GEODESY AND CARTOGRAPHY
Vol. 69, No. 2, 2020, pp. 189–204

DOI: https://doi.org/10.24425/gac.2020.131087

Review paper

The use and evaluation of ecological and economic efficiency of agricultural land in Ukraine

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Received: 15 May 2020 / Accepted: 19 October 2020

Abstract: The article proves a particular bias in the agricultural land use for assessing the ecological and economic efficiency of only cost indicators. The methodology for evaluating the ecological and economic efficiency of agricultural land use by the energy content of foods is considered. The purpose of the article is to consider the methodology and justification of the practical significance of assessing the environmental and economic efficiency of the agricultural land use by the energy content of products. The article presents the initial data for correlation-regression analysis on the average performance of agricultural producers of Ukraine to determine the weight of each indicator. We used land statistical collections, National reports on the state of the environment in Ukraine for the period 2012–2018. The analysis was carried out based on the average performance indicators of agricultural producers of Ukraine to determine the weight of factors and leverage on the ecological and economic efficiency of agricultural land use. The output of a unit of land in relative terms through exchange energy is not only a kind of indicator, a criterion for the efficient use of agricultural land but also a criterion for the effectiveness of all production activities of agricultural producers, a particular district, and even regions. The main advantage of the proposed approach is the focus on achieving the ultimate goal of agricultural production, which allows us to recommend it for extended use in assessing the ecological and economic efficiency of agricultural land use.

Keywords: ecological and economic efficiency, the efficiency of agricultural land use, the energy content of foods, Ukraine

1. Introduction

Nowadays, in the formation and determination of the pace, scale, and direction of the development of productive forces, the rational structure of material needs, sufficient means, methods, and technologies for their satisfaction, it is impossible to ignore the interests of the environment (Ivanyuta, 2012). Therefore, it is advisable to go through the integration of the interests of ecology and economy in all sectors of the national economy, including agriculture. This is a complicated task. Two interrelated problems – "meeting the needs of society" and "the potential of the biosphere" – should be considered and solved simultaneously with the development of optimal, environmentally friendly options for the interaction of nature, society and agricultural production, nature management processes control in agriculture (MENRU, 2012).

However, despite the significant amount of work in the direction of rational land use, the problems of assessing the efficiency of land use in Ukraine in current market conditions remain insufficiently studied, resulting in the need to continue research to determine the methodological and applied areas of the process (Muzyka et al., 2019). We substantiate the need for research in the field of environmental and economic efficiency of land resources concerning modern sources of literature.

Land as a natural resource is an integral part, and the main feature of the production potential of agricultural enterprises is the biological and economic basis of the process of material goods production, which are necessary for human existence and development of society. Therefore, agricultural production must be combined with a system of technical and economic measures aimed at its reproduction, protection, and rational use. The need for efficient use of land resources is also because they ensure the livelihood of the population of the state, create raw materials for the processing industry. Thus, land resources, namely, their efficient use is the basis for food security. Rational use of land resources and their exploitation with the use of environmental measures will never lose relevance because the independence of the country in the modern world is primarily determined by food security, which can be achieved only when sustainable land use is ensured. However, issues related to the assessment of ecological and economic efficiency of agricultural land use by the energy content of foods in Ukraine need further study, which determines the relevance of this study (Melnyk et al., 2018). Given that one of the most important factors influencing the country's competitiveness is the efficient use of land resources, it is crucial to continually conduct research and analyze the current state of their use. In particular, this issue is significant for Ukraine, as it is the agricultural sector that significantly affects the economic performance of the country (Yaremko et al., 2018).

An analysis of the anthropogenic impact on natural ecological systems makes it possible to assert that the rate of environmental degradation in our state has acquired a slightly menacing character and exceeds in speed the biological adaptation of living organisms to their environment (Ivanyuta, 2012). Solving these problems, developing and adopting effective management decisions regarding the improvement of land use, in our opinion, depends to a large extent on the perfection of the methodology for estimation of the environmental and economic efficiency of the use of agricultural lands.

The presented vision of land management and land use indicates the need to highlight the assessment of managerial decisions of the highest state officials and the land users themselves, and this model should be considered in several directions:

– regarding the environment – as environmental efficiency;
– regarding material production – as economic efficiency;
– regarding society as a whole, as social and budgetary effectiveness.

The economic efficiency of land resources management and land use is conditioned by the influence of management actions on land resource allocation and land use organization on production organization and vice versa (Tretyak, 2004; Tretyak, 2013).

For management efficiency, criteria are proposed regarding trends in the distribution of land resources, depending on the economic interest and the increase in the cost of land resources. It should be noted that individual scientists propose to evaluate the efficiency of land use by land rent I and II since the values of land rent I and II depend directly on the cost of land resources and land use. Under the absolute free regulation of prices for agricultural products in the worst lands, the differential rent II is not formed on them. The higher the rent, the greater will be the land capital with the same rate of bank interest (Teremets, 2012; Li et al., 2020).

However, the evaluation of agricultural land use efficiency by this criterion is also not perfect. The situation is complicated by the fact that there are more efficient areas of land use, on the one hand, and, on the other, restrictions on their use. In this case, the ability of lands (soils) to meet specific needs and create the corresponding benefits directly affects the size of land capital. Therefore, land rent largely depends on the purpose of using the lands, that is, from their intended purpose. Therefore, the use of rent as one of the criteria for assessing the agricultural land use efficiency also will not provide objective results.

Recently, the problem of economic efficiency and rational use of agricultural lands is increasingly explored both in the world and in Ukrainian scientific literature, as evidenced by numerous publications (Bober et al., 2016; Gasiorowski and Bielecka, 2014; Maleta and Bielecka, 2018; Maleta and Mościcka, 2018; Perovich and Hulko, 2019) and others. However, despite the scientific achievements and considerable practical experience in the field of assessing the efficiency of agricultural land use and land conservation, unified criteria and approaches to assessment have not yet been determined.

Unified criteria, in essence, is the methodological basis for the choice of a rating system. Unlike assessment criteria, indicators are measurable values and are partial, derived from the criteria. At the same time, only the system of indicators makes it possible to characterize the criteria of the environmental and economic assessment thoroughly and effectively influence the complex process of ensuring the sustainable use of agricultural lands (Palyanichko, 2011). From the experience of research and analysis of land use indicators, it is evident that the environmental and economic assessment of the use of agricultural lands should be carried out through an assessment of the scale and intensity of the impact of economic activity on the state of land resources. Indeed, at the current stage, the desire of the agricultural producer to obtain maximum profit leads to adverse environmental consequences (Palyanichko, 2011).

Based on the specifics of the mechanism of the effective use of agricultural land, the assessment of efficiency should be simultaneously determined by economic and envi-

ronmental efficiency. Therefore, assessment criteria should be determined separately for each type of efficiency. The cost-effective use of land should be understood as the use of land, the economic feasibility of which will be determined by the ratio of the economic effect with the area of the land, considering its quality and distance. Technological efficiency of land use is the level of land use in the production process, the main criterion of which is a scientifically-based agricultural system (Teremets, 2012).

First of all, it is considered the criteria for the estimation of the economic efficiency of agricultural land use. One of the most common areas of land use assessment is the evaluation of the results of their use, in particular, due to volumes of gross output, commodity products, income, the profitability of production, etc. (Stupen, 2012). Using these indicators allows us to take into account through the cost and cost price of production, production volume, saving the total cost of materialized and living labour, which is achieved by improving the organization of the territory, as well as increasing soil fertility through crop productivity and production costs (Fig. 1) (MENRU, 2012). Figure 1 shows the analysis that characterizes the value of Gross Domestic Product (GDP) per 1 ha of the planted area. An indicator of the efficiency of agricultural land use is the output of GDP from 1 ha of the planted area.

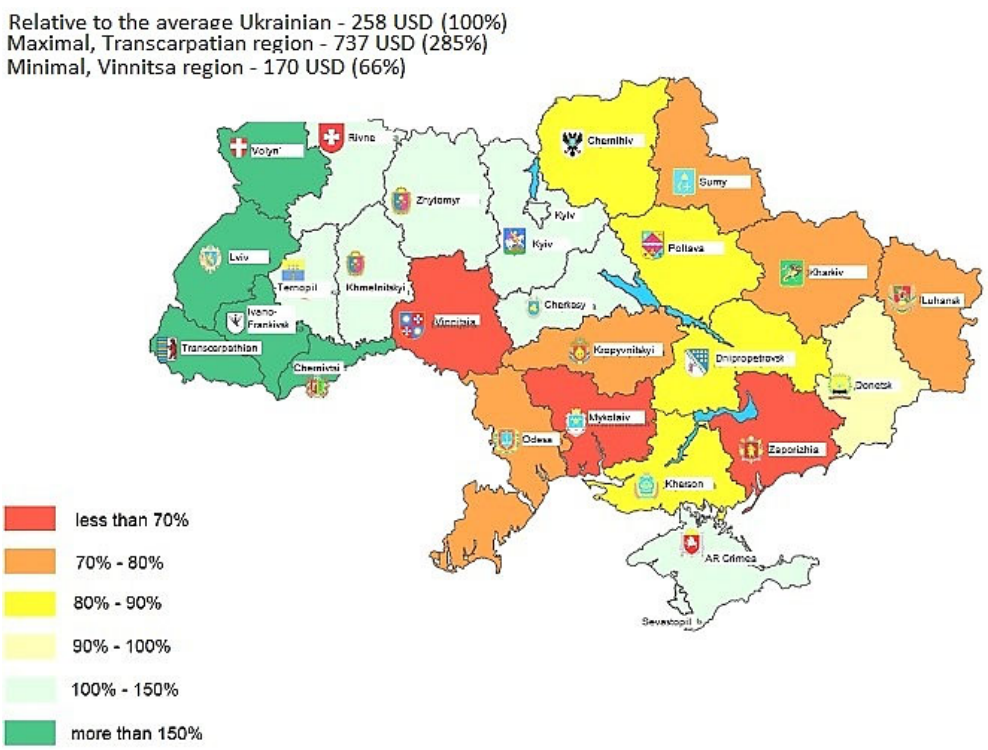

Fig. 1. Agricultural land use in 2012, GDP per 1 ha of acreage, UAH

The criterion for the land management efficiency should not only be the basis of measurement, which allows quantitative assessment of land management actions and

activities but first of all, it should characterize their quality. In agriculture, output growth is expressed in gross output. A comparison of production results with costs is achieved in terms of income and profitability.

However, if the calculation of income and profitability of production in specific enterprises gives a particular idea of the effectiveness of land use, then national and regional levels of these indicators cannot accurately assess the effectiveness of land use, which is due to several causes (Meiying et al., 2020; Teremets, 2012). Firstly, because the effectiveness often leads to savings, that is, the achievement of efficiency turns into a desire to reduce costs, rather than to improve. Secondly, since it is more difficult to determine socially necessary costs than economic costs, the external factors affecting the efficiency of agricultural land use are often not considered. Thirdly, economic benefits are more accessible to detect than public ones. In the case of an artificial increase in efficiency, some criteria are replaced by others that are easier to calculate.

The purpose of the article is to consider the methodology and justification of the practical significance of assessing the environmental and economic efficiency of the agricultural land use by the energy content of products. The relevance of the topic is that the systemic study on the assessment of environmental and economic efficiency of agricultural land use require further activation, since the coordination of ecological and economic interests of particular importance in the context of environmental protection, conservation and reproduction character of exploitation of agricultural land. However, considering the scientific achievements and significant practical experience in the field of assessing the effectiveness of agricultural land use and the protection of land resources, there are currently no uniform methods and approaches for assessment.

Since the ecological and economic efficiency of using agricultural lands is intended to reflect the relationship between various aspects of the activity, in particular product and resources, output and costs, result and goals, result and needs, utility and values, we believe that such a criterion should supplement the list of criteria for assessing the effectiveness as the energy content of foods. Such a proposal is based on the fact that the general criterion of ecological and economic efficiency of agricultural land use should be aimed at satisfying the ultimate goal of agrarian production – meeting the needs of people in food products. Since science has proved that any food product carries energy, which by transforming in an organism of a living creature, restores cells of its organism, promotes livelihoods and efficiency, the same ultimate goal of agrarian production should be considered – the satisfaction of human needs in energy.

2. Materials and methods

The article presents the initial data for correlation-regression analysis on the average performance of agricultural producers of Ukraine to determine the weight of each indicator. We used land statistical collections, National reports on the state of the environment in Ukraine for the period 2012–2018 from statistical collections for this period. The article uses statistical methods, economic and mathematical research methods using correlation-regression analysis.

Assessment of the impact of land on the ecological stability of the territory, the stability of which depends on agricultural land use, is characterized by the coefficient of ecological stability. The values of the coefficients for assessing the ecological properties of land are given in Table 1.

Table 1. Average values of ETMs chosen (before normalization) with their average and normalized average weights (coefficients of LRI)

No.	Name of lands	Coefficient of ecological stability of the land
1	Built-up area and roads	0.00
2	Arable land	0.14
3	Vineyards	0.29
4	Forest belts	0.38
5	Fruit gardens	0.43
6	Vegetable gardens	0.50
7	Hayfields	0.62
8	Pastures	0.68
9	Ponds and swamps of natural origin	0.79

With a different composition of the land, the coefficient of ecological stability of the territory K_{ec} is calculated by the formula:

$$K_{ec} = \frac{\sum K_i \cdot A_i}{\sum A_i} \cdot K_m \tag{1}$$

where K_i is the coefficient of land ecological stability of the i-th type, A_i is the land area of the i-th type, K_m is coefficient of morphological stability of the relief ($K_m = 1.0$ for stable areas and $K_m = 0.7$ for unstable territories).

The anthropogenic load factor (K_{an}) characterizes the impact of human activities on the environment, including land resources.

$$K_{an} = \frac{\sum A \cdot S}{\sum A} \tag{2}$$

where A is the area of land with the appropriate level of anthropogenic load, hectares, S is the score, of the corresponding area with a certain level of anthropogenic load (measured on a 5-point scale). Assessment of the degree of the anthropogenic load is carried out according to the scale given in Table 2.

If the obtained K_{ec} value is less than 0.33, then the land use is ecologically unstable, if it changes from 0.34 to 0.50, then it refers to stably unstable, if it is in the range from 0.51 to 0.66, then it goes into the limits of average stability, if it exceeds 0.67, then the land-use area is ecologically stable.

Using correlation and regression analysis presented in (Shkuratov, 2018), we found the relationship between indicators that characterize environmental factors, namely the

Table 2. Assessment of the degree of anthropogenic load on land use

No.	Types of land use (land)	Score in points
1	Lands of industry, transport, settlements	5
2	Arable land, perennials	4
3	Natural forage lands, tinned beams	3
4	Forest belts, shrubs, forests, swamps, underwater	2
5	Micro Reserves	1

coefficient of ecological stability and the coefficient of anthropogenic load, and the volume of gross agricultural output per 100 hectares of agricultural land in the regions of Ukraine, which can be described by a linear equation: $y = ax + b$, where y is the volume of gross agricultural output, thousand UAH, x is the indicator of environmental factors of agricultural production, a, b are the constant coefficients, the values of which are given in Table 3.

Table 3. Numerical values of the regression coefficients of the influence of environmental factors on the volume of gross agricultural output in Ukraine. Source: Shkuratov (2018)

Indicator	Values of coefficients for a linear equation		Coefficient	
	a	b	correlations	determination
Coefficient of ecological stability (units)	7.6324	359.31	0.44	0.19
Anthropogenic load factor (units)	−308.44	1714.7	−0.40	0.16
The volume of organic fertilizers application (t/ha)	196.87	548.44	0.50	0.25
The content of humus in the soil (%)	−64.54	855.66	0.35	0.12

Acting as a general indicator of output, the energy indicator should become the basis for determining the effectiveness of all economic activity, as well as the efficiency of certain types of resources, production, which will allow tracing the dynamics of the agricultural land use efficiency objectively. The efficiency of agricultural land use should be determined by the gross output ratio expressed in terms of the amount of exchange energy to the area of agricultural land, which is used in the cultivation of these crops. In this case, the criterion for assessing the ecological and economic efficiency of agricultural land use should be the output of units per square meter in comparable terms through the exchange energy, i.e. in other words, the energy content of foods (E_n):

$$E_n = GO/S \tag{3}$$

where GO is the gross output, expressed in terms of exchange energy in J, S is the area of agricultural lands in hectares.

Today the norms of energy content in almost all products, both animal and vegetable origin, are developed. Therefore, it is not difficult to determine the total amount of energy nutrition of different kinds. The content of energy in the unit of the product of the most common species in Ukraine is given in Table 4.

Table 4. Coefficient of conversion of products into exchange energy.
Source: State Statistics Service of Ukraine (2016)

Type of product	Content of exchange energy in 1 ton (MJ)
Grain	10758
Potato	3474
Vegetables	1172
Meat	8372
Milk	3056

It should be noted that the data in Table 2 contain averaged results of the conversion of products into exchange energy, considering the current structure of products by species and sorts. For different regions, the energy content per unit of product will vary, which is due not only to varietal and qualitative differences in products but also to natural and climatic conditions and production technologies.

Since many factors influence the output of the exchange energy of production per unit area of agricultural land, the most significant of them were selected. Based on the correlation-regression analysis by the averaged indicators of activity of agrarian commodity producers of Ukraine, the importance of each indicator is determined:

$$y = a_0 x_1^{a1} \cdot x_2^{a2} \cdot x_3^{a3} \cdot x_4^{a4} \tag{4}$$

where x_1 is the weighted average index of humus content in the soil in percentage, x_2 is the organic fertilizers per 1 hectare in centner, x_3 is the mineral fertilizers per 1 hectare in centner, x_4 is the improvement of unproductive lands in hectare.

3. Results

Thus, we conclude that economic efficiency does not reflect all the specifics of relations that are inherent in the mechanism of effective agricultural land use, so there is an urgent need for simultaneous determination of ecological efficiency indicators. The main criteria for the ecological efficiency of agricultural land use should be the degree of functional use of land resources, ecological stability, the level of anthropogenic load, the degree of land erosion, etc. Table 5 shows the financial results of activities of the agricultural enterprises by region for 2015 (State Statistics Service of Ukraine, 2016). To calculate the degree of functional use of land resources, environmental sustainability, the level of anthropogenic load, the degree of land erosion can be calculated from the indicators given in (Tretyak, 2013).

Table 5. Results of the financial activity of agricultural enterprises by region for 2015. Source: State Statistics Service of Ukraine (2016)

	Net profit (loss) (thousand USD)	Share in the total number of enterprises (%)		The level of profitability (loss) (%)	
		enterprise that received a net profit	enterprises that received a net loss	all activities	operating activities
Ukraine	3697 118.40	89.2	10.8	31.8	44.3
Vinnitsia	203 802.17	86.9	13.1	18.8	37.9
Volyn	34 099.23	85.8	14.2	21.3	32.5
Dnipropetrovsk	236 678.96	91.4	8.6	37.4	44.3
Donetsk	75 245.99	89.6	10.4	29.6	37.6
Zhytomyr	65 443.78	74.7	25.3	27.1	42.1
Zakarpattya	6 038.44	93.4	6.6	26.6	29.3
Zaporizhia	170 747.49	91.0	9.0	52.3	56.3
Ivano-Frankivsk	4 654.95	88.0	12.0	2.0	12.7
Kyiv	251 540.73	85.3	14.7	25.9	36.2
Kropyvnitskyi	319 197.51	94.7	5.3	60.3	68.7
Lugansk	52 445.26	91.9	8.1	30.9	31.4
Lviv	−13 253.03	84.8	15.2	−3.5	12.8
Mykolayv	136 648.24	92.9	7.1	36.8	40.5
Odesa	150 836.38	92.8	7.2	37.2	41.9
Poltava	588 182.78	91.0	9.0	61.2	69.3
Rivne	40 336.23	78.1	21.9	14.5	30.6
Sumy	175 567.35	88.6	11.4	32.4	64.4
Ternopil	47 216.10	85.7	14.3	11.2	24.1
Kharkiv	214 271.52	88.8	11.2	30.9	42.6
Kherson	162 503.11	88.6	11.4	49.7	55.8

Based on the analysis and data on the impact of environmental factors on the efficiency of agricultural production, it was determined that the planning of economic activities of agricultural enterprises and the development of directions for sustainable development of the agricultural sector should be based on priority strategic tasks, taking into account the natural resource potential and the ecological state of agriculture. The considered ecological factors can be levelled in the course of the organization of production. However, their importance in the formation of economic indicators of agricultural production is different. Therefore, it is crucial to determine the degree of influence of each of the factors or their groups on the efficiency of agricultural production through the use of scientifically based methodological approaches.

The final result of agricultural production depends on many factors, the main of which is the environmental factor characterizing the environment and conditions for the production of agricultural products and plays a decisive role in the development of rural areas. The variety of factors influencing the economy of agricultural production indicates the complexity of causal links in the interaction of agricultural production and the environment between economic and environmental indicators that characterize the results of enterprises. Summarizing the effect of the economic consequences of negative impact based on agricultural production, we can highlight the main signs of their manifestation:

- imbalance between agroecosystems;
- development of wind and water erosion of lands;
- large amount of mineral fertilizers and reduction of organic fertilizers;
- deviation of soil moisture from optimal norms.

To analyze the influence of environmental factors on the efficiency of agricultural production, it is proposed to determine the relationship between environmental and economic indicators by evaluating various calculated and statistical data. Thus, it is recommended to apply economic-mathematical methods of analysis to identify the relationship between factor and result indicators, in the particular correlation-regression analysis. This analysis provides an identification of the main factors of dependence, reflecting a quantitative assessment of the degree of their relationship. The studies were carried out according to the statistical indicators of agricultural production in the regions of Ukraine and the calculated data of our research. Currently, Ukraine has an energy and resource-consuming model of economic development with energy-intensive GDP, which is 2–3 times higher than the European average. The imbalances in the distribution of productive forces, which took place over a long period, led to the fact that anthropogenic impact on the natural environment in Ukraine is 4–5 times higher than in the countries of the world. The plowed land reached 80% of all agricultural land (Dovhyy et al., 2010).

For a more detailed analysis of the influence of these factors (except less influential ones) on the volume of gross agricultural output, a linear multiple regression model was built. The results confirmed the existence of a close relationship between factorial and effective indicators (multiple correlation coefficient $R = 0.83$). The obtained regression equation has the form:

$$Y = 298.5 + 200.48\text{X1} + 1.69\text{X2} - 2.06\text{X3} + 67.76\text{X4} \tag{5}$$

where Y is the volume of gross agricultural output per 100 ha of agricultural land (at constant prices for 2018) in thousand UAH, X1 pesticide load in kg/ha, X2 is chemical load in kg/ha, X3 is land erosion in percentage, X4 is the amount of organic fertilizers in ton/ha. The value of the determination coefficient ($R2 = 0.68$) indicates that 68% of the variation of the dependent variable is due to the factors introduced into the correlation model, and the rest – by other unaccounted factors.

Input data for the correlation-regression analysis is presented in Table 6. As a result of the correlation-regression analysis, the following equation of multiple regression is obtained:

$$y = 0.84x_1^{0.58} \cdot x_2^{0.18} \cdot x_3^{1.27} \tag{6}$$

Table 6. Input data for correlation-regression analysis by regions of Ukraine.
Source: State Statistics Service of Ukraine (2016)

Regions	Y	X_1	X_2	X_3	X_4	Lny	Lnx_1	Lnx_2	Lnx_3	Lnx_4
Vinnitsia	12.82	3.00	7.45	10.50	7.20	2.551	1.099	2.008	2.351	1.974
Volyn	6.85	2.30	6.35	10.10	5.80	1.924	0.839	1.848	2.313	1.758
Dnipropetrovsk	14.69	2.10	5.14	9.90	5.30	2.687	0.742	1.637	2.293	1.668
Donetsk	7.63	1.80	5.16	8.50	3.40	2.032	0.588	1.641	2.140	1.224
Zhytomyr	8.97	2.30	5.15	10.60	6.30	2.194	0.839	1.639	2.361	1.841
Zakarpattya	8.20	2.8	5.90	8.70	7.00	1.884	1.030	1.775	2.163	1.946
Zaporizhia	10.58	2.30	9.77	11.70	6.70	2.359	0.839	2.279	2.460	1.902
Ivano-Frankivsk	6.58	2.80	5.90	8.70	7.00	1.884	1.030	1.775	2.163	1.946
Kyiv	6.90	2.70	7.49	9.00	4.70	1.932	0.993	2.014	2.197	1.548
Kropyvnitskyi	9.54	2.20	4.54	8.20	3.70	2.255	0.788	1.513	2.104	1.308
AR Crimea	6.27	1.50	6.90	8.90	5.90	1.836	0.405	1.932	2.186	1.775
Lugansk	4.74	1.20	6.59	7.00	4.60	1.556	0.182	1.886	1.946	1.526
Lviv	5.74	2.10	5.83	9.80	6.40	1.747	0.742	1.763	2.282	1.856
Mykolayv	8.18	1.50	5.38	5.50	1.90	2.102	0.405	1.932	2.186	1.775
Odesa	5.01	1.50	5.66	8.80	5.10	1.611	0.405	1.733	2.175	1.629
Poltava	10.13	2.90	9.22	9.30	5.10	2.316	1.065	2.221	2.230	1.629
Rivne	6.26	1.50	5.72	9.00	5.50	1.834	0.405	1.744	2.197	1.705
Sumy	9.53	2.50	4.45	7.10	3.30	2.254	0.916	1.942	1.960	1.194
Ternopil	6.42	1.40	6.78	13.50	8.20	1.859	0.336	1.914	2.603	2.104
Kharkiv	9.69	1.80	6.07	10.20	4.90	2.271	0.588	1.803	2.322	1.589
Kherson	10.61	2.60	7.20	9.60	5.60	2.362	0.956	1.974	2.262	1.723
Khmelnitskyi	7.84	2.20	5.78	8.40	4.50	2.059	0.788	1.754	2.128	1.504
Cherkasy	5.63	1.50	5.47	7.90	5.30	1.728	0.405	1.699	2.067	1.668
Chernivtsi	7.50	1.70	5.24	10.30	4.60	2.015	0.531	1.656	2.332	1.526
Chernihiv	5.47	2.80	4.29	8.00	6.00	1.699	1.030	1.456	2.079	1.792
Average	8.50	2.20	6.17	9.20	5.10	2.140	0.788	1.82	2.219	1.629

The multiple coefficients of correlation for the model are equal to 0.94, which indicates a sufficiently high reliability of the regression equation. The correlation coefficient for the first factor is 0.51, for the second factor, it is 0.25, and for the third, it is 0.24. This indicates that the crucial factor in the energy efficiency of agricultural land is the humus content in the soil, i.e., its fertility. The influence of this factor more than twice exceeds the weight of other factors. Consequently, if gross exchange energy tends to increase, it means that in general, the qualitative composition of soils also improves.

In market conditions, the interpretation of efficient land use has changed to economically feasible and profitable use of land for its intended purpose without deteriorating its quality and environmental and aesthetic characteristics and compliance with the requirements of encumbrances and restrictions, which is achieved by intensifying production in scientific and technological progress and improving the territorial organization. In our opinion, the efficiency of land use is a set of qualitative and quantitative parameters of efficient use of land resources to achieve the goals for minimal costs, taking into account the socio-economic consequences of land use. The literature on economic theory mainly distinguishes three types of efficiency: economic, technical, and structural. Technical efficiency is the ability to obtain the maximum volume of products with available resources. Structural efficiency is characterized by the amount of resource costs to obtain the planned volume of products. The symbiosis of technical and structural efficiency is economic efficiency, which is the lever between the results obtained and the costs incurred.

4. Discussion

Exploring the work of Ukrainian scientists such as Tretyak and others, on the problems of assessing the efficiency of land use, it can be argued that they mainly focus on methodological approaches to evaluate the effectiveness of land use management. However, the essence and components of the system of ecological and economic efficiency of agricultural land use differ from the essence and components of the management system of land resources and land use (Tretyak, 2004). According to scientists, the defining condition for increasing the contribution of land assets to economic growth and sustainable development of the country is the use of economic methods of administration (regulation) of land greening, aimed at increasing national wealth and welfare while preserving environmental potential. However, these issues remain unresolved. Recently, the issues of protecting the ecological potential of the territory by economic methods have become extremely important. This is because almost all countries study the solution of environmental problems as one of the conditions for their sustainable and effective development (Tretyak, 2013).

Despite the available research on the efficiency of land use, this issue requires a more detailed study and generalization of indicators for determining the efficiency of land use. Ecologically and economically efficient use of land resources in agriculture should be understood as a socio-economic category that represents the relationship between people in the process of technological production processes associated with agricultural production, to meet the needs of the population in food to ensure recovery natural soil fertility, increasing the productive potential of land resources and their use in a high level of environmental friendliness of both these resources and the environment as a whole (Sedov, 2014). The concept of "efficiency of land use" is a quantitative expression of the maximum effect from the use of land resources at the expense of minimum costs. To determine the ecological and economic efficiency, a method of the economic evaluation of land use is proposed, which is an expression in money of the maximum possible ef-

fect of their integrated use, taking into account social and environmental functions. An indicator of the economic evaluation of land use is its value, which is determined by the value to society and expressed by the indicator of total economic value or other indicators that form the overall economic value (Rosa-Schleich et al., 2019; Tretyak, 2004). The assessment of ecological efficiency of land use is carried out in the following directions: ecological and economic efficiency of project decisions of land use greening as an indicator that characterizes the ratio of total economic benefits and losses from project decisions, including external environmental effects and related social and economic consequences. The general economic valuation of land and other natural resources acts as their valuation, which takes into account in value terms the value of land and other natural resources, the market value of which in this period is absent or undeveloped. Thus, for ecological and economic efficiency of land use greening, a method of ecological and economic assessment of land use is proposed, which is an expression in money of the maximum possible effect of their integrated use, taking into account social and environmental functions. An indicator of the economic assessment of land use is its value, which is determined by the value to society and expressed as an indicator of total economic value or other indicators that form the total economic value.

Today the problem of formation of bases of rational use of agricultural lands is aggravated by strengthening of ecological imbalances caused by infringement of scientifically based provisions of managing and production of agricultural products (agrotechnical requirements of cultivation of crops, system of crop rotations, innovative technologies of cultivation and care), an imbalance in the development of crop and livestock industries, which limits the parameters for applying organic fertilizers to the soil and hinders the reproduction of the natural fertility of the latter, total intensification of production and economic activities in the agricultural sector, increased anthropogenic load on the ecosystems of rural areas, insufficient level of responsibility of business entities in the agricultural sector for the possible consequences of deepening economic imbalance, meager amounts of fines and sanctions for violation of environmental legislation (Asimeh et al., 2020; Muzyka et al., 2019). In our opinion, increasing the efficiency of land use provides for the expediency of maintaining a strategic focus on achieving such priorities as the formation of an institutional basis for the phased introduction of the agricultural land market, overcoming the manifestations of the practice of shadow turnover of agricultural land, minimizing the risks of excessive concentration of land in the use of one owner, eliminating ecological imbalances in the development of the agrarian sector of Ukraine, coordination of resource capacities with the environmental risks of functioning, organization of the foundations of rational nature management in agriculture, strengthening the protection of agricultural lands, preventing the processes of soil degradation, ensuring the reproduction and preservation of the fertility of agricultural lands.

Therefore, the estimation objectivity of the efficiency of agricultural land use by the indicators of gross output, income, profitability is far from perfect. Besides, the significant impact of inflationary processes on the value of production significantly distorts the dynamics of real economic phenomena and processes. Consequently, focusing only on quantitative and cost indicators, as practice shows, does not give an objective assess-

ment, but this does not mean that the listed indicators should not occupy their place in the system of indicators of land use efficiency estimation.

The article is a review and not a purely scientific and is a recommendation. The article presents the initial data for carrying out the correlation-regression analysis according to the averaged indicators of the activity of agricultural producers of Ukraine with the determination of the significance of each indicator. The results of correlation-regression analysis by multiple regression equations are also given. The obtained multiple correlation coefficient for the proposed model is equal to 0.94, which indicates a very close relationship between the studied indicators and sufficiently high reliability of the regression equation.

5. Conclusions

Thus, the advantages of the energy nutrition indicator of products as one of the criteria for assessing the efficiency of agricultural land use as follows:

- its simplicity of calculation and orientation towards achieving the ultimate goal of agricultural production, which in turn stimulates the ecological and economical use of land resources;
- the suitability of use in the formulation and resolution of questions on the self-sufficiency of districts and regions, as well as the assessment of food security of the country as a whole;
- the study of this indicator in dynamics will allow concluding the efficiency of agricultural land use and the feasibility of making decisions on the transition to new technologies, changing the structure of sown areas, etc.

Agricultural enterprises are of great importance in the study of land-use efficiency. Analysis of the structure of agricultural enterprises in Ukraine shows that most of them have a small area of land use: potatoes – by 30%, vegetable crops – by 58%. Irrational and depleting use of agricultural land remains a problem for Ukraine. To overcome the inefficient use of agricultural land in Ukraine in 2003, the Concept of Balanced Development of Agroecosystems in Ukraine for the period up to 2025 was approved. The Concept presents measures that will contribute to the formation of a balanced (sustainable) system of nature management in agriculture and ensure the development of the ecological network (Verkhovna Rada of Ukraine, 2020).

It should be acknowledged that the proposed approach to assessing the ecological and economic efficiency of agricultural land use, like others, is not perfect, since it has its disadvantages, which are primarily related to the use of the average energy content of products, in turn, reduces the level of reliability of the calculations. At the same time, the main advantage of this approach is the focus on achieving the ultimate goal of agricultural production, which allows us to recommend it for extended use in assessing the ecological and economic efficiency of agricultural land use. The output of a unit of land in relative terms through exchange energy is not only a kind of indicator, a criterion for the efficient use of agricultural land but also a criterion for the effectiveness of all production activities of agricultural producers, a particular district, and even regions. By

comparing the output from a unit of land in comparative terms through the exchange of energy by economic entities, we can determine their rating, select the best, and propose concrete measures to improve the environmental and economic efficiency of agricultural land use. Also, land resources from the point of view of public interests are proposed to be evaluated by indicators of changes in the distribution of land resources by economic interests and by changes in the value of land resources. The capitalization of rental income determines trends in the effectiveness of managing changes in the value of land resources. The cost of land is increased as a result of the improvement in market conditions, growth in business activity (low bank rate – the so-called "low-cost funds"), and as a result of additional investments.

Author contributions

Conceptualization: I. P.; Methodology development: L. P.; Writing – original draft: O.H.; Writing – review and editing: M. M.

Data availability statement

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an ongoing study.

Acknowledgements

This research study has not received any external funding.

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