Environmental assessment of land as a basis for improving the efficiency and sustainability of agricultural land use

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Abstract. Today, in agricultural land use, there is an increase in environmental problems, deterioration of environmental indicators, which negatively affect the economy of the agro-industrial complex. Elimination of negative environmental consequences often requires huge financial costs, which significantly exceed the costs of maintaining and protecting the environment, as a result of which production yield and the profitability of individual enterprises decreases, as well as the efficacy of the industry as a whole. The only way to preserve soil quality is to introduce economic mechanisms for greening land use, the most important of which is the environmental assessment of land. The aim of the research was to develop a concept for improving the efficiency and sustainability of agricultural land use based on environmental land assessment. The presented two-stage methodology for assessing the ecological state of arable land made it possible to reflect the nature and degree of manifestation of negative processes, as well as to establish the degree of anthropogenic impact on agricultural landscapes. The materials of the conducted environmental assessment served as an objective basis for the development of the concept of rational and environmentally sustainable land use within the boundaries of the municipal district and made it possible to formulate measures to improve the efficiency and sustainability of the use of arable land by agricultural enterprises.

1. Introduction
Land resources determine the socio-economic wealth of the state, and arable land is the most important component of the natural resources of any country. In the process of anthropogenic impact, a person changes the course of natural development of soils and vegetation, which raises the question of the need for a comprehensive study of the transformation of soil properties, determining the limits of stability, as well as establishing thresholds for rational impact on land resources [1]. Currently, the world is experiencing rapid population growth, and due to its irrational economic activities, the landscape is changing dramatically. In the world, there is an annual loss of fertile areas of 6-7 million hectares, and as a result, the provision of humanity with land resources is rapidly decreasing [2].

The problem of rational use of agricultural land in a variety of forms of ownership and land management requires the introduction of a whole range of measures to further increase the intensity of land use and, above all, increase soil fertility, improve the efficiency and sustainability of agricultural land use [3].

2. Problem statement
The deterioration of environmental indicators in agriculture negatively affects the economy of the agro-industrial complex. For instance, with low soil fertility, much more costs are required to obtain a...
unit of yield than with high fertility. This factor leads to an increase in production costs and in some cases, it is simply impossible to have high land productivity due to poor soil structure, a high degree of manifestation of negative processes, and its pollution with heavy metals and pesticides. Elimination of negative environmental consequences often requires huge financial investments, which significantly exceed investments in maintaining and protecting the environment. The result of this is a decrease in the production of products and the profitability of individual enterprises, as well as the deterioration of the industry as a whole [4]. The only way to preserve soil quality is to introduce economic mechanisms for greening land use, the most important of which is the environmental assessment of land.

3. Research goal
The development of a concept to improve the efficiency and sustainability of agricultural land use based on environmental land assessment.

4. Research object
The object of assessing the ecological state of agricultural land is arable land within the boundaries of the Tara municipal district of the Omsk region. The Tara municipal district is an administrative-territorial unit in the north-east of the Omsk region of the Russian Federation. The total area of land within the boundaries of the district is 1,556 thousand hectares, 14.1% of which are agricultural land. The Tarsky district, like other districts in the north of the Omsk region, is unique in its industrial complex, where, along with agricultural production, forestry is also developed. Nine agricultural enterprises, 15 peasant (farmer) households and more than 13 thousand personal subsidiary plots are engaged in the production of agricultural products in the region [5]. As of January 1, 2020, 85.4% of the district’s territory is occupied by forestry lands, while the most valuable lands intended for agricultural purposes account for only 14% of the district’s territory. This picture is typical for all northern regions of the Omsk region (Table 1).

Table 1. Agricultural development, plowing and forest cover in the northern districts of the Omsk region

| North area of Omsk region | Total area, thousand ha | Agricultural development, % | Arable land, % | Forest cover, % |
|---------------------------|------------------------|-----------------------------|---------------|----------------|
| Bolsheukovsky             | 950.0                  | 6.0                         | 2.0           | 49.0           |
| Znamensky                 | 365.1                  | 21.1                        | 8.3           | 59.7           |
| Sedelnikovsky             | 522.1                  | 16.1                        | 11.5          | 60.8           |
| Tarski                    | 1,556.1                | 10.1                        | 4.8           | 68.2           |
| Tevrizki                  | 981.5                  | 7.6                         | 3.6           | 63.2           |
| Ust-Ishimsky              | 788.6                  | 7.1                         | 3.9           | 59.8           |
| Total for the northern zone | 5,163.4               | 9.8                         | 4.8           | 61.1           |

The analysis of the table shows that the Tarsky region is a typical representative of the regions of the northern zone, which is characterized by low agricultural development and plowing, high forest cover of the territory. Agricultural development of the territory of the region is 10.1%, 4.8% of the territory are plowed up. If we consider the areal indicators of land use in the Tara region, then for 2020 the structure of agricultural land includes 157.6 hectares of agricultural land, 74.9 hectares of which are arable land, 58.8 hectares are fodder land and 23.9 hectares are fallow.

The basis of the economy of the Tara region is the production of agricultural products. The main specialization of the district is the production of livestock products, since it accounts for 63% of the
total agricultural production [6]. The dominance of the livestock industry both in the Tara region and in other areas of the northern zone of the Omsk region is due to natural and climatic conditions.

5. Research methods
The research methods are based on the use of balance, cartographic, economic and statistical methods, as well as the method of system analysis. Scientific research was carried out using the equipment of the Shared Use Center with the scientific equipment “Agricultural and technological research”, created on the basis of Omsk State Agrarian University.

6. Results and discussion
Within the framework of this study, an ecological assessment of arable land in the Tara region was carried out, the materials of which made it possible to formulate measures to improve the efficiency and sustainability of the use of these lands by agricultural land use.

In the Tara region, arable land occupies 47.5% of all agricultural land in the region. The predominantly soil cover of the arable land of the region as a whole is characterized by an average content of mobile phosphorus (77.5 mg/kg), a low content of exchangeable potassium (67.3 mg/kg), a moderately acidic reaction of the soil solution (5.0) and a low content of humus (3.4%) [7]. It should be noted that land plots represent a significant part of the resource potential of the Tara district of the Omsk region. This aspect not only determines the economic specifics of the region, but also affects social development [8, 9].

According to previously conducted studies in the field of assessing the natural resource potential of the Tara region, the southern part of the region has the most favorable potential, which explains the activity of agricultural land use systems and the concentration of large agricultural organizations [5].

The assessment of the ecological state of the arable land of the district was carried out in two stages in the context of assessment groups, which are the settlements of the district:
1. Assessment of the existing environmental background;
2. Assessment of anthropogenic impact (load).

During the assessment of the ecological state at the first stage, the nature and degree of manifestation of negative processes, the humus content of the soils and the thickness of the humus horizon were taken into account; at the second stage of the assessment, the anthropogenic load on agricultural landscapes was established.

To assess the ecological state of arable land in the area at the first stage, indicators of negative natural and anthropogenic factors were taken, which have the greatest impact on the level and profitability of agricultural production. The main indicators of the assessment were: the degree of manifestation of soil erosion and deflation, salinization and waterlogging, the thickness of the humus horizon, the humus content in the arable horizon.

The results of the assessment showed that, mainly in all assessment groups, arable land is in medium environmental stress (52.4% of arable land). A strong ecological impact on arable land was revealed in rural settlements in the northern part of the district, where there is a high level of waterlogging and washout (14.5% of arable land). In southern rural settlements, arable land is in a low degree of environmental stress (33.1% of arable land). If we consider the results of the environmental assessment in the territorial context, then the degree of environmental tension is distributed zonally: it intensifies when moving from south to north.

Based on the materials of the ecological state of arable land, methods and measures were established to regulate and improve the properties (Table 2).

Thus, in order to improve the ecological state of the arable land of the region, it is proposed to carry out localized transformation of land, reclamation, biological and chemical reclamation in areas with a strong degree of ecological tension. Within the boundaries with an average degree of environmental stress, it is more rational to carry out organizational and economic measures, agrotechnical and biological reclamation, as well as changes in land use regimes (to introduce
restrictions on the sowing of certain crops). Organizational and economic measures and agrotechnical reclamation are proposed to be carried out on arable land of a low degree of environmental stress.
Table 2. Recommendations for the regulation of the properties of arable land

| Degree of environmental stress | Regulation techniques | Improving properties by: |
|-------------------------------|-----------------------|-------------------------|
|                               | Transformation | Changing use regimes | Organizational and economic measures | Agrotechnical measures | Biological measures | Forest reclamation measures | Chemical reclamation | Recultivation | Conservation |
| Strong degree                 | +            | +                     | +                                   | +                      | +                      | +                      | +                      | +                      |             |
| Average degree                | +            | +                     | +                                   | +                      | +                      | +                      | +                      | +                      |             |
| Weak degree                   | +            | +                     |                                     | +                      |                        |                        |                        |                        |             |

In order to assess the ecological state at the second stage, the anthropogenic load on agricultural landscapes was established. This assessment is performed on the basis of the index assessment method. This method has found wide application in various types of assessments, and environmental assessment is no exception. Using this method, the system of all indicators characterizing the state of land within the boundaries of large economic entities leads to a single relative indicator or index.

The initial data for assessing the anthropogenic load were such indicators as the areas of the objects of assessment, soil quality scores, humus content, areas under water and forest plantations.

To determine the values of indicators that characterize the arrangement of natural components of the territory and play the role of environment stabilizing, the values of forest cover, water cut and swampiness were calculated. To determine the agricultural load on agricultural landscapes, the values of agricultural development and plowing were calculated.

Thus, partial indices were calculated on the basis of the above indicators characterizing the landscape-ecological load on land (plowing, development, swampiness). These indices are calculated as the ratio of the value of the indicator of a rural settlement to the value for the Tara region as a whole. These indicators characterize the negative aspects of the assessment.

The positive aspects of the assessment are characterized by the indicators of the quality score of agricultural land, the content of humus in the soil of arable land, indicators of forest cover and water cut. These indicators characterize the degree of land improvement. Their indices are calculated as the ratio of the value for the Tara region as a whole to the value of the indicator of a particular settlement within the region.

Thus, the indicators are brought to a single system. The integrated index of environmental stress characterizes the state of land and is taken as a unit for each indicator. If the index is less than one, the reserve of the anthropogenic load potential is manifested; if the index is greater than one, an increased landscape-ecological load on agricultural landscapes is manifested. The final index of landscape-ecological tension is calculated as the ratio of the sum of the values of particular indices of specific regions to the number of adopted indices.

Evaluation using the index method allows linking the system of indicators that reflect both positive (forest cover, water cut, quality score, humus content) and negative aspects of the ecological situation (salinity, waterlogging, etc.) in the study object, bringing them to a single relative indicator. An index less than one shows conditions with a potential reserve of anthropogenic load, an index greater than one, on the contrary, determines an increased landscape-ecological load (Table 3).
Table 3. Index-based assessment of the ecological tension of the agricultural landscapes of the settlements of the Tara region

| Settlement name | Plowing degree | Development degree | Swampiness | Quality score | Humus content | Forest cover | Water cut | Environmental stress index |
|-----------------|----------------|--------------------|------------|---------------|---------------|-------------|-----------|-----------------------------|
| Ermakovskoe     | 2.16           | 2.69               | 0.07       | 1.45          | 1.21          | 0.99        | 1.55      | 1.45                        |
| N.-Ivanovskoe   | 2.23           | 4.12               | 0.01       | 1.61          | 1.10          | 1.26        | 2.84      | 1.88                        |
| Vstavskoe       | 3.83           | 4.81               | 1.03       | 1.48          | 0.81          | 2.48        | 0.62      | 2.15                        |
| B.-Turalinskoe  | 3.21           | 4.21               | 1.04       | 1.63          | 0.74          | 2.03        | 1.17      | 2.01                        |
| Lozhnikovskoe   | 3.03           | 3.33               | 1.12       | 1.21          | 1.03          | 1.63        | 1.30      | 1.81                        |
| Souskanovskoe   | 5.11           | 3.55               | 0.44       | 1.16          | 1.36          | 1.30        | 0.77      | 1.96                        |
| Chernyaevskoe   | 3.40           | 3.25               | 1.75       | 1.30          | 0.62          | 2.67        | 0.17      | 1.88                        |
| Samsonovskoe    | 2.39           | 3.35               | 0.31       | 1.79          | 0.79          | 1.31        | 0.26      | 1.46                        |
| Chekrushanskie  | 3.97           | 4.43               | 1.03       | 1.68          | 0.85          | 2.75        | 0.17      | 2.12                        |
| Vasisskoe       | 0.10           | 0.07               | 1.50       | 2.50          | 1.62          | 0.93        | 2.45      | 1.31                        |
| Imshegalskoe    | 1.21           | 1.24               | 0.14       | 2.03          | 2.27          | 0.82        | 1.31      | 1.29                        |
| Litkovskoe      | 0.25           | 0.17               | 1.66       | 2.46          | 1.21          | 1.05        | 1.95      | 1.25                        |
| Egorovskoe      | 3.54           | 2.38               | 0.04       | 1.66          | 3.40          | 0.93        | 1.99      | 1.99                        |
| Martyushevskoe  | 3.02           | 2.18               | 0.08       | 1.62          | 3.40          | 0.92        | 2.10      | 1.90                        |
| Atirskoe        | 0.31           | 0.52               | 0.25       | 2.01          | 3.09          | 0.77        | 2.05      | 1.29                        |
| Pologrudovskoe  | 1.90           | 2.36               | 0.17       | 1.81          | 3.40          | 1.01        | 0.88      | 1.65                        |
| Ust-Tarsko      | 4.30           | 3.28               | 0.09       | 2.02          | 1.48          | 1.18        | 0.22      | 1.80                        |
| Zapivinskoe     | 4.30           | 3.76               | 0.61       | 1.32          | 0.74          | 1.73        | 0.22      | 1.81                        |
| Orlovskoe       | 3.40           | 3.22               | 1.37       | 1.64          | 0.65          | 1.97        | 0.46      | 1.81                        |
| Mezhdurechenskoe| 0.57           | 0.68               | 0.17       | 1.85          | 1.00          | 0.82        | 3.10      | 1.17                        |
| Ekaterininskoe  | 0.97           | 0.59               | 0.03       | 1.62          | 1.10          | 0.78        | 1.08      | 0.88                        |
| Tarsko          | 7.02           | 4.58               | 0.50       | 1.28          | 2.83          | 29.88       | 0.03      | 6.59                        |
| Total for district | 1.00        | 1.00               | 1.00       | 1.00          | 1.00          | 1.00        | 1.00      | 1.00                        |

The analysis of the results obtained allowed the following conclusions. From a landscape-ecological point of view, the most unfavorable lands are the lands of the Tarsky urban and Vstavsky, Bolshe-Turalinsky and Chekrushanskie rural settlements, where the environmental stress index exceeds the general regional level by 2 times or more. The arable lands of Nagorno-Ivanovskiy, Lozhnikovskiy, Souskanovskiy, Chernyaevskiy, Yegorovskiy, Martyushevskiy, Pologrudovskiy, Ust-Tarskiy, Zapivinskii and Orlovskiy rural settlements also belong to the unfavorable ones (Fig. 1).

The increased index of environmental stress in these settlements is due to the fact that the agricultural sector is more developed on their territories, as a result of which arable lands experience a significant overload during their anthropogenic use. In the remaining rural settlements of the district, there is a slight excess of anthropogenic load on the land, which is caused by the low agricultural activity on the lands within the boundaries of rural settlements.
Thus, the index assessment of the landscape-ecological state of arable lands in the Tara region showed that there are significant environmental problems in 14 out of 22 (64%) settlements. Basically, these settlements are located in the southern and central parts of the region, where agricultural production is part of the industrial complex of the region and has a more pronounced manifestation, in connection with which the land is experiencing a high overload during use. This circumstance requires a search for solutions to environmental problems.

**Figure 1.** Cartogram of the results of assessing the anthropogenic load of arable land. Settlement designations: 1 – Vasisskoe; 2 – Atirskoe; 3 – Imshegalskoe; 4 – Litkovskoe; 5 – Pologrudovskoe; 6 – Martyushevskoe; 7 – Egorovskoe; 8 – Samsonovskoe; 9 – Ermakovskoe; 10 – Souskanovskoe; 11 – Chekrushansko; 12 – Tarsko; 13 – Ekaterinensko; 14 – Lozhnikovskoe; 15 – Vstavskoe; 16 – Zalivinsko; 17 – Mezhdurechenskoe; 18 – Bolshe-Turalinskoe; 19 – Orlovskoe; 20 – Chernyaevskoe; 21 – Ust-Tarsko; 22 – Nagorno-Ivanovskoe

### 7. Conclusions

Within the framework of this study, an ecological assessment of the arable land of the Tara municipal district was carried out. The materials of the conducted environmental assessment serve as an objective basis for rational and environmentally sustainable land use within the boundaries of the municipal district. When solving the problems of the rational use of arable land, it is necessary to proceed from the fact that their regulation is carried out by all means of agricultural farming systems, the main of which is the establishment and optimization of the composition and proportions of land, the organization of the crop rotation system, the choice of the soil cultivation system, the implementation of anti-erosion measures when organizing the territory, the use of mineral and organic fertilizers. Thus, ecological optimization using the developed system of agroecological assessment of soils makes it possible to achieve greater compliance of agricultural land use in the region with its soil and climatic conditions and ensure high productivity of arable land.
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