AgroLife Scientific Journal - Volume 8, Number 2, 2019
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

METHODICAL APPROACH TO ASSESSMENT OF RISK OF ENVIRONMENTAL SAFETY IN THE AGRICULTURAL ECONOMY SECTOR

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Abstract

The article has developed a methodical approach to assessing the risk of environmental safety in the agricultural sector of the economy. In order to prevent the introduction of complex methods for assessing the risks of environmental safety, it has been proposed to use a binary method for making managerial decisions to determine the likelihood of the latter occurring. To assess the level of environmental safety risk in the agricultural sector of the economy, its conditional gradation has been proposed, taking into account and based on the results of calculations of the integral index conducted in the regions of Ukraine, their grouping has been carried out. The calculation of the overall environmental safety risk in the agricultural sector (RI_{ES}) is proposed to be carried out by determining the sum of the calculated risk values for the environmental safety indicators, taking into account the respective weights of these indicators. As a result of approbation of the methodological approach, the grouping of the regions of Ukraine on the level of risk of environmental safety in the agrarian economy sector has been carried out, on the basis of which the corresponding strategic priorities of implementation of strategies for management are proposed.

Key words*: agricultural, assessment, risk, environmental, safety.*

INTRODUCTION

The issue of sustainable development of the agricultural sector in recent years has been developing in the direction of ensuring the integrated, systemic development of rural areas, including the sphere of production, the social sphere and the environmental component. So, the sustainable development of the agrarian sector and agro-ecosystems is now impossible without ensuring environmental safety, which is one of the most important components of national security, since it performs a dual function: as an integral part of national security and as a necessary condition for life and other basic types of national security.

Modern environmental policy, as an integral part of the country's national state policy, should characterize the directions, forms, methods and techniques for managing environmental problems and, ultimately, determine the environmental activities of enterprises and the environmental and economic level of sustainable development. Therefore, the idea of systematically combining the imperatives of environmental safety and sustainable development opens up new methodological horizons for the study of environmental and economic problems, the solution of which will further contribute to the formation of a modern strategy for the environmentally balanced development of society and nature.

The modern strategy of development of domestic agricultural production is based on the principles of balancing and ensuring the interests of society. In view of this, the issue of ensuring environmental safety in the agrarian sector of the economy for many years remains extremely important, first of all, for the balanced development of agroecosystems (Soest et al., 2016; Wood et al., 2000). It is in this regard that each branch needs a transformation of the management system, which would allow the implementation of a balanced development program, increased environmental safety through the creation of a

flexible system for responding to external and internal threats.

To ensure environmental safety in the agricultural sector, at each stage of agricultural activity, a strategy appropriate to its characteristics is applied. The main criterion for choosing a strategy is the level of environmental safety and the results of assessing the impact of threats and risks on the agroecosystem. Strategic forecasting of environmental safety, especially long-term, is based on thorough analysis, forecasting and probabilistic assessment of the whole complex of internal and external conditions, modeling the development of events for further decision-making. One of the most significant features of the strategic management of environmental safety within a market economy is the high level of uncertainty about threats and risks (Samoilik and Onyshchenko, 2012).

It should be noted that theoretical-methodological developments in the sphere of environmental risks are, as a rule, limited by the analysis of situations caused by negative environmental impacts in the event of violation of regulatory regulations. Such situations are also directed to methods for assessing ecological damage. In developed countries, the assessment of ecological damage is directly caused by a disruption in the functioning of the economic system for causing harm to the environment (Freeman and Kunreuther, 1997).

Representatives of the National Institute of Strategic Studies S.P. Ivaniuta, A.B. Kachinskiy notes that "the level of ecological safety in Ukraine in the future is determined by the magnitude of the risk from both possible natural and man-made disasters, and from negative processes that occur slowly, but in time can lead to social explosions (environmental issues, social conflicts)". Such a methodology will correspond to the "parameters of determining the grade of ecological safety in the event of emergency situations of natural and technogenic origin, and while ensuring the ecological safety of the regions, we emphasize that it is necessary to pay attention not only to environmental risks" (Ivanyuta and Kachinskij, 2012). In this connection, it should be noted that S. Lisovskiy offers "a method of an integrated indicator of ecological safety, namely, calculated on the basis of eight indices". In our opinion, the advantage of this technique is its complexity in combination with the relative simplicity of calculations, and the main drawback is the failure of many indicators that reflect the qualitative parameters of natural resources (Lisovskij, 2014). Scientists G. Obihod and T. Omelyanenko emphasize that the construction of a certain rating, providing for a sufficient number of indicators, is possible only if the latter is built up to an integral estimate (Obihod and Omelyanenko, 2012). Thus, the integrated assessment allows, in addition to the study of hazard phenomena, to conduct statistical comparisons, which greatly facilitates the analysis process and makes it objective.

It should be noted that in the domestic sphere of environmental, there is a state system for monitoring it, in accordance with which a system for monitoring ecological indicators is being implemented. However, analysis and estimation of the situation based on the results of observations in order to identify negative trends, determine and assess their level of danger, and then develop scientifically sound proposals for their overcoming, requires the use of modern methods of quantitative and qualitative analysis. Among such methods, the importance of an indicative analysis should be noted, which implies the use of limit (threshold) values of indicators, going beyond which indicates the emergence of threats in the area under study (Lundgren and Zhou, 2017).

However, during the forecasting of environmental safety scenarios in the agrarian sector there is a need not only to state the level of this safety, but also to determine the trends of its change to take into account the probability of its risks. Unlike the threat, the risk is defined as the possibility of adverse and undesirable consequences (Dobriansky et al., 2012). Therefore, the risk of environmental safety in the agrarian sector of the economy will be understood as the probability of adverse consequences for agroecosystems caused by ecological destructive effects of agricultural activity or emergency situations (natural and man-made), which involve the emergence of danger to human health and the degradation of natural resources and biodiversity.

However, given the current theoretical and methodological developments and analytical

developments in the area of identifying the risks of environmental safety in the agricultural sector of the economy, it is worth noting that there is still no single, generally accepted and normatively approved procedure for their assessment. Thus, the main task is to develop and substantiate the methodological approach to assessing the risk of environmental safety in the agrarian sector.

MATERIALS AND METHODS

The analysis of the issues of environmental risk assessment showed that this method should be used locally. In the region or countries in general, this method is practically not used, as there are no databases for the estimation of environmental risks that characterize the scale and frequency of their manifestation. In addition, existing methods for assessing environmental damage do not correspond to the economic relations established in the country, and most of them do not have the necessary legal status for use in the agrarian sector of the economy.

In order to prevent the implementation of complex methods for assessing the risks of environmental safety in the agricultural sector, it is proposed to use the binary method to determine the likelihood of its occurrence, since the value of the output variable (risk occurrence) may have two values: it will come (1, or true) or will not come (0 or false). The essence of this method is that if the actual value of the indicator (at the reporting date) included in the system of diagnostics of the level of environmental safety, in accordance with the basic (initial period) has improved or remains at the same level then assigned to it 0, in another case - 1.

The advantages of the proposed system include the lack of expert assessments, the need to apply their own criteria for each indicator and the formation of burdensome mathematical calculations for valuation methods. However, the binary system has drawbacks because it is characterized by lack of flexibility and does not reflect the amount of change in each indicator of environmental safety.

Consequently, for the modeling of environmental safety in the agrarian sector of the economy taking into account the risk calculation is carried out in this way:

$$Rx_i = \begin{Bmatrix} 1, when \dots x_i^{tf} \prec x_i^{tb} \\ 0, when \dots x_i^{tf} \geq x_i^{tb} \end{Bmatrix}, \qquad (1)$$

where: R_{xi} - estimated value of risk on the i-th indicator of environmental safety in the agrarian sector of the economy;

x_i^{tb} - the unregulated value of the i-th indicator for the base period;

x_i^{tf} - the unregulated value of the i-th indicator for the reporting period.

Accordingly, calculation of the aggregate risk of environmental safety in the agrarian sector of the economy (RI_{ES}) is proposed to be carried out by way of determining the amount of estimated risk values for the i-th indicator of environmental safety in the agrarian sector of the economy, taking into account the respective weighting factors of these indicators:

$$RI_{ES} = \sum_{i=1}^{n} Rx_i \times d_i \ , \qquad (2)$$

where: di - weighting factor determining the contribution of the i-th indicator to the integral index of environmental safety in the agrarian sector of the economy;

n - number of indicators used in calculating the integral index of environmental safety in the agrarian sector of the economy.

The choice of the system of indicators was carried out taking into account the accumulated domestic and international experience, methods in ensuring ecological safety, as well as the recommendations of state authorities and relevant international organizations, in particular World Economic Forum, United Nations Commission on Sustainable Development, Food and Agriculture Organization of the United Nations, Scientific Committee on Problems of the Environmental.

Indicators illustrating environmental safety in the agrarian sector of the economy according to the calculations carried out, as well as taking into account certain principles (representativeness, availability and reliability of statistical data, efficiency, timeliness and continuity of their receipt, and costs of obtaining), conditions and features of the domestic information support. The main issue in the choice of the

system of environmental safety indicators in agriculture is the contradiction regarding the importance of the indicator and the availability of its information characterizing.

The mentioned indicators characterize the state of agroecosystems and ecological destructive influence of factors on them and human life in general (land resources, water resources, exogenous geological processes, waste management, biodiversity, etc.).

Some indicators also characterize the state of natural resource potential and the assimilation potential of agroecosystems.

The system of these indicators was formed taking into account indicators of the Environmental Performance Index (EPI) (Hsu et al., 2016).

The translation of the actual values into the normalized is carried out with the range of normalized values of each indicator from 0 to 1. In addition, the indicators, among which there is a direct connection to the integral index (ie, the desired growth rate relative to baseline) is calculated as the ratio of the actual value to the limit (threshold) and, accordingly, those indicators which are optimal for their reduction, are calculated by the ratio of the threshold value to the actual (Eq. 3 and Eq. 4):

$$\text{when } x_i \to \max, \quad \text{then } x_i = \begin{Bmatrix} 1, y_i \geq z_i \\ \dfrac{y_i}{z_i} \end{Bmatrix}, \quad (3)$$

$$\text{when } x_i \to \min, \quad \text{then } x_i = \begin{Bmatrix} 1, y_i \leq z_i \\ \dfrac{z_i}{y_i} \end{Bmatrix}, \quad (4)$$

The determination of the threshold values of the indicators was carried out with the help of an expert assessment (Table 1).

The organization of conducting of examinations was carried out by the method of questioning, determination of weight coefficients - by the method of direct assessment.

Weight index coefficients for calculating the integral index of environmental safety in the agrarian sector are presented in Table 1 (Shkuratov, 2018).

Table 1. The main indicators of environmental safety in the agrarian sector of Ukraine and their thresholds

No.	Name of the indicator	Threshold values of the indicator	Indicator optimality criterion	The value of the weight factor
x_1	Ecological risk to public health, %	0.05	Min	0.07
x_2	Child mortality rate, unit.	5	Min	0.06
x_3	Ecological-agrochemical estimation of lands, score	100	Max	0.07
x_4	Coefficient of ecological stability of territories, units.	0.51	Max	0.08
x_5	Landseness of the land, %	10	Min	0.12
x_6	Pesticide load, kg/ha a.s. a year	1.2	Min	0.08
x_7	Chemical load, kg/ha a.s. a year	90	Min	0.08
x_8	Dynamics of humus content in the soil, %	100	Max	0,11
x_9	The level of implementation of the normative-based norm for the introduction of organic fertilizers, %	100	Max	0.06
x_{10}	Area of agricultural land contaminated with radionuclides, %	1	Min	0.05
x_{11}	The level of pollution of drinking water by decentralized water supply with nitrates, %	5	Min	0.04
x_{12}	Expenditure on biodiversity and ecosystem conservation in the overall structure of environmental spending, %	10	Max	0.07
x_{13}	The share of ecological network components in the general structure of agricultural land, %	40	Max	0.06
x_{14}	Coefficient of coverage of damage caused by environmental pollution, UAH/UAH	1	Max	0.05

Using the postulates of the classical theory of risk presented by modern economists (Balackij, 2007; Illiashenko and Bozhkova, 2004; Kovalevska, 2015; Shmal, 2010; Burgman, 2005), we can conclude that the measurement of uncertainty determines the minimization of risk, the steady state of agroecosystem and environmental safety in the agrarian sector of the economy as a whole. Such a statement is conceptual for our study. Risk management is implemented and the adaptive system of ensuring environmental safety in the agricultural sector is based on precisely the measurement of uncertainty (Mingjun, 2012). Conducting an analysis of environmental risks

enables to form a series of management decisions, aimed, first of all, to minimize the manifestations of environmental hazards and localization, with the further minimization of damage and losses in the event of their implementation.

RESULTS AND DISCUSSIONS

Assessment and diagnostics of the level of environmental safety in the agricultural sector of Ukraine were conducted in terms of regions in the reporting and baseline period (Table 2).

Table 2. Ranking of the regions of Ukraine on the level of risk to environmental safety in the agrarian sector

Region/Area	Value of integral index in the base period (2010)	The value of the integral index for the reporting period (2018)	The value of the integral index of the risk of environmental safety
Transcarpathian	0.76	0.76	0.24
Kyiv	0.63	0.62	0.25
Dnipropetrovsk	0.51	0.50	0.30
Luhansk**	0.55	0.56	0.31
Chernivtsi	0.60	0.61	0.32
Ivano-Frankivsk	0.57	0.58	0.34
Poltava	0.55	0.54	0.37
Kharkiv	0.56	0.54	0.42
Kherson	0.60	0.61	0.44
Vinnytsia	0.48	0.46	0.46
Kirovohrad	0.54	0.53	0.47
Volyn	0.68	0.67	0.47
Khmelnytsky	0.47	0.47	0.47
Cherkasy	0.49	0.48	0.48
Zhytomyr	0.61	0.60	0.51
Lviv	0.55	0.53	0.52
Mykolaiv	0.57	0.54	0.58
Donetsk**	0.54	0.49	0.59
Odesa	0.59	0.57	0.61
Ternopil	0.67	0.58	0.67
Sumy	0.68	0.62	0.67
Crimea*	0.61	0.61	0.68
Rivne	0.56	0.50	0.69
Zaporizhzhya	0.55	0.51	0.70
Chernihiv	0.69	0.64	0.74

*Data for 2013 for the temporarily occupied territory of Crimea;
**Data without regard to part of the zone of anti-terrorist operation.

The use of the considered methodological approaches to assessing the risk of environmental safety in the agrarian sector of the economy made it possible to differentiate the regions of Ukraine depending on the integral index and rank them at the level of the risk of environmental safety.

In order to assess the level of the risk of environmental safety, its conditional gradation was proposed (Table 3), taking into account and based on the results of calculations of the integral indicator of the level of risk of environmental safety in the agricultural sector of the economy, conducted in the regions of Ukraine, they have been grouped.

Table 3. Grouping of Regions on the risk of environmental safety in the agricultural economy sector, 2018

Level of risk	The value of the integral index	The region
High	0.67-1.00	Crimea*, Zaporizhzhya, Rivne, Sumy, Ternopil, Chernihiv
Average	0.33-0.66	Vinnytsia, Volyn, Donetsk, Zhytomyr, Ivano-Frankivsk, Kirovohrad, Lviv, Mykolaiv, Odesa, Poltava, Kharkiv, Kherson, Khmelnytsky, Cherkasy
Low	0-0.32	Dnipropetrovsk, Transcarpathian, Kyiv, Luhansk**, Chernivtsi

*Data for 2013 for the temporarily occupied territory of Crimea;
**Data without regard to part of the zone of anti-terrorist operation.

Graphic interpretation of the levels of environmental security risk in the agrarian sector by region of Ukraine is shown in Figure 1.

For a clear illustration of the real situation, it is suggested to form a matrix that demonstrates the obtained values of integral indicators of environmental safety and its risks (Figure 2). To determine the zone of ecological safety, based on the given matrix, it is possible to form a crossroads between values of integral indicators and environmental safety and overall environmental risk. The zone of environmental safety will be located to the left of the intersection. According to the proposed matrix of the environmental safety assessment of the agrarian sector, the following areas can be identified: sustainable environmental safety; unsustainable environmental safety; ecological danger, ecological catastrophe.

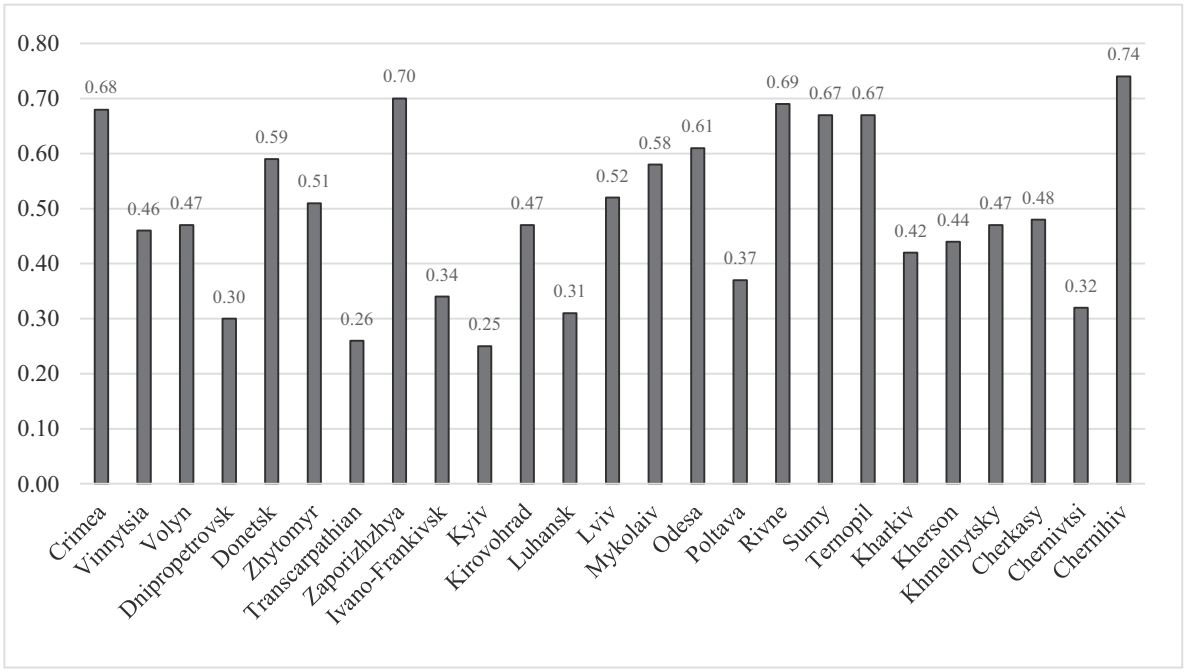

Figure 1. Level of the environmental safety risk in the agricultural economy sector of regions of Ukraine, 2018

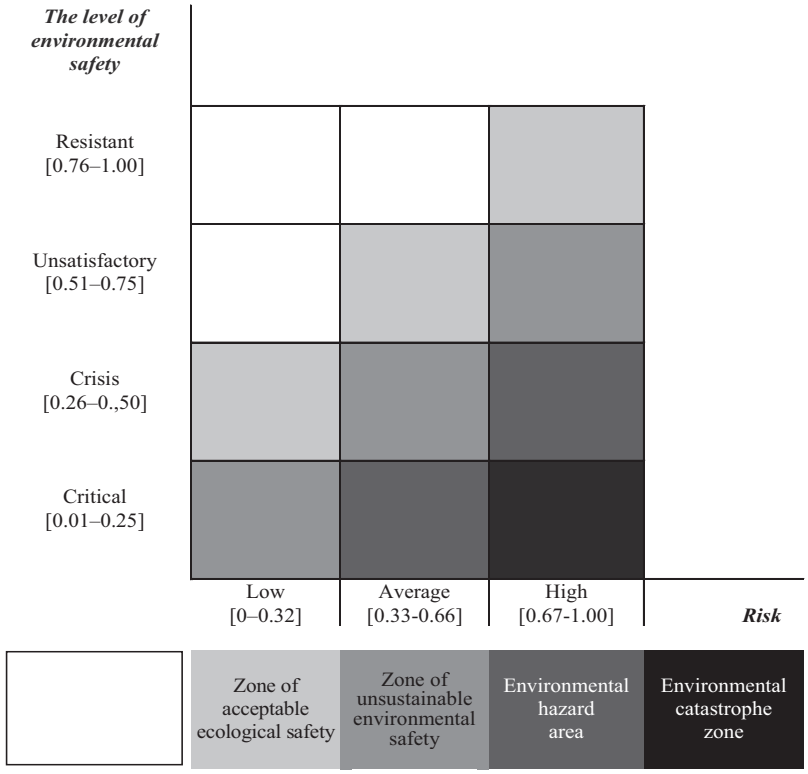

Figure 2. Matrix of the results of environmental safety assessment in the agricultural sector taking into account the level of risks

Thus, solving the issue of forming a strategy for ensuring environmental safety in the agrarian sector of the economy under risk conditions can be realized by applying the scenario approach (Manos et al., 2010).

At the same time, the sustainable level of environmental safety strategy, aimed at preventing possible threats to the security object. Management decisions taken as part of a defined strategy and appropriate measures aimed at exploiting the opportunities that are emerging and discovered during the study of threats and the state of environmental safety, as well as in the process of adopting preventive environmental measures.

Threat limitation strategy is an environmental safety management strategy that limits unwanted actions to security objects. Such a strategy assumes that the response to threats begins when threats to environmental safety in the agrarian sector are beginning to affect agroecosystems (Martynenko and Ihnatiieva, 2006). In this regard, the strategic objectives of such objects, in fact, should include the localization of threats to environmental safety in the agricultural sector and the gradual restoration of environmental equilibrium. Given the foregoing, it can be argued that the implementation of such a strategy requires the use of liquidation and preventive measures with the prevailing share of liquidation funds. A similar strategy is characterized by the need for both rigid and soft controls.

Thus, the destabilizing effect of ecological destructive factors on agroecosystem requires strict regulation of agricultural activity, aimed at ensuring stability and improving the qualitative characteristics of the environment. In addition, the need to ensure the sustainable development of the agrarian sector requires the use of tools that will be characterized by the economic efficiency of production and economic-stimulating effect.

The strategy of risk insurance is aimed at functioning of the management tools and minimization of risks of environmental safety in the process of agricultural activity. In this case, the loss is assumed, however, it is offset by actions (for example, through a policy of risk assessment and environmental insurance) that are provided by an appropriate strategy through pre-established reserves. For objects whose level of environmental safety is critical, a strategy is adopted that involves the restoration of the level of safety while simultaneously compensating for the possible damage incurred (Ivanyuta and Kachinskij, 2012). Within the framework of such a strategy, liquidation measures are envisaged that include concentration of means and efforts on localization and minimization of the consequences of environmental degradation of certain factors, in particular on population health. In general, the process of providing this strategy for environmental safety management in the agricultural sector is implemented through a set of administrative tools with rigorous control methods: licensing, standardization, environmental audit.

Consequently, depending on the levels of environmental safety in the agrarian sector of the economy and its risk, for each region the relevant strategic priorities of its implementation are chosen (Table 4).

Table 4. Characteristics of strategies for environmental safety management in the agrarian sector of the economy of the regions of Ukraine

Environmental safety zones	Strategy	The region	Strategic priorities*
Sustainable environmental safety	Preventing of threats	Transcarpathian	S1
		Kyiv, Luhansk, Zaporizhia	S1; S2
Acceptable environmental safety	Limitation of threats	Volyn, Poltava	S1; S2
		Zhytomyr, Kirovohrad, Kherson	S2
		Dnipropetrovsk, Ivano-Frankivsk, Lviv, Mykolaiv, Odesa, Kharkiv	S2; S3
Unstable environmental safety	Risk insurance	Crimea, Zaporizhia, Sumy, Ternopil, Chernihiv	S3
		Vinnitsa, Donetsk, Khmelnytsky, Cherkasy	S3; S4
Environmental hazard	Preservation	Rivne	S4

*Note: S1 - preventive measures to prevent environmental threats; S2 - minimizing the manifestation of environmental threats as a result of environmental degradation factors; S3 - minimizing environmental risks; S4 - minimizing the consequences of environmental hazards and possible environmental damage.

In accordance with the identified priorities of the strategy of environmental safety, the necessary resource provision of the appropriate measures is determined, thus the structure of the strategy is formed on the basis of the need to achieve the goal taking into account the possible risks.

The most commonly used mechanism in the system of branch management is the programmatic approach, since within it the complexes of program-targeted measures, pre-grounded, agreed in the economic, budgetary, normative and interdepartmental plan, are developed in its framework, is one of the most effective variants of intervention in the agrarian economy.

CONCLUSIONS

Thus, when forecasting environmental safety scenarios in the agrarian sector, there is a need

not only for establishing a certain level of this safety, but also for determining trends in its changes, taking into account the probability of risks. In order to prevent the introduction of complex methods for assessing environmental risks, it is justified in determining the probability of its occurrence the need to use a binary method of making management decisions.

The proposed scenario approach to the development of a strategy for environmental safety management in the agrarian sector will provide an opportunity to adopt flexible management solutions and propose appropriate measures taking into account its existing level and possible risks. Depending on the levels of environmental safety and its overall risk, each region is selected by appropriate strategies and strategic priorities, implemented through a set of tools and impact measures with appropriate methods. Proceeding from this, the prospect of further research is to substantiate the mechanisms and tools for implementing the selected strategy for ensuring environmental safety in the agricultural sector of the economy.

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