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FOOD RESILIENCE IN UKRAINE DURING MARTIAL LAW

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ABSTRACT

The assessment of a country's food security level is a crucial task due to the need to ensure a stable supply of food during periods of economic and social upheaval, particularly during military conflicts or other emergencies. For Ukraine, amid ongoing hostilities, issues of food security and mitigating the negative effects of disruptions in agricultural production are of particular importance. As of today, there is no universally accepted scientific approach to assessing the level of food resilience that takes into account the specifics of each region and the country as a whole, allowing for analytical comparisons and providing scientifically grounded data for the formation of effective policies in this area. The aim of this study is to justify methodological recommendations for determining the level of food resilience using Ukraine as a case study. Accordingly, the proposed methodological recommendations include a set of indicators based on the selection of those that most comprehensively characterize the country's food security in structural and cyclical aspects. It has been determined that the level of a country's food resilience is the degree of stability, adaptation, and recovery from external and internal shocks that affect the food system's ability to provide the population with sufficient, safe, and nutritious food. The results of the assessment of Ukraine's food resilience level using the Integrated Food Resilience Index in 2022 indicate an adequate level. The country has favourable conditions for food supply, although there are some issues in certain cyclical and structural aspects. The food system is developed despite the war, but there are opportunities for improvement.

Keywords: food resilience, shock influences, agriculture, state food policy, military aggression

JEL Classification: I31, Q01, Q18, Q19, Q58

INTRODUCTION

The food industry is one of the key sectors of Ukraine's economy. In wartime, this sector suffers significant losses due to destroyed infrastructure, blocked logistics routes, reduced production capacities, and lost markets. In Ukraine, food resilience is disrupted in temporarily occupied territories and regions where regular food supplies have ceased due to hostilities. Ensuring food resilience is critically important to maintaining social stability in the country.

The food industry includes all processes related to the production, processing, storage, and distribution of food products. This sector is one of the most important in any economy as it meets the basic needs of the population and contributes to the development of other sectors such as agriculture, trade, and logistics. Food resilience is defined as the ability of a country to ensure its population with sufficient safe and nutritious food that meets dietary needs and preferences for an active and healthy life (Somlanaré, 2013).

Ukraine has long been positioned as a guarantor of food security in many countries of the world due to its traditionally strong food exports. The war between Russia and Ukraine has exposed the vulnerability of both national and global food systems. It highlighted the impact of anthropogenic factors like armed conflicts and economic issues such as rising global food prices. Additionally, it underscored the natural challenges posed by crop failures, which are exacerbated by disrupted global food supplies.

Determining the level of food resilience is crucial for the socio-economic development of any country. For Ukraine, which is currently in extremely difficult conditions of martial law, the issues of food resilience and overcoming the negative consequences of disruptions in agricultural production processes gain special importance. As of today, economists don't have any methodology to assess food resilience at the national level that would consider the specifics of each region and country in general, allow for analytical comparisons, and provide scientifically grounded data for formulating effective policies in this area.

LITERATURE REVIEW

The FAO expert group defines a food system as "the activities related to the production, processing, distribution, preparation, and consumption of food, as well as the outcomes of these activities, including socio-economic and environmental results" (HLPE, 2014). Food systems are multidimensional, including socio-cultural, economic, environmental, and political aspects, and complex with many participants: food producers, food chain participants, and consumers (CGIAR, 2021).

The UN established the Decade of Action on Nutrition aimed at creating a clearly defined and time-bound plan of work to ensure the fulfilment of commitments made at the II International Conference on Nutrition and in the Sustainable Development Agenda until 2030. The Decade of Action program covers six cross-cutting and interrelated areas of activity (FAO, n.d.):

- formation of sustainable and shock-resistant food systems that promote healthy diets;
- coordination of health systems to ensure universal coverage of essential nutrition interventions;
- social protection and nutrition education;
- trade and investment for improved nutrition;
- creation of safe and supportive environments to ensure nutrition at any age;
- strengthening governance and accountability mechanisms in the field of nutrition (United Nations, 2016).

Regarding the first area of activity, it should be noted that the economic aspects of sustainable food systems are formed in terms of food prices and food accessibility (Herforth et al. 2020). Social dimensions of sustainable food systems are evaluated using various constructs, including consumer preferences and behaviours, labour issues, and the perceived societal value of food systems (Johnston, Fanzo & Cogill, 2014). Environmental dimensions of food systems are assessed in terms of the energy, water, and land use involved in food production, distribution, retail, consumption, disposal, and waste (Perignon et al., 2017).

A developed food system contributes to job creation and increased economic activity, especially in rural areas, reducing migration to cities and abroad. A food system that considers the needs of the most vulnerable groups, such as children, the elderly, and low-income families, helps maintain their health and well-being, which is important for overall demographic resilience (Shkuropadska et al., 2024). Agricultural cooperatives are a key factor in post-war recovery in Ukraine, enhancing competitiveness, and ensuring sustainable rural development and are one of the crucial parts of building a reliable and resilient food supply system (Gerasymenko et al., 2022; Shovkun-Zablotska et al., 2024).

Broadly speaking, food system resilience refers to the ability of a food system to endure and bounce back from disruptions while maintaining a sufficient supply of acceptable and accessible food for everyone (Johns Hopkins Center for a Livable Future, 2024). Food resilience is socio-economic access to food, biophysical capacity for production, and current domestic food production diversity (Seekell et al., 2017).

The measurement of food resilience at a country level for the purposes of regional comparison includes such food system components as agro-ecological conditions, producers, agricultural value chains markets, and infrastructure, and data on shocks and stressors that threaten the functional integrity of one or more components (climate and weather shocks, natural hazards, health shocks, livestock diseases etc.) (Constas et al., 2021).

Food resilience is a broad concept that includes a variety of factors, namely economic factors (poverty levels, income), political factors (subsidies, governance); social capital (local network of farmers to sustain in crisis); physical infrastructure to produce and distribute food; informational capacities of food systems; environmental capacity; agricultural (food production and of output markets for farmers diversity, improved agricultural technologies); health (nutritional capacities of food) (Roosevelt et al., 2023).

The concept and measurement of food resilience is closely linked to the concept of food security that encompasses such quantitative indicators as the level of food security of the state (region) as a whole: population, food balance indicators

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and FAO food security indicators, consumption in major food groups and state policy to support food production (Melnyk, Tunitska, & Banas, 2023). Other studies break down a country's food security index into components like affordability, availability, quality and safety, sustainability, and adaptation, encompassing various indicators of the food system and agricultural policy performance (Lagodiienko et al., 2022).

So, there is a variety of approaches to assessing food resilience, however, the criteria, aspects, and methods for calculating the level of food resilience at a country level are explored insufficiently.

AIMS AND OBJECTIVES

The aim of this research is to substantiate methodological recommendations for determining the level of food resilience in the example of Ukraine.

METHODS

The research employs such methods of scientific inquiry, as analysis and synthesis for forming a list of indicators to calculate the level of food resilience; statistical analysis for normalizing indicators and calculating the Integrated Food Resilience Index in Ukraine; comparison for assessing food resilience in Ukraine based on structural and cyclical indicators; and the abstract-logical method for formulating conclusions.

RESULTS

Methodological recommendations for determining the level of food resilience in a country

The methodological recommendations are formed to assess food resilience in a country, defining a list of main indicators, their threshold values, and an algorithm for calculating the Integrated Food Resilience Index. The formation of the list of indicators is based on the selection of metrics that most comprehensively characterize food resilience at a country level in terms of structural and cyclical aspects. This approach allows for the assessment of both short-term changes and long-term structural aspects that affect the resilience of the food system.

Cyclical indicators are divided into production (4 indicators) and consumption (4 indicators), accounting for 40% of the total quantity of indicators. Structural indicators are divided into economic (5 indicators), infrastructural (2 indicators), and environmental (5 indicators), accounting for 60% of the total quantity of indicators (Table 1).

Table 1. Cyclical and structural indicators of the Integrated Food Resilience Index.

No	Cyclical indicators (40%)	No	Structural indicators (60%)
1.	Production indicators	3.	Economic indicators
1.1	Food Loss	3.1	Agricultural Productivity
1.2	Index of agricultural products	3.2	Agriculture orientation index for government expenditures
1.3	Food production index	3.3	The share of products of the food industry and processing of agricultural raw materials in the export of groups 1-24 UKTZED
1.4	Volatility of agricultural production	3.4	Public expenditure on agricultural research and development
		3.5	Commitment to innovative technologies
2.	Consumer indicators	4.	Infrastructure indicators
2.1	Consumer price index for food products	4.1	Supply chain infrastructure
2.2	Change in average food costs	4.2	Irrigation infrastructure
2.3	Food supply adequacy	5.	Environmental indicators
2.4	Global Hunger Index	5.1	Ecosystem Health
		5.2	Water Availability
		5.3	Climate Stability
		5.4	Biodiversity
		5.5	The share of agricultural land under organic production, in the total area of agricultural land

Cyclical factors influence food resilience in the short term and can vary depending on seasonal fluctuations, economic conditions, and other temporary phenomena. Structural factors have a long-term effect and determine the fundamental characteristics of the country's food resilience. This distribution of indicators helps to assess both the short-term and long-term aspects of a country's food resilience better. The indicators used for calculation are presented in Table 2.

Table 2. Food resilience assessment indicators.

No	Indicator	Characteristics of the indicator	Threshold value	Source of input information
		Cyclical indicators		
1.	Food Loss	Post-harvest and pre-consumer food loss rate as a ratio of domestic supply of crops, livestock and fishery products.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
2.	Food production index, %	Reflects the change in the volume of food production in the country. The indicator is used to analyze the economic situation in the agricultural sector.	≥ 100	State Statistics Service of Ukraine (State Statistics Service). URL: https://sdg.ukrstat.gov.ua/uk/2-3-1/
3.	Index of agricultural products, %	Reflects the change in the volume of production of agricultural products in the country. This index is used to assess the productivity of the agricultural sector.	≥ 100	State Statistics Service of Ukraine (State Statistics Service). URL: https://sdg.ukrstat.gov.ua/uk/2-2-2/
4.	Volatility of agricultural production	A measure of fluctuations in agricultural production, defined as the standard deviation in growth rates of grain and vegetable production over the last 5-year period for which data are available.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
5.	Consumer price index for food products, %	Reflects the change in the average level of prices for food products purchased by consumers. The index is an important tool for assessing inflation, particularly for food products.	≤ 100	State Statistics Service of Ukraine (State Statistics Service). URL: https://sdg.ukrstat.gov.ua/uk/2-4-1/
6.	Change in average food costs	A measure of changes in average food costs derived from the food CPI, which tracks changes in the price of an average basket of food items.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
7.	Food supply adequacy	Indicator of food sufficiency, availability for human consumption, as a percentage of the average food energy requirement.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
8.	Global Hunger Index	An indicator that measures and assesses the level of hunger at the global, regional and national levels.	≤ 20	Concern Worldwide. URL: https://www.globalhungerindex.org/pdf/en/2022.pdf
		Structural indicators		
9.	Agricultural Productivity	The indicator that reflects the level of production efficiency in agriculture.	≥ 4.5	Fund of Peace. URL: https://fundforpeace.org/SRI/about.html
10.	Agriculture orientation index for government expenditures	The indicator that reflects the degree of priority the government assigns to the agricultural sector in its budget expenditures.	≥ 1	Our World in Data. URL: https://ourworldindata.org/grapher/agriculture-orientation-index
11.	Share of food industry and agricultural raw material processing products in the export of groups 1-24 of the Ukrainian classification of goods in foreign trade, %	The indicator reflects the share in the total export of goods of certain groups taken by the products of the food industry and the processing of agricultural raw materials.	≥ 50	State Statistics Service of Ukraine (State Statistics Service). URL: https://sdg.ukrstat.gov.ua/uk/2-3-2/
12.	Public expenditure on agricultural research and development	A measure of government spending on agricultural research, derived from the Agricultural Focus Index, a proxy indicator for government investment in agriculture.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
13.	Commitment to innovative technologies	The indicator measures the political framework that promotes the development of innovative agricultural technologies.	≥ 50	Economist Impact. URL: https://impact.economist.com/new-globalisation/digital-future/priorities
14.	Supply chain infrastructure	An indicator that measures the ability to transport the crop to market	≥ 50	EIU. URL: https://store.eiu.com/product/countrydata
15.	Irrigation infrastructure	Indicator of the percentage of cultivated agricultural area equipped for irrigation.	≥ 50	FAO. URL: https://www.fao.org/faostat/en/#home
16.	Ecosystem Health	The indicator that assesses the overall state and functioning of ecosystems. It takes into account various aspects such as biodiversity, resilience, productivity, water and air quality, as well as the ecosystem's ability to sustain life and provide ecosystem services.	≥ 4.5	Fund for Peace. URL: https://fundforpeace.org/SRI/about.html
17.	Water Availability	The indicator that reflects the availability of water resources for various needs in a specific region or country.	≥ 4.5	Fund for Peace. URL: https://fundforpeace.org/SRI/about.html
18.	Climate Stability	The indicator that reflects the degree of stability of climatic conditions in a specific region or on a global level. It assesses the variability of climatic parameters such as temperature, precipitation, humidity, and other weather phenomena over time.	≥ 4.5	Fund for Peace. URL: https://fundforpeace.org/SRI/about.html
19.	Biodiversity	The indicator that assesses the level of biodiversity in a specific ecosystem, region, or on a global scale. It takes into account the number of species (species richness), their abundance (or relative abundance), and diversity at the genetic, species, and ecosystem levels.	≥ 4.5	Fund for Peace. URL: https://fundforpeace.org/SRI/about.html
20.	The share of agricultural land under organic production, in the total area of agricultural land, %	Reflects the percentage ratio of the area of land where organic farming is carried out to the total area of agricultural land in a certain region or country.	≥ 5	State Statistics Service of Ukraine (State Statistics Service). URL: https://sdg.ukrstat.gov.ua/uk/2-3-3/

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The forming of the Integrated Food Resilience Index is done using 20 indicators. For each indicator, the threshold values have been set, as shown in Table 2. Indicators are normalized to their thresholds. The higher (or lower) value of the indicator compared to the thresholds means that it will be normalised as 0 if the value corresponds to a threshold – 1. For the calculation of the Integrated Food Resilience Index, the following formula has been used (Boiko, Shkuropadska et.al., 2021):

$$I = \frac{\sum N_{x=1}}{\sum N_x} \times 100\% \quad (1)$$

I - the Integrated Food Resilience Index; $N_{x=1}$ – the number of indicators with a normalized value of 1; N_x – overall quantity of indicators.

A country's level of food resilience is the degree to which it resists, adapts to, and recovers from external and internal shocks that affect the food system's ability to provide the population with enough safe and nutritious food. The measurement of the resilience level is presented in Table 3.

Table 3. Levels of food resilience at a country level.

No	Food resilience levels	Measurement scale	Qualitative characteristics
1.	High resilience level	80-100%	A country has enough food to meet the needs of the population. Infrastructure and government policies support the resilience of the food system in the face of shocks. A characteristic feature is a high level of food resilience and a low level of hunger.
2.	Sufficient resilience level	60-79%	A country has good conditions for providing the population with food, although there may be some challenges in some aspects. The food system is developed, but there is room for improvement.
3.	Medium resilience level	40-59%	A country can meet the food needs of the population, but there are significant challenges and risks that could affect the resilience of the food system. Substantial improvements in infrastructure and public policy are needed.
4.	Low resilience level	20-39%	A country is facing serious problems in food supply. There are significant risks to the food system, with high levels of malnutrition and hunger. There is a need for immediate political action to improve the situation.
5.	Critical resilience level	0-19%	A country has a critical shortage of food. High rates of hunger and malnutrition. A country needs significant international aid and reforms to overcome the food crisis.

According to the table provided, the analysis of a country's food resilience is measured according to five levels: a high level is measured on a scale from 80% to 100%; a sufficient resilience level is measured on a scale from 60% to 79%; a medium resilience level is measured on a scale from 40% to 59%; a low resilience level is measured on a scale from 20% to 39%; a critical resilience level is measured on a scale from 0% to 19%.

Assessment of the level of food resilience in Ukraine

The results of the assessment of the level of food resilience are shown in Table 4. The Integrated Food Resilience Index of Ukraine in 2022 was 60%, which indicates a sufficient level. The country has good conditions for providing the population with food, although there are certain problems in some cyclical and structural aspects. The food system is developed despite the hostilities, but there is room for improvement. Let's consider and analyse in detail the indicators of the cyclical and structural component of food resilience.

Table 4. The level of food resilience in Ukraine in 2022.

No	Indicators	Indicator value	Normalized value
1.	Food Loss	74.9	1
2.	Food production index, %	79.0	0
3.	Index of agricultural products, %	80.6	0
4.	Volatility of agricultural production	74.8	1
5.	Consumer price index for food products, %	127.1	0
6.	Change in average food costs	46.5	0
7.	Food supply adequacy	60.3	1
8.	Global Hunger Index	7.5	1
Cyclical Score, %		50.0%	
9.	Agricultural Productivity	4.9	1
10.	Agriculture orientation index for government expenditures	1.97	1
11.	Share of food industry and agricultural raw material processing products in the export of groups 1-24 of the Ukrainian classification of goods in foreign trade, %	53	1
12.	Public expenditure on agricultural research and development	6,7	0
13.	Commitment to innovative technologies	33.3	0
14.	Supply chain infrastructure	23.6	1
15.	Irrigation infrastructure	10.5	1
16.	Ecosystem Health	4.3	0
17.	Water Availability	5.1	1
18.	Climate Stability	5.1	1
19.	Biodiversity	6.6	1
20.	The share of agricultural land under organic production, in the total area of agricultural land, %	0.6	0
Structural score, %		66.6%	
The Integrated Food Resilience Index, %		60.0%	

The "Food Loss" indicator is cyclical due to several main reasons. Firstly, it is related to the seasonality of agriculture. For example, the harvests of fruits, vegetables, and grains have their peak collection periods. During these periods, significant losses can occur due to overproduction, inadequate storage, or processing infrastructure. Secondly, the food storage and transportation system also face cyclical challenges. For example, in summer, losses of perishable products increase due to heat if proper refrigeration equipment is not available. Thirdly, economic conditions, such as fuel prices, labour costs, and other factors, can affect food losses at certain times. In 2022, Ukraine scored 74.9 on the "Food Loss" indicator, which corresponds to the threshold value.

The "Food Production Index" is a cyclical indicator due to a number of factors affecting food production. Climatic conditions, such as temperature, rainfall, droughts, and frosts, affect crop yields. As these conditions can vary from year to year, they cause fluctuations in production. Farmers usually follow crop rotation to maintain soil fertility and reduce the risks of pests and diseases. Some crops are grown in specific years, contributing to the cyclical nature of production. Fluctuations in agricultural product prices influence producers' decisions to increase or decrease production volumes, creating cyclicality as producers respond to market signals. Ukraine scored 79.0% on the Food Production Index in 2022, which is below the threshold value. For example, in 2021, this indicator was 94.1%. Military actions led to the destruction of infrastructure, and farmland, disruption of supply chains, and evacuation of the population, negatively affecting food production.

Regarding the Agricultural Production Index, it reflects changes in the production of agricultural goods over a certain period. The agricultural sector is an important part of Ukraine's economy. Fluctuations in production affect the economic stability of regions, employment, and farmers' incomes. Ukraine is one of the largest exporters of agricultural products. A decrease in production negatively impacts the country's export revenues and its position in the international market.

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Ukraine scored 80.6% on the Agricultural Production Index in 2022, which is below the threshold value. For example, in 2021, this indicator was 111.4%. Military actions led to the destruction of critical agricultural infrastructure, such as warehouses, roads, bridges, irrigation systems, and farmland. Some agricultural lands became inaccessible or unsuitable for cultivation due to mines, military activities, and occupation. Mobilization, evacuation, and displacement of the population led to a labour shortage in agriculture. The decline in production volumes negatively affects the country's ability to export agricultural products, reducing foreign currency earnings.

The "Volatility of Agricultural Production" indicator also significantly impacts the country's food security. A high level of volatility in agricultural production leads to unstable food supply, price increases, economic losses for farmers, and increased risks for food system development. Ukraine scored 74.8% on the "Volatility of Agricultural Production" indicator in 2022, which corresponds to the threshold value.

The "Food Consumer Price Index" significantly impacts the resilience of the food system through several key aspects. High food prices reduce the accessibility of food products for the population, especially for vulnerable groups, worsen the nutritional status of the population, and increase the risks of food insecurity. High food consumer price indices indicate overall inflation in the country's economy, which in turn negatively affects economic stability and drives up prices for other goods and services. Ukraine scored 127.1% on the "Food Consumer Price Index" in 2022, which is above the threshold value. For example, in 2021, this indicator was 111.3%.

The "Change in Average Food Costs" indicator is cyclical due to several key reasons. Changes in economic conditions, such as inflation, exchange rate fluctuations, increased transportation costs, and other economic factors, affect the overall level of food prices. The Russian military aggression led to a decrease in agricultural production due to infrastructure destruction, population evacuation, and loss of arable land. Military actions also caused disruptions in food transportation, reduced access to production areas, and increased supply costs. Ukraine scored 46.5 on the "Change in Average Food Costs" indicator in 2022, which is below the threshold value.

The "Food Supply Adequacy" indicator is cyclical due to the interaction of seasonal production factors, economic fluctuations, political and geopolitical risks, as well as social and demographic changes that affect the overall level of food supply at different times. Ukraine scored 60.3 on this indicator in 2022, which corresponds to the threshold value.

The Global Hunger Index (GHI) is an international indicator used to assess the level of hunger based on the following criteria: the level of undernourishment, the percentage of children who do not survive to the age of five, and stunting (which measures deviations in weight and height of children). Based on these criteria, the GHI takes into account not only the caloric intake but also the diversity of diet and food availability. Thus, the GHI can evaluate the multidimensional nature of hunger. Ukraine scored 7.5 on this indicator in 2022, which corresponds to the threshold value.

Analysing the cyclical indicators of food security, 50.0% of the indicators correspond to the threshold values. This result indicates an average level of food resilience from a cyclical aspect. Next, let's analyse the structural indicators of food resilience.

The "Agricultural Productivity" indicator is structural, as it reflects the main characteristics and efficiency of the agricultural sector of the economy. This indicator allows for assessing how effectively production resources, such as land, labour, and capital, are used to grow agricultural products. It considers the use of modern technologies and innovations in agriculture, such as genetically modified organisms, modern land cultivation methods, automated irrigation systems, etc. High agricultural productivity contributes to economic growth by increasing production and profitability in agriculture, which in turn positively impacts employment levels, population income, and other aspects of the economy. Ukraine scored 4.9 on this indicator in 2022, which fully corresponds to the threshold value.

The "Agriculture Orientation Index for Government Expenditures" is a structural indicator that reflects the long-term and systemic commitments of the government to support and develop the agricultural sector. This indicator determines the share of government expenditures allocated to agriculture relative to its share in the Gross Domestic Product (GDP). This indicator for Ukraine was 1.97 in 2022, which corresponds to the threshold value, indicating significant government attention to the development of agriculture amid military actions.

The indicator "Share of food industry and agricultural raw material processing products in the export of groups 1-24 of the Ukrainian classification of goods in foreign trade" is structural for several key reasons related to its impact on the country's economic structure, long-term sustainability, and development of the agro-industrial complex. A high share of the food industry and agricultural raw material processing products in exports indicates a significant contribution of this sector to the country's economy, serving as an indicator of economic structure. The indicator reflects the level of export diversification, which can reduce dependence on raw materials and increase the added value of products. A high share of processed

products in exports makes the country's economy more resilient to price fluctuations of raw materials in international markets and indicates a developed agro-industrial sector. This indicator for Ukraine was 53% in 2022, which corresponds to the threshold value.

The "Public Expenditure on Agricultural Research and Development" indicator is structural because it reflects the long-term and systemic commitments of the government to support the agricultural sector. Investments in R&D foster the creation of new technologies, enhance productivity, and drive overall economic growth. This indicator reflects the government's commitment to innovation and the long-term development of the agro-industrial sector. This indicator for Ukraine was 6.7 in 2022, which is below the threshold value. In developed countries, a significant portion of research expenses is covered by private companies. In Ukraine, the private sector is less interested in investing in research due to high risks and low expected returns.

The "Commitment to Innovative Technologies" indicator is structural, as commitment to innovative technologies is usually formed at the level of organizational structures, policies, and regulations. Investments in research and development, both from the state and the private sector, are structural elements. They include long-term planning and strategies to ensure stable funding. In 2022, this indicator for Ukraine was 33.3, which is below the threshold value.

The "Supply Chain Infrastructure" indicator significantly impacts food security, as a developed supply chain infrastructure ensures the timely and efficient transportation of products from producers to consumers. Efficient logistics systems minimize transportation time and enhance storage conditions, thereby reducing food losses. Modern tracking and control technologies within the infrastructure ensure food safety throughout all stages of the supply chain. Therefore, the "Supply Chain Infrastructure" indicator directly affects the system's ability to provide a sufficient amount of safe and accessible food for the population, which is the foundation of food security. This indicator for Ukraine was 23.6 in 2022, which corresponds to the threshold value.

The "Irrigation Infrastructure" indicator is structural because irrigation infrastructure promotes rural development by increasing agricultural productivity, which in turn positively affects the overall economic development of the region. The construction and maintenance of irrigation systems require significant capital investments and resources. These systems are created for the long term and determine the possibilities for agriculture for many years ahead. This indicator for Ukraine was 10.5 in 2022, which corresponds to the threshold value.

The "Ecosystem Health" indicator plays a critical role in ensuring food resilience by contributing to the preservation of natural resources, increasing crop yields, and stabilizing agricultural systems. Healthy ecosystems help maintain soil fertility, which is a key aspect of growing agricultural crops. Healthy soils provide the necessary nutrients and structure for plants, increasing yields. The negative impact of the war on nature has persisted throughout the 10 years of Russian aggression, but since February 2022, the geography and scale of this impact have increased significantly. The total area of potentially affected territories may exceed 25% (Deep State, 2024). Especially considering that some areas have not been occupied for a single day but are still regularly shelled or used for establishing defensive lines (such as the border with Belarus). The "Ecosystem Health" indicator for Ukraine was 4.3 in 2022, which is below the threshold value.

Water availability for irrigation is also an important factor for growing many crops, especially in arid and semi-arid regions. Irrigation systems provide the necessary moisture for plant growth, increasing yield and stability of agricultural production. Water helps maintain soil structure and fertility. Insufficient water can lead to soil degradation, reduced productivity, and erosion, ultimately decreasing food production volumes. The "Water Availability" indicator for Ukraine was 5.1 in 2022, which corresponds to the threshold value.

Experts from the World Wildlife Fund (WWF, 2023) in their catalogue of nature-based solutions offer measures to help restore water potential. One such measure is the restoration and protection of natural protective strips. Thanks to riparian buffer zones, water bodies are not polluted or silted. Surface runoff from adjacent areas is filtered through these buffer zones. Riparian buffer zones provide shelter, shade, and food for fish and other aquatic organisms. They also protect downstream farmlands and settlements from flooding.

Climate Stability is an indicator that characterizes the degree of variability in climatic conditions over a certain period. This indicator considers various aspects of climate, such as temperature, precipitation, humidity, wind speed, and other factors that affect the overall stability of the climate system. Changes in average temperature impact the growing seasons and productivity of agricultural crops. Climate stability implies predictable precipitation patterns. Changes in the amount and distribution of precipitation can cause droughts or floods, negatively affecting food production. Stable climatic conditions support healthy ecosystems, which provide essential services such as pollination, soil fertility, and water regulation. The "Climate Stability" indicator for Ukraine was 5.1 in 2022, which fully corresponds to the threshold value.

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Biodiversity is an indicator that characterizes the diversity of living organisms, their genetic variations, and the ecosystems in which they exist. Different plant and animal species provide diverse and balanced nutrition. Crop diversity reduces the risk of crop loss due to diseases and pests, as certain species may be more resistant to specific threats. Biodiversity helps agroecosystems adapt to climate change since different species have different levels of resilience to environmental conditions. The "Biodiversity" indicator for Ukraine was 6.6 in 2022, which corresponds to the threshold value.

The indicator "Share of agricultural land under organic production in the total area of agricultural land" is structural because it reflects changes in agricultural practices and land use structure. Transitioning to organic production involves significant changes in farming methods, including the abandonment of synthetic fertilizers and pesticides, and the implementation of practices that promote soil health. Increasing the share of organic production changes the structure of the agricultural sector, affecting market prices and demand for organic products. Organic production helps preserve the environment by reducing water and soil pollution, improving ecosystem health, and promoting biodiversity conservation. The indicator "Share of Agricultural Land Under Organic Production in the Total Area of Agricultural Land" for Ukraine was 0.6 in 2022, which is below the threshold value.

Thus, by analysing the structural indicators of food resilience as of 2022, it can be concluded that 66.6% of the indicators meet the threshold values. This result indicates a sufficient level of food resilience in the structural aspect. Most of the critical elements of food resilience function properly, ensuring the stability and availability of food supply for the population under shock conditions.

DISCUSSION

Food system resilience is measured in different ways. Depending upon the aim of the assessment, different indicators and methodologies are used. The CRFS Resilience Indicator Framework by the FAO assesses food resilience, focusing on vulnerabilities to climate and pandemic shocks, natural resources, emergency food provisioning, and governance (FAO (n.d.) a). The analytical framework to assess the resilience of food systems at the local level includes identifying shocks, actors' resilience capacities, and mitigation strategies (Béné, C. et al., 2023). The Food Insecurity Experience Scale (FIES) measures hunger and food access, aiming to end hunger and promote sustainable agriculture by 2030 (FAO, (n.d) b). The Household Dietary Diversity Score (HDDS) assesses economic access to diverse foods, providing a holistic view of food security (Kennedy, Ballard and Dop, 2013). The Integrated Food Security Phase Classification (IPC) classifies food insecurity, malnutrition, and famine, aiding decision-makers (IPC Global Partners, 2021). The Committee on Sustainability Assessment (COSA) evaluates households' and communities' capacity to cope with stressors and support sustainable agricultural practices (COSA, 2022).

Our research comprises of a methodology to assess food resilience at a country level, taking into account the specifics of each region and country, and allowing for analytical comparisons and the provision of scientifically grounded data for the formation of effective policies in this field. This is achieved, unlike previous approaches, through the integration of structural and cyclical indicators of food resilience, which allows for a comprehensive and consistent assessment of the food system's resilience to external and internal shocks.

CONCLUSIONS

Food resilience is one of the major issues facing any country in the world, requiring analysis of both structural and cyclical aspects characterized by a complex of interdependent factors. Overall, Ukraine's food system, under conditions of full-scale war, demonstrated sufficient capacity to supply food to both domestic and international markets. The Integrated Food Resilience Index was 60% in 2022, with cyclical indicators at 50% and structural indicators at 66.6%. At the same time, significant financial losses occurred in agricultural production due to complicated export processes, limited opportunities to restore material and technical resources, infrastructure, and return to cultivating land damaged by the war.

Negative values in the cyclical aspect of the Integrated Food Resilience Index occur in the Food production index, Agricultural production index, Consumer price index for food, and Change in average food costs. These indicate a decrease in production volume, an increase in prices, and reduced food accessibility for the population (in active combat zones and occupied territories). Positive values in the cyclical aspect of the Integrated Food Resilience Index occur in the Food loss, Volatility of agricultural production, Food supply adequacy, and the Global Hunger Index. These reflect the resilience and stability of food supply to the population, despite the complexities of these processes during military actions.

Negative values in the structural aspect of the Integrated Food Resilience Index occur in the Public expenditure on agricultural research and development, Commitment to innovative technologies, Ecosystem health, and the Share of agricultural land under organic production in the total area of agricultural land. These suggest insufficient investment and innovation development in the agricultural sector, deterioration of the ecological situation, and low levels of organic farming. Positive values in the structural aspect of the Integrated Food Resilience Index occur in the Agricultural productivity, Agriculture orientation index for government expenditures, Share of the food industry and agricultural raw material processing products in the export of groups 1-24 of the Ukrainian classification of goods in foreign trade, Supply chain infrastructure, Irrigation infrastructure, Water availability, Climate stability, and Biodiversity. These indicate sufficient agricultural productivity, balanced agri-industrial policies, and stable food infrastructure, which are particularly significant for ensuring food and economic resilience under conditions of war.

Key directions for ensuring the resilience of the food system under full-scale war conditions should focus on maintaining the efficiency of the "production - processing - storage - supply to the population" chain (NISS, 2023). It is extremely important to increase agricultural production, seek and create new facilities for storage and primary processing of products, and use all possible state and private sector resources to supply food to markets. In the context of post-war recovery, it is necessary to ensure the diversification of agricultural production development based on increasing capitalization and investment attractiveness of agro-enterprises and forming market institutions. This would imply increasing the efficiency of resources used in agriculture, strengthening the country's food resilience, developing diversity, and increasing the export of higher value-added products. There is a need to form a new post-war model for the development of the food system, balancing its cyclical and structural components.

ADDITIONAL INFORMATION

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ПРОДОВОЛЬЧА СТІЙКІСТЬ В УКРАЇНІ ПІД ЧАС ВОЄННОГО СТАНУ

Визначення рівня продовольчої стійкості країни є важливим завданням у зв'язку з необхідністю забезпечення стабільного постачання харчових продуктів у періоди економічних і соціальних потрясінь, особливо під час воєнних конфліктів або інших надзвичайних ситуацій. Для України в умовах бойових дій, що тривають, особливого значення набувають питання продовольчої стійкості та подолання негативних наслідків збоїв у процесах сільськогосподарського виробництва. На сьогодні не існує єдиного науково обґрунтованого підходу до оцінки рівня продовольчої стійкості, який би враховував специфіку кожного регіону та країни загалом, дозволяв проводити аналітичні порівняння й надавати науково обґрунтовані дані для формування ефективних політик у цій царині. Метою цього дослідження є обґрунтування методичних рекомендацій щодо визначення рівня продовольчої стійкості на прикладі України. Відповідно запропоновані методичні рекомендації містять базу індикаторів, яка ґрунтується на відборі тих, які найбільш повно характеризують продовольчу стійкість країни в структурному та циклічному аспектах. Визначено, що рівень продовольчої стійкості країни – це ступінь стійкості, адаптації та відновлення після зовнішніх і внутрішніх потрясінь, які впливають на здатність продовольчої системи забезпечувати населення достатнім обсягом безпечної та поживної їжі. Результати оцінювання рівня продовольчої стійкості за допомогою Інтегрального індексу продовольчої стійкості для України 2022 року свідчать про достатній рівень. У країні хороші умови для продовольчого забезпечення, хоча є певні проблеми в деяких циклічних і структурних аспектах. Система харчування розвинена попри війну, але є можливості для вдосконалення.

Ключові слова: продовольча стійкість, шокові впливи, сільське господарство, державна продовольча політика, воєнна агресія

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