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ECONOMIC EFFICIENCY OF APPLYING MEASURES FOR REDUCTION OF SOIL DEPLETION IN RUSSIAN AGRICULTURAL LAND USE

Alla GORDOPOLOVA, Evgeniy ZAVOROTIN, Nataliya TIURINA

Volga Research Institute of Economics and Organisation of Agro-Industrial Complex,
12 Shehurdin Street, Saratov, Russia

Corresponding author email: GordopolovaAA@yandex.ru

Abstract

The current state of Russian land use is characterized by heterogeneity, instability and uncertainty of further development. Its efficiency is affected by the processes of cover destruction, waterlogging, salinization, and desertification. Fertility especially intensely decreases on old-arable lands and under monoculture cultivation. Effective agricultural land management is required and that involves the use of effective administrative and economic tools. The methods of cost optimization described by the process model are recommended, including the classification of costs, identification of ways to reduce them, introduction of a correction factor for determining the amounts of land payments, differentiation of responsibility for the implementation of mandatory measures, and differentiation of the amount of monetary penalties in accordance with the behavior of subjects in land relations. The practical value of the work is that its results contribute to improving the efficiency of agricultural land use in terms of its economic justification, environmental and social adaptation.

Key words: *agriculture, costs, land use, method, process model.*

INTRODUCTION

In the conditions of transformation of land relations, it is necessary to clarify and supplement the methodological framework for the efficiency of agricultural land use. In our opinion, the concept of efficiency in the use of agricultural land is limited and has a contradictory content - the interest in obtaining maximum income while maintaining soil fertility. The economic efficiency of national production depends largely on the fertility of the land, since in infertile countries "a moderate accumulation of capital will be accompanied by a significant decrease in the rate of profit and a rapid increase in rent" (Ricardo, 1955).

Efficient agricultural land use should be systemic and include three main components (Zavorotin et al., 2017; Zavorotin et al., 2018):

- economic, exogenous and endogenous, conditions of which contain a legal-regulatory framework ensuring the equilibrium of market exchange and adequate distribution of the income earned;
- environmental, conditioned by the impact of natural factors (soil fertility, natural environment, farming system) on the agricultural production;
- social, aimed at increasing responsibility for harming the environment and encouraging agricultural producers to rational use of land.

The criteria for the efficiency of agricultural land use are obtaining a concrete volume of output with a minimum cost of labor, production and natural resources, and preserving soil fertility (economic efficiency), preventing environmental degradation and improving the quality of productive land (ecological efficiency) as well as the degree of achieving a standard of living (social efficiency).

To understand the essence of agricultural land use, a careful study of its various definitions is necessary. Narrowly defined, land use is a form of disposal of land for the purpose of extracting useful properties or income from it through free management, rational organization of the territory, and protection from processes of destruction and pollution (Volkov et al., 1992; Masyutenko et al., 2012).

Within the process of research, land use is considered to be not a method of land exploitation but the right of the subject specified by the triune of powers (possession, use, and disposal of lands), assigned by a set of relevant legislative acts.

Efficient agricultural land use will be understood as an organized use of the functional potential of land with reduced costs and minimal negative consequences, most adapted to legal, economic, environmental and social conditions.

Areas for improving the efficiency of agricultural land use are as follows:

- organizational-and-managerial, involving the intensification of activities of management bodies, impact on public and individual consciousness for land use rationalization (Krylatykh, 1997);
- socio-economic, consisting of measures for financing federal and regional programs, income distribution, optimization of labor conditions;
- environmental, characterized by the level of use of natural resources, reduction of land intensity of products, and improvement of their quality (Bazilevitch et al., 1968; Gordeev et al., 2008);
- technical-and-technological, involving the use of resource-saving machinery and application of the latest achievements in the economy of agriculture, a scientifically based system of farming (Chernyaev et al., 2014).

According to the chosen areas, methods for cost optimization are scientifically based in order to obtain savings as a result of reducing the negative impact of erosion, soil salinization, consequences of continuous cultivation of commercial crops, full or partial reimbursement by the state of the costs for soil protection measures, etc.

The aim of the study is to develop the method of cost optimization, to calculate costs of lost opportunities as reduction in crop yields, to create process model for cost optimization taking into account measures for reduction of agricultural depletion of soils.

MATERIALS AND METHODS

The author's method of cost optimization taking into account measures for reducing agricultural depletion of soil is consigned to determining ways to suspend negative changes caused by violations of the farming system when cultivating crops, improving soil fertility indicators, and strengthening the responsibility of land relations participants for economically inefficient agricultural land use in order to avoid applying monetary penalties.

The idea of the method is in minimization of production costs, imputed costs, land tax, rental payment, costs for conservation, restoration of soil fertility, fines, etc. The following costs are most important (Table 1).

The effect for each type of cost (E_i) is expressed in annual savings:

$$E_i = \Delta C_i \quad (1)$$

where C_i is the cost of the *i*-th type, RUB/ha.

RESULTS AND DISCUSSIONS

The current state of land use is characterized by heterogeneity, instability, significant deformations, reduced returns to agricultural production, and uncertainty of further development. According to the World Data Atlas (2020), the area of agricultural land in the Russian Federation is 216.2 million hectares. The Food and Agriculture Organization (FAO) defines the category "Agricultural area" as the sum of areas under "Arable land and Permanent crops" and "Permanent pastures". A comparison of the specific weight of agricultural-purpose land in the land area (Table 2), the specific weights of arable land in the total area of agricultural land (Table 3) were made by the fifteen countries bordering on the Russian Federation and the three main European Union states (France, Germany and the United Kingdom) and United States of America and Canada.

In the specific weight of agricultural-purpose land in the land area the Russian Federation is on the 17 places (13.21%).

In the compiled ranking of agricultural land under crops, Finland (98.53%), Japan (93.43%), and Democratic People's Republic of Korea (89.38%) are at the top three places, respectively. In these terms the Russian Federation is on the 14th place (56.24%), all while in contrast to other countries in 2010-2017 the specific weight changes slightly.

In the land legislation of the Russian Federation, the concept of "agricultural-purpose land" is used. They include agricultural land, land occupied by intra-organizational roads, communications, forest plantations designed to protect land from negative impacts,

Table 1. Grouping of costs in the agricultural land use

Cost type	Cost components	Factors of impact on costs
1. Costs for agricultural crops cultivation	Costs for: employee compensation, purchase of material and production stocks, depreciation of fixed assets, maintenance, repair, storage of equipment, other.	Activities and interaction of land relations participants.
2. Costs of lost opportunities (imputed costs)	Lost profit due to the presence of land plots which are abandoned, unused, unsuitable for cultivation of agricultural crops.	Possible crop losses from degraded (highly-eroded, highly-salted, highly-waterlogged), infected (due to unbalanced land use), infertile (with reduced soil fertility under anthropogenic impact) lands.
3. Land payments	Land tax, rental payment.	Land tax and lease rates, cadastral value of the land plot, land rent amount.
4. Costs for agro-technical measures	Costs for measures for conservation, restoration of soil fertility, prevention of soil degradation, as well as monoculture cultivation.	Acidity, humus content, liable phosphorus, exchangeable potassium, the degree of soil degradation (undegraded, slightly-degraded, moderately-degraded, highly-degraded, extremely-degraded), shift of crops in the crop rotation.
5. Monetary penalties	Penalties for damaging the soil fertility.	Land legislation compliance, use of land as intended, the degree of damaging the soil fertility.

Table 2. Agricultural land (% of land area)

Country	2010	2011	2012	2013	2014	2015	2016	2017	On average over 8 years
1. Kazakhstan	80.44	80.38	80.38	80.38	80.38	80.38	80.38	80.38	80.39
2. Mongolia	73.11	73.06	72.99	72.94	72.70	72.67	71.49	71.28	72.53
3. Ukraine	71.23	71.26	71.29	71.68	71.66	71.65	71.67	71.62	71.51
4. United Kingdom	71.19	70.95	71.02	71.30	71.23	70.84	71.71	72.19	71.30
5. Azerbaijan	57.67	57.69	57.68	57.71	57.71	57.71	57.74	57.80	57.71
6. China	54.68	54.90	54.89	54.89	54.89	56.31	56.30	56.30	55.40
7. France	52.83	52.74	52.68	52.55	52.54	52.46	52.45	52.41	52.58
8. Germany	47.91	47.97	47.81	47.86	47.94	47.96	47.68	47.76	47.86
9. Poland	47.18	48.26	47.45	47.06	47.11	46.93	46.94	47.23	47.27
10. Lithuania	44.22	44.77	45.35	46.12	47.12	47.98	47.16	46.86	46.20
11. United States of America	44.86	44.77	44.68	44.61	44.54	44.47	44.40	44.34	44.58
12. Belarus	43.85	43.74	43.35	42.93	42.49	42.24	42.04	41.84	42.81
13. Georgia	35.40	35.14	35.04	35.77	34.77	34.80	34.45	34.32	34.96
14. Latvia	29.00	29.20	29.61	30.18	30.13	30.34	31.08	31.12	30.08
15. Estonia	22.39	22.32	22.55	22.20	22.41	22.84	23.07	23.05	22.60
16. Democratic People's Republic of Korea	22.26	21.84	21.84	21.84	21.84	21.84	21.84	21.84	21.89
17. Russian Federation	13.23	13.21	13.20	13.20	13.20	13.20	13.20	13.20	13.21
18. Japan	12.60	12.51	12.48	12.45	12.39	12.33	12.26	12.19	12.40
19. Finland	7.54	7.53	7.52	7.43	7.46	7.48	7.49	7.47	7.49
20. Canada	6.50	6.44	6.44	6.45	6.46	6.47	6.47	6.44	6.46
21. Norway	2.75	2.74	2.72	2.70	2.70	2.70	2.70	2.70	2.71

Source: Calculated by the authors according to World Data Atlas

Table 3. Arable land (% of agricultural land)

Country	2010	2011	2012	2013	2014	2015	2016	2017	On average over 8 years
1. Finland	98.39	98.43	98.42	98.45	98.41	98.64	98.73	98.77	98.53
2. Japan	93.23	93.27	93.34	93.39	93.45	93.53	93.58	93.63	93.43
3. Democratic People's Republic of Korea	89.55	89.35	89.35	89.35	89.35	89.35	89.35	89.35	89.38
4. Norway	82.11	81.88	81.77	81.86	81.86	81.85	81.81	81.32	81.81
5. Ukraine	78.70	78.73	78.74	78.93	78.94	78.96	78.95	78.99	78.87
6. Lithuania	76.73	77.90	79.56	79.25	79.61	72.26	72.55	71.69	76.19
7. Poland	74.95	75.09	75.19	74.89	75.76	75.76	75.18	75.42	75.28
8. Germany	70.93	71.03	71.02	71.13	70.97	70.80	70.61	70.55	70.88
9. Estonia	67.97	66.81	64.96	66.11	67.15	67.98	69.39	68.26	67.33
10. Canada	64.67	64.62	64.97	65.32	65.67	66.02	66.37	66.17	65.48
11. Latvia	64.99	63.77	63.99	64.36	64.58	65.25	66.70	66.74	65.05
12. Belarus	62.20	62.30	62.78	63.83	65.65	66.21	66.61	67.42	64.63
13. France	63.27	63.28	63.38	63.62	63.73	64.33	63.92	64.34	63.73
14. Russian Federation	56.16	56.24	56.25	56.25	56.25	56.25	56.25	56.25	56.24
15. Azerbaijan	39.52	39.55	39.79	40.36	40.40	40.63	41.88	43.85	40.75
16. United States of America	38.46	38.20	37.95	38.14	38.09	38.53	38.72	38.92	38.38
17. United Kingdom	34.66	35.32	36.15	36.32	36.18	35.07	34.73	34.83	35.41
18. China	20.92	20.79	20.67	20.63	20.63	22.62	22.61	22.61	21.43
19. Georgia	16.06	15.44	15.20	16.73	15.11	15.22	14.37	13.58	15.21
20. Kazakhstan	13.21	13.45	13.52	13.55	13.55	13.55	13.55	13.55	13.49
21. Mongolia	0.54	0.54	0.57	0.50	0.50	0.50	0.51	0.51	0.52

Source: Calculated by the authors according to World Data Atlas

water bodies, as well as buildings and structures used for the production, storage and primary processing of agricultural output (Land Code of Russian Federation, 2001). The specific weight of agricultural-purpose land in the total area of the subjects of the Russian Federation varies from 1.2% (Republic of Karelia) to 94.5% (Nenets Autonomous district (okrug)) (Federal Service for State Registration, Cadastre and Cartography, 2020). More than a third of the soil of the country's agricultural land is subjected to cover destruction, waterlogging, salinization, and desertification. In the Volga Federal district, the main degradation process is erosion, which covers more than three-quarters of the region's area. In many regions and republics, with the exception of separate land uses, they tend to increase. The most developed water erosion processes are in the republics of Tatarstan and Bashkortostan and they are progressing in the Samara, Saratov, and Volgograd regions.

According to the long-term research conducted by the Agricultural Research Institute of South-East Region (2020) and the State Station of Agrochemical Service "Saratovskaya" (2020), water erosion, deflation and their overall impact are noted on 4525.0 thousand hectares, which is 52.7% of the total area of agricultural land in the Saratov region. Distribution of agricultural land area by type of erosion is in Table 4.

Table 4. Distribution of agricultural land area by type of erosion, thousand ha

Natural zone	Type of erosion		
	water	wind	water-wind
Forest-steppe	1319.2	27.4	166.8
Steppe	1365.9	44.7	62.1
Dry steppe	1304.1	64.2	29.5
Semidesert	138.2	0.5	2.6

The processes of water erosion are the most evident in the steppe zone, wind erosion is in the dry-steppe and water-wind erosion is in the forest-steppe natural zone. Water erosion is observed on 4127.4 thousand hectares (48.1%) of the agricultural lands, there is wind erosion on 136.6 thousand hectares (1.6%) and water-wind erosion is on 261.0 thousand hectares, or 3.0%.

In our opinion, cost saving is provided by the correct combination of the proposed methods of impact:

- reimbursement by the state of part of the costs for agricultural production, taking into account the soil fertility index in the subject of the Russian Federation (reduction of costs of the first type);
- reduction of the specific weight of land unsuitable for cultivation of agricultural crops in their total area, including through conservation (reduction of costs of the second type);
- introduction and use of the correction factor for the area actually occupied by agricultural crops (harvested) (reduction of costs of the third type);
- implementation of measures for prevention of dehumification, soil fatigation, soil depletion (use of grassland crop rotations, application of organic fertilizers), erosions and deflations (non-mouldboard soil cultivation, placement of protective forest belts, contour organization of territories), formation of structurless crusts and over-compacted horizons (use of modern lightweight equipment, reducing the number of treatments, etc.) (reduction of costs of the fourth type);
- advisory engagement, regulation of the agricultural land use (reduction of costs of the fifth type).

The areas of minimizing the lost opportunity costs are considered on the example of soils of different natural zones of the Saratov region, different degrees of their erosion and salinization.

The actual data of eroded lands are used in the calculations: total area of lands - 3443 ha, productivity - 1.87 t/ha, profit - 1117.1 RUB/t. Standard of reduction in crop yields of slight-eroded lands - 18 %, of moderate-eroded lands - 35%, of high-eroded lands - 52% (Masyutenko et al., 2012).

Reduction in crop yields (t/ha) is calculated as productivity (t/ha) multiply by standard of reduction in crop yields. Lost profit (costs of lost opportunities, RUB/ha) is calculated as reduction in crop yields (t/ha) multiply by profit (RUB/t) (Table 5).

The economic effect of agricultural eroded land use depends on conducting subsurface tillage, compliance with requirements for crop rotation. Economic effect, RUB/ha is calculated as reduction in the loss of crop yields (t/ha) multiply by profit (RUB/t) (Table 6).

Table 5. Calculation of the lost profit from grain production on eroded lands (on the example of separate land plots in the Saratov region)

Soil	Reduction in crop yields, t/ha	Lost profit, RUB/ha
slight-eroded	0.337	376.46
moderate-eroded	0.655	731.70
high-eroded	0.972	1085.82

Table 6. Economic effect from the grain production on soils with improved quality indicators (on the example of erodibility reduction of separate land plots in the Saratov region)

Change in the degree of soil degradation (erodibility reduction)	Reduction in the loss of crop yields, t/ha	Economic effect, RUB/ha
moderate → slight	0.318	355.24
high → moderate	0.317	354.12
high → slight	0.635	709.36

Max economic effect from erodibility reduction is 709.36 RUB/ha.

The actual data of salted lands are used in the calculations: total area of lands - 609 ha, productivity - 1.56 t/ha, profit - 918.2 RUB/t. Standard of reduction in crop yields of slight-salted lands - 20%, of moderate-salted lands - 50%, of high salted lands - 70%, of severe-salted lands - 90% (Bazilevitch et al., 1968).

Reduction in crop yields (t/ha) is calculated as productivity (t/ha) multiply by standard of reduction in crop yields.

Lost profit (costs of lost opportunities, RUB/ha) is calculated as reduction in crop yields (t/ha) multiply by profit (RUB/t) (Table 7).

Table 7. Calculation of the lost profit from grain production on salted lands (on the example of separate land plots in the Saratov region)

Soil	Reduction in crop yields, t/ha	Lost profit, RUB/ha
slight-salted	0.312	286.48
moderate-salted	0.780	716.20
high salted	1.092	1002.67
severe-salted	1.404	1289.15

The economic effect of agricultural salted land use depends on conducting melioration and agricultural activities (Table 8).

Table 8. Economic effect from the grain production on soils with improved quality indicators (on the example of salinization reduction of separate land plots in the Saratov region)

Change in the degree of soil degradation (salinization reduction)	Reduction in the loss of crop yields, t/ha	Economic effect, RUB/ha
moderate → slight	0.468	429.72
high → moderate	0.312	286.48
extreme → high	0.312	286.48
high → slight	0.780	716.20
extreme → slight	1.092	1002.67
extreme → moderate	0.624	572.96

Max economic effect from salinization reduction is 1002.67 RUB/ha.

The base for calculating the amount of land payments is the cadastral value of the land plot without taking into account the quality and condition of agricultural land provided for use. To determine the land tax amount accrued for payment, it is multiplied by 0.3%, and for determining the rental amount, cadastral value is multiplied by the corresponding rate and time factors, inflation processes (Zavorotin et al., 2019). This circumstance makes it necessary to apply a substantiated coefficient, excluding the area occupied by communications and roads, disturbed and other lands from the total area not involved in economic turnover.

Reduction the costs for the measures related to improving the soil quality and eliminating monoculture specialization should be achieved by implementing a set of proposed steps supported by the state, performed by owners, land users, landowners, and lessees by themselves (Table 9).

The assistance of the authorities should be specified in the relevant program, and their intervention can be determined by implementing a normative-rent approach to the establishment of marginal lands. This category usually includes agricultural land that has a zero or negative rent value in the following cases:

- anthropogenic impact (uncontrolled, excessive use of fertilizers, pesticides, etc.), leading to degradation of the soil cover;
- establishing payments for land that exceed the income it generates;

Table 9. Expected participation of the state in the implementation of measures on reduction of agricultural land depletion

Circumstance	Degree of participation	Method of influence
Implementation by owners, land users, landowners and lessees of mandatory measures for maintenance and restoration of the normal land condition	Low	Control
The amount of mandatory costs for improving the quality of land does not correspond to the financial capabilities of agricultural producers	Moderate	Subsidizati on
Complete exhaustion of useful properties of land in the use as not intended	High	Removal

- allotment of lands that are unsuitable for profitable production of crop output (erodible, hillside, bushy, stony, swampy, salty, etc.).

The effect of penalties for damaging the soil fertility should be fair towards the owners, land users, landowners, and lessees, so it is necessary to differentiate the number of monetary penalties in accordance with the behavior of subjects.

Inefficient land relations participants who do not use land, use land as not intended, use land in agricultural production irrationally or damage land should be subject to penalties in full in accordance with the current legislation. The same measure of material impact should be applied to the subjects that use land for agricultural production with that unreasonably increasing the anthropogenic load on agricultural land. If they get land that has been subjected to slope, degradation and other natural processes, they have the right to apply for the cancellation or reduction of fines. Penalties in the form of fines should not be applied to effective participants in land relations who use land in agricultural production with restoration measures.

The essence of the developed method can be traced by the model of the process of its functioning, the effect of agricultural land use consists of three components (Figure 1).

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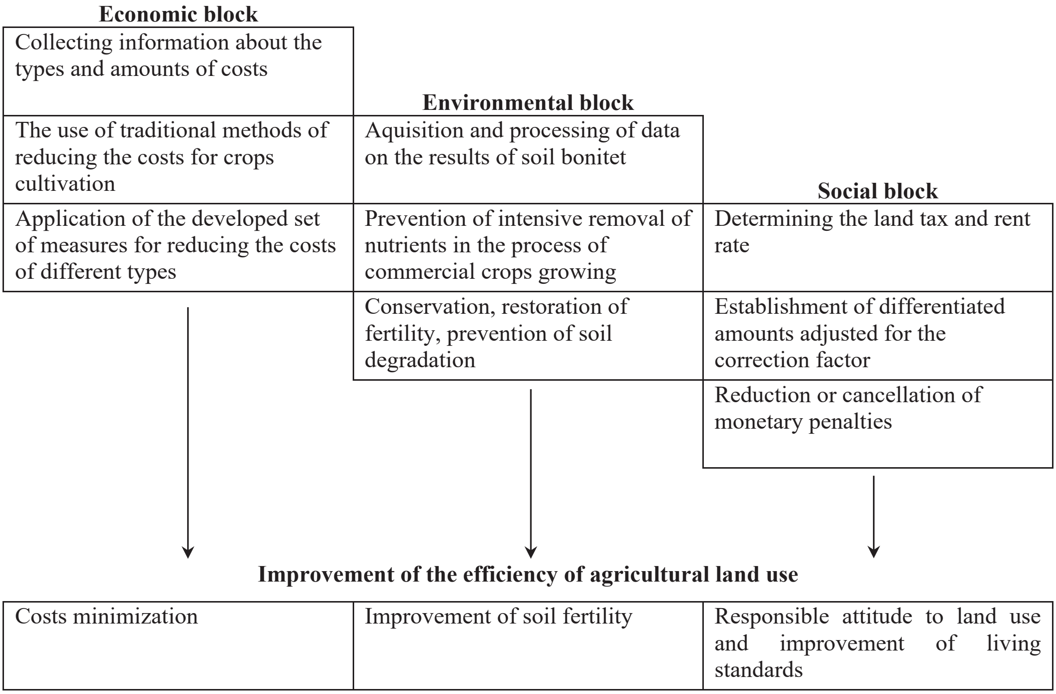

Figure 1. Process model for cost optimization taking into account measures for reduction of agricultural depletion of soils

The system is described by three coordinated stages, which include step-by-step implementation of the proposed actions in the economic, environmental and social areas of improving the efficiency of agricultural land use. Each of them has a significant impact on the process of land management and all together make it possible to optimize the costs of different types, reduce the destructive impact of soil erosion (deflation), avoid variances from crop rotation requirements and recommendations of scientific institutions for placing crops in the crop rotation, contribute to the reproduction of fertile properties of land, raise environmental awareness, etc.

CONCLUSIONS

Methods of cost optimization taking into account measures for protection of soils from depletion, implemented through the use of agro-technical, fiscal, economic, legal and other opportunities to improve the efficiency of agricultural land use, are proposed. Five groups of costs are identified, and the reduction of them creates the necessary prerequisites for the rational activity of agricultural producers; the results for typical farms used for enhancement of anti-erosion resistance and soil salinity are obtained. One of the areas is stimulation of land relations participants, which ensures establishing the degree of state participation in the financing of soil protection measures, expedience of differentiation of the amounts of monetary penalties and other relevant payments to encourage land users who observe the regulations of environmental safety standards.

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