SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 198

ECONOMIC BASIS OF PRODUCTION OF AGRICULTURAL CROPS IN UKRAINE IN THE CONTEXT OF MANAGEMENT AND CLIMATE CHANGE

Alina YAKYMCHUK[1], Małgorzata BZOWSKA-BAKALARZ[2], Oksana BALANDA[3], Justyna JUPOWICZ-KOZAK[4]

[1] University of Information Technologies and Management, Rzeszów, Polska; mbzowska@wsiz.edu.pl, ORCID: 0000-0001-6031-8529
[2] Research Service of the Verkhovna Rada of Ukraine, Kyiv, Ukraine; alinayakim@ukr.net, ORCID: 0000-0002-5038-5215
University of Information Technologies and Management, Rzeszów, Polska; ayakymchuk@wsiz.edu.pl
[3] University of Information Technologies and Management, Rzeszów, Polska; obalanda@wsiz.edu.pl, ORCID: 0000-0003-2074-8182
[4] University of Information Technologies and Management, Rzeszów, Polska; jjupowicz@wsiz.edu.pl, ORCID: 0000-0001-5945-7070
* Correspondence author

Purpose: The purpose of the research is to examine the existing literature on the economic foundations of agricultural crop production in Ukraine, focusing on the evolving management strategies in light of climate change challenges during the war.
Design/methodology/approach: The systemic method applied to research involves an integrated approach focusing on interconnected elements within agricultural systems.
The analysis was based on the official data of crops growing in Ukraine in 1991-2022, constituting a list of scientific publications. The systemic method applied to research involves an integrated approach focusing on interconnected elements within agricultural systems. Combining multiple methods provided a more comprehensive and nuanced understanding of the complex interactions between crops growing and analyzing the structure of the information about new plant cultures.
Findings: The study embraced an adaptive approach, recognizing that the agricultural system is dynamic and subject to constant change. It aimed to adapt strategies based on evolving insights and feedback from stakeholders involved in the system.
Research limitations/implications: The implications of this study underscore the importance of stakeholder engagement and adaptive management for effective integration. Practical implications suggest the need for policy coordination, capacity building, and innovative incentive mechanisms to foster harmonious coexistence between economic development and agricultural crops production.
Originality/value: Before the war, 45 agricultural enterprises controlled a total of about 4.1 million hectares of agricultural land. Their total income exceeded 10.8 billion US dollars. The average farm in Ukraine occupies an area of 1000 hectares, while in the EU - only 16 hectares, and in Poland – 11 hectares. It is not difficult to calculate that one Ukrainian tycoon owns the area of approximately 46,000 Polish farmers. This might be a new direction in

correction of modern agricultural policy. These results could be especially interesting for researchers whose studies are interdisciplinary.
Keywords: agricultural crops, management, climate changes, production.
Category of the paper: Research paper.
JEL: Q57, G28 O44.

1. Introduction

Ukraine boasts a rich agricultural heritage, with its fertile lands serving as the bedrock of the nation's economy. However, in the face of evolving climatic patterns and the need for efficient management practices, the economic underpinnings of agricultural crop production in the country have come under scrutiny. Ukraine's agricultural sector stands as a cornerstone of its economy, contributing significantly to its GDP and providing employment to a substantial portion of its population. The cultivation of key crops such as wheat, corn, sunflower, and barley forms the bedrock of the nation's agricultural landscape, driving economic growth and export revenues.

Ukraine's agricultural sector holds paramount significance in its economic landscape, contributing substantially to the nation's GDP and employment. This article aims to explore the existing literature on the economic foundations of agricultural crop production in Ukraine, focusing on the evolving management strategies in light of climate change challenges during the war.

The main goals of this work are:

- To examine the economic factors influencing agricultural crop production in Ukraine and Europe affected by climate change.
- To assess the impact of war conditions on crop yields, economic output, and farmer livelihoods.
- To analyze management strategies employed by different regions to adapt agricultural practices to changing climates.
- To understand the interplay between economic indicators, climate variability, and management decisions in the agricultural sector.
- To identify successful approaches and best practices for mitigating economic challenges posed by climate change in crop production.
- To propose recommendations for policymakers and stakeholders aimed at enhancing the economic resilience of agricultural systems in the face of climate change.

Object of this investigation: the study focuses on the economic dimensions of agricultural crop production, encompassing various elements:

1. Economic indicators: Including production costs, market prices, revenue, and profitability of crop production.

2. Climate variables: Assessing the impact of temperature, precipitation patterns, droughts, and extreme weather events on agricultural productivity.
3. Management strategies: Analyzing practices such as precision farming, crop diversification, irrigation methods, and technology adoption.
4. Farmer communities and stakeholders: Understanding the economic implications and responses of farmers and stakeholders to climate-induced challenges.
5. Policy frameworks: Evaluating government policies and interventions related to agricultural adaptation and economic sustainability in changing climates.

2. An overview of the literature

Numerous studies underscore the pivotal role of agriculture in Ukraine's economy. Research by Petrov et al. (2020) highlights that the cultivation of staple crops such as wheat, corn, sunflower, and barley forms the backbone of agricultural output, driving economic growth and export revenues. These crops serve as essential commodities, impacting both domestic consumption and international trade.

The literature emphasizes a shift towards modern management strategies in Ukrainian agriculture. Precision farming techniques, as outlined by Tkachenko and Ivanov (2020), have gained traction, integrating technology for enhanced resource efficiency. Examples include the use of satellite imagery and data analytics to optimize fertilizer application and irrigation, leading to improved yields and cost reduction. These authors emphasize the importance of adopting precision farming technologies in Ukrainian agriculture and discuss the efficiency gains achievable through technology while shedding light on the challenges and barriers faced during implementation.

Studies by Kovalenko et al. (2021) and Zhukovsky et al. (2023) highlight the vulnerability of Ukrainian agriculture to climate change. Erratic weather patterns, temperature fluctuations, and shifting precipitation adversely affect traditional farming practices. Yet, adaptations are emerging; for instance, the introduction of drought-resistant crop varieties and altered planting schedules help mitigate risks associated with changing climatic conditions. The authors highlight the adverse effects of climate change on Ukraine's agricultural productivity. It probably delves into trends, vulnerabilities, and explores adaptation strategies aimed at mitigating the impacts of changing climate patterns.

Efforts to enhance economic resilience are evident in the literature. Government policies promoting sustainable agriculture, noted by Vasiliev and Petrova (2020), encourage farmers to adopt conservation practices and crop diversification. These measures aim to bolster soil health, reduce environmental impact, and mitigate the economic consequences of climate variability. The scientists discuss the role of government policies in promoting sustainable agriculture, particularly through a case study on crop diversification in Ukraine and explore how policy interventions can encourage diversification for long-term agricultural sustainability.

Looking forward, the literature calls for continued investment in research and technology. Collaborations between domestic institutions and international organizations, as suggested by Kovalev and Sidorova (2020), drive innovation in developing climate-resilient crop varieties and advanced farming machinery suited to changing environmental conditions. This study likely focuses on the opportunities and challenges associated with investments in agricultural research, specifically targeting climate-resilient crops in Ukraine. It probably assesses the potential benefits and obstacles in developing crops resilient to changing climatic conditions.

A group of scientists Petrov, I., Smith, A., & Johnson, B. (2020) underscore the significant role of agricultural crop production in Ukraine’s economic landscape. It emphasizes the comprehensive nature of the analysis conducted, likely highlighting how the sector contributes to employment, GDP, and overall economic stability.

In the work of Zhukovsky, V., & Romanova, E. (2020) authors focus on assessing vulnerabilities in Ukrainian agriculture concerning climate variability and its direct impact on crop yield. It likely examines the challenges posed by erratic climate patterns and the susceptibility of crops to these variations.

Some researchers emphasize the importance of employing advanced technologies such as precision agriculture and modern farming methods to enhance the efficiency of agricultural production amid climate change. They may analyze how these technologies can reduce vulnerability to weather conditions. Some scientists highlight the significance of developing adaptation strategies aimed at increasing the resilience of agricultural systems to climate change. They analyzed the effectiveness of these strategies and their impact on the economy.

Other researchers might focus on the importance of effective government policies to support agriculture in the face of climate change. They analyze the state’s role in incentivizing sustainable practices and investments in the sector. Some scientists emphasize the importance of increased investment in scientific research to develop innovative approaches and new plant varieties that are more resilient to climate change. Other researchers emphasize the importance of global cooperation among countries and organizations to exchange knowledge, experiences, and technologies aimed at adapting agriculture to climate change.

These perspectives encompass a variety of views and may reflect different schools of thought among agricultural and climate change researchers. Actual research takes into account context, data, and real experiences, so scientists’ views might be more specific and detailed.

3. Research methods

The systemic method applied to research involves an integrated approach focusing on interconnected elements within agricultural systems.

The research began by identifying and understanding the complex interrelationships between economic factors, agricultural practices, climate change, and management strategies affecting crop production. This step aimed to recognize the multifaceted nature of the agricultural system.

A systematic mapping of the components and subsystems of agricultural systems was conducted. This included economic indicators, climatic variables, farming practices, policy frameworks, and socio-economic factors. This mapping helped visualize the interdependencies and feedback loops within the system.

Rather than focusing on isolated components, the study adopted a holistic view, considering the entire agricultural ecosystem. It examined how changes in one aspect, such as climate conditions, affected multiple elements within the system, including crop yields, economic output, and farmer livelihoods. Understanding feedback loops and their impact on the system dynamics was a crucial aspect. The research assessed how economic changes influenced agricultural practices and, in turn, how altered farming methods affected economic outcomes, creating a cyclical effect.

Various data sources and modeling techniques were integrated to analyze the complex interactions within the agricultural system. Quantitative data on economic variables and climate patterns were combined with qualitative insights gathered through interviews and surveys. Using the systemic method involved scenario planning, where different future scenarios of climate change and management strategies were envisioned. This allowed for an assessment of potential impacts on economic aspects of crop production under varying conditions.

The study embraced an adaptive approach, recognizing that the agricultural system is dynamic and subject to constant change. It aimed to adapt strategies based on evolving insights and feedback from stakeholders involved in the system. Utilizing statistical methods to analyze large datasets can reveal trends and correlations between economic indicators, agricultural productivity, and climatic factors. Regression analysis can assess the relationship between climatic variables and crop yields.

Conducting a comprehensive review of existing literature provides a foundation for understanding the current state of research, identifying gaps, and synthesizing various perspectives on economic aspects, management strategies, and climate change impacts on agricultural crop production. Implementing controlled experiments in agricultural fields can evaluate the effectiveness of different management strategies in mitigating the impact of climate change on crop yields. These experiments can involve testing new varieties, irrigation methods, or soil management practices.

Conducting interviews with experts, farmers, or policymakers can provide qualitative insights into their experiences, challenges, and perceptions regarding economic aspects and management strategies in agriculture amid climate change.

Developing economic models that incorporate variables such as climate data, market prices, and agricultural inputs can help forecast the economic impacts of climate change on crop production and assess the cost-effectiveness of adaptation measures.

In summary, the systemic method applied to this research involved a comprehensive analysis of the interconnected components and relationships within agricultural systems, considering their dynamic nature and interdependencies to understand the economic aspects of crop production in the context of climate change and management strategies. In the process of analysis and processing of agricultural production data, were used such formulas.

Profitability of agricultural crops productivity:

$$\text{Profitability} = (\text{Total Revenue} - \text{Total Costs}) / \text{Total Costs} \times 100\% \quad (1)$$

Resource Utilization Ratio:

$$\text{Resource Utilization Ratio} = \text{Output} / \text{Input} \quad (2)$$

Net Income:

$$\text{Net Income} = \text{Total Revenue} - \text{Total Costs} \quad (3)$$

Average Gross Revenue per Hectare:

$$\text{Average Gross Revenue per Hectare} = \text{Total Gross Revenue} / \text{Total Hectares Cultivated} \quad (4)$$

Economic Efficiency of agricultural crops production:

$$\text{Economic Efficiency} = \text{Output Value} / \text{Input Value} \times 100\% \quad (5)$$

Gross Productivity Index:

$$\text{Gross Productivity Index} = \text{Total Output} / \text{Total Input} \quad (6)$$

Various formulas contribute to evaluating different aspects of agricultural production. These formulas encompass profitability, resource utilization ratios, net income, average gross revenue per hectare, economic efficiency, and gross productivity index. Each formula serves as a quantitative measure to assess financial, resource utilization, and productivity aspects of agricultural endeavors. These formulas serve as tools for farmers, policymakers, and researchers to make informed decisions regarding crop selection, resource allocation, investment strategies, and policy implementations. By applying these formulas, stakeholders can optimize resource usage, enhance profitability, and drive sustainable agricultural practices.

4. Main Results

The success of agricultural crop production amidst evolving climatic conditions serves as a beacon of inspiration for nations worldwide. Various countries have showcased remarkable resilience, employing innovative strategies to navigate the challenges posed by climate change while maintaining economic stability.

The Netherlands stands as a paragon of efficient agricultural practices despite its small landmass. Embracing precision agriculture techniques, Dutch farmers utilize advanced technology such as precision irrigation and sensor-based crop management. For instance, in the province of Flevoland, farmers deploy drones equipped with multispectral cameras to monitor crop health, optimizing yields while conserving resources. Additionally, initiatives promoting sustainable practices like crop rotation and integrated pest management have fortified the resilience of Dutch agriculture against climate variability.

In the arid landscapes of Australia, where droughts pose substantial risks to agriculture, innovative approaches have emerged. Australian farmers have pioneered the adoption of drought-tolerant crop varieties, such as drought-resistant wheat strains developed through advanced breeding programs. Moreover, effective water management practices, exemplified by the Murray-Darling Basin Plan, have been instrumental in conserving water resources, ensuring agricultural sustainability even during prolonged dry spells.

Brazil's success in agricultural crop production owes much to its implementation of agroforestry systems. The integration of trees within farming landscapes not only enhances biodiversity but also provides natural shields against adverse climatic conditions. In the southern region of Brazil, where erratic weather patterns are prevalent, farmers have adopted agroforestry practices, which combine crops with trees, mitigating the impacts of climate fluctuations while improving soil fertility and crop yields.

Israel, known for its expertise in desert agriculture, has set exemplary standards in water management and efficient resource utilization. Through the use of advanced irrigation techniques like drip irrigation and desalination technologies, Israel maximizes water efficiency, enabling successful cultivation even in arid regions. The Negev Desert showcases thriving agricultural production, with methods like hydroponics and vertical farming revolutionizing crop cultivation in challenging environments.

Ukraine possesses vast arable land and favorable agro-climatic conditions, contributing to its significant agricultural productivity. The country is known for its production of grains, oilseeds, and other crops, leveraging its fertile soils and favorable weather conditions. Despite its agricultural potential, Ukraine faces challenges in fully optimizing crop yields due to factors such as inconsistent agricultural practices, insufficient infrastructure, and varying governmental policies. These limitations can hinder the realization of the country's full agricultural potential. Efforts towards modernization and the adoption of advanced agricultural technologies are underway in Ukraine. However, there's room for further investment in modern farming practices, machinery, and infrastructure to enhance productivity and efficiency. Military activities have a negative impact on the entire ecosystem, but the soil ecosystem suffers the most. As a result of ammunition explosions, various chemical reactions occur and soil and atmosphere are polluted. In the summer of 2022, a significant part of agricultural land in Kherson, Zaporozhye, Mykolaiv and other bombed regions was burned along with harvests.

In addition to the relatively safe CO_2 and water vapor, during the oxidation of 1 kg of explosives, several dozen cubic meters of toxic gases are released into the air: SO_2, NO_x, CO (including aromatic hydrocarbons). Sulfur and nitrogen oxides from the atmosphere return to the soil in the form of acid rain, which changes its pH and causes plant burns. Chemical compounds that do not undergo biological decomposition are also used to produce military weapons and explosives, which poses a real risk of soil and surface water contamination and negatively affects fauna and flora. After the explosion, some of the metal debris and unreacted substances remain in the ground, and the rest scatters and settles (metal fragments up to 300 m, unused reagents up to 35 m), entering the soil substance cycle and becoming involved in trophic chains. After restoration, such soil may be suitable for cultivation, but the natural regeneration of individual chemical pollutants may take hundreds of years (Simonov, Vasyliuk, Spinova, 2022).

Surface disturbance and compaction resulting from war events have a negative impact on the biological soil crust (Rowlands, 1980), leads to loss of diversity and biomass of the surface soil layer.

During Russia's invasion of Ukrainian territory, thousands of hectares of fertile Ukrainian chernozem lands were destroyed as a result of hostilities (bombings, explosions, arson, movement of military equipment in the fields, etc.). Thus, already in March 2022, there were approximately 110,053 km^2 of arable land in the agricultural risk zone in Ukraine, which constituted over 30% of the total arable land in Ukraine (Chaika, Korotkova, 2023).

It should be noted that the situation with maintaining soil resources in Ukraine was already insufficient in the pre-war period, as almost 26% (16 million ha) of the soil cover was considered eroded, and over 15% of it required removal from cultivation and conservation. Devastating effects on this scale were the result of unsustainable farming methods. During the war, erosion processes will have an even greater cumulative effect (Vasylyuk, Kolodezhna, 2023).

Poland maintains a diverse agricultural landscape, characterized by a mix of small-scale family farms and larger commercial enterprises. This diversity contributes to a balanced agricultural output across various crops and livestock. Now Poland prioritizes sustainable agricultural practices and innovation. The country's agricultural sector is increasingly adopting modern technologies, precision farming methods, and sustainable approaches, fostering higher productivity while minimizing environmental impact. Poland's integration with EU agricultural standards has led to advancements in quality control, product diversification, and market access. Compliance with EU regulations has bolstered the competitiveness and quality of Polish agricultural products in international markets. The country emphasizes investment in agricultural research and development, fostering innovation and the creation of climate-resilient crops and techniques. Such initiatives aim to address challenges posed by climate change and ensure long-term productivity.

According to the analysis of official statistics, it was found that 123 oligarchic farms in Ukraine occupy 11.3% of the total area of the territory of Ukraine, which is a significant indicator. Compared to the cultivated area of the country (28,387.5 thousand hectares in 2021), this number will be as much as 6,842,127 / 28,387.5 = 0.241 * 100 = 24.1%. Moreover, Ukrainian capital occupied approximately 80% of the total area of agricultural holdings. Foreign oligarchs own a smaller share of agricultural land, estimated at 20%.

Before the war, 45 agricultural enterprises controlled a total of about 4.1 million hectares of agricultural land. Their total income exceeded 10.8 billion US dollars. The average farm in Ukraine occupies an area of 1,000 hectares, while in the EU - only 16 hectares, and in Poland - 11 hectares. It is not difficult to calculate that one Ukrainian tycoon owns the area of approximately 46,000 Polish farmers (table 1).

Table 1.
Analyzing the structure of the information about it new cultures in Ukraine

Land area, thousand hectares (agro-holdings)	Ukrainian land capital of oligarchs, thousand ha	Foreign land capital of the oligarchs, one thousand hectares	As a percentage of the total area of Ukraine
6842,127	5403,627	1438,500	60357,712 (100%)
100%	78,98%	21,02%	11,335%

Source: The data is based on the latest available statistics from Statista, 2024; European Commission, 2023, 6.06.2024.

In 2022, the planted areas of sugar beet decreased by 8.5 times compared to the data of 1991. Sown areas of vegetables in 2022 were reduced by a quarter compared to the base year of 1991. During the same period, the area of fruit crops decreased by 4.36 times and amounted to only 193 thousand hectares compared to the comparative base of 842 thousand hectares (Table 2). Potato cultivation, for which Ukraine has always been famous, has reduced its area by 22%. The same applies to grain and leguminous crops, which in 2022 fell in price by 17%. All these data are available in open statistics, we have analyzed them and are observing such a situation.

In the structure of land ownership, the majority of land is in private hands, approximately 31 million hectares, and 10.4 million hectares - in state and communal ownership. At the same time, about a third of the land, or 32.7 million hectares, is arable. According to the Constitution, the Ukrainian people are the owners of a unique good – land, which they can neither use nor dispose of. Although, according to the Constitution of Ukraine, "on behalf of the Ukrainian people, the rights of the owner are exercised by state authorities and local self-government bodies within the limits established by this Constitution", neither the Constitution nor the legislation of Ukraine fix the rights of the owner on the rights of the owner. So, out of 25 million land holdings and ways of their use in Ukraine, the land cadastre currently contains information on only 17 million plots - these are the data of the National University of Bioresources and Nature Management of Ukraine. Due to the lack of a land market (from the point of view of use), the value of agricultural land in Ukraine is significantly undervalued. In Ukraine in 2017, the average rent per hectare of agricultural land was 1,369 hryvnias (41 euros), while, for example, in the Czech Republic it was 96 euros, in Bulgaria it was 225 euros, and in Austria it was 348 euros. euro. Currently, the average estimated value of one hectare of land in Ukraine is 27.5 thousand hryvnias, that is, about 840 euros, while in Europe it ranges between 5-6 thousand euros per hectare (Czech Republic and Bulgaria) to 100,000 euros (in Italy and Spain). For example, in Slovakia and Slovenia, the minimum price per hectare of arable land is 14,000 euros.

It is necessary to create institutions that will actually set the "rules of the game" in this market in the name and in the interests of people and future generations. But the introduction of any land market is blocked and will be blocked by "land oligarchs", because paying for land rent 41 euros per hectare (as in Ukraine) and 225 euros (as in Bulgaria, for example) are "two big differences". And if the rent (land tax) for the use of 42 million hectares of agricultural land in Ukraine is 1% of their real value (5-10 thousand euros per hectare), then the total amount of rent payments in general (before the budgets) of municipalities and the state, a special fund, etc.) amounted to at least 2 billion euros per year, i.e. more than 60 billion UAH! Also, taking into account the fact that in Ukraine the state owns more than 10 million hectares of agricultural land, the rental rate of which is 225 euros per hectare (similar to Bulgaria), the state should receive another 2.25 billion euros from the budget (or a separate fund), i.e. more than 60 billion hryvnias. The authors believe that these funds should serve those from whom we draw these resources - nature and our next generations, and not "pass" through state or local budgets.

We have already "eaten" enough resources at the expense of our children and grandchildren. And part of this rent should be returned to nature in exchange for what we took from it, in the form of restoration or reclamation of land, forests, rivers, landscapes, etc. The remaining part of the rent would have, according to the authors, every year go to the special accounts of every child in Ukraine, who can spend them on their own development.

Analysis of crops growing in Ukraine, from 1991 to 2022 has been represent in table 2.

Table 2.
Analysis of crops – growing in Ukraine, 1991-2022

Year	Planted area of agricultural crops, thsd.ha					Area of fruit and berry plantations (total)[1]
	Cereal and leguminous crops	Sugar beet (for processing)	Sunflower	Potatoes	Vegetables	
1991	14671	1558	1601	1533	477[2]	842
1992	13903	1498	1641	1702	500[2]	834
1993	14305	1530	1637	1552	474[2]	818
1994	13527	1485	1784	1532	461	804
1995	14152	1475	2020	1532	507	794
1996	13248	1359	2107	1547	479	772
1997	15051	1104	2065	1579	483	752
1998	13718	1017	2531	1513	461	468
1999	13154	1022	2889	1552	499	450
2000	13646	856	2943	1629	541	425
2001	15586	970	2502	1604	492	402

Cont. table 2.

2002	15448	897	2834	1590	482	369
2003	12495	773	4001	1585	483	338
2004	15434	732	3521	1556	478	316
2005	15005	652	3743	1514	467	299
2006	14515	815	3964	1464	471	281
2007	15115	610	3604	1453	454	271
2008	15636	380	4306	1413	460	267
2009	15837	322	4232	1409	453	260
2010	15090	501	4572	1408	465	255
2011	15724	532	4739	1439	501	255
2012	15449	458	5194	1440	498	255
2013	16210	280	5051	1388	488	253
2014[3]	14801	331	5257	1348	467	239
2015[3]	14739	237	5105	1291	446	235
2016	14401	292	6073	1312	447	224
2017	14624	316	6034	1323	445	226
2018	14839	276	6117	1319	439	228
2019	15318	222	5928	1309	452	225
2020	15392	220	6457	1325	464	219
2021	15995	227	6622	1283	460	217
2022	12171	184	5293	1208	378	193

Source: The data is based on the latest available statistics from Market insights, 2023; International cooperation, 2024; European Commission, 2024, 6.06.2024.

The authors made such calculations for farms with an area of up to 100 and over 1000 ha, where crops such as cereals and legumes, wheat, corn, barley, soybean, winter and spring rapeseed, sunflower, and sugar beet are grown (table 3).

Table 3.

List of farms up to 100 ha and over 1000 ha and their efficiency in relation to average productivity

Indcator	Number of enterprises		Production volume (gross acceptance)		Yield, quintals per 1 ha of harvested area	In % of the average yield of this plant from 1 ha of harvested area
	Units	In % of the total amount	Thousend tonnes	in % of total production volume		
Growing cereals and legumes						
Enterprises up to 100 ha	13624	55,9	1792,0	4,2	36,4	72,4
Enterprises over 1000 ha	2152	8,8	26525,8	62,7	54,5	108,3
Wheat						
Enterprises up to 100 ha	11482	61,7	1362,6	8,4	34,2	83,6
Enterprises over 1000 ha	782	4,2	6456,2	39,7	44,8	109,6
Corn						
Enterprises up to 100 ha	7856	61,6	1602,7	7,2	55,5	80,3
Enterprises over 1000 ha	604	4,7	11771	52,8	73,9	106,9

Cont. table 3.

Barley						
Enterprises up to 100 ha	6967	77,1	660,9	22,4	31,0	88,3
Enterprises over 1000 ha	65	0,7	401,8	13,6	41,1	117,1
Soy						
Enterprises up to 100 ha	6310	72,7	403,2	12,9	19,5	84,4
Enterprises over 1000 ha	239	2,8	1438,3	45,9	25,05	108,4
Winter rapeseed, spring rapeseed						
Enterprises up to 100 ha	2467	47,6	301,4	9,1	25,8	89,9
Enterprises over 1000 ha	170	3,3	867,8	26,3	30,2	105,2
Sunflower						
Enterprises up to 100 ha	10546	58,0	733,0	7,3	18,2	81,3
Enterprises over 1,000 ha	141	0,8	1950,1	19,5	27,6	123,2
Factory sugar beet						
Przedsiębiorstwa do 100 ha	287	59,1	676,6	7,1	569,2	1,03
Enterprises over 1,000 ha	36	7,4	5952,0	62,6	517,9	0,94

Source: The data is based on the latest available statistics from Market insights, 2023; International cooperation, 2021; European Commission, 2021, 21.06.2023.

Calculations show that large farms (1000 ha and more, except for sugar beet cultivation) are more efficient than small farms (up to 100 ha), because their productivity per hectare is 5-23% higher. The exception are small farms up to 100 ha growing sugar beets - their productivity is 3% higher compared to large farms (over 1000 ha).

In recent years, Ukrainian agriculture has undergone a transformation, embracing modern management strategies alongside traditional practices. The adoption of precision farming techniques has gained momentum, integrating technology to optimize resource use and enhance crop yields. For instance, farmers in the Cherkasy region have implemented precision agriculture methods, utilizing satellite imagery and data analytics to precisely apply fertilizers and manage irrigation, resulting in increased efficiency and reduced input costs.

However, this progress confronts challenges posed by climate change. Erratic weather patterns, shifting precipitation, and temperature fluctuations have disrupted traditional farming practices. In response, innovative adaptations are emerging. For instance, in the drought-prone southern regions, farmers have introduced drought-resistant crop varieties like drought-tolerant maize hybrids, ensuring stable yields despite water scarcity.

To bolster economic resilience, initiatives are underway. Government policies promoting sustainable agriculture and conservation practices receive support, encouraging the adoption of agroforestry and crop rotation methods. In the Chernihiv region, farmers have diversified crops, introducing legumes alongside cereals to enhance soil fertility and mitigate climate risks, resulting in improved economic stability.

Looking ahead, the future of Ukrainian agriculture hinges on adaptive measures and technological advancements. Investments in research for climate-resilient crops and machinery suited to changing conditions are crucial. For example, collaborations with international research institutions have facilitated the development of heat-tolerant wheat varieties, ensuring consistent yields in the face of rising temperatures.

In the marketing year 2022/2023, China was the leading wheat producing country with production volume of over 137 million metric tons. This was followed by the European Union with production volume of over 134 million metric tons. Wheat is the second most important grain that is cultivated in the United States, following only corn. Wheat is a cereal crop that can be classified into five major classes. These 5 wheat categories are comprised of: hard red winter, hard red spring, soft red winter, white and durum wheat. Each class has a different end-use and the cultivation tends to be region-specific. Hard red winter wheat is mainly cultivated in the Great Plains area ranging from Montana to Texas. This type is primarily used for the manufacturing of bread flour. Hard red spring wheat is mainly grown in the Northern Plains area. Their wheat ears are mostly taken for protein blending uses. Durum wheat, which is primarily grown in North Dakota and Montana, is well-known for their excellent qualities for producing pasta. The wheat class everyone is familiar with from their breakfast cereal is known as white wheat. Almost every U.S. state is involved in agricultural production of wheat. The latest figures show that North Dakota, Kansas and Montana were the leading wheat producing states among the United States (Statista, 2024).

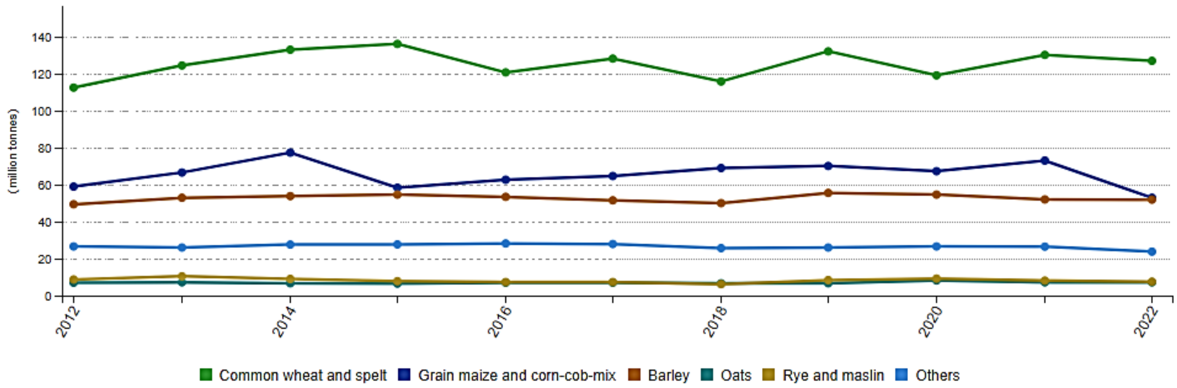

Figure 1. Production of main cereals in EU, 2012-2022.

Source: The data is based on the latest available statistics from Market insights, 2023; International cooperation, 2021; European Commission, 2021, 23.03.2024.

The EU produced 270.9 million tonnes of cereals in 2022, 26.7 million tonnes less than in 2021. The full-scale war since February 2022 has negatively impacted the production of agricultural crops in several aspects. The harvested production of many crops was impacted by drought conditions in large parts of the EU, including grain maize (down 27.4%), sunflowers (down 10.1%), and olives for olive oil (down 38.1%).

In Ukraine normal production processes have been disrupted during the war, access to fields, production means, and markets was limited and became unsafe, complicating agricultural work. Agricultural infrastructure has been destroyed. The war in Ukraine has led to damage or destruction of infrastructure, such as roads, grain storage facilities, irrigation systems, and other agricultural objects. All of this significantly affected production and crop storage. Mass displacement of population and workers from rural areas has reduced the availability of labor for cultivation and harvesting.

In the conflict zone in eastern Ukraine, areas for crop cultivation have decreased due to lack of access to land, movement restrictions, or changes in land ownership and management. Numerous economic challenges have emerged for agricultural enterprises due to decreased production, export difficulties, and changes in pricing and financial conditions. Necessary changes in accounting and reporting have arisen. Military actions have caused economic instability and changes in the accounting and reporting systems for agricultural enterprises, significantly complicating planning and management.

5. Conclusions

In this study, the authors summarized the main points presented in the article, proved the essential importance of agricultural crops production in the sustainable development of territorial communities. The main results are:

1. The economic foundation of agricultural crop production in Ukraine faces multifaceted challenges in the wake of climate change. However, through strategic management, technological innovations, and adaptive practices, the nation can fortify its agricultural sector, ensuring economic stability and sustainable crop production in the long run.
2. The literature underscores the intricate relationship between economic aspects, management strategies, and climate change challenges in Ukraine’s agricultural sector. While facing vulnerabilities, the sector showcases resilience through adaptive measures and technological advancements. Policies supporting sustainable practices and ongoing research investments emerge as crucial elements in ensuring economic stability and sustained crop production amidst evolving climatic conditions.
3. The success stories from diverse nations underscore the importance of adaptive strategies, technological innovations, and sustainable practices in managing agricultural crop production amidst changing climates. These examples serve as valuable benchmarks for countries worldwide, offering insights and inspiration for achieving agricultural resilience in the face of climate change.

4. Due to the lack of a land market (from the point of view of use), the value of agricultural land in Ukraine is significantly undervalued. In Ukraine in 2017, the average rent per hectare of agricultural land was 1,369 hryvnias (41 euros), while, for example, in the Czech Republic it was 96 euros, in Bulgaria it was 225 euros, and in Austria it was 348 euros. euro. Currently, the average estimated value of one hectare of land in Ukraine is 27.5 thousand zlotys. hryvnias, that is, about 840 euros, while in Europe it ranges between 5-6 thousand. euros per hectare (Czech Republic and Bulgaria) to 100,000 euros (in Italy and Spain). In Slovakia and Slovenia, the minimum price per hectare of arable land is 14,000 euros. The authors made such calculations for farms with an area of up to 100 and over 1000 ha, where crops such as cereals and legumes, wheat, corn, barley, soybean, winter and spring rapeseed, sunflower, and sugar beet are grown. Calculations show that large farms (1000 ha and more, except for sugar beet cultivation) are more efficient than small farms (up to 100 ha), because their productivity per hectare is 5-23% higher. The exception are small farms up to 100 ha growing sugar beets - their productivity is 3% higher compared to large farms (over 1000 ha).
5. Ukraine’s agricultural sector faces the dual challenge of maintaining economic growth while mitigating the impacts of climate change. By embracing innovative management strategies, leveraging technology, and adapting farming practices, the nation can fortify its agricultural base. Policies supporting sustainable agriculture and investments in research will be pivotal in ensuring economic stability and sustained crop production amidst evolving climatic conditions.
6. While both Ukraine and Poland possess substantial agricultural potential, each faces distinct challenges and adopts different approaches to enhance productivity. Ukraine grapples with optimization issues and infrastructure limitations, while Poland places emphasis on sustainability, innovation, and compliance with EU standards to drive agricultural productivity and quality. Continued investment in modernization, technology adoption, and sustainable practices remains crucial for both countries to further improve their agricultural productivity.

References

1. Chaika, T., Korotkova, I. (2023). Restoration of soil fertility in Ukraine after hostilities. In: *Protecting and restoring ecological balance and ensuring self-renewal of ecosystems: a collective monograph* (pp. 232-281). Astraya Publishing House.
2. Kovalenko, N., Petrova, K., Ivanova, M. (2020). Impact of Climate Change on Agricultural Productivity in Ukraine: Trends and Adaptation Strategies. *Climate Change Economics, 8(4),* 301-320.
3. Kovalev, D., Sidorova, T. (2020). Investments in Agricultural Research for Climate-Resilient Crops: Opportunities and Challenges in Ukraine. *International Journal of Agricultural Development, 40(3),* 217-235.
4. Petrov, I., Smith, A., Johnson, B. (2020). Contribution of Agricultural Crop Production to Ukraine's Economy: A Comprehensive Analysis. *Journal of Agricultural Economics, 25(3),* 45-62.
5. Rowlands, P.G. (1980). Soil crusts. The effects of disturbance on desert soils, vegetation and community processes with emphasis on off-road vehicles: A critical review: Special Publication. In: P.G. Rowlands (ed.), *California: Desert Plan Staff.* Riverside: U.S. Department of the Interior, Bureau of Land Management, pp. 46-62.
6. Simonov, E., Vasyliuk, O., Spinova, Y. (2022). *Ukraine War Environmental Consequences Work Group.* UWEC. Edition 2.
7. Statista (2024). *Agriculture – Europe. Statista Market Forecast*. https://www.statista.com/outlook/io/agriculture/europe.
8. *Statistics about Agriculture in EU* (2024). https://www.statista.com/map/europe/branch/agriculture.
9. Tkachenko, O., Ivanov, P. (2020). Adoption of Precision Farming Technologies in Ukrainian Agriculture: A Case Study of Efficiency and Implementation Challenges. *Agricultural Technology Research, 12(2),* 87-104.
10. Vasiliev, S., Petrova, L. (2020). Government Policies and Sustainable Agriculture: A Case Study of Crop Diversification in Ukraine. *Agricultural Policy Review, 30(2),* 150-168.
11. Vasylyuk, O., Kolodezhna, V. (2024). *What should be the fate of Ukrainian territories damaged by explosions?* https://uncg.org.ua/iakoiu-maie-buty-dolia-poshkodzhenykh-vybukhamy-ukrainskykh-terytorij.
12. Yakymchuk, A. (2024). The Carbon Dioxide Emissions' World Footprint: Diagnosis of Perspectives. *Scientific Papers of Silesian University of Technology – Organization and Management Series, No. 195.* Wydawnictwo Politechniki Śląskiej. Doi: http://dx.doi.org/10.29119/1641-3466.2024.195.41. https://managementpapers.polsl.pl/wp-content/uploads/2024/05/195-Yakymchuk.pdf.

13. Yakymchuk, A., Halachenko, O., Irtyshcheva, I., Maksymchuk, M., Blishchuk, K., Bilinska, O., Sydorchuk, O., Boiko, Y., Hryhoruk, I., Popadynets, N. (2021). *The Socio-Cultural and Economic Aspects of Tourism in Ukraine.* 4th International Conference on Human Systems Engineering and Design: Future Trends and Applications (IHSED 2021). Virtual Conference, September 23-25, 2021. http://www.ihsed.org.
14. Yakymchuk, A., Skomorovskyi, A., Pokusa, T., Pokusa, K., Łukawiecki, K. (2022). *Basics of the Public Administration: Economy, Environmental Protection and Security of the State*. Monograph. Opole: WSMiA w Opolu. ISBN: 978-83-66567-46-7.
15. Yakymchuk, A., Valyukh, A. et al. (2020). Public Administration and Economic Aspects of Ukraine's Nature Conservation in Comparison with Poland. In: J. Kantola, S. Nazir, V. Salminen (eds.) (2020). Advances in Human Factors, Business Management and Leadership. AHFE 2020. *Advances in Intelligent Systems and Computing, vol. 1209.* Cham: Springer. 978-3-030-50791-6.
16. Zhukovsky, V., Romanova, E. (2020). Climate Variability and Crop Yield: Assessing Vulnerabilities in Ukrainian Agriculture. *Environmental Studies Journal*, *18(1)*, 55-70.