Ensuring Food Security of Ukraine in the Conditions of Globalization Dimensions

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Abstract: The purpose of this article is to develop a model that implements the interaction of food security processes through the resource capacity of regions for self-sufficiency in the identification of threatening factors influencing its reproduction. Methodological support for assessing the food security of the country, which on the basis of targeted analytical studies of its domestic needs, reveals interregional relationships between the volume of its own agricultural production and the factors of import dependence of the state on world markets. Sub-indicators and food security indicators have been identified. Methods of research of food security of the country are substantiated. The level of self-sufficiency of food of Ukraine in agricultural and food products in the administrative centers of the country is calculated. The ratio of production and consumption of agricultural products and food products in Ukraine is substantiated. The ratio of imports to market capacity in the country is given. Partial indicators and integrated risk factors for loss of food security of Ukraine have been established. Predicted indicators of food security by land potential of agricultural production of the country, as well as its dependence on cattle, the level of self-sufficiency in fruits and berries, grain production and consumption are calculated. It is proved that given the strengthening of openness of the national economy, expansion of domestic and foreign agri-food markets, as well as European integration intentions of Ukraine, its level of food security should be carried out in the context of simultaneous evaluation of economic and social indicators and effective management.

Keywords: Food Security; Agricultural Products; Food Independence; Import; Export; Market Capacity.
JEL Classification: Q13, Q18

1. INTRODUCTION

Food security is an important component of the state's socio-economic policy from the standpoint of local and global dimensions, because, along with the undeniable mission of ensuring national sovereignty, it determines its status in the international agri-food arena. Such an important and at the same time multi-vector context of the food security formation of Ukraine envisages, firstly, systematic steps towards making managerial decisions in the area of actively seeking opportunities to increase the potential of food security for social growth. Secondly, it stimulates the need for systematic monitoring of the level of food self-sufficiency and constant identification of consumer needs in affordable, high quality, organic food products. Thirdly, it is necessary to develop indicators for assessing the level of food security in the context of the formation of their individual groups in accordance with the imperatives of strategic development in the field of food security.

Under modern conditions of internationalization of the world market and increasing openness of the national economy, the food sector is one of the most important sectors of the economy of any country, which determines the special role and importance of its final products in meeting the needs of the population. Foods are important and indispensable in human life. Therefore, the development of the food industry and agricultural products, which are the basis of nutrition, is a demographic factor. This factor is essential for meeting the

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natural needs of a man. Therefore, the study of food security is of great importance and urgency.

Currently, research in the field of food security is carried out quite actively, as evidenced by a number of fundamental works on the state of food security, which is determined by the list of existing threats of external and internal nature, as well as improving the regulatory framework. Devoted to the study of the fundamental foundations of the country food security several research works are V. Dankevych, Y. Dankevych and O. Sheheda (2020), I. Fedulova (2014), I. Markina, A. Chykurkova, M. Shkilniak, N. Somych and O. Taran-Lala (2020), V. Ploeg, J. Douwe and H. Renting (2000), A. Shevchenko and O. Shevchenko (2011), V. Shyshliuk and V. Samokysh (2020), M. Sychevskyi (2019), V. Tkachuk, M. Yaremova and L. Tarasovych (2017), S. Urba (2017), O. Yakovenko and O. Cherevko (2016), T. Zinchuk, O. Kovalchuk, N. Kutmus and O. Charutska (2018). Mechanisms and features of food security management in the context of state agricultural policy are revealed in research works N. Kravchuk, L. Tarasovych and M. Yaremova (2017), N. Kutsmus, O. Kovalchuk and V. Dankevych (2017), Ya. Pushak (2012), V. Shoiko (2017), K. Utenkova (2019), M. Zos-Kior, V. Ilin, I. Kyryliuk and O. Solod (2020). Close attention was paid to the substantiation of food security evaluation indicators O. Horniak and O. Saliuk-Kravchenko (2016), H. Kaletnik and O. Damohrai (2016), S. Kozlovskyi, I. Khadzhynov, R. Lavrov, O. Skydan, N. Ivanyuta and N. Varshavska (2019), R. Levkina, I. Kravchuk and I. Sakhno (2019), A. Poltorak (2015), Yu. Yurchenko and V. Antoshkin (2019).

However, the issues related to the mechanisms of forming an effective food security system of Ukraine, comprehensive assessment of its current state, identification of food security trends and identification of risks of possible loss of food independence in different perspectives of different food security scenarios need considerable attention. Because the effectiveness of food security depends on the nature of the structured links of the food subsystems of the regions, the influence of internal and external factors, the balance of interregional and foreign economic relations form a mechanism for supplying food market.

The priority of our study is to develop a model that implements the interaction of food security processes through the resource capacity of regions for self-sufficiency in the identification of threatening factors influencing its reproduction.

2. MATERIALS AND METHODS

Food security is a determinant of sustainable development of the country to develop effective tools for analytical research on the state, trends and prospects of the main factors that affect it, shape the transformation of the economy in general and the agro-industrial sector in particular (Zinchuk et al., 2018). The objectivity of the methodological support for assessing the food security of the country, which on the basis of targeted analytical studies of its domestic needs, reveals interregional relationships between the volume of its own agricultural production and factors of import dependence on world markets (Horniak and Saliuk-Kravchenko, 2016). At the same time, the assessment of the resource potential of agricultural production and quantitative measurement of the degree of its realization by producers is aimed at a system of financial and economic indicators that either reflect the level of food security or are quantitative estimates of factors influencing it. These indicators are defined as development landmarks that reflect the limits of negative processes, giving signals to market participants about possible disadvantages, reducing the global level of national security (Kaletnik and Darmohrai, 2016; Mostova, 2017).

In quantitative terms, indicators reflect the state of food security, which provide an assessment of its various forms of manifestation and factors influencing it. Determining the level (i.e. state) of food security necessarily involves comparing the actual values of the indicators with the desired ones. Instead, values that reflect the desired values of food safety indicators are standards (Soloviova, 2016). It is advisable to include relative indicators in food security indicators, which are defined as the ratio of different food security sub-indicators, the values of which should be as close as possible to each other. An example of this type of sub-indicator is the self-sufficiency coefficients, which are calculated as the ratio of production to consumption and should be as close as possible to each other. That is, the analysis of food security involves the definition of indicators that quantify the processes and phenomena that shape it, as well as the calculation of standards (normative values) of food safety indicators that reflect the discrepancy between actual and desired values (Skydan et al., 2019).

The result of the quantitative assessment of food security is integrated coefficients, which aggregate the values of partial sub-indicators into synthetic food security coefficients. The hierarchy of food safety quantitative assessments is determined by the set of processes, objects and phenomena that shape food security, taking into account all analytical sources of assessment methods. Such methodologies include national and international methodological approaches (including the FAO methodology) (Fig. **1**).

An integrated system of food security indicators should be distributed depending on the impact on the formation of the security process itself. Given the methodology of structural modeling, the process of food security formation can be represented as a gradual transformation of input parameters (signals) into output results (Kozlovskyi et al., 2019). The input signals are the resource potential of the country (region). Output signals are directly the level of food security, which in quantitative terms takes the form of its indicators (Skrypnyk and Starychenko, 2017).Two types of factors influence the process of transformation of resources into food security, namely: 1) factors of direct influence – processes that are directly involved in the transformation of inputs into outputs; 2) factors of indirect influence – factors that affect the efficiency of conversion of inputs to outputs.

The processes during which security is formed (i.e. the transformation of inputs into outputs), are appropriately include: food production (including agricultural production, processing); distribution of available food (distribution between regions, formation of conditions in domestic food markets); food consumption. Among the factors of direct influence, we must also take into account the efficiency of agrarian (especially agricultural) producers (Poltorak, 2015).

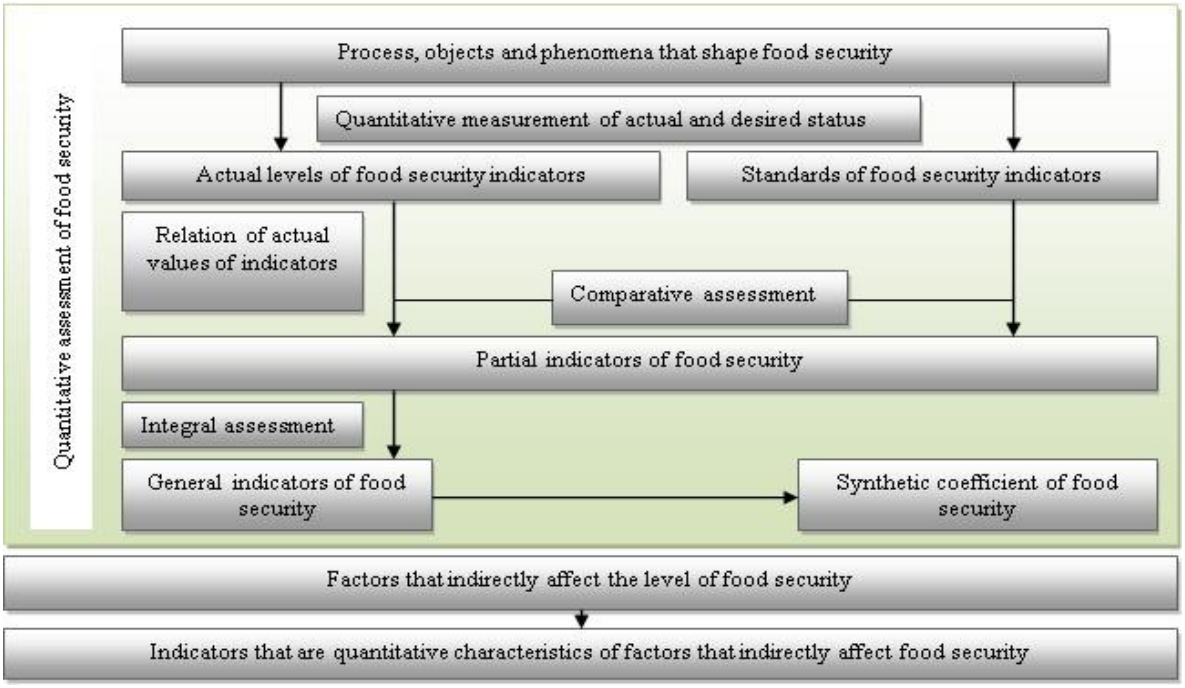

Fig. (1). The structure of quantitative assessments of food security of the country.
Source: improved by the authors according to data (Soloviova, 2016; Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020; The State of Food Security…, 2018).

Quantitatively, most direct action factors take the form of food security indicators. The main factors that do not shape, but significantly affect the level of food security are the situation on world markets, domestic and international policy (in the field of market, including customs, regulation, tax and fiscal policy, land market policy, etc.), inflationary processes in the state (Yakovenko and Cherevko, 2016). Given the above logic, in Table **1** we systematize sub-indicators and indicators of food security of the state.

Table 1. Sub-indicators and Indicators of Food Security.

Sphere of the Formation	Food Safety Sub-Indicators	Food Security Indicators
Formation of resource potential	Available volumes of resources (area of agricultural land, arable land, number of rural population employed in agriculture, cost of material resources), potential volumes of food production	The degree of realization of resource potential
Food production	Production volumes, production costs (in particular, cost structure) Indicators of agricultural production efficiency and activities of agriculture enterprises	The level of self-sufficiency in food, the ratio of production and consumption
	Stock levels of strategic types of agricultural products	Adequacy of reserves
Distribution of food	The share of food consumed in the region, which was produced in other regions	–
	Exports and imports	The ratio of imports to market capacity, imports to exports
	Domestic prices, the value of the consumer basket, household income, average wages	The ratio of the value of the food basket to wages and income (economic affordability)
	The structure of food distribution by sales channels, the presence of a retail network per 10 thousand people, the number of outlets in food markets per 10 thousand people, the state of development of wholesale food products, the density of public paved roads and railway tracks	–
Consumption	Volumes of food consumption by region (in physical units)	The ratio of actual and regulatory consumption
	Volumes of food consumption per capita (in physical units and in terms of proteins, fats and carbohydrates), energy value of the daily diet – actual and regulatory indicators	
	Volumes of food consumption by quintile (20%) by groups depending on the amount of total income	–

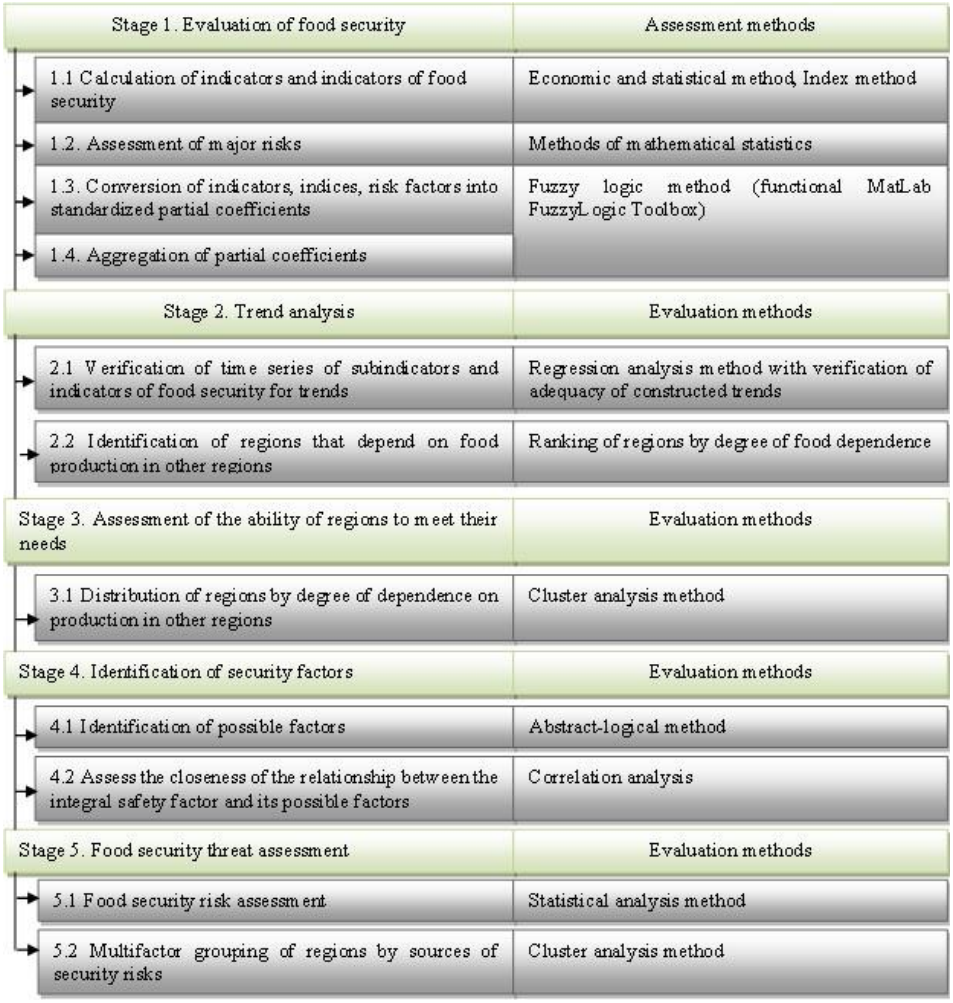

Fig. (2). Research methods of food security of the country.
Source: improved by the authors according to data (Soloviova, 2016; Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020).

	Consumer price and income index	Ratio of consumer price indices to inflation and wage (income) indices

Source: improved by the authors according to data (Yakovenko and Cherevko, 2016; Soloviova, 2016; Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020).

To measure the level of food security, the theory of fuzzy sets is used, on the basis of which we determine: food security sub-indicators, which are distributed according to the nature of the impact on the spheres of resource provision (indicators of resource potential), production and consumption. In addition, a category of assessments should be identified that will reflect the level of risk of adverse fluctuations in the main sub-indicators. Such estimates include the coefficient of semi-variation, which reflects the variation (variability) of fluctuations around its average value in the unfavorable direction for the country. The higher the value of this factor, the higher the risk and the lower the level of food security. As a result, a vector of food safety sub-indicators Xwas formed (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020):

$$X = \{x_1, x_2, \dots x_i, \dots x_n\}, \quad (1)$$

where, $x_1, x_2, \dots x_i, \dots x_n$– the first, second, …, i-th, …, n-th sub-indicator of food security; n– the number of food security sub-indicators;

threshold levels of each of the food security sub-indicators, as well as risks. In order to simplify the assessment methodology as much as possible, it is necessary to focus on minimizing the limit values of sub-indicators and indicators by risk factors (for example, low, medium and high levels);

the ratio of the actual value of each of the sub-indicators and indicators with dimensionless partial coefficients. It should be noted that the partial coefficients must be characterized by the same dimension and be distributed in the range from 0 to 1;

food security in the MatLab environment of the MatLab Fuzzy Logic Toolbox functionality.

Fig. (**2**) summarizes the methodology for assessing the country food security, which includes the stages of assessing its

current state, as well as analysis of trends in food interdependence with identified factors that provoke a threat to the country self-sufficiency in agricultural products.

Systematization of the results of the analysis according to the methodology allows to get the perception of the integrated state of food security of the country and regions in the current period with the identification of trends of external threats and promising areas to strengthen resource potential, given the strengthening of competitive positions of agricultural producers in European and world food markets.

Thus, the cluster analysis allows to generalize results of self-sufficiency of regions of the country with food on integral sub-indicators which are divided into such: sub-indicator of self-sufficiency with meat and milk, sub-indicator of self-sufficiency with all basic kinds of food and sub-indicator of dynamics of self-sufficiency with food products (formulas (2)-(4)) (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020).

$$K_i^m = \frac{1}{2}\left(\frac{k_{i_{meat}}^f}{k_{i_{meat}}^{max}} \frac{k_{i_{milk}}^f}{k_{milk}^{max}}\right), \quad (2)$$

$$K_i^g = \frac{1}{n}\sum_{j=1}^{n\Sigma} \frac{k_{ij}^f}{k_{ij}^{max}}, \quad (3)$$

$$K_i^d = \frac{1}{n}\sum_{j=1}^{n\Sigma} \frac{k_{ij}^{df}}{k_{ij}^{dmax}}, \quad (4)$$

where, K_i^m, K_i^g– integrated sub-indicators of self-sufficiency of the i-th region of the country, respectively, with meat and milk, as well as with all food products; K_i^d – sub-indicator of the dynamics of self-sufficiency of the i-th region of the country with food; $k_{i_{meat}}^f$,$k_{i_{milk}}^f$ – actual values of self-sufficiency coefficients of the i-th region of the country, respectively, with meat and milk; $k_{i_{meat}}^{max}$, k_{milk}^{max} – the maximum average value of all regions of the country in terms of self-sufficiency indicators of the first type with meat and milk; k_{ij}^f – the actual value of sub-indicators of self-sufficiency of the i-th region with j-th food product; k_{ij}^{max}, k_{ij}^{dmax} – respectively, the actual and maximum average value of all regions of the country in terms of the average annual growth rate of self-sufficiency of the i-th region with j-th product; n– the amount of food.

Most growth rates are negative. In this case, the calculation of the integrated self-sufficiency indicator by formula (4) is impossible. To solve this problem, the initial levels of growth rates are adjusted by formula (5) (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020):

$$K_{ij}^{df'} = k_{ij}^{df} + \left|min_j k_{ij}^{df}\right|, K_i^d = \frac{1}{n}\sum_{j=1}^{n} \frac{k_{ij}^{df'}}{k_{ij}^{dmax}} \quad (5)$$

where, $K_{ij}^{df'}$, K_i^d – adjusted and actual value of the average annual growth rate of self-sufficiency of the i-th region with j-th food product.

Based on fuzzy estimates, the values of integrated self-sufficiency indicators are divided into three groups, which correspond to low ("L"), medium ("M") and high ("H") levels:

self-sufficiency indicator for meat and milk: 0-0.6 – low level; 0.61-0.8 – average level; over 0.8 – high level;

sub-indicator of self-sufficiency for all types of food: 0-0.4 – low level; 0.41-0.7 – average level; over 0.7 – high level;

sub-indicator of self-sufficiency dynamics: 0-0,7 – low level; 0,71-0,9 – average level; over 0,9 – high level.

The generalized synthetic indicator of self-sufficiency of the regions of Ukraine in food is a function of three variables (Skydan et al., 2019; Skrypnyk and Starychenko, 2017; Skydan and Hrynyshyn, 2020):

$$K_i = f(K_i^m, K_i^g, K_i^d), \quad (6)$$

where,K_i^m, K_i^g– integrated sub-indicators of self-sufficiency of the i-th region of the country, respectively, with meat and milk, as well as with all food products; K_i^d– an integral sub-indicator of the dynamics of self-sufficiency of the i-th region of the country with food.

3. RESULTS AND DISCUSSION

The basis for effective food security is the potential value of agricultural products, which increases the functionality of the regions, in the context of using the productivity of land, labor and monetary resources as the most effective administrative centers. Analysis of the level of realization by agricultural producers of Ukraine of their resource potential, given the specificity of their food direction, is related to the study of trends in agricultural production and related indicators of economic efficiency of agricultural enterprises (profitability, productivity). According to Table **2**, there is a negative trend in the use of labor and monetary resources by agricultural producers of Ukraine. The use of labor resources in Kyiv region is the most effective (2017-2021). At the same time, the maximum value of gross agricultural output per one EUR of invested funds is typical for Volyn and Chernivtsi regions. In general, using the experience of the most productive regions of Ukraine, we note that to increase the total volume and value of gross agricultural output by 70-80% is possible by increasing the efficiency of land use and in 2-4 times – by increasing efficiency of the use of labor and capital resources.

Table 2. Indicators of the Level of Realization of Resource Potential of Ukraine.

Indicators	2017	2018	2019	2020	2021
Ukraine					
The cost of agricultural production per 1 thousand hectares of agricultural land, million EUR	0.198	0.189	0.201	0.197	0.214

The cost of agricultural products per 1 thousand employed in agriculture, million EUR	2.66	2.73	2.91	2.85	3.00
The cost of agricultural products per 1 EUR of production cost, EUR	0.078	0.034	0.029	0.020	0.020
Maximum value among the administrative centers of the country					
The cost of agricultural production per 1 thousand hectares of agricultural land, million EUR	0.299	0.330	0.346	0.332	0.336
The cost of agricultural products per 1 thousand employed in agriculture, million EUR	8.72	9.40	10.78	9.98	12.44
The cost of agricultural products per 1 EUR of production cost, EUR	0.189	0.219	0.199	0.156	0.150
The potential value of gross agricultural output, including available resources, million EUR					
Land resources	13104.11	13691.84	14379.85	13770.32	14002.27
Labor resources	25378.98	26977.39	30901.61	28555.38	36534.55
Capital resources	1884.74	19057.17	20184.54	27261.10	23546.43
Deviation of the potential value of gross output from the actual one, %					
Land resources	2.78	2.44	2.37	2.25	2.77
Labor resources	7.99	8.86	8.19	10.29	10.38
Capital resources	4.21	4.68	4.65	7.67	5.47

Source: calculated by the authors according to data (Global food safety…, 2018; Global food security…, 2016; Norms of physiological needs…, 2017; Osaulenka, 2019; Balances and consumption of basic…, 2020).

From the standpoint of ensuring food security of strategically important agricultural products, sub-indicators of the level of self-sufficiency in food of administrative centers of Ukraine in the ratio of production and consumption in each of them, show a trend of gradual decline (Table **3**).

Table 3. The Volume of Food Production in Ukraine.

Indicators	**2017**	**2018**	**2019**	**2020**	**2021**
Agricultural products, million tons					
Cereals and legumes	63.86	60.13	66.09	61.92	70.06
Sunflower seeds	10.13	11.18	13.63	12.24	14.17
Potatoes	23.69	20.84	21.75	22.21	22.50
Vegetables	9.64	9.21	9.41	9.29	9.44
Meat	2.36	2.32	2.32	2.32	2.35
Milk	11.13	10.62	10.38	10.28	10.06
Eggs, million units	19.59	16.78	15.10	15.51	16.13
Foodstuffs, thousands tons					
Sausages and similar products, of meat, meat offal or blood of animals and similar products and food products based on them	54.1	228.8	51.4	247	248
Milk and cream, not condensed or containing added sugar	223	3715.8	209.5	5276.8	5148.6
Milk and cream, not condensed or containing added sugar	310	472.3	267	478.2	496.7
Milk and cream, coagulated, yoghurt, kefir, sour cream	108.5	297.5	101	272.4	275
Flour, wheat or rye flour	141	2056.4	139.8	1974.3	1746
Bread and bakery products	163.2	1232	163.7	1072.6	975.1

Source: calculated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020).

Therefore, the most significant decline is characteristic of livestock products. Increasing the production of sunflower seeds should be considered in the context of conquering world markets and increasing the competitiveness of the agricultural sector of Ukraine. We can apply the same to the positive dynamics of production of cereals and legumes in Ukraine. Food production volumes have a steady and pronounced tendency to increase. This is especially true of oil, flour, bread and bakery products. At the same time, it should be emphasized that the need of the population of Ukraine for animal protein is met mainly through the consumption of meat, rather than products of its processing. Therefore, in addition to increasing the production of sausages, the development of meat industries is relevant.

The level of self-sufficiency in a particular type of product reflects how many percent of its production is greater than the norm of consumption. Therefore, if the level of self-sufficiency of a country (region) is greater than 1, we can argue that it is able to provide the minimum necessary needs for the product.

Ukraine is unable to meet domestic needs for fruits and berries, meat, milk, bread and bakery products. The declining dynamics of the level of self-sufficiency of Ukraine for all (except fruits, berries and meat) types of food products is unfavorable (Fig. **3**).

The ability to self-sufficiency in meat and milk within 12.5%is demonstrated by three administrative centers of

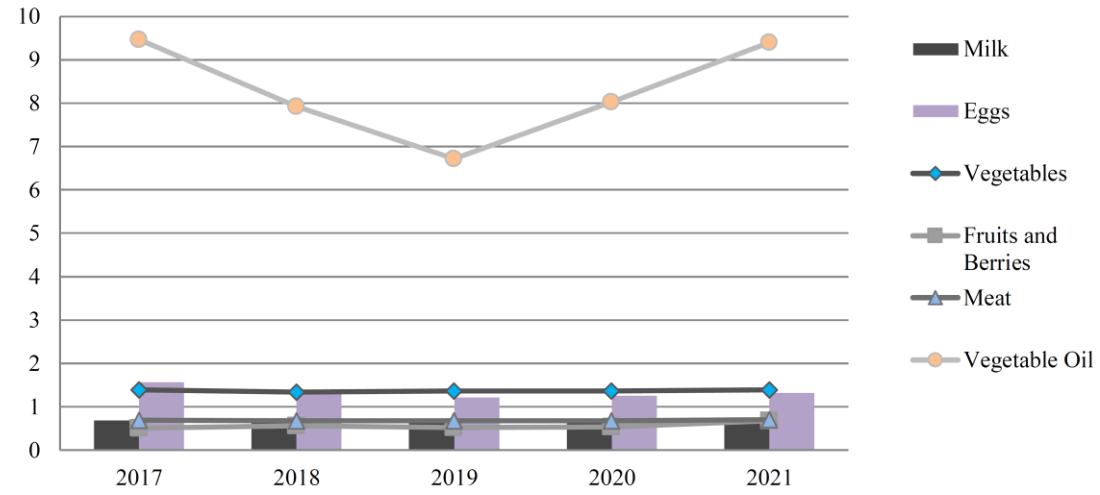

Fig. (3). The level of food self-sufficiency in Ukraine for 2017-2021.
Source: generated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020).

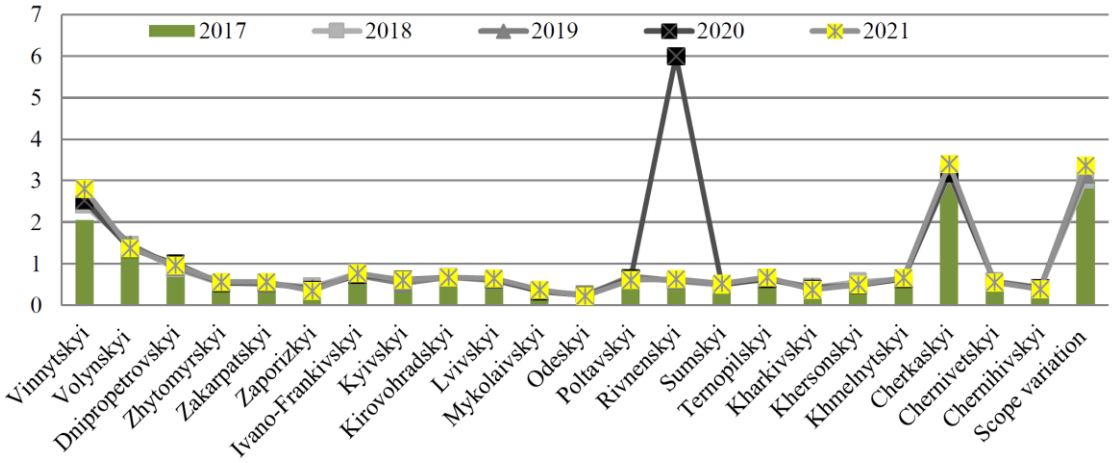

Fig. (4). The level of self-sufficiency in meat of the administrative centers of Ukraine for 2017-2021
Source: calculated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020; Development of trade and consumer protection, 2021).

Ukraine, namely: Vinnytsia, Volyn and Cherkasy regions (Fig. **4**).

Mykolaiv and Odesa regions are the most dependent on foreign production. However, in almost 60% regions during 2017-2021 there is a tendency to reduce the level of self-sufficiency in meat. The magnitude of the variation (the difference between the minimum (in Chernihiv region (0.39) – and the maximum (in Cherkasy region(3.40)) values of the level of self-sufficiency in meat in 2021 was 3.36, that in 8.7 times more (against 6.4 times in 2017) than in Chernihiv region. This trend is a negative challenge to the food security of the country.

One of the least supplied with own milk is Dnipro region (24% from the minimum need), which, at the same time, is almost 100% provided with its own meat production (Fig. **5**).

For all types of both agricultural and food products, there is an excess of the ratio of production to consumption (Fig. **6**).

In particular, during 2017-2021 there was a significant increase in exports, mainly to all strategically important product groups for the country food security. The only exceptions were fruits and berries, the export of which decreased by about 5%. every year. As for the volume of imports, along with the increase in exports of potatoes, vegetables, eggs, milk and dairy products, the volume of their imports decreased significantly (by 30%, 16%, 43% and 50%, respectively). The above gives grounds to claim that during 2017-2021 there was a strengthening of food security of Ukraine within these types of food.

The annual increase in exports of meat and meat products is about 16%, milk and dairy products – 12%, vegetables – by 10%. However, in parallel with these trends, there is a growing trend of imports of meat and meat products (annually 9%). As the growth of the ratio of imports to market capacity (by 46% for 2017-2021) is unfavorable for the food security of Ukraine, we checked the ways of redirection of meat imports to the domestic market (Figure **7-8**).

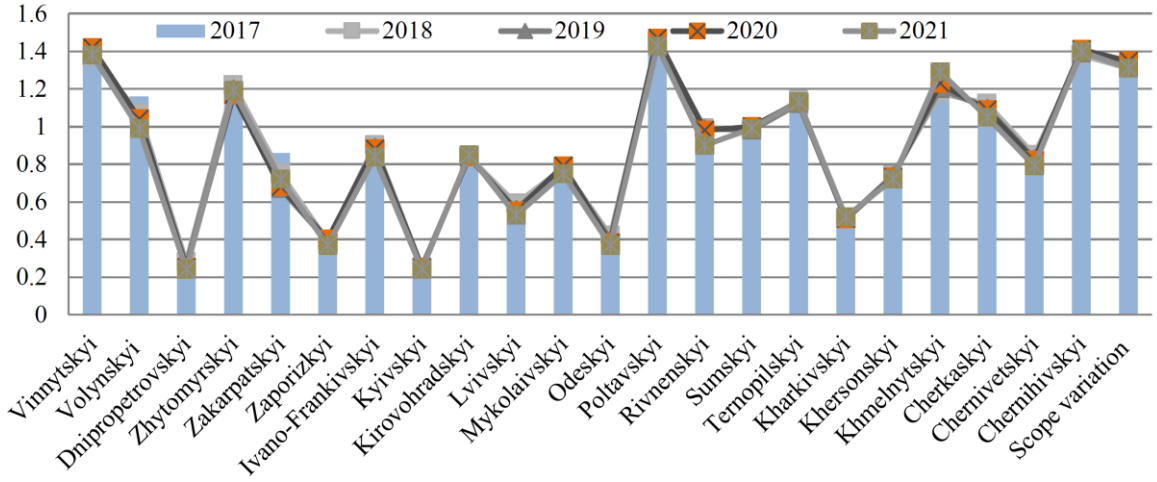

Fig. (5). The level of self-sufficiency in milk of the administrative centers of Ukraine for 2017-2021.
Source: calculated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020; Development of trade and consumer protection, 2021).

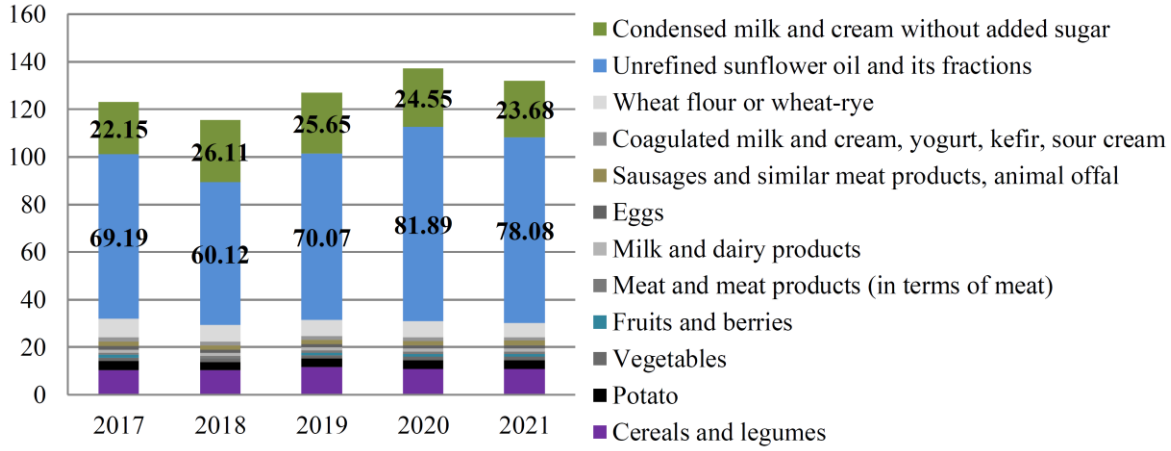

Fig. (6). The level of the ratio of production and consumption of agricultural products and food products in Ukraine for 2017-2021.
Source: calculated by the authors according to data (Balances and consumption of basic…, 2020; Meyers et al., 2018; Prokopenko, 2019; Rozhko, 2020; Development of trade and consumer protection, 2021).

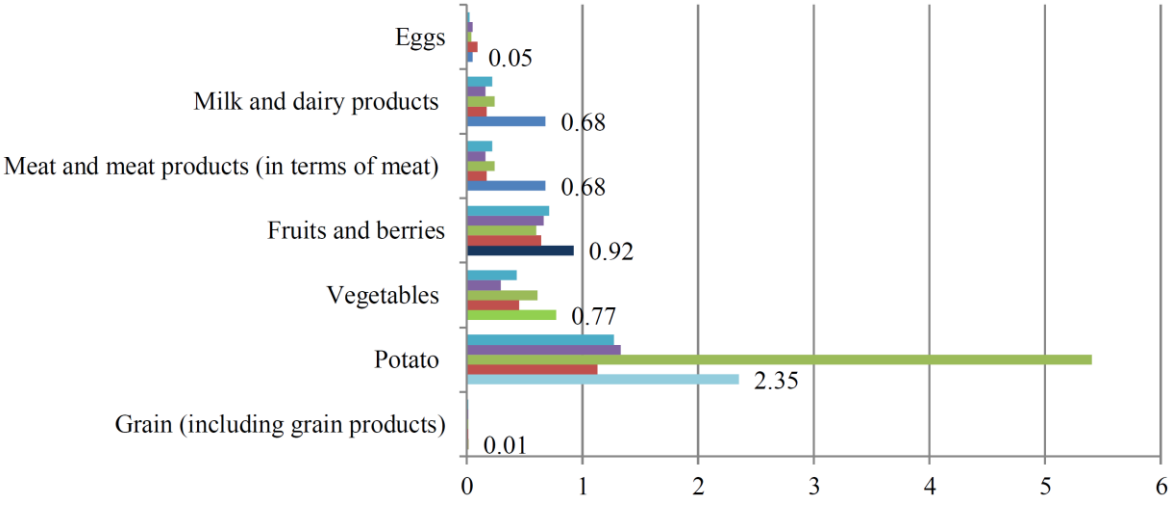

Fig. (7). The ratio of imports to exports in Ukraine for 2017-2021
Source: calculated by the authors according to data (Meyers et al., 2018; Development of trade and consumer protection, 2021; Fryzorenko, 2019).

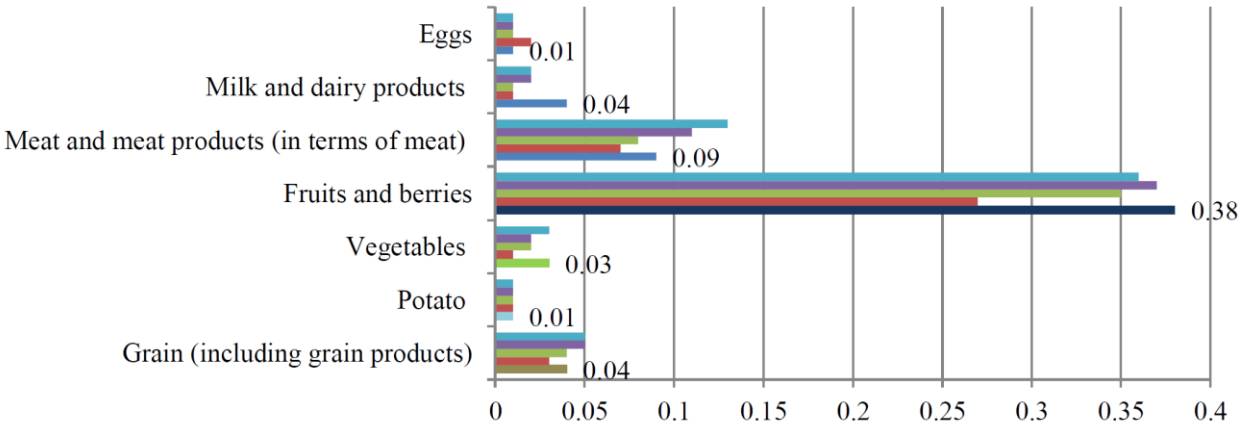

Fig. (8). The ratio of imports to market capacity in Ukraine for 2017-2021.
Source: calculated by the authors according to data (Meyers et al., 2018; Development of trade and consumer protection, 2021; Fryzorenko, 2019; Food security strategies…, 2020).

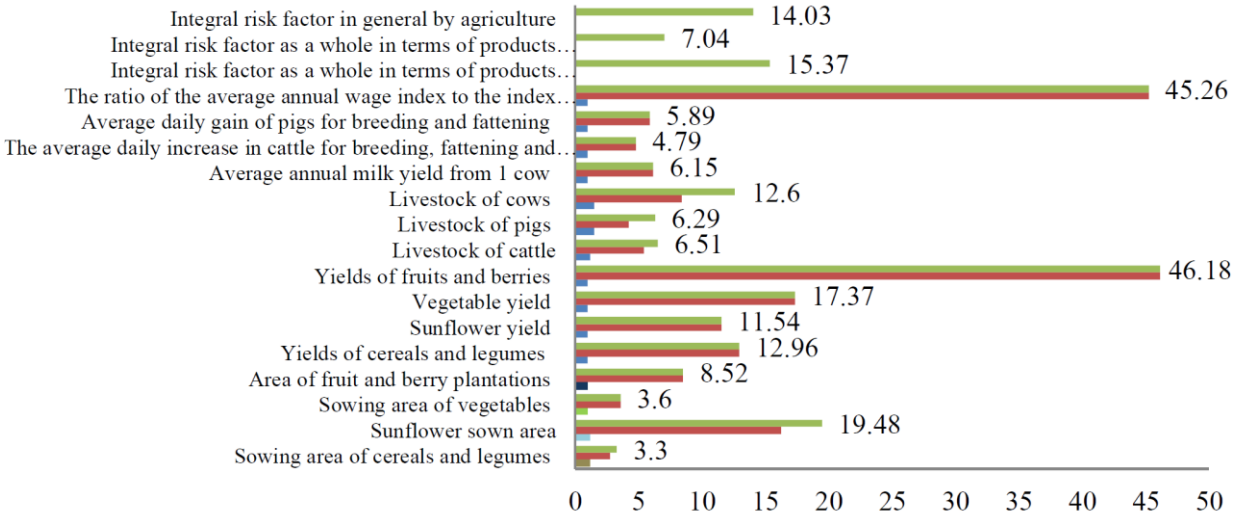

Fig. (9). Partial indicators and integrated risk factors for the loss of food security of Ukraine.
Source: calculated by the authors.

The country food security is always accompanied by threats and risks of losing food independence. Trends in food security in Ukraine involve the use of risk management tools in terms of each of the groups of food security indicators that operate in both domestic and foreign markets in the field of resource potential, food production, and food distribution and consumption.

Based on dynamic series, the risk coefficient of negative deviations of crop yields and livestock is determined, level trends are constructed and coefficients of semi-variation, loss of food independence are calculated (sown area, population and ratios of wage indices and inflation) by formula (7) (Kozlovskyi et al., 2019; Levkina et al., 2019):

$$r_i = \omega_i \times SSV_i, \quad (7)$$

where, r_i– the risk factor for negative fluctuations of the i-th food security indicator; ω_i– the coefficient of risk weight of negative fluctuations of the i-th indicator of food security; SSV_i– the coefficient of risk of negative fluctuations of the i-th indicator of food security.

For indicators with elasticity coefficients from 0.1 to 1, the weights are set at 1.2, and from 1 to 2-1.5. For other risk indicators, the coefficients of elasticity are equal 1. The calculated risk indicators are presented in Fig. (**9**).

The established levels of risk in crop production and animal husbandry confirm that the risks in animal husbandry are much lower than in crop production. The integrated risk factor in the field of crop production is 15.37, livestock – 7.04. The weighted risk factor for agriculture as a whole is 14.03. The high risk of losing food independence in the field of crop production indicates the need for active action in this direction by the state. The declining trend in livestock is seen as a manifestation of low risk, but confirms the high probability of declining livestock production due to well-predicted and determined factors. The coefficient of semi-variation in calculating the ratio of the average annual wage index to the consumer price index at the level 45.26% indicates an in-

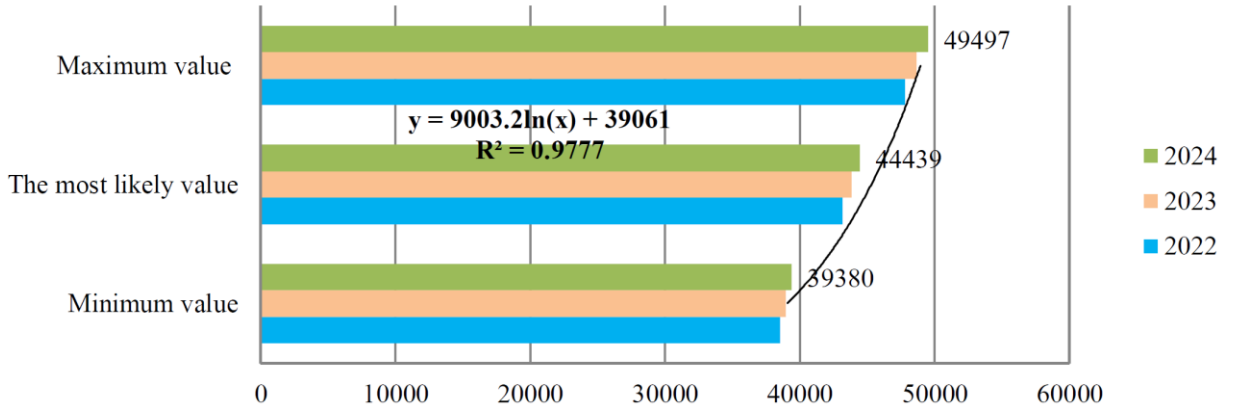

Fig. (10). Indicator of food security by land potential of agricultural production in Ukraine for 2022-2024
Source: calculated by the authors.

creased risk of negative fluctuations in the economic affordability of food in Ukraine.

An effective food security system, as one of the key tools and at the same time an indicator of assessing the quality of life of citizens, is the key to sustainable development of Ukraine in the context of globalization. Its formation is influenced by various factors of the internal and external environment (the binary nature of such influence is defined by local and global determinants) (Strategy for the development of the agricultural…, 2013). Timely identification of existing and potential threats to food security involves assessing existing trends in its main indicators and further forecasting them. Carrying out the corresponding researches allows to form the forecast model of the development of key parameters of food safety and to establish, in what direction sources of its formation within the formed system change (Mostova, 2017).Thus, the results of regression analysis of the food security indicators in Ukraine show the lack in trend of changing the level of self-sufficiency in milk, the ratio of imports and market capacity of milk and eggs, the ratio of actual and regulatory consumption of meat and meat products, milk and dairy products, eggs. An increase in the area of agricultural land, the level of self-sufficiency in fruits and berries, the ratio of production and consumption of grain, imports and capacity of the grain market is defined (Table **4**). Instead, the number of cattle and the ratio of imports to the capacity of the vegetable market tend to decrease.

Table 4. Results of Regression Analysis of the Food Security Indicators (Resource Potential, Food Production and Distribution).

Indicator	Model Type	Trend Equation
Area of agricultural land	Linear	$y = 35000.14 + 629.12t$
Livestock of cattle	Growth	$Y = e^{8.62-0.4t}$
Self-sufficiency in fruits and berries	Degree	$y = 0.32t^{0.256}$
Ratio of grain production and consumption	Linear	$y = 34.731 + 60.691t$
Ratio of grain imports to market capacity	Degree	$y = 0.17t^{0.438}$
Ratio of vegetable imports to market capacity	Logarithmic	$y = 0.054 – 0.014\ ln\ (t)$

Source: calculated by the authors.

On the basis of the built models the scenario forecasts of indicators of the food security of Ukraine (resource potential, production and distribution of food) for 2022-2024 are constructed (Figure **10**-**15**)).

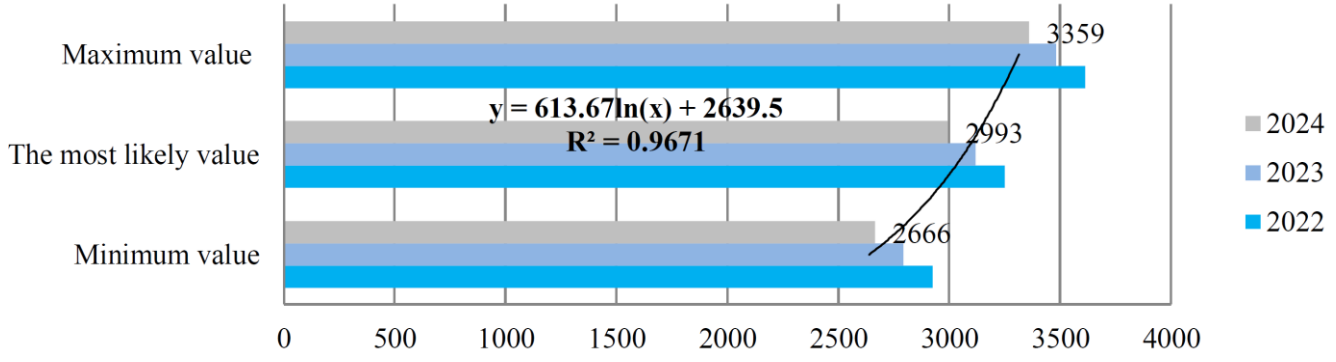

Fig. (11). Indicator of the food security for livestock of agricultural production in Ukraine for 2022-2024
Source: calculated by the authors.

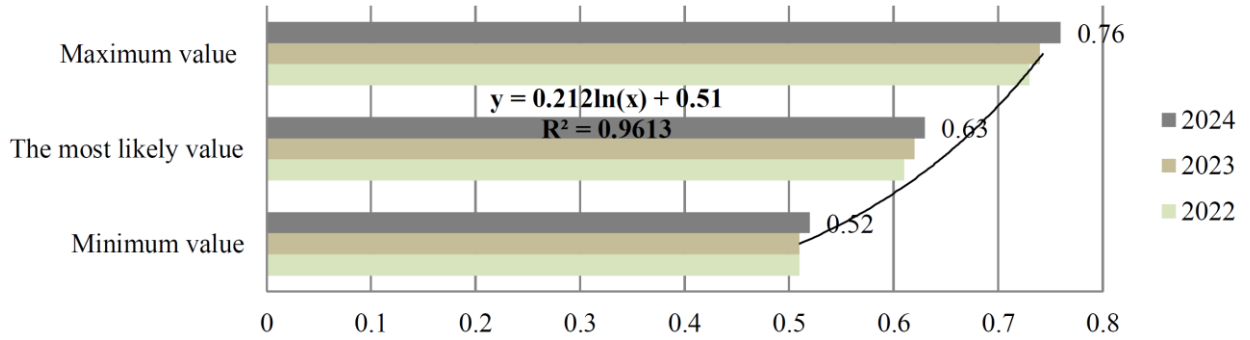

Fig. (12). Indicator of the food security on the level of self-sufficiency in fruits and berries of agricultural production of Ukraine for 2022-2024
Source: calculated by the authors.

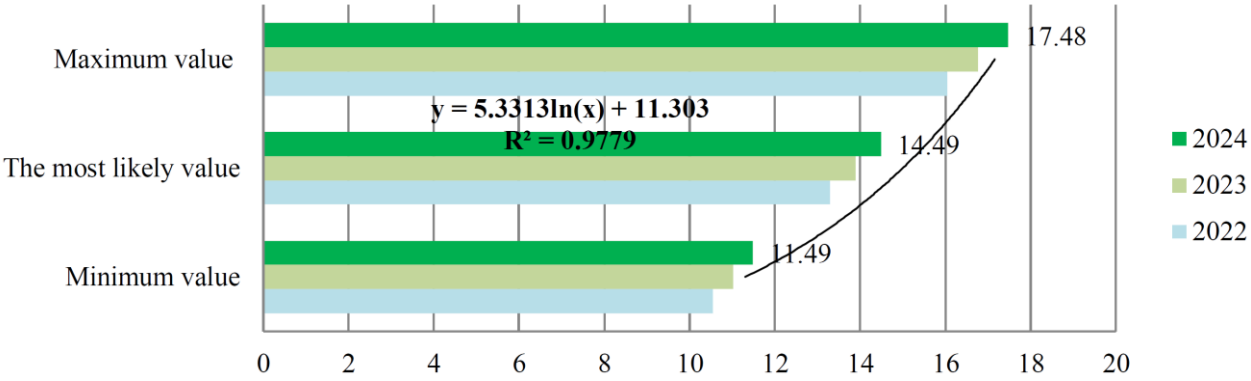

Fig. (13). Indicator of the food security in the ratio of grain production and consumption in Ukraine for 2022-2024
Source: calculated by the authors.

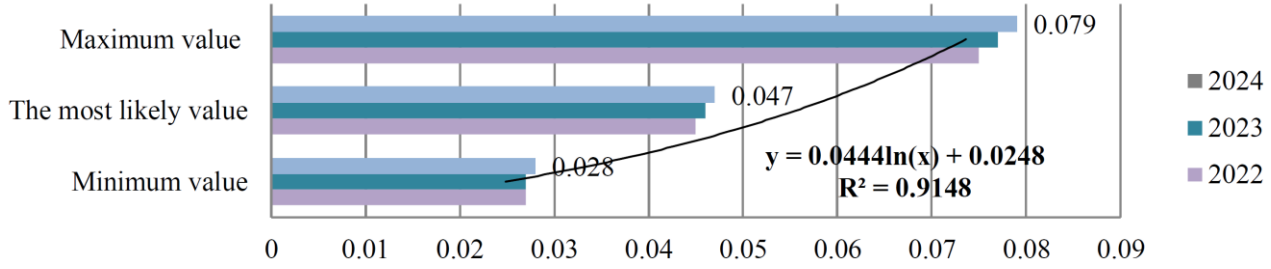

Fig. (14). Indicator of the food security in the ratio of grain imports to market capacity in Ukraine for 2022-2024
Source: calculated by the authors.

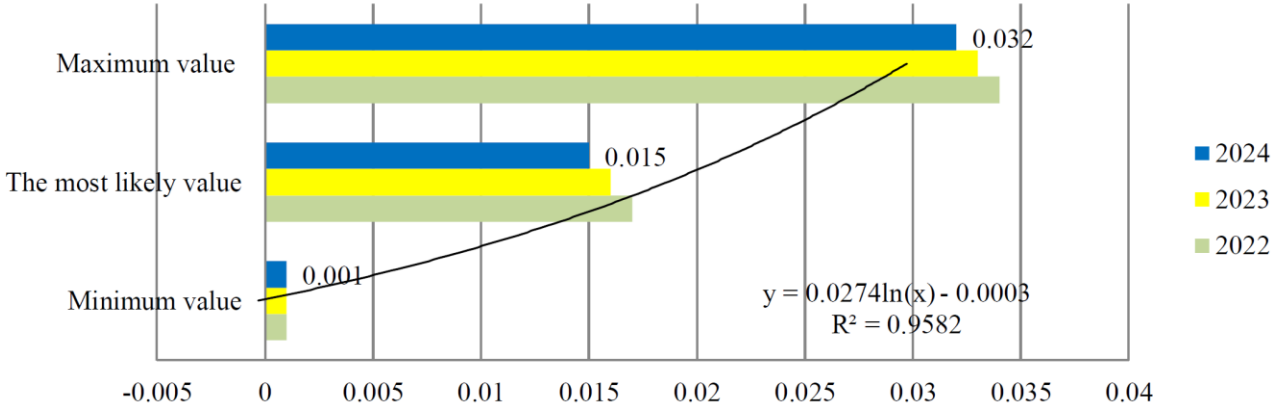

Fig. (15). Indicator of food security in the ratio of vegetable imports to market capacity in Ukraine for 2022-2024
Source: calculated by the authors.

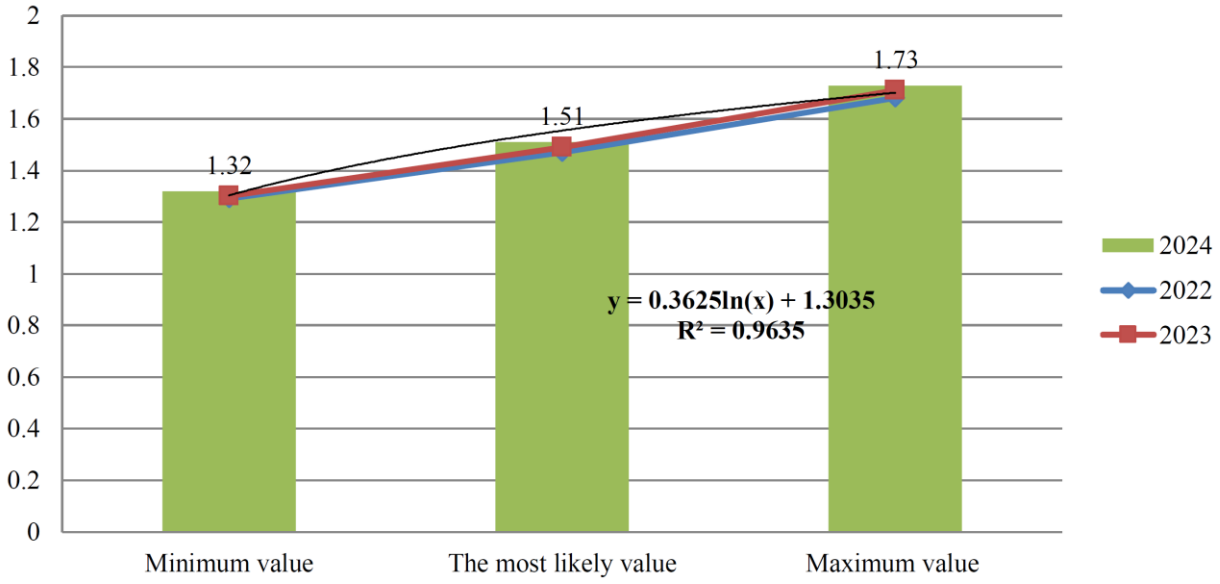

Fig. (16). Indicator of the food security by the level of self-sufficiency in vegetables in Ukraine for 2022-2024.
Source: calculated by the authors.

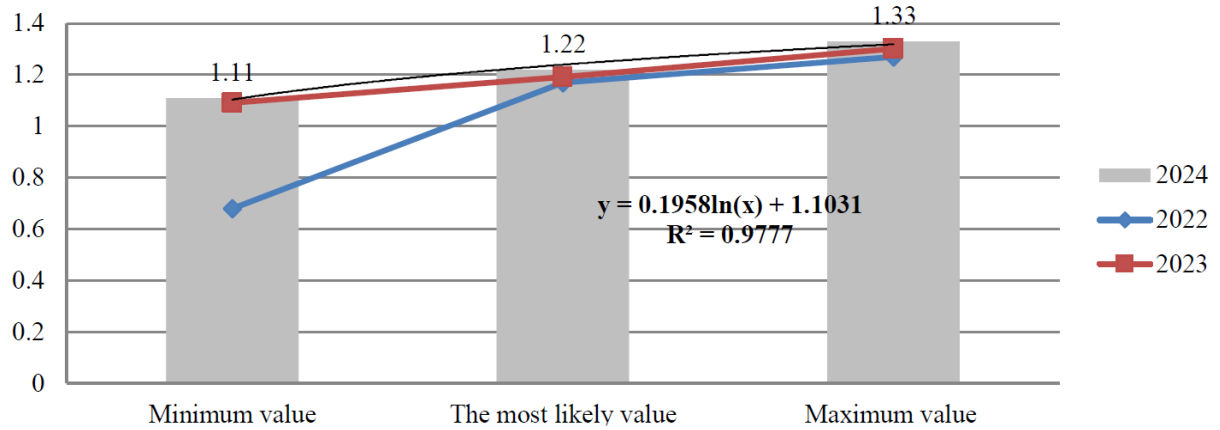

Fig. (17). Indicator of the food security by the level of self-sufficiency in meat in Ukraine for 2022-2024.
Source: calculated by the authors.

Among the positive forecasts, we note the maximum possible reduction in vegetable imports in the case of an optimistic scenario. Significant expected growth is characterized by the ratio of grain production to consumption (approximately 14%), which is due to the potential increase in its production. In the case of relative stability of external and internal conditions, we can expect an increase in the level of self-sufficiency of Ukraine in fruits and berries by 2.6-4.4%. Instead, a previously declining trend in livestock, all other things being equal, could lead to a reduction in livestock by 10-13% during 2022-2024.

The forecast results show a positive dynamics of growth in the level of self-sufficiency in meat (growth by1.3-1.6% annually). However, even with an optimistic forecast, Ukraine is unable to ensure full independence in meat products and meet the physiological needs of the population. Therefore, it is strategically important not to support the existing trend, but to create conditions for its change in the direction of acceleration. The ratio of milk production to consumption will remain virtually unchanged. In particular, it is expected that Ukrainian agricultural producers will continue to cover the domestic demand for milk, but will not create reserves in the case of force majeure and a basis for increasing exports of agricultural products of this type.

It is established that according to the coordinated time series, the dynamics of most food security indicators is described by increasing degree functions (Table **5** and Figure **16-19**).

Table 5. Results of Regression Analysis of the Food Security Indicators of Ukraine (Smoothed Time Series)

Indicator	Model type	Trend Equation
Self-sufficiency in vegetables	Degree	$y = 0.982t^{0.163}$
Self-sufficiency in meat	Degree	$y = 0.450t^{0.194}$
The ratio of production of fruits, berries, grapes to consumption	Growth	$y = e^{-0.76+0.1t}$
The ratio of egg production to consumption	Degree	$y = 1.217t^{0.55}$

Source: calculated by the authors.

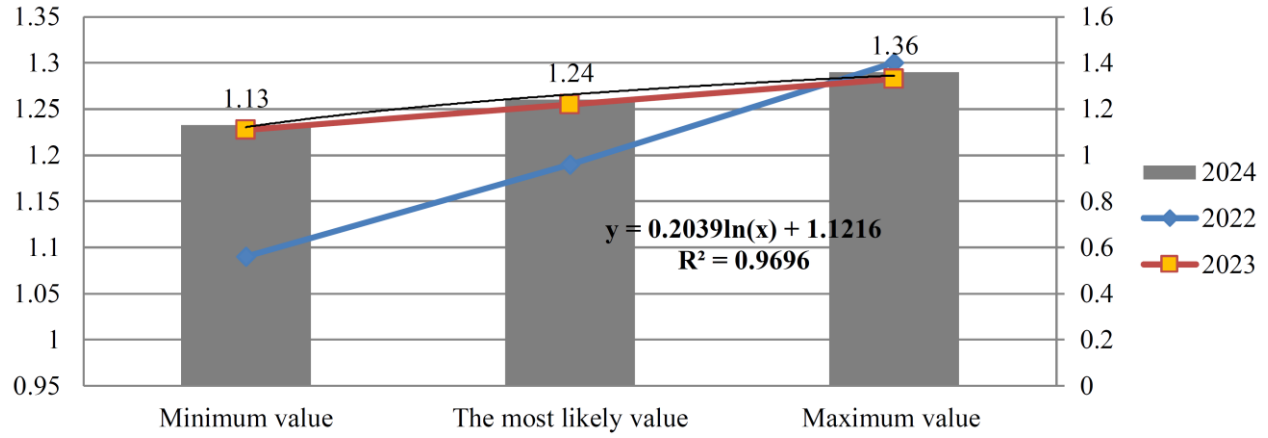

Fig. (18). Indicator of the food security in the ratio of production and consumption of fruits and berries in Ukraine for 2022-2024. Source: calculated by the authors.

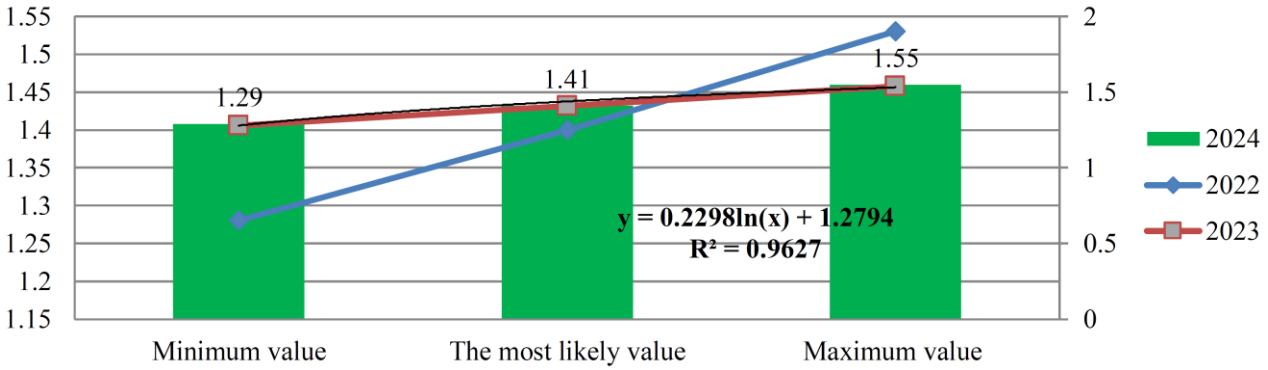

Fig. (19). Indicator of the food security in the ratio of milk production and consumption in Ukraine for 2022-2024. Source: calculated by the authors.

The largest increase in food security is in terms of production and consumption of fruits, berries and grapes – by 4.8-7.2% for 2022-2024. However, given that the demand for these products is met by more than a half, such growth is also insufficient. The best situation is with the ratio of production and consumption of vegetables, which will gradually increase. It is expected that the needs of the population of Ukraine in vegetables will also be fully met.

We summarize the trends of changes in the food security indicators of Ukraine. In the context of its strengthening, it is necessary to note such dynamics. First, we expect a rapid reduction in cattle by 10-13% during 2022-2024. Second, the ratio of grain production to consumption is expected to increase (by 14% for 2022-2024). Third, the level of self-sufficiency in fruits and berries is projected to increase by 4-6% at a moderate level of risk of reduced yields of fruits and berries. Fourth, the level of self-sufficiency in vegetables is expected to increase by 3-4%.

Given the increasing openness of the national economy, expanding domestic and foreign agri-food markets, as well as European integration intentions of Ukraine, the level of food security should be carried out in the context of simultaneous assessment of economic and social indicators and effective governance. Prompt response to changes and restructuring of the state food policy is the result of systematic monitoring of the formative resource potential during changes in the food basket and the definition of strategic priorities of socio-economic growth.

4. CONCLUSIONS

Thus, a more rational use of world food and agricultural resources is possible only if the food security system of the country is created at the national and local levels. Certain risks of the developing regions in specific territorial and sectoral conditions encourages the state to implement a set of international standards and requirements of other countries and actively address urgent issues at the national and local levels to minimize threats to the economy of agriculture and other spheres. It will ensure the food security and economic interests of economic entities, taking into account the needs of citizens. Ukrainian producers of food products and raw materials directly have to compete in the markets with representatives of this business, which have more developed resource potential and a sufficient amount of state support, better technological security and so on. That is why it is necessary to form a balance of domestic food supply, in the presence of modern doctrine of food security and ensure the effectiveness of the mechanism of public management of its implementation.

In the field of food security of Ukraine, state support policy should provide a platform to increase opportunities to overcome threats to the development of agro-industrial complex,

which should be based on regional and local public-private partnership programs, combined with national health policy and key national priorities of security in the international arena. At the same time, the systematization of key provisions of world practices, in the context of food security regulation policy, will identify a number of effective tools for state regulation of market pricing and product quality, support for social policy and meet the needs of the population. At the same time, the formation of an appropriate legal and institutional platform to ensure the balance of the "production – consumption" of food products should encourage agribusiness in the regions to clearly and effectively implement the functions of food security institutions, with clear steps to determine the imperatives of the growth and enhancing the independence of the food continuum (production, processing, storage, transportation, marketing and consumption) in the food infrastructure.

CONFLICT OF INTEREST

There is no conflict of interest.

REFERENCES

Balances and consumption of basic food products of the population of Ukraine. Statistical collection. (2020). http://www.ukrstat.gov.ua/druk/publicat/Arhiv_u/07/Arch_spog_zb.htm.

Dankevych, V.Y., Dankevych, Y.M. and Sheheda, O.V. (2020). Formation of the land market as a prerequisite for ensuring food security of a country. *The Problems of Economy*, 2, 91-103.

Development of trade and consumer protection. (2021). https://me.gov.ua/?lang=uk-UA

Fedulova, I.V. (2014). Research of food security: principles and approaches to evaluation. *Strategy of Economic Development of Ukraine*, 34, 40-46.

Food security strategies for the period up to 2030. (2020). https://www.me.gov.ua/Documents/Detail?lang=uk-UA&id=33eec8aa-b768-4234-8f5d-7014601cf6e7&title=ProktRoz.

Fryzorenko, A.O. (2019). *Ukraine's foreign trade*. Kyiv: State Statistics Service of Ukraine. http://www.ukrstat.gov.ua/druk/publicat/kat_u/2019/zb/06/zb_ztu_2018.pdf.

Global food safety initiative. (2018). http://tms-ua.com/food-safety/gfsi/.

Global food security index. An annual measure of the state of global food security. (2016). *The Economist Intelligence Unit*. http://foodsecurityindex.eiu.com.

Horniak O.V. and Saliuk-Kravchenko O.O. (2016). Assessment of food security of the state on the basis of regional indicators. *Bulletin of Odessa National University. Series: Economics*, 21(10), 17-21.

Kaletnik, H.M. and Darmohrai, O.V. (2016). Methodical approaches to the assessment and analysis of indicators of food security of Ukraine. *Economy. Finances. Management: Current Issues of Science and Practice*, 6, 7-20.

Kozlovskyi, S., Khadzhynov, I., Lavrov, R., Skydan, O., Ivanyuta, N. and Varshavska, N. (2019). Economic-mathematical modeling and forecasting of competitiveness level of agricultural sector of Ukraine by means of theory of fuzzy sets under conditions of integration into European market. *International Journal of Recent Technology and Engineering*, 8(4), 5316-5323.

Kravchuk, N., Tarasovych, L. and Yaremova, M. (2017). Development of the socially-oriented economy in Ukraine: prereguisites and strategic forecasting. *Baltic Journal of Economic Studies*, 3(2), 66-72.

Kutsmus, N., Kovalchuk, O. and Dankevych, V. (2017). Agricultural Development in Ukraine: Institutional Changes and Socio-Economical Results. *Vistula scientific*, 2 (52), 84-98.

Levkina, R.V., Kravchuk, I.I. and Sakhno, I.V. (2019). The economic-mathematical model of risk analysis in agriculture In conditions of uncertainty. *Financial and Credit Activity: Problems of Theory and Practice*, 3(30), 248-255.

Markina, I., Chykurkova, A.D., Shkilniak, M.M., Somych, N.I. and Taran-Lala, O.M. (2020). Assessment of food security in country or geographic region: management and administration. *International Journal of Management*, 11(6), 1729-1745.

Meyers, W., Karasova, N. and Yatsenko, O. (2018). Highly marginal goods as source of export efficiency rise in agrarian sector. *Management Theory and Studies for Rural Business and Infrastructure Development*, 40(4), 577-586.

Mostova, A.D. (2017). Improving the methodological support for the analysis of the food security of the country. *Economy and State*, 10, 42-47.

Norms of physiological needs of the population of Ukraine in basic nutrients and energy. (2017). https://zakon.rada.gov.ua/laws/show/z1206-17?lang=en#n14.

Osaulenka, O.H. (2019). *Statistical Yearbook of Ukraine for 2018*. Kyiv: August Trade LLC.

Ploeg, V., Douwe, J. and Renting, H. (2000). Rural development: from practices and policies towards theory. *SociologiaRuralis*, 40, 391-408.

Poltorak, A.S. (2015). Comprehensive assessment of the state of food security in Ukraine. *Economic Journal – XXI*, 7-8(2), 15-18.

Prokopenko, O.M. (2019). *Livestock of Ukraine – 2018*. Kyiv: State Statistics Service of Ukraine. http://www.ukrstat.gov.ua/druk/publicat/kat_u/2019/zb/05/zb_tu2018.pdf.

Pushak, Ya.Ya. (2012). Food security of the state and its regions: methodological aspect. *Culture of the Peoples of the Black Sea Region*, 219, 189-191.

Rozhko, N.I. (2020).Current trends in the market of fruit and vegetables. *Black Sea Economic Studies*, 51, 106-111.

Shevchenko, A.F. and Shevchenko, O.M. (2011). Food security of Ukraine in the context of the formation of a transparent market for agricultural land. *Scientific Bulletin of Poltava University of Economics and Trade*, 6(51), 16-21.

Shoiko, V.A. (2017). Essential characteristics of state regulation of food security. *Efficient economy*, 11. http://www.economy.nayka.com.ua/?op=1&z=6202.

Shyshliuk, V.R. and Samokysh, V.P. (2020). Legal support of food security of Ukraine: current state and prospects. *Law and Society*, 1, 133-138.

Skrypnyk, A.V. and Starychenko, Ye.M. (2017). Methodical approaches to determining the integrated indicator of food security. *Economics of Agro-Industrial Complex*, 9, 25-28.

Skydan, O. and Hrynyshyn, V. (2020). Risks and threats to ensuring food security of Ukraine: methodological foundations and practical evaluation. *Economics and Education*, 5(2), 96-101.

Skydan, O., Nykolyuk, O., Pyvovar, P. and Martynchuk, I. (2019). Methodological approach to the evaluation of agricultural business system flexibility. *Management Theory and Studies for Rural Business and Infrastructure Development*, 41(4), 444-462.

Soloviova, N.I. (2016). Methodological correctness of forecast assessment of parameters of socio-economic development of regions. *Current Problems of the Economy*, 11(185), 268-277.

Strategy for the development of the agricultural sector of the economy until 2020. (2013). http://zakon2.rada.gov.ua/laws/show/806-2013-%D1%80.

Sychevskyi, M.P. (2019). Global food security and Ukraine's place in its achievement. *Economics of Agro-Industrial Complex*, 1, 6-17.

The State of Food Security and Nutrition in the World 2018: Building climate resilience for food security and nutrition. (2018). Rome: FAO.

Tkachuk, V., Yaremova, M. and Tarasovych, L. (2017). Providing the food security of Ukraine. *Modern Issues of Economics and Law. Series: Economic Sciences*, 1-2(5, 6), 173-178.

Urba, S.I. (2017).Theoretical and methodological principles of assessing food security of the state. *Scientific Bulletin of Kherson State University*, 25(1), 106-111.

Utenkova, K.O. (2019). Economic security as a component of national security of Ukraine. *Bulletin of VN KarazinKharkiv National University*, 9, 133-144.

Yakovenko, O.V. and Cherevko, O.V. (2016). The main factors influencing the food security of the region as a basis for national security. *Economy and State*, 12, 68-72.

Yurchenko, Yu. and Antoshkin, V. (2019). Socio-economic assessment of destructive factors of food self-sufficiency. *Economy and State*, 10, 4-13.

Zinchuk, T., Kovalchuk, O., Kutsmus, N. and Charutska, O. (2018). Challenges of sustainable development of rural economy. *Management Theory and Studies for Rural Business and Infrastructure Development*, 40(4), 609-619.

Zos-Kior, M.V., Ilin, V.Y., Kyryliuk, I.M. and Solod, O.V. (2020). Digitalization in realization of ecological and economic principles of managing sustainable development of agrarian enterprises. *The Mechanism of Economic Regulation*, 2, 29-37.

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