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Natalia PRYSHLIAK¹, Vitalii DANKEVYCH², Dina TOKARCHUK³, Oleksandr SHPYKULIAK⁴

The sowing and harvesting campaign in Ukraine in the context of hostilities: challenges to global energy and food security

ABSTRACT: The specificities of the sowing and harvesting campaign of 2022–2023 in Ukraine and its impact on the world energy and food market in the conditions of the full-scale invasion of Ukraine by the Russian Federation are analyzed in this paper. The purpose of the study is to determine the role of Ukraine in ensuring energy and global food security, to analyse the situation regarding the possibility of conducting a sowing and harvesting campaign in Ukraine in the conditions of hostilities and to provide recommendations on preserving the potential of Ukraine in meeting the energy and food needs of Ukraine and other countries. The provided analysis of data of the Food and Agriculture Organization (FAO), the State Customs Service and the State Statistics Service of Ukraine has confirmed the role of Ukraine in ensuring energy and food safety of many countries in the Middle East and North Africa, which are the main importers of agricultural products from Ukraine. It has

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been found that the 2022–2023 sowing and harvesting campaign in Ukraine is facing a number of problems, including: military operations over a large area, which makes it impossible to conduct agrotechnical activities in a timely manner; a lack of seed material due to its systematic destruction by the Russian military; problems with the supply of fuel and lubricants (systematic shelling and destruction of oil bases throughout Ukraine); problems with the supply of fertilizers; bombing wheat fields and food warehouses; blocking Ukrainian sea ports; mobilization of a significant part of the population in the ranks of the Armed Forces of Ukraine; logistics problems. The study proposes recommendations to preserve the potential for meeting energy and food needs in Ukraine and for countries importing agricultural products from Ukraine.

KEYWORDS: agriculture, biofuel production, food security, energy security, alternative energy

Introduction

Energy and food security are key factors for the functioning and sustainable development of any state. The energy-security policy of a country that heavily relies upon energy imports is particularly sensitive. As the majority of European Union countries are energy importers, the political context of their relationships with energy resource suppliers and transitors is critical for ensuring energy sustainability. Since 2014, the collective efforts of Europe have been aimed at containing Russia's hybrid aggression. Since 2022, these efforts have intensified due to the transition of the war into an active phase of hostilities.

Ukrainian energy security has been in danger since 2014. With the massive invasion of 2022, Russian troops have been massively shelling not only Ukrainian cities and towns but also trying to destroy critical objects of the energy infrastructure: high-voltage networks, transformer substations, control centers, as well as directly attacking power plants, including objects of renewable energy industry. Renewable-energy power plants became the second priority of destruction after nuclear power facilities and power lines.

Military actions can have a significant impact on energy security, also including the production of first-generation biofuels in Ukraine. In times of conflict, access to raw materials and transportation routes can be disrupted, which can lead to a shortage of the necessary resources for both food and biofuel production.

The food security of many countries has also been under threat since the start of hostilities in Ukraine, which is a major food exporter. Based on the Ministry of Agrarian Policy and Food of Ukraine's (MAPFU) report in 2022, agriculture in Ukraine had a production increase of 14.4% in 2021, which is the highest increase in recent years. Moreover, data from the same year revealed that the production of agricultural enterprises grew by 19.2%. This contributed to the agricultural sector's contribution of more than 10% to the country's GDP, which was the highest among all economic sectors in Ukraine. Furthermore, agro-food products accounted for the most significant share of Ukraine's total exports, comprising approximately 41% annually. Ukraine's food supply

has vastly expanded in recent years, from providing food to only forty million people worldwide two decades ago to now having the capability to feed over 400 million people worldwide, excluding Ukraine's population. The Ukrainian development strategy until 2030 aims to provide food for one billion people worldwide, as stated in the Cabinet of Ministers of Ukraine Resolution №179 of March 3, 2021, approving the National Economic Strategy for the period up to 2030. Currently, it is impossible to use the agrarian potential of Ukraine due to hostilities on the territory, which made it impossible to use the occupied territory for full-fledged agricultural use.

This article analyzes the impact of the Russian invasion of Ukraine on the energy and food security of Ukraine and the world, summarizes the current problems related to energy and food security and identifies possible ways to overcome these threats. A clear understanding of the causes, consequences, and possible solutions to energy and food security challenges is essential for justifying coordinated efforts to counter Russia's invasion of Ukraine.

1. Literature review

Scientific research into the development of the agricultural sector and its impact on ensuring energy and food security is a pertinent topic for nations worldwide, and researchers have continuously pursued this area of study. A number of investigations on the role of the agricultural sector as a component of energy security have been performed by [Korpaniuk et al. \(2019\)](#); [Pryshliak et al. \(2021\)](#), [Tokarchuk et al. \(2020\)](#) and others.

According to [Korpaniuk et al. \(2019\)](#) the idea of using agricultural materials for energy purposes is not new; however, over the last decade, there has been a growing emphasis on renewable fuels, which is reflected in increased production and consumption. This trend has resulted in a rise in the production and consumption of such fuels, underscoring the need to acknowledge biofuels as a crucial determinant of contemporary energy policies and agricultural industries worldwide. Of specific interest is the agricultural sector, which produces the biomaterials used in biofuel manufacturing and can gain direct advantages from utilizing biofuels to fulfill their energy and fuel demands.

[Pryshliak et al. \(2021\)](#) explored that the production of biofuels in Ukraine is expected to have a positive impact not only on reducing the country's energy dependence but also on improving its socio-economic and environmental conditions; the combination of economic, social and energy benefits of biofuel production will give a synergistic effect.

[Tokarchuk et al. \(2020\)](#) suggested that the use of biogas is a viable option to substitute conventional fuels and ensures the energy supply of agricultural enterprises which will be a significant contribution to the energy security of the state.

Green cooperatives can promote energy independence and efficiency as well as local food production in Ukraine in the face of Russian hostilities. According to [Shpykuliak and Bilokinna \(2019\)](#), by reducing Ukraine's reliance on Russian natural gas and promoting renewable energy

sources, green cooperatives can increase energy security. They can also support local farmers and contribute to the local economy through sustainable food production. Additionally, promoting local ownership and the control of energy and food production can build greater community resilience in the face of external disruptions.

As noted by [Kaletnik et al. \(2021\)](#), the production of energy crops in Ukraine and their processing into solid biofuels can play a role in promoting energy security and reducing Ukraine's dependence on Russian natural gas. By using energy crops such as switchgrass and miscanthus to produce solid biofuels, Ukraine can reduce its reliance on imported fossil fuels and increase its energy independence. This would make Ukraine less vulnerable to energy disruptions caused by Russian hostilities. Additionally, the production of energy crops and solid biofuels can support local farmers and contribute to the local economy, promoting greater resilience in the face of external disruptions. Overall, the use of energy crops and solid biofuels can play a part in building greater energy security and promoting self-reliance in Ukraine.

[Skydan et al. \(2022\)](#) conducted a study on the main components of the European Green Deal, energy and food-safety policy, using Poland as an example. These components include ending land reform and lifting the moratorium on the sale of agricultural land, ensuring equitable economic development of rural areas across different regions, and promoting competitiveness in the rural economy by increasing agricultural efficiency and encouraging related industries. Additionally, research has emphasized the need to bridge the urban-rural divide and improve the quality of life in rural areas to facilitate sustainable agricultural practices.

[Varchenko et al. \(2020\)](#) emphasized the significance of forming sustainable food chains that create value as a crucial means of addressing poverty and low income levels in small farms in developing countries. Their research emphasizes the need for state support in developing small farms and recognizes their vital contribution to agricultural production.

[Patyka et al. \(2021\)](#) established methodological approaches for assessing the competitiveness of Ukraine's agricultural sector. They calculated an integrated indicator index and demonstrated that the sector's competitiveness is driven by enhancements in profitability indicators, improved management of production processes and an increase in the financial stability and solvency of agricultural enterprises.

The World Food Summit (WFS) in 1996 provided the definition of food security as "all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This definition is associated with both food availability and food affordability, acknowledging that people need access to an adequate supply of safe and nutritious food as well as the means to acquire it.

The conventional understanding of food security involves four dimensions: food availability, food accessibility, food utilization, and stability, as identified by the Food and Agriculture Organization (FAO) in 2008. Achieving the Sustainable Development Goals (SDGs) depends on ensuring food security, according to [Ma et al. \(2020\)](#).

[Dasgupta and Robinson \(2022\)](#) conducted research on the correlation between food security and human health and also conducted a quantitative evaluation of the consequences of climate change on food insecurity.

Sarkar et al. (2021) conducted a study on the unique aspects of guaranteeing food security during the COVID-19 pandemic. They examined the interpretation of this economic category through the perspective of efficient food utilization, food availability, and food access.

The military invasion of Ukraine by Russia could potentially present an unparalleled danger to the global energy and food supply. David Beasley, the head of the World Food Program, has stated that half of the grain purchased by the program to provide food for 125 million people is produced in Ukraine. He also noted that rising food, delivery, and fuel costs have led to a monthly increase of \$71 million in the program's operating expenses. Meanwhile, Ukraine's Permanent Representative to the UN, Serhiy Kyslytsia, has warned that Russia may be planning to destroy Ukraine's agricultural potential as a "Plan B" after its troops failed to quickly capture the country. This could result in a humanitarian crisis in Ukraine (UNSC 2022). In addition, Human Rights Watch (HRW 2022) has cautioned that a potential Russian invasion of Ukraine may worsen the food crisis in the Middle East and North Africa.

The President of Ukraine, Volodymyr Zelenskyi, stated that problems with the export of agricultural products from Ukraine will hit many regions of the world. At the same time, Ukraine itself is estimated to have enough food supplies. Considering the gross production volumes and domestic demands in Ukraine, the export capacity for grain and oil crops in the 2023/24 marketing year is estimated to be around thirty-five million tons or approximately three million tons per month. To provide some context, in the 2021/22 marketing year, the export potential was much higher, at around eighty-five million tons of grain and oil products, or approximately seven million tons per month (PU 2022).

During the spring of 2023, Ukraine is preparing for a second round of sowing campaign amidst the challenges of a full-scale war. These challenges include a lack of working capital, expensive resources, and logistical issues. The Ministry of Agrarian Policy and Food of Ukraine has reported that the area used for growing grain crops will be 22% less in 2023 compared to 2022, and 45% less compared to 2021. This means that the area of land used for growing grain crops in Ukraine will be reduced by 45% in 2023 and the harvest will be 60% less than the pre-war year of 2021. The direct reasons for this decrease are attributed to the continued occupation, hostilities, and minefields.

2. Aim of the research

The purpose of the study is: a) to determine the role of Ukraine in ensuring energy and food security; b) to perform an analysis of the situation regarding the possibility of conducting a sowing and harvesting campaign in Ukraine in the conditions of hostilities; c) to provide recommendations on preserving the potential of Ukraine in meeting the energy and food needs of Ukraine and countries importing agricultural products.

3. Results and discussions

With a population of 44 million people, Ukraine is the largest country in Eastern Europe. It is characterized as an industrial-agrarian nation and is recognized as one of Europe's and the world's largest food producers. Ukraine's agrarian sector has natural and climatic advantages, abundant human resources, a favorable geographical location and ample land resources. The country's total area is 60.4 million hectares, with 42.7 million hectares of agricultural land, constituting 71% of Ukraine's total area. Additionally, Ukraine has 9% of the world's reserves and 30% of Europe's reserves of Ukrainian black soil, as reported by MAPFU in 2022.

The world has been witnessing a continuous rise in food prices every year. However, the ongoing full-scale invasion of Ukraine by the Russian Federation has severely complicated agricultural activities in the country, potentially leading to a significant shortage of food worldwide and consequently causing further price hikes.

The overall FAO food price index for January 2022 rose by 1.1% from December 2021, reaching a value of 135.7 points. With the ongoing military conflict in Ukraine, there is a looming threat of a major surge in world food prices. The aggression of Russia towards Ukraine poses a risk to the food and humanitarian security of multiple nations across the globe. Prior to the outbreak of war between Russia and Ukraine, there was already a significant increase in global food prices (see Fig. 1).

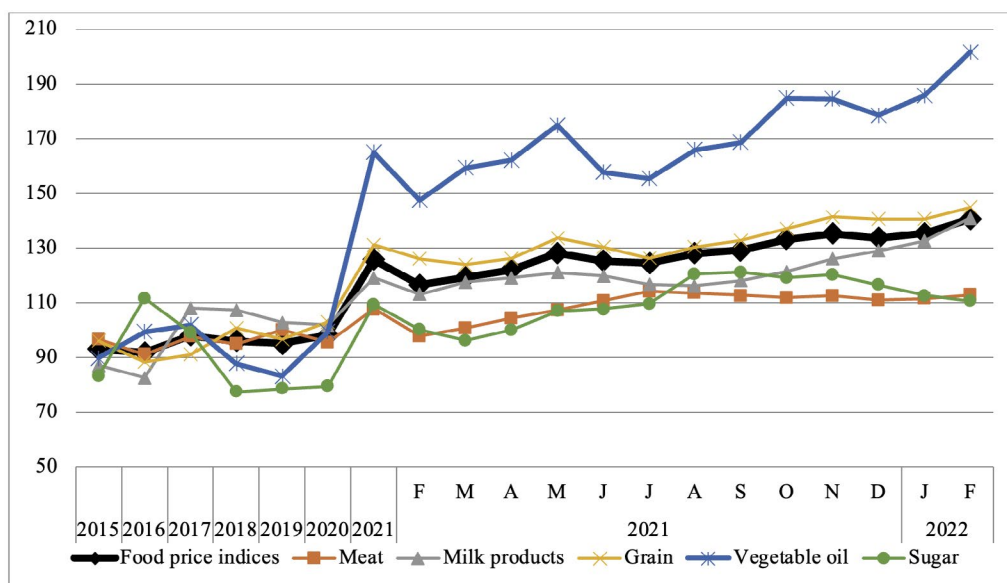


Fig. 1. FAO food price index [%]

Source: generated by the authors according to FAO 2022

Rys. 1. Wskaźnik cen żywności FAO [%]

In addition to the above factors, the rise in fuel prices is a negative trend affecting agricultural producers and exporters, with fuel costs accounting for up to 30% of their production expenses. The increase in prices for gasoline and other petroleum products in Ukraine began before the Russian Federation's invasion and has further intensified with the outbreak of hostilities, as shown in Figure 2.

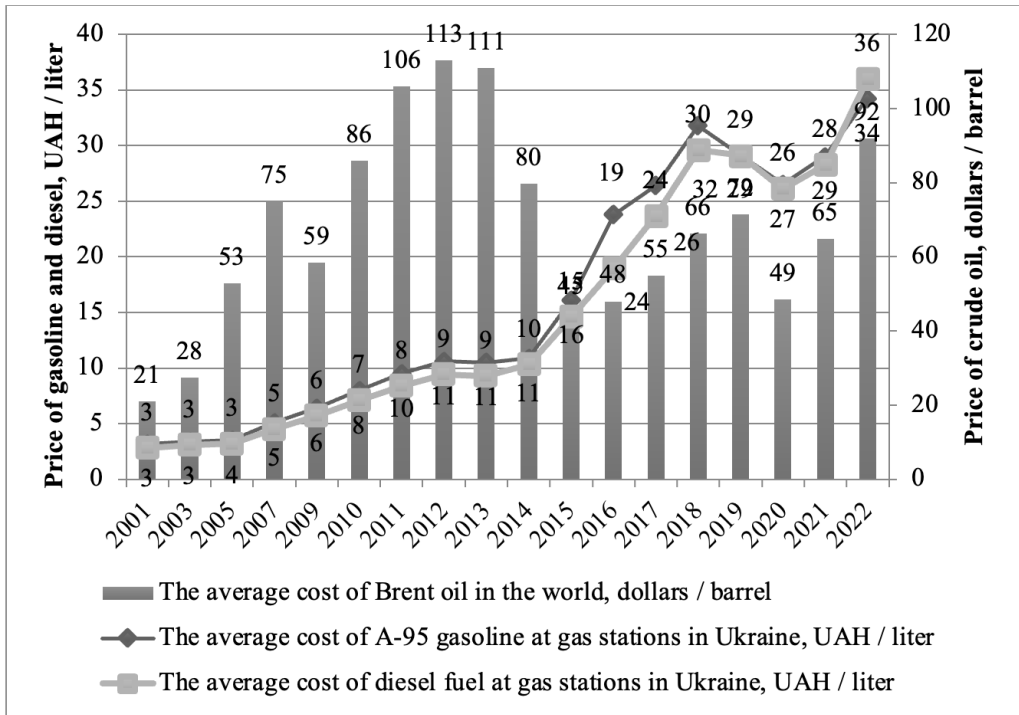


Fig. 2. Dynamics of prices for gasoline, diesel oil in the world
Source: formed by the authors according to the SSSU (2022) and USEIA (2022)

Rys. 2. Dynamika cen benzyny i oleju napędowego na świecie

One week after the Russian invasion of Ukraine, gasoline and diesel fuel prices in Ukraine rose to a record high. In response, the Ukrainian government eliminated the excise tax on fuel and reduced the VAT rate from 20% to 7%, which helped to stabilize fuel prices in the country. However, rising oil prices have also affected EU countries due to sanctions against Russia. The agricultural sector in Ukraine faces additional challenges due to the damage caused by rocket attacks on gas stations oil depots, and refineries by Russian troops. For instance, in early April, the Kremenchug refinery, the only refinery in Ukraine, was attacked and destroyed by Russian troops. Moreover, several oil depots in different regions of Ukraine were also destroyed. The prices of gasoline and diesel fuel at gas stations in Ukraine are shown in Figure 3.

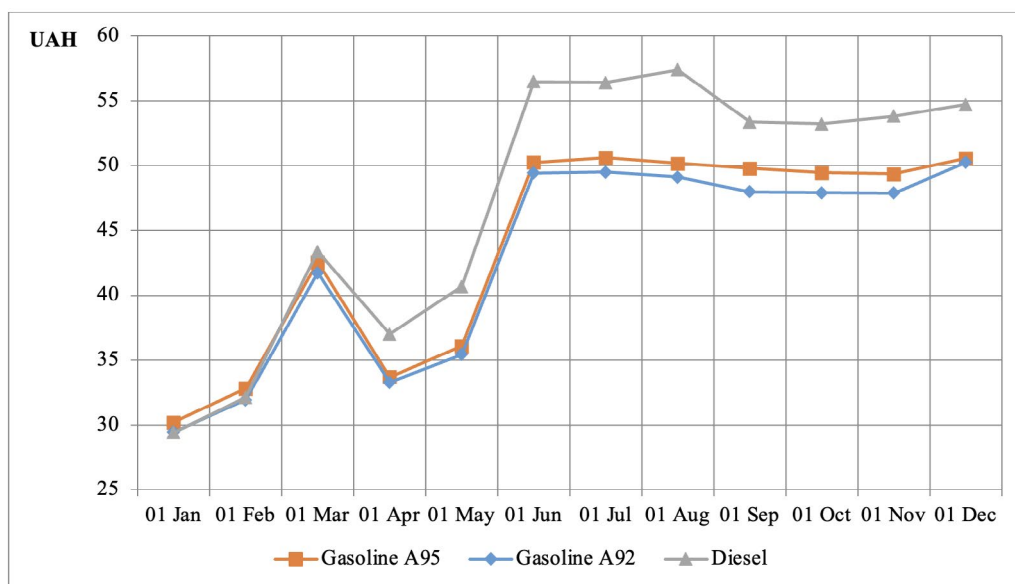


Fig. 3. Dynamics of prices for gasoline and diesel fuel at gas stations in Ukraine, 2022
 Source: composed by the authors according to the data from MFS 2023

Rys. 3. Dynamika cen benzyny i oleju napędowego na stacjach benzynowych na Ukrainie, 2022

Ukraine is considered one of the world’s leading agricultural producers and exporters, ranking in the top five globally. Together with Russia, the two countries account for a significant portion of the world’s wheat exports, corn supplies and sunflower oil exports, according to data from the FAO. The U.S. Department of Agriculture also reports that Ukraine contributes 16% of the world’s corn exports, 12% of wheat exports, and 50% of sunflower oil exports, with approximately 30% of China’s corn imports sourced from Ukraine (as shown in Fig. 4).

Furthermore, based on OEC statistics, Ukraine is the largest sunflower oil exporter worldwide, responsible for up to 46% of sunflower-seed and safflower oil production. Meanwhile, Russia is the second-largest producer, exporting around 23% of the global supply. Any supply disruptions from the Black Sea region could have an impact upon the overall global food availability. Despite these challenges, Ukraine’s Ministry of Agrarian Policy maintains that the country is not at risk of famine, as there are adequate internal reserves to sustain the nation for at least two years, based on a standard annual grain consumption of nineteen million tons.

According to A. Dikun, the head of the All-Ukrainian Agrarian Council, in the first week of hostilities on the territory of Ukraine, the cost of food wheat on the world market increased by 100% and amounts to \$400 per ton. By comparison, in February last year, this figure was \$150 per ton. Currently, the export of grain from Ukraine has been almost completely stopped, which means that Ukraine will not be able to supply the world with the contracted minimum of 6 million tons of wheat and 15 million tons of corn if the war continues. From the harvest of 2021, Ukraine exported 16.7 million tons of wheat and 13.7 million tons of corn (SCSU 2022).

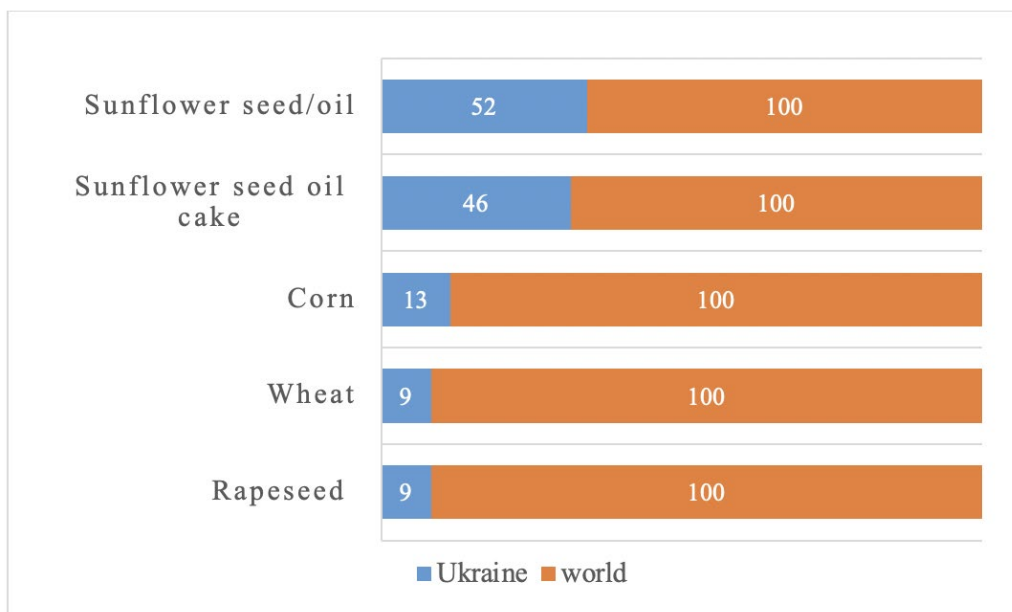


Fig. 4. Main trends of the Ukraine's agricultural export in 2020
 Source: According to the US Department of Agriculture (USDA 2021)

Rys. 4. Główne trendy ukraińskiego eksportu rolnego w 2020 r.

As of 2019, 690 million people in the world suffered from hunger (FAO). The UN projections for an increase in the number of hungry people in 2030 reached 840 million. However, by the end of 2021, humanity reached the mark of 821 million hungry people. The reasons for such rapid growth were the COVID-19 pandemic and global climate change.

In addition to the pandemic, climate change is also affecting food security by disrupting agricultural production and reducing crop yields. Extreme weather events such as droughts, floods, and heat waves are becoming more frequent, which makes it harder for farmers to grow crops and raises the risk of food shortages.

About fifty countries in the world depend more than 30% on Ukraine to supply wheat. Most of them are the least developed, or countries with low incomes and food shortages (North Africa, Asia and the Middle East).

Food prices, which have been rising since the second half of 2020, reached a record high in February 2022. For example, world prices for wheat and barley rose by 31% in 2021. The cost of rapeseed and sunflower oil increased by more than 60%.

Cereals are the main crops that feeds the world. Wheat, corn and rice account for more than 40% of all calories consumed. Ukraine provided about 10% of the world's wheat and almost 16% of all corn (as of the end of 2021) according to [FAO 2022](#).

The main buyers of Ukrainian grains are in the Middle East and North Africa, and for these countries, the food security problem is extremely sensitive (Table 1).

TABLE 1. Countries heavily dependent on some Ukrainian food products

TABELA 1. Kraje silnie uzależnione od niektórych ukraińskich produktów spożywczych

Country	Ukraine's share [%]	Import volume [ths. t.]	Population [mln]	GDP per capita [\$]
Wheat				
Pakistan	67.0	1,344.0	220.9	1,192
Lebanon	50.0	630.0	6.825	4,891
Libya	41.0	570.0	6.871	3,699
Tunisia	36.0	646.0	11.82	3,319
Ethiopia	36.0	607.0	115.0	936
Sunflower oil				
Saudi Arabia	100.0	90.0	34.8	20,110
EU	82.0	1,447.0	447.0	30,997
India	65.0	1,569.0	1,380.0	1,900
Libya	48.0	29.0	6.8	3,699
Iran	46.0	263.0	40.2	4,157

Source: SCSU 2022; FAS USDA 2022.

The success of the upcoming sowing campaign in 2023 in Ukraine will significantly affect the food security of Ukraine and the Middle East and North African countries, which are major importers of agricultural products from Ukraine. However, the campaign is facing enormous challenges due to the ongoing hostilities. Many agricultural enterprises are lacking resources, with only 30–50% of the necessary resources being available. According to a survey of agricultural producers, the most significant challenges are the lack of fuel and logistics, including blocked ports. Fertilizers, seeds, plant protection products, and spare parts for machinery are also in short supply. Some producers have already purchased these resources, but transportation across Ukraine is now difficult. Additionally, the loss of agricultural machinery due to theft is also a significant issue. Agricultural holdings from the temporarily occupied regions of Kharkiv, Luhansk, Donetsk, and Mykolaiv report that much of Ukraine's equipment has been stolen and taken to Russia. Furthermore, bombing has resulted in the significant destruction of seeds, fertilizers, and fuel.

According to the report of the State Customs Service of Ukraine, Ukraine exported agricultural products worth \$27.9 billion in 2021, which is a significant increase from the previous year. Among the exported products, wheat, poultry, frozen berries and fruits, and pasta were the most significant with the export of 20,000,000 tons, 459,000 tons, 76,000 tons, and 38,000 tons, respectively. Asian countries were the main importers of Ukrainian agricultural products, with a record purchase of \$13.7 billion in 2021. Additionally, exports to Africa increased from \$2.9 billion in 2020 to \$3.7 billion in 2021.

According to research by the Kyiv School of Economics, the most dependent countries on Ukrainian food imports are Egypt, Indonesia, Yemen, Bangladesh, Ethiopia, Lebanon, Libya, Iraq and Pakistan.

In 2021, 6.5 million hectares of winter wheat, 1 million hectares of winter barley and 109,000 hectares of winter rye were sown. Considering the military actions, of the 7.6 million hectares sown, only 5.5 million hectares may be available, corresponding to a loss of 28% (Table 2).

TABLE 2. Sown areas of winter cereals in Ukraine

TABELA 2. Obszary zasiewów zbóż ozimych na Ukrainie

Name of region	Grain sowing area [ths. ha]	The presence of active hostilities	Name of region	Grain sowing area [ths. ha]	The presence of active hostilities
Cherkasy	208	are absent	Lviv	177	are absent
Chernihiv	175	>50% of territory	Mykolaiv	629	<50% of territory
Chernivtsi	39	are absent	Odessa	795	are absent
Dnipropetrovsk	609	are absent	Poltava	273	are absent
Donetsk	395	>50% of territory	Rivne	126	are absent
Ivano-Frankivsk	59	are absent	Sumy	177	<50% of territory
Kharkiv	590	<50% of territory	Ternopil	207	are absent
Kherson	563	>50% of territory	Vinnytsia	325	are absent
Khmelnyskyi	228	are absent	Volyn	175	are absent
Kyiv	200	<50% of territory	Zakarpattia	18	are absent
Kirovohrad	446	are absent	Zaporizhzhia	733	>50% of territory
Luhansk	330	>50% of territory	Zhytomyr	142	are absent

Source: formed by the authors according to the data from the State Statistics Service of Ukraine (SSSU 2022), President of Ukraine (PU 2022).

Considering the above, the sowing campaign in Ukraine in 2022–2023 has the following characteristics (Fig. 5):

1. Changes in timing

Considering Russia's war against Ukraine, a shortage of production and exports is inevitable. The war impacted the sowing campaign, which usually starts in the third decade of March (depending on weather conditions). Some areas couldn't start a sowing campaign at all.

2. Human resources

According to the UN, since the beginning of hostilities in Ukraine, the total number of people displaced within the country and abroad has reached 11.4 million. According to the latest report of the United Nations, at least twelve million people have been displaced inside the country. A decree on general mobilization was signed in Ukraine on February 24, 2022. According to the document, the mobilization has been carried out throughout the country. The decree provides for the calling up of conscripts, reservists and the involvement of vehicles to meet the needs of the armed forces of Ukraine. Accordingly, a significant number of workers involved in agricultural works joined the armed forces and territorial defense. To ensure sowing and harvesting, the government has introduced a simplification of the procedure for the

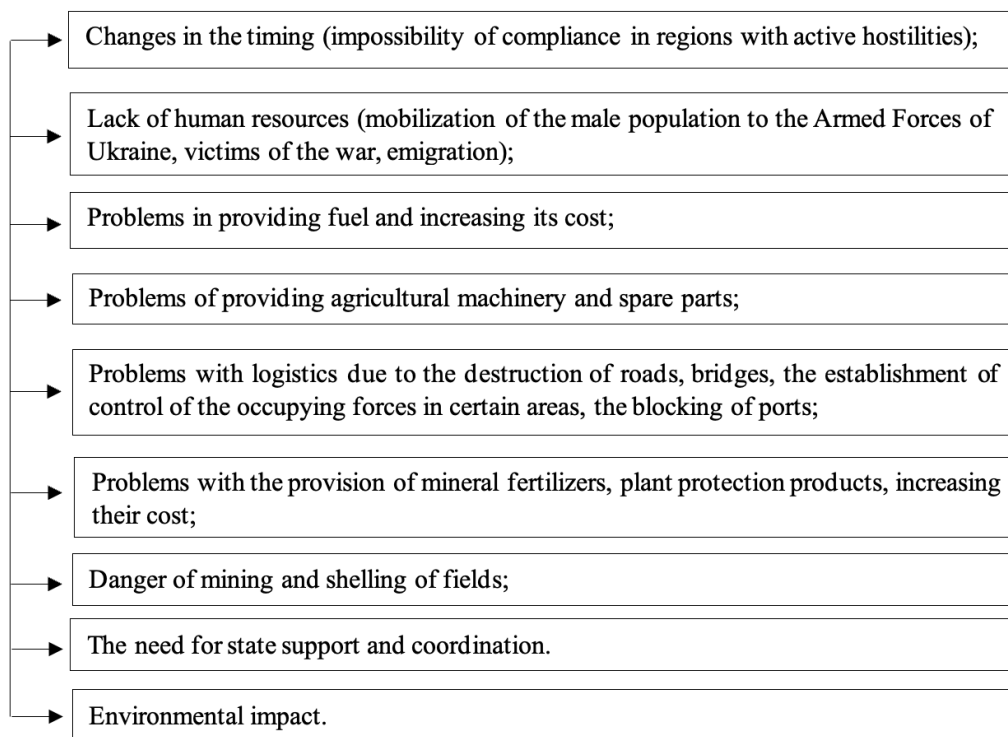


Fig. 5. Features of the sowing and harvesting campaign in Ukraine in 2022–2023

Source: generated by the authors

Rys. 5. Charakterystyka kampanii siewu i zbioru na Ukrainie w latach 2022–2023

special temporary exemption from mobilization in the army for machine operators who are not mobilized to the armed forces during the sowing and harvesting campaign. “In order to timely conduct a set of spring and summer field work, ensure the production of agricultural products and food for the armed forces of Ukraine, other military formations and agricultural companies should have submitted a letter with proposals for temporary exemption from mobilization of conscripts with justification, e-mail address, contact phone numbers, etc.” (MAPFU 2022). Thus, agricultural enterprises and food producers have provided the Ministry of Agrarian Policy with lists of critical workers who will be granted deferment from conscription during mobilization and wartime.

3. Provision of fuel

Of particular relevance is the issue of providing agricultural enterprises with diesel fuel. Thus, according to the A-95 consulting group, in 2021, 2.05 million tons of diesel fuel were imported from Russia (30% of all imports). Although this is less than in 2020 (2.61 million tons, 42% of imports), it is still a fairly high figure. It is clear that in the conditions of Russia’s war against Ukraine, buying fuel from an aggressor country is out of the question. It is also impos-

sible to obtain fuel from Belarus, as the local political regime supports military action against Ukraine. In 2021, Belarus was the largest supplier of diesel fuel to Ukraine – 2.89 million tons of diesel fuel was imported (42% of all imported diesel), which is 0.7 million tons more than in 2020. Therefore, there is an urgency to look for alternative fuel suppliers.

4. Provision of agricultural machinery with spare parts

A large number of spare parts in Ukraine were produced in Melitopol, Mariupol and Kharkiv. Some enterprises have been destroyed, others are trying to move their facilities to other regions, but their full functioning is impossible. Farmers are facing a shortage, especially for tractors MTZ, T-150, KAMAZ, MAZ (this equipment and the spare parts for it are produced in Belarus and Russia). Often, there are no spare parts for MANs and DAFs, and those that are, have risen in price by almost two times. The only plant that produced agricultural machinery and spare parts was the Kharkiv Tractor Plant, which was also shelled by Russian troops.

5. Logistics and port control

Port control is also critical to ensure an efficient provision of the world's food safety. Of all agricultural exports, 90% took place through the ports of Odessa and Mykolaiv.

In 2021, 1.2 million tons of diesel fuel (one and a half times more than in 2020) entered Ukraine by sea. The largest volume – 405.5 thousand tons or 33% – came through the port of Mykolaiv. Thus, it will be possible to close Russian and Belarusian fuel imports by sea if the port blockade is lifted. Lithuania can become a promising alternative supplier of fuel and other components of sowing. Last year, Ukraine bought 691 thousand tons of fuel from Lithuania, which is 11% more than in 2020.

Russia's attack on Ukraine has led to the closure of ports and a ban on the movement of merchant ships in the Sea of Azov, which connects with the Black Sea, one of the world's most important regions for trade.

The hostilities in the Black and Azov Seas create a bottleneck for exports, leaving only rail and road transport with very low capacity.

6. Mineral fertilizers and plant-protection products

The Russian invasion of Ukraine may cause significant disruptions to the global supply of potash and nitrogen fertilizers, which are essential for crops. If sanctions are imposed on Russia and Belarus, who control a large share of the global potash fertilizer market, prices will increase, resulting in decreased usage by farmers and lower yields. Although alternatives for nitrogen fertilizers may exist, Russia and Belarus control a substantial portion of the global market. Additionally, the import of fertilizers, plant-protection products and seed material to Ukraine is currently restricted due to customs limitations. As a result, it is critical to use internal stocks as much as possible. However, it is expected that the crop yield in 2022 will be significantly lower than in previous years due to the fertilizer shortage.

7. Danger of the mining and shelling of fields

By analyzing the data from the online resource "Harvest Online 2021", it becomes evident that Odessa (4.4 million tons), Kharkiv (3.8 million tons), Dnepropetrovsk (3.8 million tons), Mykolaiv (3.6 million tons), Zaporizhzhia (3.3 million tons), Kherson (3.2 million tons), Vinnitsa (2.3 million tons) and Donetsk (2.1 million tons) are the regions with the largest gross harvest

of grain and leguminous crops. It is worth noting that these regions are the main food-growing areas in Ukraine and are situated adjacent to Russia and Belarus, where there have been ongoing hostilities since February 24th, due to Russia and Belarus' aggression. Consequently, the sowing campaign in these regions is difficult, and in some cases, even impossible.

According to Figure 6, about 30% of Ukraine's territory has faced challenges initiating spring field work due to the effects of hostilities, with some areas even sustaining direct damage. Even if the occupied territories are liberated, agricultural production in some of these regions will remain impossible until complete demining operations are conducted.



Fig. 6. Zone of risky agriculture in Ukraine (marked in red)
Source: data of the Ukrainian Nature Conservation Group (UNCG 2022)

Rys. 6. Strefa ryzykownego rolnictwa na Ukrainie (zaznaczona na czerwono)

8. State support and coordination

The Cabinet of Ministers of Ukraine has allocated more than UAH 25 billion in interest compensation and guarantees for loans to agricultural enterprises for sowing. The government has already created additional financial support programs to launch a sowing and harvesting campaign in Ukraine. Ukrainian agricultural producers can receive loans at 0%. Furthermore, the government guarantees 80% of a full amount of such loans to banks. The government has provided

more than UAH 25 billion for these two areas of support. These funds will be partially enough to support all small and medium-sized farms who have started agricultural production this year.

The Government also adopted a Resolution of the Cabinet of Ministers of Ukraine “On Amendments to Certain Acts of the Cabinet of Ministers of Ukraine Concerning the Provision of Credit Support to Agricultural Producers”, which provides financial support for farmers (Fig. 7).

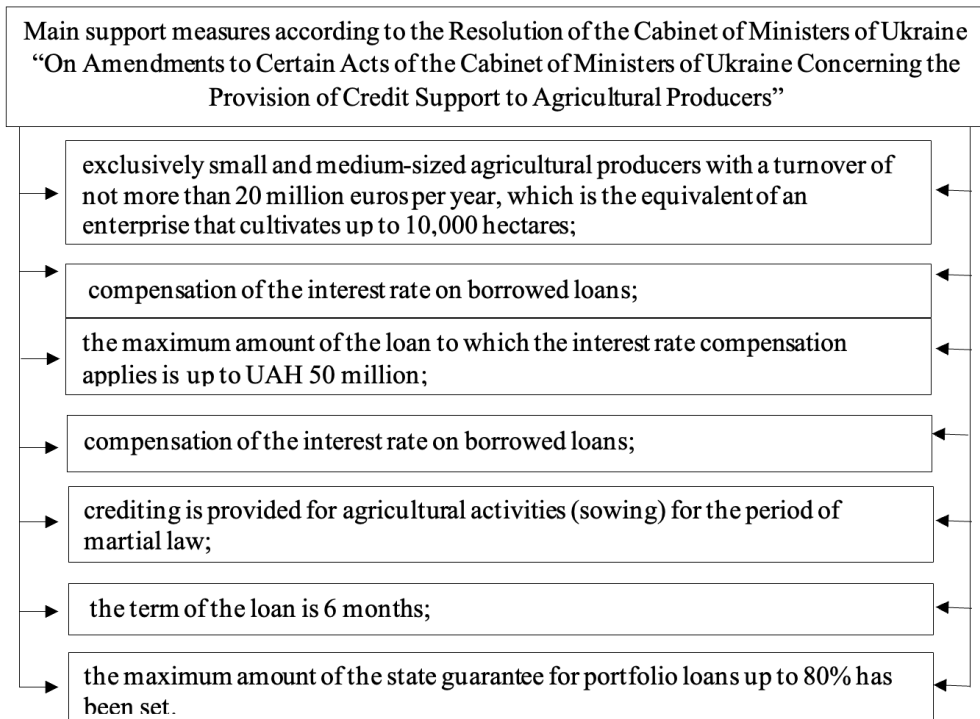


Fig. 7. Financial support for Ukrainian farmers from the government during sowing and harvesting under Russian hostilities

Source: summarized by the authors

Rys. 7. Wsparcie finansowe dla ukraińskich rolników od rządu w czasie trwania siewu i zbioru podczas rosyjskich działań wojennych

It is good to know that the Ministry of Agrarian Policy and Food of Ukraine has launched a platform to assist in the sowing and harvesting campaign and help meet the needs of farmers. Simplifying the seed bureaucracy and eliminating the additional certification procedures during martial law can help streamline the process of the constant sale of seeds and planting material. This can enable farmers to obtain the necessary materials more quickly and efficiently to start their sowing campaign. However, it is still unclear how the ongoing conflict and disruptions caused by the invasion of Russian troops will affect the supply of seeds and other agricultural inputs, especially in the areas affected by the conflict.

Also very important is the fact that the big agricultural investors remain in Ukraine. According to Forbes, the shares of the largest Ukrainian agricultural holdings remains the same despite the war. Thus, the capitalization of the largest agricultural companies as of March 28 was as follows: Kernel (510 thousand hectares) – \$623 million, Myronivsky Hliboproduct (370 thousand hectares) – \$365 million, Astarta (220 thousand hectares) – \$135 million.

The main problems of harvesting campaign in Ukraine are identified in Table 3.

TABLE 3. The main problems of harvesting campaign in Ukraine and proposed ways to solve them

TABELA 3. Główne problemy kampanii żniwnej na Ukrainie i proponowane sposoby ich rozwiązania

No.	Nature of the problem	Ways to solve
1.	Safety of workers during harvesting	<ul style="list-style-type: none"> ◆ demining of territories freed from occupation, where the crops will be harvested; ◆ conducting thorough briefings on labor protection and fire safety; ◆ provision of workers with overalls and first-aid kits.
2.	Labor shortage	<ul style="list-style-type: none"> ◆ employers' booking of workers, subject to mobilization for the harvest period.
3.	The need to ensure the export of the crop	<ul style="list-style-type: none"> ◆ implementation of measures to increase throughput on the western border of Ukraine; ◆ wider use of railway transport for crop transportation; ◆ providing guarantees of compliance with peace agreements when using sea ports for the export of Ukrainian agricultural products.
4.	The problem of saving the new crop	<ul style="list-style-type: none"> ◆ modernization of existing storage; ◆ organization of mobile storage facilities, taking into account international experience (will allow Ukraine to increase storage volumes by 10–15 million tons).
5.	Provision of fuel for farmers	<ul style="list-style-type: none"> ◆ active work of relevant ministries to ensure the necessary amount of diesel fuel for the harvest season.

Source: formed by the authors.

9. Environmental impact

The Russian invasion of Ukraine in 2022 has resulted in significant and enduring environmental impacts that pose a threat to both the environment and human health. The detonations have caused both physical destruction and toxic damage, releasing hazardous substances such as lead, mercury, and depleted uranium into the air, water, and soil. As a result, when these toxic particles enter the human body, they can disrupt the function of various organs and systems. Explosives like TNT, DNT, and RDX can cause widespread malfunctioning of the body's internal systems.

Fighting in heavily industrialized areas can result in technological disasters that cause spills of tailings and fuel, contaminating vast areas not only in Ukraine but also in Europe and Russia. Buildings that are destroyed during conflict can release carcinogenic dust for decades. Heavy metals and chemicals can seep into underground water sources and poison rivers and other bo-

dies of water, killing all life within them. The destruction of civil infrastructure has left more than four million people without access to safe drinking water. The soils in areas of military conflict are no longer suitable for agriculture because plants absorb and accumulate pollutants.

War also brings the threat of nuclear accidents. Power shortages at nuclear plants, along with fighting in the vicinity of these stations, could result in disasters similar to those that occurred in Chernobyl or Fukushima. Additionally, military emissions of carbon dioxide (CO₂) can reach hundreds of millions of tonnes and undermine the goals of the Paris Agreement.

Over 12,000 square kilometers of Ukraine's nature reserves have been transformed into a war zone, resulting in significant losses for populations of rare endemic and migrant species. Birds have been forced to abandon their nests and alter their migration routes. Decades-long conservation efforts have been devastated as a result.

It will only be possible to estimate the full extent of the environmental damage caused by the war once the active phase has ended. Preliminary data suggests that it will take at least fifteen years for Ukraine's nature to recover from the damage inflicted.

4. The impact of the Russian invasion of Ukraine on EU and Ukrainian energy security

The Russian invasion of Ukraine in 2022 and subsequent conflict has had significant implications for the energy security of both Ukraine itself and the European Union (EU).

As the heating season commenced, Russia has escalated missile strikes and kamikaze drone attacks on Ukrainian energy facilities. The Ukrainian government reported that as of December 2022, the aggressor had successfully destroyed and inflicted significant damage to approximately 50% of the vital electricity infrastructure. Heat-supply facilities are also being targeted by the Russians, with nearly 600 units damaged, according to the Ministry of Regions. The attackers have specifically targeted 444 boiler houses, thirteen thermal power plants, seven combined heat and power plants, and 128 central heating points. While half of these facilities have already been restored, the situation remains concerning.

Efforts are currently underway to find solutions for importing energy equipment from abroad to Ukraine as quickly as possible. Some countries are willing to work with companies, while others prefer to cooperate solely with the Ukrainian government. International financial organizations have expressed their willingness to assist, but effective mechanisms must be developed to ensure the prompt delivery of financial aid where needed. Recently, the state has implemented preferential import policies for generators and low-power energy storage to enable individuals and businesses to establish their own energy supply.

Military actions in Ukraine have a significant impact on the European energy system. Ukraine is an important transit country for Russian gas, with a number of pipelines passing through

its territory to deliver gas to Europe. The conflict in Ukraine has disrupted gas supplies to some EU countries, leading to concerns about energy shortages and price increases.

The EU has been working to reduce its reliance on Russian gas in recent years, in part due to concerns about the political implications of its energy dependence. The EU's long-term energy strategy, outlined in its Energy Union package, includes a focus on diversifying energy sources and building a more integrated and resilient energy system.

In practice, this has involved increasing imports of liquefied natural gas (LNG) from other countries as well as investing in new pipelines and interconnectors to transport gas from other regions, such as the Caspian and the Mediterranean. For example, the Southern Gas Corridor, a series of pipelines connecting Azerbaijan to Europe via Turkey, is a key project for the EU's energy diversification efforts.

The EU has also sought to enhance its energy security and resilience through measures such as increasing gas-storage capacity, improving energy efficiency, and promoting the development of renewable energy sources.

Despite these efforts, the conflict in Ukraine has highlighted the challenges of achieving a truly diverse and resilient energy system. Existing pipelines and infrastructure are vulnerable to physical damage, as well as cyberattacks and other security threats. In addition, some EU member states remain heavily reliant on Russian gas, which limits the effectiveness of the EU's diversification efforts.

The problems of Ukrainian energy security with Russian invasion include: the destruction of traditional energy facilities; limited possibilities of using solar and wind energy in the occupied territories; problems with the production of first-generation biofuels due to a possible shortage of raw materials that will be used for food purposes to ensure food security in the world. Most of the renewable energy facilities currently installed in the country are concentrated in the southern and southeastern regions of Ukraine, where active hostilities have been ongoing for a year. According to the Ukrainian Wind Energy Association, since the beginning of the large-scale war in Ukraine, more than three quarters of wind energy capacities have been stopped, i.e. out of a total of 1,673 MW, about 1,462 MW of Ukrainian wind turbines are currently not working, and five wind turbines in the Kherson region, installed on Myrmenskaya, Sivaska and Novotroitska wind power stations, have been destroyed. Overall, wind and solar power generation has more than halved from its pre-war level.

In the case of Ukraine, restrictions on the production of first-generation biofuels could be caused by a shortage of raw materials such as corn and wheat, which are used to produce ethanol and biodiesel, respectively. This shortage could occur if farmers are unable to plant and harvest their crops due to the conflict, or if transportation routes are blocked, preventing the transportation of raw materials to processing plants.

To address this problem, Ukraine could explore alternative sources of raw materials for biofuel production, such as non-food crops or agricultural waste. In addition, the country could invest in more efficient biofuel production processes to reduce the amount of raw materials needed.

Another possible solution would be to diversify the country's energy sources and reduce reliance on biofuels. This could involve expanding the use of renewable energy sources such as

wind and solar sources as well as investing in more traditional energy sources such as natural gas or coal.

Ultimately, the key to ensuring energy security in the face of military conflict is to have a flexible and adaptable energy policy that can respond to changing circumstances and disruptions. By prioritizing energy security and investing in a variety of energy sources, Ukraine can reduce its vulnerability to supply disruptions and ensure a reliable and secure energy supply.

After analyzing the current situation in Ukraine, recommendations have been developed that help preserve the potential of Ukraine in meeting the food needs and energy security of Ukraine and countries importing agricultural products (Fig. 8).

Conclusions

Sowing and harvesting in Ukraine in 2022–2023 raises remarkable concerns regarding sufficient fuel, seeding materials, fertilizers, plant-protection products etc. A significant issue may arise concerning grain crops (wheat, barley, corn), soybeans and sunflower, as Ukraine has been one of the leading exporting countries for these commodities. The best situation is with wheat crops, more than 70% of which is winter. At the same time, winter crops still need additional feeding and the introduction of crop protection agents.

The invasion of the Russian Federation into Ukraine may lead to humanitarian food crises in a number of countries of the world. FAO reports show that the food price index went up by a record of 12.6% from February to March, which is to a great extent as a result of Russia's war against Ukraine. Therefore, the war of Russia against Ukraine is a war against all countries importing food products from Ukraine.

In the face of Russian hostilities, strengthening the energy and food security of Ukraine requires the prioritizing of several key tasks. The first priority is to establish safe logistics to ensure the secure transportation of goods and resources. The second priority is to enable farmers to continue working by providing them with the necessary resources and support. The third priority is to ensure that workers remain employed, earn a reliable income, and pay taxes to contribute to the country's economic stability.

To guarantee the energy and food security of Ukraine and other countries that import its agricultural crops, the Ukrainian government must establish new rules for the export of agricultural goods. Additionally, diversifying the energy sector of Ukraine is crucial for long-term energy security. By implementing these measures, Ukraine can enhance its resilience and independence in the face of ongoing geopolitical challenges.

As a result of the study, a number of recommendations for preserving the potential in meeting the energy and food needs in Ukraine and countries importing agricultural products from Ukraine have been suggested. The recommendations include growing crops with the maximum specific value so that in case of problems with the export of agricultural products, they receive

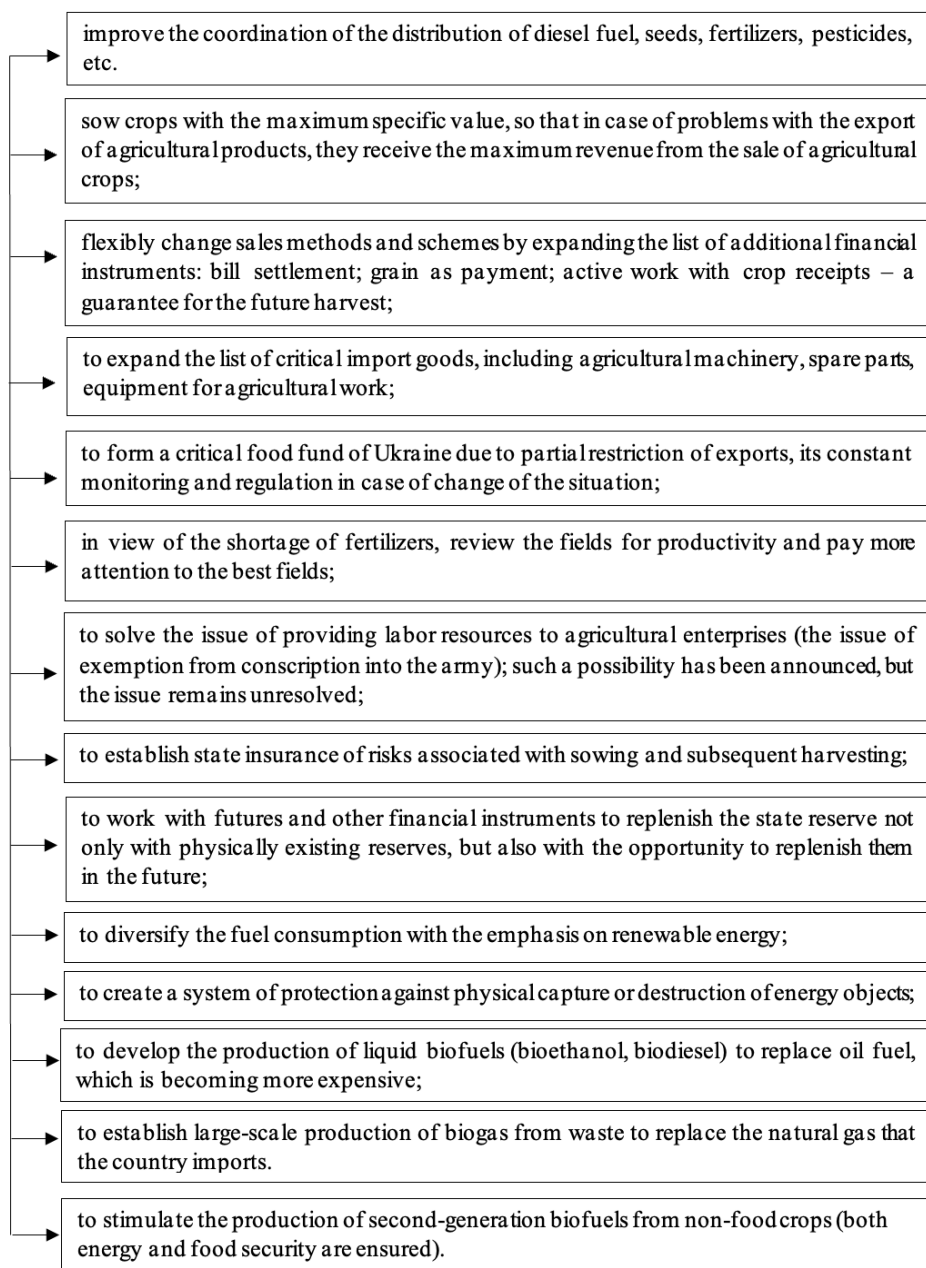


Fig. 8. Recommendations for preserving the potential of Ukraine in meeting the food needs and energy security of Ukraine and countries importing agricultural products

Source: composed by the authors

Rys. 8. Zalecenia dotyczące zachowania potencjału Ukrainy w zaspokajaniu potrzeb żywnościowych i bezpieczeństwa energetycznego Ukrainy oraz krajów importujących produkty rolne

the maximum revenue from the sale of agricultural crops; forming a critical food fund of Ukraine due to the partial restriction of exports, its constant monitoring and regulation in the case of change of the situation; increasing the production and use of alternative energy; expanding the import of critical goods, including agricultural machinery, spare parts, equipment for agricultural work, equipment for alternative energy generation; establishing state insurance against the risks associated with sowing and subsequent harvesting; diversifying fuel consumption with an emphasis on renewable energy.

Overall, the conflict in Ukraine has underlined the importance of energy security as a key component of Europe's geopolitical strategy. The EU will need to continue investing in diversification and resilience measures, while also working to build stronger relationships with key energy suppliers and transit countries, in order to reduce its dependence on Russian gas and ensure a stable and secure energy supply for the future.

MAPFU: Ministry of Agrarian Policy and Food of Ukraine; WFS: World Food Summit; FAO: Food and Agriculture Organization of the United Nations; SDGs: Sustainable Development Goals; HRW: Human Rights Watch; MEU: Ministry of Economy of Ukraine; USDA: U.S. Department of Agriculture; UNSC: United Nations Security Council; SCSU: State Customs Service of Ukraine; MFS: Minfin statistics; FAS USDA: Foreign Agricultural Service of U.S. Department of Agriculture; OEC: Observatory of Economic Complexity; UNCG: Ukrainian Nature Conservation Group.

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Kampania siewu i zbioru na Ukrainie w kontekście działań wojennych: wyzwania dla globalnego bezpieczeństwa energetycznego i żywnościowego

Streszczenie

W artykule przeanalizowano specyfikę kampanii siewnej i żniwnej 2022–2023 na Ukrainie oraz jej wpływ na światowy rynek energii i żywności w warunkach pełnej inwazji Federacji Rosyjskiej na Ukrainę. Celem opracowania jest określenie roli Ukrainy w zapewnieniu bezpieczeństwa energetycznego i światowego bezpieczeństwa żywnościowego, analiza sytuacji w zakresie możliwości prowadzenia akcji siewnej i żniwnej na Ukrainie w warunkach działań wojennych oraz przedstawienie zaleceń dotyczących zachowania potencjału Ukrainy w zaspokajaniu potrzeb energetycznych i żywnościowych Ukrainy i innych krajów. Dostarczona analiza danych Organizacji ds. Wyżywienia i Rolnictwa (FAO), Państwowej Służby Celnej oraz Państwowej Służby Statystyki Ukrainy potwierdziła rolę Ukrainy w zapewnieniu bezpieczeństwa energetycznego i żywnościowego wielu krajów Bliskiego Wschodu i Afryki Północnej, które są głównymi importerami produktów rolnych z Ukrainy. Stwierdzono, że kampania siewno-zbiorowa 2022–2023 na Ukrainie napotyka szereg problemów, w tym: działania wojenne na dużym obszarze, co uniemożliwia terminowe prowadzenie działań agrotechnicznych; brak materiału siewnego z powodu jego systematycznego niszczenia przez wojsko rosyjskie; problemy z zaopatrzeniem w paliwa i smary (systematyczne ostrzały i niszczenie baz naftowych na terenie całej Ukrainy); problemy z zaopatrzeniem w nawozy; bombardowanie pól pszenicy i magazynów żywności; blokowanie ukraińskich portów morskich; mobilizacja znacznej części ludności w szeregach Sił Zbrojnych Ukrainy; problemy logistyczne. W opracowaniu zaproponowano zalecenia dotyczące zachowania potencjału zaspokojenia potrzeb energetycznych i żywnościowych Ukrainy oraz krajów importujących produkty rolne z Ukrainy.

SŁOWA KLUCZOWE: rolnictwo, produkcja biopaliw, bezpieczeństwo żywnościowe, bezpieczeństwo energetyczne, energia alternatywna

