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Impact of environmental risks on key parameters of development of regional sectors of economy (Case study: Agricultural industry in the Republic of Tatarstan)

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ABSTRACT
The region's economy forms and develops in the wake of a whole set of external and internal factors. At the same time, despite the recent stable trends in the popularization of intangible factors of production in models of economic growth, it should be noted that material production factors undoubtedly retain their relevance and highest importance. In this regard, their research is currently an important research task. The article describes the main approaches to assessing one of the key material factors of production - the ecological and economic infrastructure, which provides the basis for the development of the most important sectors of the economy, including, undoubtedly, agriculture. As a result of the study, the principles for assessing environmental and economic risks in complex spatially distributed systems have been formulated. Environmental and economic risk (EER) has been shown as a function of three states of the system: impact, response (sustainable efficiency) and productivity. At the same time, the degree of impact clearly increases the risk of destabilization of the system, the stability of the system absorbs the environmental, and productivity compensates for the economic component of the risk. On the basis of the constructed economic and mathematical model, a significant influence of the growth of risks of violation of the ecological balance of the territory on the economic parameters of the development of agriculture in the region is proved.

Keywords: Ecological and economic infrastructure, Risks, Economic growth, Region, Agriculture, Catchments.

INTRODUCTION
Regions, as complex, multi-structural socio-economic systems, develop in the wake of a wide range of processes. These include the transformation of the social environment, production factors of a material and non-material order, adjustments in the development of the institutional environment, resource opportunities and limitations, etc. It is important to note that, despite the recent trends, focused on the search and study of models of economic development based on the assessment of intangible factors of production, production factors of the material order have undoubtedly determined and will determine the stability and dynamics of development of socio-economic systems of various levels, including, of course, the regional one. Natural resources are critical in the context of the question posed, forming the resource base and potential of the region; they determine the vector and quality of its socio-economic development (Woodside, G 1998, Costanza, R 2008, Murzin, A.D 2012, Anopchenko, T.Iu 2012, Revunov, R.V & Revunov, S.V 2018). In this regard, a study devoted to assessing the level of such impact is extremely significant and relevant for modern science and practice.

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Also, it should be stated that the practical development of various methods for assessing the impact of the specifics of a particular territorial organization with a certain level of its socio-economic potential on the general economic condition of the region, as well as on the way of implementing innovative approaches in managing economic development with scientifically based consideration of the maximum possible economically verified and objective external and internal factors remains only within the framework of discussion platforms and is still far from attempts at practical implementation (World Health Organization 2003; Jonathan, 2010; Abramenko *et al.* 2018). Thus, this research (on the example of river catchments of one of the regions of the Russian Federation - the Republic of Tatarstan) attempts to develop a methodological toolkit for studying and assessing the impact of a formed regional ecosystem on the key parameters of its economic development.

MATERIALS AND METHODS

Just like any open regional ecological and economic systems, inflows, translocation flows and outflows of matter and energy are characteristic of river catchments (Ackerman 2010). It is impossible to keep track of all of them or fully calculate and simulate absolutely all processes occurring in these systems. However, it is possible to determine an increase in which indicators (and in what combination) leads to an increase in tension in the system, to a decrease in the possible limits of adaptive fluctuations, and which, on the contrary, ensures the stability of the system, expanding the range of permissible deviations. Knowing all this, it is possible to calculate the probability of bifurcations, the probability of the system going beyond the limits of permissible fluctuations of its current functioning, the quantitative expression of which is the generalized ecological and economic risk.

In accordance with the author's approach, environmental and economic risk (EER) is a function of three states of the system: impact, response (sustainable efficiency), and productivity. At the same time, the degree of impact clearly increases the risk of destabilization of the system, the stability of the system absorbs the environmental, and productivity compensates for the economic component of the risk. Various combinations thereof at any given time interval or within a catchment area of any order form a system of triggers that initiate the adoption of certain managerial decisions that ensure the optimal ratio of the natural balance with the parameters of economic development of territories. Being guided by the proposed research paradigm, further, methodological approaches to the implementation of the set task are presented on the example of the Republic of Tatarstan. Long-term series (2009-2019) of environmental and economic information reflecting the functioning and state of various aspects of the ecological and economic infrastructure of the catchment basins of 49 small rivers of the Republic of Tatarstan served as the initial data. As most of the parameters under consideration are related to the administrative regions of the republic, we used their values reduced to the share of the territory of certain catchments for a formalized assessment of the ecological and economic infrastructure. The catchment areas were calculated using MapInfo Professional v.7.2. At the same time, the catchment area of the region was divided into segments geographically relating to some administrative municipal district, with a subsequent assessment of the share of each segment in the total area of the district:

$$\text{К site} = \text{S site}/\text{Sregion} \qquad \textbf{(1)}$$

The obtained value of the coefficient formed the basis for adjusting the absolute values of indicators characterizing a certain parameter of the socio-economic development of the municipal district in relation to the studied territorial segments (sites). Thus, the entire drainage basin of an individual river is estimated by summing the values of the same indicators obtained for different topological sections, in the case of absolute values, and averaging them, in the case of specific ones (for example, reduced to a unit area). These transformations provided values weighted in relation to the basins of various water bodies. The selection of indicators was determined based on the principles of the functioning of ecological and economic systems considered above: impact, sustainability, efficiency, and productivity. The set of indicators used in subsequent calculations and assessments was taken from official statistical collections published by the state statistics bodies of the Russian Federation. In total, the study used and involved in the calculations more than 160 indicators characterizing the ecological and economic state of the region and its individual territories (sites). The first stage of the study involved factor analysis, which provides the process of interpreting the initial variables in the form of their special sets - components “that affect not one, but an entire set of indicators characterizing the phenomenon under study” (Urbakh 1975). It is important to note that each indicator has a different effect on the resulting factor (component), therefore, it is advisable to calculate the level

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of influence of each indicator on the component under study and to highlight those of them that have the highest level of factor loads. Factor loadings are, in fact, correlations between the corresponding variables and components; they reflect the contribution of a particular variable within a particular component. The most significant variables can be distinguished by the value of the factor load. These variables are grouped into factors, each of which covers a certain aspect of the phenomenon under consideration. The necessary calculations were performed using the Principal Components method in Statistica 6.0 (StatSoft, Inc.). Using this method, 3 factors (components) were identified. The number of factors was selected according to the value of the total variance, using the “scree” method. Considering that the investigated and identified factors are orthogonal, the entire set of indicators/variables involved in their determination was subdivided into three large groups characterizing such parameters of the studied systems as "impact", "response”, and "productivity". The indicators being used in the further iterative calculations included those for which the factor loadings exceeded 0.7. Based on the position assuming that factor loadings are nothing more than the correlation coefficients between the analyzed variables and factors, the obtained values form the basis for determining the so-called weighting coefficients. The values of the "weights" were calculated using the formula 2:

$$\mathrm{Kfn} = \mathrm{fn}/\mathrm{fn\ max} \quad \textbf{(2)}$$

RESULTS AND DISCUSSION

The results of the implemented assessments and calculations are shown in Table 1. The indicators identified as a result of the previous iteration of the study were subjected to a standardization procedure for the purpose of their unification and subsequent data processing (Formula 3).

$$\mathrm{Value\ n_{reduced}} = \mathrm{Value\ n}/\mathrm{Value\ n\_max} \quad \textbf{(3)}$$

Further, implementing the algorithm of "weighing" the obtained normalized (reduced) values according to formula 4, the initial, basic series were obtained, characterizing the level of development of the ecological and economic system of the catchment area of the region and its individual territories (segments).

$$\mathrm{Indicator\ n} = \mathrm{Value\ n_{reduced}} * \mathrm{K_{fn}} \quad \textbf{(4)}$$

To determine the level of the critical value characterizing the upper limit of the acceptable risk, the method of estimating the upper quartile in the resulting series of the sample of calculated medians was applied. Relying on an approach based on an assessment of the ratio of the values obtained for the studied catchments to the constructed critical values (the so-called background values), indicators were obtained that characterize the level of risk of individual components of the development of the ecological-economic system of the region and its individual territories (Formula 5). This approach is fully consistent with the methodological principles set forth by V.Iu. Urbakh in his study (Urbakh 1975).

$$\mathrm{Risk\ i} = 1 - \exp\left(-\left(\frac{(\mathrm{m\ i}/\mathrm{m\ ф})2}{2}\right)\right) \quad \textbf{(5)}$$

Where, $Risk\ i$ is the probability of exceeding the risk parameters over the limiting (critical) values of risk in the ith area; m i is the normalized value of the indicator in the section i; m f is a critical risk value corresponding to the calculated parameters of the first quartile. The implementation of a series of calculations, formed on the basis of the above approaches and methods, made it possible to determine for each catchment area of the Republic of Tatarstan risk values for the studied parameters: “impact”, “instability”, “inefficiency” (Table 2). The integral index of ecological and economic risk (EER) in different areas of the study of the analyzed region was obtained on the basis of calculating the power function according to formula 6. The results are shown in Table 2.

$$EER = (\mathrm{Risk_{Impact}} * \mathrm{Risk_{Instab}} * \mathrm{Risk_{Ineffic}})^{1/3} \quad \textbf{(6)}$$

The results assessing the risks of ecological and economic systems (using the example of the analyzed 49 catchments) are graphically shown in Fig. 1.

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Table 1. Variables selected as a result of factor analysis, their factor loadings and weight coefficients.

Variables	Factor loadings	Weighting Coefficients (K_{fn})
Factor 1 ("impact")		
Industrial potential (points)	0.734	0.744
Water intake (million cubic meters)	0.771	0.782
Amount of pollutants (tons)	0.705	0.715
Discharge of contaminated water (million cubic meters)	0.797	0.808
Atmospheric emissions (tons)	0.747	0.758
Waste generated (tons)		
Rural population (thousand people)	0.702	0.712
Total population (thousand people)	0.962	0.976
Lime materials introduced for crops (tons)	0.957	0.971
Organic fertilizers introduced for crops (tons)	0.958	0.972
Mineral fertilizers introduced for crops (tons)	0.786	0.797
Total energy capacity	0.952	0.966
Total tractors (units)	0.986	1.000
Total harvesters (units)	0.986	1.000
	0.980	0.994
Factor 2 ("performance")		
Farm profitability (%)	-0.857	0.869
Pea yield (kg ha^{-1})	-0.702	0.712
Beet yield (kg ha^{-1})	-0.706	0.716
Potato yield (kg ha^{-1})	-0.700	0.710
Agricultural products (thousand rubles)	-0.977	0.991
Livestock of cattle (heads)	-0.961	0.975
Livestock of pigs (heads)	-0.940	0.953
Livestock of sheep (heads)	-0.947	0.960
Livestock of horses (heads)	-0.956	0.970
Water used (million cubic meters)	0.816	0.828
Products and agriculture used (million cubic meters)	0.811	0.823
Milk production (tons)		
Meat production (tons)	-0.977	0.991
Egg production (thousand pieces)	-0.952	0.966
Gross harvest of grain (tons)	-0.700	0.710
Gross harvest of peas (tons)	-0.956	0.970
Gross harvest of potatoes (tons)	-0.939	0.952
Perennial grasses hay harvest (tons)	-0.977	0.991
	-0.975	0.989
Factor 3 ("response")		
Land fund (thousand ha)	-0.913	0.926
Arable land area (thousand ha)	0.947	0.960
Total sown area (ha)	0.952	0.966
Specially protected nature reserve area (ha)	-0.745	0.756
Surface runoff (point)	-0.777	0.788
Environmental protection costs (million rubles)	-0.701	0.711
Cost of production of 100 kg weight gain of cattle (rub)	0.778	0.789
Cost of production of 100 kg of milk (rub)		
Forest cover (%)	0.785	0.796
Erosion rate (%)	-0.730	0.740
	0.700	0.710

The relationship of the calculated risks is well known, where the risk values are presented in the form of polynomials. Using the methods of statistical analysis (quartile methods), the obtained EER values were divided into 4 groups characterizing the level of risk: critical, high, medium, and low. The resulting ranges of values are presented in Table 3.

The high level of the EER value indicates high loads experienced by ecological and economic systems. Low risk of instability - about the growth of the sustainability of the ecological and economic system to anthropogenic impact on it. A high level of risk of inefficiency - about a decrease in productivity and economic efficiency of the functioning of the catchment system of the region.

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Table 2. Risk values at different survey sites (for the first 10 catchments).

Catchments	Types of risk			
	Impact $Risk_{Impact}$	Instability $Risk_{Instability}$	Inefficiency $Risk_{inefficiency}$	EER
Aktai	1	0.382	0.400	0.535
Amgamka (Karamalka)	0.709	0.657	0.459	0.598
Anzirka	0.479	0.454	0.470	0.468
Ashit	1	0.379	0.326	0.498
B. Cheremshan	1	0.396	0.174	0.409
Bezdna	0.602	0.482	0.453	0.508
Bersut	0.844	0.516	0.454	0.583
Betka	0.437	0.490	0.468	0.464
Bima	0.993	0.551	0.458	0.630
Bolshaya Bakhta	0.914	0.429	0.451	0.561
...	…	…	…	…

Table 3. Range of values of the level of ecological and economic risk.

Risk level			
critical	**high**	**medium**	**low**
$0.563 \leq EER$	$0.480 \leq EER < 0.563$	$0.385 \leq EER < 0.480$	$0 < EER < 0.385$

Further, relying on the obtained estimates of the EER level, calculations were carried out that fix the level of impact of the emerging environmental and economic risks on the parameters of agricultural development in the region - one of the key economic activities of the Republic of Tatarstan. As part of the implementation of a series of econometric calculations, a final regression model was obtained that estimates the above parameters (Table 4).

Table 4. Values of regression coefficients and their statistical significance.

	Coefficients	Standard error	P Value
Y intersection	163683.7	0,29	0.002
$Risk_{Impact}$	9823.4	0.21	0.000
$Risk_{Instability}$	-85824.8	0.62	0.12
$Risk_{inefficiency}$	-255197.7	0.25	

(R = 0.77; R2 = 0.59; F = 42.7; p < 0.001).

SUMMARY

The result obtained largely indicates the need for the formation of management systems for the ecological and economic infrastructure of the region, since, as proved on the basis of the above calculations, the ineffective organization of this process can lead to significant economic risks and losses. Thus, according to the estimates obtained, it has been established that an increase in the risk of instability and inefficiency of ecological and economic systems leads to significant losses in the sphere of financial stability of the functioning of agriculture in the region. Thus, a precise adjustment of risk values to the values of absolute indicators of water consumption was established, which determines the level of development of the ecological and economic infrastructure of the region. In general, limiting to the research subjects constructed in this article, we should state that all the constructed relationships are quite natural and are presented here as an illustration of the adequacy of the calculated risks to the absolute indicators of the state of the ecological and economic infrastructure of various watersheds.

CONCLUSION

The key result of the research was that, guided by the methods of scientific knowledge of the phenomena, we established and proved, on the basis of formalized assessment methods, the need to search on a systematic basis for solutions focused on understanding not just a compromise between environmental and economic interests, but

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the unity of ecological and economic components of the system and ideas about their sustainable balanced development.

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تأثیر خطرات زیست محیطی بر فراسنجه‌های اصلی توسعه بخش‌های منطقه‌ای اقتصاد (مطالعه موردی: صنعت کشاورزی جمهوری تاتارستان)

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چکیده

اقتصاد منطقه در پی مجموعه‌ای از عوامل خارجی و داخلی شکل گرفته و توسعه می‌یابد. در عین حال، به‌رغم روند پایدار اخیر در محبوبیت عوامل ناملموس تولید در مدلهای رشد اقتصادی، باید توجه داشت که عوامل تولید مواد بدون شک اهمیت و بالاترین اهمیت خود را حفظ می‌کنند. در این راستا ، تحقیقات آنها در حال حاضر یک کار مهم تحقیقاتی است. در این مقاله روشهای اصلی ارزیابی یکی از عوامل اصلی تولید - زیرساختهای اقتصادی بررسی می شود که زمینه را برای توسعه مهمترین بخشهای اقتصاد، از جمله، کشاورزی فراهم می‌کند. در نتیجه این مطالعه، اصول ارزیابی خطرات زیست محیطی و اقتصادی در سیستم‌های پیچیده توزیع مکانی تدوین شده است. ریسک اقتصادی و زیست محیطی (EER) تابعی از سه حالت سیستم نشان داده شده است: تأثیر، پاسخ (کارایی پایدار) و بهره‌وری. در عین حال، میزان تأثیر به وضوح خطر بی‌ثبات سازی سیستم را افزایش می‌دهد، پایداری سیستم محیط را جذب می‌کند و بهره‌وری مولفه اقتصادی خطر را جبران می‌کند. بر اساس مدل اقتصادی و ریاضی ساخته شده، تأثیر قابل توجهی در رشد خطرات نقض تعادل بوم شناختی قلمرو بر فراسنجه‌های اقتصادی توسعه کشاورزی در منطقه اثبات شده است.

*مولف مسئول

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