

Increasing the efficiency of land use as a condition of ensuring sustainable development of rural areas

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Abstract. The study includes the development and justification of specific measures aimed at increasing the efficiency of land use to ensure sustainable development of rural areas. It contains justification for research methodology, analysis of methodological and scientific information, assessment of the environmental and economic efficiency of using land resources using the example of the Krasnodar Territory. The interpretation of the concept of sustainability of rural territories is given, a causal relationship between increasing the efficiency of land use and ensuring the sustainability of rural territories, including economic, social and environmental components, is established. To increase the efficiency of land use, the methodology for identifying unused land plots has been clarified, which is applied on the example of the Rodnikovsky rural settlement of the Kurganinsky district, where unused arable land overgrown with woody and shrubby vegetation has been established, resulting in an annual lost profit of 18.1 million rubles. The necessity of developing directions for improving the efficiency of land use to ensure sustainable development of rural areas is substantiated. The scientific novelty of the work consists in substantiating the categorical apparatus of research and methodological approaches to assessing the effectiveness of land use, determining the motivation of land users (landowners) to organize the rational use of land to ensure sustainable development of rural areas on the example of Krasnodar Territory.

1 Introduction

The development of rural areas is directly related to the use of land as the main means of production and a resource that determines the possibility and effectiveness of agricultural activities, creates conditions for the implementation of entrepreneurial initiatives in rural areas, affects the quality of life of the population and affects the food security of the country and its regions, which determines the relevance of this study. Most modern researchers in their works consider separately the problems of the effective use of land

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resources in agricultural production and the problems of sustainable development of rural areas.

Thus, A. S. Mindrin presents the systems and forms of land use and land ownership in the context of historical development and the change of industrial relations, emphasizes that new socio-economic conditions determine the new nature and content of conditions for effective land use. We agree with the researcher that the effectiveness of the use of land resources should be analyzed in the context of the systematic formation of the structure and relations of ownership, taking into account changing forms of management, institutional transformations of the land market, etc. [1]. Considering in retrospect the use of agricultural land by land users (landowners) at different stages of the country's economic development, it can be argued that in the case of an effective option, they traditionally provided solutions to social issues in rural areas.

A.I. Altukhov and L.V. Bondarenko in their works made an attempt to link the efficiency of land use with industrial, social and environmental factors that determine living conditions in rural areas. They believe that the effectiveness of land use is interrelated with the peculiarities of on-farm relations, specialization and concentration of production, the quality of production technologies, the level of wages, and the complex of environmental protection measures [2-3].

According to Academician of the Russian Academy of Sciences V.N. Khlystun, the rational use of land resources makes it possible to develop consistently the agro-industrial complex, determine the nature, functionality and vector of development of land relations [4].

E.G. Meshchaninova and O.A. Tkacheva link the sustainable development of rural areas with the sustainable development of land use (land ownership), emphasizing the ecological importance of natural landscapes and agro-landscapes that geographically form a rural territory. The authors provide a comprehensive assessment of the efficiency of land use in the ecological and economic aspect, which assumes consideration of the coefficients of plowing, intensity of land use, environmental stability, anthropogenic load, susceptibility to water erosion, waterlogging and others [5].

L.Yu. Boginovich considers several types of the category "sustainability", highlighting "economic sustainability" and "sustainability of production", draws attention to the bioclimatic potential involved in the reproduction process of the agricultural sector. The researcher proved that the sustainability of production is a crucial condition for the rapid and stable growth of the entire agro-industrial complex [6].

A.V. Tsvetnykh and N.V. Shevtsova consider the category of "sustainable development of rural territories", taking into account the development of subsystems of rural localities: natural resource, industrial, social, socio-cultural and financial-budgetary [7].

It can be stated that the purpose of the above studies was not to determine the causal relationship between the efficiency of land use and sustainable rural development in order to identify the interdependence and interdependence of these categories. The authors mainly focus on methodological approaches to solving the problems of increasing the efficiency of land use in the economic activities of agricultural producers in the framework of improving the conditions for the development of rural areas.

A review of scientific papers devoted to the problem of effective use of land resources allowed us to conclude that the socio-economic essence of land use (land ownership) is determined by the nature of social production, the social type of economy in which land functions as a means of production, however, research is needed on the specifics of the formation and effective use of the resource potential of rural areas as a factor determining the sustainability of their development, which confirms the timeliness and importance of this study.

2 Materials and methods

The purpose of the work is to clarify, develop and justify measures to improve the efficiency of land use to ensure sustainable rural development.

The following tasks have been formulated and solved:

- Based on the analysis of regulatory, methodological and scientific information on the research problem, methodological approaches to research are considered and clarified, the concepts of rural sustainability are defined, and the factors determining it are identified.
- The analysis of the current state of the efficiency of the use of land resources (agricultural land) on the example of landholdings (land use) of Krasnodar Territory is carried out.
- The directions of increasing the efficiency of the use of land resources (agricultural land) to ensure sustainable development of rural areas are substantiated.

The object of the study is land resources (agricultural lands) on the example of landholdings (land uses) of Krasnodar Territory.

The subject of the study is economic relations arising in the process of achieving sustainable rural development based on increasing the efficiency of land use (agricultural land).

Sources of information:

- Satellite images from the interactive Google Earth Pro 2023 application (spatial resolution of about 0.5 m).
- Public cadastral map of Rosreestr (<https://pkk.rosreestr.ru/>).
- Rules of land use and development of rural settlements and municipalities.
- Report on the state and use of Krasnodar Territory lands 2000, 2022.
- Agriculture of the Krasnodar Territory, 2023. Statistical collection.

Research methods: monographic, statistical, computational and constructive, and geoinformation technologies.

3 Results

We believe that the degree of sustainability of rural development should be determined taking into account the degree of realization of the available resource potential. It should be noted that currently the classification of structural elements of resource potential at the level of rural settlements has not been finalized. The prevailing point of view is that its main components are financial, natural, primarily land and human resources, but at the same time various options for sets of qualitative and quantitative indicators are offered. V. I. Nechaev, E. I. Artemova and L. A. Belova propose to evaluate the effectiveness of land use in agriculture in two aspects: to fulfill the general economic assessment of the effectiveness of land use as a means of production and a private assessment of the effectiveness of crop cultivation [8].

To assess the resource potential of arable land, we proposed an effective approach that includes indicators of production of the main types of crop production in dynamics over a number of years – natural indicators based on the entire area of arable land and from 1 ha (crop yields, gross and marketable products by crops, and cost indicators of production of the main types of products from the entire area and from 1 ha (the cost of gross and marketable products, net income, the level of profitability of production [9-10]. Increasing the efficiency of land resources use is possible with the full realization of their potential on the basis of measures that increase the level of production intensity. At the same time, it is necessary to take into account the existing environmental and nature-saving restrictions on

increasing the intensity of agricultural production. The ecological and economic assessment of lands involves an ecological assessment of the degree of development of agricultural landscapes included in rural areas, shows the degree of severity of environmental risks, and allows studying the impact of anthropogenic stress on agricultural land. Table 1 shows the indicators of the ecological and economic assessment of the use of agricultural land in agricultural production in the Krasnodar Territory for 23 years.

Table 1. Ecological and economic indicators of the use of agricultural land in the agricultural production of Krasnodar Territory.

Index	Years	
	2000	2022
Area of agricultural land in the category of agricultural land, thousand hectares	4181.6	4197.2
Share of agricultural land in the area of the region, %	62.6	62.3
Share of arable land in the structure of agricultural land in all categories of land, %	84.3	84.7
Specific weight of crops in the area of arable land, %	91.6	93.5
Ratio of arable land: meadows: forests, %	52.7:22.5:8.0	52.8:22.5:7.9
Coefficient of plowing	89.0	88.5
Coefficient of environmental stability	0.43	0.43
Anthropogenic load factor	3.30	3.31
Hectare of agricultural land, thousand rubles/ha	46.8	87.0

The analysis of the indicators allows to conclude that during the analyzed period there was a slight decrease in the area of arable land and an increase in the area of agricultural land due to the expansion of forage lands. There is a high coefficient of plowing and anthropogenic load with a low level of environmental stability of the territory, during the analyzed period the value of these indicators has practically not changed. The hectare yield of agricultural land has increased significantly in accordance with the increase in the cost of gross output due to an increase in the production of basic agricultural crops (winter wheat, corn for grain, sugar beet, sunflower) and an increase in their sales prices (Figure 1).

Over the past 23 years, there has been an increase in the efficiency of land use in agricultural production of land use and land ownership, which is a criterion for increasing the sustainability of rural areas of Krasnodar Territory. At the same time, environmental indicators have changed slightly. It can be noted as a negative situation, a decrease in acreage, their reduction over the analyzed period (2000-2022) amounted to 110.4 thousand hectares or 3.0% (Figure 2).

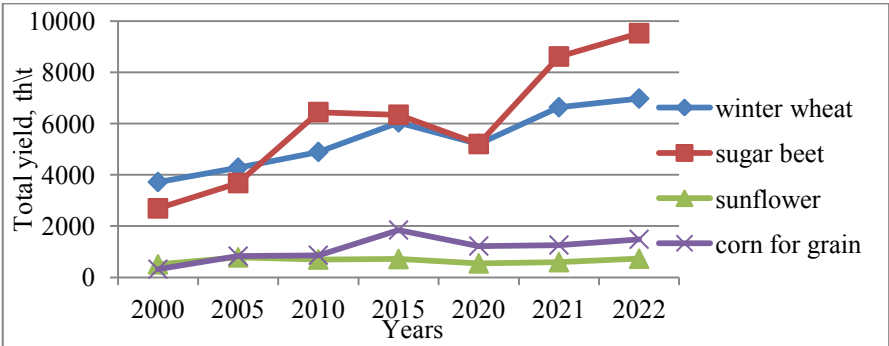


Fig. 1. The dynamics of the gross harvest of agricultural crops in agricultural organizations of Krasnodar Territory according to information from the territorial body of the Federal State Statistics Service for Krasnodar Territory.

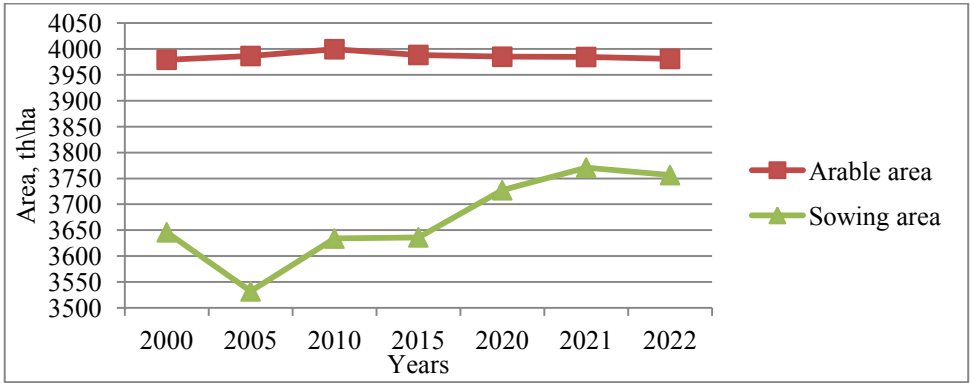


Fig. 2. The area of arable land and crops in farms of all categories of Krasnodar Territory (information from the territorial body of the Federal State Statistics Service for Krasnodar Territory).

Despite the increase in the intensification of crop production and its effectiveness, the problem in Krasnodar Territory for a long period remains the presence of unused arable land in the category of agricultural land, which is withdrawn from agricultural circulation for various reasons, is not sown from year to year, often overgrown with shrubs and small forests, is withdrawn from agricultural circulation. This situation does not contribute to the sustainable development of land ownership and land use, and in general rural areas.

For the effective realization of the land resource potential, it is necessary to develop land management work projects for carrying out cultural and technical measures on arable land overgrown with woody and shrubby vegetation.

Within the framework of the strategic project "Welfare of rural areas" (Priority 2030), G. N. Barsukova, K. A. Yurchenko and other authors developed a methodology for identifying unused land plots for subsequent involvement in agricultural turnover [11]. In our research, this technique has been supplemented and developed. Certain stages of identification of such land plots have been changed for the conditions of work within the framework of a rural settlement of a municipality or within the boundaries of a region. The use of geoinformation systems has been expanded, the use of which was previously used in the study of degradation processes on arable land and forest strips [12]. It is proposed to digitize real estate objects using the interactive application "Google Earth Pro", the advantage of which is the ability to analyze the condition of a real estate object or explore processes in retrospect. The application allows you to select satellite images of land plots over a number of years and determine their intended use, the degree of overgrowth of woody and shrubby vegetation in retrospect. It is proposed to search for such land plots in the sequential implementation of the stages shown in table 2.

Using the proposed methodology, unused plots with cadastral numbers have been identified 23:16:0801000:101, 23:16:0801000:102, 23:16:0801000:99, 23:16:0801000:158, 23:16:0801000:78, 23:16:0801000:79, 23:16:0801000:1055, 23:16:0801000:100, located in the Rodnikovsky rural settlement of the Kurganinsky district of the Krasnodar Territory with a total area of 385 hectares, suitable for development for growing crops. Satellite images over the past 20 years, using the example of a land plot with cadastral number 23:16:0801000:101, showed an obvious process of overgrowth with woody and shrubby vegetation (Figure 3).

According to the Rules of Land use and development of rural settlements and municipalities, the identified land plots are included in the zone of agricultural use, but are not used for their intended purpose. According to the public cadastral map, the plots have an unspecified category and permitted use, and are in state unrestricted ownership.

Table 2. Stages of identification of unused land plots.

Stage	Name of stage	Stage content
1	Choice of MF to determine the availability of unused land (arable land)	Definition of the object of research within the boundaries of the MF
2	Selection of satellite images for the study area	Analysis of information about land plots in the presented images and EGRN data
3	Selection of cadastral blocks on the public cadastral map	Identification of blocks with possible unused land plots
4	CTP request for the selected cadastral quarter	Processing of data on real estate objects contained in the KPT
5	Inventory of land plots in the area	Comparative analysis of CBT data with the presence of unused land at the specified addresses on the site
6	Identification of unused land plots	Checking the sites for compliance criteria set for unused plots
7	Vectorization of land plots without borders	Digitization of the boundaries of land plots, calculation of the area and checking it for compliance with the area specified in the KPT
8	If necessary, the establishment of boundaries of unused land plots on the site	Entering information about unused land plots into the Unified State Register



Fig. 3. Retrospective description of the condition of a land plot with cadastral number 23:16:0801000:101.

Calculations of the volume of lost products from these sites were performed based on the actual structure of crops in the Kurganinsky district, market prices prevailing in 2023 for certain types of agricultural products and their average yield (Table 3).

As a result of the assessment, the annual loss of income on unused land plots amounts to 42.8 million rubles, the net loss is about 18.1 million rubles. The latter indicator can be considered as an annual loss of profit.

Carrying out cultural and technical works to clear areas of woody and shrubby vegetation as part of the implementation of work projects, including measures to remove woody vegetation, stumps, stones, hummocks, eliminate small-scale structures, inconvenient for processing configuration of work sites, primary tillage, planning and leveling of the surface, will increase the possibility of maximizing the potential of land resources.

Table 3. The effectiveness of the involvement of unused land plots in the Rodnikovsky rural settlement, 2023.

Crop	Share of crop in the structure of crops, %	Area of crop, ha	Yield, kg/ha	Sale price, RUB/c	Lost products		Production costs		Net income, thousand rubles
					c	th. RUB	on 1 c, RUB	total, th.RUB	
Winter wheat	45.9	176.7	66.4	1576.5	11732.9	18496.9	932.6	10942.1	7554.8
Winter barley	10.5	40.3	57.7	1327.7	2325.3	3087.3	762.9	1774.0	1313.3
Spring barley	1.6	6.2	39.0	1019.5	241.8	246.5	646.3	156.3	90.2
Corn for grain	22.2	85.6	53.6	1424.8	4588.2	6537.2	941.4	4319.3	2217.9
Oats	0.7	2.8	31.0	1159.4	86.8	100.6	682.2	59.2	41.4
Pea	0.4	1.6	25.4	2568.2	40.6	104.4	1116.6	45.4	59.0
Sugar beet	1.3	4.9	519.9	3005.1	2547.5	7655.5	1526	3887.5	3768.0
Sunflower	11.2	43.0	24.7	3901.1	1062.1	4143.4	1972.8	2095.3	2048.0
Soybean	5.9	22.7	20.6	4822.4	467.6	2255.1	2725.4	1274.5	980.6
Potato	0.2	0.7	126.2	1475.9	88.3	130.4	949.3	83.9	46.5
Perennial grasses of previous years	0.2	0.6	39.4	910	23.6	21.5	526.8	12.5	9.1
Total	100	385	–	–	23204.8	42778.8	–	24649.8	18129.0

4 Discussion

Taking into account the research of modern authors, we have developed a methodological approach to assessing the effectiveness of land use as a means of production: traditional efficiency indicators should be supplemented by indicators of ecological and economic efficiency. This is confirmed by a study carried out by A. S. Nekrich in dynamics over 12 years, which shows that the spatial differentiation of the levels of transformation of ecosystems in the Bryansk region is largely determined by environmental conditions, the structure of natural landscapes and depends on the specifics of agriculture [13]. Analyzing this study, we can state with a high degree of certainty that the established transformation of ecosystems using official statistical data and satellite images within the boundaries of agricultural landscapes has a mutual impact on the sustainability of rural development.

The issue of defining rural areas remains controversial. According to the strategy for sustainable development of rural territories of the Russian Federation for the period up to 2030, rural territory should be understood as a rural settlement and an inter-settlement territory. We believe that we should consider rural settlements within the boundaries established by general plans and territorial planning schemes. The inter-settlement territory mainly includes lands of the agricultural category, which are dominated by agricultural land in use or owned by land users and landowners, represented by a variety of organizational and legal forms. Therefore, the territorial boundaries of rural areas should be considered combined with the borders of the administrative-territorial division of the Russian Federation.

Considering the types of sustainability, L. Yu. Boginovich emphasizes the importance of using the bioclimatic potential, where the economic process of reproduction is closely intertwined with biological processes. The sustainability of agriculture is a crucial condition for the rapid and stable growth of the entire agro-industrial complex [14].

Yu. V. Evdokimova et al., considering the features of the formation of new production models during the transition to sustainable development, offer characteristics of sustainable production and consumption, sustainable development of the enterprise, the development of sustainable and high-quality infrastructure [15]. Ensuring food security is linked to the sustainable macroeconomic development of the country, it should be based on the rational use of domestic production resources, primarily land. Important areas of activity within the

framework of the import substitution program are the development of small and medium-sized businesses, while investing, special attention should be paid to the direction of public-private partnership [16].

Academician of the Russian Academy of Sciences A. I. Kostyaev points out the need to change the paradigm of rural development, which is represented by three thematic blocks: a new look at rural territories as consumer spaces, a new vision of agro-food systems, a new look at the revitalization of the social sphere [17].

Taking into account different points of view, the following definition of sustainable rural development is proposed – it is stable socio-economic and environmental development of rural areas, based on increasing the volume of agricultural products and ensuring employment and quality of life, effective use of land resources, subject to compliance with environmental and environmental requirements.

The development of innovative processes in agriculture depends on the recovery of agriculture from the crisis, ensuring the competitiveness of domestic food and its sustainable functioning. When forming a unified system of innovative development of agriculture, the core of the innovation cluster should be agricultural entities (large agricultural enterprises, personal subsidiary farms, peasant farms, etc.) and processing enterprises connected by a technological chain [18].

In the context of increasing economic pressure from foreign countries on the Russian economy and the aggravation of the global geopolitical situation, state support for the innovative development of the agro-industrial complex is necessary.

The role of land management in ensuring the sustainability of rural areas is important, which is the main mechanism of the state's agrarian policy, the main factor in increasing the efficiency and competitiveness of agriculture: "Digital land management today – This is a system of geoinformation support for agricultural territories, which includes not only on-line processing of significant geospatial information flows (big geo data), but also issues of forming a transparent land ownership structure, issues of systemic territorial development and farming" [19].

Analyzing the results obtained in the course of this study, we note that the data obtained by us are correlated with data from other studies devoted to assessing the effectiveness of the use of rural land resources within the framework of the criteria for their sustainable development. The basis of life in rural areas and a factor in their qualitative development is the constant increase in the efficiency of land use, which allows us to develop various entrepreneurial initiatives related to the agricultural sector, increase the profitability of agricultural production, which at the same time is an important source of social and environmental well-being of local residents, makes rural areas attractive from the standpoint of investment, development of innovative activities, the widespread use of digital technologies.

5 Conclusion

A causal relationship has been established between increasing the efficiency of land use and ensuring the sustainability of rural areas, including economic, social and environmental components. It is proved that achieving high results from the use of the land and resource potential of rural territories is possible with the improvement of the regulatory framework of land relations, clarifying methodological approaches to assessing the effectiveness of land use, strict compliance with environmental requirements for the production process, taking into account qualitative assessments of land and the social component of rural development.

In the course of the research, a new interpretation of the concept of "sustainable rural development" was methodically and analytically substantiated, which in a broad sense

assumes consideration of modern trends and needs of the national and world economy, interpreted as an opportunity to meet the criteria of the quality of life of the rural population, including natural, economic, social and other aspects, providing opportunities for expanded reproduction of rural resources territories. This approach makes it possible to conduct a comprehensive analysis of rural development, identify existing problems and justify ways to solve them.

The methodology for identifying unused land plots has been clarified in order to increase the efficiency of land use, which has been tested on the example of the Rodnikovsky rural settlement of the Kurganinsky district of the Krasnodar Territory, where unused arable land overgrown with woody and shrubby vegetation has been established. As a result of calculations using the proposed methodology for assessing the use of land and resource potential, annual income losses on unused land plots amounted to 42.8 million rubles, lost net income - about 18.1 million rubles, this indicator can be considered as an annual lost profit.

The main directions of increasing the efficiency of land use in agricultural production are: rational use of production resources, including land and resource potential, taking into account bioclimatic features, digital land management, development of innovative processes in agriculture.

Increasing the profitability of agricultural production is an important source of social and environmental well-being of local residents, makes rural areas attractive from the point of view of investing, developing innovative activities, and widespread use of digital technologies.

Multifunctional, integrated development of rural areas will become sustainable only if the quality of life of rural workers is improved, the efficiency of using the resource potential of rural localities and, first of all, land increases.

Sustainable development of rural areas involves the preservation of national and cultural traditions of rural residents, taking into account the economic, social, and environmental needs of the rural population.

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References

1. A. S. Mindrin, Economic, social and legal problems of effective land use. Agri-food Policy of Russia, **1(61)** (2017)
2. A. I. Altukhov, Improving the efficiency of grain production in the Russian Federation. M.: RU VNIIM (1994)
3. L. V. Bondarenko, Expert assessment of the scenario for the development of the domestic agricultural sector and the effectiveness of various forms of management. Economics of agricultural and processing enterprises, **5** (2017)
4. V. N. Khlystun, Development of land relations in the agro-industrial complex. Bulletin of the Russian Academy of Sciences. **89**, 7 (2019)
5. E. G. Meshchaninova, O. A. Tkacheva, Assessment of the ecological and economic state of land use. monograph, Saarbrücken (2013)

6. L. Yu. Boginovich, Ensuring economically sustainable production of crop production. Modern socio-economic processes: problems, patterns, prospects. monograph, edited by G. Y. Gulyaev, Penza, ICNS "Science and Education" (2018)
7. A.V. Tsvetitskykh, N. V. Shevtsova, Methodology for assessing sustainable rural development. The azimuth of scientific research: economics and management, **9, 3 (32)** (2020)
8. V. I. Nechaev, E. I. Artemova, L. A. Belova, Economics of agriculture. M.: KolosS (2010)
9. G. N. Barsukova, E. I. Artemova, K. A. Yurchenko, Assessment of the land and resource potential of rural areas. Proceedings of Kuban State Agrarian University, **100** (2022)
10. E. I. Artemova, G. N. Barsukova, E. N. Litera, A. A. Skomoroshchenko, K. A. Yurchenko, Management of the resource potential of rural territories of the Krasnodar Territory. Krasnodar : Printing house of Kuban State Agrarian University (2023)
11. G. N. Barsukova, K. A. Yurchenko, E. N. Litra, D. A. Zolotukhin, Identification of reserve land plots for the placement of personal subsidiary farms within the boundaries of rural settlements. International Agricultural Journal, **65, 6** (2022)
12. G. N. Barsukova, D. K. Derevenets, Application of modern GIS technologies for inventory of protective forest strips, identification of waterlogged areas. IOP Conf. Series: Earth and Environmental Science, **723 (3)** (2021)
13. A. S. Nekrich, Transformation of ecosystems in Bryansk Oblast caused by the agro-industrial complex development. IOP Conf. Earth Environ. Sci. **1212** (2023)
14. L. Yu. Boginovich, Ensuring economically sustainable crop production. Modern socio-economic processes: problems, patterns, prospects. monograph. under the general editorship of G. Y. Gulyaev. – Penza : ICNS "Science and Education" (2018)
15. Y. V. Evdokimova, E. N. Egorova, A. A. Evdokimova, A. A. Larionova, Ensuring the development of production in the conditions of transition to sustainable development. IOP Conf. Series: Earth and Environmental Science, **1045** (2022)
16. A. V. Kuchumov, J. V. Gnezdova, S. E. Terentyev, Development of the agricultural industry in the conditions of food security. IOP Conf. Series: Earth and Environmental Science, **723** (2021)
17. A. I. Kostyaev, G. N. Nikonova, The development of the processes of territorial differentiation of agricultural production, Non-Chernozem regions and their modern trends. Economic and social changes: facts, trends, forecast, **14, 4** (2021)
18. O. V. Mamai, I. A. Bondin, T. A. Potenko, I. N. Mamai, Scientific support of innovative development of agriculture, IOP Conference Series: Earth and Environmental Science : II International scientific and practical conference "Ensuring sustainable development in the context of agriculture, green energy, ecology and earth science", 23-27 January 2022. Sci. **1045**, Smolensk, Russian Federation (2022)
19. S. N. Volkov, D. A. Shapovalov, Digital land management – new horizons of the agro-industrial complex. The role of agricultural universities in the implementation of the national project "Science" and the Federal Scientific and Technical Program for the development of Agriculture for 2017-2025. Materials of the All-Russian seminar-meeting of vice-rectors for scientific work of universities of the Ministry of Agriculture of Russia (2019)