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Rural Population and the Agricultural Economy Sector of Ukraine – Pre-War Assessment

Abstract

Agriculture has always been a leading occupation for the inhabitants of Ukraine. The agricultural sector is an important source of livelihood for approximately 13 million Ukrainians living in rural areas. Despite about two-thirds of agricultural production being generated by enterprises, rural households account for around 30% of food. Despite the availability of modern and complex machinery and technologies, the inhabitants of rural settlements remain the primary driving force behind the development of the agricultural economy. This research aims to formulate recommendations for the post-war rebuilding of Ukraine's agricultural economy, based on answers to the following scientific questions: What are the dynamics and changes in specific indicators of Ukraine's agricultural economy sector during the 12 prewar years, from 2010 to 2021? Is there a correlation between the size of the rural population and these indicators, and if so, how strong is it? How can the identified patterns assist in rebuilding post-war Ukraine? To ensure the most robust results possible, various scientific research methods and tools were employed, including empirical, comparative, univariate, statistical, and time series analyses, a correlation research design, as well as textual, tabular, and graphical methods of data presentation. The research findings indicate that the following segments of the Ukrainian agricultural economy sector are correlated: rural population and agricultural products output, rural population and agro-food exports, and agricultural products output and agro-food exports.

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Introduction

Agriculture is one of the oldest and most significant human activities, dating back to the earliest stages of human civilisation. For informational purposes, agriculture is defined by Britannica as “the active production of useful plants or animals in ecosystems that have been created by people” (Britannica 2024). The primary importance of agriculture lies in its provision of food for people and fodder for animals. However, agriculture also plays a crucial role in the economic, social, and environmental development of any nation (Cornelius 2023). As the fabric of rural communities and their main economic activity, agriculture significantly contributes to rural development by supporting employment, ancillary businesses, environmental services, and the economic and social infrastructure (European Commission 2000). Approximately half of the world’s economically active population is employed in agriculture, with some differences between countries with varying levels of economic development. In developing countries, this figure can be as high as two-thirds or more, while in developed countries, it is less than 10%. For instance, in the USA and some Western European countries, it is only 2–3% (Sustainable Development for Ukraine, n.d.).

Agriculture has always been a leading occupation for the inhabitants of Ukraine due to the country’s favourable climatic conditions, fertile soil, advantageous geographical location, and availability of a skilled workforce. Agriculture is a vital source of livelihood for approximately 13 million Ukrainians living in rural areas. Despite about two-thirds of agricultural production being generated by enterprises (big agro-holdings as well), rural households produce around 32% of food (Mykhalchuk 2022). This further underscores the importance of small and family farms for the sustainable functioning of agriculture and rural settlements, which in turn impacts the demographic situation in these areas. Accordingly, the development of small and family farms means an increase in the number of jobs remote from cities, ensuring the rural population not only the possibility to provide itself with everything it needs, but also guarantee social stability and a decent standard of living in

the local community (Odarchenko 2021). That is another confirmation for the importance of small and family farms either for the successive functioning of agriculture or rural settlements, having a consequent impact on the demographic situation in the country in general and small towns/villages in particular. According to the FAO report “Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine” (FAO 2022), 25% of the Ukrainian rural population engaged in agriculture has ceased or reduced production due to the war, with the situation being even more dire in the most agriculturally dependent regions of Ukraine, where over 40% of rural families are affected by the war (Mykhalchuk 2022).

However, the war has exacerbated the socio-economic challenges faced by the rural population, as, besides an increase in the natural mortality rate, the birth rate has been declining for a long time (Sánchez Nicolás, 2025). This is not unique to Ukraine but reflects a broader European trend. Moreover, over the past quarter-century, the challenges confronting rural areas have evolved (Wilczyński 2023), with climate change – characterised by increasing water scarcity and a growing number of natural disasters – complicating agricultural production and making life for the rural population even more difficult. Although modern machinery and mechanisms, developed through extensive technological advancements, have the potential to ease agricultural production and improve the lives of the rural population, they still require human operation, even those equipped with AI. Further, acquiring modern machinery often necessitates significant financial investment, which can be prohibitive. Consequently, despite the availability of advanced machinery and technologies, rural residents remain the primary driving force behind the development of the agricultural economy. Therefore, all aspects of the rural population dynamics, such as fertility and death rates, standard of living, and migration, are critically important not only for the communities per se but also for the successful functioning of the nation’s economy and, by extension, the economies of other countries. In outlining the course of the research presented in this paper, the following research questions have been framed: What are the dynamics and changes in specific indicators of Ukraine’s agricultural economy sector during the 12 pre-war years from 2010 to 2021? Is there a correlation between the size of the rural population and these indicators, and if so, how strong is it? How can the identified patterns assist in rebuilding post-war Ukraine? Consequently, the goals of the research are to

formulate recommendations for Ukraine for the post-war rebuilding of its agricultural economy, based on the answers to the outlined scientific questions.

Literature Overview

Among those who research topics related to various aspects of rural population functioning, notable contributions include those of Dinu and colleagues, who investigated the extent to which Romania accessed European funds for agriculture and rural development during the 2014–2020 period and how these funds influenced rural population functioning in the country (Dinu 2020). Mittenzwei and co-authors studied the effects of climate policy on agriculture and rural areas in Norway (Mittenzwei 2023). Dazhuan Ge and colleagues analysed the effects of rural-urban migration on agricultural transformation in China's traditional farming areas (Dazhuan 2020). Ngadi and co-authors examined youth mobility, job choice, and the implications for agricultural workers (Ngadi 2023). Sodoma and colleagues investigated the socio-economic aspects of rural development in the context of decentralisation of management, the organisation of rural areas, and the formation of development potential in Ukraine (Sodoma 2022). Nwachukwu and co-authors endeavoured to develop a model through which components of agricultural development can enhance rural livelihoods (Nwachukwu 2023). Kalogiannidis and colleagues assessed the risk, vulnerability, and resilience of agriculture, as well as its impact on sustainable rural economic development, using Greece as a case study (Kalogiannidis 2023). Romanenko and colleagues explored the development directions of rural territories in EU countries by stimulating the agricultural sector and tourism (Romanenko 2020).

Cvijanovic and colleagues conducted a systematic analysis of indicators of agriculture and rural development in East Central and South-East European countries (Cvijanovic 2020). Sikandar and colleagues examined the role of foreign aid in sustaining agricultural production and eradicating rural poverty in Pakistan (Sikandar 2022). Yigezu Wendimu and Tejada Moral reviewed existing agricultural challenges and prospects in Ethiopia (Yigezu & Tejada 2021). Boudet and colleagues assessed urbanisation processes affecting rural areas, exploring spatial patterns in rural-urban connectivity across the Global South and testing for its effects (Boudet 2020). Zhang and colleagues

examined the structure, changes, and regional differences in agricultural cultivation under urbanisation, analysed the reasons for the restructuring of agricultural cultivation, and revealed the adaptation linkages between rural-urban transition and agricultural restructuring (Zhang 2020). Maharjan and colleagues investigated agricultural land use change in Chitwan, Nuwakot, and Lamjung districts of Nepal from 1990–2017 vis-a-vis rural outmigration (Maharjan 2020). Chipfupa and Tagwi assessed the potential for rural youth participation in agriculture in South Africa using a typology formulation approach (Chipfupa & Tagwi 2021). Lucian examined the impact of the Rural Development Policy and Common Agricultural Policy on rural development in Romania (Lucian 2020).

A group of authors led by Dziamulych researched the interdependence and interrelation of monetary and non-monetary expenditures incurred for the maintenance of private peasant farms, alongside other socio-economic factors and the differentiation of rural population food consumption in the regional context, specifically in the Volyn region of Ukraine (Dziamulych 2020b). Another group of researchers, also led by Dziamulych, evaluated the rural labour market development in the Volyn region of Ukraine, identifying trends in rural population employment and unemployment (Dziamulych 2020a). Grujić-Vučkovski and colleagues analysed the importance of agriculture, forestry, and fisheries (AFF) through their contribution to the gross domestic product (GDP) of Serbia and the amount of funds allocated in local self-government units (LSUs) for agricultural needs (Grujić-Vučkovski 2022). Grodzicki and Jankiewicz investigated the impact of the Common Agricultural Policy (CAP) in the European Union (EU) on job creation and economic growth in rural areas (Grodzicki & Jankiewicz 2022). Gava and colleagues researched strategies to reduce rural poverty in Bosnia and Herzegovina through diffusing berry farming as an emerging strategy for increasing farm incomes (Gava 2021). Liangshan Li examined rural labour transfer from agriculture to non-agricultural sectors, identifying it as a key factor in increasing rural household income and improving agricultural productivity (Liangshan 2023), *inter alia*. Though some of the researchers mentioned above explored different aspects of either the agricultural economy sector or rural area functioning, they demonstrate the scope of topics being researched, and both their findings and methodologies can be studied and further implemented, where applicable, for Ukraine.

Focusing on research by Ukrainian authors, notable works include those by Pasemko and Taran, who discussed the peculiarities and challenges of state regulation for the agricultural sector of Ukraine during the war, using the Kharkiv region as a case study (Pasemko & Taran 2023); Minyaylenko and Kharchenko, who examined key factors and challenges facing the agricultural economy of Ukraine during the war (Minyaylenko & Kharchenko 2022); Khaietska and Udalov, who researched modern aspects of organic agriculture development in Ukraine under war conditions (Khaietska & Udalov 2024); Mishchenko and Mishchenko, who focused on the main principles and priorities for the post-war reconstruction of agriculture in Ukraine (Mishchenko & Mishchenko 2022); Bulavka, who explored the conceptual principles for the development of rural territories in Ukraine in the war and post-war periods (Bulavka 2022); Nesterenko and Kauk, who studied the use of artificial intelligence in agriculture (Nesterenko & Kauk n.d.); Neyter and colleagues who explored assessing damages, losses, and needs for Ukrainian agriculture due to the full-scale invasion (Neyter, Zorya & Mulyar 2024); Maryna and Yankovska, who investigated the functioning of the Ukrainian agricultural economy during the war (Maryna & Yankovska 2022); Kovtun, who discussed threats to the sustainable development of the agricultural sector and rural areas during the Russian-Ukrainian war (Kovtun 2023); Vykliuk and colleagues, who researched tools for supporting reproductive processes in Ukrainian agriculture under war conditions (Vykliuk, Kundyt-skyj & Garasym 2022); Nevar, who explored the consequences of the war for Ukraine's industry and agriculture (Nevar 2022), and others. Despite the publications being numerous, none of them studies the rural population in the context of its correlation with other indicators of agricultural economy development over a defined period, focusing on their dynamic peculiarities. This indicates a scientific gap that this paper aims to bridge.

Materials and Methods

A profound and precise data analysis is essential for robust research results. The data analysed in this article were sourced from the official publications and website of the State Statistics Service of Ukraine (State Statistics Service of Ukraine 2023b). The timeframe under analysis encompasses 12 periods (years) from 2010 to 2021. In order to see the data fluctuations better, a longer period of time was selected for the presentation of the dynamics for the population of Ukraine in Figure 1. Data for the agricultural products output in Ukraine are expressed in millions of UAH, adjusted to constant prices from 2016 to minimise the impact of inflation on the calculations.

The following terms are used in this article according to the methodological explanations of the State Statistics Service of Ukraine (State Statistics Service of Ukraine 2023c): “available population” refers to the population present in a specific territory at the time of the census, including individuals temporarily residing there (provided their absence from their place of residence does not exceed 12 months)” (State Statistics Service of Ukraine 2024). The term “rural population” denotes individuals living in villages and settlements (State Statistics Service of Ukraine 2023c), while “urban population” refers to those living in urban-type cities and towns (State Statistics Service of Ukraine 2024). “Export” is defined as a customs regime under which goods are exported outside the customs territory of Ukraine for free circulation without the obligation to return them and without establishing conditions for their use outside the customs territory (State Statistics Service of Ukraine 2021). Conversely, “import” is a customs regime under which goods are imported into the customs territory of Ukraine for free circulation without limitations on their period of stay and can be used without any customs restrictions (State Statistics Service of Ukraine 2021). Notably, since 2014, the State Statistics Service of Ukraine has not included data from the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol due to the Russia-Ukraine war. To conduct the research and ensure the most robust results possible, various scientific research methods and tools were employed, including empirical, comparative, univariate, statistical, and time series analyses, a correlation research design, as well as textual, tabular, and graphical methods of data presentation.

The calculations regarding data correlation were performed using R statistical software (R Core Team 2023). Pearson's correlation coefficient, which quantifies the strength of the association between two variables (Stewart 2024), was calculated according to the formula below:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}} \quad (1)$$

where r – Pearson correlation coefficient, n – number of stock pairs (Srivastav (ed.), Dheeraj Vaidya. 2024).

Given that the number of observations under analysis is not sufficiently large, which may lead to non-normality in their distribution, and to enhance the robustness of the presented research results, the Spearman correlation coefficient, a measure of the relationship between two variables when data are available in the form of rank orders (Sweeney, Anderson & Williams 2024), was also calculated in this article. A simpler formula for calculating the Spearman rank correlation coefficient is presented below:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (2)$$

where ρ is the Spearman rank correlation coefficient, d_i the difference between a pair of ranks, and n the number of observations (Cheusheva 2022).

Additionally, Kendall's rank correlation non-parametric test was calculated according to the following formula:

$$\tau = \frac{\text{number of concordant pairs} - \text{number of discordant pairs}}{n(n-1)/2} \quad (3)$$

where τ is the Kendall's rank correlation coefficient and n the number of observations (Finnstats 2021).

Results and Discussion

Agriculture is vitally important for the Ukrainian economy, as it is the main source of livelihood for approximately one-third of the country's population. The abundance of fertile land, suitable climatic conditions, and a relatively favourable investment climate have enabled Ukraine not only to feed itself but also to provide food for millions of people in Asia, Africa, and the Middle East (Mamonova, Borodina & Kuns 2023). As labour is one of the production inputs in agriculture, besides land and capital (some also include entrepreneurship), understanding the dynamics and general trends of a country's population from which this labour is drawn will significantly contribute to comprehending the country's past functioning and improving its future. Ukraine is a predominantly urban country, with a significant excess of urban population over rural population (Figure 1).

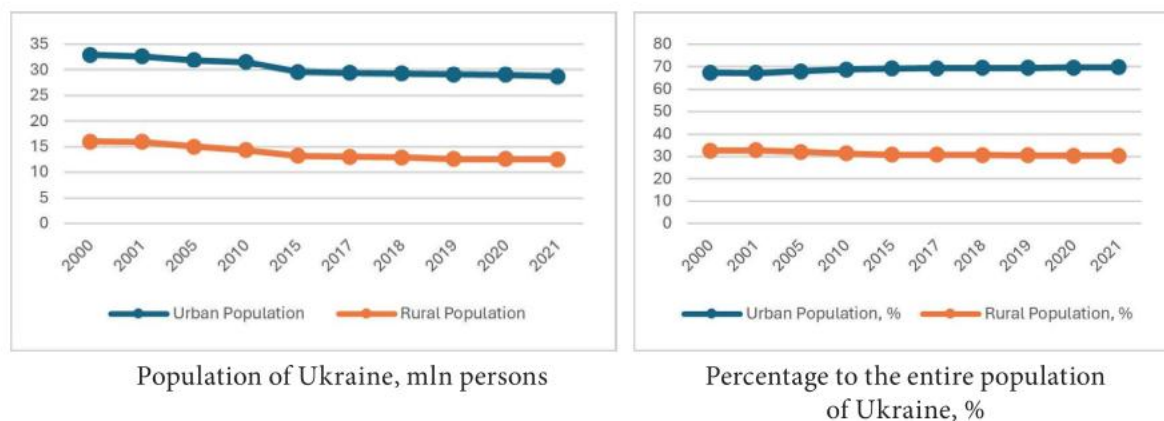


Figure 1: Dynamics for the Population of Ukraine

Source: Author's elaboration based on the data of (State Statistics Service of Ukraine 2023c).

The general trend for both the available and urban and rural populations of Ukraine is negative, indicating a constant decline over the analysed time-frame, with the only exception observed in 2020, when the rural population remained the same as in the previous year. A somewhat different picture emerges when analysing the percentage of the urban and rural populations vis-à-vis the available population of Ukraine. Here, we observe a decrease in the percentage of the urban population only in 2001 (0.2 percentage points),

with all subsequent years experiencing an increase. Conversely, the rural population exhibited only one percentage increase in 2001, with the remainder of the years showing a decline.

To contextualise the situation regarding towns, urban-type settlements, and rural settlements, as of January 1, 2022, there were 461 towns, 881 urban-type settlements, and 28,369 rural settlements (villages) in Ukraine. This compares with 460 towns, 885 urban-type settlements, and 28,385 rural settlements in 2015, and 459 towns, 885 urban-type settlements, and 28,457 rural settlements in 2010 (State Statistics Service of Ukraine 2023c). The general trend indicates an increase in the number of towns, while both urban-type settlements and rural settlements are decreasing. Such negative dynamics of the number of both types of rural settlements are extremely alarming, as, despite the availability of modern and complex machinery and technologies, rural residents remain the primary driving force behind the development of the agricultural economy.

An important factor contributing to the depopulation and "aging" of villages is labour migration, which is exacerbated by socio-economic problems that are more acute in rural areas (Vikhrov 2018). For example, the average monthly nominal salary of full-time employees in agriculture, forestry, and fisheries was UAH 13,061 (UAH 12,243 in agriculture), while in industry, the salary was UAH 15,176 (as of 2022) (State Statistics Service of Ukraine 2023c). Further, the number of jobs and agricultural entities also influence the aforementioned indicators. Additionally, among the factors affecting these trends, one should note the tendency of young people to leave rural areas – not only in Ukraine but also as a general European trend – primarily due to their desire to move to larger towns and cities for higher education and subsequently to settle there or seek employment abroad to find a better job, with higher salaries and not that are less demanding than those in agriculture. In addition, young people contribute to the depopulation of rural areas, because they do not have access to service networks" that would help them remain in their areas of origin (Álvarez Díaz 2024). It is indeed a combination of factors that impact the overall population size and that of rural areas, which vary from region to region. Agricultural production in Ukraine is carried out by three types of farming entities – enterprises, private farms, and households (Figure 2).

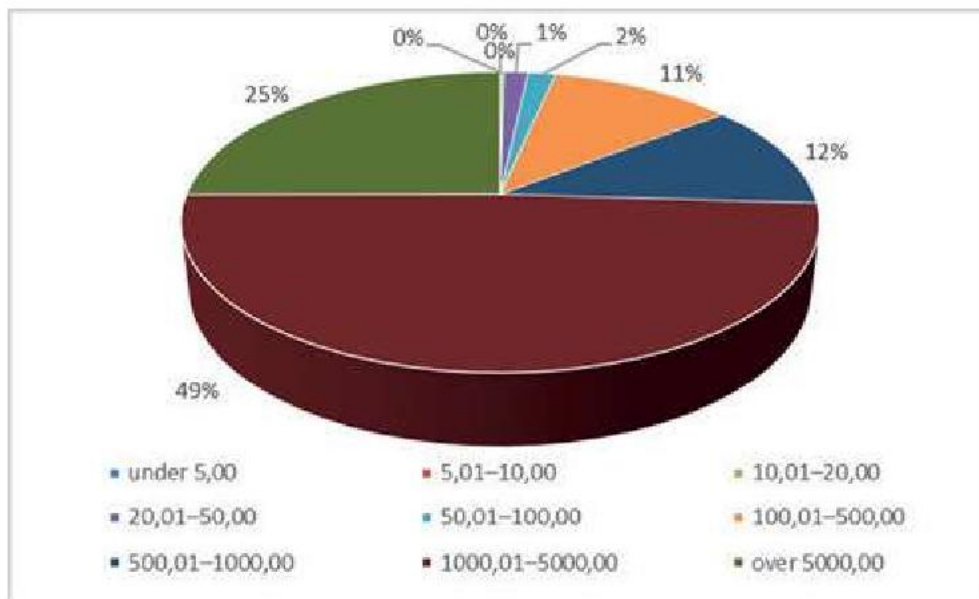
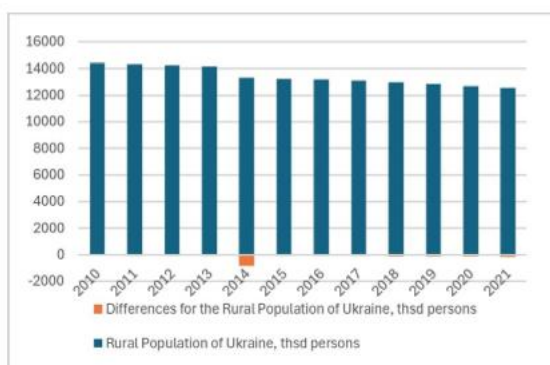


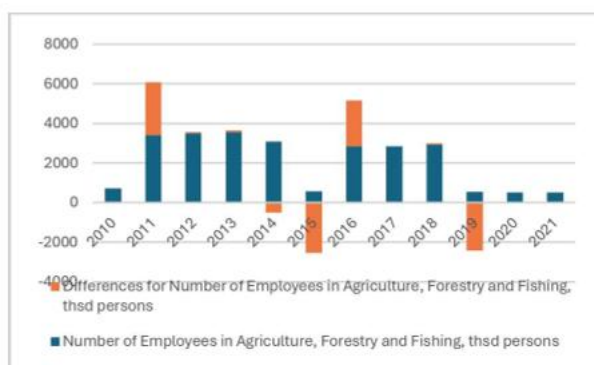
Figure 2: Distribution Structure of Enterprises Engaged in Agricultural Activity in 2022, by the Size of Owned/Leased Agricultural Land, ha

Source: Author's elaboration based on the data of (State Statistics Service of Ukraine

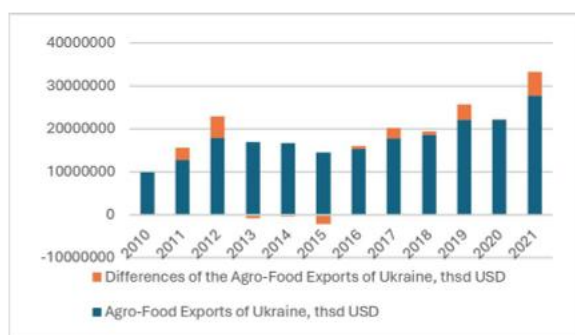
According to data from the State Statistics Service of Ukraine (2023), the largest proportion of agricultural land (approximately 49%) in Ukraine is cultivated by entities possessing or leasing between 1,000.01 and 5,000 hectares, followed by those possessing or leasing more than 5,000 hectares (approximately 25%); 11.5% is cultivated by those possessing or leasing between 500.01 and 1,000 hectares, just over 11% by entities possessing or leasing between 100.01 and 500 hectares, 1.6% by those possessing or leasing between 50.01 and 100 hectares, 1.4% by those possessing or leasing between 20.01 and 50 hectares, 0.2% by those possessing or leasing between 10.01 and 20 hectares, and 0.1% by those possessing or leasing between 5.01 and 10 hectares as of 2022 (State Statistics Service of Ukraine 2023c) (Figure 2). The percentage of land cultivated by entities possessing or leasing less than 5 hectares is too small to be represented in whole numbers. To propose options for future improvement of the Ukrainian agricultural economy in the post-war period, we shall analyse the development tendencies and dynamics of its segments during the pre-war timeframe (Figure 3).



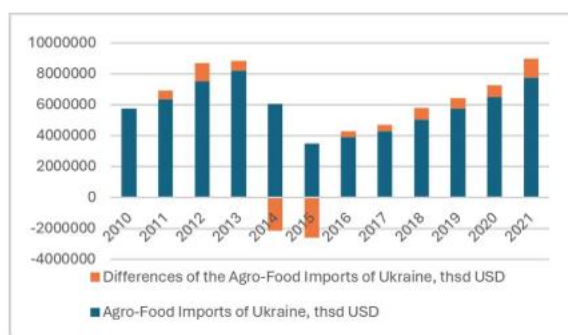
Rural Population, thsd persons



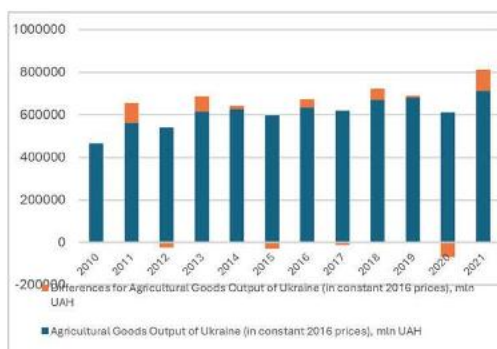
Employees in Agriculture, thsd persons



Agro-Food Exports, thsd USD



Agro-Food Imports, thsd USD



Agricultural Products Output (in constant 2016 prices), mln UAH

Figure 3: Dynamics with Differences for the Main Segments of the Agricultural Economy Sector of Ukraine Functioning

Source: Author's elaboration based on the data of (State Statistics Service of Ukraine 2023a).

The overall trend for the rural population of Ukraine has been negative throughout the whole timeframe under analysis, with no exceptions. The most significant decrease was observed in 2014, while the smallest decrease occurred in 2016. One might be tempted to attribute the drastic decline in rural population in 2014 solely to the annexation of certain Ukrainian territories; however, the situation is more complex. While the aforementioned events undoubtedly impacted the decline, such changes are generally the result of a combination of factors, including the general depopulation of rural territories across Europe (Eurostat 2024). A markedly different situation can be observed when analysing the dynamics for the number of employees in agriculture, forestry, and fishing, which is rather variable, lacking a clear trend. There are two consecutive periods, each lasting three years, where the first period denotes an increase in the number of employees from 2011 to 2013, while the second period shows a decrease from 2019 to 2021. The largest increase in the number of employees in agriculture, forestry, and fishing in Ukraine was noted in 2011, and the largest decrease in 2015.

The dynamics of the next indicator of the Ukrainian agricultural economy development differ from the previous two, as the value of agro-food exports increased from the beginning of the analysed timeframe until 2013, after which it declined for the next three years, before rising again from 2016 to the end of the analysed period. The most significant increase in agro-food exports from Ukraine was in 2021, while the biggest decrease occurred in 2015. The dynamics of Ukrainian agro-food imports closely mirror those of exports, but for 2013, when a decrease was observed alongside an increase in imports. The most significant increase in agro-food imports occurred in 2021, while the largest decrease was recorded in 2015, which further parallels the dynamics of the analysed exports. The final indicator of the Ukrainian agricultural economy development is agricultural output, the dynamics of which differ significantly from the others. Although the analysed timeframe is relatively short for drawing substantial conclusions, some cyclicity can be observed, with alternating periods of one-year increases and decreases followed by two-year increases and one-year decreases. The most significant increase in agricultural output was noted in 2021, while the largest decrease was in 2020. Factors influencing changes in Ukraine's agricultural output include the seasonality of agriculture in general and climate change, along with

alterations in the agricultural output structure caused by changes in export regulations and other related factors.

The agricultural economy of any country comprises numerous interrelated segments and subjects, as the sector, like any other, is a complex system. Therefore, it is essential to analyse it as a whole to understand its functioning and propose options for improvement. The first step in this analysis is to determine whether specific segments, including recognised production factors such as employees and product output, are correlated with one another and, if so, how strong this correlation is. The results of the Pearson correlation coefficient calculations are presented in the table below (Table 1).

Table 1. Pearson Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, thsd persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro-Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population, thsd persons	1	0.479479276	-0.82904998	-0.747	0.2817
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.4795	1	-0.12388945	-0.338	0.1391
Agricultural Products Output (in constant 2016 prices), mln UAH	-0.829	-0.12388945	1	0.7911	-0.01
Agro-Food Exports, thsd USD	-0.747	-0.33752452	0.791094548	1	0.3795
Agro-Food Imports, thsd USD	0.2817	0.139140612	-0.00992675	0.3795	1

Source: Author's elaboration made with the help of (R Core Team 2023) based on the data of (State Statistics Service of Ukraine 2023a).

Analysis of the results presented in Table 1 reveals that the rural population has a medium positive correlation with the number of employees in agriculture, a strong negative correlation with agricultural output and agro-food exports, and a weak positive correlation with agro-food imports in Ukraine.

The number of employees in agriculture, forestry, and fisheries has a weak negative correlation with agricultural output and agro-food exports, and a weak positive correlation with agro-food imports. Agricultural products output has a strong positive correlation with agro-food exports and a weak negative correlation with agro-food imports. Additionally, agro-food exports exhibit a weak positive correlation with agro-food imports in Ukraine. Given that the number of observations in the analysed data sets is limited, and therefore the assumption of normality in data distribution cannot be perfectly met, the robustness of the Spearman correlation coefficients for the analysed data was calculated and is presented in Table 2.

Table 2. Spearman Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, thsd persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro-Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population, thsd persons	1	0.692307692	-0.783216783	-0.8321678	0.0769231
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.692308	1	-0.34965035	-0.4125874	0.2237762
Agricultural Products Output (in constant 2016 prices), mln UAH	-0.78322	-0.34965035	1	0.6153846	-0.097902
Agro-Food Exports, thsd USD	-0.83217	-0.412587413	0.615384615	1	0.3566434
Agro-Food Imports, thsd USD	0.076923	0.223776224	-0.097902098	0.3566434	1

Source: Author's elaboration made with the help of (R Core Team 2023) based on the data of (State Statistics Service of Ukraine 2023a).

The results from Table 2 lead to the following conclusions: the correlation between the rural population and the number of employees in agriculture in Ukraine is strongly positive, the correlation between the rural population

and agricultural output strongly negative, that between the rural population and agro-food exports a strong negative, and the correlation between the rural population and agro-food imports is weakly positive. The correlation between the number of employees in agriculture, forestry, and fishing in Ukraine and agricultural products output, as well as with agro-food exports, is a weak negative, while with agro-food imports, it is weakly positive. The correlation between agricultural products output, agro-food exports, and agro-food imports in Ukraine is strongly positive, while with agro-food imports, it is weakly negative. Simultaneously, the correlation of agro-food exports with agro-food imports is weakly positive. For the results, Kendall correlation coefficients for the analysed data were calculated and are presented in Table 3 below.

Table 3. Kendall Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, thsd persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro-Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population, thsd persons	1	0.545454545	-0.666666667	-0.69697	-0.060606
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.54545	1	-0.272727273	-0.30303	0.2121212
Agricultural Products Output (in constant 2016 prices), mln UAH	-0.6667	-0.272727273	1	0.484848	-0.030303
Agro-Food Exports, thsd USD	-0.697	-0.303030303	0.484848485	1	0.3030303
Agro-Food Imports, thsd USD	-0.0606	0.212121212	-0.03030303	0.30303	1

Source: Author's elaboration made with the help of (R Core Team (2023) based on the data of (State Statistics Service of Ukraine 2023a).

A thorough examination of the results presented in Table 3 reveals that the rural population has a medium positive correlation with the number of employees, a medium negative correlation with agricultural products output and agro-food exports, and a very weak negative correlation with agro-food imports. The number of employees in agriculture, forestry, and fishing in Ukraine has a weak negative correlation with agricultural products output and agro-food exports, and a weak positive correlation with agro-food imports. Agricultural products output in Ukraine has a medium positive correlation with agro-food exports and a weak negative correlation with agro-food imports. Agro-food exports has weak positive correlation with agro-food imports. To ensure robust research results and check their statistical significance, the p-values for the calculated correlation coefficients were determined and are presented in Table 4 below. It should be noted here that alpha equals 0.05. The first p-values to be analysed are those for the Pearson correlation coefficients.

Table 4. P-values for the Pearson Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, that persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro- Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population, thsd persons		0.1147191	0.0008564	0.005244	0.374976
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.114719		0.7012696	0.283293	0.66627
Agricultural Products Output (in constant 2016 prices), mln UAH	0.000856	0.7012696		0.00218	0.975574
Agro-Food Exports, thsd USD	0.005244	0.283293	0.0021801		0.223739
Agro-Food Imports, thsd USD	0.374976	0.66627	0.9755741	0.223739	

Source: Author's elaboration made with the help of (R Core Team 2023) based on the data of (State Statistics Service of Ukraine 2023a).

The p-values presented in the table indicate that the following correlation calculations results are significant: the correlation between the rural population and agricultural products output, and the correlation between agricultural products output and agro-food exports. The p-values for the Spearman correlation coefficients of the analysed data are presented in Table 5.

Table 5. P-values for the Spearman Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, thsd persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro-Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population of Ukraine, thsd persons	0	0.0159	0.00412	0.00144	0.817
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.0159	0	0.266	0.184	0.485
Agricultural Products Output (in constant 2016 prices), mln UAH	0.00412	0.266	0	0.0373	0.766
Agro-Food Exports, thsd USD	0.00144	0.184	0.0373	0	0.256
Agro-Food Imports, thsd USD	0.817	0.485	0.766	0.256	0

Source: Author's elaboration made with the help of (R Core Team (2023) based on the data of (State Statistics Service of Ukraine 2023a).

According to these values, the correlation between the rural population and the number of employees, agricultural products output, and agro-food exports, as well as between agricultural products output and agro-food exports in Ukraine, is statistically significant. The p-values for the Kendall correlation coefficients of the analysed data are presented in Table 6.

Table 6. P-values for the Kendall Correlation Coefficient of Ukraine's Agricultural Sector Functioning Data

	Rural Population, thsd persons	Number of Employees in Agriculture, Forestry and Fishing, thsd persons	Agricultural Products Output (in constant 2016 prices), mln UAH	Agro-Food Exports, thsd USD	Agro-Food Imports, thsd USD
Rural Population, thsd persons	4E-09	0.0138	0.0018	0.001	0.841
Number of Employees in Agriculture, Forestry and Fishing, thsd persons	0.0138	4.18E-09	0.25	0.197	0.381
Agricultural Products Output (in constant 2016 prices), mln UAH	0.0018	0.25	4.18E-09	0.0311	0.947
Agro-Food Exports, thsd USD	0.001	0.197	0.0311	4E-09	0.197
Agro-Food Imports, thsd USD	0.841	0.381	0.947	0.197	4E-09

Source: Author's elaboration made with the help of (R Core Team (2023) based on the data of (State Statistics Service of Ukraine 2023a).

The results of the p-values for the Kendall correlation coefficients indicate the statistical significance of the following correlation pairs: rural population – number of employees, rural population – agricultural products output, rural population – agro-food exports, and agricultural products output – agro-food exports. After conducting exclusion analysis, the following segments of the Ukrainian agricultural economy sector were found to be correlated: rural population and agricultural products output, rural population and agro-food exports, and agricultural products output and agro-food exports. Importantly, the correlation does not automatically mean causation; hence, the cause-and-effect relationships between the variables analysed in this article are a direction for future research.

The research presented in this article will continue, either by expanding the list of segments in the agricultural economy or by applying different sta-

tistical tools to deepen the analysis and explore new horizons of Ukrainian agricultural functioning. Comparing pre-war and during-war data on the functioning of Ukrainian agriculture, examining their differences, dynamics, and tendencies, and treating the war period as a statistical shock in calculations and model building would not only be of interest to researchers but would also provide valuable insights for all stakeholders involved in the political and economic life of Ukraine, both domestically and internationally. However, a significant limitation to conducting such research arises from the war itself and its numerous adverse impacts on the country's functioning, particularly the incomplete statistical data or even their absence, which complicates research or even makes it impossible to conduct.

Conclusions

Ukraine as a whole, and its agriculture in particular, face enormous challenges today, exacerbated by the ongoing war in the country. Some scholars argue that this conflict has been provoked by extraordinary circumstances stemming from global changes in social relations, climate, intensifying competition for global resources and spheres of influence, as well as efforts by previous authorities to maintain their place on the geopolitical stage (Hadzalo 2023). This conflict has triggered unprecedented population migrations since the end of World War II, not only within Ukraine but throughout Europe (Halamska 2023). Further, due to the war, Ukraine – a leading grain exporter – has experienced a dramatic decline in its exports, leading to significant food security concerns for millions of people worldwide (European Council, 2024). Compared to the 2021/2022 period, Ukraine's grain production dropped by 29% for the market year 2022/2023, with further declines expected (European Council, 2024). The research findings indicate that the following segments of the Ukrainian agricultural economy sector are correlated: rural population and agricultural products output, rural population and agro-food exports, and agricultural products output and agro-food exports. The possible explanation for the first correlation pair includes the development of more modern machinery, which does not need so many workers to operate but is more efficient, as well as the usage of better production technologies, sowing materials, and fertiliser, which help increase agricultur-

al production despite the declining rural population size. The correlation of the second pair of variables can be explained by more people leaving rural areas and fewer small and individual farmers cultivating the land, leading them to lease it to larger producers who are more export-oriented. The correlation between the third pair of variables is straightforward: the more agricultural products produced, the more can be exported.

Given the vital importance of agriculture for Ukraine, including its trade and political partners, and for every citizen, not only in Ukraine but also beyond, renewal of the rural communities will become one of the leading tasks in post-war Ukraine. A crucial element of rural renewal is the support of the local communities and the coordination of activities undertaken therein by regional public administration authorities (Sykała 2023). In this context, attracting former rural residents back to their villages should be a priority for public administrators at all levels, not just local ones. In outlining the main directions for post-war reconstruction in Ukraine, it is essential to acknowledge that the trend of rural population reduction was evident even before the war. It would be simplistic to assert that the total reduction of the population, in general, and the rural population, in particular, occurred solely due to natural causes; such simplicity can be misleading, especially when planning the country's post-war renewal. The first step should be to identify the reasons driving rural people to abandon Ukrainian villages. This requires a two-pronged cooperation with each rural community to ensure the effectiveness of the collaboration. Once these reasons are identified, the best practices from other countries regarding rural territory renewal and support should be studied. For instance, the EU's Rural Vision 2040, which aims to create stronger rural areas and more resilient local communities with improved access to services and the introduction of social innovations tailored to specific local contexts (Hałasiewicz 2023), should be thoroughly explored. The next step should involve examining the possibilities for adapting and implementing these best practices to the realities of the Ukrainian rural communities. Successfully fulfilling these tasks will positively influence not only the functioning of individual communities but also contribute to the renewal of the entire Ukrainian economy, thereby strengthening the country's economic and political position on the global stage. The research itself, along with its findings, would be of great interest and utility to public administrators at all levels in Ukraine, potential inves-

tors in the post-war renewal of the Ukrainian economy, particularly its agricultural sector, domestic and foreign business entities, decision-makers, and the academic community, as well as both novice and experienced specialists in statistics and data analysis.

References

- Alvarez Diaz, J. 2024 The emptying out of rural areas and the accompanying brain drain are fuelling inequality in the EU's most depopulated regions. <https://www.equaltimes.org/the-emptying-out-of-rural-areas#:~:text=And%20in%20turn%2C%20the%20populations%20of%20these,them%20remain%20in%20their%20areas%20of%20origin> [accessed: 2025-11-13].
- Appinio. 2023 What is Comparative Analysis and How to Conduct It? <https://www.appinio.com/en/blog/market-research/comparative-analysis> [accessed: 2025-11-12].
- Boudet, F. et al. 2020 'Rural-urban connectivity and agricultural land management across the Global South' *Global Environmental Change* Vol. 60, DOI:10.1016/j.gloenvcha.2019.101982.
- Britannica. 2024 Agriculture & Agricultural Technology, <https://www.britannica.com/browse/Agriculture> [accessed: 2024-07-23].
- Bulavka, O. 2022 Conceptual Principles of the Development of Rural Territory in the War and Post-War Periods, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nubip.edu.ua/sites/default/files/u349/zbirnik_tez_iae.pdf [accessed: 2024-11-06].
- Cheusheva, S. 2022 How to do Spearman correlation in Excel, <https://www.ablebits.com/office-addins-blog/spearman-rank-correlation-excel/>, [accessed: 2024-207-26].
- Chipfupa, U. & Tagwi, A. 2021 'Youth's participation in agriculture: A fallacy or achievable possibility? Evidence from rural South Africa' *South African Journal of Economic and Management Sciences* 24(1), DOI:10.4102/sajems.v24i1.4004.
- Cornelius, E. 2023 How Agriculture Helps a Nation: Benefits, Drawbacks and Environmental Impacts. <https://www.linkedin.com/pulse/how-agriculture-helps-nation-benefits-drawbacks-edwin-cornelius> [accessed: 2024-07-23].
- Cvijanovic, D. et al. 2020 Indicators of agricultural and rural development in the east central and south-east European countries, DOI:10.17707/AgricultFor-est.66.2.02.
- Dazhuan, G. et al. 2020 'Effects of rural-urban migration on agricultural transformation: A case of Yucheng City, China' *Journal of Rural Studies*, Vol. 76. DOI: 10.1016/j.jrurstud.2020.04.010.
- Dinu, M. et al. 2020 Accessing the European funds for agriculture and rural development in Romania for the 2014-2020 period, DOI:10.2478/picbe-2020-0068.

- Dovetail. 2024 From ANOVA to regression: 10 key statistical analysis methods explained. <https://dovetail.com/research/key-statistical-analysis-methods-explained/> [accessed: 2024-11-12].
- Dremio (n.d.) Univariate and Multivariate Analysis. <https://www.dremio.com/wiki/univariate-and-multivariate-analysis/> [accessed: 2025-11-12].
- European Commission. 2000 Agriculture's Contribution to Rural Development. https://www.iatp.org/sites/default/files/Agricultures_Contribution_to_Rural_Development.htm [accessed: 2024-07-23].
- Eurostat. 2024. Urban-rural Europe - demographic developments in rural regions and areas. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Urban-rural_Europe_-_demographic_developments_in_rural_regions_and_areas [accessed: 2025-11-13].
- FAO. 2022 Ukraine: Impact of the war on agriculture and rural livelihoods in Ukraine. <https://openknowledge.fao.org/items/7d8bfe35-2335-4439-bbab-61def98b61c1> [accessed: 2024-07-29].
- Finnstats. 2021 Kendall's rank correlation in R-correlation test. <https://www.r-bloggers.com/2021/06/kendalls-rank-correlation-in-r-correlation-test/> [accessed: 2024-07-26].
- Gava, O. et al. 2021 'Agricultural cooperatives contributing to the alleviation of rural poverty. The case of Konjic (Bosnia and Herzegovina)' *Journal of Rural Studies*, Vol. 82, DOI:10.1016/j.jrurstud.2021.01.034.
- Geeksforgeeks. 2023(a) Tabular Presentation of Data: Meaning, Objectives, Features and Merits. <https://www.geeksforgeeks.org/data-science/tabular-presentation-of-data-meaning-objectives-features-and-merits/> [accessed: 2025-11-12].
- Geeksforgeeks. 2023(a) Textual Presentation of Data: Meaning, Suitability, and Drawbacks. <https://www.geeksforgeeks.org/data-science/textual-presentation-of-data-meaning-suitability-and-drawbacks/> [accessed: 2025-11-12].
- Grodzicki, T. & Jankiewicz, M. 2022 'The role of the common agricultural policy in contributing to jobs and growth in EU's rural areas and the impact of employment on shaping rural development: Evidence from the Baltic States' *PLoS ONE* 17(2), DOI:10.1371/journal.pone.0262673.
- Grujić-Vučkovski, B. et al. 2022 The role of agriculture in the economic structure of Serbia and budget support for rural development of Kladovo municipality, DOI: 10.5937/ekoPolj2203863G.
- Hałasiewicz, A. 2023 'Nie ma już wsi, którą można odnawiać' *Wieś i Rolnictwo* 3(200), DOI: 10.53098/wir032023/05.
- Indeed. 2025 Empirical Analysis: Definition, Characteristics and Stages. <https://www.indeed.com/career-advice/career-development/empirical-analysis> [accessed: 2025-11-12].
- Kalogiannidis, S. 2023 Risk, Vulnerability, and Resilience in Agriculture and Their Impact on Sustainable Rural Economy Development: A Case Study of Greece' *Agriculture* Vol. 13(6), DOI:10.3390/agriculture13061222.

- Khaietska, O. & Udalov, D. 2024 Modern Aspects of the Development of Organic Agriculture in Ukraine under War Conditions, DOI:10.32782/2524-0072/2024-65-107.
- Kovtun, O. 2023 Threats to the Sustainable Development of the Agricultural Sector and Rural Areas during the Russian - Ukrainian War, DOI: 10.30890/2709-2313.2023-24-03-021.
- Liangshan, L. 2023 'An Empirical Analysis of Rural Labor Transfer and Household Income Growth in China' *Journal of Chinese Human Resources Management* Vol. 14(1), DOI: 10.47297/wspchrmWSP2040-800505.20231401.
- Lucian, P. 2020 'Rural Development in Romania – a few Considerations' *Studies in Business and Economics* Vol.15(2), DOI:10.2478/sbe-2020-0032.
- Maharjan, A. et al. 2020 'Understanding rural outmigration and agricultural land use change in the Gandaki Basin, Nepal' *Applied Geography* Vol. 124, DOI:10.1016/j.apgeog.2020.102278.
- Mamonova, N., Borodina, O. & Kuns, B. 2023 Ukrainian Agriculture in Wartime. <https://www.tni.org/en/article/ukrainian-agriculture-in-wartime?translation=uk> [accessed: 2024-07-24].
- Maryna, A. & Yankovska, Y. 2022 The agrarian sector of the economy of Ukraine under the conditions of war. chrome-extension://efaidnbmnnnibpcajpcgglefindmkaj/https://www.researchgate.net/profile/Tetiana-Obikhod/publication/365198916_PODOLANNA_KLANOVOSTI_EKONOMIKI_UKRAINI_AK_ZAPORUKA_II_EFEKTIVNOGO_ROZVITKU/links/636a45fc37878b3e879119c7/PODOLANNA-KLANOVOSTI-EKONOMIKI-UKRAINI-AK-ZAPORUKA-II-EFEKTIVNOGO-ROZVITKU.pdf [accessed: 2024-11-06].
- MathWorks. n.d. What Is Time Series Analysis? <https://www.mathworks.com/discovery/time-series-analysis.html> [accessed: 2025-11-12].
- Minyaylenko, I. & Kharchenko, Y. 2022 Problems of the Development of Agriculture in Ukraine during the War. chrome-extension://efaidnbmnnnibpcajpcgglefindmkaj/https://reposit.nupp.edu.ua/bitstream/PolNTU/12957/1/zbirnik_%209%20%D1%87%D0%B5%D1%80%D0%B2%D0%BD2022-319.pdf [accessed: 2024-11-06].
- Mishchenko, L. & Mishchenko, D. 2022 Post-War Reconstruction of Agriculture in Ukraine: Main Principles and Priorities, DOI: 10.32702/2306-6814.2022.15—16.87.
- Mittenzwei, K. et al. 2023 'Perceived effects of climate policy on rural areas and agriculture: A rural-urban- divide' *Journal of Rural Studies* Vol. 100, DOI: 10.1016/j.jrurstud.2023.03.009.
- Mykhalchuk, V. 2022. Ukraine: New UN assessment indicates that rural households are increasingly affected by war [text accessed: 2024-07-29].
- Nesterenko, V. & Kauk, V. n.d. Use of Artificial Intelligence in Agriculture. <chrome-extension://efaidnbmnnnibpcajpcgglefindmkaj/https://openarchive.nure.ua/server/api/core/bitstreams/05ea3c88-19d5-4cb7-827c-5aa065b42902/content> [accessed: 2024-11-06].

- Nevar, O. 2022 The Consequences of the War for the Industry and Agriculture of Ukraine. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://wiki.vnu.edu.ua/images/d/d0/Zbirnyk_tez_3.pdf [accessed: 2024-11-06].
- Neyter, R., Zorya, S. & Mulyar, O. 2024 Damages, Losses and Needs for Agriculture due to Full-Scale Invasion. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://kse.ua/wp-content/uploads/2024/02/RDNA3_ukr.pdf [accessed: 2024-11-06].
- Ngadi, N. et al. 2023 'Challenge of Agriculture Development in Indonesia: Rural Youth Mobility and Aging Workers in Agriculture Sector' Sustainability Vol. 15(2), DOI:10.3390/su15020922.
- Nwachukwu, E. A. 2023 'Rural development as a panacea to stimulating rural livelihood in the post-COVID era: is agriculture still the key?' Ianna Journal of Interdisciplinary Studies, Vol. 5(1). <https://iannajournalofinterdisciplinarystudies.com/index.php/1/article/view/100> [accessed: 2024-07-29].
- Odarchenko, K. (2021). Small farming in Ukraine, why is it needed and how to develop it? https://lb.ua/blog/katerina_odarchenko/497135_male_fermerstvo_ukraini_navi-shcho.html#:~:text=3a%20даними%20ООН%202021р%20Фермерські%20господарства%20у,формують%20державну%20податкову%20та%20законодавчу%20політику%20України. [accessed: 2025-11-11].
- Pasemko, G. & Taran, O. 2023 State Regulation of the Agricultural Sector during the War (Example of Kharkiv Region), DOI: 10.32782/2524-0072/2023-51-36.
- Pubrica. n.d. Correlational Research Design. <https://pubrica.com/insights/experimental-methodology/correlational-research-design/> [accessed: 2025-11-12].
- R Core Team. 2023 *_R: A Language and Environment for Statistical Computing_*. R Foundation for Statistical Computing, Vienna, Austria. <<https://www.R-project.org/>>.
- Romanenko, Y.O. et al. 2020 'Rural Development by Stimulating Agro-Tourism Activities' International Journal of Management. Vol. 11(4), [text accessed: 2024-07-29].
- Sánchez, N. E. (2025). Born into war: How Ukraine's demographic crisis became a catastrophe. <https://euobserver.com/health-and-society/ar978eff35#:~:text=Ukraine%27s%20population%20has%20been%20in,search%20of%20a%20better%20life> [accessed: 2025-11-9].
- Sikandar, F. et al. (2022). Sustainable Agriculture and Rural Poverty Eradication in Pakistan: The Role of Foreign Aid and Government Policies. Sustainability. Vol. 14(22). DOI:10.3390/su142214751.
- Srivastav Ashish Kumar (ed.) 2024 Dheeraj V., Pearson correlation coefficient, <https://www.wallstreetmojo.com/pearson-correlation-coefficient/#h-pearson-correlation-coefficient-formula> [accessed: 2024-06-09].
- State Statistics Service of Ukraine. 2011 Statistical Yearbook of Ukraine 2011. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-25].

- State Statistics Service of Ukraine. 2016 Statistical Yearbook of Ukraine 2015. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-25].
- State Statistics Service of Ukraine. 2021 Cooperation between Ukraine and the EU Countries. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-04].
- State Statistics Service of Ukraine. 2023a Agriculture of Ukraine 2022. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-02].
- State Statistics Service of Ukraine. 2023b Official Web Page. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-06].
- State Statistics Service of Ukraine. 2023c Statistical Yearbook of Ukraine 2022. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-02].
- State Statistics Service of Ukraine. 2024 Demographic and social statistics. <https://www.ukrstat.gov.ua/> [accessed: 2024-07-24].
- Stewart, K. 2024 Pearson's correlation coefficient, Encyclopedia Britannica. <https://www.britannica.com/topic/Pearsons-correlation-coefficient> [accessed: 2024-07-24].
- Sustainable Development for Ukraine n.d. Agriculture. <https://sd4ua.org/golovni-temi-stalogo-rozvitku/silske-gospodarstvo/> [accessed: 2024-07-24].
- Sweeney, D. J., Anderson, D. R. & Williams, T. A. 2024 Statistics. Encyclopedia Britannica. <https://www.britannica.com/science/statistics> [accessed: 2024-07-24].
- Sykała, Ł. 2023 'Miejsce odnowy wsi w systemie polityk rozwojowych i programów wsparcia obszarów wiejskich w Polsce' *Wieś i Rolnictwo* 3(200), DOI: 10.53098/wir032023/02.
- Tableau n.d. What Is Data Visualization? Definition, Examples, And Learning Resources. <https://www.tableau.com/visualization/what-is-data-visualization#:~:text=Data%20visualization%20is%20the%20graphical%20representation%20of,present%20data%20to%20non%2Dtechnical%20audiences%20without%20confusion.> [accessed: 2025-11-12].
- Vikhrov, M. 2018 Ukrainian village: extinction or evolution. [text accessed: 2024-07-25].
- Vykliuk, M., Kundytskyj, O. & Garasym, P. 2022 Tools for Supporting Reproductive Processes in Ukrainian Agriculture in War Conditions, <https://doi.org/10.32782/easterneurope.35-8>.
- Wilczyński, R. 2023 '25 lat odnowy wsi w Polsce – koniec misji czy zaczn odnowy wsi 2.0?' *Wieś i Rolnictwo* 3(200), DOI: 10.53098/wir032023/01 [accessed: 2024-07-29].
- Yigezu Wendimu, G. & Tejada Moral, M. 2021 'The challenges and prospects of Ethiopian agriculture' *Cogent Food & Agriculture*, Vol. 7(1), DOI:10.1080/23311932.2021.1923619.
- Zhang, S. et al. 2020 'Has Rural Migration Weakened Agricultural Cultivation? Evidence from the Mountains of Southwest China' *Agriculture* Vol.10(3), DOI:10.3390/agriculture10030063.