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Analysis of the structure and fertility of agricultural land in western Ukraine and its monetary assessment

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Abstract. An important sector of the Ukrainian economy is agriculture, which is based on the fertility of agricultural land, in particular, the land of the western region of Ukraine. Analysis of the structure, fertility of agricultural land, and its monetary valuation can provide insight into its productivity and potential for agricultural development. The purpose of the study is to analyse the structure and fertility indicators of agricultural land in the west of Ukraine, demonstrate their main characteristics, and compare land prices in the western regions of Ukraine. In the study, the materials of the land directory of Ukraine and regional reports on the state of the environment of the west of Ukraine were used, involving analysis and comparison of the state of land resources by the content of humus, mobile compounds of phosphorus and potassium, easily hydrolysed nitrogen, their material and monetary assessment. After analysing the structure of the land fund of the



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west of Ukraine (13125.5 thousand hectares), it was identified that agricultural land accounts for more than half of the total area (56.1%), and forests and other wooded zones – about a third of the total area (32.8%). Built-up land, open wetlands, open land without vegetation cover or with little vegetation cover, and other land account for less than 10%. Among agricultural land, the largest share is arable land, a little less is hayfields and pastures, and the least is perennial plantations and fallows. The total value of agricultural land in the western administrative regions is markedly different. The highest land value is in Khmelnytskyi and Ternopil regions (1.71 and 1.09 billion USD), and the smallest – in Ivano-Frankivsk and Zakarpattia (489.90 and 317.21 million USD). 1420223 shares were leased on the territory of western Ukraine. The largest number of them was leased in Khmelnytskyi and Ternopil regions (25.2 and 20.7%), and the smallest – in Zakarpattia (1.0%). Thus, the total area of land cultivated by farmers is 330.8 thousand hectares, the largest in the Ternopil and Khmelnytskyi regions (23.3 and 22.7%). The findings of the study will contribute to the adoption of managerial decisions on conducting efficient agriculture and the preservation of soil fertility of agricultural lands in the region under study. Monetary assessment of these territories is useful for the country's population in the context of changes in the law on the land market in Ukraine, and in the implementation of an environmentally balanced agricultural policy

Keywords: land fund; pastures; humus; land shares; agricultural land; administrative region

INTRODUCTION

Agricultural land is vital for the development of society, as it is the main means of production for agriculture. The study of the structure and fertility of such lands is becoming increasingly relevant in the context of global climate change, as it affects the solution of a number of the following tasks, such as: ensuring food security, rational and environmentally safe land use, and environmental conservation. In addition, it is crucial to establish the material and monetary assessment of land in the context of changes in the law on the market land in Ukraine.

Agricultural land, due to climatic, social, and economic conditions, may be suitable, partially suitable, and unsuitable for farming (Kowalczyk *et al.*, 2019, 2021). A detailed examination and analysis of such features are of great importance for rational farming and reliable production (Ambros & Granvik, 2020) of agricultural products for the population in sufficient quantity.

During the last decades, the management of agriculture in Ukraine has sometimes been irrational. Often there is non-compliance with crop rotations, depletion of the soil due to the cultivation of rapeseed, corn, sunflower, and soybeans, and a substantial decrease in the application of organic and mineral fertilisers, which reduces soil fertility. The state of the fertility of agricultural land (Demianenko, 2022) depends on many indicators: the content of nutrients, the level of productivity of the arable soil layer, the conditions of land exploitation and measures for its preservation. Therefore, a detailed analysis of these indicators of individual territories can demonstrate the expediency, prospects, and even threats of conducting a particular agricultural activity there.

According to data (Demianenko, 2022), humus losses in Ukraine due to processes of mineralization and water and wind erosion have already affected about 15 million hectares of agricultural land (35% of their total area), and humus losses range from 32 to 33 million tonnes, which amounts to losses in the financial equivalent of

2 billion USD. Thus, in the future, as a result of such processes, Ukraine may lose its humus potential, which will lead to an environmental catastrophe. It will not be possible to restore it through land reclamation, agrotechnical, organisational, economic, and environmental measures, which will lead to a decrease in the agrotechnical potential of the land and soil degradation.

The purpose of the study is to analyse the structure, indicators of agricultural land fertility and its monetary valuation in the Volyn, Rivne, Lviv, Ternopil, Khmelnytskyi, Zakarpattia, Ivano-Frankivsk, Chernivtsi administrative regions of Ukraine, that is, the entire territory of western lands of Ukraine.

The following research tasks were set to achieve this purpose: analyse the structure of the land fund and the structure of agricultural land in the west of Ukraine and individual administrative regions; establish the normative and monetary evaluation of agricultural land, determine the share of soil areas by the content of humus, mobile compounds of phosphorus, potassium and easily hydrolysed nitrogen, in the territory of the west of Ukraine and in certain administrative regions.

LITERATURE REVIEW

In the twenty-first century, agriculture in Europe has been affected by a substantial number of global indicators. Thus, as a result of the application of fertilisers, and pesticides, the growth of agricultural plants, the chemical composition of soils and mineral metabolism in the soil changes (Hader *et al.*, 2022), which in certain cases can contribute to the emergence of negative natural phenomena (reduction of biodiversity, soil degradation, wind and water erosion).

The European Union recently announced a new soil strategy until 2030 that provides a framework and measures to protect and restore soils and ensure their sustainability (Montanarella & Panagos, 2021; Köninger *et al.*, 2022). This will eventually have a positive impact on soil

conservation and the introduction of ecological farming. Yet such processes require a fairly long period of time, so effective planning of such work is constantly relevant. Similar developments are also needed for agricultural land in Ukraine, even at the level of individual territories.

Researchers actively investigate the problem of preserving soil fertility, publish information on this subject in the studies, and present it at conferences. Researchers thoroughly examine the soil fertility in the territory of Ukraine by natural zones, administrative regions, districts, and territorial communities. In the west of Ukraine (Kyrylchuk *et al.*, 2022), special attention is paid to exploring changes in soil fertility. Thus, changes in soil fertility occur due to various factors that can negatively affect the productivity of agricultural land, biodiversity, and ecosystem services provided by the soil. Preserving and restoring soil fertility is one of the main tasks of researchers and practitioners. It is necessary to develop soil management methods that will help prevent the negative consequences of changes in fertility to do this.

The soil cover of the Carpathian region is the basis for agriculture and forestry, and the life and traditions of the local population. However, the current state of the soil and the need for investments (Pozniak *et al.*, 2020) require an assessment of the investment potential of soils. Factors such as the complexity of the soil structure, dependence on weather conditions, imperfect infrastructure and legislation contribute to the low investment attractiveness of soils.

Researchers (Ma *et al.*, 2020) from all over the world are engaged in the analysing of soil degradation and desertification within a particular region. Factors such as population growth, socio-economic land-use changes, and climate change can contribute to this. Similar phenomena were recorded by researchers during studies in the Mediterranean region of Europe in the form of chemical (soil organic matter, pollution, salinity), physical (soil compaction, compaction, erosion), and biological degradation of Mediterranean soils (Ferreira *et al.*, 2022). Therewith, it was identified that the most recorded degradation processes are soil erosion, and the least is the loss of biodiversity. Therefore, the researchers propose to create a national and regional soil monitoring system to analyse its degradation and determine the economic and environmental consequences. This should facilitate management decisions in accordance with the sustainable development goals of the region.

Processes that also have a very negative impact on the soil (Brannigan *et al.*, 2022) and, as a result, on the deterioration of agricultural conditions, include wind and water erosion.

Wind erosion causes soil degradation and is one of the main threats (Bartosz *et al.*, 2023) for European soils. This problem is constantly being investigated in virtually all regions of Europe: the semi-arid Mediterranean region (Teng *et al.*, 2019; Bartosz *et al.*, 2023) and

the temperate continental climate region of southern European countries using the example of Romania's adjacent to the studied region area (Niacsu *et al.*, 2019), and Ukraine (Tarariko *et al.*, 2021). The consequences of wind erosion are a decrease in soil fertility, which in turn negatively affects the yield of agricultural crops, and, as a result, leads to a decrease in the economic efficiency of agriculture (Abuzaid *et al.*, 2023). All this encourages farmers and politicians to pay more attention to solving this problem. Foreign experience can be used to solve these issues. For example, in northern China, (Ma *et al.*, 2022) precisely to prevent wind erosion, the way of large-scale management of human land use is quite effective, that is, increased control over the management of agriculture. Such goals and objectives should also be solved in Ukraine, because according to Ukrainian researchers, information on the state and changes of soils is minimal, and it is received once every few years.

As a result of water erosion, particles of nitrogen, calcium, and other elements are washed away from the soil, which negatively affects soil fertility (Brannigan *et al.*, 2022; Panagos *et al.*, 2022). Researchers (Panagos *et al.*, 2021) developed 19 possible global climate models of water erosion rates. As a result of modelling, it was determined that in agricultural areas of Europe and the United Kingdom, it is necessary to increase the area of pastures and, accordingly, reduce arable land. A similar issue (Land Directory of Ukraine, 2020) is very acute in Ukraine.

Detailed examination of the structure of agricultural land in certain administrative regions of Ukraine and assessment of agricultural work there help prevent negative natural phenomena, such as soil degradation, wind and water erosion, and reduced biological diversity. This is possible only under the conditions of taking scientifically based measures to prevent these negative phenomena and implementing agroecological policy in Ukraine based on the principles of balanced nature management.

MATERIALS AND METHODS

Materials of environmental passports of administrative regions were used to analyse the structure of the land fund, which are available on the official website of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Environmental Protection and Natural Resources of Ukraine, 2023), materials of the state Geodetic cadastre (State Service of Ukraine..., 2023) as of 01.01.2023.

Analysis of the structure of the land fund of the west of Ukraine (Volyn, Rivne, Lviv, Ternopil, Khmelnytsky, Zakarpattia, Ivano-Frankivsk, Chernivtsi regions) was conducted in such categories as: agricultural land, forests and other forest-covered areas, built-up land, open wetlands, open land without vegetation cover or with little vegetation cover (sands, ravines, land occupied by landslides, rubble, pebbles, bare rocks), other land.

Geographical coordinates of the extreme points of the research region: in the north 25°15'33", 51°58'09", south 24°53'05", 47°43'26", west 22°08'31", 48°25'43" and the east 27°54'05", 49°11'10". The following administrative regions belong to the territory of western

Ukraine (Fig. 1): Volyn (1), Rivne (2), Lviv (3), Ternopil (4), Khmelnytsky (5), Zakarpattia (6), Ivano-Frankivsk (7), and Chernivtsi (8). The construction of a map scheme for the west of Ukraine was conducted using Geoinformation technologies *MapInfo Professional 12.3. beta*.



Figure 1. Diagram-map of the research region

Source: compiled by the authors

For a more detailed comparison of the distribution of agricultural land throughout the study area, the following distribution was used: arable land, fallows, perennial plantings, hayfields, and pastures. The materials of the land directory of Ukraine were used (Land directory of Ukraine, 2023) to analyse the number of land plots (shares) and farms, compare the normative and monetary evaluation of land, the cost of renting 1 ha of public and private agricultural land.

Indicators in US dollars were used to conduct a normative and monetary evaluation of agricultural land in western Ukraine (arable land and perennial plantings), and to determine the cost of hayfields and pastures, the arithmetic mean between them was taken. Objective data on geographical, genetic-morphological, agrochemical, agrophysical, and other characteristics of soil composition and properties on various land plots and their suitability for farming are based on data from a large-scale soil survey (State standard of Ukraine, 4362:2004).

The indicator of soil fertility is considered, that is, its ability to meet the needs of plants for nutrients, water, air, and heat in sufficient quantities for their normal development, which together are the main indicator of soil quality. It is necessary to constantly monitor land to do this, that is, check the state of land to identify changes in a timely manner, assess them, prevent and eliminate the consequences of negative processes (State standard of Ukraine, 4362:2004). The above data are presented and compared in the study on the example of certain regions of western Ukraine.

The following classifications were used according to DSTU 4362:2004 to characterise soils by humus content: very low <1.1; low 1.1-2.0; medium 2.1-3.0;

increased 3.1-4.0; high 4.1-5.0; very high >5.0 (State standard of Ukraine, 4362:2004). To analyse the degree of availability and grouping of soils by the content of mobile forms of easily hydrolysed nitrogen, the following distribution was used: very low <100; low 101.0-150.0; medium 151.0-200.0; increased >200 (State standard of Ukraine, 4362:2004).

The following classifications were used to characterise soils by the content of mobile phosphorus compounds: very low <20; low 21-50; medium 51-100; increased 101-150; high 151-200; very high >200 (State standard of Ukraine, 4362:2004). To analyse soils by the content of mobile potassium compounds, the following distribution was used: very low ≤20; low 21-40; medium 41-80; increased 81-120; high 121-180; very high >180 (State standard of Ukraine, 4362:2004).

Materials from the land directory of Ukraine (Land directory of Ukraine, 2020) were used to analyse the normative and monetary evaluation of agricultural land and the number of shares of farms. The analysis of statistical materials and calculation of additional indicators was conducted using the Microsoft Excel 2020 computer programme.

RESULTS AND DISCUSSION

The land structure was formed as a result of the recognition of the independence of Ukraine and the approval of the administrative division of the state's territory. The total area of Ukraine is 60.3 million hectares, and agricultural land accounts for 41.4 million hectares, of which arable land is 32.7 million hectares, that is, the level of ploughed land is 54%, which is a much higher indicator compared to other European countries.

Therewith, such indicators may differ markedly at the level of different regions and regions of Ukraine. A detailed analysis of the structure of the land fund of certain regions of western Ukraine has shown that the largest total

areas (more than 2 million square meters) are in Volyn (2014.4 thousand hectares), Rivne (2005.1 thousand hectares), Lviv (2183.1 thousand hectares), and Khmelnytskyi (2062.9 thousand hectares) regions (Table 1).

Table 1. Structure of the land fund of the regions of western Ukraine, as of 01.01.2023

Administrative region	Indicators	Total area of the region	1. Agricultural land	2. Forests and forest-covered areas	3. Built-up land	4. Open wetlands	5. Open land without vegetation cover or with little vegetation cover	6. Other land
Volyn	thousand hectares	2014.4	1047.6	697.7	61.2	115.8	14.5	77.6
	%	100.0	52.01	34.63	3.04	5.75	0.72	3.85
Rivne	thousand hectares	2005.1	926.2	805.8	59.6	106.6	31.9	75.0
	%	100.0	46.19	40.19	2.97	5.32	1.59	3.74
Lviv	thousand hectares	2183.1	1240.0	694.7	115.6	9.4	30.5	92.9
	%	100.0	56.80	31.82	5.30	0.43	1.40	4.25
Ternopil	thousand hectares	1382.4	1046.2	201.7	63.7	5.9	18.5	46.4
	%	100.0	75.68	14.59	4.61	0.42	1.34	3.36
Khmelnyskyi	thousand hectares	2062.9	1566.2	287.6	85.1	20.2	24.1	79.7
	%	100.0	75.92	13.94	4.13	0.98	1.17	3.86
Zakarpattia	thousand hectares	1275.3	451.0	724.0	48.2	0.8	14.8	36.5
	%	100.0	35.36	56.77	3.79	0.06	1.16	2.86
Ivano-Frankivsk	thousand hectares	1392.7	621.2	635.7	63.4	2.5	22.4	47.5
	%	100.0	44.60	45.65	4.55	0.18	1.61	3.41
Chernivtsi	thousand hectares	809.6	469.7	258.0	40.1	1.2	9.8	30.8
	%	100.0	58.02	31.87	4.95	0.15	1.21	3.80
Total	thousand hectares	13125.5	7368.1	4305.2	536.9	262.4	166.5	486.4
	%	100.0	56.14	32.80	4.09	2.0	1.27	3.70

Source: official website of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Environmental..., 2023)

Notably, among these territories, the largest share of agricultural land falls on the Khmelnytsky region (75.92 %), while in other regions this indicator ranges from 35.36 to 75.68%. That is, as an example, in this area, it is necessary to conduct more enhanced control of the fertility of agricultural land and constantly fight various erosion processes. The share of the land category "forests and other forest-covered areas" in this region is the smallest – 13.94%, while in other western regions, the average percentage is about 36%. This once again underlines the importance of enhanced research and control of wind erosion in the region.

Slightly smaller land area is in Ivano-Frankivsk (1392.7 thousand hectares), Ternopil (1382.4 thousand

hectares), Zakarpattia (1275.3 thousand hectares) regions, and the smallest in Chernivtsi (809.6 thousand hectares). In the Ternopil region, the second most important category of land is agricultural land – 75.68% and forests and other forest-covered areas – 14.59% are of the lowest value. That is, in this area, there is also a need for increased control over the management of agriculture, as in the above case.

The built-up land category in all regions of western Ukraine does not differ substantially – from 2.97 to 5.30%. The situation is similar to open lands without vegetation cover or with little vegetation cover – from 0.72 to 1.61%. Only in two regions (Volyn and Rivne), does the category of "open wetlands" account for the

maximum indicators (5.75% and 5.32%, respectively), while in other regions, this value ranges from 0.06 to 0.98%.

The share of the other lands category in the examined areas ranges from 2.86% to 4.25%. This analysis showed the difference in the land structure of various administrative regions of Ukraine and, importantly, where exactly it is necessary to implement soil conservation measures constantly.

A detailed analysis of the structure of agricultural land and its distribution by categories “arable land”, “fallow”, “perennial plantings”, “hayfields and pastures” in the regions of western Ukraine is presented in Table 2. Thus, the distribution of agricultural land in the west of Ukraine is quite diverse. The largest area is arable land (69.77% of the total area of agricultural land) and hayfields and pastures (27.69%). The share of fallows (0.14%) and perennial plantings (2.40%) is insubstantial.

Table 2. Distribution of agricultural land areas by administrative regions of western Ukraine, as of 01.02.2023

Administrative region	Total area of the region thousand hectares	Indicators	Agricultural land				
			Total	including			
				arable land	perelogs	perennial plantings	hayfields and pastures
Volyn	2014.4	thousand hectares	1047.6	672.6	-	11.7	363.3
		%	100.0	64.20	-	1.12	34.68
Rivne	2005.1	thousand hectares	926.2	656.8	3.5	11.7	254.2
		%	100.0	70.91	0.38	1.26	27.45
Lviv	2183.1	thousand hectares	1240.0	770.9	-	22.8	446.3
		%	100.0	62.17	-	1.84	35.99
Ternopil	1382.4	thousand hectares	1046.2	856.4	3.4	15.7	170.7
		%	100.0	81.86	0.32	1.50	16.32
Khmelnyskyi	2062.9	thousand hectares	1566.2	1252.7	1.2	41.6	270.7
		%	100.0	79.98	0.08	2.66	17.28
Zakarpattia	1275.3	thousand hectares	451.0	200.2	-	27.3	223.5
		%	100.0	44.39	-	6.05	49.56
Ivano-Frankivsk	1392.7	thousand hectares	621.2	400.6	2.2	15.5	202.9
		%	100.0	64.49	0.35	2.50	32.66
Chernivtsi	809.6	thousand hectares	469.7	330.7	-	30.3	108.7
		%	100.0	70.41	-	6.45	23.14
Total	13125.5	thousand hectares	7368.1	5140.9	10.3	176.6	2040.3
		%	100.0	69.77	0.14	2.40	27.69

Source: official website of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Environmental..., 2023)

The share of arable land from the total area of agricultural land in the structure of all the administrative regions examined is the largest. The maximum share of arable land is in Ternopil (81.86%) and Khmelnytskyi (79.98%) regions. A slightly smaller share of these lands is represented in Rivne (70.91%), Chernivtsi (70.41%), Ivano-Frankivsk (64.49%), Volyn (64.20%), Lviv (62.17%), and Zakarpattia (44.39%) regions, respectively.

The area of hayfields and pastures throughout the west of Ukraine is 2040.3 thousand hectares. Thus, the share of this category of land in administrative regions ranges from 16.32% (Ternopil region) to 49.56% (Zakarpattia region) of the total area of agricultural land.

The total area of perennial plantings in the west of Ukraine is 176.6 thousand hectares. Thus, its share in administrative regions varies from 1.12% (Volyn region) to 6.45% (Chernivtsi region). The area of fallow areas is insubstantial (10.3 thousand hectares). This category of land occurs only in Rivne (3.5 thousand hectares), Ternopil (3.4 thousand hectares), Ivano-Frankivsk (2.2 thousand hectares), and Khmelnytskyi (1.2 thousand hectares). Its share in the represented regions ranges from only 0.08% to 0.38%.

For the economically rational conduct of agricultural work in a certain territory, it is also necessary to constantly carry out its normative and monetary evaluation.

A comparison of the value of different categories of agricultural land in the administrative regions of western Ukraine clearly illustrates certain features. The normative and monetary evaluation is one of several types of assessments provided for by the law of Ukraine "On

Land Valuation", the calculation of which is based on rental income from the use of a land plot for a certain period of time. The normative and monetary evaluation of agricultural land in administrative regions of western Ukraine is presented in Table 3.

Table 3. Normative and monetary evaluation of agricultural land in administrative regions of western Ukraine, USD/1 ha*

Administrative region	Cost, USD/ ha				
	Arable land	Perennial plantings	Hayfields	Pastures	Middle ground between hayfields and pastures
Volyn	888.2	1684.3	246.0	182.4	214.2
Rivne	893.6	1510.1	206.6	150.7	178.7
Lviv	875.4	1103.5	236.2	166.6	201.4
Ternopil	1182.7	2323.2	255.8	230.1	243.0
Khmelnyskyi	1241.4	2148.9	275.5	214.2	244.8
Zakarpattia	1110.7	1510.1	265.7	214.2	239.9
Ivano-Frankivsk	1062.6	1510.1	196.8	182.4	189.6
Chernivtsi	1354.9	2555.5	226.3	206.2	216.3
Average	1076.2	1793.2	238.6	193.4	216.0

Note: *As of 01.01.2020, the average exchange rate of 1 dollar was 24.55 UAH

Source: Land directory of Ukraine (Land directory of Ukraine, 2020)

Thus, the value of land according to the normative and monetary evaluation in the examined administrative regions varies substantially. The average value of arable land is \$1,076.2, perennial crops – \$1,793.2, hayfields – \$238.6, pastures – \$193.4. The total value of

agricultural land in western Ukraine is about 6.3 billion dollars (Table 4). Thus, among them, arable land costs the most – 5.543 billion dollars, and the value of perennial plantations (330.47 million dollars) and hayfields and pastures (436.46 million dollars) is much lower.

Table 4. Normative and monetary evaluation of agricultural land in administrative regions of the west of Ukraine, USD million, as of 01.01.2023

Administrative region	Category of agricultural land			
	Arable land	Perennial plantings	Hayfields and pastures	Total
Volyn	597.42	19.71	77.82	694.95
Rivne	590.05	17.67	45.42	653.13
Lviv	674.88	25.16	89.87	789.90
Ternopil	1016.88	36.47	41.47	1094.82
Khmelnyskyi	1556.62	89.40	66.28	1712.30
Zakarpattia	222.36	41.22	53.62	317.21
Ivano-Frankivsk	428.02	23.41	38.47	489.90
Chernivtsi	448.08	77.43	23.51	549.02
Total	5534.31	330.47	436.46	6301.23

Source: compiled by the authors

The total value of agricultural land in western administrative regions varies. Thus, the highest value of these lands is in Khmelnytskyi (1.71 billion dollars)

and Ternopil (1.09 billion dollars) regions. The value of agricultural land is slightly lower in Lviv (USD 789.90 million), Volyn (USD 694.95 million), Rivne

(USD 653.13 million), Chernivtsi (USD 549.02 million), Ivano-Frankivsk (USD 489.90 million), and Zakarpattia (USD 317.21 million) regions, respectively.

The cost of renting private and state-owned agricultural land in the examined administrative regions is

also different (Fig. 2). Thus, the average cost of 1 ha of state land costs 3553 UAH, and private 1497 UAH. The cost of renting state-owned agricultural land in the west of Ukraine ranges from UAH 1442 (Volyn region) to UAH 7781 (Khmelnitskyi region).

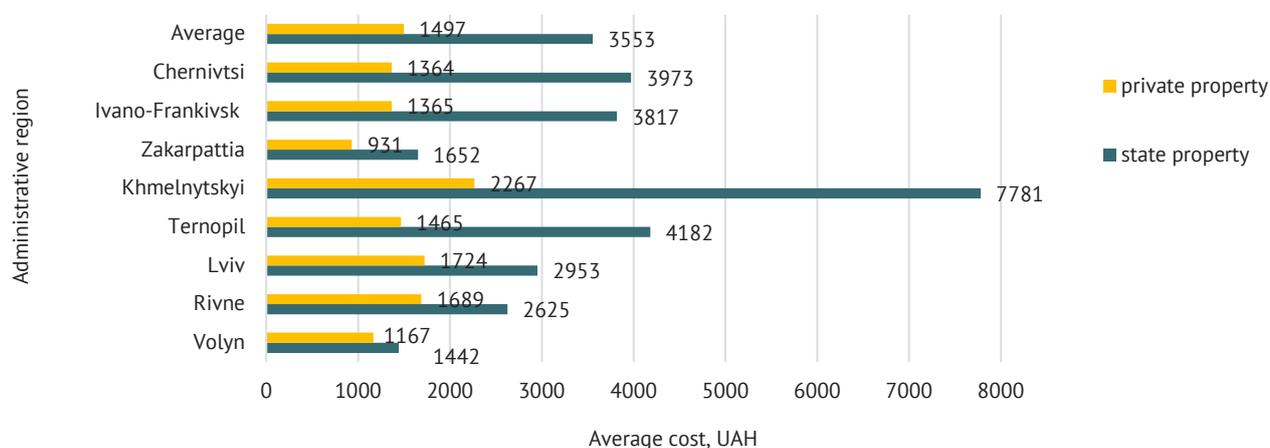


Figure 2. The cost of renting agricultural land in the administrative regions of western Ukraine, UAH

Source: Land directory of Ukraine (2020)

The cost of renting private agricultural land in the research region varies from UAH 931 (Zakarpattia region) to UAH 2267 (Khmelnitskyi region). On the territory of western Ukraine, 1420223 shares were leased. Thus, the largest number of shares was leased in Khmelnitskyi (25.2% of the total number of units

on the territory of the research facility) and Ternopil regions (20.7%). Slightly less in the Lviv region – 17.9%. The share of leased units in Ivano-Frankivsk, Rivne, Volyn, and Chernivtsi ranges from 6.2 to 11.5%, and the least in the Zakarpattia region – only 1.0% (Table. 5).

Table 5. Distribution of the number of shares and their area in the administrative regions of western Ukraine, as of 01.01.2023

Administrative region	Number of shares		Area	
	thousand units.	%	thousand hectares	%
Volyn	109.1	7.68	212.0	8.93
Rivne	139.4	9.81	280.0	11.80
Lviv	253.6	17.85	312.0	13.15
Ternopil	294.1	20.71	513.0	21.62
Khmelnitskyi	358.2	25.22	803.0	33.84
Zakarpattia	13.6	0.96	20.0	0.84
Ivano-Frankivsk	163.7	11.53	123.0	5.18
Chernivtsi	88.6	6.24	110.0	4.64
Total	1420.3	100	2373.0	100

Source: compiled by the authors

Comparative analysis of arable land areas (Table 2) and the area of shares showed that the largest providers of land for lease are Khmelnitskyi (64.1% of the total amount of arable land in the region) and Ternopil regions (59.9% of the total amount of arable land in the region).

In Volyn, Rivne, Lviv, Ivano-Frankivsk, and Chernivtsi regions, the share of land leased ranges from 30.7% to 42.6%, and the smallest in the Zakarpattia region – 10%. There are 7 105 farms operating in the west of Ukraine (Table 6). Most of these farms are concentrated in Ternopil (19.5% of the total number

of farms on the territory of the experimental facility), Khmelnytskyi (18.8%), Zakarpattia (18.6%), and Lviv (16.2%) regions. A slightly smaller share of farms

is concentrated in Volyn (10.7%), Rivne (9.0%), and Ivano-Frankivsk (6.1%) regions, and the smallest in Chernivtsi region (1.1%).

Table 6. Distribution of the number of farms and the area of land that they cultivate in the administrative regions of Ukraine, as of 01.01.2023

Administrative region	Number of farms		Total land cultivated by farms		On average, per farm
	units	%	thousand hectares	%	thousand hectares
Volyn	759	10.68	67	20.25	0.088
Rivne	642	9.04	33	9.98	0.051
Lviv	1149	16.17	52	15.72	0.045
Ternopil	1386	19.51	77	23.28	0.056
Khmelnytskyi	1339	18.85	75	22.67	0.056
Zakarpattia	1324	18.63	9.3	2.81	0.007
Ivano-Frankivsk	430	6.05	17	5.14	0.040
Chernivtsi	76	1.07	0.5	0.15	0.007
Total	7105	100.0	330.8	100.0	0.04

Source: Land directory of Ukraine (2020)

The total area of land cultivated by 7 105 farms is 330.8 thousand hectares. Thus, the largest share of these lands is concentrated in Ternopil (23.28% of the total area of land cultivated by farmers on the studied territory), Khmelnytskyi (22.67%), Volyn (20.25%), Lviv (15.72%), Rivne (9.98%) regions. In the Ivano-Frankivsk, Zakarpattia, and Chernivtsi regions, this share ranges from 0.15 to 5.14%.

On the studied territory, on average, one farm accounted for 0.04 thousand hectares. Thus, the largest average land area of farms was recorded in Volyn (0.088 thousand hectares), Ternopil (0.056 thousand hectares), Khmelnytskyi (0.056 thousand hectares), Lviv (0.051 thousand hectares), Rivne (0.045 thousand hectares), and Ivano-Frankivsk (0.040 thousand hectares) regions, respectively. In the Zakarpattia and Chernivtsi regions, this figure is 0.007 thousand hectares.

Humus is the main source of nutrients in the soil. The higher the humus content in the soil, the greater its fertility. The preservation and accumulation of humus is the basis of soil fertility. Constant monitoring of the proportion of soil areas with different humus content, mobile compounds of phosphorus and potassium is of great importance in examining the efficiency of land resource use. The analysis of the presented data for various administrative regions of western Ukraine shows that most of the areas are occupied by groups with average and increased levels according to all three characteristics. Therewith, there are certain features in particular areas that must be considered in detail.

Thus, for example, in terms of humus content in the Volyn region, very low (18.2%) and low (69.7%) levels substantially exceed all other levels for this region, and

for other regions, the value for the very low level ranges from 0 to 2.1%, and the low level is more substantial – from 1.3 (Ternopil region) to 43.6% (Rivne region).

Significant indicators of the share of humus content reaching a high level were recorded in five regions at once: Lviv (7.7%), Ternopil (4.9%), Khmelnytskyi (7.3%), and Zakarpattia (7.8%). The maximum share value for this level is typical for the Ivano-Frankivsk region (15.0%), and the minimum value is typical for the Volyn region (0.1%). In the other two areas, this value ranges from 1.2% to 3.5%. The share of land with a very high level of humus content in the soil is completely absent in the Volyn and Ternopil regions. However, in all other regions, the share of such soils is insubstantial and does not exceed 4.8% (Lviv region).

The weighted average humus content is most valuable in Ternopil (3.25 mg/kg), Khmelnytskyi (3.24 mg/kg), and Ivano-Frankivsk regions (3.17 mg/kg). The minimum value of this indicator is typical for the Volyn region (1.53 mg/kg). In all other regions, the weighted average humus content is more or less similar and ranges from 2.26 to 2.73 mg/kg (Table 7). On average, for the examined region of western Ukraine, this indicator is 2.7 mg/kg.

There is a similar case with the distribution of the proportion of soil areas in the examined areas by the content of mobile phosphorus compounds. Most areas have the largest share for the average and increased groups. Only in the Zakarpattia and Ivano-Frankivsk regions, high values are typical for the very low (26.7 and 20.8%) and low (15.5 and 21.3%) groups. For the group "high" level of the content of mobile phosphorus compounds, the highest value was determined for

the Volyn (24.0%), Rivne (23.1%), and Lviv (26.6%) regions. In all other regions, the indicators are slightly lower and range from 5.9% (Ternopil region) to 15.7% (Ivano-Frankivsk and Chernivtsi regions).

The maximum and rather substantial share for the “very high” level is set for the Lviv region (14.3 %). In all other administrative regions, from 0 % (Ivano-Frankivsk region) to 7.1% (Rivne region). The weighted average index for the content of mobile phosphorus compounds in all eight regions ranges from 81 mg/kg (Ivano-Frankivsk region) to 136 mg/kg (Lviv region). The average for the entire examined region of western Ukraine is 105.5 mg/kg.

Comparison of mobile potassium compounds in the regions of the examined region of western Ukraine

showed that the maximum values for the different levels differ in virtually all regions. Thus, the maximum value for a low level of the content of mobile potassium is typical for Volyn (43.2%) and Rivne (33.4%) regions. For the medium level group, the maximum share is set for the Volyn (34.2%) region. Increased potassium levels are observed in Ternopil (53.4%) and Khmelnytsky regions (55.6%) high – in Ivano-Frankivsk (32.0%) and Chernivtsi (44.9%).

Areas, where there are no mobile potassium compounds, were identified. For example, in the Ternopil region, there are no areas with very low and low levels, in Khmelnytskyi – very low, and in Ivano-Frankivsk – very high levels of potassium content (Table. 7).

Table 7. The share of soil areas by the content of humus, mobile compounds of phosphorus and potassium in the administrative regions of western Ukraine, as of 01.01.2023, %

Administrative region	very low, %	low, %	medium, %	increased, %	high, %	very high, %	weighted average index, mg/kg
<i>Humus content</i>							
Volyn	18.2	69.7	11.3	0.8	0.1	0.0	1.53
Rivne	1.7	43.6	40.7	12.6	1.2	0.2	2.26
Lviv	1.7	25.5	32.6	27.7	7.7	4.8	2.80
Ternopil	0.0	1.3	26.4	67.4	4.9	0.0	3.25
Khmelnytskyi	0.1	4.6	30.4	57.4	7.3	0.2	3.24
Zakarpattia	2.1	28.1	40.3	18.5	7.8	4.2	2.73
Ivano-Frankivsk	0.1	10.0	37.4	34.6	15.0	2.9	3.17
Chernivtsi	0.0	29.0	51.3	14.7	3.5	1.5	2.50
Average for the experiment region	3.0	26.5	33.8	29.2	5.9	1.7	2.7
<i>Content of mobile phosphorus compounds</i>							
Volyn	0.6	8.9	31.9	34.3	24.0	0.3	120.0
Rivne	8.6	14.0	27.5	19.7	23.1	7.1	114.9
Lviv	0.7	3.7	26.3	28.4	26.6	14.3	136.9
Ternopil	0.0	0.3	34.3	59.4	5.9	0.1	112.0
Khmelnytskyi	0.1	3.1	39.2	43.4	9.4	4.8	107.8
Zakarpattia	26.7	15.5	23.7	13.3	14.6	6.2	88.4
Ivano-Frankivsk	20.8	21.3	28.0	14.2	15.7	0.0	81.0
Chernivtsi	8.1	18.0	27.1	25.8	15.7	5.3	83.0
Average for the experiment region	8.2	10.6	29.8	29.8	16.9	4.8	105.5
<i>Content of mobile potassium compounds</i>							
Volyn	8.1	43.2	34.2	12.2	2.4	0.0	47.8
Rivne	30.7	33.4	18.4	10.8	5.8	0.9	75.2
Lviv	3.1	19.4	28.4	24.9	16.9	7.3	79.1
Ternopil	-	-	2.9	53.4	43.2	0.5	118.0
Khmelnytskyi	-	0.1	27.5	55.6	14.6	2.2	97.5
Zakarpattia	6.3	1.3	18.0	28.2	27.7	18.5	140.0
Ivano-Frankivsk	3.6	24.3	21.4	18.7	32.0	-	94.0

Table 7, Continued

Administrative region	very low, %	low, %	medium, %	increased, %	high, %	very high, %	weighted average index, mg/kg
Chernivtsi	2.4	7.7	11.9	13.3	44.9	19.8	149.0
Average for the experiment region	6.8	16.2	20.3	27.1	23.4	6.2	100.1

Source: official website of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Environmental..., 2023)

Thus, the results of the conducted studies show differences in the soils of the western regions of Ukraine in the content of humus, mobile compounds of phosphorus and potassium. It is essential information for the practical introduction of agriculture there.

According to the analysis of the distribution of soil areas in the western regions of Ukraine by the content of easily hydrolysable nitrogen (Table 8), it was established that for the "very low" group, the maximum value is typical for the Volyn region (75.6%). Ivano-Frankivsk (63.6%), Zakarpattia (47.5%), Chernivtsi (43.5%), and Rivne (42.1%)

regions also have quite high indicators of areas with a very low level. That is, in these five areas, it is necessary to handle the problem of increasing the nitrogen content right now. In the other three regions examined, this share is noticeably lower – Khmelnytskyi (18.7%), Lviv (16.5%), and in the Ternopil region, this indicator is minimal and amounts to only 3.5%. However, for this region, the maximum value of a low level (75.4%) was recorded. The minimum value of a low level is typical for the Volyn region (12.8%), while only there the values are several times smaller than all other regions, ranging from 35.3 to 65.5%.

Table 8. The share of soil areas by easily hydrolysed nitrogen content in the administrative regions of the west of Ukraine, as of 01.01.2023 %

Administrative region	very low	low	medium	increased	Weighted average index, mg/kg
Volyn	75.6	12.8	1.5	10.1	122.3
Rivne	42.1	36.3	12.3	9.3	125.3
Lviv	16.5	65.5	13.5	4.5	121.9
Ternopil	3.5	75.4	20.9	0.2	137.0
Khmelnytskyi	18.7	55.7	24.7	0.9	121.0
Zakarpattia	47.5	40.7	10.3	1.5	107.2
Ivano-Frankivsk	63.6	35.3	1.1	0.0	95.0
Chernivtsi	43.5	50.6	4.8	1.1	107.0
Average for the experiment region	38.9	46.5	11.1	3.5	117.1

Source: official website of the Ministry of Environmental Protection and Natural Resources of Ukraine (Ministry of Environmental..., 2023)

The lowest values of the nitrogen fraction of the average level are typical for Volyn (1.5%), Ivano-Frankivsk (1.1%), and Chernivtsi (4.8%) regions. In all other administrative regions, this share ranges from 10.3 to 24.7%. The highest values of the share of land with an increased level of nitrogen were recorded for Volyn (10.1%) and Rivne (9.3%) regions. Although they are not substantial, they are several times higher than in other areas where there is a fluctuation in the content of easily hydrolysed nitrogen in the range from 0.2 to 4.5%.

In the examined territory of the west of Ukraine, it is necessary to constantly introduce a scientifically based and ecological-reclamation system of farming, since in its absence, certain negative consequences of soil cover destruction, reduced soil fertility, reduced crop yields

and, as a result, an increase in economic losses for both the state and private farms are possible.

It is vital to conduct economically sound agriculture, especially in areas where soil conditions are already deteriorating and further negative changes are possible, such as wind and water erosion of the soil, increased land use and high levels of ploughed land. It is advisable to constantly monitor degraded land, reduce the area of unproductive soils, and identify areas that are subject to conservation and need reclamation.

Since 01.07.2021, the agricultural land market has been functioning in Ukraine. Thus, in the first stage, agricultural land up to 100 hectares per individual can be bought or sold (Transitional Provisions..., 2021). During the implementation of this reform, about 28 million

hectares of agricultural land is privately owned, and 56% is leased. In the process of their lease, a certain disproportionality arose between landowners and land users. In such circumstances, it is necessary to control the use of these lands by the state regarding their appropriate use and implementation of the environmental strategy. This experience can be learned from many foreign countries (Gorgan & Hartvigsen, 2022). For example, Maxim Gorgan and Morten Hartvigsen analysed the development of agricultural land markets in Eastern Europe and Central Asia based on materials from the Food and Agriculture Organisation of the United Nations (FAO).

The results of the study on agricultural land are to a certain extent confirmed by the findings of other researchers. In particular, Muzyka *et al.* (2019) establishes that the area of agricultural land in the west of Ukraine decreased by 29.8 thousand hectares (when comparing the area of agricultural land in 2023 with 2018). The largest decrease in agricultural land areas was identified in Lviv (20.8 thousand hectares), Ivano-Frankivsk (8.7 thousand hectares), Khmelnytskyi (2.0 thousand hectares), and Zakarpattia (0.3 thousand hectares) regions, while in Chernivtsi region it remained unchanged. The decrease in this category of land is caused by a change in its intended purpose. However, the area of agricultural land in some regions, on the contrary, increased: in Volyn (0.1 thousand hectares), Rivne (1.5 thousand hectares), and Ternopil (0.4 thousand hectares) regions by 2 thousand hectares. This may be caused by Russia's invasion of Ukraine, which has led to an increase in the area of agricultural land in the rear areas, as a substantial part of the land in the north, east, and south of Ukraine, where active military operations took place or are being conducted (World Bank, 2022), has become unusable.

According to Eurostat (Eurostat statistics..., 2020), as of 2020, there are 9.1 million farms in the European Union. In particular, the number of farms cultivating less than 5 hectares of agricultural land is 63.8% of the total number of farms in the EU. The area of farms in the EU depends on the geographical location (Thompson, *et al.*, 2022; Ulukan, *et al.*, 2022; Staniszewski, *et al.*, 2023), which is influenced by geomorphological, climatic conditions, and the location of the farm. The average area of farms in western Ukraine varies from 7 hectares (Zakarpattia and Chernivtsi regions) to 88 hectares (Chernivtsk region). In general, the average farm rate in the study region is 40 hectares, which is 8 times higher than in the European Union.

Ballabio *et al.* (2019; 2022) in their study developed a mapping of the chemical properties of the upper soil layer by the following chemical properties: pH, pH (CaCl), cation exchange capacity, calcium carbonates (CaCO₃), C:N ratio, nitrogen (N), phosphorus (P) and potassium (K). These chemical indicators vary within the limits of the indicators of the European Union countries.

Thus, on the territory of agricultural land in Italy, there is an increased level of phosphorus, its content is affected by the application of phosphorous and other types of fertilisers used in agriculture.

To optimise the use of agricultural land in western Ukraine, it is crucial to conduct an ecological and landscape organisation of the experimental territory, which includes four components. First, it is necessary to develop the territorial and landscape organisation of agroecosystems to ensure their optimal use. Secondly, an important stage is the agroecological evaluation of land, which will allow assessing the state of natural complexes and determining the possibility of their use for agricultural purposes. Third, it is important to conduct environmental optimisation of the structure of agricultural landscapes to ensure more sustainable and efficient use of land resources. Fourth, it is necessary to plan, organise, and manage the state of agroecosystems, ensuring their rational use and conservation.

CONCLUSIONS

The largest share is represented by agricultural land (56.14% of the total area of the land fund), while forests and other forest-covered areas account for slightly less (32.80%). The area of built-up land (4.09%), open wetlands (2.0%), open land without vegetation cover or with little vegetation cover (1.27%) and other land (3.70%) is small.

It was established that the largest share is represented by arable land – 69.77% of the total area of agricultural land and hayfields and pastures (27.69%), the rest is occupied by perennial plantings (2.40%) and fallows (0.14%). The total value of agricultural land in western Ukraine is 6.3 billion dollars. Among them, arable land costs the most – 5.53 billion dollars, and the value of perennial plantations (316.68 million dollars) and hayfields and pastures (436.46 million dollars) is much lower.

The average cost of renting state agricultural land in western Ukraine ranges from UAH 1442 in the Zakarpattia region to UAH 7781 in the Khmelnytskyi region, while the cost of renting private land varies from UAH 931 in the Zakarpattia region to UAH 2267 in Khmelnytskyi Oblast. 1 420.3 shares were leased in the west of Ukraine. The largest number of shares was leased in Khmelnytskyi (25.22%) and Ternopil (20.71%) regions, and the smallest in the Zakarpattia region – 0.96%. There are 7105 farms operating in western Ukraine. Most farms are concentrated in Ternopil (19.51% of the total number), Khmelnytskyi (18.85%), Zakarpattia (18.63%), and Lviv (16.17%) regions, and the least – in Rivne (9.04%), Ivano-Frankivsk (6.05%), and Chernivtsi (1.07%).

The largest average land area of farms was recorded in Volyn (0.088 thousand hectares), Ternopil (0.056 thousand hectares), Khmelnytskyi (0.056 thousand hectares), Lviv (0.051 thousand hectares), Rivne (0.045 thousand hectares), and Ivano-Frankivsk (0.040 thousand hectares) regions, respectively. In the

Zakarpattia and Chernivtsi regions, this figure is 0.007 thousand hectares. On the territory of western Ukraine, the shares of soil areas in terms of humus content in various administrative regions differ markedly. The average value of the share of soil areas of the study region by humus content with the highest indicators was determined for the following levels: average (33.8%), high (29.2%), and low (26.5%). Other levels are characterised by substantially lower indicators: high (5.9%), very low (3.0%), and very high (1.7%).

The distribution of the proportion of soil areas by the level of phosphorus and potassium compounds for both the entire region under study and individual regions also differs substantially. The highest proportion of phosphorus and potassium compounds is: medium (29.8 and 20.3%), increased (29.8 and 27.1%), high (16.9 and 23.4%), respectively, the lowest – very low (8.2 and 6.8%), low (10.6 and 16.2%), and very high (4.8 and 6.2%). When dividing the proportion of soil areas by the

content of easily hydrolysed nitrogen, certain differences are also established. Thus, the largest share for the entire studied region falls on the “very low” (38.9%) and “low” (46.5%) levels, and the smallest values – on the “average” (11.1%) and “high” levels (3.5%).

Thus, to preserve and increase soil fertility, and its protection on the research territory, it is necessary to introduce scientifically based systems and technologies for using fertilisers and chemical land reclamation based on data from agrochemical certification of agricultural land. Further studies should be aimed at preserving soil fertility and the balanced use of agricultural land in Ukraine.

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Absent.

CONFLICT OF INTEREST

Absent.

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Аналіз структури, родючості сільськогосподарських земель Заходу України та їх грошова оцінка

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Анотація. Важливим сектором економіки України є сільське господарство, яке базується на родючості сільськогосподарських земель, зокрема земель західного регіону України. Аналіз структури, родючості сільськогосподарських земель, їх грошова оцінка може надати уявлення про їх продуктивність та потенціал для розвитку сільського господарства. Метою роботи є аналіз структури та показників родючості сільськогосподарських земель заходу України, демонстрування їх основних характеристик та порівняння цін на землю в західних областях України. Під час написання статті використовували матеріали земельного довідника України та регіональних доповідей про стан навколишнього середовища заходу України, послуговуючись методами аналізу та порівняння стану земельних ресурсів за вмістом гумусу, рухомих сполук фосфору та калію, азоту, що легко гідролізується, їх матеріально-грошової оцінки. Проаналізувавши структуру земельного фонду заходу України (13125,5 тис. га) було становлено, що сільськогосподарські угіддя становлять більше половини загальної площі (56,1 %), а ліси та інші лісовкриті площі – близько третини загальної площі (32,8 %). Забудовані землі, відкриті заболочені землі, відкриті землі без рослинного покриву або з незначним рослинним покривом та інші землі становлять менше 10 %. Серед сільськогосподарських земель найбільшу частку становить рілля, дещо менше припадає на сіножаті та пасовища, а найменше – на багаторічні насадження та перелоги. Загальна вартість сільськогосподарських земель у західних адміністративних областях помітно відрізняється. Найвища вартість земель у Хмельницькій та Тернопільській областях (1,71 і 1,09 млрд. дол), а найменша – в Івано-Франківській та Закарпатській (489,90 і 317,21 млн. дол). На території заходу України здано в оренду 1420223 паїв. Найбільша їх кількість здана в Хмельницькій та Тернопільській областях (25,2 та 20,7 %), а найменша – у Закарпатській (1,0 %). Так, загальна площа землі, що обробляється фермерськими підприємствами, становить 330,8 тис. га, найбільша частина зосереджена в Тернопільській та Хмельницькій областях (23,3 і 22,7 %). Результати досліджень сприятимуть прийняттю управлінських рішень ведення ефективного сільського господарства та збереження родючості ґрунтів сільськогосподарських земель досліджуваного регіону. Грошова оцінка даних територій є корисною для населення країни в умовах зміни закону про ринок землі в Україні, а також під час здійснення екологічно виваженої аграрної політики

Ключові слова: земельний фонд; пасовища; гумус; земельні паї; сільськогосподарські угіддя; адміністративна область