribution of cooperatives across the country is uneven. The regions of the western part of Ukraine with strong private ownership traditions have the greatest

number of them. As of 01 January 2023, the distribution of the number of operating agricultural service cooperatives by region is evidence of the integration of producers by region and specialisation (Fig. 2). However, in wartime, a decrease in the number of members and employees of agricultural service cooperatives was recorded.



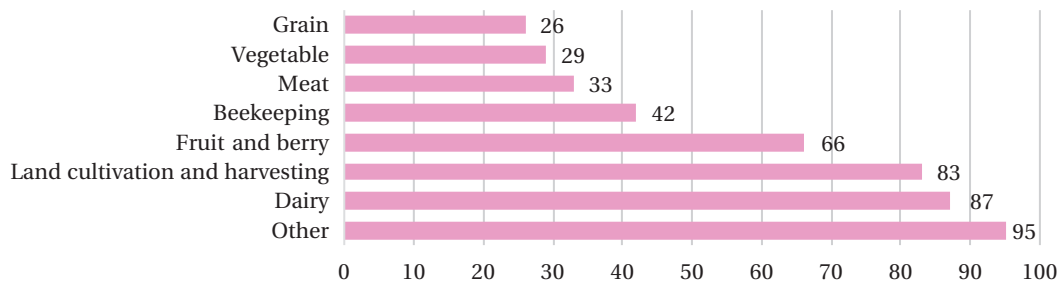
**Figure 2.** Number of operating agricultural service cooperatives by region as of 01 January 2023

**Note:** this information was not yet available as of 01 January 2024

**Source:** Report on scientific research and development for the period from January 1, 2021, to December 31, 2023, on the implementation of tasks under the scientific and technical program (2024)

Among the existing agricultural service cooperatives, the most widespread were cooperatives in the following areas: other – 95 (20.6%); dairy – 87 (18.87%); land cultivation and harvesting – 83 (18.00%); fruit and berry – 66 (14.31%); beekeeping – 42 (9.11%); meat – 33 (7.15%); vegetable – 29 (6.29%); grain – 26 (5.64%) (Fig. 3) (Report on scientific research..., 2024). One example of the effective functioning of agricultural service cooperatives is the development of the Pokrova and Stryiskyi Yas cooperatives in Lviv Oblast. In times of armed conflict and warfare, it is important to encourage citizens to increase their

cooperative capacity (Should agricultural cooperatives..., 2022). The agricultural service cooperative Ivankovetskyi Svitanok in the Znamianskyi district of Yuhymivka village, Kirovohrad region, was registered and has been operating since 03 May 2006. The cooperative has a milk processing capacity of 3 tonnes per shift. It distributes its products under the brand name Family Farm. The cooperative serves 3 settlements. The cooperative has about 50 members. Another example. In 2010, 8 cooperatives were established in the Dnipro region. The members of these cooperatives include 1,100 families in the Synelnikivskyi district.



**Figure 3.** Areas of development of existing agricultural service cooperatives as of 01 January 2023, units

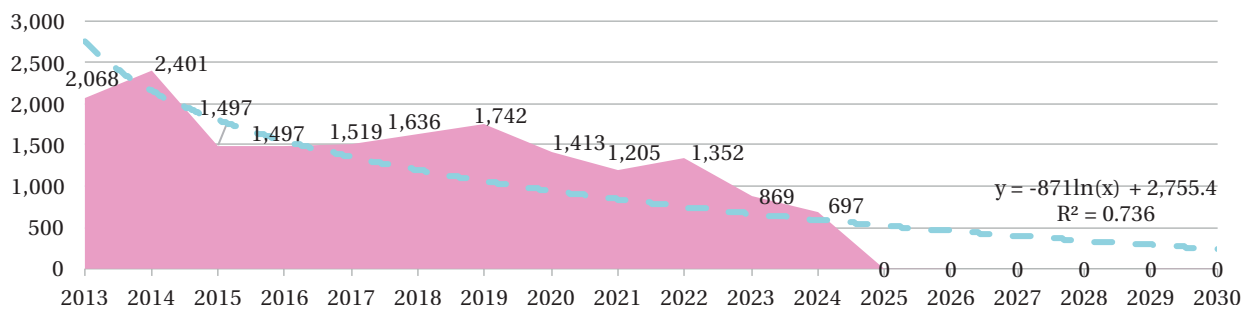
**Note:** this information was not yet available as of 01 January 2024

**Source:** Report on scientific research and development for the period from January 1, 2021, to December 31, 2023, on the implementation of tasks under the scientific and technical program (2024)

A cooperative dairy farm was also established. For this purpose, UAH 17 million was raised. The sponsors were Danone Ukraine, the International Charitable Fund Community Wellbeing and the Canadian International Development Agency. These cooperatives were used to create the association of agricultural service cooperatives 'Hospodar' (registered on 16 May 2011). The purpose of its functioning is to develop the activities of ports of quality raw materials. It also provides training for members of cooperatives, institutional support for the production of quality products to prepare for EU accession in compliance with regulations, lending to family farms, and promoting rural development (Malik, 2019). The development of cooperatives is particularly relevant in the context of military operations. The agricultural sector has suffered and continues to suffer tremendous losses, estimated at hundreds of billions of dollars. Agricultural infrastructure has been destroyed: farms, elevators, processing plants, and agricultural machinery. Furthermore, thousands of hectares of land have been mined. Restoration of the destroyed assets requires funds and human resources. The war with Russia has adversely affected the activities of certain cooperatives and their associations.

For instance, while in 2021 the Hospodar agricultural service cooperative (n.d.) received net income from

the sale of products and services in the amount of UAH 103,489 thsd, in 2023 it was UAH 10,307 thsd, and the profit was UAH 1,828 thsd and UAH 630 thsd, respectively. Revenues in the Kazarnyansky Dobrobut agricultural cooperative (Kazarnyansky Dobrobut agricultural..., n.d.) also decreased from UAH 432 thsd in 2021 to UAH 377 thsd in 2023. In ASC Ivankovetsky Svitanok (Ivankovetsky Svitanok agricultural..., n.d.) – from UAH 477 thsd in 2021 to UAH 168 thsd in 2022. Agricultural cooperation can help to meet the needs of small and medium-sized enterprises and private farms and make a valuable contribution to the development of territorial communities in the free territories and in preparation for accession to the European Economic Community. Information on the key indicators of agricultural cooperatives' development as of 01 January 2024 was not yet available. There was also no body that would monitor the development of agricultural cooperatives, the number of members and employees. General statistics were limited to 2018. The available information base on the development of agricultural cooperatives provided only quantitative characteristics of cooperatives. The share of employed workers was insignificant and had no impact on rural employment. On average, there were 1.3 people per cooperative, and the number of cooperative members was 23, with 38 people in dairy cooperatives (Fig. 4).



**Figure 4.** Number of employees in agricultural service cooperatives, persons

**Note:**  $y = -871 \ln(x) + 2755.4$  is a logarithmic function for forecasting changes in the number of employees in agricultural service cooperatives in 2030; the correlation coefficient is 0.736

**Source:** Report on scientific research and development for the period from January 1, 2021, to December 31, 2023, on the implementation of tasks under the scientific and technical program (2024)

It was found that 1,298 cooperatives were registered at the beginning of 2023. However, only about 3/4 were active. The most active were agricultural cooperatives in the Lviv, Cherkasy, and Lviv regions. It was found that

the number of members of cooperatives, as well as the number of people working in them, has changed slightly, ranging from 23-29 thsd people and 1,200-1,600 people, respectively (Fig. 5, Table 1).

**Table 1.** Performance indicators of agricultural service cooperatives

Year	Number of cooperatives	Number of cooperative members, thsd people	Number of employees, people	Financial support received from the local budget for the year, UAH thsd	Amount of taxes and duties paid, UAH thsd	Mutual fund size, UAH thsd	Availability of property, plant, and equipment, UAH thsd	Proceeds from sales of products, UAH thsd	Funds received per cooperative, UAH thsd	Funds received per cooperative member, UAH thsd
2016	949	26.515	1,497	1,274.5	16,174.5	36,008.6	77,198.8	87,113.6	91.8	3.3
2017	1,017	23.520	1,519	995.2	5,952.6	87,627.9	74,939.5	81,694.1	80.3	3.5
2018	1,073	24.818	1,636	3,438.7	13,981.5	26,263.3	91,449.2	109,624.2	102.1	4.4
2019	1,207	25.736	1,742	-	14,635.5	28,936.5	91,896.3	122,896.1	101.8	4.8
2020	1,269	26.700	1,413	5,380.8	10,606.7	34,816.4	148,937.5	143,703.9	113.2	5.4
2021	1,282	26.400	1,205	1,177.4	9,454.8	41,766.5	135,024.5	528,808.7	412.5	20.0
2022	1,096	26.200	1,352	2,040.7	13,139.2	42,431.4	103,407.6	178,973.4	150.3	6.4

Table 1, Continued

Year	Number of cooperatives	Number of cooperative members, thsd people	Number of employees, people	Financial support received from the local budget for the year, UAH thsd	Amount of taxes and duties paid, UAH thsd	Mutual fund size, UAH thsd	Availability of property, plant, and equipment, UAH thsd	Proceeds from sales of products, UAH thsd	Funds received per cooperative, UAH thsd	Funds received per cooperative member, UAH thsd
average for 2016-2022	1,127.6	25.698	1,480.6	2,384.5	11,992.1	42,550.1	103,264.8	178,973.4	150.3	6.8
per 1 cooperative per year	-	0.023	1.313	2.115	10.635	37.735	91.579	158.721	-	-

Note: information for 2023 was not yet available

Source: Official website of the State Statistics Service of Ukraine (n.d.); M. Malik *et al.* (2022)

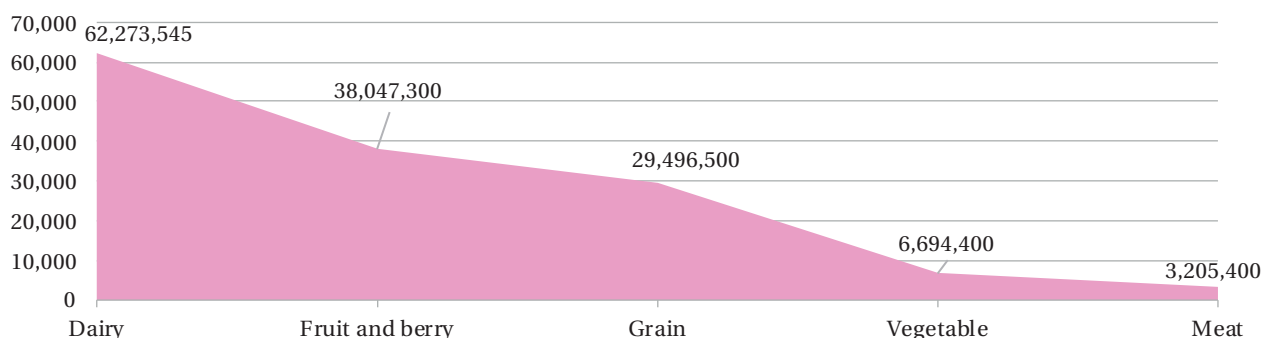


Figure 5. Funds received from the sale of certain types of products by agricultural service cooperatives as of 01 January 2023, UAH thsd

Source: Report on scientific research and development for the period from January 1. 2021. to December 31. 2023. on the implementation of tasks under the scientific and technical program (2024)

The development of agricultural cooperation in Ukraine is negatively affected by large farms with land banks of 50 hectares or more and centred in urban areas. The existence of business entities of varied sizes, such as private households (up to 2 ha of land), farms (130 ha), and medium-sized farms (500 ha or more), does not contribute to the development of cooperatives. This will not be corrected by the provision in the Law of Ukraine No. 819-IX (2021) on voting depending on the amount of capital invested, which is generally accepted by cooperative entities. In such conditions, cooperation can successfully develop when business entities that are equal in terms of both production volumes and organisational forms are united. For instance, private farms and family farms. This is because a cooperative successfully combines the interests of owners, producers, and consumers. In addition, despite the lack of a coherent state policy to support agricultural cooperatives, caused by the military actions of the Russian Federation, the pace of development of cooperative structures has changed slightly over the past 10 years. Between 2017 and 2023, the number of agricultural cooperatives increased by 1,017 in 2017 to 1,229 in 2023, or about 5% per year. However, the number of cooperatives is slowing down due to the hostilities. In 2022, 7 cooperatives were organised, while in 2023 – 17.

The efficiency of the economic activities of some cooperatives decreased in 2022-2023. Thus, while the Dobrobut Andriivky cooperative (Sinelnivskiy district, Dnipro region) was profitable in the pre-war years, it

suffered losses during the hostilities. Revenue decreased from UAH 2,765 thsd in 2021 to UAH 1,354 thsd in 2023. Despite the crisis caused by the hostilities, there are positive results. In August 2022, the village of Troyandove, Odesa region, received UAH 100 thsd from the Embassy of the Kingdom of the Netherlands to implement the “Rose Kingdom” project. However, the total cost of the project is UAH 399 thsd (of which UAH 50 thsd are funds of the territorial community). In October of that year, a 3-hectare rose garden was laid and an agricultural cooperative was established (In the Odesa region..., 2022). In addition, in 2022, an agricultural service cooperative ‘Victory Gardens’ (Vita-Poshtova village, Kyiv region) was established to unite market participants to jointly purchase the necessary inputs for production, sell surplus products, train cooperative members, and grow various types of products (A cooperative ‘Victory Gardens’ .... 2022). The main services of the Victory Gardens cooperative include training in modern technologies; development of technologies for growing the necessary crops; conducting excursions to households; payment for consulting and advisory services, etc. A member of Victory Gardens can receive discounts for the cooperative; access to business plans and technologies (greenhouse, poultry, rabbit, sheep farm); access to events or training programmes; and the opportunity to take part in joint sales of products.

The first cooperative elevator was established in 2022 to help agricultural service cooperatives export their products (“Zernovyi”, “Hospodar” in Dnipro region,

“Zerno-Bunk” in Kirovohrad region) (Agro-Business. n.d.). The purpose of the “Zernoyi” cooperative (n.d.) in Dnipro region, which unites 101 grain farms with a land bank of 35,000 ha, is to store and process grain and oilseeds. Net income from sales of products and services in 2023 amounted to UAH 23,999 thsd, compared to UAH 15,999 thsd in 2021. Profit increased 4.6 times and amounted to UAH 1,664 thsd in 2023. The purpose of the “Zerno-Bunk” cooperative (Agricultural Cooperative “Zerno-Bunk”. n.d.) in Bobrynets, Kirovohrad region, which unites 35 farms with a land bank of 17 thsd ha, is to form commercial volumes of grain both on the internal and external markets. Revenues increased by 23% in 2022 compared to 2020. Net income increased by 53%. An analysis of the activities of cooperative structures suggests that the crisis caused by the military actions of the Russian Federation negatively affected the development of cooperation. The pace of creation of new cooperatives has slowed down and the revenue component of their activities is decreasing. However, there are also positive results, and this gives hope for the prospects of cooperation development despite the military challenges.

**Implementation of international technical aid programmes.** The implementation of international technical aid programmes is of great value for the development of cooperation and is aimed at increasing the mobilisation of business income, which will improve living standards, create new jobs, and help to support the post-war recovery and reconstruction of the agricultural sector of the economy as effectively as possible. The most effective projects to support agricultural cooperation in Ukraine are as follows: a) Dairy Business Development in Ukraine project (2014-2021; financial partners: the Government of Canada, the Ministry of Foreign Affairs, Danone Ecosystems Foundation (France), Danone in Ukraine, ICF ‘Community Welfare’, Dnipro and Lviv regional state administrations; CAD 27.7 million raised; uniting 5000 small and medium-sized dairy producers into a network of associations in Lviv, Dnipro, Ivano-Frankivsk, and Kherson regions); b) the EU/UNDP Community Based Approach to Local Development Project (support for the establishment of agricultural service cooperatives); c) the USAID Agricultural and Rural Development Support Project (funding for service cooperatives or producers to receive advisory and information support, purchase of agricultural equipment) (Malik, 2019; Kutsyk *et al.*, 2023). International technical aid programmes have played a key role in the development of agricultural cooperation in Ukraine, contributing to increasing incomes, creating jobs, and supporting the post-war economic recovery.

**Development of agricultural production cooperatives.** The fundamental principles of agricultural production cooperatives include the following: voluntary membership; distribution of income according to labour participation; personal labour participation of members (therefore, only an individual can be a member of a production cooperative); economic independence; and democratic governance. The development of agricultural production cooperatives plays a major role in the country's food security system. In the interpretation of the Law of Ukraine “On Agricultural Cooperation” (On the approval of the Model Rules..., 2013), an agricultural production

cooperative is an association of individuals for the purpose of joint management by combining resources to create jobs (employment of cooperative members) and make a profit. However, the Law of Ukraine No. 819-IX (2021) of 27 July 2020 does not stipulate production cooperatives as such.

Examples of successful development of production cooperatives include Batkivshchyna (Batkivschyna agricultural cooperative., n.d.) in Poltava region, Urozhai (Urozhai agricultural production cooperative, n.d.) in Volyn region, V. Stefanyk (Collective Agricultural Cooperative..., n.d.) in Lviv region, and Rodyna (SVK “Rodyna”, n.d.) in Odesa region. The Batkivshchyna ASC in Kotelva village, Poltava region, is a voluntary statutory association of citizens who own land and property shares for joint economic activity. In 2023, the land bank of Batkivshchyna ASC totalled 6,886 ha. The cooperative is a diversified dairy, grain, and beet-root farm. It has 2,200 heads of cattle, including 905 cows. The milk yield per cow is over 7,000 kilograms per year. In 2022, the cooperative had an income of UAH 131,042 thsd. The cooperative has a breeding farm of Ukrainian Red and White cows. It produces reproductive seeds of winter and spring crops, maize, and sunflower hybrids. The success of the cooperative is based on sound management, proper organisational skills of managers and specialists, compliance with labour and technological discipline, constant care for people, strong material and moral interest, encouraging initiative and increasing the responsibility of each member of the cooperative (Zaliiivska-Shyshak & Fesun, 2021). The V. Stefanyk Production Cooperative in Yaseniv village, Lviv region, is a diversified farm that grows oilseeds, pulses, grains, potatoes, and vegetables. In 2022, revenue grew by +2.43%, but net profit decreased by 33% compared to 2021.

Agricultural production cooperatives (998 in 2023) have developed social capital. The success of production activities is influenced by the rational resolution of social issues, employment, and care for members-owners of farms. The transformation processes in the development of production cooperatives will continue in the future due to the biased perception of them as the prototype of collective farms. In the post-war period, the development of new forms of cooperative relations – simple partnerships, joint land cultivation partnerships, and contractual sales of products – intensified.

## ► Discussion

Overall, the authors of the present study agree with the researchers of agricultural cooperation on the state and preconditions for their development. Therewith, these proposals do not always factor in the economic situation, the state of war, legislative changes, and the vision of cooperation development during the period of Ukraine's accession to the EU. N. Denissova & R. Born (2021) focused on the trends in the functioning of cooperatives and farming entities to stimulate the use of information systems and innovative technologies. N. Abu Hasan *et al.* (2022) emphasised the need to develop digital technologies in the management decision-making system and agricultural business to increase competitiveness and productivity in agriculture. D. Shelenko *et al.* (2022) fully covered the specific features of the future development of rural cooperatives under martial law. The authors of the present

study support the position of researchers that the capacity of the market niche will grow due to the implementation of innovative, digital technologies in business and the integration of cooperative structures.

The findings of A. Semysal (2022) on the development of cooperative relations in wartime are noteworthy. It was found that in dairy farming, the development of cooperation will help to establish control over the quality of dairy products; optimised use of resources; reduction of transaction costs, etc. The authors of the present study agree that without substantial state support, the development of dairy cooperatives and the creation of network-type structures is challenging. O. Litvak & S. Litvak (2023) emphasised the significance for agricultural entrepreneurs to cooperate with scientific and research institutions to introduce innovative systems and technologies, improve professional skills, and optimise production. Furthermore, I. Tomashuk *et al.* (2023) focused on the significance of developing the socio-environmental policy of business entities, which is also relevant to the development of agricultural cooperatives in a market environment.

S. Jerčinović (2023) substantiated the specific features of the development of the organisational culture of entrepreneurs and the sustainability of their marketing strategies to increase productivity in agriculture. P. Kutsyk *et al.* (2023) covered the state and priorities for the development of agricultural cooperation in extreme operating conditions. The authors of the present study agree that social, human, and organisational capital; care for members and communities; and a prominent level of unity are substantial advantages of cooperation. P. Kutsyk *et al.* (2023) praised the Law of Ukraine No. 819-IX (2021), attributing only to this Law the provisions that were in the framework Law of Ukraine No. 1377-IV (2003). The researchers highlighted as an achievement the granting of the right to receive dividends and patronage dividends to members of cooperatives instead of share payments (Kutsyk *et al.*, 2023). The statement that cooperative members are given the opportunity to choose the types and directions of activity – production or service – is also not true. These are distinct types of activities. There are considerable differences when establishing a production cooperative. For a production cooperative, the labour participation of members is mandatory, and therefore only individuals can be members of such cooperatives.

Thus, the Law of Ukraine No. 819-IX (2021) legislatively approximated the institutional status of an agricultural cooperative to the model of a business entity. The abandonment of the division of cooperatives by type of activity into production and service ones and the change to the status of 'profitable-unprofitable' do not factor in the essence of cooperatives as the structures that formed them. Harmonising provisions that put the functioning of production cooperatives, of which there are about a thousand, outside the scope of the Law, have been removed. By using the text of the framework Law of Ukraine No. 1087-IV (2003), the logical construction of cooperative legislation, which means the specifics of the formation and organisation of cooperative structures – on agricultural, consumer, construction, and credit cooperation – was violated. Vasyl Ivchenko, a member of the Committee on Agrarian and Land Policy of the Verkhovna Rada of

Ukraine, noted that the generic feature of a cooperative, the mutual fund, has disappeared from the text of the Law. Now, instead of equity shares, there is a share in the authorised capital, and instead of a mutual fund, there is an authorised capital (Report on scientific research..., 2024). This begs the question of how a cooperative will now differ from any business company. A negative consequence of this Law may be that fictitious labour relations are covered by cooperative relations, the rights of employees to wages are violated, and conditions are created for inefficient use of budget funds. Currently, there is no common approach to the development of agricultural cooperatives in the country. The replacement of cooperative payments with patronage payments in the Law of Ukraine will not substantially affect the development of cooperation. Legislation on agricultural cooperation needs to be improved, but with due regard to national traditions, the opinion of NGOs and researchers, and European practices, and to eliminate the shortcomings that still exist.

O. Kovbasa & V. Maznyi (2024) covered topical issues of the development of integration processes in modern agricultural business from the standpoint of horizontal, vertical, and intersectoral cooperation of producers in the market environment. It was found that Ukraine has potential opportunities for considerable development of agricultural cooperation, the presence of a significant number of private households, small and microenterprises, farms, considering the requirements of association with the EU following the requirements of the European Community. However, research revealed that there are quite problematic issues that hinder the development of agricultural cooperation. So far, Ukraine has not created a proper database of statistical data on the development of agricultural cooperatives and their contribution to the national economy. The cooperatives face problems related to the lack of qualified personnel, low level of implementation of innovative technologies, which are affected by insufficient financial support, low production volumes, inadequate quality of marketing, and lack of advisory services. In terms of organisational and economic development, further development of small businesses and cooperatives should be ensured. The state should continuously focus on developing the inclusiveness of family farming and cooperation as a basis for sustainable rural development.

Agricultural cooperation has great prospects, but not all agricultural producers, especially small ones, are ready to take advantage of the opportunities offered by the EU-Ukraine Association Agreement. Some are afraid of changes in the absence of funds, while others are afraid of competition and new requirements for product quality in line with EU standards. Ukraine is committed to implementing reforms in wartime, although the practice is challenging. The EU-Ukraine Association Agreement opens a way for small businesses to become part of the European community through cooperation and become part of the internal production. A common form in the agricultural sector is integrative associations based on cooperative principles, which will provide conditions for the competitiveness of small agricultural producers. Such cooperative formations are created by integrating all parts of production. The idea of agricultural cooperation is based on the following principles: objective advantages of large-scale

production over small-scale production; limited capabilities of each individual (small) commodity producer in the development of specialisation processes; the need to develop processes of concentration of business entities in the production of a concrete type of product in the theory of differential incentives, where each process has its optimised modes and size.

### ► Conclusions

The purpose of this study was to assess the state of development of agricultural cooperation for 2018-2023, considering the effects of the crises caused by the military actions of the Russian Federation, and to identify strategic issues of its further functioning. The task was largely completed. The prospects for the development of cooperation are based on its function – meeting the economic, social, and other concerns of its members. In extreme operating conditions, if small and micro businesses do not unite, their further development will be challenging and problematic. The key obstacles to their activities include financial, price-related, and export problems. It is only through the association of producers that it is possible to operate efficiently, which is confirmed by the activities of selected cooperatives and their economic performance. It was found that as of 1 January 2024, there were 1,227 agricultural service cooperatives and 961 production cooperatives. 28 thsd farmers in the country are members of agricultural service cooperatives. All cooperatives are structured by specialisation, but most of them are dairy cooperatives, land cultivation, and harvesting cooperatives. It was found that in 2016-2022, agricultural service cooperatives received UAH 178,973.4 thsd from the sale of products and paid taxes in the amount of UAH 11,992.1 thsd. To create

conditions for the successful development of agricultural cooperation, it is necessary to determine and forecast agricultural policy (long-term, predictable, and understandable); improve cooperative institutions (streamline cooperative legislation); create a framework for the development of cooperatives (development of family farms and small businesses); support at the beginning (financial support for paying a manager, accountant, purchase of equipment, information support); borrowing the practices of other countries (EU – identification of the legislative framework); cooperative diplomacy (contacts with other foreign organisations); cooperative education (cooperative law, cooperative education system); donor assistance (coordination of various programmes, information and advisory support, general knowledge base); training of officials and pseudo-cooperatives (control over the registration of cooperatives, development of programmes, development strategies for cooperatives).

The practical significance of this study lies in the assessment of the state of development of the cooperation process and the activities of individual entities. The necessity of improving the legislative and regulatory framework was confirmed. Further research should clarify the principles of conceptualising the prospects for the organisational and economic development of entrepreneurship, cooperation, and agro-industrial integration under martial law and post-war transformations.

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### ► Conflict of interest

The authors of this study declare no conflict of interest.

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## Стан та перспективи розвитку сільськогосподарських кооперативів в контексті євроінтеграційних процесів

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► **Анотація.** Активізація діяльності сільськогосподарських кооперативів має особливе значення в системі нарощування конкурентостійкості та адаптивності аграрного сектору економіки, стабілізації продовольчої безпеки в умовах інтеграції із європейською спільнотою. Метою статті було обґрунтувати економічні, теоретико-методологічні, соціальні положення функціонування сільськогосподарських кооперативів в контексті євроінтеграційних процесів. В процесі дослідження використовувалися загальнонаукові методи пізнання при узагальненні тенденцій розвитку кооперації в передвоєнні та воєнні часи, особливостей нормативно-правових засад; структурно-функціональний метод при визначенні показників, що гальмують процеси функціонування сільськогосподарських кооперативів; аналізу і синтезу при оцінці тенденцій розвитку кооперативів; аналізу при оцінці і характеристиці окремих кооперативних структур. Розглянуто сучасний стан, місце і роль сільськогосподарських кооперативів в контексті євроінтеграційних процесів при вступі України до європейської спільноти. Проведено системний аналіз проблем і тенденцій функціонування сільськогосподарських кооперативів в Україні в період воєнного часу. Розглянуто теоретико-методологічні аспекти функціонування кооперативних утворень. Виявлено причини, що гальмують активізацію кооперативного руху в аграрній сфері економіки на сучасному етапі розвитку. Розглянуто тенденції розвитку сільськогосподарських кооперативів в Європейському Союзі та світі. Оцінено динаміку розвитку сільськогосподарської кооперації в Україні та виявлено негативні аспекти, які необхідно враховувати при організації та функціонуванні сільськогосподарських кооперативів в залежності від виду та діяльності кооперативу. З'ясовано роль міжнародної технічної допомоги та державної підтримки в стимулюванні та стратегії розвитку сільськогосподарської кооперації в Україні. Виявлені можливості та перспективи розвитку кооперативного руху та проблеми стабільного розвитку кооперативів шляхом залучення особистих селянських господарств до інтеграційних процесів. Розкрита роль кооперативів у формуванні соціального капіталу та сталому розвитку сільських територій в післявоєнній відбудові економіки України. Інформаційний матеріал можливо використовувати при розробленні програм розвитку суб'єктів підприємництва в аграрному бізнесі регіонів

► **Ключові слова:** кооперація; підприємництво; кооператив; суб'єкт підприємництва; інтеграційні об'єднання; соціальний капітал; сільські території

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