

OPTIMIZATION OF LAND USE STRUCTURE IN THE REPUBLIC OF MOLDOVA ON THE BASIS OF THE METHOD OF ECOLOGICAL-ECONOMIC BALANCE OF THE TERRITORY

Ivan Kapitalchuk¹

Key words: land use, anthropogenic load, optimization, ecological and economic balance of the territory, sustainable development.

Abstract. The problem of the ecological and economic organization of the territory of the Republic of Moldova and its regions is considered. The assessment of the intensity of the ecological and economic state of the country's territory was carried out and the possibility of optimizing the structure of land use on the basis of improving the balance of various types of land use was shown. It is established that a characteristic feature of the land use structure in Moldova is the dominance of lands with a high anthropogenic load, which occupy 64 % of the country's territory. The indicators of the ecological and economic state of the territory of the country and its regions for the current land use structure and for the proposed variant of its optimization are calculated. The relationship between the relative coefficient of tension of the ecological and economic state and the coefficient of natural protection of the territory is revealed. It is shown that the land use structure developed in Moldova caused a high degree of tension in the ecological and economic state of its territory, which can be reduced by 1.3-2.7 times when implementing the proposed measures.

Introduction

Spontaneous economic development of the territory leads to significant deformations of the spatial organization of society's life and cannot ensure the prosperity of the country and society. Therefore, it is necessary to develop a special strategy for the use of the territory of the country and its regions, the construction of its functional and spatial structure that will ensure an effective and balanced implementation of the main socio-economic, ecological and cultural functions by

¹ Transdnistrian State University, Tiraspol, Republic of Moldova, imkapital@mail.ru

the territory. Only if such a strategy is available, it is possible to achieve sustainable development.

Priority goals and objectives of the organization of the territory of a particular region depend mainly on the degree and nature of its development. The Republic of Moldova has a high agro climatic and soil potential. Land resources are its main natural wealth. However, the territory of Moldova is fully and intensively developed by agriculture. Therefore, the organization of balanced land use is of paramount importance to it. Here, the problem of the correlation of different uses of lands: fields and meadows, pastures and hayfields, forest belts and forest areas, etc., comes first. This problem was previously considered for the steppe regions of the country (Kapitalchuk I., 2006) and for the left-bank regions of the Dniester (Kapitalchuk I., Soloviova N., 2014).

The purpose of this work is to assess the intensity of the current ecological and economic status of the territory of the Republic of Moldova and to show the possibility of optimizing the structure of land use on the basis of improving the ecological and economic balance of its territory.

Material and methods

Tension of the ecological and economic state of the territory of Moldova and ways to improve its land use structure were assessed on the basis of the method of ecological and economic balance, which is understood as a balanced ratio of various activities and interests of different population groups in the territory, taking into account the potential and real possibilities of nature (Kochurov B., 1999, p.105; 2003, p. 258).

The methodology for assessing the ecological and economic state of the territory was as follows:

1) the area of land with different anthropogenic load was determined in accordance with Table 1.

Table 1. Distribution of land types by the degree of anthropogenic load

Load category	Degree of anthropogenic load	Types of land use
A_1	very low	protected areas, unused land
A_2	low	hayfields, forests, swamps, lands under water
A_3	middle	deposits, perennial plantations, tree and shrub plantations, protective forest belts
A_4	high	arable land; Pastures used irrationally; Plots at the stage of improving and restoring fertility
A_5	very high	industrial lands, roads, streets and squares, buildings and yards, disturbed lands, ravines, landslides

2) the coefficients of the absolute (K_a) and relative (K_o) intensity of the ecological and economic state of the territory were calculated, which are the following relationships (Kochurov B., 2003, p. 260):

$$K_a = \frac{A_5}{A_1} \quad (1)$$

$$K_o = \frac{A_4 + A_5}{A_1 + A_2 + A_3} \quad (2)$$

3) the coefficient of natural protection of the territory (K_e) was determined (Kochurov B., 2003, p. 264):

$$K_e = \frac{P_{ef}}{P_t} \quad (3)$$

where $P_{ef} = A_1 + 0,8A_2 + 0,6A_3 + 0,4A_4$ – the total area of land contributing differently to the performance of the environmental function; P_t – the total area of the territory.

The data for the state land cadastre of the Republic of Moldova served as materials for the assessment.

Land administration is carried out within the administrative units. Therefore, as environmental and economic systems, we considered the structure of land use of administrative regions and the country as a whole. When calculating the components of the ecological and economic balance of the territory of the whole country, the total area of land for individual types of use was summed up for all districts and individual city municipalities (Chişinău, Balti, Tighina).

Results and discussion

The results of land grouping according to the degree of anthropogenic load in the regions of Moldova and in the whole territory of the country are shown in Fig. 1. A characteristic feature of the land use structure in Moldova is the dominance of lands with a high anthropogenic load. (A_4), the share of which in different regions varies from 30 to 83 %. In most cases (19 districts), the land area of category A_4 is 60-70 %. On a significant part of the territory (7 districts), land with a high anthropogenic load occupies 70-80 %, and in the Drochia region - about 84 %. Only in four districts (Călăraşi, Hînceşti, Nisporeni, Străşeni) located within the

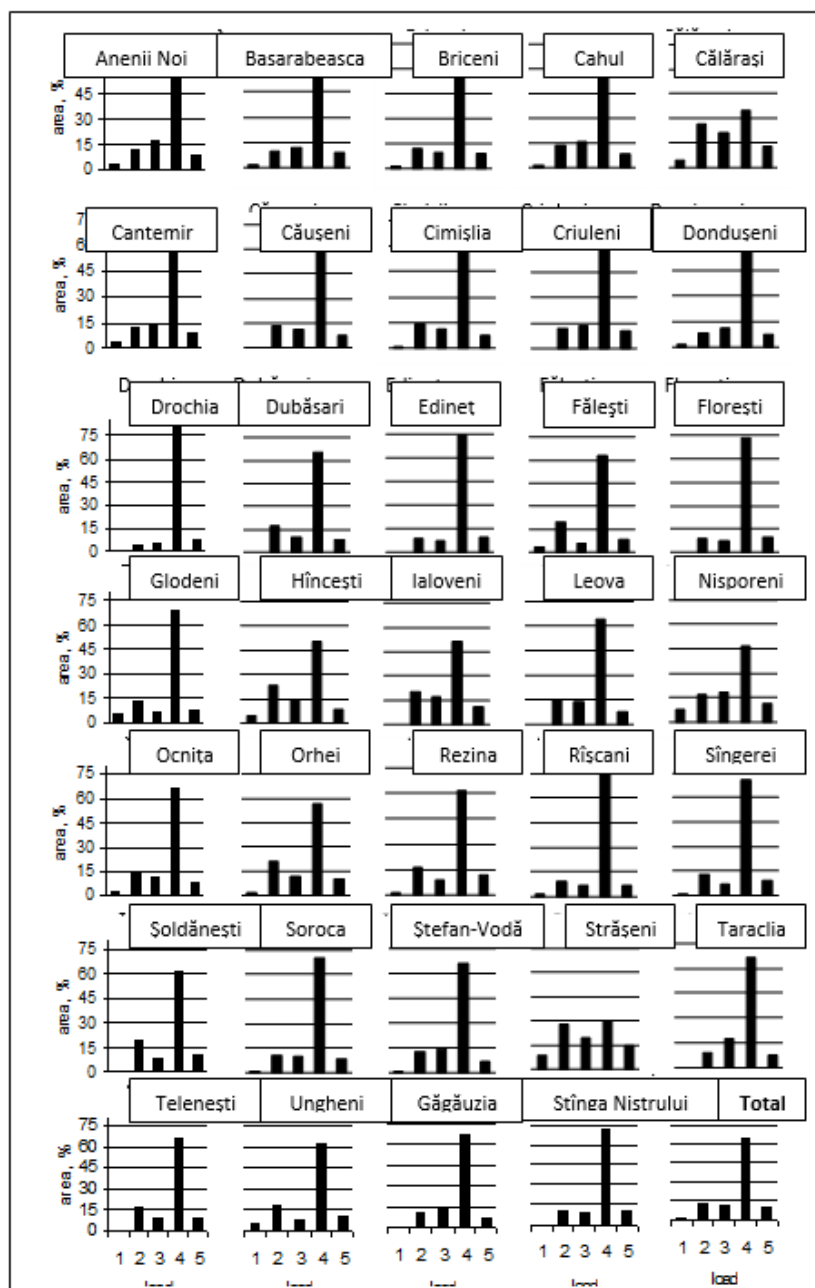


Fig. 1. The ratio of anthropogenic load in the territory of Moldova

Table 2. Coefficients of intensity of the ecological and economic state (ECS) of the territory of Moldova

District name	Coefficients of territory ECS					
	Actual			After optimization		
	K _a	K _o	K _e	K _a	K _o	K _e
Anenii Noi	3,4	2,1	0,47	1,0	1,44	0,50
Basarabasca	5,0	3,3	0,44	1,0	1,61	0,49
Briceni	5,8	3,3	0,44	1,0	2,18	0,48
Cahul	5,0	2,2	0,47	1,0	1,69	0,49
Călărași	3,0	0,9	0,53	1,0	0,62	0,56
Cantemir	2,5	2,5	0,47	1,0	1,43	0,50
Căușeni	36,4	3,1	0,45	1,0	1,91	0,49
Cimișlia	17,9	3,0	0,46	1,0	1,67	0,49
Criuleni	40,6	3,0	0,44	1,0	2,05	0,47
Dondușeni	5,4	3,8	0,44	1,0	1,91	0,47
Drochia	60,4	10,1	0,40	1,7	3,83	0,43
Dubăsari	—*	2,8	0,46	1,0	1,91	0,49
Edineț	39,5	5,2	0,42	1,04	2,69	0,45
Fălești	2,5	4,0	0,45	1,0	1,75	0,49
Florești	79,2	5,1	0,42	1,1	2,76	0,45
Glodeni	1,6	3,4	0,46	1,0	2,09	0,44
Hîncești	2,0	1,4	0,51	1,0	0,95	0,54
Ialoveni	32,6	1,7	0,48	1,0	1,17	0,51
Leova	—	2,6	0,46	1,0	1,32	0,50
Nisporeni	1,5	1,4	0,51	1,0	0,88	0,53
Ocnîța	3,7	2,8	0,46	1,0	1,73	0,49
Orhei	7,0	2,0	0,48	1,0	1,26	0,51
Rezina	7,3	2,8	0,45	1,0	1,89	0,48
Rîșcani	4,4	4,8	0,44	1,0	2,25	0,47
Sîngerei	37,1	3,9	0,44	1,0	1,59	0,49
Șoldănești	16,4	2,6	0,46	1,0	1,83	0,49
Soroca	9,5	3,7	0,44	1,0	2,08	0,47
Ștefan-Vodă	19,2	2,7	0,46	1,0	1,88	0,48
Strășeni	1,8	0,8	0,54	1,0	0,68	0,56
Taraclia	33,6	2,8	0,45	1,0	1,73	0,48
Telenești	27,7	2,9	0,46	1,0	1,48	0,50
Ungheni	1,9	2,5	0,48	1,0	1,27	0,51
UTA Găgăuzia	75,7	2,9	0,45	1,0	1,84	0,48
UAT Stînga Nistrului	31,9	4,5	0,42	1,1	3,02	0,45
Total area	5,9	2,8	0,45	1,0	1,72	0,48

*Note. There are no protected natural territories.

Central Moldovan Highland Woodland, the share of lands with a high anthropogenic load is reduced to less than 50 %. In general, land category A₄ occupies 64 % of the country's area.

Contribution to the ecological and economic balance of lands with anthropogenic load of other categories increases as the share of land in category A₄ decreases (see Figure 1: Călărași, Hîncești, Nisporeni, Strășeni districts).

Thus, for the current land use structure of Moldova, the key element is the lands with high anthropogenic loads, which mainly determines the degree of tension of the ecological and economic state of the territory and serve as the main target for reducing this tension.

The parameters of the ecological and economic state of the territory of Moldova, calculated using equations (1), (2) and (3), are presented in Table 2. Proceeding from equation (1), the absolute tension coefficient characterizes the balance of land with a very high (A₅) and very low (A₁) anthropogenic load. At $K_a \leq 1.0$, these categories of land are considered to be balanced.

From the data presented in Table 2 it follows that in the territories of all districts this indicator does not correspond to the optimal value. At the same time, in 14 districts of Moldova the coefficient K_a exceeds the critical value by 10 times or more, and in the districts of Dubăsari and Leova there are no conservation facilities with the corresponding legal status. The most favorable balance of land with a very high (A₅) and very low (A₁) anthropogenic load occurs in the areas of Glodeni, Nisporeni, Strășeni and Ungheni, where $K_a < 2.0$. In general, the country's absolute tension coefficient is 5.9. The ecological and economic state of the territory most fully characterizes the coefficient of relative tension, since it determines the balance of land with the anthropogenic load of all categories (see equation (2)). For a territory balanced by the degree of anthropogenic load, the values of this coefficient should be within $K_o \leq 1.0$ (Kochurov B., 1999; 2003).

As follows from Table 2, the value of K_o in the territory of Moldova varies in the range of values from 0.8 to 10.1. However, the extreme values of K_o are rare: in the regions of Călărași and Strășeni an optimal balance of land with minimum values of $K_o \leq 1.0$ has been formed, and in the Drochia area – the maximum imbalance of anthropogenic load at $K_o > 10$. In most of the territory of Moldova (15 districts), the relative intensity of its ecological and economic state is characterized by the values $K_o = 2.0-3.0$; On a large area (8 districts) – $K_o = 3.0-4.0$; The average for the whole country is $K_o = 2.8$.

Thus, the values of the coefficients of absolute and relative tension testify to the unfavorable ecological and economic state of the territory of Moldova and the majority of its regions. Violation of the balance of lands with different anthropogenic load caused a decrease in the stability of landscapes. The ability of landscapes to perform functions for the reproduction of the resource potential and

the quality of the habitat reflects the coefficient of natural protection of the territory (K_e), determined from relation (3). The critical value of this index is 0.5 (Kochurov B., 2003, p. 264).

In contrast to the coefficients K_a and K_o , which vary widely, the indicator K_e in the current land use structure in Moldova varies within a narrow range of values from 0.40 to 0.54 (Table 2). In addition, the coefficients K_a and K_o are practically independent of each other, while the coefficients K_o and K_e are closely interrelated (Figure 2).

The statistically significant correlation coefficient between K_o and K_e is -0.90, and the form of their relationship is well described by the power function.

The presence of a correlation between the coefficients K_o and K_e means that there is a correspondence of their critical values in determining the optimality of the land use structure of the territory. It follows from figure 2 that the minimum critical value $K_e=0.5$, at which the ecological stability of landscapes is ensured, corresponds to the value $K_o=1.5$, reflecting the acceptable balance of various categories of anthropogenic load on the territory. Taking into account this amendment, areas of Hîncești and Nisporeni, where $K_o=1.4$ and $K_e=0.51$ (Table 2), can be assigned to areas with relative strength below the critical value.

The method of ecological and economic balance allows not only to assess the degree of tension of the ecological and economic state of the territory, but also to calculate various options for optimizing the structure of land use. Measures to reduce the tension of the ecological and economic state for a particular area should be developed proceeding from the existing structure of land use and real possibilities for transferring land to other uses with less anthropogenic load

Optimization of the balance by the coefficient of absolute tension can be achieved both by increasing the area of protected objects, and by reducing the area of land category A_5 .

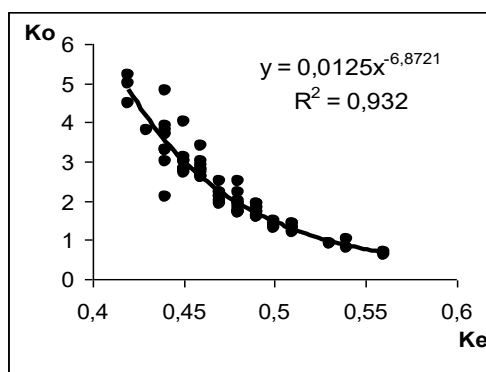


Fig. 2. Correlation between the coefficients K_o and K_e .

To a very high degree of anthropogenic load (A_5) are the lands of several uses (Table 1), of which only disturbed lands, ravines and landslides can in principle be transferred to other uses after their restoration. However, the restoration of these lands requires considerable economic costs and time. In addition, the effect of such measures will be small, since the share of these lands is mainly 1-3 % of the area and 2.4 % of the total area of the country. In this regard, optimize the balance of the absolute tension coefficient should, first of all, by transferring land with anthropogenic load A_2 to category A_1 .

The size of areas in areas with low anthropogenic load (A_2) in most cases is sufficient to organize new protected natural areas for equilibration of lands with very high anthropogenic load (Table 2). Exceptions are the districts of Drochia, Edineț, Florești and UAT Stînga Nistrului, where the potential of A_2 land does not allow the organization of protected areas in the required area.

It is advisable to reduce the relative intensity of the ecological and economic state of the territory primarily by reducing the anthropogenic load on the lands of the dominant category A_4 and transferring them to categories with less anthropogenic load. The largest areas with a high anthropogenic load are occupied by arable land, the share of which in the land fund of the districts varies from 26 % (Straseni area) to 65 % (UAT Stînga Nistrului) and makes up about 54 % of the country's territory. To optimize the structure of land use, it is necessary to transfer a significant part of the arable land to other types of land, for example, perennial plantations.

An important reserve for improving the structure of land use in Moldova is pastureland, which makes up 4 % to 18 % in the land fund, and more than 10 % in the country as a whole. Increasing the productivity and rational use of these lands will allow them to be transferred from category A_4 to category A_3 . The results of such optimization, provided that the absolute tension of the territory can be reduced, are presented in Table 2. Depending on the share of pastures in the land use structure of a particular area, due to such relatively low-cost measures, it is possible to reduce K_o coefficient by 1.3-2.7 times, and in The whole country – 1.6 times. The number of areas with optimal values of K_o and K_e will increase to 11.

Conclusions

1. The ecological and economic state of the territory of the Republic of Moldova and its individual regions is characterized by a high degree of tension, and the natural protection of landscapes is below the critical level.

2. The cause of the crisis ecological and economic state of the territory of Moldova is the violation of the balance of lands with different anthropogenic load,

in particular the dominance of lands with high anthropogenic load in the land use structure.

3. Reduction of the level of intensity of the ecological and economic state of the territory of Moldova can be achieved by optimizing the balance of land with different anthropogenic load:

a) by the coefficient of absolute tension K_a – by organizations of additional nature protection territories on lands with low anthropogenic load;

b) relative tension coefficient K_o – by transferring lands with high anthropogenic load to other uses with less anthropogenic load.

Achieving the optimal balance between different types of land use will ensure efficient and balanced implementation of the main socio-economic, ecological and cultural functions by the territory.

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