Study of ecological and economic state of agricultural lands of foothill areas in Altai region

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Abstract. The article discusses the method of integrated assessment of environmental economic states agricultural lands of Krasnogorsky and Sovetsky districts of the Altai Region. Joint analysis of results of data processing of remote sensing, cadastral information and forms of statistical reporting allowed carrying out an area assessment of lands classified by different degrees of anthropogenic transformation. The characteristics of areas subject to anthropogenic influences were identified. They allowed us to allocate lands with special mode of use and adjust the ecological and economic state towards balanced and sustainable development.

1. Introduction
At present the concept of sustainable development has found wide application in economic, social and environmental spheres of public activity. One of the main tasks of the program for sustainable development is to optimize the spatial organization of country areas based on the rational use of existing resource potential. For the successful implementation of this task within the framework of the concept sustainable development requires new approaches to the study of natural-anthropogenic systems. One of such approaches is the concept of the ecological and economic balance of the territory. It includes the following conditions: the organization of territories on the landscape ecological basis; conservation and maintenance of natural and slightly modified landscapes that perform important environmental and resource functions; rational use of the natural potential of the territory; development of innovation processes [1].

The study and analysis of the prerequisites that exist in a particular territory for realization of each of the conditions of the concept of ecological and economic balance will allow identify the main problems, as well as positive and negative factors of development for taking action on its sustainable development.

2. Materials and methods
The object of research was the territory of Krasnogorsky and Soviet districts, which are situated in the east in the foothills of the Altai Region. The territory is bordered by Republic of Altai, Altaysky, Smolensky, Biysky and Soltonsky districts of Altai Region.

We used some methods to solve the problem of assessing the ecological and economic condition of agricultural territories by the way of their sustainable development. They are: analysis land use patterns based on land registry cadastral units and remote sensing data; definitions of integrated environmental and economic ratings; geographic information technology to create a thematic cartographic material on the results of the research. In the process of research used remote sensing data obtained by multispectral
3. Results and Discussion

As a result of the joint processing of all available data, a map was constructed agricultural land of Krasnogorsky and Sovetsky districts (Figure 1). Analysis showed that the total area of study areas in the administrative boundaries is 479401 hectares (308984 ha - Krasnogorsky district and 170417 ha - Sovetsky district).

![Figure 1. Agricultural land Krasnogorsky and Sovetsky districts](image)

The basis of the land fund areas are agricultural land (64.3%). They include agricultural land and land occupied on-farm roads, trees and bushes, buildings and constructions, which are necessary for functioning farming. Distribution agricultural land within the individual farms of administrative regions is different. There is dependence between the features of the relief and a location of agricultural land. Arable lands prevail in the flat part of the Sovetsky district and occupy 52% of all territory. Hayfields and pastures predominate in the Krasnogorsky district. They are 36% of area of the district.

The second place of area is forests. They are 28.6%. Forests are common in western and southwestern part of the Krasnogorsky district and occupy 40% of the territory. There are minor forest tracts along the Katun River and in the south of the Sovetsky District. The greatest number of the forests is in Krasnogorsky, Ust-Kazhinsky and Novozykovsky village administrations.

Special meaning are the lands of specially protected areas, which constitute 10% of total area (42898 ha), among which there is a reserve Swan (38000 ha) in Sovetsky area and reserve Mikhailovsky (4100 ha) in the Krasnogorsky district. Other lands with small areas include development land, under roads, under water, deposits, perennial plantings and other lands.

Given the structure of land use and the availability of land of various categories calculate the level of anthropogenic transformation of the territory [4, 5]. Anthropogenic level the load of the studied areas...
was determined by the method of B I Kochurova [6]. According to the proposed method in the case of extensive development of the territory structure analysis land use is carried out in administrative boundaries. To determine the degree anthropogenic load of land introduced expert scoring: $\text{An1}$ - very low (conservation and unused land); $\text{An2}$ - low (hayfields, forests used limited); $\text{An3}$ - medium (perennial plantations, recreational land); $\text{An4}$ - high (arable land, areas of intensive logging, pastures and hayfields used irrational); $\text{An5}$ - very high (irrigated and drained lands); $\text{An6}$ - highest (land industry, transport, settlements, infrastructure, disturbed land). Every kind of land gets the appropriate score. Joint analysis of space processing results images, cadastral information and statistical reporting forms № 22-2 of Krasnogorsky and Sovetsky districts allowed to carry out an area assessment of land classified by varying degrees of anthropogenic transformation and identify the next point land classification presented in Table 1 ($\text{An5}$ category is absent in the study area).

Table 1. Point classification of land according to the degree of anthropogenic transformation in the administrative boundaries of the village councils of Krasnogorsky and Sovetsky districts

| The village council | $\text{An1}$, ha | $\text{An2}$, ha | $\text{An3}$, ha | $\text{An4}$, ha | $\text{An6}$, ha |
|---------------------|----------------|----------------|----------------|----------------|----------------|
| Krasnogorsky district |                |                |                |                |                |
| Berezovsky          | 1058.60        | 5724.00        | 11.80          | 10292.86       | 253.80         |
| Bystryansky         | 2603.30        | 7277.80        | 17.50          | 11512.40       | 403.30         |
| Krasnogorsky        | 7608.20        | 62125.30       | 7.00           | 24105.68       | 949.60         |
| Novozykovsky        | 6229.70        | 18681.00       | 2.00           | 11161.51       | 238.60         |
| Novotalovsky        | 976.50         | 5138.20        | 2.00           | 7193.60        | 177.60         |
| Souskanykhinsky     | 588.40         | 12244.40       | 6.00           | 11114.97       | 325.10         |
| Ust-Ishinsky        | 588.40         | 15460.90       | 16.60          | 12546.70       | 447.70         |
| Ust-Kazhinsky       | 1762.80        | 56049.50       | 11.25          | 13393.06       | 676.70         |
| Sovetsky district   |                |                |                |                |                |
| Sovetsky            | 1897.00        | 821.00         | 126.00         | 11593.00       | 445.00         |
| Krasnoyarsky        | 3951.00        | 1762.00        | 47.00          | 11746.00       | 313.00         |
| Kokshinsky          | 2805.00        | 1460.00        | 9.00           | 9454.00        | 268.00         |
| Talitsky            | 487.00         | 1346.00        | 17.00          | 4707.00        | 112.00         |
| Platovskiy          | 2859.00        | 2413.00        | 48.00          | 4661.00        | 109.00         |
| Polovinsky          | 1823.00        | 1091.00        | 2.00           | 6561.00        | 139.00         |
| Setovskiy           | 2940.00        | 2701.00        | 7.00           | 13097.00       | 267.00         |
| Yields th           | 5347.00        | 1260.00        | 119.00         | 17544.00       | 262.00         |
| Shulgin-Logsky      | 1779.00        | 6729.00        | 64.00          | 9525.00        | 827.00         |
| Kolovskiy           | 179.00         | 2257.00        | 20.00          | 8480.00        | 104.00         |
| Nikolsky            | 2740.00        | 596.00         | 3.00           | 12612.00       | 253.00         |
| Shulginsky          | 185.00         | 374.00         | 630.00         | 2709.00        | 361.00         |

The grouping of lands according to the degree of anthropogenic load makes it possible to evaluate the anthropogenic transformation of the territory in comparable terms [7, 8]. They are absolute coefficients ($K_a$) and relative ($K_o$) the tension of the ecological and economic situation of the territory, calculated by the formulas:

$$K_a = \frac{\text{An6}}{\text{An1}}, \quad K_o = \frac{\text{An4} + \text{An5} + \text{An6}}{\text{An1} + \text{An2} + \text{An3}},$$

where $\text{An1}, ..., \text{An6}$ - the numerical value of the degree of anthropogenic transformation corresponding to the ball score.

The lower $K_a$, the better the state of the environment. In general, the ecological and economic balance of the territory is most characterized by the coefficient $K_o$, because it covers the study area.
With $K_o$ equal or close to 1.0, the intensity of the ecological and economic balance of the territory turns out to be balanced in terms of the degree of anthropogenic load and the potential for sustainability of nature.

Each anthropogenic impact or their combination has its own limit of sustainability of natural and natural-anthropogenic landscapes. The more diverse the landscape, the more stable it is. This is expressed by a large number and uniform distribution of natural biogeocenoses, tracts, conservation areas and protected areas, the total area of which is the ecological fund of the territory. The larger it is, the higher the natural security of the territory and, accordingly, the stability of the landscape.

So, the total land area with environmental and resource-stabilizing functions can be calculated using the following formula:

$$P_c = An1 + 0.8An2 + 0.6An3 + 0.4An4.$$  \hspace{1cm} (2)

If you compare the land area $P_c$ to the total area of the study area ($P_o$), then we obtain the coefficient of natural security of the territory:

$$K_e = \frac{P_c}{P_o}.$$  \hspace{1cm} (3)

Meanings $K_e$ less than 0.5 characterize the critical level of protection of the territory.

On the basis of the point classification of the lands of the Krasnogorsky and Sovetsky districts according to the degree of anthropogenic transformation, coefficients characterizing the ecological and economic condition of the studied territory were calculated (Table 2) and cartograms of the distributions of these indicators were constructed (Figure 2, Figure 3).

**Table 2.** Indicators of the main factors of ecological and economic state of the area of village councils of Krasnogorsky and Sovetsky districts

| The village council | $K_o$ | $K_o$ | $P_c$, ha | $K_e$ |
|---------------------|-------|-------|-----------|-------|
| **Krasnogorsky district** |       |       |           |       |
| Berezovsky          | 0.24  | 1.55  | 9761.99   | 0.57  |
| Bystryansky         | 0.15  | 1.20  | 13041.12  | 0.62  |
| Krasnogorsky        | 0.12  | 0.36  | 66954.89  | 0.72  |
| Novozykovsky        | 0.04  | 0.46  | 25640.30  | 0.78  |
| Novotolovskiy       | 0.18  | 1.21  | 7965.74   | 0.59  |
| Soukanykhinsky      | 0.18  | 0.82  | 16030.27  | 0.60  |
| Ust-Ishinsky        | 0.76  | 0.81  | 17985.71  | 0.60  |
| Ust-Kazhinsky       | 0.38  | 0.24  | 51966.32  | 0.71  |
| **Sovetsky district** |       |       |           |       |
| Sovetsky            | 0.23  | 4.23  | 7266.60   | 0.55  |
| Krasnoyarsky        | 0.08  | 2.09  | 10087.20  | 0.65  |
| Kokshinsky          | 0.10  | 2.27  | 7760.00   | 0.56  |
| Talitsky            | 0.23  | 2.60  | 3456.80   | 0.52  |
| Platovskiy          | 0.04  | 0.90  | 6682.60   | 0.83  |
| Polovinsky          | 0.08  | 2.30  | 5321.40   | 0.65  |
| Setovskiy           | 0.09  | 2.37  | 10343.80  | 0.60  |
| Yields th           | 0.05  | 2.65  | 13444.00  | 0.67  |
| Shulgin-Logsky      | 0.46  | 1.21  | 11010.60  | 0.62  |
| Kolovsky            | 0.58  | 3.50  | 5388.60   | 0.46  |
| Nikolsky            | 0.09  | 3.85  | 8263.40   | 0.60  |
| Shulginsky          | 1.95  | 0.67  | 4645.00   | 0.56  |
**Figure 2.** Distribution of the values of the coefficients of relative anthropogenic tensions. Legend: Village councils: Sovetsky District: I – Shulginsky, II – Krasnoyarsky, III – Kokshinsky, IV – Talitsky, V – Sovetsky, VI – Urozhayny, VII – Nikolsky, VIII – Setovskiy, IX – Polovinsky, X-Shulginlogsky, XI– Kolovsky, XII – Platovsky; Krasnogorsky District: XIII – Souskanikhinsky, XIV – Ust-Kazhinsky, XV – Berezovsky, XVI – Bystryansky, XVII – Novotalovsky, XVIII – Krasnogorsky, XIX – Ust-Ishinsky, XX – Novozykovsky.

**Figure 3.** Distribution of the values of the coefficients of natural security. Legend: Village councils: Sovetsky District: I – Shulginsky, II – Krasnoyarsky, III – Kokshinsky, IV – Talitsky, V – Sovetsky, VI – Urozhayny, VII – Nikolsky, VIII – Setovskiy, IX – Polovinsky, X-Shulginlogsky, XI– Kolovsky, XII – Platovsky; Krasnogorsky District: XIII – Souskanikhinsky, XIV – Ust-Kazhinsky, XV – Berezovsky, XVI – Bystryansky, XVII – Novotalovsky, XVIII – Krasnogorsky, XIX – Ust-Ishinsky, XX – Novozykovsky.
An analysis of the results showed that the territories of village administrations councils located in the west of the Krasnogorsky district have a prosperous ecological and economic condition, as there is a sufficient proportion of tree-bushes vegetation in their lands, and in the eastern part of the district, the complexity of the relief and the presence of small contours of hayfields, pastures and arable lands, low proportion of forest cover.

In the Sovetsky district, a high degree of development of the territory in the form of arable land and pastures with an insufficient amount of unused land and lands with environmental and resource-stabilizing functions in the form of forests, undeveloped territories, lands in the redistribution fund, etc., determined the coefficient of relative tension coefficient greater than 1.0 in most village administrations. The good situation is in the Platovsk, Shulgin-Logsk and Shulga village councils. There is enough forests for their stabilization on the territory, despite the existence of 120 hectares - sand-gravel pits in the Shulginsky village council. The unfavorable situation develops in Kolovsky, Nikolsky and Sovetsky village councils. The coefficient of natural security is mostly low, in the Kolovsky village council it is critical, measures for stabilization are required, in Platovskoy village council there is the highest level of natural protection due to the presence of a forest area of 1005 hectares. Within the administrative boundaries of the district there are territories that are part of the Lebediny reserve, which are Kokshinsky, Talitsky and Urozhny village councils. Land use in these village councils should be strictly regulated, but according to the analysis of statistical reporting data, there is an increased level of anthropogenic pressure. The same situation in Kolovskiy village council is a critical level of natural security with rich landscape diversity and the presence of several nature monuments of a local nature. There is intensive use of land, and there is a small percentage of forest coverage and unused lands in the fund reallocation.

In general, the ecological and economic balance of the entire territory of the district is characterized by the following indicators:

For the Krasnogorsky district – $K_a = 0.16$, $K_o = 0.51$, $P_e = 208149.58$ ra, $K_e = 0.67$;

For the Sovetsky district – $K_a = 0.13$, $K_o = 2.14$, $P_e = 93670.00$ ra, $K_e = 0.55$.

According to the result in the regions today, the ratio of higher and very low anthropogenic load remains favorable, because the last transcend over the first. But, if we consider the indicators $K_a$, it can be noted that the Sovetsky district is different in the tense situation in terms of the degree of anthropogenic load, which indicates an imbalance in the degree of anthropogenic load and sustainability of nature. This situation has been created by that on the territory of the Sovetsky district a significant proportion of arable land as part of land is 54% of the total territory. This percentage of tillage characterizes a high intensity of the load, besides, the proportion of hayfields used irrationally is taken into account - 11% of the entire territory. Krasnogorsky district save a good situation, thanks to a significant proportion of forest cover - 42% of the total area of the district and a small share of plowing up - 15%, which is an increased intensive load. In general, the situation on the anthropogenic load on the total territory of the regions can be considered satisfactory.

4. Conclusion
The natural conditions and resources of the regions of the study allow us to conduct successful economic activities and ensure, with rational and effective use of them, a high level and a decent quality of life for the local population. The modern economic system has developed so that most of the land of the territory and district s has the category of agricultural land, the main industrial enterprises of the districts are intended for processing agricultural products, wood processing enterprises are located in the Krasnogorsky district. Extensive farm management has led to a number of environmental problems associated with the existence of high anthropogenic pressures, which in turn identified a number of negative things in the area: pasture digression, soil erosion, decrease in humus in the soil, waterlogging, etc. These districts have tourist potential for creating an extensive recreation area. The study of the ecological and economic condition of the territory of Krasnogorsky and Sovetsky districts was carried out within the boundaries of village councils. As a result of the analysis, the characteristics of areas of land exposed to anthropogenic influences were identified, which allowed to allocate land with a special
mode of use and adjust the ecological and economic state in the direction of balanced and sustainable development. Also on the territory of the district it is necessary to revise the nature of the use of land, forest and water resources, moving to intensive management, introducing innovative technologies and projects to eliminate and solve the growing problems of society, the economy and the environment.

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