

## ENVIRONMENTAL AND ECONOMIC PROBLEMS RELATED TO RATIONALIZING THE USE OF AGRICULTURAL LANDS IN THE IRTYSH LAND

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**ABSTRACT:** This article discusses the problem of improving modern cultivated lands. For this purpose, the current scientific understanding of the essence and the system of agricultural lands has been studied. Efficient land use formula allowed to substantiate the main trends in the rationalization of cultivated lands and to suggest methodological approaches for analyzing the state of its individual components. Agricultural lands were for the first time studied on the example of the land use system in the Isilkulsky district of the Omsk region. The research showed that during the transformation of a natural landscape into an agricultural one, plant communities were mainly affected, and partly - the soil cover. Classes, genera and types of cultivated lands were determined and allocated to soils and the landscape. Natural, anthropogenic and mixed processes that influence properties of cultivated lands had been shown. Agricultural production uses cultivated lands in the system of agricultural lands, crop rotations and technologies of agricultural crops' cultivation. Assessment of the extent and kinds of modern anthropogenic impact on the components of cultivated lands showed various degrees of both mechanical and chemical effect on agricultural companies. Based on the developed scientific and methodological principles of cultivated land rationalization, there are several models of improving the state of its components. This allows ensuring the integrity and improving the efficiency of cultivated lands.

*Keywords: Cultivated land, Cultivated land classification, Environmental state, Agricultural production, Land suitability.*

### 1. INTRODUCTION

The research was aimed at studying the development of the scientific and methodological principles of improving the system of cultivated lands in the modern world.

The land reform in Russia destroyed the system of rational use of land, especially in terms of ensuring the environmentally sound consumption of cultivated lands. This reduces the effectiveness of agrarian transformations, given the cost of human-induced renewal of natural potential.

The methodological bases of the study were the fundamental laws of nature and of social development, the dialectical perception of the reality, works of Russian and foreign researchers on sustainable land and environmental management, guidelines and regulatory documents. Dobrotvorskaya N.I., Kiryushin V.I., Stepanova L.P., Tatarinzev L.M., Yushkevich, L.V., etc. worked on the rationalization of the cultivated lands use [1-4]. The study used the following research methods: system, mathematical, statistical, comparative-geographical, cartographic analysis, expert and index assessments.

### 2. PECULIARITIES OF CULTIVATED LAND FUNCTIONING IN THE MARKET

### ECONOMY

A distinguishing feature of the modern development in the Siberian region and Russia, in general, is an aggravation of environmental problems on the background of agrarian and other transformations. This shows the objective necessity of studying the problem of ensuring the ecological balance in the modern cultivated lands in the conditions of market economy development. The landscape is a unique geosystem which should be regarded as the space-time complex of all components of the nature that are interrelated and interdependent in their placement, and represent a single whole [1, 2, 5, 6].

Agricultural land is a complex system that consists of natural and anthropogenic components interacting in the course of agricultural production. In the period of planned economy, with regard to the state-owned nature of land ownership, large areas (of land use) were as a rule in the use of a single producer, therefore, land management was concentrated in the hands of territorial bodies of the department of agriculture, and the land use - in the hands of a single producer. In the modern economy, the performed reforms seriously disrupted the unity of the land management and use. Privatization of land resulted in the emergence

of many small and alienated from direct land use owners, who were mainly interested in obtaining either dividends or rent, i.e. income. It is, therefore, important to form a new eco-economic basis for modern cultivated lands' functioning.

The modern cultivated land is the product of human activity during a historically long period. In the modern sense, cultivated land is the natural land transformed in the course of agricultural production. Its main part is represented by agricultural lands where activities aimed at obtaining agricultural products are systematically and deliberately performed [2]. Safonov A. F. understands cultivated land as a "natural-and-territorial complex with the natural vegetation replaced with cultivated lands in most of its parts". For the conditions of Western Siberia, the most appropriate definition would be "Cultivated land represents a territory within regional borders formed within the framework of the natural landscape as a result of its agricultural development, and maintained in productive state" [7]. Thus, the definition highlights the close association of the agricultural and the natural lands, and the possibility of their adaptive convergence, since the modern cultivated land is always the reflection of the previous activities of men, and respectively, of the spatial-temporal organization of agrophytocenoses. The more optimal the structure of the agrocoenosis is, the better the result of production in the form of yield, productivity, etc. will be, where the ecological system will have environmental reliability, and will not show degradation.

During the last century, the formula for sustainable land management was used for cultivated land. In land use planning literature, the concept of "rational land use" includes three aspects: full, correct and efficient use. The use of land as a natural resource means consumption of the matter and energy, which ensures stable functioning of the entire natural environment within its natural and anthropogenic genesis. Proper use is in the ratio between the consumed amount of energy and matter, and the permissible amount obtained from the landscape. Effective use is characterized by the highest human need with the lowest cost of rehabilitation and maintenance of land properties. Proper use of land is its use in accordance with the goal established by state agencies. However, there are nuances: efficiency does not always ensure proper use, since most of the plots are of different quality, and some of them are unsuitable for agricultural production. In addition, aiming at the complete use of land results in the destruction of the existing cultivated lands. In turn, proper use of these plots of various qualities in agricultural production can ensure the efficiency of land use.

Land transformation in the past has altered the agrarian system, which significantly affected the essence of proper land use. Restoration of the private ownership institution in Russia resulted in the advent of the function of land as real estate and, consequently, product. The economic significance of land dramatically increased, which brought up the idea that land-and-environment aspect of land use has fallen by the wayside. The most striking example of that is the current situation in agricultural land use. During land privatization, the involvement of unsuitable land into the turnover of arable land in the past years was ignored. As a result, about 1 million ha of the former arable land in the Omsk region is not currently used. The problem of proper land use in modern conditions is primarily of national significance. The state ensures long-time land preservation as a natural and production resource, which guarantees the sustainable development of society.

Based on using the formula of proper land use, the following can be stated for consideration of the modern problems of cultivated land functioning:

1. In nature, without human intervention, any land is a harmonious system and is used completely, properly, and environmentally efficiently, however, production and recreation destroy this state by converting them into anthropogenic landscape systems that depend on the time and intensity of the human activities. As a consequence, the land, while preserving the main features of a natural system, acquires elements of unstable artificial formations, the lifetime of which is largely determined by the duration of the anthropogenic effect. Such quasi-natural formations include arable land, irrigated and drained land. Sustainability of cultivated land, in this case, is determined by the duration of recovery of the properties of natural forest, forest-steppe and steppe land.

2. A plot with cultivated land on it, as an object of property, is intended for maximizing profits. However, it should ensure agricultural production or should be sold or leased as an asset. Therefore, completeness of land use, as a property asset, is associated with the suitability of its properties for solving the business tasks determined by the entrepreneur.

3. The propriety of land use is determined by the degree of coincidence of the anthropogenic turnover of matter and energy (in accordance with production tasks) and natural turnover, in accordance with the type of terrain and uniformity of the anthropogenic turnover of the matter and energy within its boundaries. If these conditions cannot be ensured, the unity of the natural system is disrupted, and, instead of the single agricultural landscape, its new types start forming on this basis.

4. The efficiency of cultivated land functioning

is not associated with various market and industrial changes and is determined by the preservation and reproduction of its main properties during the life of the parenting landscape. Efficiency is ensured by the recovery of the used matter and energy of the land and by the accumulation of useful properties. Cultivated land will be inefficient in case of loss of its production ability and transition to the state of decreasing or loss of land suitability for agricultural use. In this regard, the vectors of cultivated land efficiency and land management diverge sharply. Efficient land management is focused on maximum production. This implies the maximum removal of the matter for creating crop production. However, the need for reducing the costs of land management usually results in saving the costs of restoring the natural properties of the land. The maximum efficiency of land management, in this case, is achieved during a short period of land use. In contrast, the vector of developing the efficiency of cultivated land is generally aimed at long-term preservation of its properties, since only this ensures long-term sustainable development of the territory.

These provisions are the scientific and methodological basis for rational use of cultivated land in the modern conditions, which will be shown on the example of the Isilkulsky district in the Omsk region.

### 3. CULTIVATED LAND STATE ASSESSMENT

Cultivated land is subject to special research and classification, as it is involved in public production, is a strategic resource for producing food, and has great influence on the ecological state of land [5]. Depending on the business activities, cultivated land may be of the following types: fields, gardens, and meadow pastures (Table 1).

For Western Siberia, the most common is the field and the meadow-and-pasture types. The state of cultivated land was analyzed by its main components according to the degree of their transformation during use, by the ecological condition and economic use [2, 5, 8].

Table 1 Main types of cultivated land in the Isilkulsky district of the Omsk region

Class	Type	Kind	Terrain
Agricultural (cultivated land)	A-1 Undulating lowland field	A-1-a on black soil, meadow-chnozem, chernozem-meadow soils	Undulating plain
		A-1-b on dark gray forest soils	Plain elevations
		A-1-c on meadow-chnozem, in combination with crusted solonetz from 10 to 25%	Undulating plain
		A-1-d on alkaline podzols	Sinks and depressions
		A-1-e on crusted solonetz	Depressions adjacent to swamps
		A-1-f on solonetz	Plain depressions
		A-1-g on salt marshes	Undulating plain
	B-1 Meadow-pasture watershed plain-valley	B-1-a on black soil, meadow-chnozem, chernozem-meadow soils	Undulating plain
		B-1-b on gray forest soils	Plain elevations
		A-1-c on meadow-chnozem, in combination with crusted solonetz from 10 to 25%	Undulating plain
		B-1-d on alkaline podzols	Sinks and depressions
		B-1-e on crusted solonetz	Depressions adjacent to swamps
		B-1-f on solonetz	Plain depressions
		B-1-g on salt marshes	Undulating plain
	B-2 Meadow-pasture steppe lake-ridge	B-2-a on marshy alkaline podzols	Depressions adjacent to swamps
		B-2-b on salt marshes	Depressions adjacent to marshes and lakes
		B-3-c on meadow-marshy soils	Swampy depressions

Assessing the degree of natural landscape transformation, it can be noted that over one and a

half century of using cultivated lands in the Isilkulsky district, changes mainly affected

vegetation, and partly affected the soil (Table 2). This is due to cultivation of the plots in the

Northern steppe of Western Siberia that are suitable for cultivation of agricultural crops.

Table 2 Changes in the main components of natural landscapes during the transformation into modern cultivated land (soil, topography, vegetation) (expert opinion) (0 - virtually absent, 1 - a slight change, 2 - medium change, 3 - strong change)

Type	Kind	Terrain	Soils	Vegetation
A-1 Undulating lowland field	A-1-a on black soil, meadow-chnozem, chernozem-meadow soils	1	2	3
	A-1-b on dark gray forest soils	1	2	3
	A-1-c on meadow-chnozem, in combination with crusted solonetz from 10 to 25%	1	2	3
	A-1-d on alkaline podzols	1	2	3
	A-1-e on crusted solonetz	1	1	1
	A-1-f on solonetz	1	1	2
	A-1-g on salt marshes	1	1	1
B-1 Meadow-pasture watershed plain-valley	B-1-a on black soil, meadow-chnozem, chernozem-meadow soils	1	2	3
	B-1-b on dark gray forest soils	1	2	3
	A-1-c on meadow-chnozem, in combination with crusted solonetz from 10 to 25%	1	2	3
	B-1-d on alkaline podzols	1	2	3
	B-1-e on crusted solonetz	1	1	0
	B-1-f on solonetz	1	1	2
	B-1-g on salt marshes	1	1	0
B-2 Meadow-pasture steppe lake-ridge	B-2-a on marshy alkaline podzols	0	0	0
	B-2-b on salt marshes	0	0	0
	B-3-c on meadow-marshy soils	0	0	0

Ecological statuses of the types of cultivated lands were assessed by the following parameters: favorable, relatively favorable, of the weak, medium, strong environmental stress; critical, crisis state [2].

During the study it has been found that of the 17 types of cultivated land, 4 are in the critical condition, 7 are in the state of severe ecological stress, 4 are in the state of moderate environmental stress, and 2 are in the state of weak environmental stress. Assessment of the ecological condition of cultivated land allows determining the methods of adjusting properties of their components.

The state of cultivated land affects the state of the lands. The Kamyshlovsky ravine divides the territory of the district into two parts – the swampy, forest-covered Northern, and the dry forest-steppe Southern. Therefore, for assessing the ecological state of lands and comparing them to each other, the territory of 3 rural settlements was chosen: Medvezhinskoye in the North of the district, Solntsevskoye in the Central part of the district, and Ukrainskoye in the Southern part of the district.

Assessment of the ecological state of the lands in the Medvezhinsky rural settlement showed that 12% of the territory was in the state of weak environmental stress, 22% – in the state of

moderate environmental stress, and 66% – in the state of severe environmental stress.

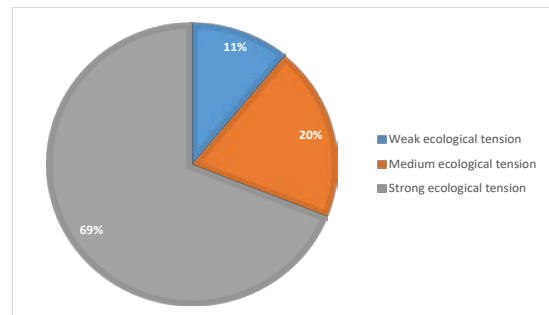


Fig. 1. Ecological state of the Medvezhinsky rural settlement (northern part)

Assessment of the ecological state of the lands in the Solntsevsky rural settlement showed that 11% of the territory was in the state of weak environmental stress, 69% – in the state of moderate environmental stress, and 20% – in the state of severe environmental stress.

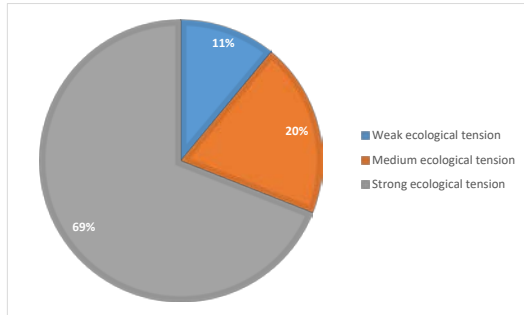


Fig. 2. Ecological state of the Solntsevsky rural settlement (central part)

Assessment of the ecological state of the lands in the Ukrainsky rural settlement showed that 3% of the territory was in the state of weak environmental stress, 79% – in the state of moderate environmental stress, and 18 % – in the state of severe environmental stress.

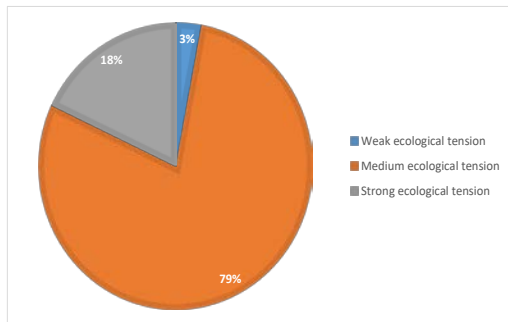


Fig. 3. Ecological state of the Ukrainsky rural settlement (southern part)

Assessment of the ecological state of the lands in the Medvezhinsky rural settlement showed that 12% of the territory was in the state of weak environmental stress, 22% – in the state of moderate environmental stress, and 66% – in the state of severe environmental stress. Thus, the environmental state of the lands in the Northern part of the district is more critical than in the Southern part.

#### 4. ASSESMENT OF THE CONDITIONS OF USING CULTIVATED LANDS

The influence of natural processes forms the natural (ecological) bases for the functioning of cultivated lands. However, cultivated land in its further functioning encounters both natural and anthropogenic effects that have a significant impact on its stability and on productive properties of its components.

The manifestation of the degradation processes (erosion, deflation, waterlogging, salinization) in the Isilkulsky district is evidence of the fact that

the existing cultivated lands are unstable and deteriorating. Human activities have resulted in significant changes in the natural stability of cultivated lands, as evidenced by the large percentage of development and ploughness of the territory. It is necessary to choose appropriate measures for stabilizing the negative natural and anthropogenic processes, optimize the cultivated land, i.e. perform its reformatting. No less important for cultivated land is the influence of the agricultural production system, where matter and energy of its components are consumed during implementation [1, 9]. Among parameters of agricultural production that mostly influence the state and the use of cultivated land are the following: specialization, types and amount of products, the technology of crop production, the intensity of the crop production system, grazing system, land protection systems, and agricultural equipment used.

Specialization, types and amount of products of an economic entity determine the demand for agricultural land and their areas. With that, cultivated lands start appearing in the form of various qualitatively different agricultural lands. However, even if the specialization remains stable, changes in the production volumes result in the correction of the areas. The technology of crop production, the intensity of the crop production processes, the system of grazing, the system of land protection, and the used agricultural equipment greatly influence the basic components of cultivated lands.

The total land area in the Isilkulsky district of the Omsk region is 275 thousand ha. Agricultural lands (cultivated lands) occupy 78.7% of the territory, which is typical for the agricultural district of the Omsk region. The structure of agricultural lands in the district shows that the largest share of the territory is occupied by fields (arable land - 58.71%) and pastures and meadows (pastures - 12.61%, haylands – 7.36%) Figure 1).

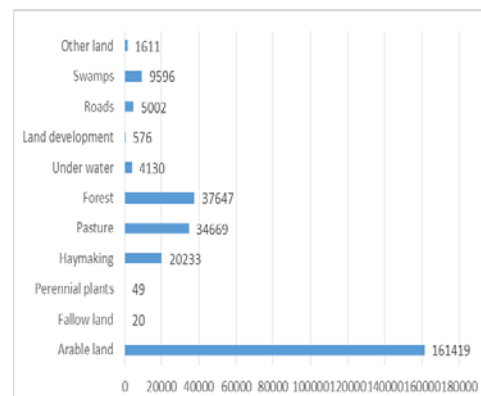


Fig. 4. Distribution of land in the Isilkulsky district of the Omsk region (ha)

Most important indicators of the influence intensity are the structure of sown areas, the used crop rotations and the technology of cultivating individual crops. Each crop, for ensuring its

cultivation, requires various amounts of mechanical action (plowing, harrowing, rolling, sowing, harvesting, etc.). Based on studying the process maps, the amount of such influence has been determined for usual cultivation, and its average amount has been calculated, given the structure of the cultivated area.

Table 3 Extent of human impact on cultivated land

The name of the agricultural entity	Used arable land, ha	The average number of technological operations on the arable land	Amount of fertilizers introduced per 1 hectare, kg		Percentage of the area of fertilizers' introduction to the entire area of arable land %	
			organic	mineral	organic	mineral
CJSC Solntsevo	12,510	10.3	1,649	-	2.0	-
LLC KE Agro	7,947	11.7	-	3.5	-	17.0
JV Siberia	10,292	10.7	1,749	0.7	3.0	0.8
CJSC Novorozhdestvenskoye	11,791	9.6	356	-	0.7	-
FSUE Boevoe	17,875	9.9	-	1.3	-	4.9
Agricultural production co-operative Lesnoy	24,525	10.0	403	15.6	0.7	34.4
Agricultural production co-operative Ukrainsky	20,177	10.1	-	-	-	-
All-Russian Research Institute of Oil Crops Siberian Experimental Station	4,938	9.3	-	-	-	-
NPSSS LLC Siberian Oils and Seeds	8,183	10.7	-	-	-	-
IE Dirksen	4,398	14.0	-	41.2	-	18.1
IE K(F)H	26,681	12.2	-	-	-	-
Personal subsidiary economy	9,677	5	-	-	-	-

The mechanical impact on cultivated lands, as it can be seen from Table 3, varies considerably by the agricultural organizations of the district. The highest is observed in those that actually perform monocrop seeding. To restore the structure of soils in the conditions of increased impact, it is important to use organic fertilizers. However, as one can see from the above data, this method of restoring properties of cultivated lands is used by large farms with livestock and fodder crops. Farms without livestock production actually perform monocrop sowing of grain crops, sometimes alternating it with fallow. Significant soil disturbance may be assumed. Recovery of nutrients' removal as a means of maintaining the sustainability of the agricultural landscape is used more or less definitely only at the Lesnoy agricultural production cooperative. At the Siberia agricultural enterprise and in JSC Solntsevo, the area of using the fertilizer is not significant, even

with the use of large dosages of organic fertilizers. This shows the unacceptable level of anthropogenic impact on cultivated land, which results in its rapid degradation.

Large agricultural organizations specialize in the production of grain, milk and meat. Farms and individual entrepreneurs are mainly involved in grain production. With that, the area of arable land is fully used – part of it (of 15.53%) is used for fallow, and another part (84.47%) is used for spring sowing and perennial grasses. The largest area is used for grain crops. In general, arable land in the area is used intensively.

To identify possible (regulated) crops yield, including grain, ball-bonitet is used, which is the indicator that characterizes natural soil fertility. Ball-bonitet of agricultural lands varies from 50 to 83 with an average of 73. Table 4 shows the assessment of the level of completeness of cultivated land use (soil fertility).

Table 4 Determination of the level of completeness of cultivated land use (soil fertility) by agricultural organizations in the Isilkulsky district

Name of the agricultural organizations	Average actual yield of cereals (hw/ha)	Ball-bonitet of soils, score	The yield based on ball-bonitet (calculated), hw/ha	The level of land fertility use, index
CJSC Solntsevo	24	75	19.83	1.21
LLC KE Agro	16.4	73	19.30	0.85
JV Siberia	19.3	83	21.94	0.88
IE Dirksen	16.4	50	13.22	1.24
CJSC Novorozhdestvenskoye	18.9	63	16.66	1.13
Agricultural production co-operative Lesnoy	18.6	80	21.15	0.88
NPSSS LLC Siberian Oils and Seeds	16.7	75	19.83	0.84
Agricultural production co-operative Ukrainsky	16.3	73	19.30	0.84
FSUE Boevoe	22.6	80	21.15	1.07
All-Russian Research Institute of Oil Crops Siberian Experimental Station	20.4	78	20.62	0.99
Average for organizations	19.3	73	19.30	1.00

Comparison of the actual and estimated yields has shown that only in 4 agricultural organizations of 10 the level of arable land use is high, and the potential fertility of cultivated lands is used carefully.

## 5. RATIONALIZATION OF USING CULTIVATED LANDS IN THE CONDITIONS OF THE MARKET ECONOMY

Optimization, or rather rationalization of cultivated lands is a complex of activities aimed at the preservation or improvement of the existing, and formation of new relations among their components for preserving and developing their mineral properties and preventing their possible loss, establishment of the most complete and proper compliance of the natural potential of the land with the socio-economic functions determined by the man. Currently, no clear recommendations are available about the optimal ratio of acreages on the cultivated lands. It is therefore proposed to use the formula of its rationality and to harmonize the structure of cultivated lands in accordance with the modern challenges in the society and production [5, 6, 8, 10]. The main aspects of cultivated lands' rationalization include the following:

- ensuring the sustainability of the natural and anthropogenic properties of cultivated lands and their development for ensuring efficient agricultural production;
- ensuring cultivated land suitability for the intended use;
- ensuring the maximum degree of coincidence of the anthropogenic turnover of matter and energy (in accordance with production tasks) and natural turnover, in accordance with the type of terrain and

uniformity of the anthropogenic turnover of the matter and energy within its boundaries; and

- ensuring recovery of the used matter and energy of the land (restoring the balance) and accumulation of useful properties.

In course of implementing the ideas outlined in the first area of rationalization, and using the determined limitations in the proposed inequality, it has been found that stabilization of cultivated lands requires converting 17,612 ha of destabilizing acreage into the stabilizing one. One of the scenarios may be the conversion of 20 ha of wild land to forage land and transferring for perennial herbs 17,592 ha of arable land located on strongly saline soils and used for annual crops. Thus, cultivated lands pass from the "unstable" and "critical level of security" state to the "relatively stable" and "normal security level" state. This model of rationalization is aimed at stabilization and development of cultivated lands.

Another area of agricultural lands' improvement is increasing the fitness of the cultivated land properties for reaching the specified goal. It envisages conversion of 20 ha of wildland and 5,600 ha of arable land, which are strongly saline and heavily swamped, into forage grasslands. Withdrawing low-productive arable lands from the intensive use into grassland is the main stage of cultivated land development. On heavily deflated arable land, the creation of forest belts is envisaged for protection from wind erosion on the area of 1,070 ha (mainly in the central and southern part of the district). In the Isilkulsky district, there is 947 ha of forest belts. Based on the project area of forest belts, every 80 ha of arable land are subject to protection. It is proposed to introduce soil-protecting crop rotations with a lot of perennial herbs on the arable land of 10,900 ha.

The third area of rationalization is based on the environmental balance of the cultivated land (providing recovery of used energy and matter of the cultivated land, and accumulation of useful properties). The area of arable land in the actual structure of land use is 161,419 ha. The determined optimal area is 133,882 ha, i.e. arable land should be reduced to the optimal area on 27,537 ha, or by 17%. On this basis, it is proposed to convert 26,467 ha of arable land (including all waterlogged, saline and heavily deflated land) into forage grassland, and 1,070 ha - into forest belts. 20 ha of wild land should also be converted into haylage. Thus, accelerated soil erosion is automatically avoided, and soil degradation is reduced.

In the examples above, the individualized implementation of the chosen areas of cultivated land rationalization is shown. However, in the practice of management, one has to deal with a combination of methods of cultivated land rationalization by harmonizing the areas in which one should consider the improvement of the crop rotation system, the used technologies of agricultural crops' cultivation, and equipment. Proposals about cultivated land rationalization determine further development of agricultural production and preserving the land as a natural complex, prevention of adverse environmental effects from unsubstantiated and unsecured transformations of natural and anthropogenic systems into predominantly anthropogenic ones.

## 6. CONCLUSIONS AND SUGGESTIONS

1. For the first time, a detailed analysis of cultivated lands was carried out for one large district of the Omsk region. The proposed classification allows the development of groups of measures to maintain the ecological balance for each type of cultivated lands.

2. Rational land management based on sustainable cultivated land suitable for solving the economic goals allows achieving long-term production of the maximum amount of products at the minimum cost, with the reproduction of the natural properties of land.

3. It is necessary to ensure the functioning of agricultural landscapes within land-tenures as an integrated system. The results identified in the study allow solving the economic problems of agricultural producers, while cultivated lands are often under the threat of destruction. The landscape and the modern system of property relations are in a serious confrontation, which tears the unity of the landscape, generates quasi-landscapes within the same land plot. The consolidated natural system is unnaturally fragmented, it is gradually degraded and transformed into predominantly artificial systems.

4. The modern production requires constant adaptation of cultivated lands to efficient resolving of production problems, which allows considering rationalization of their properties as a necessity.

5. The areas and the essence of the cultivated lands' rationalization are based on revealing the nature of their formation, the dynamics of their components and properties, and suitability for resolving the production tasks in agriculture.

6. Rationalization of the use of cultivated lands, despite the difference in methods, ensures the recreation of their basic balances. In the future, for the final choice of rationalization, it is suggested to use the economic efficiency of crop production.

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