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«Київський політехнічний інститут імені Ігоря Сікорського»THREAT OF GLOBAL HUNGER: UKRAINE IN THE FOOD
SECURITY SYSTEM AND MILITARY AGGRESSIONЗАГРОЗА ГЛОБАЛЬНОГО ГОЛОДУ: УКРАЇНА У СИСТЕМІ
ПРОДОВОЛЬЧОГО ЗАБЕЗПЕЧЕННЯ ТА ВІЙСЬКОВА АГРЕСІЯ

The article is devoted to the global problem of overcoming hunger in the context of achieving the goals of sustainable development. To achieve the goals of the study, methods of analysis and synthesis, statistical, visualization and forecasting methods based on Double Exponential Smoothing were used. The conducted analysis made it possible to reveal fundamental differences between the level of daily food supply in terms of kcal per person. Analysis of the food structure based on Food Supply indicators (kcal/capita/day) revealed significant differences in the range and energy value of food products. At the same time, wheat and the products of its processing constitute the essential basis of the food diet at the level of 10-21%. The forecasting results indicate the strengthening of the trend of decreasing supply of the wheat and its processed products. New approaches to agricultural production in different climatic conditions, improvement of production chain management mechanisms with the minimization of losses, and strengthening of the responsibility of states for collective security are needed to restore progress in achieving the goals of sustainable development in matters of overcoming hunger.

Keywords: forecasting, food security, sustainable development, global hunger, risk factors, export, food supply.

Стаття присвячена глобальній проблемі подолання голоду у контексті досягнення цілей сталого розвитку. В основу дослідження покладено аналіз показників недоїдання та продовольчого забезпечення різними видами продовольства у розрізі окремих груп країн. Для досягнення цілей дослідження були використані методи аналізу та синтезу, статистичний, метод візуалізації та прогнозування на основі Double Exponential Smoothing. Ризикоутворюючими факторами, що призвели до погіршення ситуації є природні (повінь, засуха, тропічний циклон), політичні (політична нестабільність, військовий конфлікт, невизначеність) та соціально-економічні (економічні потрясіння, перенаселення). У регіональному розрізі проблеми голоду найбільшою мірою торкаються африканських країн і часто пов'язані з низьким рівнем доходів. Різний рівень економічної стійкості дозволив різним групам країн по-різному пережити період пандемії COVID-19, яка звела нанівець багаторічний прогрес досягнення цілі подолання голоду. Проведений аналіз дозволив виявити кардинальні відмінності між рівнем щоденного забезпечення продовольством у перерахунку ккал на особу. Забезпечення країн ЄС та найменш розвинутих відрізняється майже у три рази. Аналіз структури харчування на основі показників продовольчого забезпечення дозволив виявити суттєві відмінності у наборі та енергетичній цінності продуктів харчування. Разом з тим пшениця та продукти її переробки становлять суттєву основу харчового раціону на рівні 10-21%. Результати прогнозування вказують на посилення тренду зниження продовольчого забезпечення (пшениця та продукти її переробки) у всіх групах аналізованих країн. Проте для країн ЄС це не критичним зменшенням з огляду на достатній рівень енергетичного забезпечення продуктами харчування, який перевищує нормативні показники, розраховані Всесвітньою організацією охорони здоров'я. Україна, як гарант світової продовольчої безпеки навіть в умовах військової агресії продовжує виробництво та експорт зернових, який у 2022/23 маркетинговому році склав 49 млн т. Замінована територія та військові дії призвели до падіння експорту пшениці у поточному періоді на 37,5%. Для відновлення прогресу досягнення цілей сталого розвитку у питаннях подолання голоду необхідні новітні підходи щодо аграрного виробництва у різних кліматичних умовах, удосконалення механізмів управління виробничими ланцюжками з мінімізацією втрат та посилення відповідальності держав за колективну безпеку.

Ключові слова: прогнозування, продовольча безпека, сталий розвиток, глобальний голод, ризикоутворюючі фактори, експорт, продовольче забезпечення.

Problem statement. Among the Millennium Development Goals, defined at the Millennium Summit in 2000, the goal related to the eradication of poverty and hunger took the first place. It was expected that by 2015, the number of hungry people in the world would decrease from 850 million to 450 million people.

However, this goal was never achieved. According to the FAO, almost 770 million people were undernourished in 2021, which is 46 million more than in 2020 and 150 million more than in 2019 [1]. In 2022, about 285 million people in 58 countries experienced acute food insecurity. During the period from 1990 to 2015, the number of undernourished people was almost halved thanks to the introduction of the latest technologies in the agricultural sector and the growth of its productivity. At the same time, the disruption of the logistics system as a result of the Covid-19 pandemic in 2019–2021, and thus the blockade of Ukrainian ports by the Russian aggressor, caused a new wave of growth in the number of people who do not receive regular food (Figure 1). The global food crisis is not limited to the negative impact of the war in Ukraine, but also depends on climate change and a number of other factors.

Ukraine, as a guarantor of world food security, having a powerful production and export potential, faced a number of challenges related to the military aggression of the Russian Federation, which caused significant damage to the system of food supply and food security. With this in mind, the scientific problem of the study is to assess the consequences of the implementation of a number of risk-creating factors for global food security in order to justify possible scenarios of food availability for different groups of countries, highlighting the role of Ukraine in this process.

Analysis of recent research and publications.

A number of scientific works by Ukrainian and foreign researchers are devoted to the scientific problems of overcoming global hunger in the context of overcoming risks and achieving the goals of sustainable development and the Millennium Development Goals. Studies by Pawlak K, Kolodziejczak M. [2], Brüntrup M. [3], Skydan O., Hrynyshyn V. [4] focus on risks and threats to food safety. Pereira M., Oliveira A. [5], O'Hara S., Toussaint E.C. [6] pay attention to the negative consequences of the

COVID-19 pandemic for the logistics system, and therefore to the problems of food supply. Ahakerimova R. [7], Berezyuk S., Gontaruk Y., Yasinska B. [8], Bioko V., Bioko L. [9], Pruntseva G. [10] conducted an in-depth study of the impact of the war in Ukraine on the food security of various groups of countries. Scenario forecasts for the development of the export potential of fodder corn producers are presented in the study by Okhrimenko O. and Zhukovska O. [11]. Taking into account the considerable work done by scientists in the research of achieving the goals of sustainable development, overcoming global hunger and ensuring food security, we consider it necessary to supplement the acquisition by forecasting the availability of food products across different groups of countries in order to find resources to overcome hunger.

Formulating the purposes of the article. The purpose of the study is to develop forecasts of the availability of food consumption for different groups of countries in the context of achieving the goal of sustainable development – zero hunger and taking into account the export potential of Ukraine.

Research methodology. The research is based on general scientific research methods: analysis, synthesis, classification, abstraction. We used the Double Exponential Smoothing method to forecast the food supply of wheat and its processing products by individual groups of countries:

$$\hat{y}_{0k} = \alpha y_k + (1 - \alpha)(\hat{y}_{0k-1} - t_{k-1}), \tag{1}$$

$$t_k = \beta (\hat{y}_{0k} - \hat{y}_{0k-1}) + (1 - \beta) t_{k-1}, \tag{2}$$

$$\hat{y}_{k+p} = \hat{y}_{0k} + p t_k, \tag{3}$$

Where

\hat{y}_{0k} – the smoothed amount for the current period,

α – the smoothing coefficient of the series,,

y_k – the current value of the series,

\hat{y}_{0k-1} – the smoothed value for the previous period,

t_{k-1} – the trend value for the previous period,

β – the trend smoothing coefficient,

\hat{y}_{k+p} – the forecast for p period,

p – the serial number of the period for which we make a forecast,

t_k – the trend for the last period.

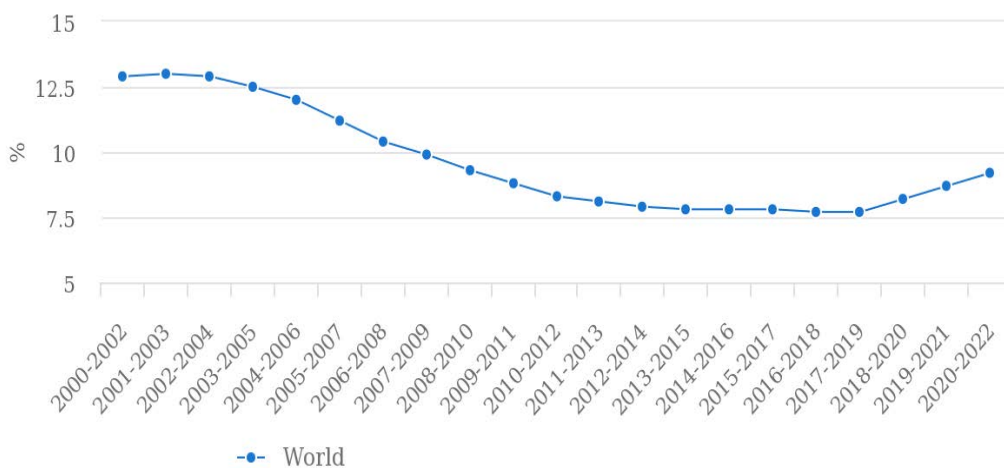


Figure 1. Prevalence of undernourishment in the world, %

Source: developed by the authors based on FAO indicators

Presentation of the main research material. The goals of sustainable development by 2030 include: overcoming all forms of malnutrition among different population groups; doubling the productivity of agricultural production, and therefore the income of producers, including by providing access to land and other types of resources, knowledge, financial services, etc.; development of sustainable food production systems and methods of agricultural production, taking into account climate change and ecology; ensuring uninterrupted functioning of food markets.

According to the definition adopted at the World Food Summit in 1996, food security is defined when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

There are four main dimensions of food security: physical availability of food is determined by the level of food production, stock levels and net trade; Economic and physical access to food, which is related, among other things, to the level of household income and expenditure, and prices; Food utilization through adequate energy and nutrient intake by individuals; Stability over time is determined by the impact of adverse weather conditions, political instability or economic factors (unemployment, rising food prices, etc.) [12].

According to FAO data, in 2021, from 702 to 828 million people suffered from hunger. Since the outbreak of the COVID-19 pandemic, this number has increased by approximately 150 million. The further increase in global hunger in 2021 resulted from increased economic inequality between countries due to different approaches to economic recovery policies. In 2021, 278 million people suffered from hunger in Africa, 425 million in Asia, and 56.5 million in Latin America and the Caribbean – 20.2, 9.1, and 8.6 percent of the population, respectively. How-

ever, Africa remains the region with the highest prevalence of malnutrition [13].

As shown in Table 1, the main risk factors for the occurrence of hunger are natural (flooding, drought, tropical cyclone), political (political instability, conflict, uncertainty) and socio-economic (economic shocks, overpopulation). For example, in the countries of Central America – Guatemala, Honduras, Nicaragua and El Salvador – risk factors are drought, storms and high food prices.

The listed factors have given impetus to the aggravation of the problem of food shortages in countries where hunger is observed. This especially applies to countries that are at the most threatening stages of food insecurity: Phase 3 Crisis; Phase 4 Emergency; Phase 5 Catastrophe/Famine. Almost 243 million people in the world are currently in this situation.

Difficult food security situations are observed in the Central African Republic, Democratic Republic of Congo, Kenya, Ethiopia, Pakistan and Myanmar, where risk factors include armed conflict, economic turmoil, drought and increasing displacement.

Regional differences in the prevalence of malnutrition (PoU is defined as the percentage of individuals in a given region who are undernourished) indicate unequal opportunities for providing food in different regions of the world. The largest share of people suffering from hunger is in Africa – almost 20% (according to 2021 data). In Asia, Latin America and the Caribbean region, this indicator is 8.6-9.1%, in Oceania – 5.8%, in North America and Europe < 2.5. The notable progress that was achieved in 2017–2018 was nullified by the Covid-19 pandemic, which led to the disruption of logistical links and thus contributed to the growth of malnutrition in the most economically vulnerable regions.

Table 1

Threats of hunger in the countries of the world, 2023

Region	Country	Risk of acute food insecurity, mln people*	Risk factors							
			Drought	Flooding	Tropical cyclone	Political instability	Conflict / uncertainty	Economic shocks	Migration	
Africa	Burkina Faso	3,4		+				+	+	+
	Federal Democratic Republic of Ethiopia	20,1	+					+	+	+
	Republic of Kenya	5,4	+	+					+	
	Democratic Republic of Congo	24,5					+			+
	Republic of Malawi	3,8	+	+					+	
	Republic of Mali, Federal Republic of Nigeria	26,1		+			+	+	+	+
	Republic of Somalia	6,5	+				+	+	+	+
	Republic of Sudan, Republic of Yemen	36,1					+	+	+	+
Asia	Republic of South Sudan, Central African Republic	10,8	+	+			+	+	+	+
	Islamic Emirate of Afghanistan	15,3	+						+	+
	Republic of the Union of Myanmar, Syrian Arab Republic	27,3					+	+	+	+
America	Islamic Republic of Pakistan	8,6		+		+			+	+
	Republic of Haiti	4,9		+	+	+	+	+	+	
	Republic of Guatemala / Republic of Honduras / Republic of Nicaragua / Republic of Salvador	7,4	+		+				+	

Source: developed by the authors based on FAO indicators*Phase 3-5 according to Integrated Food Security Phase Classification (Number of people in acute food insecurity in hunger hot spot countries)

Table 2

Prevalence of Undernourishment (PoU) in the regions of the World

	2015	2010	2015	2016	2017	2018	2019	2020	2021
World	12,3	8,6	8,0	7,8	7,6	7,7	8,0	9,3	9,8
Africa	20,7	16,5	15,8	16,3	16,4	17,0	17,4	19,6	20,2
Asia	13,9	9,1	8,0	7,5	7,1	7,1	7,4	8,6	9,1
Latin America and Caribbean	9,3	6,6	5,8	6,7	6,4	6,6	6,7	8,0	8,6
Oceania	6,8	6,2	5,7	5,8	5,8	5,7	5,6	5,4	5,8
Antithern America and Europa	< 2,5	< 2,5	< 2,5	< 2,5	< 2,5	< 2,5	< 2,5	< 2,5	< 2,5

Source: [13]

The indicator "Prevalence of Undernourishment" (PoU) is defined as the percentage of individuals in a given region who are undernourished. Typically defined as three-year moving averages to control for some underlying parameters, such as the annual change in food stocks. At the same time, the following parameters are taken into account: the average food energy consumption, the degree of inequality in food energy consumption and the minimum food energy requirement for the national population.

The analysis of the relative indicator of food supply in kcal per person per day allows us to reveal fundamental differences between groups of countries. If in the EU countries this indicator is 3500 kcal/person/day, then in the least developed countries it is about 2400 kcal, or almost a third less. The dynamics of the trend of this indicator in EU countries shows that, despite the poverty caused by the pandemic, food supply continued to grow. Quite the opposite is the trend in the least developed countries, low-income and food-scarce countries, small island countries, etc.

In accordance with the norms of the population's physiological needs for basic nutrients and energy, the daily energy requirement according to WHO requirements for women is 1750-2200, for men 2500-3000 kcal. A person's age, activity, and physique affect the daily requirement.

If we talk about these indicators for a specific country or group of countries, then they are also influenced by the age and gender structure of the population. For the purposes of this study, we abstract from the specification of daily needs. Instead, we focus on the indicators of Food Supply (kcal/capita/day) for groups of countries (Table 3). As evidenced by the given data for 2020, within the average indicators of energy consumption, there are significant differences in the structure of basic food products. At the same time, cereals (Excluding Beer) occupy the first position in all groups of countries, which indicates the energy value of this food group and high consumer demand. Within this group, the focus is on wheat and its processing products, as this is the main article of international trade in agricultural products intended for food purposes. Wheat and processed products occupy a significant share in the food structure – from 10 to 21%, and therefore play an important role in achieving the SDG – overcoming hunger.

The dynamics of daily wheat and product supply in the period 2010–2020 did not have pronounced fluctuations, which indicates the stability of preferences in view of economic opportunities in each group of countries (Figure 3). At the same time, the available changes in supply are largely related to risk-creating factors that occur in each

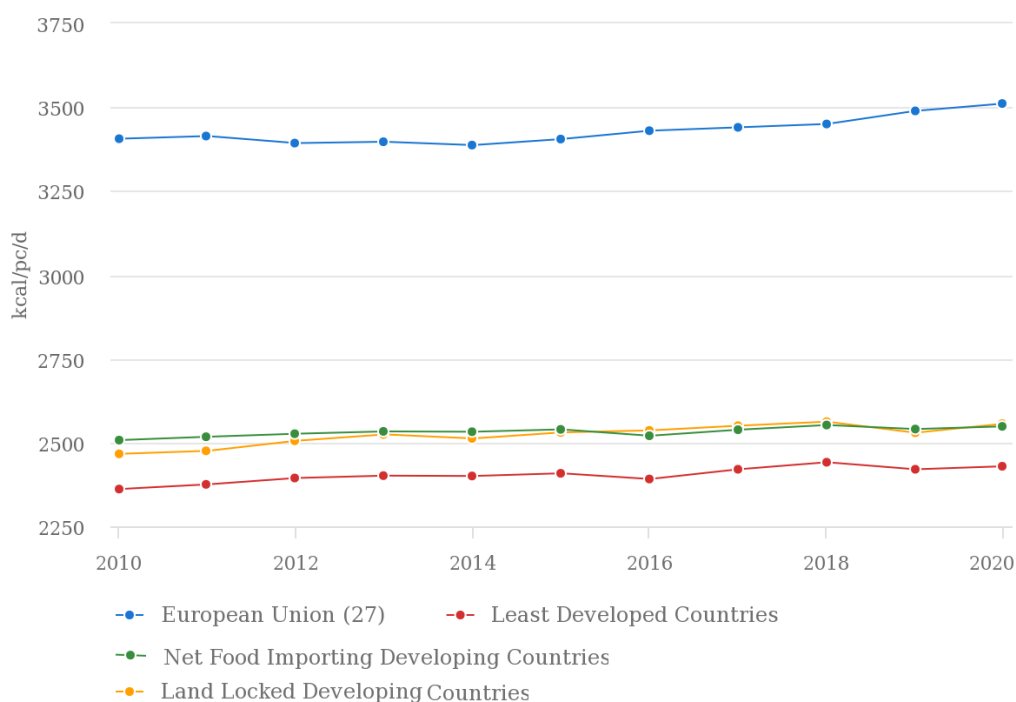


Figure 2. Food supply

Source: developed by the authors based on FAO indicators

Table 3

Food Supply Structure, 2020					
	EU	Least Developed Countries	Land Locked Developing Countries	Small Island Developing States	Low Income Food Deficit Countries
Grand Total kcal/capita/day	3511	2429	2556	2703	2551
including in %					
Cereals – Excluding Beer	26,7	53,7	53,1	36,0	53,2
Including wheat and products	21,4	10,0	17,8	12,8	17,1
Starchy Roots	3,3	12,6	7,1	7,3	6,8
Sugar & Sweeteners	10,6	4,6	4,6	11,6	6,5
Vegetable Oils	14,4	7,2	6,5	10,1	7,7
Meat	10,0	3,2	4,9	8,2	2,2
Animal fats	10,5	0,7	1,3	1,3	2,0
Milk – Excluding Butter	10,9	2,3	4,8	3,7	4,7
Other	13,6	15,7	17,7	21,8	16,9

Source: FAO

specific period, such as climatic, political, economic and social shocks.

The developed forecast for wheat and products supply for the period up to 2024 made it possible to identify some trends. In the EU countries, after a significant drop in food supply in the assortment group "Wheat and processed products", there will be some stabilization of energy supply at the level of 771 kcal per person daily. In general, these values correspond to the long-term trend of the beginning of the millennium. And some insignificant changes in the nutrition structure of the EU countries are caused by mass migration, which brings other parameters of nutrition culture (Figure 4).

In the countries of the Land Locked Developing Countries group, high volatility of food supply with this assortment was observed in previous periods. Given the complex logistics and fluctuations in world prices, forecast data

indicate a drop in this indicator at the level of 453-456 kcal. During the pandemic period, its value did not fall below 460 kcal. Violations of the logistics system, and hence the drop in incomes of the population, lead to a drop in consumption in this group of countries. In addition, a number of countries from this group provide their own needs for wheat and export it, for example, Kazakhstan (Figure 5).

The level of consumption volatility in the Net Food Importing Developing Countries group is closely dependent on world prices and the political situation. Taking into account the high economic and political instability in the world, the forecast values of food supply are headed for a decrease to the level of 432-435 kcal per person every day (Figure 6).

The least developed countries are the most vulnerable group, which depends on cheap and nutritious food, which includes cereals (more than 50% of the daily diet), includ-

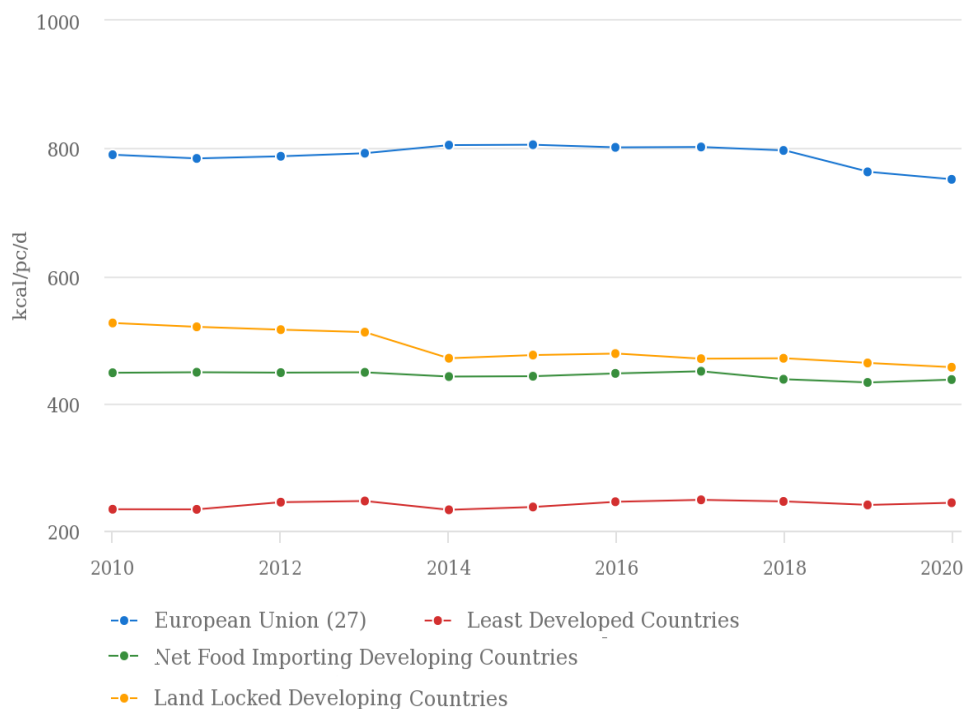


Figure 3. Wheat and products supply

Source: developed by the authors based on FAO indicators



Figure 4. Wheat and processed products in European Union

1 – initial data, 2 – predicted data, $\alpha = 0,7$, $\beta = 0,62$

Forecast: 2023 year – 771,55 kkal/capita/day; 2024 year – 771,20 kkal/capita/day

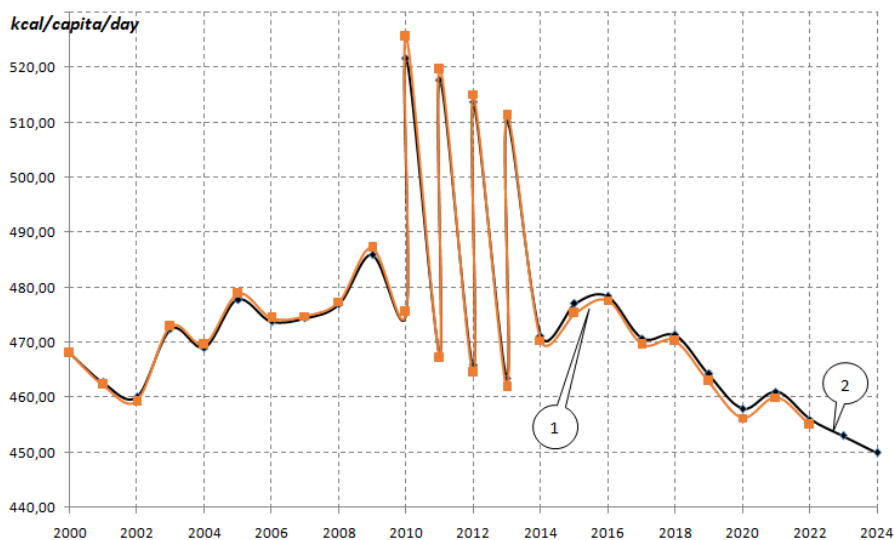


Figure 5. Wheat and processed products in Land Locked Developing Countries

1 – initial data, 2 – predicted data, $\alpha = 0,59$, $\beta = 0,55$

Forecast: 2023 year – 456,05 kkal/capita/day; 2024 year – 453,00 kkal/capita/day

ing processed wheat products. The slow growth of the share of wheat and its processing products in the diet was somewhat stabilized in the period 2014–2022 thanks to the efforts of international organizations, which systematically redistribute food reserves in favor of the countries that need it most. At the same time, the daily supply of wheat processing products to the citizens of the poorest countries is almost 3 times behind the similar supply of EU countries and almost 2 times behind that of developing countries. Forecast values are heading downwards (Figure 7).

Thus, the forecast indicates an insufficient level of food supply in the "wheat and processed products" group, which is the result of the influence of a number of negative risk-creating factors, which were discussed above, as well as military actions in Ukraine, which on the one hand contributed to a decrease in grain production, and on the other –

prevent the full functioning of the logistics system, which makes it difficult to deliver to end consumers.

Ukraine is one of the powerful global exporters of a number of products of agricultural origin, such as corn, barley, wheat, sunflower oil, etc. In the pre-war period, Ukraine exported about 50 million tons of agricultural products annually, and about 400 million people depended on these supplies.

Despite the state of war and the active phase of hostilities, grain exports of Ukraine in the 2022/23 marketing year amounted to more than 49 million tons, compared to 48.4 million tons in 2021/22. The lion's share of exports, 29 million tons, went to corn. If we analyze the structure of exports as a whole, then in 2022 the share of agricultural products amounted to 53 %, or increased by 12% compared to 2021 (Table 4).

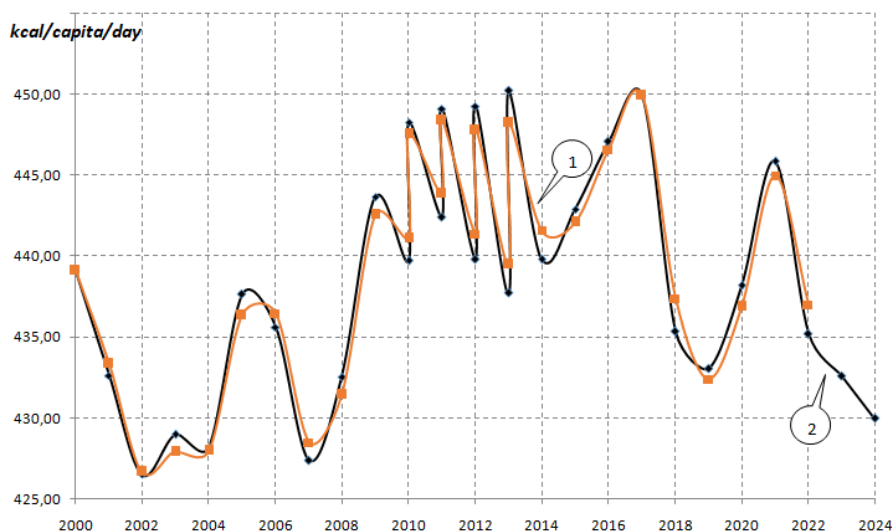


Figure 6. Wheat and processed products in Net Food Importing Developing Countries

1 – initial data, 2 – predicted data, $\alpha = 0,65$, $\beta = 0,73$

Forecast: 2023 year – 435,22 kkal/capita/day; 2024 year – 432,59 kkal/capita/day

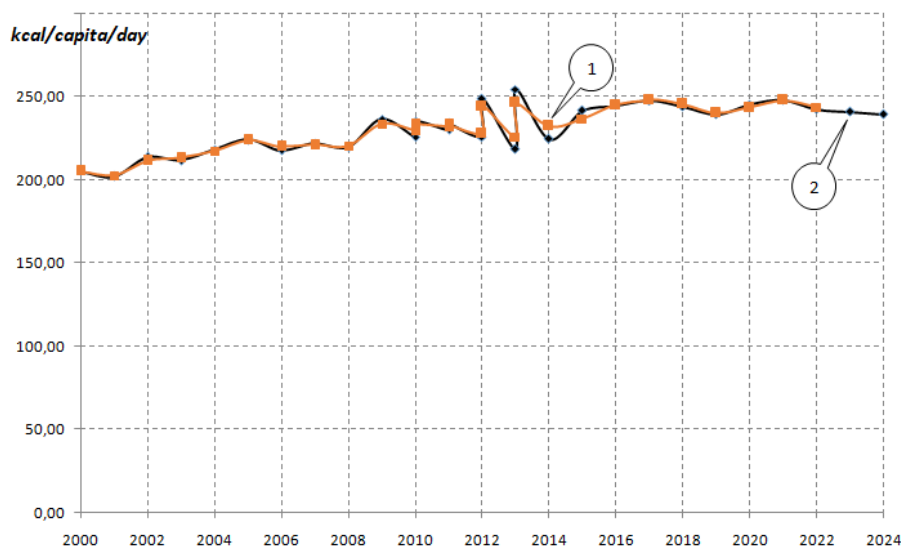


Figure 7. Wheat and processed products in Least Developed Countries

1 – initial data, 2 – predicted data, $\alpha = 0,65$, $\beta = 0,85$

Forecast: 2023 year – 242,59 kkal/capita/day; 2024 year – 241,12 kkal/capita/day

Table 4

Export from Ukraine of certain goods of the agro-industrial complex in the 2021/2022 and 2022/2023 marketing years

Name	Export in 2021/2022, tons	Export in 2022/2023, tons	Export in 2021/2022 thousand \$	Export in 2022/2023 thousand \$
Wheat and meslin	18 738 778,9	16 776 898,7	4 871 467,8	3 502 214,9
Rye	161 523,0	17 944,0	34 446,5	3 582,6
Barley	5 748 946,5	2 695 487,2	1 315 559,6	511 555,5
Corn	23 402 525,3	29 073 356,6	5 828 271,3	6 125 670,9
Soybeans, crushed or not crushed	1 152 998,1	3 236 842,4	639 281,6	1 239 390,7
Sunflower seeds	1 079 692,8	2 369 383,8	610 229,6	896 431,6
Sunflower, safflower or cottonseed oils and their fractions	4 337 266,4	5 277 604,8	5 826 835,3	5 538 947,9

Source: State Statistics Service of Ukraine, State Customs Service of Ukraine

Table 5

Commodity structure of food exports by broad economic categories

	2005	2010	2015	2020	2021	2022
mln USD						
Intermediate consumption goods	2 399	6 724	9 878	18 330	23 147	19 439
Consumer goods	1 692	3 209	4 535	3 805	4 513	3 893
Total	4 263	9 935	14 478	22 145	27 666	23 355
%						
Intermediate consumption goods	56,3	67,7	68,2	82,8	83,7	83,2
Consumer goods	43,7	32,3	31,8	17,2	16,3	16,8

Table 6

Share in the world wheat export structure, %

	2013/14	2020/21	2021/22	2022/23	2023/24
EU	19,3	14,6	15,8	15,8	18,4
USA	19,3	13,3	10,7	9,4	9,1
Canada	14,0	13,0	7,5	11,7	11,7
Australia	11,2	11,7	13,6	14,9	10,3
Rossia	11,2	19,2	16,3	21,0	22,9
Ukraine	5,9	8,3	9,3	7,7	5,0

Source: Ministry of Agrarian Policy and Food of Ukraine

Despite the significant growth of exports, their raw material nature remains (Table 5) over the past 20 years, a decrease in the share of consumer goods has been observed. On the other hand, there is a significant increase in goods of intermediate purpose, which includes cheese for the production of food products.

Strong export potential allowed Ukraine to join the UN Committee on World Food Security in February 2021 [14]. In the same year, the decree of the President of Ukraine "Issues of national priorities for the transformation of food systems in Ukraine" was signed and a plan of measures for its implementation for the period until 2030 was developed. Given the beginning of military aggression, the transformation of Ukraine's food systems has not been completed.

A significant reduction in the production and export of grain crops, particularly wheat, has been observed. If over a long period the share of wheat exports by Ukraine gradually increased and in some years reached 8-9% of world exports even during the Covid-19 pandemic, then the military aggression in Ukraine led to a decrease of this indicator to 5% in the marketing period of 2023/24, or by 37.5% in relation to the previous period, when including the accumulated reserves were used for export (Table 6). In physical terms, this drop is equal to 6,3 mln tons. For comparison, in the pre-war period, such large importers of Ukrainian wheat as Egypt and Indonesia together imported 5,4 mln tons. Thus, the drop in the volume of production and export of Ukrainian wheat nullifies the many years of work of the UN and other specialized organizations to achieve the goal of sustainable development – overcoming hunger in the world. Even taking into account the fact that the aggressor country Russia has managed to increase the volume of exports, including thanks to the illegal withdrawal of Ukrainian grain from the occupied territories, the situation with food in the world remains tense.

Conclusions. The reduction in the volume of production, and hence the export of grain by Ukraine, and in particular wheat and its processing products, which is a powerful component of the food diet of many countries, is due to a number of reasons: the reduction of cultivated areas due to mining and conducting military operations; transport restrictions caused by blocking of Ukrainian seaports, etc. All this has led to the limitation of food supply at the global level, and therefore to the exacerbation of the problem of global hunger for the most vulnerable countries and sections of the population. The conducted analysis and developed forecast showed a high level of vulnerability for land locked developing countries, net food importing developing countries and least developed countries. EU countries, taking into account the presence of their own production and a high level of income, are able to ensure food supply at a sufficient level. Countries with a high dependence on imports and low purchasing power are subject to the risk of varying degrees of malnutrition among the population, which carries disease, stunting and death.

In the previous period, the food supply system was negatively affected by the Covid-19 pandemic, and at the beginning of 2022, the world food system was balanced due to disruptions in the supply system. The start of the war in Ukraine deepened this problem and distanced the world from achieving the goal of sustainable development related to overcoming hunger.

The military aggression of the Russian Federation against Ukraine dismantled the established approaches to the global food security system and once again raised questions about the modernization of mechanisms for the formation of food reserves at the supranational level, the development of national agrarian systems, the reduction of losses at all stages of the food chain, and the strengthening of the responsibility of states for maintaining security at the regional level.

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