International Journal for Quality Research 18(3) 911–926
ISSN 1800-6450

Elena Karanina[1]
Vasily Karaulov

Article info:
Received 20.08.2023.
Accepted 05.04.2024.

UDC – 502.131.1
DOI – 10.24874/IJQR18.03-19

DIAGNOSIS MODEL FOR SECURITY AND SUSTAINABILITY OF REGIONAL ECOSYSTEMS

Abstract: *The assessment of the state of security of socio-economic systems in the context of regions is important, taking into account the peculiarities of their differentiation and the impact of external and internal environmental factors. There are many approaches to diagnosing the security of regions, but to a greater extent, standardized assessment mechanisms are based on the definition of criteria, threats, indicators, thresholds, and risk zones. The authors of the article proposed a model for diagnosing the security and sustainability of regional ecosystems based on a hierarchical structure of 58 low-level indicators grouped into 6 main projections and 15 sub-projections. The indicators were assessed at a scoring scale from 1 to 100 points based on the threshold levels of security and the method of piecewise linear scaling with the definition of three qualitative levels of security of regional ecosystems: low, medium (or average) and high level of security. The recommended methodology makes it possible to rank the Russian Federation members by the level of security and the level of threats in general and in the context of projections and sub projections, as well as to form maps of risks and security threats for the Russian Federation members.*

Keywords: *economic security, regional ecosystems, threats, indicators, projections, ecosystem security diagnostics*

1. Introduction

In modern conditions, both in Russia and abroad, diagnostics of the security and sustainability of regional development is of great importance. Threats and risks of regional development are increasing every day due to the impact of external economic environment factors. In addition, the differentiation of Russian regions, their different development conditions are essential. Positions of regions in security ratings differ significantly (Karanina & Karaulov, 2023). Under these conditions, the role of qualitative diagnostics of factors based on relative safety indicators is of great importance. This helps to increase the objectivity and accuracy of diagnostics and in the process of comparative (rating) analysis.

Today, there are many approaches to diagnosing national and regional safety indicators. When constructing a system of indicators, one should first of all refer to the legal basis for their determination.

According to the Strategy, official statistical information is generated to analyze the state of Russia's economic security. The website of federal Service state statistics presents 40 indicators of various dimensions and

[1] Corresponding author: E.V. Karanina
Email: karanina@vyatsu.ru

frequency of development for the analysis (Information for the analysis of indicators of the state of economic security of the Russian Federation, n.d). In some cases, these indicators are additionally considered in the regional aspect. The methodology for assessing indicators of regional security was considered by various researchers, in particular, in models Senchagov et al. (2012). But indicators of the national economic security are not used as a basis for developing methods and tools for monitoring the security of regional socio-economic systems (Karanina and Karaulov, 2023).

The authors of this article consider the issues of diagnosing indicators of the security of ecosystems in the regions of Russia on the basis of the author's concept and models of resilience-diagnostics (Karanina & Karaulov, 2021, 2023; Karanina et al., 2022), but in the last publication, used system of indicators only partially corresponds to the indicators defined in the framework of the Strategy for Economic Security of Russia. Most of the authors' research was related to the development of a comprehensive system of indicators and monitoring of socio-economic security at the regional level (Karanina & Loginov, 2017; Loginov & Karanina, 2016), the conclusions about the need to improve the methodology of indicative assessment from the position of revision as a system of indicators and refinement of the approach to diagnostics were drawn.

The following research objectives were set:

- to compile a system of indicators of the security of regional ecosystems (SRES) (Karanina & Karaulov, 2023) - regions of Russia on the basis of 40 specific indicators, based on national indicators;

- to group indicators of the ecosystem security (ESS) of the Russian Federation members from the standpoint of assessing individual projections and subprojections;

- to develop a methodology for assessing the ESS of individual projections and subprojections, and in Russia as a whole in the context of all regions;

- to test the proposed model for diagnosing SRES in the Russian Federation on the basis of open statistical data for the regions.

2. Model development and testing

The first publications related to the problems of the economic security in domestic science appeared relatively recently. For the first time, these questions began to be raised under the leadership of Academician Abalkin (1994), who began a comprehensive study of this issue. In the future, many authors developed approaches to determining a set of parameters and safety indicators, in particular, they are widely known and used as a basis for refining the development of the Senchagov (1995, 2001, 2005), Glazyev (1997) and Tatarkin et al. (1996, 1997), who determined the complex nature and differentiation of indicators according to the most important components characterizing the sovereignty and sustainability of the economy, investment, financial and social spheres.

2.1. Theoreticalbasis

The author's approach assumes the relationship between the economic security and the security of ecosystems. The economic security as the security of an ecosystem is a category that characterizes the ability of a system to function sustainably over a long period, including under the negative impact of environmental factors. The security of socio-economic systems is a broad concept that involves the assessment of a set of factors and indicators of socio-economic development. Taking into account the significance and complexity of the set of indicators covering social, financial, credit, environmental, technical and technological and other components of regional development, it is appropriate to use the term "safety of regional ecosystems", which determines their basic features: rationality and complexity. Therefore, taking

into account these aspects, it is more logical to apply the concept of "ecosystem security" (ESS).

ESS can be considered at macro- and mesolevels. It is also quite natural to single out the local level of the security of an enterprise (organization) as an ecosystem. Then the formation of the components will depend on the specifics, on the scale of the enterprise and other factors, but the following system of components can be quite universal: legal, financial, personnel, technical and technological, market, information, etc.

The ESS level is determined on the basis of indicators that essentially characterize the potential for development and sustainability in the face of changing environmental factors (in modern conditions, these are international sanctions and other economic and political shocks).

The potential of the ecosystem is formed in order to ensure countering threats. It is in the conditions of exceeding it above the threshold level that a sufficient level of security for the regional ecosystem is ensured, which is able to withstand threats and determine the basis for sustainable development (Karanina & Karaulov, 2023).

Diagnostics of the security of functioning of ecosystems can be built on the basis of an integral indicator (the well-being function of the system) and the well-being functions of the main components of the ecosystem. In turn, the main components are formed from separate interconnected elements. Thus, a certain structure of the ecosystem is fixed.

From the standpoint of the systematic approach and the concept of SRES, the study of security issues of the national economy and the Russian Federation members should be of a general nature. Another criterion for the formation of a system of ESS indicators is the availability of available data in open sources for all the Russian Federation members in the context of the last five or more years. This requirement for a time period is based on the following hypothesis of the authors: the category "the economic security" of the economic system, "the ecosystem security" characterizes a certain resistance and resilience-stability of the system - the ability to resist the negative effects of the external and internal environment and, upon completion of such an impact, return to an acceptable level of functioning in the short term, at least in the medium term. In the first case, this ability of the system can characterize a high level of the system security, and in the latter case - a reduced level of the security with the same nature of the negative impact. Additionally, adaptability can be considered one of the characteristics of the resilience-stability, which is the ability of the system to change locally, but retain the most important components of its structure and functional performance under internal/external negative influences. With a long-term negative impact on the system, adaptation can be expressed in significant structural changes in the security system. Therefore, the assessment of the security status of a large system in a short period reflects only its response to external/internal influences: a negative impact worsens the parameters of the current functioning, and a positive impact improves such parameters. The assessment of the current level of the system security must be carried out in the medium term, and an adequate assessment of changes in the level of the system security in most cases can be obtained in the long term, for example, when comparing the economic system security indicators with a time lag of 3–5 years.

The economic security of the Russian Federation members as systems should also be considered from the standpoint of the ecosystems of the English botanist Arthur Tansley: local communities (systems) interacting with each other and the environment; for development, these systems compete and cooperate with each other. Ecosystem security is formed in the interconnection of all elements of the circular economy and is determined by the exchange of resources both in the internal

regional and in external markets. It combines all aspects of the security of the social environment, the financial sector, production and foreign economic activity. The Russian Federation members jointly evolve as local ecosystem communities and adapt to changing external conditions. Therefore, the level of international integration plays an important role in assessing the security of members as ecosystems. When the level of international integration is very high, the factors of interaction between regional entities and foreign partners will have an impact on the level of security to a greater extent. The world community as a whole is heterogeneous and it is important to understand the nature of such international integration. The most reliable and stable integration of the Russian Federation with the CIS countries, as it is due to historical ties of common development.

2.2. Data and methods

Taking into account the outlined approaches, the principles for developing a system for diagnosing regional ecosystems were laid down:

- A hierarchical structure of the ecosystem is built on the basis of a system of indicators.
- The indicators are based on objective quantitative data from open sources for a long (5 or more years) period.
- An integral indicator is formed from the indicators of the components and individual elements of the system of indicators according to the principle of convolution, taking into account the structure of the ecosystem.
- Assessment of ESS as a whole and its components is carried out on the basis of well-being functions and threshold levels of well-being: upper and lower (positive and negative). At the negative threshold level the well-being function takes on the minimum value, and at the positive threshold level - the maximum value.
- The location of the ecosystem and its elements away from the negative threshold level ensures their sustainable and long-term functioning, including from the standpoint of preserving the spatial and temporal structure of the ecosystem.
- The ESS level reflects the state of well-being – how far or close the ecosystem or its components are from the negative threshold.
- Beyond the negative threshold the ecosystem and its most important components cannot exist for a long time without external support and they are destroyed. The presence of the ecosystem and its components near the negative threshold can also lead to the destruction of the system. Beyond the positive threshold the well-being function does not change and takes on the maximum value.
- Assessment of the level of ESS and its components in dynamics by regions calls for a high-quality comprehensive assessment of security risks and threats, a reliable comparison and rating of the efficiency and safety of regional ecosystems.

2.3. Diagnostic model

Taking into account the tasks set and the principles for developing the diagnostic system, 58 regional indicators were formed - analogues of the indicators of the Russian Federation ESS Strategy.

Figure 1 shows the system of indicators is grouped in the form of a hierarchical model of indicators for diagnosing the security of a regional ecosystem.

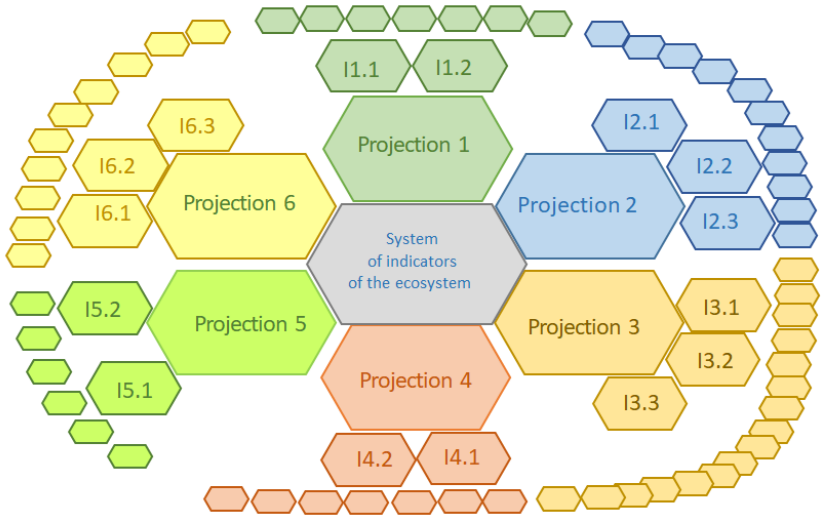


Figure 1. Systems of indicators
Sources: calculated by the authors

At the first level there are 6 main elements-indicators of ESS – projections: SED - "Security of economic development", FS - "Financial security", SEEI – "Security of external economic integration", TTS – "Technical and technological security", ERMS – "Energy -raw material security", SS – "Social security".

The SEEI projection makes it possible to assess the interaction of regional ecosystems with external ecosystems, for example, how positive and homogeneous this interaction is. Indicators of integration with the CIS countries and far-abroad countries allow us to study the structure of integration. Therefore, a large number of indicators of the integration of regional ecosystems are distinguished in the diagnostic model.

At the second level of the hierarchical diagnostic model, there are subprojections that characterize certain aspects/specifics of the main projections of ESS. Each projection includes two to three subprojections.

Sub-projections contain from three to nine ESS indicators. For a relative balancing of the assessment of SRES, indicators are used with weighting factors so that the total weight of all indicators of the subprojection is from 2 to 3, and the total weight of all indicators of the projection is from 6 to 9. The base weight of the indicator is 1 or 100%. In some cases, the use of one indicator may not always be correct, for example, due to the "base effect". Thus, the ratio of the balance of foreign direct investment to exports in percentage terms can be significant even with small volumes of exports. Therefore, such indicators should be considered in tandem with absolute indicators and indicators should be used with half weight.

The structure of the ESS of the region is presented in Table 1.

In general, the hierarchical model for diagnosing SRES in the Russian Federation consists of 58 indicators located at the third level of the hierarchy. They are grouped into 15 subprojections located on the second level of the hierarchy. The latter are included in 6 main projections of the first level of the hierarchy. Relative indicators express the essence of the structure, dynamics or performance; absolute – the scale of functioning per capita, per unit of FCB, etc. This approach allows comparing the state of the ESS of the constituent entities in different periods and among themselves.

Table 1. Indicators of economic security of the Russian Federation members: projections and subprojections

№	Projections	№	Subprojections
1	SED – Security of economic development	1.1	LSD – level and structure of development
		1.2	DED – general dynamics of economic development
2	FS – Financial security	2.1	LSFS – level and sustainability of financial security
		2.2	DPD – domestic public debt
		2.3	EPD – external public debt
3	SEEI - Security of external economic integration	3.1	IEC – import / export of capital
		3.2	LEEI – level of external economic integration
		3.3	DEEI – dynamics of external economic integration
4	TTS – Technical and technological security	4.1	LInvD – level of investment development
		4.2	LInnD – level of innovative development
5	ERMS – Energy -raw material security	5.1	RMS – raw material security
		5.2	EnB – Energy Security
6	SS – Social security	6.1	SL – standard of living
		6.2	CS – consumer security
		6.3	PS – personnel security

Sources: compiled by the authors

This system of indicators of SRES of the Russian Federation should be considered as a basic one. The result of the assessment is a set of values of indicators and levels of ESS, taking into account the structure of security, moved into a point scale and qualitative interpretations of security levels (low, medium and high): the general (integral) indicator of ESS – FESSI, security indicators of the projections of SED, FS, SEEI, TTS, ERMS and SS, as well as their subprojections and individual indicators.

The indicators in Table 1 are divided into three types: $x_{i,j,k}$, $y_{i,j,k}$ and $z_{i,j,k}$, where i and j are numbers of the projection and subprojection, which include the indicator; k is the number of the indicator in the subprojection. For the indicators $x_{i,j,k}$ a higher value indicates a higher level of system security or lower risks, and for $y_{i,j,k}$ it is vice versa: a higher value indicates a lower level of system security and higher risks of unstable functioning. The indicator $z_{i,j,k}$ assesses the degree of deviation from some "norm" $z^n_{i,j,k}$: an increase in deviation leads to a decrease in the level of security. Initial indicators $x_{i,j,k}$, $y_{i,j,k}$ and $z_{i,j,k}$ using security thresholds $x^h_{i,j,k} > x^l_{i,j,k}$, $y^h_{i,j,k} > y^l_{i,j,k}$, $z^{lh}_{i,j,k} > z^{ll}_{i,j,k}$ are moved by the method piecewise linear scaling into indicators $X_{i,j,k}$, $Y_{i,j,k}$ and $Z_{i,j,k}$, measured on the point scale from 1 point to 100 points:

$$\begin{cases} \text{if } x_{i,j,k} < x^l_{i,j,k}, \text{then } X_{i,j,k} = 1 \text{ point}, \\ \text{if } x_{i,j,k} > x^h_{i,j,k}, \text{then } X_{i,j,k} = 100 \text{ points}, \\ \text{else } X_{i,j,k} = \frac{x_{i,j,k} - x^l_{i,j,k}}{x^h_{i,j,k} - x^l_{i,j,k}} \cdot 99 + 1 \text{ point}; \end{cases} \quad (1)$$

$$\begin{cases} \text{if } y_{i,j,k} < y^l_{i,j,k}, \text{then } Y_{i,j,k} = 100 \text{ points}, \\ \text{if } y_{i,j,k} > y^h_{i,j,k}, \text{then } Y_{i,j,k} = 1 \text{ point}, \\ \text{else } Y_{i,j,k} = \left(1 - \frac{y_{i,j,k} - y^l_{i,j,k}}{y^h_{i,j,k} - y^l_{i,j,k}}\right) \cdot 99 + 1 \text{ point}; \end{cases} \quad (2)$$

$$\begin{cases} \text{if } \left|z_{i,j,k} - z^n_{i,j,k}\right| > z^{lh}_{i,j,k} - z^n_{i,j,k}, \\ \qquad \text{then } Z_{i,j,k} = 1 \text{ point}, \\ \text{else } Z_{i,j,k} = \left(1 - \frac{\left|z_{i,j,k} - z^n_{i,j,k}\right|}{z^{lh}_{i,j,k} - z^n_{i,j,k}}\right) \cdot 99 + 1 \text{ point}, \end{cases} \quad (3)$$

where $z^n_{i,j,k} = \frac{z^{ll}_{i,j,k} + z^{lh}_{i,j,k}}{2}$ is considered as the normative (most desirable) value of the indicator, and $z^{ll}_{i,j,k} < z^{lh}_{i,j,k}$ – low level thresholds – deviations from the normative value $z^n_{i,j,k}$. The indicators $X_{i,j,k}$, $Y_{i,j,k}$ and $Z_{i,j,k}$ can also be referred to as $X_{i,j,k}$ with the corresponding indices for uniformity.

Beyond the threshold levels, the security does not change and is assessed accordingly at 100 points - a high level of the system security or 1 point – a low level of the system security. For the indicators of the type $z_{i,j,k}$ outside the thresholds $z_{i,j,k}^{ll}$ and $z_{i,j,k}^{lh}$ a low security level of 1 point is fixed.

The indicators of the subprojection $X_{i,j}$ are calculated as an additive convolution of the individual indicators included in it. The weight coefficients are the shares of their weights, presented in Table 2, in the total sum of the weights of the subprojection indicators. For example,

$$DED = X_{1,2} = \frac{X_{1,1,4} + \frac{1}{2}X_{1,1,5} + \frac{1}{2}X_{1,1,6} + X_{1,1,7}}{1 + \frac{1}{2} + \frac{1}{2} + 1} = \frac{X_{1,1,4}}{3} + \frac{X_{1,1,5}}{6} + \frac{X_{1,1,6}}{6} + \frac{X_{1,1,7}}{3}. \quad (4)$$

The indicators of the projection X_i are calculated in a similar way, as the weighted average of its subprojections or indicators. For example,

$$SED = X_1 = \frac{3X_{1,1}}{6} + \frac{3X_{1,2}}{6} = \frac{X_{1,1,1}+X_{1,1,2}+X_{1,1,3}+X_{1,1,4}+0{,}5X_{1,1,5}+0{,}5X_{1,1,6}+X_{1,1,7}}{6}. \quad (5)$$

The final (integral) ESS indicator (FESSI, X) is calculated of the projections:

$$\text{FESSI} = X = \sqrt[6]{X_1 \cdot X_2 \cdot \ldots \cdot X_6}. \quad (6)$$

The model assumes that different ESS projections reflect independent or weakly dependent characteristics of the security system, i.e. the ability to compensate for some projections at the expense of others should be minimized. Therefore, to calculate the integral indicator X, the geometric mean of the projections X_1–X_6 is used.

The use of the arithmetic mean formula allows compensation for the effect of compensating for small values of some indicators by large values of other indicators. Within the framework of one projection, this is permissible, moreover, shortcomings of one indicator can be compensated by another indicator in the projection, i.e., they can be interchangeable.

Thus, the values of sub-projections, projections and the ESS integral indicator are calculated on a scoring scale from 1 point to 100 points. 1 point means a low level of ESS and a high level of risk of instability in the functioning of the regional ecosystem; 100 points mean a high level of ESS. A high level of ESS for a separate indicator creates the prerequisites for the sustainable functioning of the regional ecosystem from the standpoint of the indicator under consideration. Sustainable functioning in the current conditions makes it possible for long-term development and reaching a new qualitative level of functioning of the regional ecosystem. To achieve this goal, a high level of security of the integrated system of ESS indicators is required.

The indicator values in the scoring scale are presented in integer form according to the usual mathematical rules. The result has a qualitative interpretation of the ESS level:

- less than 34 points – low level of ESS;
- from 34 points and less than 67 points – medium (or average) level of ESS;
- upwards of 67 points – high level of ESS.

Threshold levels were used to convert to a scoring scale. When determining the thresholds, various approaches were used: taking into account target / normative values, etc., as well as those used in the world practice and by leading scientists (Senchagov & Mityakov, 2011; Avdiyskiy & Senchagov 2014; Kusi-Sarpong et al., 2018; Velichko et al., 2015; Kashin et al., 2021). Additionally, the average values of $m$indicators and their standard deviations σ for the Russian Federation in 2010-2014 were studied and the dynamics of the indicators themselves for 2000-2020 (see table 2).

Table 2. Average values of the indicators of economic security in the Russian Federation in 2010-2014 and their threshold values – fragment (compiled and calculated by the authors)

№	Code	Indicator	Average m for 2010-2014	Low threshold $x_{i,j,k}^{l}$	Upper threshold $x_{i,j,k}^{h}$
1	1,1,1	GRP percapita, FCB	33.8	24.0	48.0
2	1,1,2	Share of investments in GRP, %	24.4	15.0	30.0
3	1,1,3	Degree of depreciation of fixed assets (FA),%	48.1	30.0	60.0
4	1,2,1	Labor productivity index, %	102.7	100.0	106.0
5	1,2,2	GRP volume index, %	103.2	100.0	106.0
…	…	…	…	…	…

2.4. Research results

Approbation of the diagnostic model for regional ecosystems showed that, in general, in the country for the period 2016-2020 the average level of FEESI turned out to be slightly lower than the average level for 2010-2014. In 2019, FEESI exceeded the average of 2010-2014 by only one point, and in 2020, due to the impact of Covid-19, it decreased by 14 points. In 2019, in the context of the Russian Federation members, there are two members – the Magadan region and the city of Moscow showed a high level of ESS and two members shoed a low level – the Chechen and Kabardino-Balkarian Republics. In 2020, only one subject remained with a high level - the Murmansk region, and already seven subjects became low. Average for the period 2016-2020. three regions each had low and high FEESI levels (see table 3).

Table 3. Integral index and security rating of regional ecosystems – fragment (by the authors)

The Russian Federation member	2020		2019		2016-2020		2010-2014	
	Points	Place	Points	Place	Points	Place	Points	Place
The Russian Federation	49		63		58		62	
the Murmansk Region	71	1	66	4	68	3	52	34
the Magadan Region	64	2	68	1	69	2	63	6
the city of Moscow	63	3	67	2	67	4	64	5
the Belgorod Region	59	4	64	6	57	13	62	9
the Tyumen Region without the Autonomous Region	59	5	63	8	69	1	43	72
the Republic of Tatarstan	58	6	67	3	64	6	68	1
the Khabarovsk region	58	7	57	19	58	12	58	15
the Chukotka Autonomous Region	57	8	64	5	56	17	52	38
the Kursk Region	56	9	62	9	61	7	56	22
the Kamchatka Region	55	10	52	34	58	11	48	53
…	…	…	…	…	…	…	…	…
the Republic of Tyva	37	76	46	59	40	71	49	49
the Kabardino-Balkarian Republic	36	77	32	85	34	80	38	79
the Ulyanovsk region	35	78	46	60	40	70	51	41
the Chechen Republic	34	79	33	84	34	81	38	78
the Republic of Ingushetia	33	80	36	81	32	83	46	64
the Kurgan region	33	81	42	68	32	84	38	81
the Republic of Crimea	32	82	38	77	38	75	14	84
Krasnodar Krai	32	83	35	83	37	77	50	44
the Altai Republic	32	84	44	65	45	52	41	75
the Karachayevo-Cherkessian Republic	28	85	37	80	28	85	40	76

In the context of projections and the Russian Federation members, the level of ESS is heterogeneous. In 2019-2020 the best environment regards the financial security as a high level of ESS prevails. The worst situation is for the projections "Technical and technological security" and "Social security" (see tables 4-6).

Table 4. Index and rating of SRES in the context of the projections SED and FS – fragment

The Russian Federation member	SED 2020		SED 2019		FS 2020		FS 2019	
	Points	Place	Points	Place	Points	Place	Points	Place
The Russian Federation	37		57		78		88	
the Murmansk Region	70	4	84	2	87	3	84	18
the Magadan Region	77	1	83	4	73	43	76	57
the city of Moscow	69	6	64	20	85	7	91	7
the Belgorod Region	47	33	59	28	83	13	86	13
the Tyumen Region without the Autonomous Region	58	15	55	37	88	2	94	4
the Republic of Tatarstan	40	40	66	16	62	78	76	56
the Khabarovsk region	50	29	53	41	76	31	75	60
the Chukotka Autonomous Region	51	26	76	8	75	37	78	40
the Kursk Region	63	8	63	22	79	20	86	14
the Kamchatka Region	36	52	35	74	73	49	75	64
…								
the Republic of Tyva	29	67	42	55	85	5	89	9
the Kabardino-Balkarian Republic	60	12	35	72	77	30	73	69
the Ulyanovsk region	32	60	43	53	60	83	71	77
the Chechen Republic	74	3	69	11	85	6	85	15
the Republic of Ingushetia	39	41	55	35	80	15	84	20
the Kurgan region	12	85	44	50	72	56	79	39
the Republic of Crimea	42	39	54	40	91	1	96	1
Krasnodar Krai	32	61	37	68	73	47	70	80
the Altai Republic	58	14	64	21	83	12	91	8
the Karachayevo-Cherkessian Republic	30	66	66	18	80	18	83	22

Sources: calculated by the authors

Table 5. Index and rating of SRES in the context of the projections SEEI and TTS – fragment

The Russian Federation member	SEEI 2020		SEEI 2019		TTS 2020		TTS 2019	
	Points	Place	Points	Place	Points	Place	Points	Place
The Russian Federation	53		63		40		45	
the Murmansk Region	58	20	53	46	69	4	44	34
the Magadan Region	72	3	74	1	37	48	46	32
the city of Moscow	58	21	59	22	60	12	61	12
the Belgorod Region	69	5	63	13	53	20	71	6
the Tyumen Region without the Autonomous Region	36	80	46	64	65	7	53	22
the Republic of Tatarstan	63	12	60	20	61	10	58	16
the Khabarovsk region	62	15	57	35	67	5	60	13
the Chukotka Autonomous Region	68	6	64	12	32	53	40	41
the Kursk Region	63	14	59	24	39	46	51	26
the Kamchatka Region	57	25	56	37	56	17	52	23

Table 5. Index and rating of SRES in the context of the projections SEEI and TTS – fragment (continued)

The Russian Federation member	SEEI 2020		SEEI 2019		TTS 2020		TTS 2019	
	Points	Place	Points	Place	Points	Place	Points	Place
…								
the Republic of Tyva	42	69	49	58	26	62	36	49
the Kabardino-Balkarian Republic	53	40	51	51	26	65	21	74
the Ulyanovsk region	34	84	57	30	60	13	69	7
the Chechen Republic	48	55	67	8	22	72	10	85
the Republic of Ingushetia	48	54	48	61	11	84	12	83
the Kurgan region	55	28	71	3	43	42	50	29
the Republic of Crimea	41	72	50	53	17	80	19	75
Krasnodar Krai	39	79	37	81	11	83	14	82
the Altai Republic	60	19	59	21	12	82	32	56
the Karachayevo-Cherkessian Republic	46	62	57	31	9	85	15	80

Sources: calculated by the authors

Table 6. Index and rating of SRES in the context of the projections ERMS and SS – fragment

The Russian Federation member	ERMS 2020		ERMS 2019		SS 2020		SS 2019	
	Points	Place	Points	Place	Points	Place	Points	Place
The Russian Federation	56		79		41		58	
the Murmansk Region	79	3	79	7	64	4	66	14
the Magadan Region	72	8	75	11	62	7	63	17
the city of Moscow	44	32	60	22	68	1	72	4
the Belgorod Region	49	28	44	38	63	6	68	11
the Tyumen Region without the Autonomous Region	58	19	78	9	62	8	66	12
the Republic of Tatarstan	64	14	78	8	64	5	66	13
the Khabarovsk region	41	38	41	40	57	12	64	15
the Chukotka Autonomous Region	73	6	76	10	57	13	61	20
the Kursk Region	58	18	59	23	45	32	61	19
the Kamchatka Region	62	15	45	35	51	22	57	28
…								
the Republic of Tyva	36	43	36	51	26	74	38	73
the Kabardino-Balkarian Republic	18	79	18	79	20	80	22	83
the Ulyanovsk region	20	76	19	76	25	77	40	72
the Chechen Republic	16	84	21	74	14	84	16	85
the Republic of Ingushetia	29	62	39	45	27	72	22	84
the Kurgan region	30	56	17	81	20	81	27	79
the Republic of Crimea	16	85	16	83	25	76	42	68
Krasnodar Krai	24	69	24	71	43	39	59	25
the Altai Republic	17	80	24	70	16	83	26	80
the Karachayevo-Cherkessian Republic	20	75	22	73	22	79	23	82

Sources: calculated by the authors

The spread of Covid-19 in the Russian Federation had a greater impact on the Economic Development Security (SED) and Energy and Raw Materials Security (ERMS) projections – compared to 2019, safety indicators decreased by 20 points or more. In the Social Security (SS) projection, the decrease was 16.5 points. Least of all, the impact affected the projection "Technical and technological safety" (TTS) – the decrease was only 5 points.

In the regions there have been multidirectional changes both among leaders and outsiders. Thus, among the leaders of the overall rating, the SED indicator increased by 5 points in Moscow and by 14 positions in the SED rating, and in Tatarstan, the SED indicator decreased by 26 points and by 26 positions in the SED rating. Among the outsiders, the SED indicator increased by 25 points and 60 positions in the SED rating for the Kabardino-Balkarian Republic, and decreased by 36 points and 48 positions in the SED rating for the Karachay-Cherkess Republic. Among all subjects, the largest increase in the SED indicator in the Lipetsk region - by 30 points and 66 positions in the SED rating, and the largest decrease – 54 points and 65 positions in the SED rating in Sevastopol.

Among the leaders and outsiders of the overall rating, the largest decrease in FS occurred in the Tatarstan – 14 points and 22 positions in the FS rating; the largest increase in the Khabarovsk Territory – by 1 point and 29 positions in the FS rating, in the Kabardino-Balkarian Republic – an increase of 4 points and 39 positions in the FS rating. Among all subjects, the largest decrease in the Republic of Crimea – by 21 points and 60 positions in the FS rating, the largest increase in the Krasnoyarsk Territory – by 13 points and 69 positions in the FS rating.

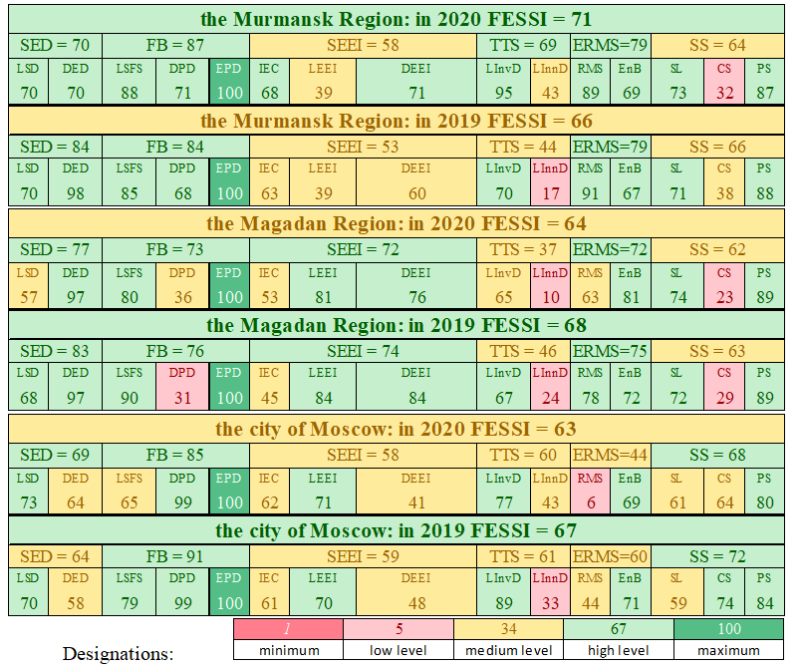
In the SEEI projection, among the leaders of the overall rating, the largest decrease occurred in the Tyumen region without autonomous regions – 10 points and 16 positions in the SEEI rating. Among all subjects, the largest decrease in SEEI in the Ulyanovsk region – 23 points and 54 positions in the SEEI rating, and the largest increase - in the Astrakhan region – 22 points and 62 positions in the SEEI rating.

In the TTS projection, among the leaders and outsiders of the overall ranking, the Murmansk region showed the highest growth – 25 points and 30 positions in the TTS ranking, the Chechen Republic – 12 points and 13 positions in the TTS ranking. Among all regions, the largest growth in the Arkhangelsk region without the Nenets Autonomous Okrug – 36 points and 51 positions in the TSS rating. The greatest decrease in the Republic of Adygea – by 36 points and by 55 positions in the TSS rating.

The ERMS indicator among the leaders of the overall rating decreased by more than 16 points in Moscow and the Tyumen region without autonomous regions, and in the Kamchatka Territory it increased by 17 points – the best indicator among all regions. The largest decrease in ERMS among 85 subjects occurred in the Arkhangelsk region without the Nenets Autonomous Okrug – 21 points. Among outsiders, the largest increase in ERMS in 2020 occurred in the Kurgan region – 13 points, and the largest decrease in the Republic of Ingushetia - 10 points.

In the SS projection, there was a decrease in the indicator in almost all subjects. In 41 regions, the decrease was 10 or more points. The Moscow region turned out to be the leader in terms of decrease in the indicator - almost 20 points. The maximum growth was recorded in the Republic of Ingushetia – 5 points.

Thus, Covid-19 has had a significant and diverse impact on the state of the ESS regions. Figures 2 and 3 show that the state of the ESS is revealed in more detail by detailing the projections in the context of subprojections.



the Murmansk Region: in 2020 FESSI = 71														
SED = 70		FB = 87			SEEI = 58			TTS = 69		ERMS=79		SS = 64		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
70	70	88	71	100	68	39	71	95	43	89	69	73	32	87
the Murmansk Region: in 2019 FESSI = 66														
SED = 84		FB = 84			SEEI = 53			TTS = 44		ERMS=79		SS = 66		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
70	98	85	68	100	63	39	60	70	17	91	67	71	38	88
the Magadan Region: in 2020 FESSI = 64														
SED = 77		FB = 73			SEEI = 72			TTS = 37		ERMS=72		SS = 62		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
57	97	80	36	100	53	81	76	65	10	63	81	74	23	89
the Magadan Region: in 2019 FESSI = 68														
SED = 83		FB = 76			SEEI = 74			TTS = 46		ERMS=75		SS = 63		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
68	97	90	31	100	45	84	84	67	24	78	72	72	29	89
the city of Moscow: in 2020 FESSI = 63														
SED = 69		FB = 85			SEEI = 58			TTS = 60		ERMS=44		SS = 68		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
73	64	65	99	100	62	71	41	77	43	6	69	61	64	80
the city of Moscow: in 2019 FESSI = 67														
SED = 64		FB = 91			SEEI = 59			TTS = 61		ERMS=60		SS = 72		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
70	58	79	99	100	61	70	48	89	33	44	71	59	74	84

Designations:	*1*	5	34	67	100
	minimum	low level	medium level	high level	maximum

Figure 2. Heat map of the state of projections and subprojections of the top three in the FESSI rating in 2020

Sources: calculated by the authors

Krasnodar Krai: in 2020 FESSI = 32														
SED = 32		FB = 73			SEEI = 39			TTS = 11		ERMS=24		SS = 43		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
47	18	55	73	100	53	24	43	19	4	*1*	47	43	52	32
Krasnodar Krai: in 2019 FESSI = 35														
SED = 37		FB = 70			SEEI = 37			TTS = 14		ERMS=24		SS = 59		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
47	28	52	67	100	47	28	40	26	2	*1*	46	41	70	65
the Altai Republic: in 2020 FESSI = 32														
SED = 58		FB = 83			SEEI = 60			TTS = 12		ERMS=17		SS = 16		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
44	73	75	76	100	56	52	71	7	18	2	33	27	*1*	21
the Altai Republic: in 2019 FESSI = 44														
SED = 64		FB = 91			SEEI = 59			TTS = 32		ERMS=24		SS = 26		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
61	68	96	74	100	63	46	70	47	17	11	37	27	34	18
the Karachayevo-Cherkessian Republic: in 2020 FESSI = 28														
SED = 30		FB = 80			SEEI = 46			TTS = 9		ERMS=20		SS = 22		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
42	18	65	81	100	64	44	36	9	10	*1*	39	27	*1*	38
the Karachayevo-Cherkessian Republic: in 2019 FESSI = 37														
SED = 66		FB = 83			SEEI = 57			TTS = 15		ERMS=22		SS = 23		
LSD	DED	LSFS	DPD	EPD	IEC	LEEI	DEEI	LInvD	LInnD	RMS	EnB	SL	CS	PS
56	75	74	81	100	65	50	58	22	7	*1*	43	25	9	36

Figure 3. Heat map of the state of projections and subprojections of the top three outsiders in the FESSI rating in 2020

Sources: calculated by the authors

Comparison of heat maps of leaders and outsiders shows that there is a significant gap in the provision of SRES. Among outsiders, the main threats are manifested in the TTS, ERMS and SS projections, the LINnD, RMS and CS subprojections cause particular concern. The minimum values of the RMS and CS subprojections indicate that the indicators of the lower level included in them take values less than the lower threshold levels of safety. Therefore, in some outsider regions, the most dangerous impact of the spread of Covid-19 has affected consumer safety. The negative impact of Codid-19 also manifested itself in the leading regions – in some of them there was a decrease in CS to a low level. The condition in the LINnD and RMS subprojections generally remained independent of Covid-19.

The proposed model can be supplemented with new indicators for solving special security problems. So, to study the dynamics of integration of regions with the CIS countries and with non-CIS countries, on the basis of 58 low-level security indicators, additional group indicators were formed: “Dynamics of external economic integration with CIS countries” and “Dynamics of external economic integration with non-CIS countries”.

The study of the impact of the sanctions policy of unfriendly countries showed that after 2014 there was no significant increase in the level of integration with the CIS countries. Also, there was no significant decrease in integration with non-CIS countries. The security of external economic integration remained mainly at the average level of the ESS.

3. Conclusion

The concept of SRES is presented. The methodology for diagnosing the level of ESS of the Russian Federation members based on the indicators of the Economic Security Strategy of the Russian Federation has been developed. The methodology is based on a hierarchical structure of 58 lower-level indicators grouped into 15 sub-projections and 6 main projections. The indicators are scored on a scale from 1 to 100 based on the security thresholds and piecewise linear scaling. Based on the scoring, three qualitative levels of security of regional ecosystems are distinguished: low, medium (or average), and high.

Approbation of the methodology according to the data of 2010-2020 showed that the overall level of the security is medium. In 2019, the integrated security indicator for the Russian Federation was able to exceed the average level of the security for 2010-2014 by only 1 point, but in 2020 it dropped again by 14 points. In the Financial Security projection after 2015, a high level of security prevails. The situation is worse in the projections “Technological and technological security” and “Social security”, especially in the context of individual sub-projections: “Level of investment development”, “Living standard”, “Consumer security”. The scoring and qualitative assessment of the indicators makes it possible to form maps of security risks and threats for the constituent entities of the Russian Federation in the context of projections and subprojections. The level of risks and threats can be measured on the same scale and use a similar qualitative interpretation:

$$\text{Level of risks and threats} = 101 - \text{Security level}.$$

The methodology allows ranking the members of the Russian Federation by the level of security and the level of threats in general and in the context of projections, subprojections.

Acknowledgment: The study was carried out within the framework of the project "Development and justification of the concept, the integrated model of resilience-diagnostics of risks and threats to SRES and technology for its application based on the digital twin" (grant of the President of the

Russian Federation NSh-5187.2022.2 for state support of leading scientific schools of the Russian Federation).

References:

Abalkin, L. I. (1994). Economic security of Russia: threats and their reflection. *Economic Issues, 12*, 4-13.

Avdiyskiy, V. K., & Senchagov, V. K. (2014). Methodologies for determining the threshold values of main (priority) risk factors and threats to the economic security of economic entities. *Economics. Taxes. Right, 4*, 73-78.

Information for the analysis of indicators of the state of economic security of the Russian Federation (n.d.). Retrieved from https://rosstat.gov.ru/storage/mediabank/pok-bezopasn.htm

Glazyev, S.Yu. (1997). *Genocide. Russia and the new world order. Economic growth strategy on the threshold of the 21st century*. Moscow: Astra seven

Karanina, E. V., & Karaulov, V. M. (2021). Resilience diagnostics of risks and indicators of the economic security of regions (on the example of the Volga Federal District). *In Economic and legal problems of ensuring the economic security: Proceedings of the IV International scientific and practical conference, Yekaterinburg, March 19, 2021* (pp. 45-50). Yekaterinburg: Ural State University of Economics

Karanina, E. V., Karaulov, V. M., & Kartavyh, K. E. (2022). Conceptual approach to the diagnostics of the ecological and economic security of the region. *Theoretical and Applied Ecology, 4*, 214-223. doi: 10.25750/1995-4301-2022-4-214-223

Karanina, E. V., & Karaulov, V. M. (2023). Differentiated approach to the diagnostics of economic security and resilience of russian regions (case of the volga federal district). *R-Economy, 9*(1), 19-37. doi: 10.15826/recon.2023.9.1.002

Karanina, E., & Loginov, D. (2017). Indicators of economic security of the region: A risk-based approach to assessing and rating. *In IOP Conference Series: Earth and Environmental Science, Khabarovsk, April 10-13, 2017* (p. 012087). Khabarovsk: Institute of Physics Publishing. doi: 10.1088/1755-1315/90/1/012087

Kashin, V. B., Pyatachkova, A. S., Smirnova, V. A., Litvinov, A. A., & Potashev, N. A. (2021). Chinese experts about the new five-year plan. *Analytical note of the National Research University Higher School of Economics*. Retrieved from https://cceis.hse.ru/data/2021/03/29/1386510407/14th%20five-year plan.pdf

Kusi-Sarpong, S., Varela, M. L., Putnik, G., Avila, P., & Agyemang, J. (2018). Supplier evaluation and selection: a fuzzy novel multi-criteria group decision-making approach. *International Journal for Quality Research*, *12*(2), 459-486. doi: 10.18421/IJQR12.02-10

Loginov, D., & Karanina, E. (2016). Risk Management the National Agricultural Policy in the Context of the Challenges of the Global Industrial World. *In Procedia Engineering, St.Petersbug, September 12–15, 2016* (pp. 972-979). St.Petersbug: Elsevier Ltd. doi: 10.1016/j.proeng.2016.11.808

Senchagov, V. (1995). On the essence and foundations of the strategy of economic security of Russia. *Questions of Economics, 1*, 97–106.

Senchagov, V. K. (2001). Economic security as the basis for ensuring national security of Russia. *Questions of Economics, 8*, 64–79.

Senchagov, V. K. (2005). *Economic security of Russia. General course: textbook*. Moscow: Delo

Senchagov, V. K., & Mityakov, S. N. (2011). Using the index method for assessing the level of the economic security. *Bulletin of the Academy of Economic Security of the Ministry of Internal Affairs of Russia, 5*, 41-50.

Senchagov, V. K., Mityakov, S. N., Mityakov, E. S., & Romanova, N. A. (2012). *Economic security of Russian regions*. Nizhny Novgorod: Publisher: Rastr-NN

Tatarkin, A., Romanova, O., Kuklin, A., & Yakovlev, V. (1996). Economic security as an object of regional research. *Questions of Economics, 6*, 78–89.

Tatarkin, A.I., Romanova, O. A., & Kuklin, A. A. (1997). *Economic security of the region. Unity of theory, research methodology and practice*. Ekaterinburg: Publishing House of the Ural State University

Velichko, M. V., Efimov, V. A., & Zaznobin, V. M. (2015). *Economics of innovative development. Management foundations of economic theory*. Berlin: Direct-Media.

Elena V. Karanina
Vyatka State University
Kirov
Russia
karanina@vyatsu.ru
ORCID 0000-0002- 5439-5912

Vasily M. Karaulov
Vyatka State University
Kirov
Russia
vm_karaulov@vyatsu.ru
ORCID 0000-0002- 9599-3740