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# Mechanism for managing the transition to sustainable development of natural-anthropogenic complexes of rural areas created as a result of the production of grain crops

O V Shumakova<sup>1</sup>, D S Nardin<sup>1\*</sup> and S A Nardina<sup>1</sup>

<sup>1</sup> Omsk State Agrarian University, 1 Institutskaya square, Omsk 644008 Russia

E-mail: ds.nardin@omgau.org

**Abstract.** The article substantiates a methodological approach to the formation of a mechanism for managing the transition to the sustainable development of natural and anthropogenic complexes in rural areas of the region, created as a result of grain production. A method of analyzing the level of impact of natural and anthropogenic complexes on natural landscapes and the level of socio-economic development of rural areas of the region has been developed. The methodology analyzed and proposed a set of measures aimed at creating a mechanism for managing the transition to sustainable development of natural and anthropogenic complexes in rural areas of the Omsk region.

## 1. Introduction

The grain industry is one of the most dynamically developing branches of agriculture. The volume of cereal production in 2017 amounted to more than 2.6 billion tons [1]. At the same time, about 30% of the global grain industry accounts for wheat. The volume of grain production in Russia in 2017 exceeded 134 million tons, which amounted to 5% of the global production [2]. Grain production in Russia is unevenly distributed across regions: the first 15 regions account for 68% of cereal production, including the Omsk region.

The Omsk region is located in the south of Western Siberia, on the border with the Republic of Kazakhstan. According to the totality of climatic conditions, the region belongs to the zone of risk farming, on average once every 5 years there are dangerous and (or) adverse natural phenomena (floods, droughts, late spring or early summer frosts), which lead to a loss of more than 50% of the grain yield. Nevertheless, the Omsk region is annually included in the list of 10-15 regions of Russia with the largest volume of grain production. The total sown area in the Omsk region exceeds 3 million hectares, of which about 55% are under wheat. In 2017, the volume of cereal production in the Omsk region was 2.7% of the Russian production volume. At the same time, more than 90% of the grain produced in the region is food and fodder spring soft wheat.

When growing wheat, natural-anthropogenic complexes of rural areas are created in the region, which significantly distort or may in the future have a significant impact on natural landscapes. The degree of negative impact of grain production on the natural landscapes in the Omsk region, compared with European countries, is currently rated as relatively low, which is explained by different levels of intensification, which is expressed primarily in the amount of fertilizers and plant protection products per 1 ha. In Russia, the amount of fertilizer applied per 1 hectare of sown area is 6 times lower compared with European countries such as Germany, Great Britain, Poland. In the Omsk region, this



figure is 35 times lower [3]. Despite the relatively low level of intensification, wheat production in the Omsk region is having an increasing impact on natural landscapes and the socio-economic development of rural areas of the region.

The purpose of this study is to develop a mechanism for managing the transition to the sustainable development of natural-anthropogenic complexes in rural areas of the region, created as a result of the production of grain crops.

To achieve this goal, the following tasks were solved:

1. The methodological approach to the formation of the mechanism for managing the transition to the sustainable development of natural and anthropogenic complexes in rural areas of the region, created as a result of the production of grain crops, is substantiated;
2. The methodology has been developed for assessing the level of impact of natural and anthropogenic complexes created as a result of grain production on the natural landscapes and the level of socio-economic development of rural areas of the region;
3. In accordance with the developed methodology, the analysis has been performed and the grouping has been carried out in the municipal districts of the Omsk Region according to the level of influence on the natural landscapes and the level of socio-economic development of rural areas of natural-anthropogenic complexes created as a result of the production of grain crops;
4. A set of measures was proposed and justified, aimed at forming a mechanism for managing the transition to the sustainable development of natural and anthropogenic complexes in rural areas of the Omsk region, created as a result of the production of grain crops.

Objects of study are the natural and anthropogenic complexes of rural areas of the Omsk region, created as a result of the production of grain crops. The subject of the research is organizational and socio-economic relations arising between the subjects of the grain industry of the region within the framework of the formation and development of natural and anthropogenic complexes; the relationship between the subjects and the polysubject environment in the process of production, processing, and sale of wheat as the main crop of the grain industry in the region.

## **2. Materials and Methods**

### *2.1. Methodological approach to the study has been substantiated*

The methodological approach to the formation of the mechanism for managing the transition to the sustainable development of natural and anthropogenic complexes (NAC) in rural areas of the region, created as a result of cereal crops, is based on a post-non-classical type of scientific rationality, the basic philosophical approach of which is a humanistic interpretation of philosophical constructivism [4].

The basic management paradigm at the methodological level of research is the relationship “Subject – Polysubject Environment”, the object of control in which are self-developing media. That is, the NAC of rural areas created as a result of the production of grain crops are considered within the framework of this study as self-organizing environments, where agricultural commodity producers with their own organizational, technological and socio-economic structure enter the subjects — the leaders of the changes. A polysubject environment is not only the set of subjects of the grain industry, but also their set of values, technological and industrial culture, culture of relations with the surrounding natural and socio-economic environment. This definition of the object of research required the application of subject-oriented and transdisciplinary scientific approaches in the framework of solving the tasks.

Third-order synergy and cybernetics [4] are the basic providing areas of the theoretical level of the present study, based on the following four values: 1) preservation and development of a person - in terms of maintaining health and minimizing the negative impact on the body of modern plant

protection technologies and technologies to increase productivity, 2) the preservation of humanity - in terms of providing high-quality and safe food resources, solving the most acute socio-economic problems, 3) preservation of the biosphere - in terms of minimization and subsequent elimination of the negative impact on natural landscapes, 4) the preservation and development of the technosphere - in terms of improving and developing technical and technological production complexes, taking into account the first three values.

At the methodological level, the management of the transition to the sustainable development of the NAC of rural areas of the region, created as a result of the production of grain crops, is characterized by the need to use soft forms of management based on the use of indirect, informal levers of influence on the subjects and the polysubject environment. The PAC is managed through the creation of conditions for the development of the system through an impact on the polysubject environment, on the culture and values of the subjects of the grain industry. The need to apply soft forms of management to the NAC of rural areas in the framework of this study is due to the following factors.

1. The high complexity of the natural-anthropogenic complexes, the complex internal organizational-technological and socio-economic structure of the subjects - agricultural producers, the various economic conditions not only within one region, but also within one municipal region, do not allow developing precise control algorithms, which significantly reduces the effectiveness of the use of decision-making management at the regional level.
2. The need to extend management to a polysubject environment (the entire set of subjects of the grain industry, their values and culture, including elements that are poorly amenable to direct management — for example, natural and climatic factors), which has a fuzzy structure, does not allow for the effective use of policy management methods. In this case, it is more efficient to manage development of natural-anthropogenic complexes by setting some benchmarks or criteria that determine priority development directions, and agricultural commodity producers determine for themselves how they can achieve these benchmarks if it is in their interests.
3. Effective application of policy management methods at the regional level is possible only if the subjects of natural-anthropogenic complexes largely (administratively or economically) depend on the regional authorities. For Russia, this situation was typical during the period of the planning and administrative economy, when all the subjects of the grain industry were state enterprises. Currently, the level of dependence of agricultural producers on regional authorities in the Omsk region does not allow for the effective application of policy management methods for the transition to sustainable development of the NAC of rural areas created as a result of the production of grain crops.

## *2.2. Methods of assessing the level of impact of the NAC of rural areas of the region on natural landscapes*

The method is intended for rapid assessment of the level of the impact of NAC created as a result of the production of grain crops on natural landscapes and the level of socio-economic development of rural areas of the region.

The methodology includes three blocks of indicators: 1 block - indicators of the impact of NAC on natural landscapes, block 2 - indicators of the positive impact of NAC on the socio-economic development of rural areas within the municipal areas, block 3 - indicators characterizing the complexity of NAC management in a municipal area. The composition of the indicators, the rationale for their use and the proposed rating scale are presented in Table 1.

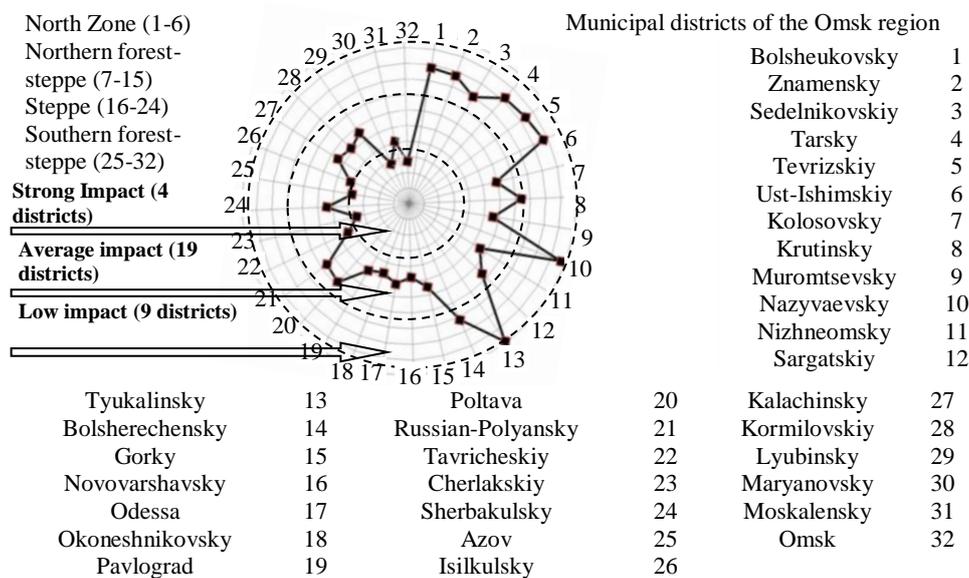
**Table 1.** The composition of the indicators, the rationale for the need for their application and the proposed rating scale.

№	Indicator Name	Rating scale - rating of municipal areas
<p>Block 1 - indicators of the impact of NAC on natural landscapes. The cumulative score for the block is formed as the sum of the places of the regions in the rating for each indicator. The higher the cumulative score, the less negative the impact of the NAC on natural landscapes. The scale of the cumulative scoring: up to 38 points - a strong impact on the natural landscapes; from 39 to 76 points - the average impact; 77 points or more - low impact.</p>		
1.1	The proportion of arable land used, %	1st place - the highest share
1.2	Dynamics of the area of arable land used, ha	1st place - the largest increase
1.3	Share of arable land, on which fertilizers are applied, %	1st place - the largest share
1.4	The amount of fertilizer applied per 1 ha, kg. a.s.	1st place - the largest amount of fertilizer applied
<p>Block 2 - indicators of the positive impact of the NAC on the socio-economic development of rural areas. The aggregate score for the block is formed as the sum of the places of the district in the rating for each indicator. The higher the cumulative score, the more positive the impact of the NAC on the socio-economic development of rural areas. The scale of aggregate scoring: up to 50 points - low impact; from 51 to 100 points - the average impact; 101 points or more - low impact.</p>		
2.1	The yield of grain crops, c / ha	1st place - the lowest yield
2.2	Increase in yield of grain crops in the current year in relation to the previous one, %	1st place the smallest gain (the greatest decrease)
2.3	The volume of sales of grain crops, c	1st place - the smallest sales volume
2.4	The share of workers employed in the grain complex of the district, %	1st place - the smallest share
2.5	The average wage of workers in the grain complex, rubles.	1st place - the lowest salary level
<p>Block 3 - indicators characterizing the complexity of the management of the NAC in the municipal area. The cumulative score for the block is formed as the sum of the places of the regions in the rating for each indicator. The higher the cumulative score, the lower the complexity of managing a NAC in a municipal area. The scale of aggregate scoring: up to 6 points - high complexity of management; from 7 to 12 points - the average complexity of management; 13 or more points - low complexity of management.</p>		
3.1	Total number of agricultural enterprises, units	1st place - the largest number of enterprises
3.2	The number of groups of ripeness of spring wheat, recommended for the area (with the recommended hard varieties), units	1st place - the largest number of ripeness groups

The integral assessment of the level of the impact of the NAC, created as a result of the production of grain crops, on the natural landscapes and the level of socio-economic development of the rural areas of the region is formed as the sum of the scores for each block. The higher the integral assessment, the less negative impact on the natural landscapes and the more positive the role played by the NAC in the socio-economic development of rural areas.

### 3. Research Results

Figure 1 shows the results of the analysis of the impact of the PAC, created as a result of grain production, on the natural landscapes of municipal areas of the Omsk region.

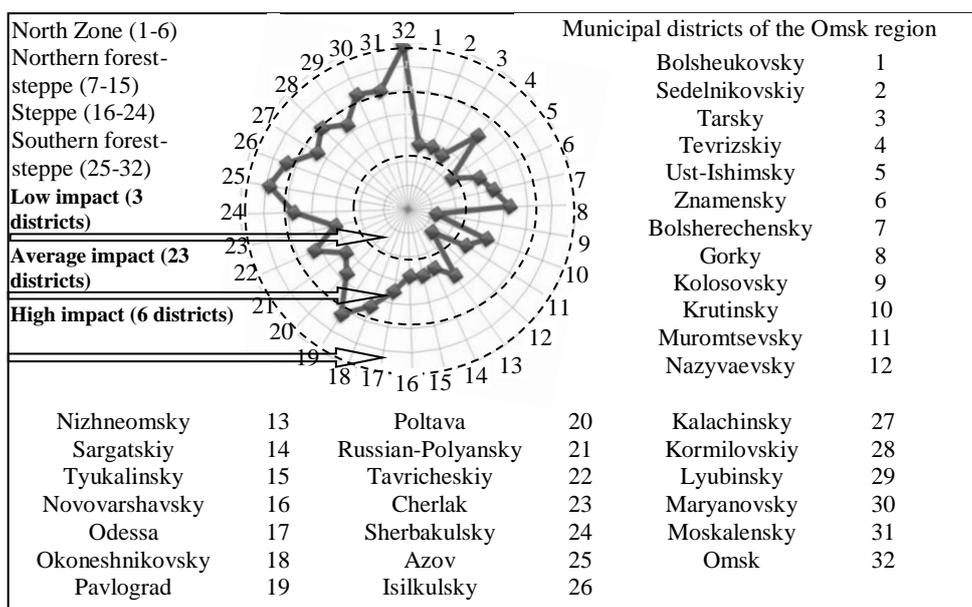


**Figure 1.** Analysis of the impact of NAC on natural landscapes.

The analysis showed that of 32 municipal districts of the Omsk region in four: the Azov, Cherlak, Maryanovsky and Omsk natural-anthropogenic complexes have the greatest impact on the natural landscapes. In these areas, the grain industry is one of the most developed in the region, with a high level of intensification. The least impact on natural landscapes is observed in all areas of the Northern zone, as well as in Nazyvaevsky, Tyukalinsky and Bolsherechensky districts. This is due to the relatively adverse climatic conditions and the high level of production and economic risks of grain production in these areas.

Figure 2 shows the analysis of the level of impact of the NAC on the socio-economic development of rural areas. The grain industry has the least impact on the socio-economic development of the Ust-Ishimsky, Kolosovsky and Nazyvaevsky districts. The greatest contribution to the socio-economic development of rural areas of the region is made by the NAC, created in Moskalensky, Pavlograd, Maryanovsky, Isilkulsky, Azov and Omsk districts, which are included in the core of the grain wedge of the Omsk region.

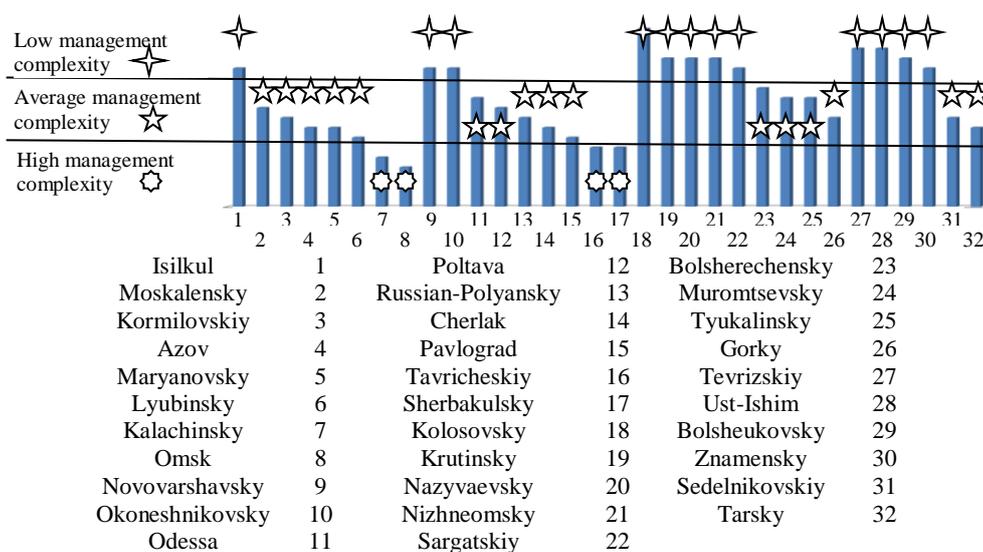
The analysis of the first two blocks of indicators allowed not only to identify municipal areas in which the impact on the natural landscapes and socio-economic development of rural areas is maximum and minimum. As a result of the analysis, key factors for the development of the grain industry were identified, which later became the basis for developing a set of measures aimed at creating a mechanism for managing the transition to the sustainable development NAC of the rural areas of the Omsk region, created as a result of grain production.



**Figure 2.** Analysis of the level of the impact of the NAC on the socio-economic development of rural areas.

Such factors in the field of influence on natural landscapes include: 1) the constant increase in doses of fertilizer and plant protection products; 2) the need to expand the acreage to increase production; 3) adjustment of crop rotation in the direction of increasing the share of grain crops. These factors in the long term can have a negative impact on the socio-economic development of rural areas, since the economically justified intensification of grain production is possible only in the conditions of the predicted market, the presence of which is not typical for the Omsk region. Most of the regional agricultural producers largely depend on intermediaries and cannot participate in the formation of an economically sound market price on the regional market. Expansion of acreage under grain crops in the region today is possible either by engaging fallow lands in economic circulation, which requires the use of specialized methods of economic and technological assessment. As a result, the majority of commodity producers cannot independently assess the effectiveness of involving fallow lands in economic circulation, which creates additional risks and makes impossible the sustainable development of the grain industry. Violation of the recommended structure of crop rotation ultimately leads to lower yields and effective return of land resources.

The mechanism for managing the transition to sustainable development of the NAC of rural areas of the Omsk region should be based on a set of measures that implement soft forms of management and create conditions for the effective development of each NAC entity. In addition, it is necessary to take into account the level of complexity of NAC management in each municipal district, which depends both on the number and main characteristics of the subjects that make up the natural-anthropogenic complexes, and on the natural-technological characteristics of the cultivation of grain crops. Figure 3 presents data characterizing the level of complexity of managing the NAC of rural areas within the boundaries of the municipal districts of the Omsk region.



**Figure 3.** Characteristics of the complexity of the management of the NAC of rural areas within the municipalities of the Omsk region.

#### 4. Conclusions

Taking into account the proposed methodological approach and the results of the analysis, the mechanism for managing the transition to sustainable development of the NAC of rural areas of the Omsk region, created as a result of the development of the grain industry, should include the following measures.

Creating conditions to reduce the negative impact of the NAC on the natural landscapes of rural areas by introducing into the commercial circulation of wheat varieties of local breeding that are resistant to diseases and pests, more effectively using the nutrients contained in the soil. The implementation of this measure will significantly reduce the use of fertilizers and plant protection products, as well as reduce the costs of producers for the purchase of seeds, which will favorably affect the socio-economic development of rural areas. On average, the savings from each ton of seed wheat will amount to \$ 35, and the total amount of direct savings of commodity producers in the region - more than \$ 5 million per year [5]. The use of new varieties in the region will also allow the subjects of the grain industry to effectively import substitution based on the competitive value of wheat. The annual economic effect will be \$ 0.8–1.6 million [6].

Significant reduction of the negative impact of the NAC on natural landscapes will allow the introduction of GIS technology, allowing in real time to determine the need for crops in fertilizers. The technology was developed at the Omsk State Agrarian University and is applied pointwise in a number of municipal districts of the Omsk region. Creation of conditions for the wide application of this technology will allow the subjects of the grain complex to save up to 10% of expenses per 1 hectare.

An important element of the mechanism for managing the transition to sustainable development of the NAC is the creation of conditions in the region for the effective marketing of grain through the development of the following areas:

1. Grain exports, for which there are all prerequisites: high quality (in terms of protein content), significant volumes (up to 2 million tons per year), availability of transport infrastructure;
2. Deep processing of grain in the region (the investment project is under development, the scientists of the Omsk State Agrarian University, commissioned by the Ministry of Agriculture and Food of the Omsk Region, are working on the scientific component of the project).

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