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ASSESSMENT OF THE GLOBAL FOOD SECURITY IMPLICATIONS OF THE KAKHOVKA DAM COLLAPSE

Evaluación de las consecuencias para la seguridad alimentaria mundial por el derrumbe de la represa de Kajovka

Avaliação das consequências para a segurança alimentária mundial pelo derrube da barragem de Kajovka

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RESUMEN

Como resultado de la guerra ruso-ucraniana, el 6 de junio de 2023 un ataque armado ruso destruyó parcialmente la represa Nova Kakhovka en la región de Kherson, en el sur de Ucrania, lo que supuso un duro golpe para la seguridad alimentaria mundial. La relevancia de esta crisis está determinada por graves perturbaciones en la agricultura, pérdidas de cosechas y amenazas a la seguridad alimentaria de numerosos grupos de población. La investigación tiene como objetivo establecer el vínculo entre la pérdida de tierras agrícolas en Ucrania y el impacto en la seguridad alimentaria mundial. Se utilizaron métodos de análisis de diversos datos, análisis de regresión del índice mundial de precios de alimentos de la Organización de las Naciones Unidas para la Alimentación y la Agricultura, métodos estadísticos y análisis de sensibilidad. Los principales resultados fueron indicadores directos de la dependencia y el impacto de la destrucción de la represa de Kakhovka. Esto se puso de relieve por los cambios dramáticos en el mercado de la Unión Europea para insumos importados como energía, alimentos para animales, aditivos alimentarios y fertilizantes. El ataque fue seguido por un fuerte aumento de los precios de los alimentos, que redujo la seguridad alimentaria mundial. Las implicaciones prácticas de este artículo se materializan en los beneficios para diversos actores interesados en la seguridad alimentaria mundial.

PALABRAS CLAVE

Crisis medioambiental, agricultura, regiones vulnerables, análisis socioeconómico, índice de precios de los alimentos.

ABSTRACT

As a result of the Russian-Ukrainian war, on June 6 2023s, an armed Russian attack partially destroyed the Nova Kakhovka dam in the Kherson region of southern Ukraine, which was a severe blow to global food security. The relevance of this crisis is determined by serious disruptions in agriculture, crop losses and threats to food security for numerous population groups. The research aims to establish the link between the loss of agricultural land in Ukraine and the impact on global food security. The methods of analysing various data, regression analysis of the global food price index of the Food and Agriculture Organisation of the United Nations, statistical methods, and sensitivity analysis were used. The main results were direct indicators of the dependence and impact of the destruction of the Kakhovka dam. This was highlighted by the dramatic changes in the European Union market for imported inputs such as energy, animal feed, feed additives and fertilisers. The attack was followed by a sharp rise in food prices, which reduced global food security. The practical implications of this article are realised in the benefits to various actors with an interest in global food security.

KEYWORDS

Environmental crisis, agriculture, vulnerable regions, socio-economic analysis, food price index.

RESUMO

Como resultado da guerra russo-ucraniana, o 6 de junho de 2023 um ataque armado russo destruiu parcialmente a barragem Nova Kakhovka na região de Kherson, no sul da Ucrânia, o que implicou um duro golpe para a segurança alimentária mundial. A relevância desta crise está determinada por graves perturbações na agricultura, perdas de colheitas e ameaças à segurança alimentária de numerosos grupos de população. A investigação tem como objetivo estabelecer el vínculo entre a perda de terras agrícolas na Ucrânia e o impacto na segurança alimentária mundial. Utilizaram-se métodos de análise de diversos dados, análise de regresão do índice mundial de preços de alimentos da Organização das Nações Unidas para a Alimentação e a Agricultura, métodos estadísticos e análises de sensibilidade. Os principais resultados foram indicadores diretos da dependência e o impacto da destrução da barragem de Kakhovka. Isso foi relevante pelos câmbios dramáticos no mercado da União Européia para insumos importados como energia, alimentos para animais, aditivos alimentários e fertilizantes. O ataque foi seguido por um forte aumento dos preços dos alimentos, que reduz a segurança alimentária mundial. As implicações práticas deste artigo se materializam nos benefícios para diversos atores interessados na segurança alimentária mundial.Recibido: 20/11/2023

PALAVRAS-CHAVE

Crise medioambiental, agricultura, regiões vulneráveis, análise socioeconômico, índice de preços dos alimentos.

Introduction

The Kakhovka Dam is an important infrastructure for agriculture in Ukraine. It provided water for irrigation of about two million hectares of agricultural land. The lower reaches of the Dnipro River, which were flooded after the dam was destroyed, grew about 6% of the wheat, 2% of the corn and 9% of the barley produced in Ukraine. The decline in food production in Ukraine has led to an increase in food prices on the global market. This will hurt the food security of many countries that depend on food imports from Ukraine (Penkova and Kharenko, 2023). Furthermore, the destruction of the Kakhovka dam, which flooded large areas, resulted in the loss of housing, property, and loss of life. It could also lead to social upheaval in Ukraine. Therefore, studying the implications of the Kakhovka dam failure for global food security is an important task that can help to take measures to mitigate these consequences.

Khilchevskyi (2022) indicate a quick solution to the existing problem involving the construction of a temporary dam near the dam failure site. This would allow for partial restoration of the reservoir's filling. To ensure an environmentally acceptable downstream discharge (520 m^3/s), it is critical to immediately replenish the reservoir to at least 13.1 m. This guarantees water supply for all consumers, although it does not consider the needs of hydropower and navigation. It should be noted that this limitation is not significant, as the power capacity of Zaporizhzhia Heat and Power Plant, Kryvyi Rih Thermal Power Plant (TPP) and Zaporizhzhia Heat and Power Plant exceeds the capacity of Kakhovka Hydroelectric Power Plant by more than ten times. This plan allows to achieve a filling level of 13.1 m and a total volume of 12.3 km^3 in just one year.

The Russian-Ukrainian war as posing serious global and regional challenges to food security. The undermining of the Kakhovka dam has displaced thousands of people and interrupted agricultural production and trade from one of the world's largest export regions. In addition to the direct human suffering and loss of lives and livelihoods in Ukraine, the destruction of the Kakhovka dam is devastating world food markets and threatening global food security (Skydan et al., 2023). This is not surprising, given that the role of the Kherson region in global food markets has been growing in recent years. The Kherson region, which was a net importer of food only thirty years ago, has become one of the main suppliers of grains and oilseeds.

The Kakhovka Reservoir disaster, stemming from a Russian attack, has not only inflicted significant environmental and agricultural consequences but has also brought about a range of social and health challenges that merit discussion. These consequences reverberate through the affected communities and beyond, underscoring the need for a comprehensive response.

One of the foremost social impacts of a natural disaster is the displacement and forced resettlement of the local population. The destruction of the reservoir and its infrastructure has forced thousands of people to flee their homes, resulting in the displacement of communities. This displacement brings about a host of social issues, including the loss of homes, livelihoods, and access to essential services. It places immense strain on already overcrowded refugee camps and can lead to a heightened risk of infectious diseases, mental health issues, and malnutrition among displaced populations. Furthermore, the disrup-

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tion of the water supply, which is essential for drinking, sanitation, and hygiene, has severe health implications. Contaminated water sources and the lack of access to clean water can give rise to waterborne diseases such as cholera and dysentery, posing a grave health risk to the affected population. The shortage of clean water also hinders proper hygiene practices, which are vital for disease prevention. Another concerning aspect is the strain on healthcare systems. The disaster places an overwhelming burden on local healthcare facilities, which may be ill-equipped to handle the influx of injured individuals and those in need of medical attention. The demand for healthcare services surges in the wake of such disasters, potentially overwhelming healthcare providers and leading to a shortage of essential medical supplies.

The Kakhovka Reservoir disaster has far-reaching social and health consequences that extend beyond the immediate environmental and agricultural impact. Displacement, water scarcity, and healthcare strain are among the pressing challenges that demand attention and coordinated efforts to mitigate their effects and support the affected communities.

In the wake of the Kakhovka Reservoir disaster, ensuring global food security has become a pressing concern that demands innovative solutions and a forward-looking perspective. This catastrophe, resulting from a Russian attack, has disrupted agricultural operations, jeopardized water resources, and posed a significant threat to the availability of food supplies not only in the affected region but also globally. One potential solution lies in the diversification of agricultural practices and the adoption of sustainable farming methods. By promoting crop rotation, reducing monoculture farming, and implementing precision agriculture, can enhance resilience in the face of such disasters. Additionally, investing in advanced irrigation systems and water management technologies can optimize water use efficiency and mitigate the impact of reservoir disruptions on agriculture.

Furthermore, international cooperation is essential for addressing global food security challenges. Collaborative efforts among nations can facilitate the sharing of expertise, resources, and technologies. It is crucial to establish emergency response mechanisms at the international level, allowing swift assistance to affected regions and ensuring the continuity of food production. Looking ahead, the disaster should serve as a catalyst for increased research and development in climate-resilient crop varieties and agricultural practices. Harnessing the potential of biotechnology and genetic engineering can lead to crops that are better adapted to extreme weather conditions, ensuring a more reliable food supply in the face of adversity. In summary, the Kakhovka Reservoir disaster has underscored the fragility of global food security. Nevertheless, through the promotion of sustainable agriculture, fostering international collaboration, and investing in innovative solutions, we can chart a path towards a more secure and robust future, where food scarcities stemming from such calamities become less frequent.

Price fluctuations complicate farmers' decision-making processes, as they have to determine more difficulty in determining what to grow and how much to sell. Businesses try to refrain from investing in food and agriculture due to volatile market conditions. In addition, high prices and/or limited availability affect consumer choices. The military conflict and rising prices for food, energy and fertilisers have led to the introduction of policy measures, including export restrictions, which have further aggravated the situation. These dynamics may contribute to further food price increases in an already vulnerable global economy recovering from the Covid-19 pandemic.

There are additional complicating factors through the lens of the timing of the Kakhovka dam collapse. First, the global economy as a whole, and especially many vulnerable countries, have not yet fully recovered from the effects of the Covid-19 pandemic. This means that many import-dependent countries have limited resources to cope with a possible next crisis. Second, even before the devastation, food and fertiliser prices were on the rise. This put pressure on the agricultural and food sector, which was already vulnerable due to the pandemic and other economic difficulties. The combination of these factors is causing severe turbulence in global food and agricultural markets, which could have a significant impact on food security in many countries.

Therefore, the research aims to identify and assess a wide range of possible environmental, economic, and social impacts resulting from the event. This will help to develop effective strategies and recommendations to prevent and reduce the negative impact of this situation on global food security.

Materials and methods

The methodology used to assess the impact of the Kakhovka Dam's destruction on global food security involves a comprehensive approach that examines various sources and methods. To obtain the information base, official data from the Food and Agriculture Organisation (FAO) (2023) and the Food and Agriculture Organisation's Corporate Statistical Database (FAOSTAT, 2025) on agricultural production, land area and other key indicators were used. In particular, statistics on yields, changes in crops and overall food productivity were analysed. Additionally, data from the official reports of the State Statistics Service of Ukraine (2022) on capital investment in agriculture were used. These data made it possible to assess the impact of financial resources on the state of the agricultural sector in the context of the dam's destruction. Economic and macroeconomic principles, as well as laws regulating the functioning of agriculture, were used to assess the consequences of the Kakhovka Dam destruction for global food security. An analysis of the works of scientists from different countries (British, Iranian, Australian, American, and Ukrainian) who have studied the impact of military conflicts on the development of the agricultural sector was carried out.

The review of academic studies, research articles, reports and other scientific sources provided a theoretical basis for further research and assessment of the consequences of the dam's destruction for global food security. An important stage was the analysis of data and research findings by experts with experience in military conflict. This was followed by an analysis of the impact on agriculture, which included consideration of the loss of cultivated area and yields due to potential flooding, as well as the potential for restoration of agricultural land and the timing of this process. In addition, the impact on the food chain was assessed, including an analysis of product losses and possible market shortages, as well as the possibility of compensating for losses with imports. Social impacts were also analysed, including possible economic and social losses for the population, such as job losses and destroyed residential properties.

An important part is the use of the statistical method, which was implemented by collecting and systematising data on the FAO Global Food Price Index (2023) for different periods. This allows to get an idea of the dynamics of price changes and identify general trends and levels of fluctuations. In addition, the impact of food prices on different regions

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and countries is analysed. This aspect identifies which geographical areas are most vulnerable to price fluctuations and which may require special attention and measures to ensure food security. Next, we analyse the impact of price fluctuations in commodities, such as sunflower oil and wheat, on the prices of finished products in different sectors of the economy. This is important for understanding which sectors are likely to be most affected by rising commodity prices. It also analyses the impact of price fluctuations on the ability of the population to provide themselves with food and the resilience of the food system to price changes. This is an important aspect as it affects the availability and stability of food for the population.

The use of these methods allows to obtain a comprehensive assessment of the impact of global price fluctuations on global food security and develop strategies to mitigate the negative consequences.

Results

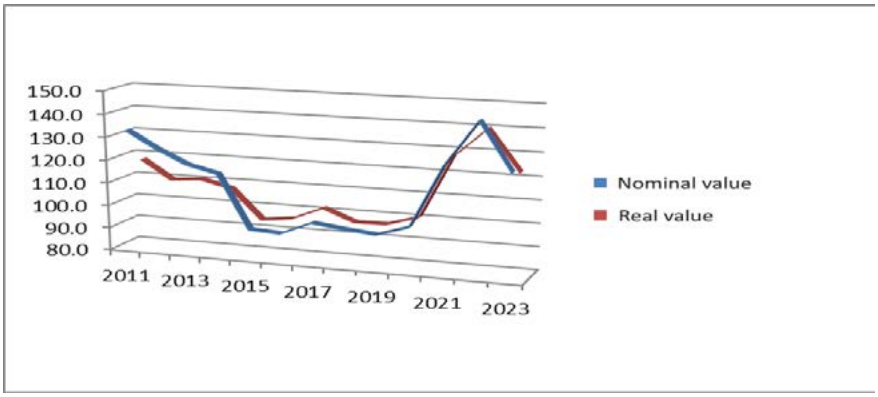
The military confrontation between Russia and Ukraine undoubtedly poses serious threats to global food security, with potentially catastrophic consequences. These assumptions are supported by research analyses and forecasts provided by the United Nations for the FAO. FAO (2023) estimates that the number of people who will be undernourished will increase by 7.7 to 12.9 million people by 2022-2023. This is a statistically supported prediction that carries with it an extremely grave global significance. In May 2022, according to data provided by the United Nations (FAOSTAT, 2025), the number of people experiencing food insecurity rose to 281 million. This sends an extremely worrying signal of the deepening global food crisis. Within Ukraine itself, which is committed to sound food security activities, it faces its challenges. According to the UN World Food Programme (2022), more than 46% of the country's population is concerned about insufficient food availability, reflecting the general state of food insecurity. However, the effects of the conflict are not limited to Ukraine. Other countries, especially those that are dependent on agricultural imports from Russia and Ukraine, are feeling the negative effects of the conflict. Countries in the Middle East, such as Jordan, Israel and Lebanon, as well as several vulnerable African nations that have been affected by disruptions in global agricultural supplies, cannot avoid the negative impact on their food security. A significant number of African and developing countries, having the status of net food importers, also remain vulnerable to fluctuations in the global food market. Shifting imports to other suppliers leads to additional costs for raw materials and logistics, as well as the need to consider important changes in eating habits and production patterns, which are time—and resource—intensive (Trusova et al., 2023).

The military conflict affecting Ukraine has serious implications for global food security that cannot be dismissed. One of these impacts is the increase in prices of domestic products in third countries by around 15-20%, which is the result of high costs of fertilisers, energy and other agricultural inputs (Sahachko et al., 2023). Consumer spending on these essential inputs to agricultural production creates significant hardship for farmers in the least developed countries. The inability to recover the high prices of fertilisers, seeds and pesticides could lead to a decline in food production. Rising prices and shortages of agricultural inputs also hurt the ability to provide humanitarian food aid in fragile countries. Ongoing confrontation with increased demand for these resources may further increase food prices

and make it more difficult to access needed food supplies. In addition, countries that depend on Ukrainian agricultural imports for their food security see the destruction of the hydroelectric power plant and Russia's possible withdrawal from the Black Sea Grain Initiative as a major threat. These factors pose a real risk to food stability and security in these countries.

Since the outbreak of the military conflict, the United States, the world's leading corn producer, has only 67% of this season's crop rated as "excellent" (FAO, 2023). This situation could have a significant impact on global supplies of this strategic product. At the same time, the wheat harvest in China also suffered major losses. This has a potential impact on global wheat markets and food security in certain regions. Winter crop production in Australia is forecast to decline by 29% to 43.8 million tonnes in 2023-2024, which could cause additional problems in the global agricultural market. The FAO Global Food Price Index (2023) is vulnerable to these fluctuations. In February 2022, it reached a record high, averaging 138.6 points, which is 4.2 points higher than the previous peak in February 2011. This indicates a rise in commodity prices that could affect the economies of countries. The situation in the European Union is also tense. In February 2022, food prices increased by 5.6% compared to February 2021 (Figure 1). Sunflower oil and wheat were trading at near-record levels, which could have an impact on consumers and industries that use these raw materials. It is important to keep in mind that despite the possibility of replacing sunflower oil with other vegetable oils, wheat is an essential product for more than 35% of the world's population, so its stability and availability are critical for global food security.

Figure 1. Dynamics of the FAO food price index
Figura 1. Dinámica del índice de precios de los alimentos de la FAO



Source: own elaboration. Fuente: elaboración propia.

The destruction of the Kakhovka dam created a crisis that seriously undermined the environment, the economy, and the livelihoods of the Ukrainian population (Figure 2). The dam's destruction caused serious disruption to irrigation systems in the south of the country. Approximately 550,000 hectares (1.28 million acres) of arable land were left without an adequate source of water for irrigation. This situation has harmed agriculture and crop production, which could lead to significant losses in food production. In different regions of Ukraine, the situation is critical. For example, in the Kherson region, 95% of irrigation systems were left without a water source. In the Zaporizhzhia region, the figure is 69%, and in the Dnipro region – 27%.

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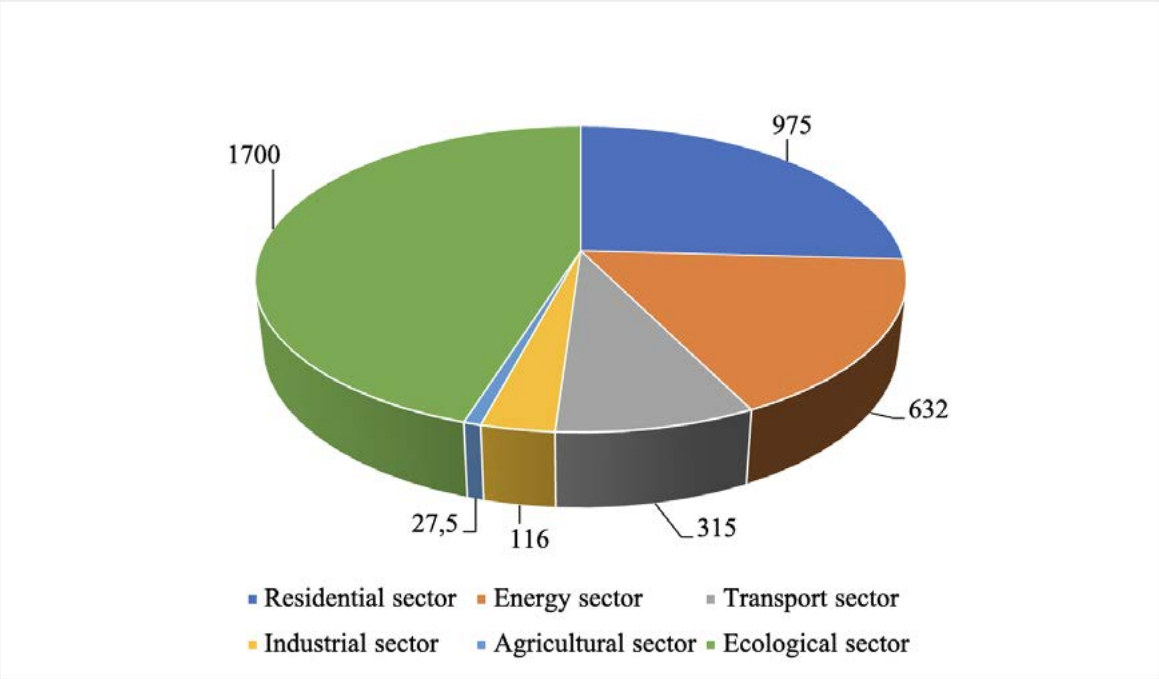
Figure 2. Losses to the Ukrainian economy (in millions of US dollars)
Figura 2. Pérdidas para la economía ucraniana (en millones de dólares estadounidenses)



Source: own elaboration based on United Nations (2023). Fuente: elaboración propia en base a United Nations (2023).

The following conclusions can be drawn from the table of losses to Ukraine's economy after the destruction of the Kakhovka dam. The residential sector suffered significant losses, estimated at USD 975 million. Between 25,000 and 32,000 houses in the Kherson region and more than 650 private houses in Mykolaiv region were flooded. This has put a heavy burden on the population of these regions, and the restoration of the housing stock will require significant financial and labour resources. The destruction of the Kakhovka Hydroelectric Power Plant resulted in losses of USD 632 million in the energy sector. Around USD 1 billion will need to be invested to build a new energy facility, which creates additional challenges for the restoration of the region's energy structure. The total losses in the transport sector are estimated at USD 315 million, with more than 310 kilometres of roads in need of immediate repair. This is an important aspect of the effective rehabilitation and normalisation of the population's life. The industry suffered damage due to the flooding of 31 large industrial facilities located on both the right and left banks of the Dnipro. Total losses in this sector are estimated at USD 116 million. This causes significant restrictions on production and economic development in the region. Agriculture was not spared from the consequences of the natural disaster. The losses in this sector amount to USD 27.5 million, which leads to great difficulties in ensuring food and agricultural production in the region. Much attention should also be paid to the environmental consequences of this disaster. The leakage of 200 tonnes of oil as a result of the dam explosion resulted in a total loss of USD 1.7 billion (United Nations, 2023). This poses a serious threat to the environment and human health.

These catastrophic events have a high potential to affect global food security, with a scientific basis for this problem. In the global agricultural market, Ukraine is primarily a key player in the production of agricultural products, in particular grains and edible oil. As of 2021, it produced a significant share of sunflower meal (45%) and sunflower oil (40%) in the world.

Ukraine also had a significant share in the export of wheat, barley, and corn (7%) (State Statistics Service of Ukraine, 2022). As of 2021, the Kherson region had between 1.2 and 1.5 million hectares of land. However, as of the first half of 2023, this area has sharply decreased to 365 thousand hectares (Malik et al., 2023). In 2021, the Kherson region also stood out for its leadership role in the development of irrigation systems. Although the area of the Kherson region is only 3% of the total agricultural area of Ukraine, it was an important locus for generating more than 5% of the country's gross agricultural production. However, after the destruction of the Kakhovka dam, grain production in the Kherson region decreased by almost 70%, as shown in Table 1. Such a huge loss in the agricultural sector has a potentially serious impact on the quality and quantity of food produced in Ukraine, as well as its ability to supply the world market.

Table 1. Grain production in the Kherson region in 2021 and the first half of 2023 (in million tonnes)

Tabla 1. Producción de cereales en la región de Kherson en 2021 y el primer semestre de 2023 (en millones de toneladas)

Grain	Year 2021	First half of 2023
Wheat	1.9	0.57
Barley	1.2	0.39
Corn	0.73	0.14
Buckwheat	0.33	0.099
Oats	1.1	0.33
Rapeseed	0.22	0.067
Soy	0.114	0.0342
Sunflower	0.44	0.12

Source: own elaboration based on World Bank (2023). Fuente: elaboración propia en base a World Bank (2023).

Analysing the production of grain crops in the Kherson region in 2021 and 2023, it can be noted that the total production of grain crops in the region in 2023 decreased significantly compared to 2021. All types of grain crops show a significant decline in production. Wheat production decreased by more than three times, corn production decreased by more than 5 times, and soybean production decreased by more than three times. Among the types of grain crops, wheat and corn have the largest production in the region in both years. However, even these crops experienced a significant decrease in production. Buckwheat, rapeseed, soybeans, and sunflower also show a significant decline in production. In particular, soybeans and sunflowers lost more than 90% of their production compared to 2021. The decline in grain production in the Kherson region is so severe that it could significantly affect Ukraine's food security and its ability to supply the global market. Losses in the agricultural sector are estimated at 70%, which is very high. All these factors point to the need to take urgent measures to restore the agricultural sector in the Kherson region and ensure Ukraine's food security (Trusova et al., 2023).

The crisis following the collapse of the Kakhovka dam has rightly highlighted the European Union's dependence on several key imported inputs, including energy, animal feed and feed additives, and agricultural fertilisers. As of 2023, while the European Union's food supply is not at risk, the affordability of food for low-income households may be at risk. Furthermore, the European Union's strategic dependence on several key inputs could affect European

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Union agricultural production (FAOSTAT, 2025). The bloc is self-sufficient in key agricultural products such as wheat and barley (of which the European Union is a net exporter), as well as corn and sugar. Except for these products, the European Union is self-sufficient in several animal products: dairy and meat products, fruits, and vegetables. However, the European Union is a significant net importer of certain products that may be difficult to replace in the short term, such as sunflower oil and seafood.

The events surrounding the destruction of the Kakhovka dam also have a profound geopolitical and economic impact on various regions of the world, especially Africa and Asia, where agricultural imports are essential for food security. According to the United Nations (2023), 37 countries depend on Russia and Ukraine for more than 55% of their wheat imports. These countries include the poorest and most vulnerable regions, such as Somalia, Syria, and Lebanon. During 2019-2021, Africa imported USD 4.1 billion worth of wheat from Ukraine, accounting for 34% of the continent's total wheat imports. The news of the dam's destruction triggered a global rise in wheat and corn prices, with grain prices increasing by an average of 4% on the international market (United Nations, 2023). These price increases have deepened concerns about food insecurity. It is also important to note that Moscow's withdrawal from the Black Sea Grain Initiative is increasing instability in the global grain market and has a detrimental impact on food security. These developments underscore the importance of diverse food supplies and the need to consider alternative ways to ensure global food security.

Discussions

Kitowski et al. (2023) point the interconnectedness of social, economic and political aspects with freshwater poses risks to communities around the world. These risks cover a wide range of issues, from diseases associated with inadequate access to clean water to agricultural crises, environmental destruction, and even water-related conflicts. At the same time, the factors that lead to such violence seem to be deepening. More research is needed to thoroughly assess the role of the key factors underlying water-related conflicts. These factors include population and economic growth, which puts greater pressure on water resources; an increase in extreme hydrological events due to climate change, such as droughts and floods; governance problems and corruption in water supply systems; and deepening infrastructural challenges to water supply in the context of conflicts that have their origins in causes other than water. This indicates a deteriorating demographic situation in the Kakhovka Dam area, which consequently reduces the ability to maintain global food security.

Harada et al. (2022) note that dam removal can have both positive and negative impacts on the agricultural sector. Globally, about half of the single-use dams were built to provide water for irrigation, and these structures supply water to more than 1 million square kilometres of rural areas. The dependence on dams for irrigation systems is primarily driven by climatic conditions. In temperate zones, agriculture can function without a water management system, while in arid or semi-arid zones, agriculture without irrigation may not be possible. Thus, the impact of dam removal on agricultural production will primarily depend on the climatic conditions of the region and the availability of water resources. For emerging economies, irrigation and hydropower facilities play a critical role in poverty alleviation, which is relevant for Ukraine.

Abay et al. (2023), assessing the situation in Ukraine, noted that this terrorist attack has serious consequences for irrigation in the region, as there is no longer enough water. Experts point out that most of the irrigation infrastructure of the Southern Land Reclamation System was connected to the Kakhovka Reservoir, and due to the height differences, it was possible to use water for the irrigation of crops. After the Russian attack, it will now be necessary to either relocate these irrigation lines to other reservoirs or use pumps to create the necessary pressure in the existing systems. However, this is a process that will require significant costs, time, and effort, especially in the frontline area. Laborde Debucquet and Mamun (2022) also note the catastrophic consequences of the terrorist attack on the fishing business. Companies that had purchased fishing quotas in the Kakhovka Reservoir through online auctions are now unable to exercise their rights. In this case, it is important that the state develops a compensation programme for entrepreneurs who have lost the value of these lots or grants them the right to catch equivalent amounts of bioresources in other reservoirs. The study cited above is consistent with the work of our American colleague and confirms the data he obtained.

Another problem is the fact that large dams often become the largest sources of energy in many poor countries, which can lead to an unbalanced and climate-damaging energy supply. While it is known that countries typically grow richer when they develop modern energy, dependence on hydropower in many cases has the opposite effect (Navrotskyi et al., 2023). Of the 40 richest countries in the world, only one is 90% or more dependent on hydropower, while among the 40 poorest countries, this figure is 15. In recent years, many of the hydropower-dependent countries have witnessed power outages and consumption restrictions caused by drought. Ensuring energy security requires these countries to diversify their sources of electricity production, rather than increasing their dependence on hydropower. Changes in precipitation caused by climate change make this issue particularly critical. This is reflected in the heavy reliance of many poor countries on Ukraine's exports, as also noted in the above study.

One of the dam failures that had a significant impact on global food security was the Banh Dam disaster that occurred in China in 1975, studied by Holt (2023). The accident killed more than 170,000 people and left about 11 million people homeless. In addition, the accident resulted in the flooding of large areas of agricultural land, which led to a reduction in food production. The Banh Dam accident caused significant damage to agricultural production in Guangdong Province. Around 1.3 million hectares of farmland were flooded, leading to a 20% reduction in food production. This led to higher food prices in China and other countries that depend on food imports from China. The Banh Dam disaster is a reminder that dams are important infrastructure assets that require proper maintenance and repair. Failure to comply with these requirements can lead to catastrophic consequences, including loss of life and reduced food production. Despite the different causes, similar consequences can be traced to the Kakhovka hydroelectric power station attack, which confirms the importance of dams for domestic and foreign policy.

A more recent situation was studied by Dezhdar et al. (2023), where in 2011 a tragic event occurred in Japan—the Tatsugata Dam disaster, which had a significant impact on global food security. During the earthquake and tsunami, this dam, built in the 1950s to provide water supply and flood protection, failed to withstand the water pressure and collapsed. This accident also led to serious losses in agriculture in the Hokkaido region. More than 10,000 hectares of farmland were flooded, leading to a 10% reduction in food produc-

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tion. This, in turn, led to higher food prices both in Japan and in other countries that were dependent on food imports from Japan. This is consistent with the work cited above and Holt's (2023) work, so the role of dams in the economy is consistent even after years and is not dependent on the geography of the country.

Baggio and D'Agostino (2022) noted that the post-Soviet area in Central Asia is the site of many long-standing conflicts over water resources involving former Soviet Union republics that are now independent states, such as Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan. A common aspect of all water conflicts in Central Asia is that the economies of these countries are heavily dependent on irrigated agriculture, and all face water shortages due to the high ratio of total freshwater withdrawals to total renewable water resources. This, in turn, is often accompanied by ethnic conflicts. Ukraine is also heavily dependent on the agricultural sector for its economy, but the impact of terrorist attacks on water storage facilities is much more reflected in the global food economy than in Central Asia.

According to Gleick and Shimabuku (2023), the Mukra Dam disaster that occurred in India in 2021 had a significant impact on global food security. The Mukra Dam was located in the Mukra Valley, in the state of Gujarat, in western India. It was built in the 1950s to provide water supply and flood protection. In 2021, during heavy rains, the dam could not withstand the water pressure and burst. The accident killed 33 people and left about 20,000 people homeless. In addition, the accident resulted in the flooding of large areas of agricultural land, which led to a reduction in food production. Around 15,000 hectares of agricultural land were flooded, leading to a 10.5% reduction in food production. This led to higher food prices in India and other countries that depend on food imports from India. Ukraine has suffered even greater costs, as indicated in the study cited above, and the implications for global food security are therefore much more serious.

Thus, the reviewed studies and their comparison with the current research show clear limits to the impact of terrorist attacks on hydroelectric power plants on the domestic economy and global food security. Most of the information is supported by related studies, which indicates its objectivity and relevance.

Conclusions

The war between Russia and Ukraine is significantly worsening the food situation in the region and affecting global food security. FAO estimates suggest that the number of people facing malnutrition could increase by millions, creating a potentially catastrophic situation. In February 2023, the FAO Global Food Price Index reached a record high, averaging 138.6 points, which is 4.2 points higher than the previous peak in February 2011. This indicates a rise in commodity prices and may affect the economies of countries. The conflict leads to an increase in food prices in third countries, which can reach 15-20%. Such increases extend the unaffordability of food for low-income households and pose a serious economic challenge to these countries. The effects of the military conflict and the decline in agricultural production may worsen the availability of food for low-income households, especially in the European Union, threatening food security and the lives of the most vulnerable.

The destruction of the Kakhovka dam has caused significant losses in Ukraine amounting to USD 1.7 billion, covering the residential (975 million), energy (632 million), transport (315 million), industrial (116 million) and agricultural (27.5 million) sectors. These losses have a se-

rious impact on the region's environment. The decrease in the cultivated area in the Kherson region from 1.2-1.5 million hectares to 365,000 hectares is an alarming indicator and points to serious difficulties in agriculture. The production of wheat, corn, soybeans, and other grain crops in the Kherson region fell by more than three times in 2023, which poses a threat to food security and economic stability.

The events related to the destruction of the Kakhovka dam have a profound geopolitical and economic impact on various regions of the world, especially Africa and Asia. This includes agricultural imports, which are essential for the food security of these regions. Damage to agriculture and infrastructure in Ukraine could have a significant impact on the global food supply and force other countries to rethink their food security strategies.

Needs to be rebuild the Kakhovka Dam to restore water resources for agriculture, energy, and transportation. This requires international investment and cooperation. Important promote sustainable farming practices and crop diversification in the Kherson region to enhance agricultural productivity and reduce environmental impact. Collaborate with international organizations to provide food aid to Ukraine and affected regions, addressing food insecurity and malnutrition. A comprehensive environmental impact assessment is needed to understand and mitigate the long-term ecological consequences of the dam failure.

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