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ENVIRONMENTAL FEATURES OF LAND USE FORMATION IN THE REGIONS OF UKRAINE

Purpose. *The objective of the study is a comprehensive evaluation of the level of environmental friendliness of land use in the regions of Ukraine, taking into account the structure of cultivated areas.*

Methodology / approach. *The evaluation of the structure of cultivated areas and the level of productivity in the regions of Ukraine was carried out using the method of complex ranking score. This allowed consolidating data on different crops to a single indicator and evaluating the situation in the regions. The regression method was used to evaluate the dependence of the ranking score on the structure of the cultivated areas and the level of productivity in the regions. A graphical method was also used to display the level of relationship between the studied indicators.*

Results. *It was established that in 2022, the structure of cultivated areas did not significantly differ from the situation in 2020 and 2021. The use of a ranking score of changes in the structure of cultivated areas made it possible to establish that in terms of crop groups, the situation was better in 2022 in the regions of Zakarpattia, Volyn and Rivne. The most violations in the structure of cultivated areas were noted in the regions of Sumy, Mykolaiv and Kirovohrad. It turned out to be the best in the regions of Zakarpattia, Lviv and Volyn in terms of individual cultures. The most problematic situation with respect to the structure of cultivated areas was in the regions of Donetsk, Zaporizhzhia and Luhansk.*

Originality / scientific novelty. *The use of methods of the complex ranking score based on the criterion of environmental friendliness of production (structure of cultivated areas) and the level of its efficiency (crop productivity) made it possible to establish that there is a direct level of connection between these indicators. This fact is proof that the optimal structure of land use has a positive effect on the level of crop productivity.*

Practical value / implications. *The obtained results of the study give grounds for raising the question of creating an economic mechanism aimed at stimulating agricultural enterprises to comply with optimal land use standards in terms of compliance with the structure of cultivated areas.*

Key words: *agroecology, ecological land use, structure of cultivated areas, ranking score, production efficiency, state agrarian policy.*

Introduction and review of literature. Land is the national wealth of the people of Ukraine, the basis of agricultural production, the foundation of the economy. This resource, when used rationally, is inexhaustible and can provide food not only for the population of Ukraine, but also for hundreds of millions of people on the planet. Thus, it is important to conduct land use at a high scientific level, which

should be based on a rational ratio of the structure of cultivated areas, the reproduction of soil fertility through the use of a system of mineral and organic fertilizers and the use of modern energy-saving technologies. Unfortunately, systemic problems of a national security nature have been formed in Ukraine for many decades with all these positions. The level of plowing is one of the highest in the world, more and more agricultural enterprises are switching to a simplified system of crop rotation with 2 to 3 crops, the livestock sector is absent in the vast majority of enterprises. According to approximate evaluations of experts, the annual loss of humus amounts to 32–33 million tons [1]. In this case, the fact that the pace of dehumification in the last quarter of a decade has significantly accelerated compared to previous decades is also important, which further aggravates this situation [2].

It should be noted that the problem of ecological land use worsened due to the military aggression of the russian federation. Huge territories were mined, removed from agricultural use, mechanically destroyed as a result of artillery shelling and airstrikes. In addition, the detonation of ammunition leads not only to the formation of craters, its consequence is chemical pollution of territories, violation of the physical and chemical properties of the soil, biological degradation [3].

Undoubtedly, all these problems exist, moreover, the list of issues related to the ecology of land use in agriculture is much wider. However, in our study it was decided to focus on the problem caused by the structure of land use in agriculture. This problem is of high importance. As evidenced by the data of many years of research, crop productivity under the conditions of applying scientifically based crop rotations increases by 1.5–2 times compared to crops that have been grown on the same field for a long time [4]. However, the question arises: what are the reasons that encourage agricultural enterprises to violate crop rotation standards?

It should be noted that the problem of ecology of land use is organically combined with the broader problem of ecology, which is considered within the limits of the entire planet. This is logical since it is impossible to create ecological conditions in only one part of the system, if other components have problems. S. Díaz et al. note that we all depend on nature – the fabric of life, but is rapidly being destroyed [5]. In order to stop this, according to the authors, it is necessary to immediately begin to eliminate the main economic, social and technological causes of the deterioration of the state of nature. At the same time, one of the fundamental problems in recent decades has been the reduction of biodiversity, which negatively affects all processes in nature, including soils [6]. M. Bazilian et al. note that the spheres of energy, water and food policy have numerous interrelated problems, ranging from ensuring access to services, environmental impact, price volatility [7].

A man is an integral part of nature and exists only thanks to other species and in interaction with them. Based on this, the object of research today is socio-ecological systems (SES). M. Janssen et al. note that these systems, which in many cases have existed almost unchanged for hundreds of years, are rapidly collapsing today and becoming vulnerable to new types of pollution [8]. In their opinion, understanding such vulnerabilities can be critically important in order to preserve and adapt these

systems to changes in the external situation. In the context of this problem, M. Rudd notes that in order to understand the social driving forces that lead to environmental changes, we must take into account the role of society in interaction through the development of standards of behaviour and their institutionalization [9]. A similar point of view is held by J. Paavola, who connects the solution of environmental problems of society with the creation of appropriate institutions through which conflicts related to environmental resources will be resolved [10]. E. Barbier and J. Burgess actually join this point of view [11]. They are the ones who can ensure effective management of resources in order to solve environmental problems.

When evaluating global environmental problems related to climate change, it should be borne in mind that, as noted by A. Rose and N. Dormady, poorer countries are much more vulnerable than richer ones [12]. However, the authors are critical of this statement, noting that there is still no reliable statistical evidence of the impact of temperature changes on economic growth. In this context, the concept of the environmental Kuznets curve (EKC) should also be mentioned. It suggests that there is an inverted U-shaped ratio between environmental degradation and per capita income, so that eventually growth reduces the environmental impact of economic activity [13]. However, this theory was also not confirmed by reliable statistical studies.

As for the direct ecological problems of land use, it is noted that the implementation of environmentally safe and balanced agricultural land use in the system of agricultural development requires the implementation of ecosystem management of agriculture [14]. Ye. Ulko notes that the problem of sustainable land use in Ukraine is one of the determining ones due to the low interest of agrarian business in the reproduction of land potential and greening of production [15]. In another publication, the author concluded that the performed calculations allowed asserting that the existing models of crop rotation make it possible to ensure the supply of the necessary amount of soil organic matter for a deficit-free balance of humus [16]. In this context, Yu. Khalep and A. Moskalenko pay special attention to the role of green manuring in the reproduction of organic agrocenoses of Polissia [17]. The authors found that for organic farms, in the absence of sufficient amount of manure, planting green-manured crops is an important factor in preserving and improving soil fertility. Also, the authors propose developed typical models of crop rotations, which are characterized by positive forecast balances of humus and acceptable balances of basic nutrients (NPK) [18].

Numerous studies also emphasize the role and place of organic production in the formation of ecological land use [19; 20]. As an example, there are some farms that have maintained soil fertility for decades thanks to the use of crop rotations and organic fertilizers. As an example of such an enterprise, private company "Ahroekolohiia" [21] is most often cited.

The purpose of the article. The objective of the study is a comprehensive evaluation of the level of environmental friendliness of land use in the regions of Ukraine, taking into account the structure of cultivated areas. This objective includes

the following tasks:

- to evaluate the impact of military activities on the change in the structure of land use in the regions of Ukraine;
- to evaluate the changes in the structure of land use in the regions of Ukraine using the comprehensive evaluation methods;
- to carry out a comprehensive evaluation of the level of land use efficiency using productivity data of the main agricultural crops in the regions of Ukraine;
- to compare the level of comprehensive evaluation of the structure of cultivated areas and production efficiency according to the production level.

The data of the Agriculture of Ukraine collection for 2021 and 2022 were used as the statistical base of the study [22; 23].

Results and discussion. Table 1 shows data on the size and structure of cultivated areas of agricultural crops in Ukraine for 2020–2022. The first conclusion that can be drawn based on the data in the Table concerns the decrease in the size of cultivated areas in 2022 compared to the previous periods. Thus, the total area of all agricultural crops in 2022 was equal to 23,405.0 thousand hectares against 28,147.5 thousand hectares in 2020 and 28,580.9 thousand hectares in 2021. At the same time, the highest decrease was in cereals and legumes. Their cultivated area decreased from 15,392.2 thousand hectares in 2020 to 12,171.0 thousand hectares in 2022. These changes are a consequence of the military aggression of the russian federation and are connected with the occupation of part of the territory and the impossibility of production in the territories adjacent to the zone of military operations.

Table 1

Cultivated areas of agricultural crops in Ukraine, 2020 to 2022

Crops	2020		2021		2022	
	thsd hectares	%	thsd hectares	%	thsd hectares	%
Agricultural crops	28,147.5	100.0	28,580.9	100.0	23,405.0	100.0
including grain and leguminous	15,392.2	54.7	15,994.8	56.0	12,171.0	52.0
technical crops	9,223.8	32.8	9,244.5	32.3	8,292.0	35.4
potato, vegetables and cucurbits	1,854.3	6.6	1,806.6	6.3	1,620.0	6.9
fodder crops	1,677.2	6.0	1,535	5.4	1,322.0	5.6

Source: formed on the basis [22; 23].

Regarding the structure of cultivated areas, it has not fundamentally changed. However, it should be noted the increase in the specific weight of technical crops from 32.8 % in 2020 to 35.4 % in 2022. At the same time, the specific weight of grain and leguminous crops decreased from 54.7 % to 52.0 %, respectively. Analysing this structure, one should take into account the Resolution of the Cabinet of Ministers of Ukraine No. 164 “On approval of standards for the optimal ratio of crops in crop rotations in various natural and agricultural regions” dated 11 February 2010 [24]. In accordance with this regulatory document, the specific weight of grain

crops in different natural and climatic zones is set for grain and leguminous crops at the level of 25–95 %, technical crops – 5–35 %, fodder crops 10–75 %. At the same time, it should be borne in mind that technical crops are represented today in a predominant way by sunflower, the specific weight of which, in accordance with this regulatory document, should not exceed 15 % in the southern regions, and 0.5 % in the Polissia zone. In fact, in 2022, the specific weight of sunflowers ranged from 0.3% in the region of Zakarpattia to 35 % in the region of Kirovohrad. On average, this indicator was equal to 22.4 %, which significantly exceeds the normative values. At the same time, the situation is completely different for fodder crops. The average value of their relative weight in Ukraine was equal to 5.6 % in 2022. This is almost half of the lower recommended value. A similar situation is related to the decline of the animal husbandry industry in many enterprises and their transition exclusively to the production of plant products. Regarding the relative weight of potatoes and vegetable crops, their specific weight in 2022 was equal to 6.9 % on average in Ukraine, which is also significantly less than the recommended values. Thus, it can be concluded that, in general, the structure of land use in Ukraine is quite significantly different from the standard one. This, in turn, will worsen the quality of the soil, negatively affect the ecology due to the imbalance of nutrients, and finally – the economic results of farming. At the same time, taking into account the effect of the law of diminishing returns in the process of intensification, a drop in the level of soil fertility will lead to a decrease in the return on investment, which will practically mean a decrease in the amount of costs and, accordingly, in productivity [25].

In order to carry out a general evaluation of qualitative changes, it was decided to carry out a comprehensive evaluation of structural changes in cultivated areas in individual regions. For this purpose, it was decided to use the method of comprehensive evaluation, which allows combining various indicators into one and analysing it from the point of view of both quantitative and qualitative changes. The main stages of this procedure are [26]:

- selection of a system of indicators;
- determination of the optimal direction of changes in indicators;
- standardization of financial and economic indicators;
- calculation of the final indicators of the ranking score;
- calculation and evaluation of the impact of individual indicators on the change in the ranking score;
- classification of periods or regions by ranking score.

The optimal direction of change of indicators depends on which direction, decrease or increase, the indicator should change in order for the situation to be better. At the first stage of the study, it was decided to take the value of the relative weight of groups of crops in the structure of cultivated areas as indicators, namely:

- grain and leguminous;
- technical crops;
- potato, vegetable and melon crops;
- fodder crops.

We have established the directionality of the change in indicators in the direction of increase in grain and leguminous crops, potatoes, vegetables and cucurbits, and fodder crops. In terms of technical crops, the direction of change was set in the direction of minimization. This direction of change is associated with a significant excess of the relative weight of technical crops in the structure of crop rotation.

Depending on the established direction of change of the indicator, the standardization of their values takes place according to the following formulas. If the direction of change of this indicator is set in the direction of its maximization, then the standardized value is determined by the formula:

$$X_i = \frac{a_{ij}}{max\, a_{ij}}, \quad (1)$$

where X_i means standardized i-th indicator.

In the case of directionality of the change of coefficients towards minimization, the standardized value is determined by the formula:

$$X_i = \frac{min\, a_{ij}}{a_{ij}}, \quad (2)$$

where X_i means standardized i-th indicator.

At the next stage, the ranking score is determined by the formula:

$$R_i = \sqrt{\beta_1(1 - x_{1j\,max(min)})^2 + \beta_2(1 - x_{2j\,max(min)})^2 + \beta_i(1 - x_{nj\,max(min)})^2}, \quad (3)$$

where R_i means a ranking score of the individual enterprise;

β_i means a relative weight of i-th indicator in the ranking score;

$x_{1j\,max(min)}$, $x_{2j\,max(min)} \ldots x_{nj\,max(min)}$ are standardized maximal (minimal) indicators.

The relative weight of the indicator (β_i) in our case will be equal to the relative weight of this group of crops in the structure of the cultivated areas. This will take this factor into account. Based on the calculation formula, the closer the ranking score is to 0, the better the situation. If it is equal to 0, we can say that the situation in this region will be the best.

Table 2 shows the results of a comprehensive evaluation of regions by crop groups for 2020 and 2022. First, take into account that the comparison of regions was carried out based on data in the middle of each year. Therefore, it would not be completely correct to claim that as a result of one or another change, the situation in one or another region, due to an increase or decrease in the ranking score, was better or worse compared to last year. At the same time, it should not be overlooked that the value of the ranking score in 2022 decreased compared to the two previous periods. This may indicate that the differences in the regions regarding the structure of the cultivated areas of the selected crops have become somewhat smaller.

In 2020, the highest ranking score was in the regions of Zaporizhzhia (0.536), Kirovohrad (0.565) and Luhansk (0.596). In 2022, the situation was somewhat different. The highest values of this indicator according to the data of 2022 were in

the regions of Sumy (0.511), Mykolaiv (0.513) and Kirovohrad (0.541). Based on the procedure used, we can say that the situation in these regions in terms of crop rotation compliance was the worst.

Table 2

Results of the comprehensive ranking score of the structure of cultivated areas of the crop groups, 2020 to 2022

Regions	2020	2021	2022	Deviation in 2022 compared to:	
				2020	2021
Vinnytsia	0.468	0.476	0.463	-0.006	-0.013
Volyn	0.384	0.389	0.334	-0.050	-0.055
Dnipropetrovsk	0.531	0.518	0.500	-0.031	-0.018
Donetsk	0.520	0.516	0.472	-0.049	-0.044
Zhytomyr	0.469	0.464	0.495	0.027	0.031
Zakarpattia	0.244	0.215	0.233	-0.010	0.018
Zaporizhzhia	0.536	0.532	0.499	-0.037	-0.032
Ivano-Frankivsk	0.441	0.463	0.439	-0.002	-0.023
Kyiv	0.451	0.470	0.438	-0.013	-0.032
Kirovohrad	0.565	0.555	0.541	-0.024	-0.014
Luhansk	0.596	0.610	0.492	-0.104	-0.118
Lviv	0.462	0.468	0.414	-0.048	-0.054
Mykolaiv	0.535	0.522	0.513	-0.022	-0.009
Odesa	0.489	0.498	0.478	-0.011	-0.020
Poltava	0.488	0.489	0.481	-0.006	-0.008
Rivne	0.448	0.400	0.391	-0.057	-0.009
Sumy	0.479	0.477	0.511	0.033	0.035
Ternopil	0.463	0.471	0.466	0.002	-0.006
Kharkiv	0.511	0.502	0.459	-0.052	-0.043
Kherson	0.506	0.513	0.497	-0.009	-0.016
Khmelnytskyi	0.498	0.506	0.508	0.010	0.002
Cherkasy	0.453	0.473	0.458	0.004	-0.015
Chernivtsi	0.506	0.510	0.440	-0.066	-0.070
Chernihiv	0.419	0.423	0.448	0.029	0.026
Mean	0.478	0.478	0.457	-0.021	-0.020

Source: own calculations.

The lowest ranking score was in 2020 in the regions of Zakarpattia (0.244), Volyn (0.384) and Chernihiv (0.419). Regarding the results of 2022, the situation was as follows: regions of Zakarpattia (0.233), Volyn (0.334) and Rivne (0.391). All these areas belong to the Polissia zone, where the relative weight of sunflower is much lower and the relative weight of fodder crops is higher, which led to the final result.

At the second stage of the study, it was decided to conduct a comparison between the comprehensive evaluation of the structure of cultivated areas and the level of crop productivity. For this purpose, data were used not for a group of crops, but for individual crops. The following cultures were taken:

- wheat;
- barley;

- corn;
- sunflower;
- rape;
- potato;
- vegetables.

It should be noted that the use of a different set of data on the structure of cultivated areas has somewhat changed the situation. The regions of Zakarpattia (0.491), Lviv (0.527) and Ternopil (0.545) had the lowest value of the ranking score by the structure of cultivated areas in 2020. In this case, according to the productivity indicator for all crops, the direction of the change of the indicator was taken to increase. The relative weight of this crop in the structure of sown areas was also used as a weight criterion (β_i). The results of the calculations are shown in Table 3.

Table 3

Results of the comprehensive ranking score of the structure of cultivated areas and the level of productivity of individual crops, 2020 to 2022

Regions	Ranking score by area			Ranking score by productivity		
	2020	2021	2022	2020	2021	2022
Vinnytsia	0.598	0.601	0.501	0.243	0.091	0.270
Volyn	0.578	0.562	0.454	0.159	0.226	0.228
Dnipropetrovsk	0.606	0.607	0.514	0.451	0.329	0.399
Donetsk	0.651	0.672	0.587	0.421	0.422	0.405
Zhytomyr	0.648	0.641	0.553	0.237	0.216	0.277
Zakarpattia	0.491	0.490	0.415	0.393	0.443	0.416
Zaporizhzhia	0.672	0.678	0.591	0.418	0.320	0.487
Ivano-Frankivsk	0.573	0.606	0.509	0.139	0.145	0.115
Kyiv	0.606	0.606	0.499	0.268	0.149	0.264
Kirovohrad	0.642	0.642	0.533	0.435	0.236	0.285
Luhansk	0.692	0.713	0.570	0.422	0.464	0.463
Lviv	0.527	0.542	0.418	0.129	0.170	0.123
Mykolaiv	0.647	0.645	0.551	0.507	0.322	0.440
Odesa	0.615	0.618	0.523	0.585	0.319	0.492
Poltava	0.652	0.651	0.554	0.237	0.229	0.185
Rivne	0.574	0.557	0.484	0.144	0.198	0.199
Sumy	0.646	0.643	0.556	0.089	0.218	0.136
Ternopil	0.545	0.538	0.461	0.075	0.060	0.063
Kharkiv	0.633	0.634	0.559	0.271	0.311	0.335
Kherson	0.647	0.646	0.570	0.334	0.276	0.457
Khmelnytskyi	0.594	0.598	0.508	0.085	0.061	0.080
Cherkasy	0.630	0.623	0.517	0.318	0.116	0.168
Chernivtsi	0.586	0.601	0.455	0.236	0.194	0.218
Chernihiv	0.652	0.651	0.561	0.118	0.160	0.181

Source: own calculations.

In 2022, it was the lowest in the regions of Zakarpattia (0.415), Lviv (0.418) and Volyn (0.454). And all the more, this is largely due to the smaller area of sunflower and the larger area of fodder crops in these areas. The highest ranking score in 2020

was in the regions of Chernihiv (0.652), Zaporizhzhia (0.672) and Luhansk (0.692). In 2022, the largest value of the ranking score was already in the regions of Zaporizhzhia (0.591), Donetsk (0.587), Luhansk (0.570) and Kherson (0.570).

Regarding the ranking score by productivity, its lowest value in 2020 was in the regions of Ternopil (0.075), Khmelnytskyi (0.085) and Sumy (0.089). In 2022, the regions with the lowest rate were in the following order: Ternopil (0.063), Khmelnytskyi (0.080), Ivano-Frankivsk (0.115). The highest value of the ranking indicator in 2022 registered in the regions of Odesa (0.492), Zaporizhzhia (0.487) and Luhansk (0.463). Therefore, the question arises: how are the ranking scores related to the structure of cultivated areas as a factor of ecological production and crop productivity as a factor of its efficiency? To answer this question, it was decided to evaluate the relationship between these indicators using the constructed correlation model. The ranking score of the structure of cultivated areas was chosen as the factor (x), and the ranking score of the regions according to the level of productivity was chosen as the dependent variable (y). Figure 1 presents a graphical representation of these dependencies for 2020 and 2022. The obtained functions testify to the direct and relatively stable character of the dependencies. From this it can be concluded that the deterioration of the structure of cultivated areas has a negative effect on the change in the level of crop productivity. However, then the question arises: why more and more enterprises are switching to a simplified crop rotation system? This situation requires a separate study, but we note that the productivity indicator was chosen as a criterion. However, the results of the indicator of profitability and economic efficiency of production could give a different result.

The analysis of calculations based on the criterion of the structure of cultivated areas allows us to draw the following conclusions. The military aggression of the russian federation led to significant losses of cultivated areas and caused economic losses to the entire agricultural sector. At the same time, there were no significant changes in the structure of land use. The main negative factor in the vast majority of regions is a significant excess of the relative weight of sunflower in the structure of cultivated areas. The use of a comprehensive ranking score based on the criterion of the structure of cultivated areas by crop group allowed us to identify the most optimal indicators in 2020 in the regions of Zakarpattia, Volyn and Chernihiv. In 2022, the best regions in terms of the structure of cultivated areas were Zakarpattia, Volyn and Rivne.

The issue of which indicators determined the value of the comprehensive ranking score in each period requires special attention. The answer to this question can be obtained by carrying out the appropriate calculation. For this, it is necessary to find the specific weight of each individual indicator in the final assessment. The formula for this calculation is as follows:

$$SW = \frac{\beta_i(1-x_i)^2}{\sum\beta_i(1-x_i)^2} \cdot 100\,, \qquad (4)$$

where SW is the share of a specific indicator in the value of the overall ranking score.

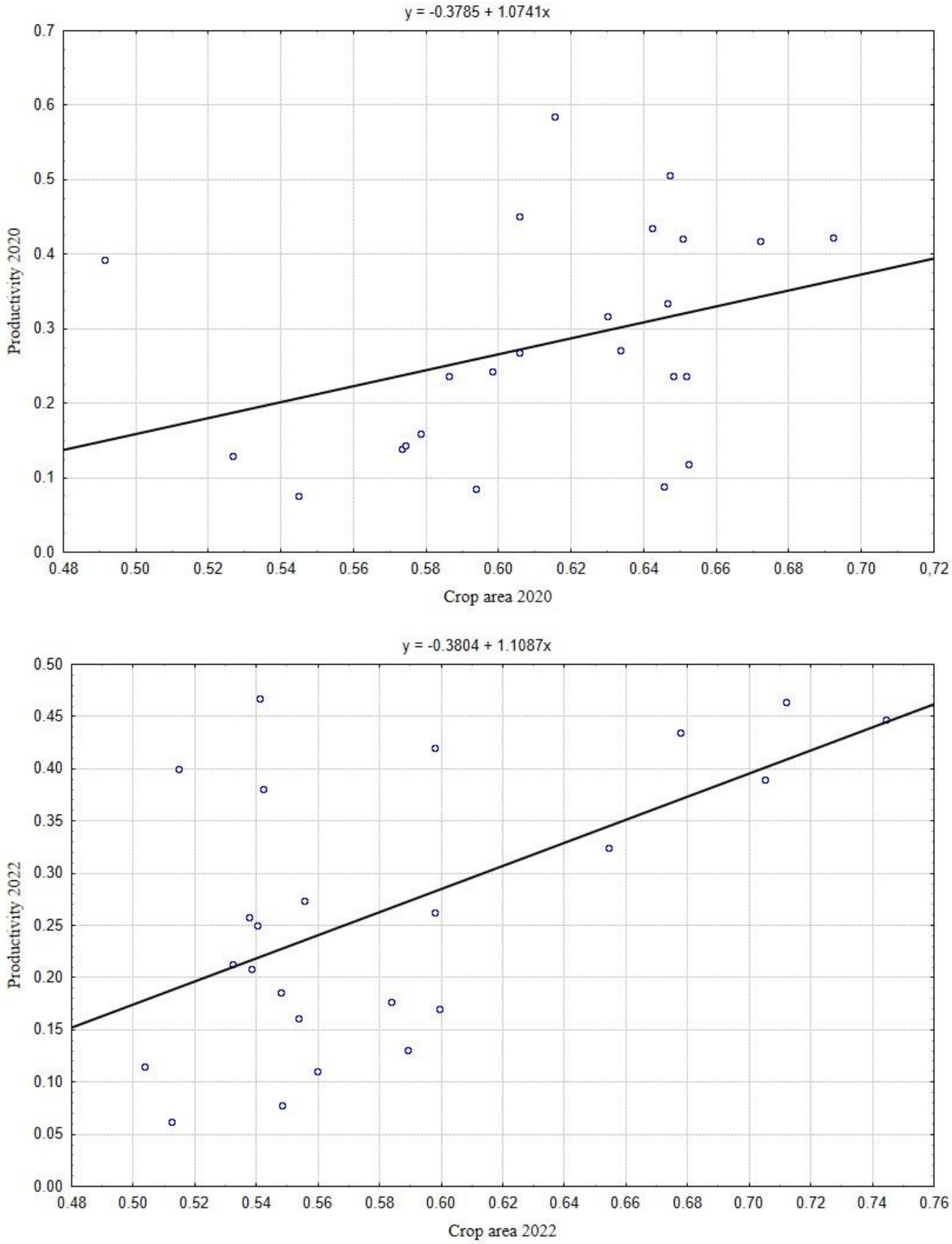

Figure 1. Dependence between the ranking score in the regions of Ukraine by the productivity and the ranking score by the structure of cultivated areas in 2020 and 2022

Source: own calculations.

The share of a specific indicator in the value of the overall ranking score will be equal to "0" if its value is optimal. The greater the share of an indicator in the ranking score, the greater the negative impact it has on the ranking score. The specific weight of all indicators must be equal to 100%. In fact, we are talking about decomposing the overall value of the ranking score into its components. Based on this, it was decided to determine the share of all indicators included in the calculation of the comprehensive ranking score for productivity and structure of cultivated areas (Table 4). It should also be noted that calculations were made for each region separately with the subsequent determination of the average value for Ukraine.

Table 4

Share of individual crops in a comprehensive ranking score by the structure of cultivated areas and productivity in 2020–2022, %

Crops	2020	2021	2022
Comprehensive ranking score by area			
Wheat	14.83	16.87	13.93
Barley	9.69	10.66	10.33
Corn	19.71	17.58	16.81
Sunflower	43.87	43.51	44.74
Rape	4.10	3.74	4.95
Potato	5.48	5.35	6.65
Vegetables	2.31	2.29	2.59
Comprehensive ranking score by productivity			
Wheat	19.56	23.48	21.63
Barley	4.80	6.74	8.79
Corn	32.99	26.20	18.73
Sunflower	24.18	22.29	30.71
Rape	4.85	5.86	6.99
Potato	5.44	4.26	10.20
Vegetables	8.20	11.19	2.95

Source: own calculations.

Based on the obtained data, it can be stated that the main negative factor for the growth of the comprehensive ranking score based on the structure of cultivated areas is the excess of the normative value of the specific weight of sunflower cultivated areas in the structure of agricultural land. In 2020, this determined 43.87 % of the total value of the comprehensive ranking score, in 2022 – 44.74 %. As for other crops, it is also necessary to note the influence of wheat and corn. In 2022, they formed 13.93 % and 16.81 % of the comprehensive ranking score, respectively. However, according to these cultures, there was a very significant differentiation of the level of influence on the ranking score. Thus, for wheat, it was the largest in Zakarpattia (42.1 %), Zhytomyr (23.4 %) and Poltava (19.6 %) regions. At the same time, the influence of this culture on the comprehensive ranking score in such regions as Donetsk and Odesa was minimal. For corn, the situation was similar. In 2022, the greatest impact of corn on the comprehensive ranking score was recorded in the Kherson (42.7 %), Volyn (40.1 %) and Donetsk (34.6 %) regions. The influence of other cultures was much less. At the same time, the negative impact of wheat in some

regions was compensated by a decrease in the impact of corn and vice versa. That is, these cultures had a conditionally negative impact on the comprehensive ranking score of the regions.

As for the ranking score by crop productivity, it should be noted first of all that it was determined to the greatest extent by the same three crops: sunflower, wheat and corn for grain. In 2022, sunflower (30.71 %), wheat (21.63 %) and corn (18.73 %) had the greatest impact. In 2020 and 2021, the most negative factor was the yield of corn, respectively 32.99 % and 26.20 % of the impact. Significant differentiation by region was also recorded. So, in 2022, the most negative impact regarding the level of corn yield was in the Vinnytsia region (35.4 %), Donetsk region (33.4 %) and Cherkasy region (32.6 %). Regarding sunflower, the most negative impact was in Lviv (68.7 %), Volyn (55.5 %) and Chernihiv (51.8 %) regions. In fact, this means that in these regions the yield level of these crops is significantly lower than in others. So, the question arises: does it make sense for enterprises to engage in the production of these particular crops in the listed regions? This is especially true for sunflower, which is generally not recommended to be produced in the Polissya zone. Searching for answers to this question can be one of the directions of future research.

Our results confirm previous studies [1; 2; 27; 28] and prove the validity of previous proposals regarding (1) taking into account the indicator of compliance with the recommended cultivated areas when assessing the sustainable competitiveness of land use of agricultural enterprises [27], as well as (2) introducing an ecological taxation mechanism for agricultural enterprises that violate the scientifically based structure of cultivated areas, to suspend the negative processes of soil degradation [28] and stabilize the agroecological situation in land use of Ukraine.

Conclusions. The study of the environmental level of land, conducted using the comprehensive ranking score of the structure of cultivated areas and the level of productivity in the regions of Ukraine has revealed their direct dependence. This suggests that the optimal structure of crop rotation allows increasing crop productivity. At the same time, a significant number of enterprises do not comply with it. We believe that this problem requires a separate statistical study in order to establish significant results.

It was established that in 2022, the structure of cultivated areas did not significantly differ from the situation in 2020 and 2021. The use of a ranking score of changes in the structure of cultivated areas made it possible to establish that in terms of crop groups, the situation was better in 2022 in the regions of Zakarpattia, Volyn and Rivne. The most violations in the structure of cultivated areas were noted in the regions of Sumy, Mykolaiv and Kirovohrad. It turned out to be the best in the regions of Zakarpattia, Lviv and Volyn in terms of individual cultures. The most problematic situation with respect to the structure of cultivated areas was in the regions of Donetsk, Zaporizhzhia and Luhansk.

According to the results of the study, the question arises regarding the development and introduction of a really effective mechanism that would stimulate

farms to comply with the optimal structure of cultivated areas. In the conditions of a market economy, this mechanism should primarily be based on economic stimulus measures. They may refer, for example, to differentiated rates of the state tax on land, or additional subsidies to those producers who implement a more optimal land use structure. After all, the task of not only the state, but also society must hand over to our descendants the main national wealth – our land in good condition, so that it can feed many more generations of Ukrainians and benefit the entire humanity.

It should be noted that the proposed methodology for assessing the level of environmental friendliness of land use has certain limitations. They are due to the fact that only the indicator of the structure of cultivated areas was used as factors. However, in reality, there is also the influence of other factors, such as the balance of humus, the technological effectiveness of crop production, and the level of suitability of soils in this area for a particular crop. Also, the indicator of crop yield does not comprehensively assess the level of land use efficiency. In further research, it is advisable to supplement it with an indicator of the amount of profit per hectare or profitability of production.

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