Comparative assessment of environmental and economic efficiency of land use in the Ural and Siberian federal districts

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Abstract. The economic efficiency of land management as a factor (means) of production is characterized by the result of comparing the objects of production with the land area or value. At the regional level, the economic efficiency of land use is determined by a system of natural and cost indicators. The purpose of this work: to conduct a comparative analysis of the regional efficiency of land use (on the example of the Ural Federal District and the Siberian Federal District) using the technique of the regional assessment of land use efficiency by G.B. Vyazov (2014). The author proposed the construction of integral assessment indicators for all land categories: Y1 - the return of land and Y2 - land profitability. The paper presents data on the typology of the Ural and Siberian federal districts regions in terms of the degree of land use efficiency by creating a matrix of pair correlation coefficients.

1. Introduction
The modern model of land relations in Russia has led to irrational forms of land use. The search for organizational and economic instruments for the implementation of land relations is currently an important factor in the economic development of the regions.

According to the proposals of Russian experts [1] in the field of land use, the characteristics of land use efficiency can be divided into eight main categories: clean (technological, economic, social, and environmental efficiency); mixed (ecological-economic, socio-economic, and production-economic).

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Since land resources are the basis of agricultural production, these indicators are the most developed in Russia for the category of agricultural land. This category is the most important of the seven categories into which the land fund of the Russian Federation is divided, according to the Land Code. The remaining categories are industrial land, residential land, land of forest and water funds, reserve lands, and specially protected areas.

For agricultural land, there is a wide variety of indicators for their effectiveness assessment. The most commonly used indicators are the following: ratio of crop production or profit volume about the land area; crop yield; the number of mineral fertilizers applied; production of the main types of crop farming (grain, sugar beet, potatoes, etc.) per 100 hectares of arable land; production of milk, cattle meat; share of arable land in farmland structure; share of intensive crops (tilled, technical) in planting structure; share of irrigated land in the area of farmland [2,3].

The ecological efficiency of agricultural land use is largely represented in the works of foreign scientists. In particular, in the works [4-6], static and dynamic multiperspective analyses are actively...
used and various indicators of the eco-efficiency of arable lands are proposed (cultivated land output efficiency coefficient; cultivated consumption return coefficient; cultivated land pollution substitution coefficient; cultivated land use intensive coefficient).

The problems of efficient land use in the context of environmental security are discussed in the work [7]. The proposed approach to the ecological and economic assessment of land use efficiency relates not only to the characteristics of agricultural land, but can be considered in the context of the typification of the entire land fund and used to determine the level of environmental danger of the population with the allocation of land areas with high environmental risk.

One of the factors that affect the state and use of land is the economic zoning of the state territory. In 2000, there was a territorial division of the Russian Federation into federal districts, which included such administrative-territorial units as territories, regions, and national republics.

Federal districts were distinguished as regional units that differ in historical traditions and the way of population lifestyle, natural resources, and mineral resources, which led to the development of industrial potential, climate, and soil fertility suitable for conducting effective agricultural production.

Today, the Russian Federation includes nine federal districts, including the Ural (UrFD), with the center in the Ekaterinburg city, and the Siberian (SFD), with the center in the Novosibirsk city.

The purpose of this work: to conduct a comparative analysis of the regional efficiency of land use (on the example of the Ural Federal District and the Siberian Federal District) using the technique of G.B. Vyazov. The author proposed the construction of an integrated assessment indicator for all land categories.

2. Materials and methods
The technique for assessing the efficiency of land resources use in the region, developed by G.B. Vyazov [8] is based on the calculation of the following generalizing indicators: Y1 - the return of land (the ratio of the gross regional product to the area of all land resources, thousand rubles (thou rub) /ha) and Y2 - land profitability (gross profit of the economy concerning the area of all land resources, thou rub/ha).

As a factor, it is proposed to use 6 indicators: X1 - the ratio of agricultural production volume to agricultural land area (rub/ha); X2 - the ratio of housing stock area to residentail land area (sq.m/ha); X3 - the ratio of the total volume of shipped commodity products by type of economic activity to the total area of industrial land, reserve and specially protected areas (thou rub/ha); X4 - the retail trade turnover to residential land area (rub/ha); X5 - the volume of freshwater used to the area of water fund-land (thou m3/ha); X6 - the volume of the wood reserve to forest land area (m3/ha).

The author considered the proposed generalizing and exposures and built a multivariate correlation and regression model on the example of 17 regions of the Central Federal District of Russia. The multiple correlation coefficient when checking the adequacy of the proposed model was 0.972, which indicates a close dependence on the studied factors since 94.5 % of the variation in the effective indicator explained by the indicators included in the model.

Next, we will focus on the characteristics of the regions whose land-use efficiency is considered in this work.

The Ural Federal District consists of 6 subjects of the Russian Federation: 4 regions (Sverdlovsk, Chelyabinsk, Kurgan, Tyumen) and 2 autonomous districts (Khanty-Mansiysk - Yugra, Yamalo-Nenets). The total area of the district is 1818.49 thousand square kilometres (10.6 % of the area of Russia). As of January 1, 2020, more than 12.3 million people (8.4% of the country's population) live in the UFD. The population density is 6.78 people per square kilometer. 81.3% of the region's population is urban residents. The Ural region is one of the richest mineral resource regions in Russia. In the Khanty-Mansiysk and Yamalo-Nenets Autonomous Districts, deposits have been explored and developed, which contain 6% of the world's oil reserves and 26% of the world's natural gas reserves. Significant reserves of ferrous and non-ferrous metals, peat, asbestos, precious and semi-precious stones have been found here. The territory of the UFD has large forest resources, about 10% of all-Russian reserves.
3. Results

The economic efficiency of land management as a factor (means) of production is characterized by the results of comparing the production volumes with the land area or value. The results of the calculation of indicators for assessing the land-use efficiency in the UrFD and the SFD for categories are shown in Table 1.

To ensure reliability, the methodology was adjusted to take into account the peculiarities of the considered federal districts. The reserve lands that G.B. Vyazov included in the calculation of the factor indicator X3 were not taken into account. These lands are temporarily excluded from circulation and do not affect the economic efficiency of regional land use. The lands of specially protected areas (SPNR) were removed from the indicator X3. They summed up with the areas of the forest fund lands of indicator X5. This is because, on the territory of the Urals and Siberia, most of the national parks and reserves are excluded from any economic activity, representing huge areas of forestlands.

The data on the distribution of the territories of the federal districts we examined according to the calculated data (Table 1) revealed the following trends. Indicator Y1 (the return of land) in the regions of the Ural Federal District averaged 85.9 thou rub/ha, in the Siberian Federal District it is more than 2 times lower (37.5 thou rub/ ha). The minimum value of Y1 in the Ural Federal District falls on the Kurgan Region - 29.8 thou rub/ ha, in the Siberian Federal District - in the Tyva Republic (4 thou rub/ha). The maximum land yield in the Urals is observed in the Chelyabinsk region - 166.5, in Siberia - in the Kemerovo region - 122.9 thousand rubles/ha. Thus, the differentiation in terms of land yield in the Urals Federal District is 5.5 times, in the Siberian Federal District - more than 30 times. The median value of the Y1 indicator for the regions of the Ural Federal District is 80.9, in the Siberian Federal District - 25.6 thousand rubles/ha, which is lower than the average, therefore, there is a left-sided asymmetry, indicating a shift in most regions to lower land yields.

In terms of Y2 (land profitability), the regions of the Urals are also significantly ahead of Siberia. The maximum value of Y2 in the Kemerovo region (12.2 thou rub/ha) is close to the minimum value in the Ural Federal District. According to the median values of Y2, both federal districts showed values below the average, i.e. land yields also shifted to lower values in most regions.

Volumes of production and land values, when compared with their area, can show the effectiveness of land management as a factor (means) of production. To assess the degree of influence on the generalizing indicators of land use efficiency – Y1 (the return of land) and land profitability Y2 - a matrix of paired correlation coefficients is constructed based on all the previously considered factor factors (X1-X6). The results of the study are shown in Table 2 for the UrFD and Table 3 for the SFD.
| Regions of the federal districts | The volume of agricultural production in relation to the area of agricultural land (rub/ha) | The housing stock in relation to the residential land area (m²/ha) | The ratio of the total volume shipped by type of economic activity to the industrial land area (rub/ha) | Retail trade turnover to the residential land area (rub/ha) | The volume of fresh water used to the land area of the water fund (thou m³/ha) | The volume of wood stock to the area of forest lands and protected areas (m³/ha) | The return of land (thou rub/ha) | Land profitability (thou rub/ha) |
|----------------------------------|--------------------------------------------|---------------------------------|-------------------------------------------------|----------------------------------|-------------------------------------|--------------------------------------|-------------------------------|-----------------------------|
|                                  | X1                                         | X2                              | X3                                         | X4                              | X5                                  | X6                                  | Y1                           | Y2                           |
| Ural Federal District            |                                            |                                 |                                             |                                  |                                     |                                     |                               |                              |
| Kurgan region                   | 10216.8                                    | 23.1                            | 2727.3                                     | 213 487                         | 0.4                                 | 132.2                               | 29.8                         | 13.9                         |
| Sverdlovsk region               | 22567.8                                    | 123.6                           | 5474.6                                     | 1608583                         | 2.1                                 | 152.2                               | 117.2                        | 17.3                         |
| Tyumen region                   | 15489.3                                    | 134.5                           | 14999.8                                    | 1864229                         | 0.8                                 | 137.1                               | 78.7                         | 32.0                         |
| Chelyabinsk region              | 23702.8                                    | 183.8                           | 6599.3                                     | 1348271                         | 26.6                                | 161.5                               | 166.5                        | 19.1                         |
| Khanty-Mansiysk AD              | 15440.2                                    | 63.0                            | 14648.7                                    | 861433                          | 6.7                                 | 110.4                               | 83.2                         | 12.9                         |
| Yamalo-Nenets AD                | 95.9                                       | 47.0                            | 14234.9                                    | 669012                          | 0.1                                 | 55.4                                 | 40.1                         | 14.2                         |
| Siberian Federal District        |                                            |                                 |                                             |                                  |                                     |                                     |                               |                              |
| Republic of Altai               | 4032.3                                     | 42.28                           | 732.4                                      | 613818                          | 0.25                                | 138.6                               | 5.4                          | 0.74                         |
| Republic of Tyva                | 1899.0                                     | 63.56                           | 1348.8                                     | 554333                          | 0.49                                | 125.6                               | 4.0                          | 0.29                         |
| Republic of Khakassia           | 7269.5                                     | 131.39                          | 4768.1                                     | 1329809                         | 0.93                                | 131.7                               | 38.2                         | 1.64                         |
| Altai Krai                      | 12531.3                                    | 78.10                           | 3310.9                                     | 965551                          | 1.79                                | 135.0                               | 32.7                         | 2.68                         |
| Krasnoyarsk Krai                | 2134.5                                     | 148.93                          | 9535.9                                     | 1567305                         | 2.63                                | 88.7                                 | 9.6                          | 4.68                         |
| Irkutsk region                  | 21593.2                                    | 121.38                          | 2175.8                                     | 952344                          | 0.41                                | 130.3                               | 18.0                         | 4.20                         |
| Kemerovo region                 | 18006.4                                    | 146.23                          | 10265.2                                    | 1032590                         | 56.48                               | 109.3                               | 129.7                        | 12.20                        |
| Novosibirsk region              | 8355.8                                     | 209.42                          | 5730.5                                     | 2001303                         | 0.92                                | 121.0                               | 70.4                         | 4.47                         |
| Omsk region                     | 12916.2                                    | 142.33                          | 19914.5                                    | 1449634                         | 1.31                                | 137.0                               | 48.3                         | 2.66                         |
| Tomsk region                    | 15081.3                                    | 138.89                          | 6904.7                                     | 1253103                         | 2.69                                | 142.4                               | 18.4                         | 1.85                         |
Table 2. Matrix of paired correlation coefficients for the Ural Federal District.

|       | X1   | X2    | X3    | X4    | X5    | X6    | Y1    | Y2    |
|-------|------|-------|-------|-------|-------|-------|-------|-------|
| X1    | 1    | 0.773 | -0.372| 0.627 | 0.587 | 0.917 | 0.859 | 0.276 |
| X2    | 0.773| 1     | -0.037| 0.834 | 0.689 | 0.664 | 0.910 | 0.580 |
| X3    | -0.372| -0.037| 1     | 0.246 | -0.208| -0.576| -0.182| 0.305 |
| X4    | 0.627| 0.834 | 0.246 | 1     | 0.205 | 0.498 | 0.640 | 0.769 |
| X5    | 0.587| 0.689 | -0.208| 0.205 | 1     | 0.478 | 0.828 | -0.012|
| X6    | 0.917| 0.664 | -0.576| 0.498 | 0.478 | 1     | 0.674 | 0.368 |
| Y1    | 0.859| 0.910 | -0.182| 0.640 | 0.828 | 0.674 | 1     | 0.211 |
| Y2    | 0.276| 0.580 | 0.305 | 0.769 | -0.012| 0.368 | 0.211 | 1     |

When considering the obtained paired correlation coefficients, it follows that Y1 (the return of land) in the UrFD has a high degree of dependence on the following factor indicators: X1 (0.858) - the ratio of agricultural production volume to the agricultural land area; X2 (0.909) - the ratio of housing stock area and residential land area; X5 (0.828) - the volume of freshwater used to water fund-land area. Other factors have little impact.

The land profitability (Y2) in the Ural FD showed a high close relationship (0.769) with the indicator X4 - retail trade turnover about residential land area, the remaining factors are in a weaker relationship with the studied effective indicator (table 2).

In contrast to the UrFD in the Siberian Federal District, the generalized indicators Y1 land yield and Y2 land profitability showed a close relationship with the factor indicator X5, the ratio of the volume of freshwater used to a land area of water fund (0.838), and (0.901), respectively. All other factors are weakly related to the performance indicators.

4. Conclusion

The materials of the conducted research have shown that the problem of economic efficiency of land management cannot solve without taking into account economic zoning and identifying statistically and practically significant criteria for the land use analysis.

The results obtained when comparing two resource regions of the Russian Federation revealed a close dependence of the generalizing indicators of land profitability and land profitability with some factors. These, it would seem, were not the most significant factors - the volume of freshwater used for irrigation of the land fund in the Southern Federal District, and the volume of agricultural production on the agricultural land in the Ural Federal District. The creation of conditions for the organization of rational and efficient use of these lands, taking into account social and industry needs can ensure stable economic development of the regions.

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