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The Impact of the War in Ukraine on the Food Security of Low-Income Countries

Wpływ wojny w Ukrainie na bezpieczeństwo żywnościowe krajów o niskich dochodach

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Abstract
The article reveals the expediency of revising the fundamental provisions of the formation of the food security system of low-income countries, since the world food system is significantly vulnerable to crisis-forming factors. The problem of the imbalance of the world's food systems and, consequently, the change in the production model in low-income countries is substantiated. It is proposed to study the impact of the war between Russia and Ukraine on the world's food security, in particular: to outline the main stages of the formation of Ukraine as a guarantor of food security in the world food system; to determine the impact of the war on the production and export of agricultural goods; to analyse the food situation in developing and low-income countries; to model the impact of inflation on the food security in developing and low-income countries; to form scenarios for ensuring Ukraine's food security in the short- and long-term periods. Food inflation rate, Core Consumer Price Index and Consumer Price Index have been selected for the analysis of the inflationary impact.

Key words: food security, low-income countries, developing countries, the impact of the war on the world's food security, the impact of inflation on food security, a food crisis, international relationships, sustainable development

Streszczenie
Artykuł ukazuje celowość rewizji podstawowych przepisów kształtowania systemu bezpieczeństwa żywnościowego krajów o niskich dochodach, ponieważ światowy system żywnościowy jest w znacznym stopniu podatny na

czynniki kryzysotwórcze. Istniejąca nierównowaga światowych systemów żywnościowych, wymusza w konsekwencji zmiany w modelu produkcji w krajach o niskich dochodach. W tej pracy proponuje się zbadanie wpływu wojny rosyjsko-ukraińskiej na światowe bezpieczeństwo żywnościowe, w szczególności: zarysowanie głównych etapów kształtowania się Ukrainy jako gwaranta bezpieczeństwa żywnościowego w światowym systemie żywnościowym; określenie wpływu wojny na produkcję i eksport towarów rolnych; analiza sytuacji żywnościowej w krajach rozwijających się i krajach o niskich dochodach; modelowanie wpływu inflacji na bezpieczeństwo żywnościowe w krajach rozwijających się i o niskich dochodach; tworzenie scenariuszy zapewnienia bezpieczeństwa żywnościowego Ukrainy w krótkim i długim okresie. Do analizy wpływu inflacyjnego wybrano stopę inflacji żywności, Core Consumer Price Index oraz Consumer Price Index.

Słowa kluczowe: bezpieczeństwo żywnościowe, kraje o niskich dochodach, kraje rozwijające się, wpływ wojny na bezpieczeństwo żywnościowe świata, wpływ inflacji na bezpieczeństwo żywnościowe, kryzys żywnościowy, stosunki międzynarodowe, zrównoważony rozwój

1. Introduction

Food security is always the most important aspect of the life of any country, as it relates to the production, distribution and consumption of food. According to the Food and Agricultural Association of the United Nations (FAO, 2021), 67% of the world's population is employed in agriculture. Along with this, it is determined that now around the world about 793 million people, of whom 98% live in low-income countries, are chronically malnourished, and one in four experiences a lack of micronutrients. For example, in 2020, more than half of the population suffering from malnutrition lived in Asia (418 million people – about 9.2% of the population), more than a third lived in Africa (282 million people – almost 21% of the population), and 93 million people – about 12.3% of the population lived in Latin America and the Caribbean. Moreover, children constituted a significant part of them.

Since the problem of malnutrition entails large economic and social costs for society, the special global goal (SDG2), which was adopted at the UN General Assembly in 2015 as part of The 2030 Agenda for sustainable development, became an important step on the way to eliminating hunger. (UN, 2015). The goal is based on a comprehensive approach to solving the problem of food insecurity and malnutrition in order to ensure sustainable development.

At the same time, the processes that make it possible to increase the efficiency of agricultural production simultaneously occur with the processes that, under appropriate conditions, neutralize the mentioned positive effect. For instance, such processes as agricultural producers' adaptation to the changing conditions of growing crops, progress in the field of genetics and agronomy and the growth of intensification go hand in hand with the processes of increasing poverty, the creation of trade barriers, disruption to logistics, etc. Access to food, as before, remains uneven and depends on the level of effective demand of the population, the competitiveness of domestically produced food in terms of quality and price, the efficiency of business entities and the volume of imported food supplies.

Therefore, food security remains a priority area of interstate cooperation, which is based on ensuring the affordability of food prices, the constant availability of healthy and diverse food.

Today the world is experiencing turning points that require a review of fundamental provisions regarding the functioning of countries that directly depend on food imports. In view of the events taking place in Ukraine and in the world, this thesis becomes especially topical, since the global increase in food prices, which shape the food security of the importing countries, outlines the problem of the imbalance in the world food systems.

Among the main problems that arise as a result of the increasing food imbalance, it is appropriate to single out:

- a rapid and too significant increase in prices in the world markets for fuel and fertilizer, which, in turn, leads to inflationary processes. In addition, even a slight rise in prices can have dire consequences for the world community; this can be clearly traced during the COVID-19 pandemic, which revealed the most vulnerable places in the world food system;
- the complication of the living conditions of the population suffering from military aggression: injuries, relocation, loss of family members and property and also hunger, which becomes a real threat to the lives of more than two billion people in the countries where active conflicts are recorded;
- the prolongation of the war between Ukraine and Russia leads to problems with the sale of products. At the same time, blocking the export of products by the Russian aggressors makes it impossible to protect the domestic market of Ukraine from price volatility and reduce the global food deficit;
- the increased dependence of individual countries on the export of food products due to a gradual change in the traditional diet resulting from the transition to the cultivation of more profitable crops. Furthermore, the strengthening of the debt spiral for food imports significantly reduces the investment opportunities of importers, especially against a background of a shortage of funds.

Consequently, in low-income countries, there is a change in the production model, which, mostly, involves the transition to the production of food products (from fuel, fodder – to food products, from export-oriented cash crops

– to goods of local consumption). On the one hand, such a change contributes to the formation of a more sustainable and differentiated food system, but on the other hand, it also has certain restraining factors:

- the lack of transparency and the presence of speculation in food markets, which exacerbates the global food crisis and completely destroys the functionality and logic of trade (comparison of supply and demand). Thus, this situation makes it impossible to protect the poorest sections of the population and creates speculative demand through the use of derivative financial instruments due to an artificial increase in price;
- too low level of adaptation to shock transformations due to the poverty of most producers of food products, a shortage of financial resources and limited access to them, the structure of income and expenses (on average, the population of the poorest countries spends 60% of income on food);
- climate change creates constant vulnerability and uncertainty in global food markets;
- impracticality and ineffectiveness of decisions to overcome the food crisis (improper allocation and use of funds and resources; the suspension of laws aimed at environmental protection and safety, the creation of new control organizations, etc.)

The list of identified problems is not final and is constantly being supplemented by new factors: the COVID-19 pandemic and Russian military aggression against Ukraine, which is the guarantor of food security for many countries of the world, including those with a low-income level. Every country in the world that directly cooperates with Ukraine (Fonitska & Kozlovskyi, 2013) is already predicting the possible negative consequences of the military aggression.

Specialists the European External Action Service (EEAS, 2022) note that for the European Union these events are the third asymmetric shock it has experienced in the last twenty years. Before that there were: the Eurozone crisis, which occurred because of the financial and economic shock of 2008, then the world was overwhelmed by the COVID-19 pandemic.

Therefore, we must investigate and draw certain conclusions regarding the significant vulnerability of the world food system to crisis-forming factors. This requires a detailed study of the current situation and the introduction of appropriate measures to mitigate the likely negative consequences of Russian aggression against Ukraine, as one of the guarantors of global food security.

2. Research materials and methods

The issues of the world's food security have always been and will be topical due to the limited resource base and the growing population. These questions are especially acute in the period of crises of a force majeure nature.

Many scientific works are dedicated to the study of the security of the world food system and they consider various issues: from the socio-economic system to behavioural economics. All of them emphasize the acuteness of the problem and determine the main directions for resolving the food crisis. Magdoff, F., & Tokar B. (2010) clearly prove the failures of market capitalism due to the inability to feed people around the world as the priority has been given to profitability over social concerns. Michael, P. (2010) also argues that the food crisis, which is the result of a long-term crisis of social reproduction, was provoked by neoliberal capitalist development. Gregory et al. (2005) note that the improvements to the systems of production, distribution and economic access to food can contribute to the adaptation of food systems to climate change. However, while making such changes, it is important to ensure the sustainability of the food system**.** Dimitri, C., & Rogus, S. (2014) state that in order to ensure the stable functioning of the food system, it is necessary to consider behavioural factors that influence the choice of food products. Wheeler, T., & von Braun, J. (2013) investigate the effects of climate change on crop productivity, which may have implications for food availability. Their research confirms the need for major investments in creating a *climate-smart food system* that is more resilient to the impact of climate change on food security (Climate Change and Food Security). Ilyash et al. (2022) justify the relationship between innovations, technological development and the volume of the organic products market, which ultimately contributes to strengthening the food and economic security of the state. Lang, T., & Barling, D. (2012) point out that ensuring the sustainability of the food system requires a more coherent policy than the one existing today. Tweeten, L. (1999) defines the need to take into account social and institutional changes, which are the foundation for the implementation of effective practices aimed at ensuring an adequate diet. Hindwan, M. (2018) examines a variety of strategies and innovative approaches to agriculture and land use that aim to achieve global food security in accordance with the principles of sustainable development, environmental security, and public health. Zilberman et al. (2014) argue that the wider introduction of genetically modified food products can contribute to further strengthening of food security and the adaptation to climate change. Along with this, the studies of the war caused by Russia's aggression against Ukraine are gaining particular importance. For instance, Tarek Ben Hassen, Hamid El Bilali (2022) describe the negative influence of a military conflict between two major agricultural powers on global food security, exacerbated by a variety of serious flaws, vulnerability and inefficiency of global food systems. In their work, Shevchuk et al. (2023) state that the actions of crisis factors of a force majeure nature, which arose as a result of the events of 2014-2021 in Ukraine, caused regional differentiation of such a scale that it generally becomes a factor undermining the economic security of the state as a whole, and its food security in particular. I. Kusa (2022) examines the causes

of the food crisis as a result of disputes between Russia and the West. Abay et al. (2022a) studied the impact of the war between Ukraine and Russia on the global wheat market, focusing on Egypt. Abay et al. (2022a), Abay et al. (2022b) also noted the significance of the impact of the Russia-Ukraine military conflict on global and regional food security. Kosar et al. (2022) study the main determinants of the development of demand in the dairy market of Ukraine and determine the forecast value of milk consumption per capita under an optimistic scenario of the development of agriculture under martial law, when the area of occupied territories and those in which hostilities are taking place will not increase during the year. At the same time, these authors note that the situation in the dairy market in modern conditions is difficult, which may threaten the country's food security.

Therefore, the given list of works proves the relevance and necessity of conducting a study of the impact of the war between Russia and Ukraine on the world's food security.

Thus, the main tasks of the study are as follows:

1) to investigate the main stages of the formation of Ukraine as a guarantor of food security in the world food system;
2) to determine the impact of the war in Ukraine on the production and export of agricultural goods;
3) to analyse the food situation in developing countries and low-income countries;
4) to model the impact of inflation on the food security of developing countries and low-income countries;
5) to form scenarios of Ukraine's provision of food security in the short- and long-term periods.

3. Results and discussion

3.1. The main stages of the formation of Ukraine as a guarantor of food security in the world food system.

For an objective view of Ukraine, as one of the guarantors of food security, it is essential to consider the main stages of its formation in the world food system, starting with the moment of its independence, which took place on August 24, 1991. During this period, Ukraine was the leader in the world export of beef, veal, sugar and sunflower (State Statistics Committee of Ukraine, 2022).

However, the specified period was characterized by critical changes in the agricultural industry – the loss of sales markets due to the collapse of the USSR and unfavourable weather conditions in the first years of independence. In the future, the situation was normalized thanks to economic stabilization, favourable climatic and natural conditions and fertility of the soils of Ukraine (Kozlovskyi, 2010). In the 2000s, Ukraine started the transition to a capital-intensive model of the agricultural sector. Technology, high-quality fertilizers, plant protection products, modern technology and equipment take first place. Ukraine began to expand exports actively and occupy leading positions in the world market.

Experts note that the increase in exports was facilitated by a change in the types of manufactured products. In particular, during the years of independence, the production of livestock products decreased by 57%, namely the amount of milk fell by 65%, the volume of meat – by 43%. The production of technical crops decreased by 37%, mainly due to a reduction in the production of sugar beets from 44.3 million tons in 1990 to 9.6 million tons in 2020. The volume of the production of grain and leguminous crops increased by 29%. This result was achieved thanks to a significant rise in the corn harvest: from 4.7 million tons in 1990 to 30.3 million tons in 2020, that is, almost 6.5 times higher.

Among grain crops, the main crops for Ukraine are corn, wheat and barley. Recently, due to growing competition, wheat and barley have become less profitable, which has affected the reduction of their production by 16% and 14%, respectively. As for corn, the opposite trend exists. During the years of independence, its production increased by several times, which gave Ukraine the opportunity to take an honourable place among the world leaders in the export of grain.

In recent years, there has been a rise in global demand for oil crops, due to which they are becoming more profitable, and in Ukraine, the structure of cultivated areas is changing again and the production of such crops is increasing by several times. Sunflower (its production increased by 5 times), soybean (by 30 times) and rapeseed (by 21 times) are considered the main oil crops for Ukraine. A positive point is that most of the sunflower is used for the production of sunflower oil. Ukraine ranks among the leaders in the world in terms of exporting sunflower oil.

For the period of 2021, the agricultural sector of Ukraine was undergoing significant transformations (Kozlovskyi et al., 2018), which were marked by digitalisation (drones, precision agriculture, farm management systems). It is especially worth mentioning the processes of the adaptation of Ukrainian agribusiness representatives to stiff competition and drastic climate changes. Favourable prices and conditions for the import of food products from Ukraine, the volume and quality of products have made Ukraine the guarantor of food security in many countries of the world. Ukraine's contribution to the world food market in 2021 was equivalent to providing food for about 400 million people (State Agency of Water Resources of Ukraine, 2022). In addition, recent events related to the COVID-19 pandemic have particularly highlighted the importance of Ukraine in ensuring food security, as, despite the disruption to global product supply chains; it has continued to fulfil its obligation (NISS, 2022a).

According to the data of the State Land Cadastre (State Service of Ukraine for Geodesy, Cartography and Cadastre, 2022), as of June 29, 2021, Ukraine has approximately 43 million hectares (ha) of agricultural land, including 32 million hectares of arable land known for its high level of fertility. This is equal to a third of the arable land in the EU and about 25% of the world's chernozem soils and gives Ukraine the opportunity to become the world's largest exporter of sunflower oil and one of the largest exporters of grain.

The experts of the Ministry of Agrarian Policy and Food of Ukraine claim (Fig. 1) that more than 30 new markets were opened for the period of 2020-2021. Such countries as Israel, Montenegro, the UAE, Serbia, the KSA, Lebanon, Belgium, Lithuania, Ethiopia, Japan, Argentina, Libya, Kuwait, Slovakia, Jordan, Turkey, Liberia, Georgia, Qatar, Bosnia and Herzegovina have become official consumers of Ukrainian food products. In addition, specialized agencies restored the access of Ukrainian goods to the markets of five CIS countries: Azerbaijan, Uzbekistan, Moldova, Tajikistan and Turkmenistan. The most popular goods during this time were mineral products (8.42 billion dollars), fats and oils of animal and vegetable origin (7.05 billion dollars). The export of ready-made food products in 2021 increased by 13.1% and amounted to 3.8 billion dollars. With regard to traditional export supplies, the experts also noted a positive trend – 36 million tons of wheat, barley, rye and corn, which is 7.8 million tons more than in the previous period.

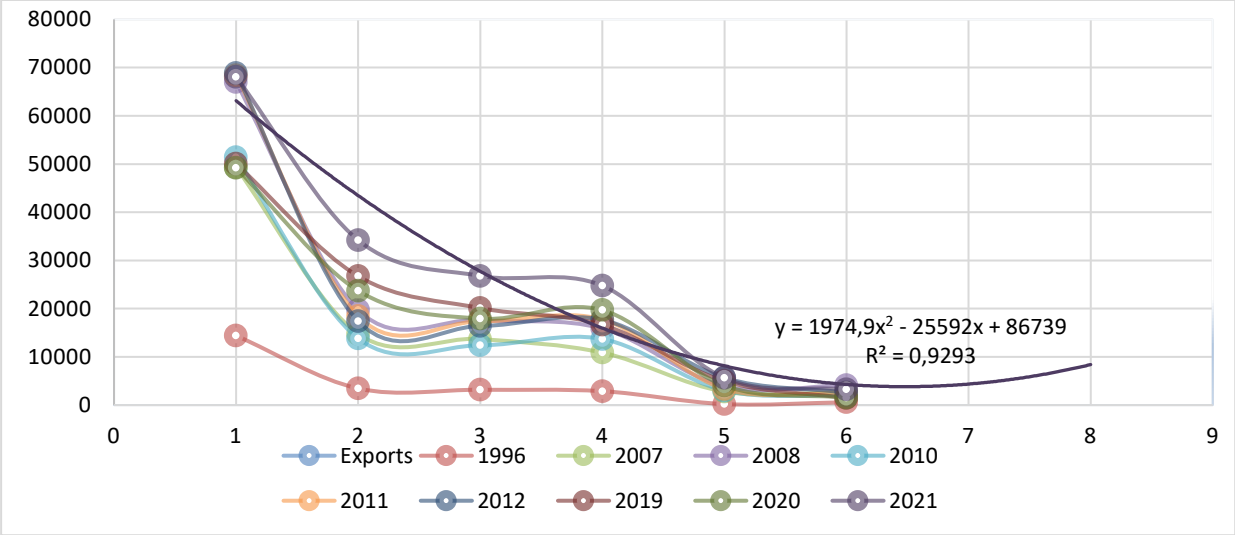

Figure 1. Dynamics of the geographical structure of foreign trade in goods, source: own author`s draft based on data from the Ministry of Agrarian Policy and Food of Ukraine (2022)

Thus, according to ICU (2022), before the start of the military aggression, Ukraine accounted for a significant share of the total world food production, in particular: about 27% of sunflower seeds, 5% of barley, 3% of wheat, 3% of rapeseed seeds, 2% of corn (Fig. 2).

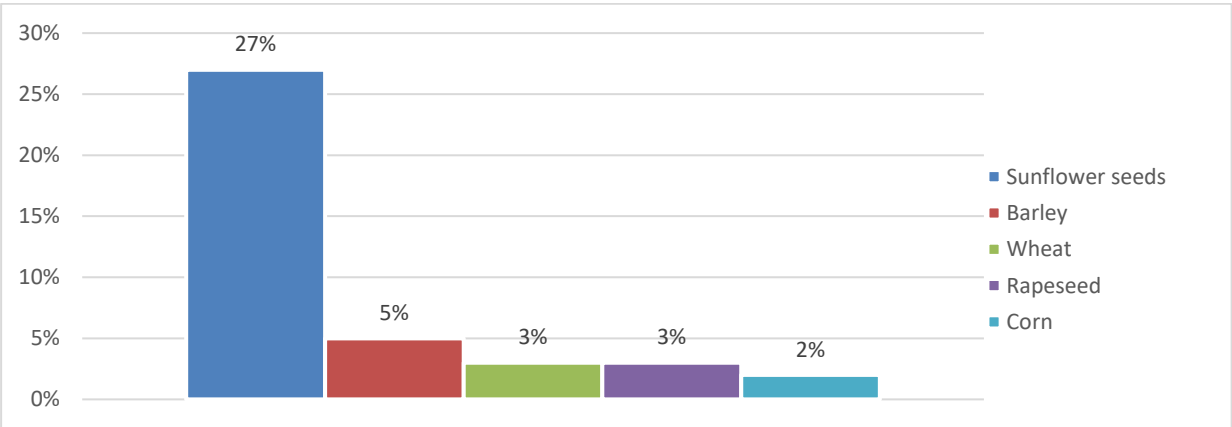

Figure 2. The share of Ukraine in the total world food production at the beginning of 2022, source: own author`s draft based on data from the ICU (2021)

In the structure of agricultural exports of Ukraine in 2021-2022, a significant share belongs to grain crops, the specific weight of which reaches 25.5%, including corn, which accounts for 14.8%.

Ukraine ranks second in the world in terms of barley exports, following Australia; it ranks third in the world in terms of the export of corn and rapeseed, after the USA and Argentina; fifth in the world in terms of wheat exports, after the Russian Federation, the USA, Canada and Australia (ICU, 2021).
The main importers of grain crops of Ukraine in 2021 were China, the EU countries, Egypt, Turkey and Indonesia. According to the results of the year, the share of Ukrainian corn supply in the total volume of China's imports reached 29%, in Egypt's imports – 25%, and in the EU's imports – 51% (Fig. 3). In the wheat segment, Ukraine supplied 25% of Indonesia's imports, 20% of Egypt's imports, and 10% of Turkey's imports (Fig. 4).

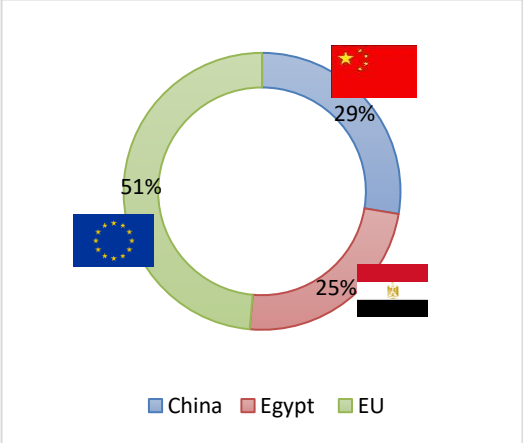

Figure 3. The share of Ukrainian corn imports in the structure of the top importing countries, source: own author`s draft based on data from the ICU (2021)

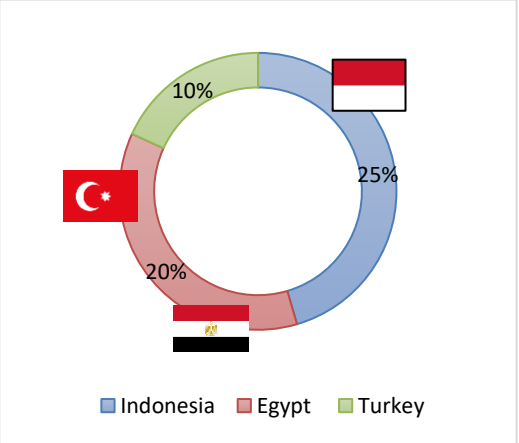

Figure 4. The share of Ukrainian wheat imports in the structure of the top importing countries Source: own author`s draft based on data from the ICU (2021)

At the same time, the country ranks first in the volume of global exports of sunflower oil with a share of 30.6%, which is 17.5 million tons of the global volume. The largest importers of unrefined oil in the 2020/21 marketing year were the EU countries – 30.8% of total exports from Ukraine, India – 27%, China – 18.3%, Iraq – 6.1 (Fig. 5).

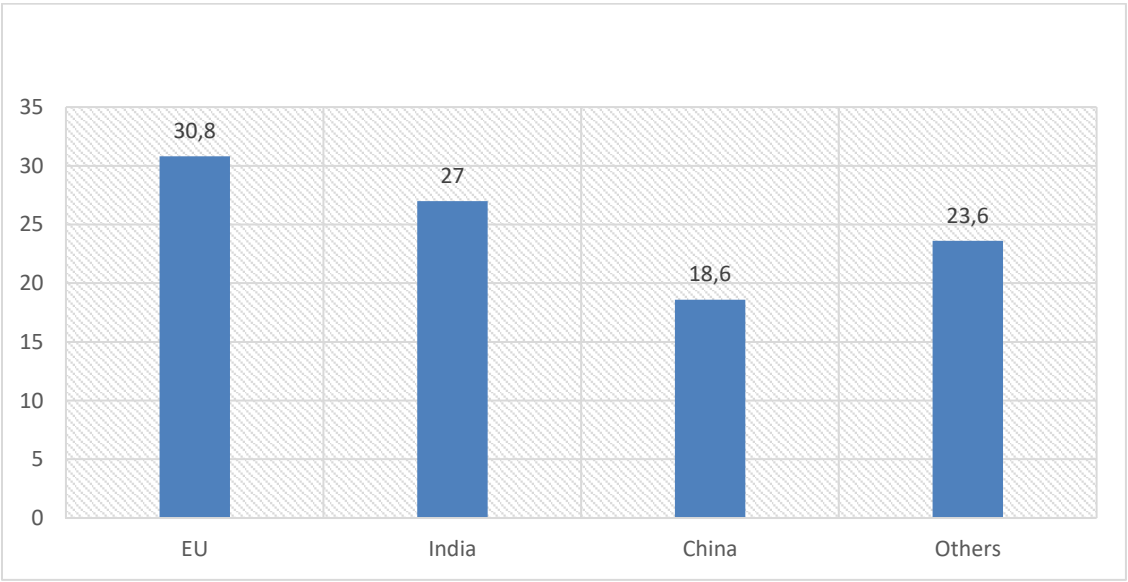

Figure 5. Top countries for the production and export of sunflower oil, 2021, source: own author`s draft based on data from the ICU (2021)

So, as it can been seen, the oil segment has a more important position in the world market. In 2021, the share of Ukrainian oil in the total imports of the top importing countries was 78% of India's import, 88% of the EU's import and 68% of China's import (Fig. 6). Ukrainian sunflower meal is also actively purchased by China and the EU, and Turkey is third in this ranking. The share of Ukrainian products in the total imports of these countries was 88%, 51% and 34%, respectively (Fig. 7).

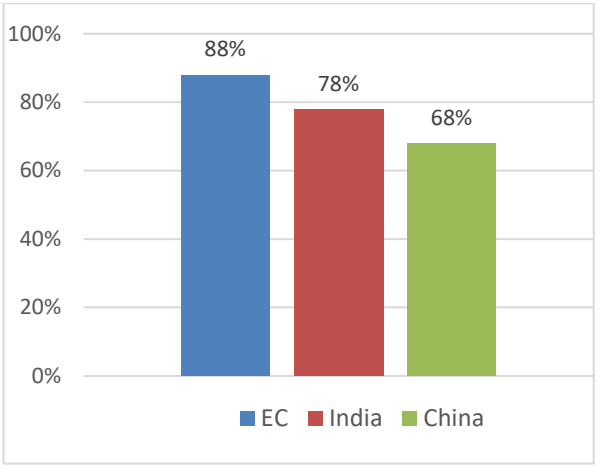

Figure 6. The share of Ukrainian sunflower oil in imports of the top importing countries, source: own author`s draft based on data from the ICU (2021)

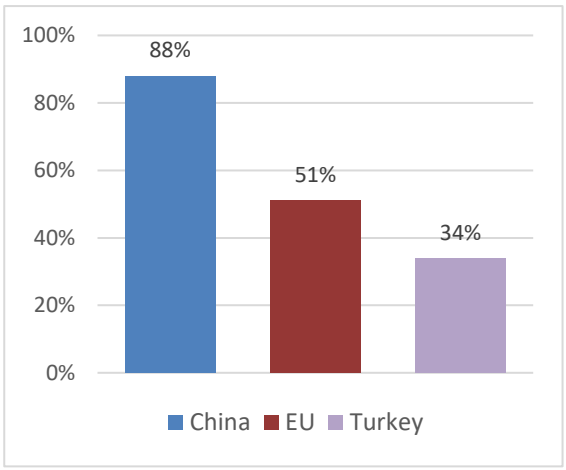

Figure 7. The share of Ukrainian sunflower meal in imports of the top importing countries, source: own author`s draft based on data from the ICU (2021)

Overall, China (10.7 million tons), the EU (10.0 million tons) and Egypt (5.5 million tons) made up the top three importers of these goods from Ukraine in 2021.

3.2. The impact of the war in Ukraine on the production and export of agricultural goods

Despite such a positive trend in the export of food products, the events of 2022 changed the expectations as for ensuring food security in the world. It is very difficult to list all the consequences of the military aggression for Ukraine and the world, but we already have the opportunity to investigate and draw some conclusions.

The World Trade Organization assessed the first half of 2022 and according to the results of the assessment, military actions in Ukraine dealt a serious blow to the world economy, because they led to a huge rise in food prices and a fall in the availability of goods that Ukraine exports (NISS, 2022b).

First, due to the war, Ukraine lost about 20% of its cultivated area (occupied territories or combat zones) in 2022. At the same time, because of the war, it was possible to sow only three quarters of the arable land of Ukraine (Petrunenko et al., 2022). Moreover, farmers faced a fuel shortage, shelling, mining of the territory, and problems with logistics. Therefore, it is already possible to claim there is a decrease in the export component of the agricultural sector of Ukraine.

As a result of Russian aggression, the 2022 sowing campaign was disrupted due to the occupation of the territories of Kherson and Luhansk regions and active hostilities in some parts of Zaporizhzhia, Donetsk, Kharkiv, and Mykolaiv regions. Consequently, 78% of the projected area was sown, which is 13.4 million hectares compared to 16.9 million hectares in peacetime (Fig. 8).

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Figure 8. Planted areas in Ukraine, 2022, source: own author`s draft based on data from the State Statistics Committee of Ukraine (2022)

Hence, sowing of the main spring agricultural crops for the 2022 harvest in the territory controlled by Ukraine amounted to 14,163.4 thousand hectares, which is 2,752.9 thousand hectares less than it was last year (16,916.3 thousand hectares).

According to the results of the 2022 sowing campaign, the biggest change in the structure of crops concerned corn and sunflower. For instance, the area of corn crops in 2022 declined by 40% from 5.4 to 3.2 million hectares. The

area of sunflower crops decreased compared to last year, but not significantly and it was possible to maintain a high figure of 4 million 702 thousand hectares. Meanwhile, the sowing area of spring wheat rose by six percent from 188,000 hectares in 2021 to almost 200,000 hectares in 2022.
The area of spring wheat and soybeans remained at the level of the previous year. There was a reduction in corn crops: this year, 4 million 639 thousand hectares compared to 5 million 500 thousand hectares last year.
Secondly, disruptions to logistics can cause a global food crisis, because many countries of the world that are dependent on Ukrainian exports will not be able to receive it at all or will not receive it in full (Fig.9)

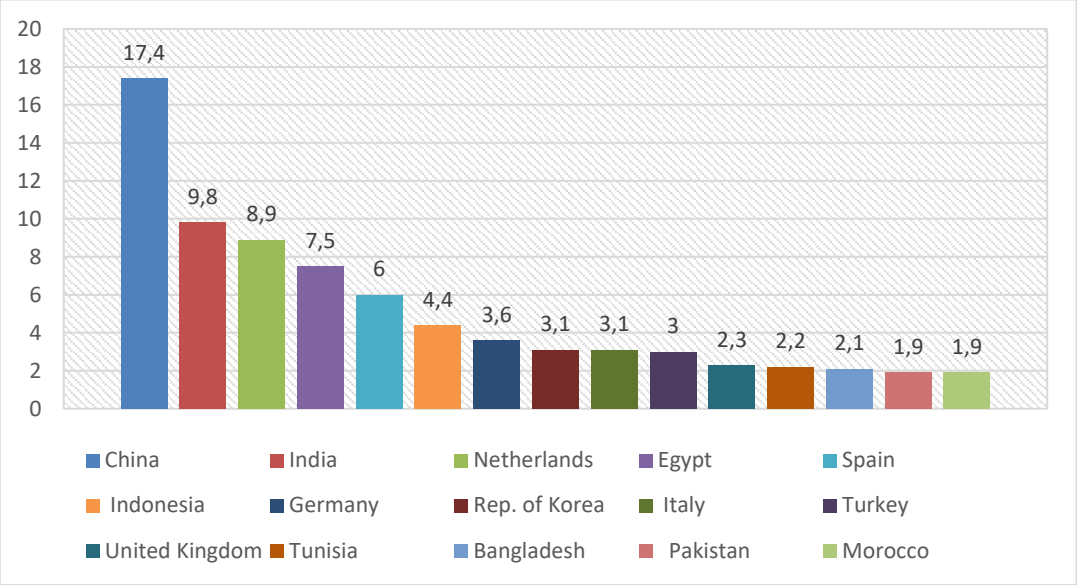


Figure 9. Dependence on agri-food commodities from Ukraine, source: own author`s draft based on data from the Impact on trade and development of the war in Ukraine (2022)

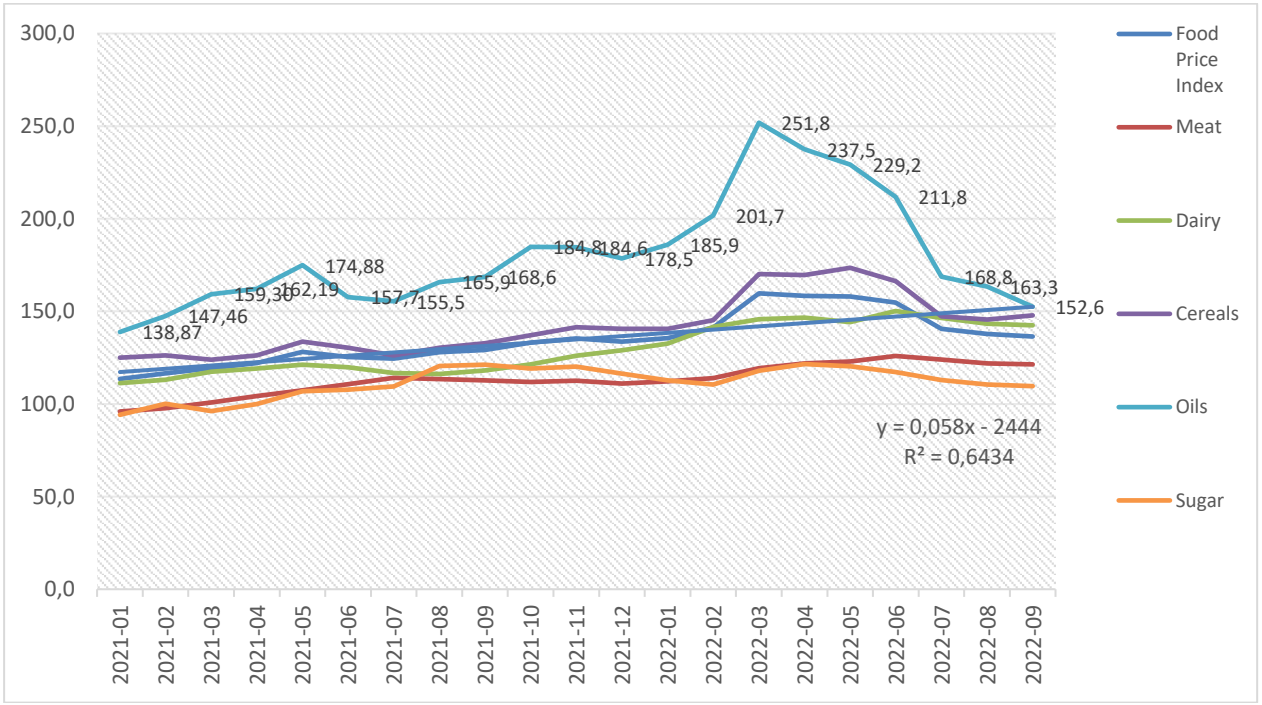


Figure 10. FAO Food Price Index, source: own author`s draft based on data from the FAO (2022)

Thirdly, the increase in world food prices.
According to the data from the Food and Agricultural Organization of the United Nations (FAO, 2022), world food prices have undergone major changes during the period of hostilities. For example, if at the beginning of 2022, the global food index was 135.6 points, then since the invasion of the territory of Ukraine by Russian troops, this indicator has increased significantly. In particular, in March 2022, it reached record values and averaged 159.7 points, which is 24.1 points (17.3%) higher than that in January 2022, and 40.5 points (33.98%) higher than its

level in March 2021, while the cereal price index during the invasion period went up by 22.54% against the same period in 2021, the vegetable oil price index rose by 23.66% (Fig. 10).
During the period of the invasion (from February to September 2022), the price of grain increased by 17.1% against the same period of 2021, the price of vegetable oils rose by 19.5%, which was primarily due to an increase in production costs.
Significant increases in the global food index have been observed for five consecutive months (from February 2022 to June 2022), putting poor households in many developing and low-income countries at even bigger risk.

3.3. The food situation in developing and low-income countries

It should be mentioned that within the framework of the UN World Food Programme, since 2020, Ukraine has become one of the largest providers of assistance to population groups suffering from food shortages. For example, the UN food assistance agency buys more than half of its wheat from Ukraine for more than 80 countries (Okonjo-Iweala, Ngozi, 2022).
At the same time, according to the Cadre Harmonisé report (IPC, 2022) based on the analysis of food instability conducted before the Russian invaders started their attack on Ukraine, the number of people who face acute food shortages and have disruptions to food consumption, which is expressed in a high degree of malnutrition and a limited ability to meet the minimum needs (phase three) are estimated at almost 38.3 million people, which is 41.3% higher than the figure for 2021, when this number was 27.1 million people. In addition, the number of people who are in the fourth phase, when households have major disruptions to food consumption, a very high level of acute malnutrition and increased mortality, was 2.7 million people at the beginning of the year (Table 1).

Table 1. Distribution of the population of African countries by regions in need of urgent humanitarian assistance according to the phase of severity of food insecurity (June-August 2022), source: own author`s draft based on data from Cadre Harmonisé (IPC, 2022)

Country	Population in need of humanitarian assistance in the regions March-May 2022				Population in need of humanitarian assistance in the regions July-August 2022				Change in the number of people in need of humanitarian assistance in %			
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
Benin	8 934 565	2 754 478	1 183 139	42 818	9 766 619	2 318 231	806 329	806 329	109	84	68	1 883
Burkina Faso	14 458 619	4 428 829	2 042 708	323 739	12 468 940	5 331 444	2 825 046	628 464	86	120	138	194
Cape Verde	346 464	106 666	29 421	1 076	299 473	138 062	43 003	3 090	86	129	146	287
Cote d'Ivoire	5 415 303	1 354 894	305 957	0	12 294 031	3 103 718	662 002	0	227	229	216	0
Ghana	4 258 382	905 166	377 680	37 018	4 504 385	794 700	262 348	16 812	106	88	69	45
Guinea	6 624 475	3 549 277	982 982	9 197	6 115 433	3 831 210	1 198 458	20 830	92	108	122	226
Guinea-Bissau	847 615	349 610	131 444	0	1 009 990	245 587	73 092	0	119	70	56	0
Mauritania	2 360 421	1 320 311	636 099	42 444	2 045 401	1 434 953	795 603	83 317	87	109	125	196
Niger	15 302 083	6 296 720	3 113 618	220 720	13 217 392	7 313 342	3 976 601	425 805	86	116	128	193
Nigeria	111 486 331	33 124 641	13 894 715	560 334	98 827 486	40 785 231	18 276 846	1 176 459	89	123	132	210
Sierra Leone	4 356 911	3 019 208	1 212 898	16 829	3 426 662	3 573 464	1 579 319	26 400	79	118	130	157
Senegal	14 106 021	3 083 750	548 280	720	12 913 552	3 943 944	872 421	8 855	92	128	159	1 230
Chad	11 466 246	3 040 129	1 257 856	35 958	9 674 973	4 026 354	1 997 572	101 289	84	132	159	282
Togo	4 375 805	1 143 498	336 548	0	4 321 152	1 145 660	389 040	0	99	100	116	0
Cameroon	17 605 479	6 082 234	2 612 054	253 853	18 450 741	5 689 589	2 228 138	185 150	105	94	85	73
Total amount	221 944 720	70 559 411	28 665 399	1 544 706	209 336 230	83 675 489	35 985 818	3 482 800	94	119	126	225

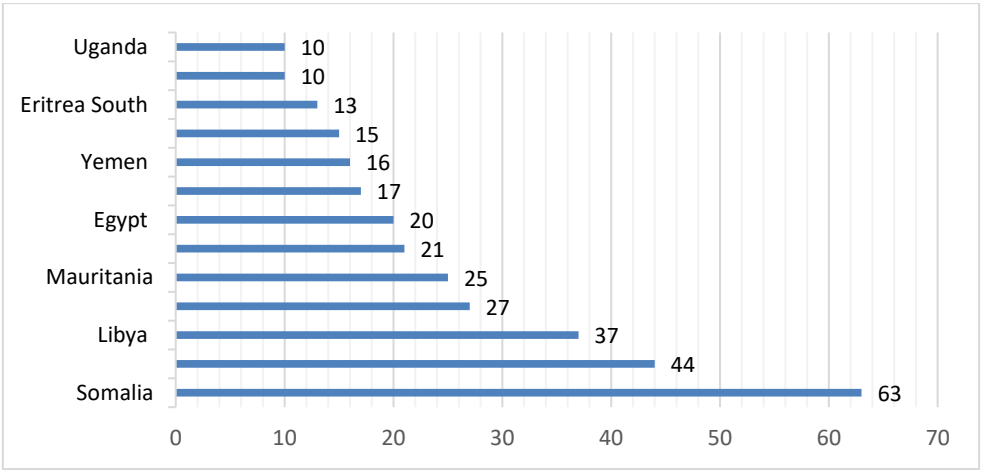


Figure 11. Dependence on wheat imports from Ukraine in African countries and the least developed countries, source: own author`s draft based on data from UNCTAD (2022)

Nigeria (19.45 million), Niger (4.4 million), Burkina Faso (3.45 million), Chad (2.1 million) and Mali (1.84 million) are among the countries that already had the highest level of food security by the beginning of 2022 (Fig.11). However, already in the middle of 2022, the level of access to food in these regions significantly worsened due to a marked increase in the price level, a reduction in the income of the population, the remaining effects of the COVID-19 pandemic and a decrease in the export of grain crops from Ukraine as a consequence of the continuation of Russia's military aggression. Such atypical growth is observed throughout the African region. It is worth noting that price increases have a more negative impact on developing countries such as the Middle East, some Asian countries, and most African countries. Some experts emphasize that a number of countries have the opportunity to shift the focus onto the import of other types of food products or to change the exporting country. However, all this requires appropriate resources and time, which, unfortunately, not everyone has.

According to the Food and Agricultural Organization of the United Nations (FAO), at the beginning of 2022, forty-four countries in the world needed foreign food assistance, thirty-three of those countries were in Africa, nine were in Asia, and two were in Latin America and the Caribbean (FAO, 2022). Already in September of 2022, one more European country joined those countries – Ukraine, where, according to estimates, 17.7 million people, of whom about 6.6 million are internally displaced persons, need urgent humanitarian assistance and protection due to the war (FAO, 2022).

As a result of military conflicts, four countries are among the most vulnerable from the point of view of food security. At the end of 2022, a considerable increase in the number of people on the verge of a humanitarian food crisis is predicted in such countries as South Sudan (7.74 million people, or about 63% of the total population), Sudan (7.7 million people), Somalia (about 6.7 million people, of whom 2.2 million may be in an emergency (phase 4) and at least 300,000 people will face hunger, death, poverty and extremely critical levels of acute malnutrition). In Ethiopia, (3 million people on the verge of a food crisis) due to macroeconomic difficulties, local trade disruptions caused by insecurity and the lack of the volume of humanitarian aid, famine is predicted.

Prices of coarse grains remain at exceptionally high levels in South Sudan, the Sudan and Somalia (FAO, 2022).

3.4. Modelling the impact of inflation on the food security of developing and low-income countries

In order to analyse the change in the capabilities of the population of these countries to meet their needs and purchase goods (consumption), namely food products, we will analyse the dynamics of changes in prices for these products. Where it is possible (available data), we will consider the Food inflation rate, where it is not possible, we are going to study the more general indicators like the Core Consumer Price Index and the Consumer Price Index, which also include changes in the dynamics (Kozlovskyi et al., 2020) of food products.

As for the countries mentioned earlier, the change in the index is dramatic, due to which consumers face significantly higher prices for basic food products.

The data on inflation rates for developing countries and low-income countries are provided on the map, a darker colour corresponds to a higher level of inflation (Figure 12, Table 2).

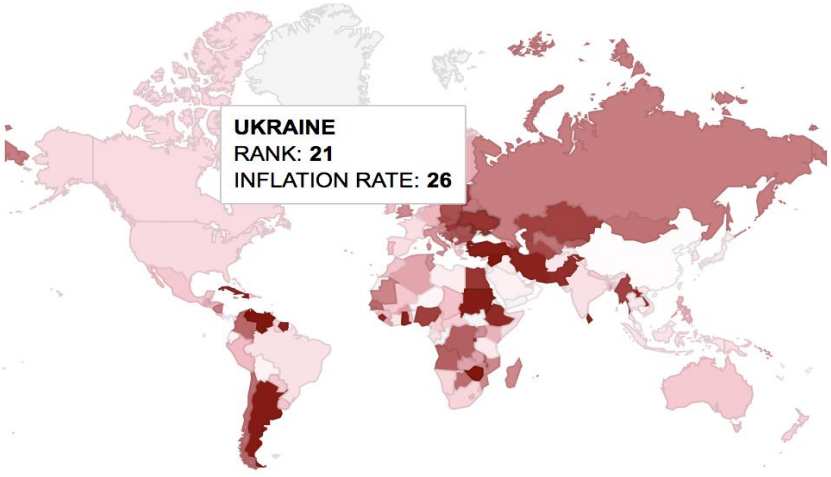
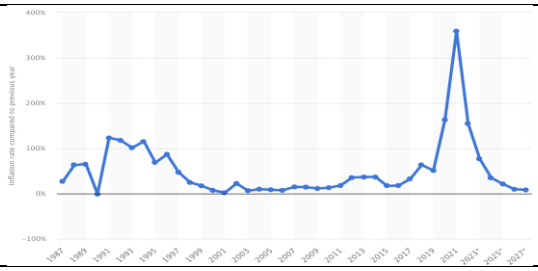
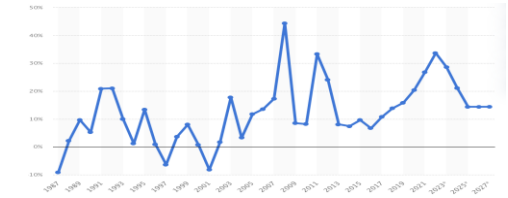
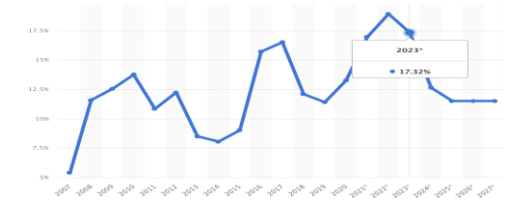
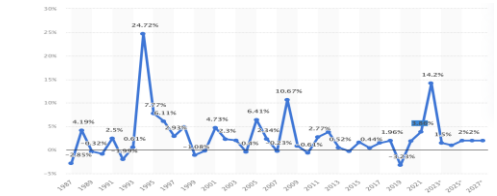
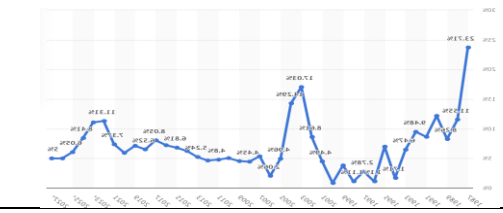
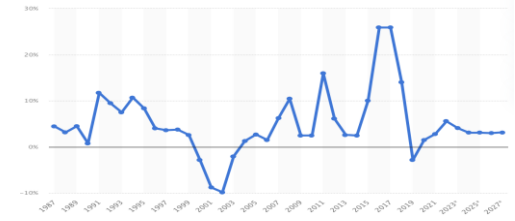


Figure 12. The inflation rate of developing and low-income countries, source: own author`s draft based on data from Trading economics, Inflation Rate (2022)

In the most extreme examples, food inflation rose by hundreds of points. Lebanon, a country heavily dependent on food imports, with much of its wheat exported from Ukraine, has seen its price index go up by more than 3,000 percentage points since 2020.

Table 2. Current inflation rates of developing and low-income countries, source: own author`s draft based on data from Trading economics, Inflation Rate (2022)

Country	Current inflation rate	Prognostic Trend (2007-2027)
Sudan	117,00	
Ethiopia	31,70	
Nigeria	21,09	
Burkina Faso	16,50	
Gambia	13,27	
Libya	4,30	

As for Egypt, the annual urban inflation rate accelerated to 15.0% in September of 2022, from 14.6% in the previous month and exceeded market expectations of 14.7%. This was the highest figure since November of 2018, staying well above the upper limit of the central bank's 5-9% target range for the seventh consecutive month amid a sharp rise in global commodity prices and currency devaluations. The main pressure on the growth came from the prices of food products and soft drinks (21.7% against 23.1% in August). On a monthly basis, consumer prices rose by 1.6%, the most in five months, and up from a 0.9% increase in August (Aljazeera, 2022).

To analyse the inflation rates by country and construct possible scenarios of changes in the inflation rate, we will study historical data. We will use the least square method, and find possible trends in the inflation rate, compare them, and select the most probable ones (Fig. 13). Based on historical data, let us add several simulated periods and combine them in the scenario. If we consider the data on Egypt's inflation in more detail, we can construct two

possible scenarios of changes in the inflation rate. The first – optimistic – is the continuation of the linear trend $y = 1.003x + 6.0333$ (at $R^2 = 0.89$) in the growth of the inflation rate under unchanged conditions. Where *y* is the inflation rate and *x* is months. Then in a year, we will see that inflation will rise to 20.1%, which will set another *anti-record* for the country. Another scenario (pessimistic) is a logarithmic approach to modelling the trend line $y = 4.2774ln(x) + 5.0893$ (at $R^2 = 0.95$), taking recent changes in the trend into account, both in the world and in the inflation rate of Egypt Then the year will end with inflation at the level of 16.4%, which is also prohibitively high. Unfortunately, in the third scenario, a decline in the inflation rate is not foreseen under current conditions.

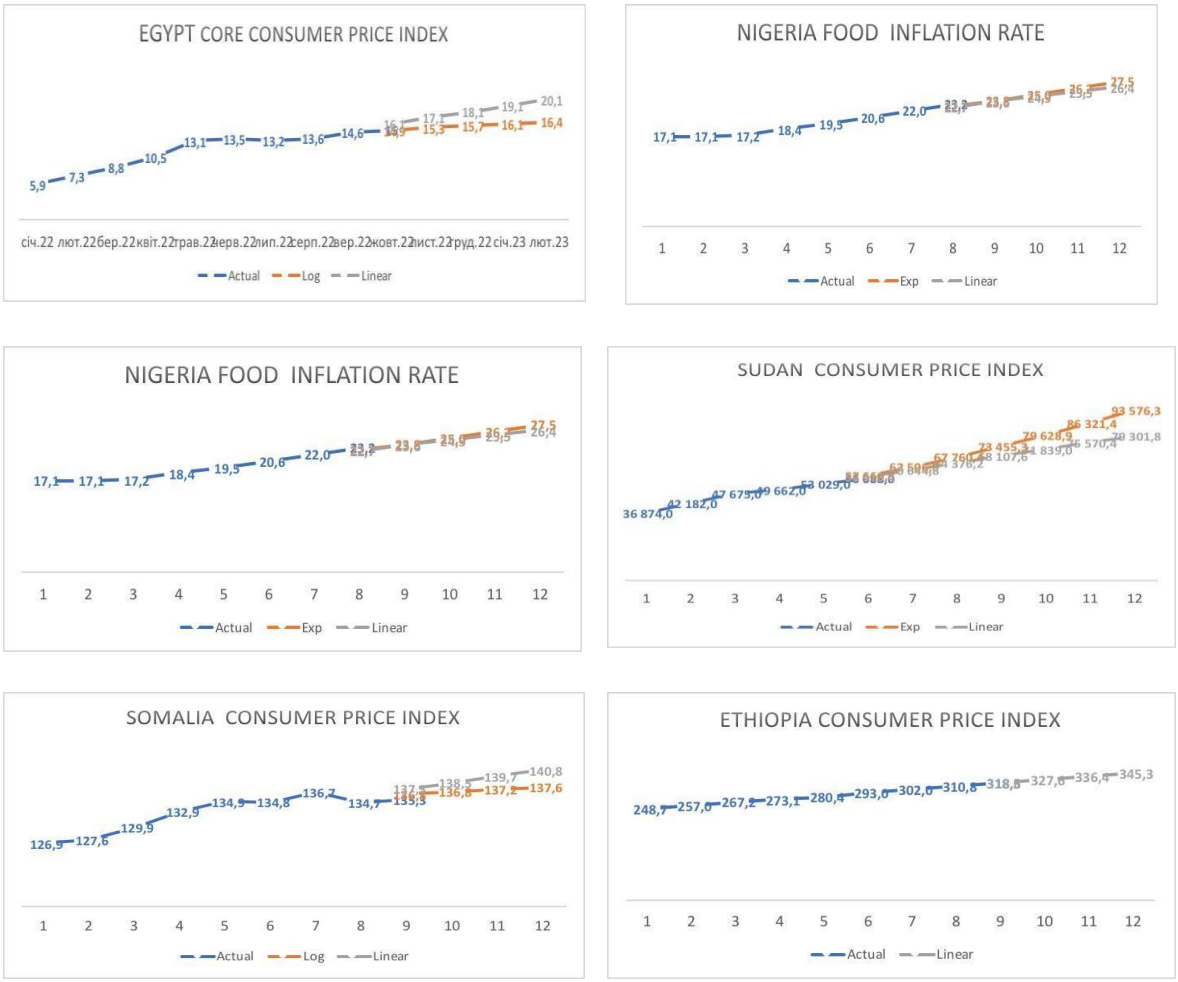


Figure 13. A model of likely scenarios of changes in the inflation rate in Egypt, Nigeria, udan, Somalia, Ethiopia, source: own author`s draft based on data from Trading economics, Inflation Rate (2022)

Based on the values of R^2(comparing them with each other), we choose the most suitable variants of the models. Thus, in the context of economics, it is interpreted as follows: a pessimistic scenario for Egypt is a logarithmic one, so there is significant growth and the point of intersection and slowdown has not yet come, an exponential scenario for Nigeria – so the growth is happening, but it is already slowing down relative to its growth peak.
Let us construct similar trends for Nigeria on the following graphs:
In Nigeria, the inflation rate was stable, the linear trend will be as follows $y = 0{,}933x + 15{,}193$ (at $R^2 = 0{,}94$), and the exponential one will be $y = 15{,}564e^{0{,}0474x}$ 193 (at $R^2 = 0{,}955$). In both cases, we will see that inflation will go up to 27% in a year.
We can see a similar situation in the consumer price index and its projected trend.
For Egypt, it will be 133 at the end of the year, if it is calculated according to the logarithmic trend.
For Nigeria, this is a constructed function that looks like a straight line ($R^2 = 0{,}999$), so it is not difficult to see that if conditions are unchanged, the consumer price index will be 502 at the end of the year, which is 20% higher than it was at the beginning of the year.

In Sudan, the level of consumer prices will increase by 2 or almost 3 times (under different scenarios), the linear trend will be as follows $y = 3731{,}4x + 34525$ (at $R^2 = 0{,}97$) and the exponential one will be $y = 35530e^{0{,}0807x}$ (at $R^2 = 0{,}955$). In both cases, we will see dramatic changes in a year.
A function that has been constructed for Ethiopia looks like a linear function ($R^2 = 0{,}997$), so it is not difficult to see that, under the same conditions, the consumer price index at the end of the year will be 345.3, which is 40% more than it was at the beginning of the year.
As can be seen on the graphs, none of the listed countries has a downward trend in the Consumer Price Index. In the best case, it is a rise of 20-40%, but it can reach up to 253% increase, and, in the worst-case scenario, it can be 340%. Even a 20% reduction in consumption opportunities is noticeable, and a 2- or 3-fold reduction in purchasing power is catastrophic for the population.

3.5. Scenarios of ensuring Ukraine's food security in the short-term and long-term periods
Limited access to the export of agricultural products from Ukraine has become one of the main problems of ensuring global food security.
That is why, in order to ensure Ukraine's food security, an agreement was signed on July 22, 2022, in Istanbul. The aim of the agreement that lasted 120 days was to unblock the export of food from three Black Sea ports: *Odessa*, *Pivdennyi* and *Chornomorsk*. The so-called *grain corridor*.
As part of the *grain initiative*, 325 ships with 16.9 million tons of cargo left Ukrainian ports for the period of three months (Fig. 14).

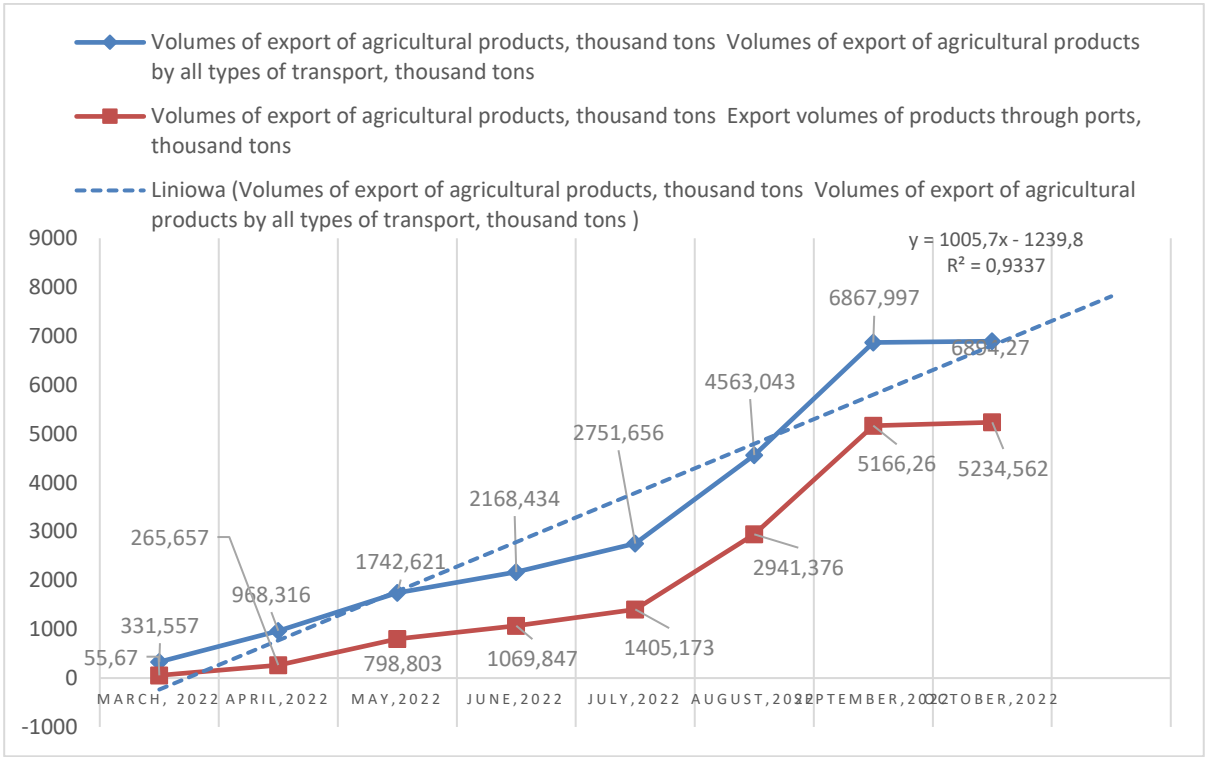


Figure 14. The volume of export of agricultural products, thousand tons, source: own author`s draft based on data from the Ministry of Agrarian Policy and Food of Ukraine (2022), Ministry of Development of Communities, Territories and Infrastructure of Ukraine (2022)

Corn accounts for almost half of the exports – 10.28 million tons and wheat accounts for a third – 5.42 million tons. Sunflower oil constitutes the rest of the exports – 2.37 million tons. In addition, a third of the food went to the countries of Africa and the Middle East, in particular, to Egypt, Yemen, Sudan and Lebanon.
In spite of some improvements in food exports from Ukraine through *grain corridors*, this is not enough to stabilize hunger in low-income countries.
That is why the international community has proposed the creation of so-called *solidarity corridors*, which will enable European countries to receive Ukrainian agricultural products for shipment by rail to European ports through accelerated border crossing.

Conclusions

The presented work opens up an opportunity to comprehensively study the causes of the world food crisis and the strengthening of the crisis-forming factors that affect the stability of the world food system due to Russian military aggression against Ukraine, which is a country that is one of the largest providers of assistance to population groups suffering from food shortages.

It should be noted that the COVID-19 pandemic, supply chain disruptions and climate phenomena have had a negative influence on the global food system and caused food prices to rise even before the beginning of 2022. The pandemic has exhausted the budgets and foreign exchange reserves of all countries without exception, making them less resistant to sharp price increases. In this regard, particular attention should be paid to African countries, which are on the brink of a humanitarian food disaster, and in which food costs account for a larger than usual share of consumer spending, and the unemployment rate is constantly increasing.

Furthermore, the Russian war against Ukraine is putting additional intense pressure on global food security.

The war in Ukraine significantly affected global food security, endangering the achievement of the Sustainable Development Goals, in particular SDG 2 (Zero Hunger) (UN, 2015) due to export restrictions, high international food prices, which caused a sharp increase in the level of hunger and malnutrition among the poorest and most vulnerable sections of the population.

This is related to the fact that since 2020, Ukraine has become one of the leading countries in food exports in the world.

The study of the stages of the formation of Ukraine as a guarantor of the world's food security provided an opportunity to find out that the country during its short existence has diametrically changed the structure of agribusiness and export of products – from a general supplier of livestock products to a leading exporter of plant products. The changes occur with constant control of the level of competition and profitability of this or that product: appropriate rapid adaptation to changing market and climate conditions; changes in the structure of cultivated areas and production processes.

Because of this, Ukraine's position in the world food system is very important and the food security of developing countries and low-income countries, which are the most vulnerable to food imports, depends on the stable functioning of Ukraine's agro-industrial sector.

A review of current events taking place in Ukraine presents an opportunity to reach a number of disappointing conclusions, both for Ukraine itself and for the entire food security:

- a reduction of cultivated areas (ongoing hostilities and mining of territories),
- a marked decrease in the liquidity of agrarians,
- lower yields due to limited access to fertilizers,
- violation of crop production technologies,
- a reduction in the use of advanced plant protection products,
- a ripple effect from the increase in costs of diesel fuel and fertilizers.

Some countries will suffer more than others will, and the overall consequences are expected to be more negative than during the food crises of 2007-2008 and 2011. As a result of the military conflict, South Sudan, Sudan, Somalia and Ethiopia were among the most vulnerable countries from the point of view of food security. At the end of 2022, a marked increase in the number of people on the verge of a humanitarian food crisis is predicted in those four countries.

Taking into account the purpose of the study, the following indicators were chosen for analysis, namely: Food inflation rate, Core Consumer Price Index and Consumer Price Index, because they, among others, can help to understand the situation in which consumers will find themselves at the end of the year.

Using the analysis of the current state of inflation rates and the construction of models and forecasting with the creation of trends, it can be clearly seen that if the conditions of the system remain unchanged, the level of consumer prices and the inflation rate will continue to grow, regardless of the country. In some countries, a rise in consumer prices can reach several hundred percent, which will be catastrophic for their population.

Quick mitigation measures that are being taken to prevent the food crisis from worsening can help to avert the worst consequences, but the conducted study shows that the window of opportunity is narrowing. However, the measures that were adopted during the COVID-19 pandemic are still very relevant today, as the war in Ukraine has exposed the gaps in the world's food systems.

First of all, it is about a ban on the export of food products to low- and middle-income countries in order to protect their markets. For example, during the global food crisis of 2007-2008, prices rose partly because major food-producing countries such as Thailand and Vietnam restricted exports to preserve their domestic stocks and protect their populations from higher prices (Bouët, A. & Laborde Debucquet, D., 2016).

In the long term, all participants that ensure food security in the world must strive to create a more sustainable food system that would be protected at every stage – from production to safe and diverse consumption.

In our opinion, the basis of such a system is access to transparent and accurate data that reflect the real situation and state of nutrition in the countries that suffer from food shortages the most. Such data are the result of global

monitoring, which should take into account not only indicators such as poverty, food security or food prices, but also the physical condition of a person. Investing money in higher quality data can optimize costs of food assistance programmes.

At the same time, for low-income countries, there is a problem of a debt burden due to the high level of food imports. Because of this, it is advisable to use innovative financing mechanisms through attracting private funds or investors on mutually beneficial terms (on the one hand – obtaining the necessary financial funds, on the other hand – taking into consideration environmental, social and management factors when making investment decisions).

We believe that one of the important steps should be targeted use of budget resources for the prevention of acute malnutrition or exhaustion in children; for supplements of trace elements for pregnant women, young children and adolescents; for educational and other tools to promote, support and encourage healthy eating and physical activity.

According to experts, for overcoming food crises and gaps, it is vital that the governments fulfil the obligations, which they already accepted. The governments determine the future vector of food security in the world and those measures that are of an urgent nature, taking into account variability and the presence of force majeure crises.

Therefore, at present, it is very important to mobilize resources to provide urgent assistance to the population of Ukraine suffering from Russia's military aggression, with simultaneous assistance to other countries affected by conflicts, pandemics or climate change. In addition, fundamental changes in global behaviour occurring in both the public and private sectors can improve the transparency and sustainability of the global food system.

In other words, unless the governments of such countries are able to prevent the negative consequences of a price shock, households will have no choice but to spend more of their finances on food.

Hence, the tasks set by the authors of the article have been achieved, and the obtained results present an opportunity to take them into account during the development of measures to prevent negative consequences for food security.

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