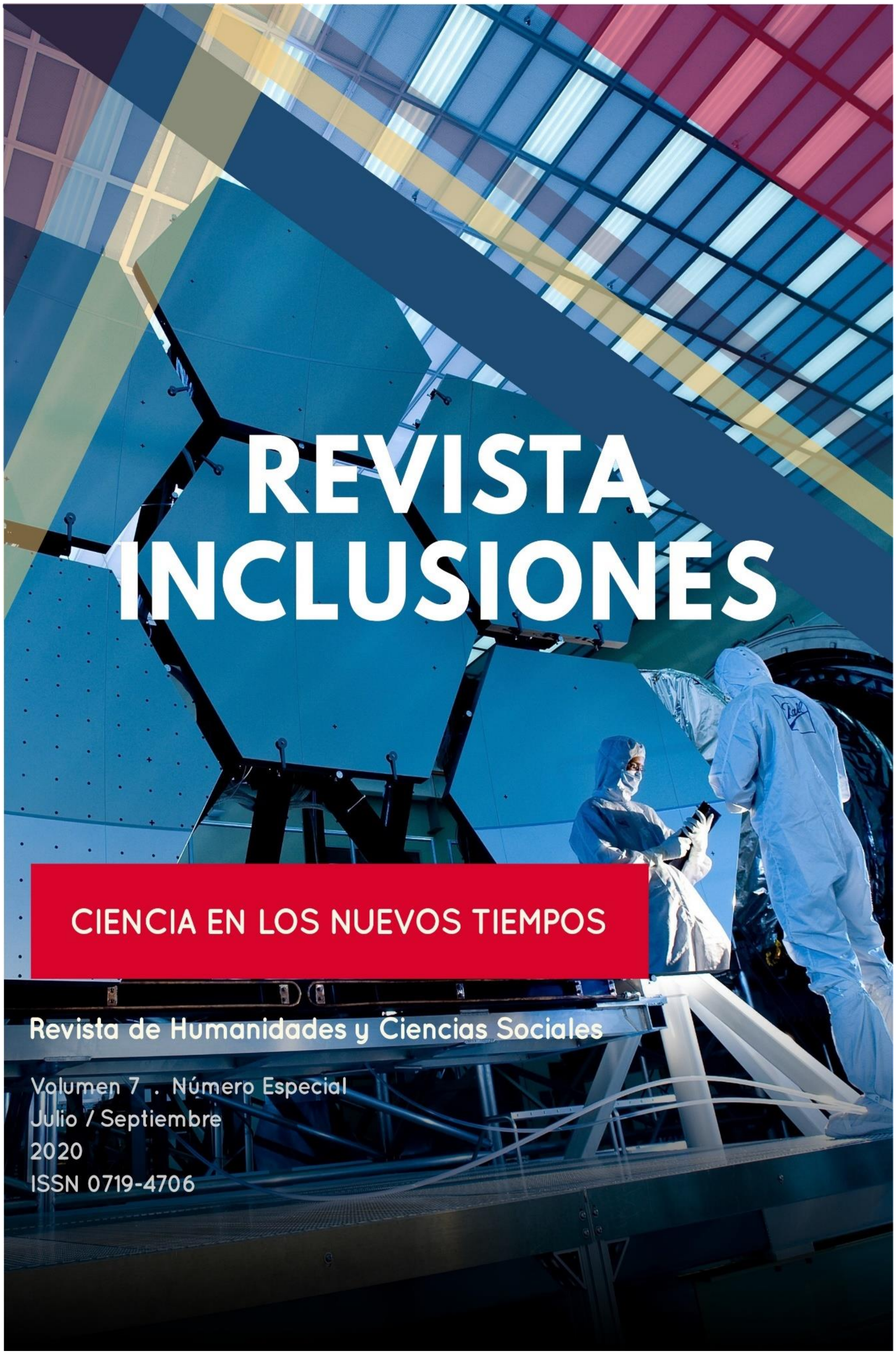
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ASSESSMENT OF FOOD SELF-SUFFICIENCY AND STABILITY BASED ON POTENTIAL THEORY

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Abstract

The paper analyses the food self-sufficiency of Siberia and its stability. The components of the consumer basket are established first. Next, economic and physical access to food is considered. Food availability is analysed further. Food self-sufficiency is determined next. The proposed methodology is applied to assess the level of food self-sufficiency for Siberia. Self-sufficiency is established for grain, potatoes, meat and eggs, though not for milk, vegetables, sugar beet, oilseeds, fish, fruit, salt, spices or tea. The methodology developed by N. V. Shalanov is used to calculate the integral index of stability of agricultural production development in Siberia. The analysis performed indicates that stability is maintained in the main components of agricultural production in Siberia. Meanwhile, the average level of economic development is at 93.09, i.e., corresponds to 93.09% of the reference value.

Keywords

Food self-sufficiency – Iintegral index – Consumption norms – Consumer basket

Para Citar este Artículo:

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Introduction

To sustain an active and healthy lifestyle, humans, households and societies as sociobiological systems have certain physical, social and spiritual requirements, including certain levels of food requirements. Such food products should be produced in appropriate quantities subject to available reserves, assortment and quality standards and their physical and economic accessibility should be ensured (physical accessibility, price, income levels). Human needs (as they evolve) are served through consumption. To produce such food products, social, environmental and economic systems have to be built, integrating elements such as manufacturing, agriculture, food production and commerce, and socioeconomic issues have to be addressed at the national and regional level. This particularly applies to the issues of food self-sufficiency in Siberia and maintaining it at a stable level, which calls for an appropriate methodology.

Methods and materials

The objective of this study is to assess the food self-sufficiency of Siberia and its stability by employing potential theory.

Abstract logical and statistical research methods, trend modelling and expert appraisal are used in this study. Analytical methods of systems analysis are based on potential theory. The research materials include official data from the Federal Statistics Service of the Russian Federation[1] and the Ministry of Health and Social Development of the Russian Federation[2].

The Doctrine of Food Security of the Russian Federation is also reviewed for this research[3].

Results and Discussion

Food self-sufficiency assessments are addressed by researchers such as G. S. Bondareva, P. D. Kosinskii, V. N. Papelo and others. In their analysis, the index (level) of food self-sufficiency is determined as the relation of internal per capita agricultural production (less industrial consumption and losses) to the set food consumption norms.

In these calculations, the numerator and denominator are measured in different units (agricultural produce and food product). Moreover, physical and economic accessibility and some other methodological aspects are not included[4].

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[1] Regions of Russia. Social and Economic Indicators. 2017. Retrieved from: http://www.gks.ru/free_doc/doc_2017/region/regpok17.pdf y Russian Statistical Yearbook. 2017. Retrieved from: http://www.gks.ru/free_doc/doc_2017/year/year17.pdf

[2] Order of the Ministry of Health and Social Development of the Russian Federation No. 593n. "On approval of recommendations on rational norms of food consumption that meet modern requirements for healthy nutrition". August 2, 2010. Retrieved from: http://legalacts.ru/doc/prikaz-minzdravsotsrazvitija-rf-ot-02082010-n-593n/

[3] Doctrine of Food Security of the Russian Federation approved by Executive Order of the President of the Russian Federation No. 120. January 30, 2010. Retrieved from: http://state.kremlin.ru/security_council/6752

[4] P. D. Kosinskii y V. A. Shabashev, Prodovolstvennaya samoobespechennost regiona i kachestvo zhizni naseleniya (Tomsk: Publishing House of Tomsk University, 2009); V. N. Papelo; A. N. Radchikov y P. V. Skurikhin, Prodovolstvennaya bezopasnost Rossii: sovremennoe sostoyanie i

In advanced economies, the coefficient of food self-sufficiency is traditionally calculated as the percentage ratio of produced and consumed amounts of agricultural produce in the country. It is calculated for each type of product with adjustments for price changes. Calculations are performed in fixed prices adjusted for wholesale price indices. For animal products, only the value added generated within the country is included[5]. This wording indicates that only agricultural produce is considered, not consumer food products.

We propose a methodology addressing such assessment issues and eliminating the above drawbacks.

Moreover, our proposition is the first food self-sufficiency assessment employing the formula proposed by Professor N. V. Shalanov[6].

Our proposed methodology of food self-sufficiency assessment begins with determining the official composition of the consumer basket. The statutory composition of the consumer basket (consumption norms) is regulated by Federal Law No. 227-FZ effective since January 1, 2013 and is subject to revisions at least once in five years according to the law. Such revision was due in 2017, but on September 28, 2017, the government decided to freeze the composition and ratios of the consumer basket (consumption norms) until 2021. The equivalent of the consumer basket is used to calculate the minimum subsistence level, which has served as a reference for the minimum statutory monthly pay level since January 1, 2018.

After the official composition of the consumer basket is established for each product, official consumption norms are determined per individual both in physical and monetary terms in current prices and the total cost is calculated for all food products. Economic accessibility is determined next. For that, the first step is to determine private per capita spending on food items.

The figure is then compared to the total cost of the official consumption norms for the recommended food products. If the actual cost turns out to be lower than the official figure by at least 5% (statistical error level), this means economic accessibility is not met, food self-sufficiency is not established. If the actual cost is above, or equivalent to, the official figure, then economic accessibility is met for food products.

Next, the physical accessibility of food products needs to be assessed. The actual food range is compared to the composition of the consumer (food) basket. If they correspond, turn to availability assessments. If the finding is there is no correspondence, then food self-sufficiency is not established, and the primary bottleneck is obvious. To relieve the bottleneck, the mismatch is analysed and assessed and proper actions are taken. In particular, analyses of individual administrative units are conducted to assess actual product ranges, transport accessibility, road network, commercial space availability, etc. For specific action, the composition of the consumer (food) basket may be refined.

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mekhanizmy obespecheniya (Novosibirsk: SIU.RANEPA, 2000) y G. S. Bondareva, Teoriya i metodologiya obespecheniya naseleniya prodovolstviem (na materialakh regionov Sibiri): dissertation. (Novosibirsk, 2019).

[5] S. L. Fallows y L. W. Whelock, “Self-sufficiency and United Kingdom Food Policy”, Agricultural Administration Vol: 11 num 2 (1982): 107–125 y O. L. P. Hagan, “National Self – sufficiency in food”, Food Policy Vol: 1 num 4 (1976): 355–366.

[6] N. V. Shalanov, Sistemnyi analiz. Kibernetika. Sinergetika: matematicheskie metody i modeli. Ekonomicheskie aspekty: monograph (Novosibirsk: NSTU Publishing house, 2008), 288.

The transition to the analysis of food product availability begins with establishing the total consumption norms for specific food items of the basket.

Total private consumption of individual food products is determined based on the official consumption norms. The resulting figures are then translated accordingly into agricultural produce volumes. Such calculations should be based on regulatory references applicable in agricultural operation[7].

The average actual figure of agricultural production (for five years) is then determined.

After the totals of agricultural production are established, the volume of production for consumption (food) is determined for each item of agricultural produce. For that, deduct from the total the amount to be used for seeds, forage, production, technical purposes, insurance stocks or other purposes other than private consumption.

Next, the level of food self-sufficiency (in %) is calculated for each product by dividing the volume of agricultural production for consumption (food) by the volume of consumption according to the norms, multiplied by 100%.

For those agricultural products used for consumption (food) where the indication of food self-sufficiency turns out to be lower than 100% or the threshold value set forth in the Doctrine of Food Security, food self-sufficiency is not established. For those items of agricultural produce for which their production volumes exceed or match the threshold level, food self-sufficiency is established (Table 1).

Products	Agricultural production volume	Production for consumption (food)	Consumption according to the norms (food)	**Food self-sufficiency level (%)**
Grain	14,551	3,567	2,122	**168**
Potato	4,550	2,406	1,973	**122**
Vegetables	1,298	1,195	2,334	**51**
Sugar beet	934	934	2,975	**31**
Sunflower	496	450	870	**52**
Milk	4,910	4,419	5,997	**74**
Meat, carcass weight	1,150	1,127	1,061	**106**
Eggs, millions	6,370	6,116	5,082	**120**

Table 1
Food self-sufficiency levels in Siberia in 2014–2018, thousand tons

According to the data in the table, food self-sufficiency is established in Siberia for grain, potato, meat, eggs, though not for milk, vegetables, sugar beet and oilseeds. Food self-sufficiency for each product primarily depends on the corresponding production levels of agricultural produce, which is characterised by stability over years, a phase portrait[8]. A phase portrait is a two-dimensional representation of the object dynamics in the multidimensional space. In the analysed case, the object is the average per capita production of items of agricultural produce in Siberia.

[7] Spravochnik ekonomista kolkhoza i sovkhoza (Moscow: Kolos, 1970).

[8] S. D. Nadezhdina y M. N. Peshkova, Sbalansirovannost razvitiya regionalnogo prodovolstvennogo rynka: monograph (Novosibirsk: NSTU Publishing house, 2014), 211.

With a known pattern of production for each crop, an integral index of production development stability can be calculated for all crops by year based on potential theory.

According to potential theory, "any object is a multidimensional dynamic object or system, as it is described by multiple indicators". A special type of problem in studying object dynamics is associated with determining object development levels (potential) as measured by a set of indicators and with building a scale to measure the object's potential.

To solve this problem, N. V. Shalanov proposed a formula, which is a classic element of analytical methods of systems analysis. The formula is as follows:

$$C(t_i) = \frac{\sum_{j=1}^{n} \alpha_j \frac{x_{ij}}{\sigma_j}}{\sum_{j=1}^{n} \alpha_j \frac{x_j^*}{\sigma_j}} \cdot 100.$$

To structure the problem, a so-called objective tree is charted. It may be a single-layer, double-layer tree, etc. For a general problem-setting, consider a double-layer problem using the following algorithm.

An algorithm to calculate the potential of an economic subject

The first layer comprises blocks of indicators and the second layer represents the indicators within the blocks. The algorithm consists of two stages.

I. Calculation of a complex estimate at the block level:

1.1. Assume x_{ijk} is the value of the *j-th* indicator of the *k-th* block in the year t_i of the analysed period;

1.2. The standard deviation σ_{jk} of the *j-th* indicator of the *k-th* block is calculated;

1.3. Standardised scores of indicators are calculated as follows:

$$Z_{ijk} = \frac{x_{ijk}}{\sigma_{jk}};$$

1.4. Expert input is engaged to determine the reference values of the indicators: x^*_{jk} is the reference value of the *j-th* indicator of the *k-th* block;

1.5. Standardised scores of the reference values are calculated as follows:

$$Z_{jk}^* = \frac{x_{jk}^*}{\sigma_{jk}};$$

1.6. Weights are determined for the indicators of the potential function:

$$\alpha_{jk} = \frac{Z_{jk}^*}{\sqrt{\sum_{j=1}^{n} (Z_{jk}^*)^2}}$$

1.7. Potential values of the function are calculated by year:

$$y_{ik} = \sum_{j=1}^{n} \alpha_{jk} Z_{jk};$$

1.8. The reference value of the potential function is calculated:

$$y_k^* = \sum_{j=1}^{n} \alpha_{jk} Z_{jk}^*;$$

1.9. Complex scores are calculated by year:

$$C_{ik} = \frac{y_{ik}}{y_k^*} \cdot 100;$$

II. Calculation of the integral index:

2.1. Weights are calculated for the blocks:

$$\tilde{\alpha}_k = \frac{y_k^*}{\sqrt{\sum_{k=1}^{m} (y_k^*)^2}};$$

2.2. Values of the potential function are calculated by year:

$$\tilde{y}_i = \sum_{k=1}^{m} \tilde{\alpha}_k y_{ik};$$

2.3. The reference value of the potential function is calculated:

$$\tilde{y}^* = \sum_{k=1}^{m} \tilde{\alpha}_k y_k^*;$$

2.4. The integral index is calculated by year:

$$\tilde{C}_i = \frac{\tilde{y}_i}{\tilde{y}^*} \cdot 100.$$

For a single-layer problem, the solution is found in stage one. In case of a multilayer problem, the third, fourth and further stages follow the same steps as in the second stage[9].

Given the direct relationship between production (per capita production) of agricultural crops and food self-sufficiency, the integral index of stability of per capita production serves as a gauge for the integral index of stability of food self-sufficiency.

If, for instance, food self-sufficiency is calculated for five years, the integral index of stability of per capita production is generally counted for a longer period, which thus provides a more reliable value.

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[9] N.V. Shalanov. Sistemnyi analiz. Kibernetika. Sinergetika: matematicheskie metody i modeli. Ekonomicheskie aspekty [Systems analysis. Cybernetics. Synergetics: mathematical methods and models. Economic aspects]: monograph. (Novosibirsk: NSTU Publishing house, 2008), 44-46.

Consider a calculation of the integral index of per capita production for all major crops for the period from 2009 till 2018, i.e., for 10 years. The algorithm begins with determining per capita agricultural production in Siberia (x_{ij}) and the standard deviation of per capita production for each product (σ_j) (Table 2).

Years	Grain, total	Vegetables	Potato	Sunflower seeds	Sugar beet	Milk	Meat, carcass weight	Eggs, millions
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
2009	950.71	86.80	280.67	14.75	23.91	293.06	51.65	296.18
2010	691.91	80.84	283.89	13.01	20.88	291.70	54.19	302.42
2011	756.58	87.80	302.85	13.85	29.58	296.74	56.51	307.95
2012	466.13	82.90	232.07	13.08	23.58	289.27	59.33	320.15
2013	794.04	82.77	276.38	22.93	34.26	274.57	60.03	324.02
2014	674.52	79.28	276.19	12.12	28.78	279.24	60.21	328.22
2015	715.21	80.57	275.86	20.52	42.47	279.09	60.09	338.27
2016	779.86	82.67	276.27	30.59	58.61	273.84	60.83	337.60
2017	817.52	81.45	266.54	32.63	56.20	273.94	61.44	344.82
2018	785.86	51.64	177.64	34.73	46.04	249.61	57.99	331.83
Average sum $\bar{x}_j$	743.23	79.67	264.84	20.82	36.43	280.11	58.23	323.15
σ_j	118.07	9.68	33.55	8.46	12.98	13.05	3.03	15.51

Table 2
Per capita agricultural production in Siberia, kg

Next, standardised scores of per capita production of agricultural items are calculated by year (Z_{ij}) by dividing per capita production (x_{ij}) by the standard deviation (σ_j) (Table 3).

A calculation of the parameters used to find the integral index of per capita agricultural production is shown in Table 4.

Years	Grain, total	Vegetables	Potato	Sunflower seeds	Sugar beet	Milk	Meat, carcass weight	Eggs, millions
	$z_{ij}=\frac{x_{ij}}{\sigma_j}$							
	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8
2009	8.05	8.97	8.37	1.74	1.84	22.46	17.07	19.09
2010	5.86	8.35	8.46	1.54	1.61	22.36	17.91	19.50
2011	6.41	9.07	9.03	1.64	2.28	22.74	18.68	19.85
2012	3.95	8.56	6.92	1.55	1.82	22.17	19.61	20.64
2013	6.73	8.55	8.24	2.71	2.64	21.04	19.84	20.89
2014	5.71	8.19	8.23	1.43	2.22	21.40	19.90	21.16
2015	6.06	8.32	8.22	2.43	3.27	21.39	19.86	21.81
2016	6.60	8.54	8.24	3.62	4.51	20.99	20.11	21.76
2017	6.92	8.41	7.95	3.86	4.33	20.99	20.31	22.23
2018	6.66	5.33	5.30	4.11	3.55	19.13	19.17	21.39

Table 3
Standardisation of per capita agricultural production indicators in Siberia

Parameters	Grain	Vegetables	Potato	Sunflower	Sugar beet	Milk	Meat	Eggs	Σ
	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8	
Consumption norm adjusted for conversion rate	110	121	102	45	154	311	55	216	
Standard deviation (σ_j)	118.07	9.68	33.55	8.46	12.98	13.05	3.03	15.51	
Standardised reference values ($z_j=\frac{x_j}{\sigma_j}$)	0.93	12.50	3.04	5.32	11.86	23.83	18.15	13.93	
Standardised reference values squared $(z_j)^2$	0.87	156.25	9.24	28.29	140.76	567.94	329.49	193.95	$\sqrt{1426.79}$[1]
$\alpha_j=\frac{z_j}{y*}$	0.02	0.33	0.08	0.14	0.31	0.63	0.48	0.37	2.37
β_j	0.007	0.358	0.044	0.045	0.087	0.264	0.099	0.095	1.0

Table 4
Parameters of indicators used to find the integral index
of per capita agricultural production in Siberia

A calculation of the integral index is shown in Table 5. The analysis of the integral index indicates the minimum level at 87.8, the maximum level at 97.0 and the average value at 93.09.

Years	Grain	Vegetables	Potato	Sunflower	Sugar beet	Milk	Meat	Eggs	$\Sigma = y_i$	$\frac{y_i}{y*}$
	$\alpha_1 z_1$	$\alpha_2 z_2$	$\alpha_3 z_3$	$\alpha_4 z_4$	$\alpha_5 z_5$	$\alpha_6 z_6$	$\alpha_7 z_7$	$\alpha_8 z_8$		
2009	0.16	2.96	0.67	0.24	0.57	14.15	8.19	7.06	34.00	90.10
2010	0.11	2.64	0.68	0.22	0.50	14.09	8.60	7.21	34.05	90.20
2011	0.12	2.99	0.72	0.23	0.71	14.33	8.97	7.34	35.41	93.80
2012	0.08	2.83	0.55	0.22	0.57	13.97	9.41	7.64	35.27	93.40
2013	0.13	2.82	0.66	0.38	0.82	13.26	9.52	7.73	35.32	93.60
2014	0.12	2.70	0.66	0.20	0.69	13.48	9.55	7.83	35.23	93.28
2015	0.12	2.74	0.66	0.34	1.01	13.48	9.53	8.07	35.95	95.20
2016	0.13	2.82	0.66	0.51	1.40	13.22	9.65	8.05	36.44	96.48
2017	0.14	2.78	0.64	0.54	1.34	13.22	9.73	8.23	36.62	97.00
2018	0.13	1.76	0.42	0.58	1.10	12.05	9.20	7.92	33.16	87.80

Table 5
Calculation of the integral index of per capita agricultural production in Siberia

Based on the calculations above, a phase portrait is charted, indicating stable patterns of per capita agricultural production in Siberia (Figure 1). The deviation of the integral index for 2009, 2010 and 2016–2018 from the mean exceeds 2.5%. In other years, the deviation is within 5% (within calculation error level), except for 2018 when it equalled 6%.

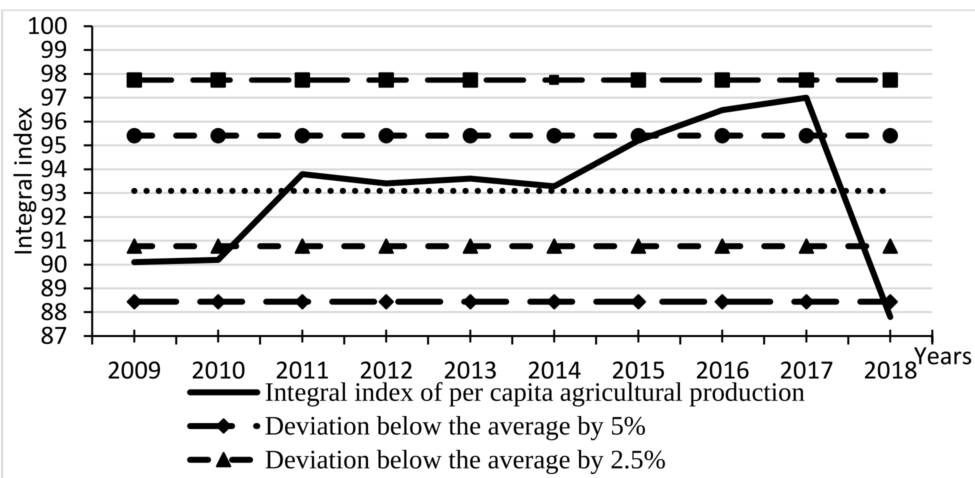

Figure 1
Phase portrait of the integral index of per capita agricultural production in Siberia (2009-2018).

As to the production volume, it stood short, in the whole discussed period, of the desired level sufficient to sustain food consumption in Siberia in line with the recommended norms. On average, the integral index of per capita production reached 93.09, i.e., 93.09% of the reference.

Conclusion

1. The conducted research and methodological analysis helped to establish the following findings for Siberia:

– official composition of the consumer basket;

– economic and physical accessibility of food products;

– food availability;

– food self-sufficiency level and its stability.

2. The assessments of food self-sufficiency levels were calculated by dividing the volume of agricultural production for consumption (food) by the volume of consumption according to the norms (food), multiplied by 100%. The principal assumption was that for those agricultural products used for consumption (food) where the indication of food self-sufficiency turns out to be lower than 100% or the threshold value set forth in the Doctrine of Food Security, food self-sufficiency is not established. For those items of agricultural produce for which their production volumes exceed or match the threshold level, food self-sufficiency is established.

3. According to the findings, the following indications of food self-sufficiency were established: 100% and above for grain, potatoes, meat and eggs; less than 100% or below the threshold set forth in the Doctrine of Food Security for milk, vegetables, sugar beet, oilseeds (sunflower).

4. The integral index of stability of food self-sufficiency was assessed using analytical methods of systems analysis based on potential theory. The algorithm for calculating the potential levels of an economic subject (the first layer comprises blocks of indicators, the second layer refers to the indicators within blocks) consists of stages. The first stage is calculating the complex index for the blocks of indicators. The second stage is calculating the integral index for each year. The results are plotted in a chart to produce a phase portrait.

5. The integral index is calculated for per capita agricultural production. Given the direct relationship between per capita production of agricultural crops and food self-sufficiency, the integral index of stability of per capita production serves as a gauge for the integral index of stability of food self-sufficiency.

The analysis of the integral index indicates the minimum level at 87.8, the maximum level at 97.0 and the average value at 93.09, i.e., the average per capita production equals 93.09% of the reference value.

Thus, the employed method based on the integral index of per capita agricultural crop production allows drawing a conclusion regarding the stability of food self-sufficiency levels in Siberia from 2009 until 2018 (2018 – 6%).

6. The findings indicate the research objective is met.

The method of assessment of food self-sufficiency can be applied for Russia as a whole.

The method of assessment of the stability of food self-sufficiency based on potential theory can be applied for Russia and other countries.

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