



Ecological and Agrochemical Condition of Soils of L'viv Region of Ukraine as a Basis of Their Investment Attractiveness

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Abstract

The use of ecological and agrochemical indicators to assess the agro-industrial properties of soils and the formation of a system of indicators of regional investment attractiveness of soils of agricultural lands is the basis for intensive development of the agro-industrial complex of L'viv region of Ukraine. The following parameters are important for assessing the investment attractiveness of land soils: the content of humus and mobile compounds of Phosphorus and Potassium in soils, the reaction of soil solution, as well as calculations of the balance of humus and nutrients. The proposed indicators of investment attractiveness of soils of L'viv region are the key to the introduction of a balanced type of land use, which is characterized by high crop yields and a deficit of nutrients in the soil, and thus minimize possible investment risks.

Keywords: ecological and agrochemical indicators; soils of L'viv region; investment attractiveness, soils of agricultural lands; soil fertility.

Yatırım Çekiciliğinin Temeli Olarak Ukrayna'nın L'viv Bölgesindeki Toprakların Ekolojik ve Zirai Kimyasal Durumu

Öz

Toprakların tarımsal-endüstriyel özelliklerini değerlendirmek için ekolojik ve tarımsal kimyasal göstergelerin kullanılması ve tarım arazilerinin topraklarının bölgesel yatırım çekiciliği göstergelerinin bir sisteminin oluşturulması, L'viv bölgesinin tarımsal-sanayi kompleksinin yoğun gelişiminin temelidir. Ukrayna. Arazi topraklarının yatırım çekiciliğini değerlendirmek için aşağıdaki parametreler önemlidir: topraklardaki humus ve hareketli Fosfor ve Potasyum bileşiklerinin içeriği, toprak çözeltisinin reaksiyonu ve ayrıca humus ve besin dengesi hesaplamaları. L'viv bölgesi topraklarının yatırım çekiciliğine ilişkin önerilen göstergeler, yüksek mahsul verimi ve topraktaki besin eksikliği ile karakterize edilen dengeli bir arazi kullanımı türünün getirilmesinin anahtarıdır ve böylece olası yatırım risklerini en aza indirir.

Anahtar Kelimeler: ekolojik ve zirai kimyasal göstergeler; L'viv bölgesi toprakları; yatırım çekiciliği, tarım arazilerinin toprakları; toprak verimliliği.

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1. Introduction

The area of L'viv region is 21.8 thousand km², which is 3.6% of the area of Ukraine. Population- 2.52 million people [17].

The northern part of the region lies within the Volyn Upland, Male Polissya and Podil Upland, separated by the Dniester Valley from the Pre-Carpathians. The ridges of the Ukrainian Carpathians are located in the south-west of the region [17].

L'viv region is characterized by diversity and richness of soil resources, as its territory is located within different soil-geographical areas.

According to a comprehensive assessment of land use of agricultural enterprises in the regions of Ukraine in terms of the value of agricultural land L'viv region is characterized by an average (satisfactory) level of investment attractiveness, and the level of economic soil fertility (land productivity) of agricultural enterprises- a sufficient level of investment attractiveness [7].

The main criterion that determines the priority areas of agricultural land use for various lands and crops, in addition to logistical aspects is the presence of productive soils with a strong humus horizon, significant content and reserves of humus, deficit-free balance of nutrients, favorable acid-air properties. mode. Actually, morphological features of soils (thickness of humus horizon), its properties (content of humus, physical clay, pH, content of mobile compounds of Phosphorus and Potassium) are the basis of qualitative assessment of agricultural lands (soil grading, economic assessment of lands, normative monetary assessment of land plots) [18].

Morphological and physicochemical properties of soils, which are the basis for quality assessment of agricultural soil groups within the natural-agricultural areas of L'viv region, are quite dynamic and necessitate the re-assessment of land once every 5-7 years. However, large-scale soil surveys have not been conducted in Ukraine for 30 years, which makes it impossible to conduct repeated land valuation works. Thus, the most reliable and dynamic information on the state of soils of agricultural lands of the region contain the results of agrochemical surveys, which should be used to improve the criteria for regional assessment of investment attractiveness of land.

A comprehensive analysis of recent publications shows that the issue of investment is studied both from a theoretical and practical point of view. Scientific publications widely cover issues related to innovation and investment activities in the agricultural sector ([7], [10]), methodological directions of forming the value of land resources ([2], [3]), problems of economic evaluation of investment attractiveness of land use of agricultural enterprises of Ukraine ([1], [2]) and others.

Theoretical and methodological provisions for assessing the investment attractiveness of soils are presented in the works of V.V. Medvedev and others [10]. They initiated a study to assess the investment attractiveness of Ukrainian lands on the basis of an integrated assessment of soil fertility, climatic and agricultural characteristics of land, which allows to establish their comparative investment attractiveness for growing crops. According to V.V. Medvedev, this will provide the necessary prerequisites for high and environmentally friendly crop yields and allow the use of modern agricultural technologies that give maximum effect if they are adapted to soil-climatic and ecological-economic conditions [10]. A promising area for

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assessing the investment attractiveness of soils is a generalized rating of soils, which is based on the assessment of ecosystem services - the suitability of soils for growing demanding and undemanding field crops, as well as a number of soil and climatic criteria [1]. Within the Carpathian region of Ukraine, it is proposed to assess the investment attractiveness of soils, taking into account the indicators of the structure of the soil cover, which is characterized by heterogeneity, diversity and mosaic ([12]-[14], [18]).

2. Material and Method

Information on ecological and agrochemical indicators of soils of L'viv region is obtained from materials of agrochemical certification of agricultural lands of L'viv region (9 rounds of agrochemical survey have been conducted since 1964) and partly from materials of large-scale soil survey with further adjustment (1957-1961) ([9], [15], [17]). The monographic works of the series "Soils of Ukraine" of the staff of the Department of Soil Science and Soil Geography of Ivan Franko National University of L'viv and the electronic map of soils of L'viv region created at the Department of Soil Science and Soil Geography ([4], [5], [8], [13], [16], [17]). The research used a comprehensive systematic approach to determine the investment attractiveness of soils of L'viv region on the basis of their ecological and agrochemical indicators, the results of the balance method of calculations of nutrients and humus, as well as methods of mathematical statistics. The nomenclature of soils of L'viv region is submitted in accordance with the Word Reference Base for Soil Resources (WRB 2015) [6].

3. Results and Discussion

Favorable physical and geographical location of the L'viv region of Ukraine in relation to the European Union, transport accessibility, a fairly high level of economic soil fertility (land productivity), a significant share of agricultural land in the land structure and the possibility of growing crops necessitate the formation of reliable systems of indicators of regional investment attractiveness of soils of agricultural land plots for the needs of foreign and domestic investors, especially during the implementation of Ukraine's European integration strategy.

The structure of the soil cover of L'viv region is dominated by Albic Retisols (Arenic) 432.2 thousand hectares (17.9%), and the main areas of their distribution are confined to Male Polissya, Nadsyannia and Eastern Carpathian Foothills. About 54% of these soils are used in agricultural production, and the rate of their plowing is 33.2%. Dystric Cambisols in the region occupy 306.2 thousand hectares (14%) and dominate in the mountains. The rate of agricultural development of Dystric Cambisols is 65.1% and plowing - 16.8%. In the structure of soil resources of the region Luvic Greyzemic Phaeozems occupy an area of 264.1 thousand hectares (12.1%). The indicator of agricultural development of Luvic Greyzemic Phaeozems is 58.1%, plowing - 50.6%. A significant share in the structure of soil resources of the region is occupied by Phaeozems (4.1%), Chernic Rendzic Phaeozems (Aric) (2.1%) and Haplic Chernozems - 2.6% of the total soil area. They are marked by the highest indicators of agricultural development: 75.2%, 67% and 78.6%, respectively. Hydromorphic soils are characterized by considerable agricultural development due to large-scale drainage reclamation: Histic Gleysols (94.7%), Gleysols (84.2%), Histic Gleysols (82.5%), Histosols (72.1%). The vast majority of these soils are used as

hayfields and pastures, as evidenced by the rate of plowing of these soils, which ranges from 0.5 to 5.2) ([15], [17]).

Albic Retisols (Arenic) (15.2%), Dystric Cambisols (14.6%), Luvic Greyzemic Phaeozems (11.2%), Gleyic Chernic Phaeozems (Pachic) dominate in the structure of soils of agricultural lands of L'viv region) and Arenosols (Ochric) (8.3%).

Thus, the presence of Phaeozems, Chernic Rendzic Phaeozems (Aric) and Haplic Chernozems and Luvic Greyzemic Phaeozems with high fertility potential, as well as quite large areas of soil with high profitability is a favorable factor in the investment attractiveness of land use of agricultural enterprises in L'viv region.

Increased level of development (agronomization), i.e their excessive plowing, exceeding the level of allowable mechanical load, a significant share of row crops in crop rotations and unregulated technologies are common causes of soil degradation in L'viv region, including their erosion. At the same time, to some extent, the modern system of agriculture is also affected, which is characterized by imbalance and insufficient use of soil protection technologies [17].

We propose to assess the investment attractiveness of soils of L'viv region of Ukraine taking into account ecological and agrochemical indicators of soils, first of all, content of humus and mobile compounds of Phosphorus and Potassium in soils, pH of

soil solution, content and balance calculations in soils of organic matter and nutrients.

The level of potential soil fertility is assessed primarily by the content of organic matter or humus, because it concentrates about 98% Nitrogen, 60% Phosphorus, 80% Sulfur and a significant number of other macro-and micronutrients ([2], [3], [11]).

The largest area ($\approx 40\%$ of arable land in L'viv region) is occupied by soils with an average humus content (2.1% - 3.0%), which are distributed mainly within the Volyn and Podil uplands. The area of soils with very low and low content is $\approx 30\%$ (common within Male Polissya and Eastern Carpathian Foothills), elevated- 20%, high and very high - 10% (typical for the Podolsk part of the region) (Table 1).

According to the materials of agrochemical certification of agricultural lands, the weighted average humus content in the soils of arable lands of L'viv region ranged from 2.26% in 1991–1995 to 2.67% in 2011–2015. The largest losses (-0.23%) were found for period between 1986 and 1996 agrochemical survey. Crucial to a significant reduction in humus losses and its restoration are the introduction of a scientifically sound system of crop rotation, including expanding the area under perennial legumes, green manure and optimizing the ratio of crop rotations and row crops, the use of crop residues in crop production. crop rotation and the quantity and quality of applied organic fertilizers.

Table 1. Distribution of area land of L'viv region by humus content [17]

Years of Survey	Surveyed area K. ha	Soil area by humus content											
		Very low		Low		Average		Increased		High		Very high	
		< 1		1.1–2.0		2.1–3.0		3.1–4.0		4.1–5		> 5	
		K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%
2001–2005	547.4	5.3	1	164.3	30	205.5	38	89.0	16	47.5	9	35.8	7
2006–2010	610.8	24.2	4	210.0	34	208.4	34	103.0	17	38.4	6	26.6	4
2011–2015	497.6	8.0	2	148.2	30	192.1	39	98.1	20	31.4	6	19.9	4

One of the important criteria for investment attractiveness of soils, which affects their potential fertility and suitability for growing different crops, is the pH_{KCl} of the soil solution. Given the predominant share in the structure of crop rotations of cereals and legumes, soil acidity is a limiting factor and is the basis for the development of measures for their balanced use and protection. It is established that the area of acid soils of arable lands of the region is $\approx 35\%$ of the surveyed lands, of which 4.5% - strongly acidic, 12% - medium acidic and 18.5% - weakly acidic (Table 2) [11]. Strongly acid soils are distributed mainly within

the Ukrainian Carpathians and Pre-Carpathians, as well as in Male Polissya (pH_{KCl} 4.5 – 6.0). Within the Volyn and Podil uplands, where soils were formed mainly on the parent rocks of the forest formation, as well as on the eluvium-deluvium of carbonate rocks, their acidity is close to neutral (pH_{KCl} 5.6 – 6.0). As a result, the investment attractiveness of such soils increases.

The area of weakly and moderately acid soils is constantly increasing due to the reduction of soil areas with a neutral reaction of the soil solution.

Table 2. Distribution of area areas by pH_{KCl} indicators [17]

Years of Survey	Surveyed area, K. ha	Soil areas by indicators pH _{KCl}											
		Strongly acidic		Average acidic		Weakly acidic		Total acidic		Close to neutral		Neutral	
		< 4.5		4.6–5.0		5.1–5.5				5.6–6.0		> 6.0	
		K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%
1986–1990	748.2	32.3	4	67.7	9	114.3	15	214.3	29	152,8	20	381.2	51
1991–1995	571.7	8.7	2	40.6	7	85.6	15	134.9	24	125.0	22	311.9	55
1996–2000	436.6	5.6	1	20.7	5	48.0	11	74.3	17	82.8	19	279.5	64
2001–2005	547.4	12.4	2	37.7	7	81.6	15	131.7	24	115.5	21	300.2	55
2006–2010	610.8	26.7	4	68.3	11	118.4	19	214.8	35	114.7	19	281.3	46

The main causes of acidification are the absence or insufficient amount of chemical reclamation, the application of physiologically acidic fertilizers, as well as the removal of Calcium and Magnesium from the crop. Thus, optimizing the reaction of the soil solution by liming acid soils is an important way to reproduce the potential fertility of soils and increase their investment attractiveness.

At the same time, changes in market conditions and demand for crops, which form the optimal yield in the range of pH_{KCl} 3.5 – 4.5 soil solution (blueberries, flax, hemp, etc.) can not only

reduce the cost of chemical reclamation, in particular medium and strongly acid soils, as well as to involve low-productive soils in agricultural production, in particular Histic Gleysols, Gleysols, Histic Gleysols and Histosols.

An important role in plant nutrition belongs to Phosphorus, which has a dominant role in the fertilizer system. The gross phosphorus content is closely related to the profile distribution of organic matter content ([2], [3], [11], [17]). On average in the region, crop yields are limited by the content of mobile phosphorus compounds (Table 3).

Table 3. Distribution of area areas by content of Phosphorus mobile compounds [17]

Years of Survey	Surveyed area, K. ha	Soil area by content of mobile Phosphorus compounds											
		Very low		Low		Average		Increased		High		Very high	
		K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%
1986–1990	748.2	52.3	7	204.9	27	229.5	31	136.1	18	114.4	15	11.0	1
1991–1995	571.7	20.2	4	78.4	14	177.0	31	137.7	24	147.0	26	11.4	2
1996–2000	436.6	18.9	4	59.4	14	155.1	36	107.2	25	93.6	21	2.4	1
2001–2005	547.4	28.5	5	70.8	13	161.9	30	119.4	22	155.3	28	11.5	2
2006–2010	610.8	23.9	4	58.5	10	149.6	24	135.9	22	210.0	34	32.9	5
2011–2015	497.6	15.3	3	42.9	9	150.6	30	105.8	23	157.8	32	61.3	12

According to the agrochemical certification of the last three rounds (2001–2015), there is a slight increase in the content of mobile phosphorus compounds in the soils of arable lands of the region. During 2011–2015, the weighted average content of mobile phosphorus in soils was 136 mg/kg of soil, which is 23 mg more than in the period 2001–2005. One of the reasons for some increase in mobile phosphorus in Luvic Greyzemic Phaeozems and Phaeozems is their acidification. due to the systematic application of mineral fertilizers. This certainly contributes to increasing the investment attractiveness of land plots within which these soils are modal.

Potassium is also one of the most important nutrients in plants. Insufficient amount of available potassium in the soil not only reduces the possibility of obtaining a high yield, but also deteriorates its quality ([2], [3], [11], [17]). Application of potassium fertilizers in optimal doses affects the productivity of major crops and reduces the harmful effects on plants of extreme conditions: high and low temperatures, insufficient humidity, diseases and pests, and so on.

According to the agrochemical certification of agricultural lands, the share of soils with very high potassium content in L'viv region is increasing, and, accordingly, the area with its average content is decreasing (Table 4).

Based on the research of the L'viv branch of the state institution "Institute of Soil Protection of Ukraine", it has been established that in recent years the content of mobile compounds of Potassium in the soils of the region has increased slightly. Therefore, the weighted average content of potassium compounds in arable soils is 88 mg/kg of soil, which is 11 mg/kg of soil more than in the previous survey period. Soils of land plots, which are characterized by high and high content of mobile compounds of Potassium, especially with medium yields and a certain set of crops, can meet the needs of plants in this element without deficit and are characterized by increased investment attractiveness.

The system of agriculture, especially the degree of its intensification, determines the role of factors in the formation of crop yields. Under intensive agriculture, about 61% of the crop is

formed by fertilizers and plant protection products, and soil fertility accounts for 15% of the crop. In the extensive system, on the contrary: fertilizers account for 10%, and soil fertility and weather conditions – 60% [11]. It is the extensive system of agriculture used in the vast majority of agricultural enterprises in the region. So, there is a constant loss of nutrients and humus. This is confirmed by the data of agrochemical certification of lands, which was carried out on all fields and land plots every five years,

as well as calculations of the balance of organic matter and nutrients.

Calculations of the balance of basic nutrients confirm the process of reducing soil fertility of arable lands of L'viv region of Ukraine. Beginning in the 1990s, a negative balance of Nitrogen, Phosphorus and Potassium was rapidly formed, ranging from 30 to 112 kg/ha. This negative process is exacerbated by soil erosion.

Table 4. Distribution of area areas by content of Potassium mixtures [17]

Year	Surveyed area, K. ha	Soil area by content of mobile Potassium compounds											
		Very low		Low		Average		Increased		High		Very high	
		K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%	K. ha	%
1986–1990	748.2	25.7	3	203.9	27	251.5	34	173.1	23	89.7	12	4.3	1
1991–1995	571.7	15.3	3	136.3	24	180.5	32	141.6	25	90.8	16	7.1	1
1996–2000	436.6	27.8	6	154.3	35	134.7	31	76.5	18	42.4	10	0.9	0.2
2001–2005	547.4	20.1	4	156.1	29	184.4	34	116.7	21	69.5	13	0.6	0.1
2006–2010	610.8	20.0	3	151.2	25	186.9	31	147.2	24	96.1	16	9.4	2
2011–2015	497.6	14.4	3	152.2	31	134.2	27	148.2	30	96.9	19	39.8	8

Long-term research shows that the use of soils under field crops with unbalanced fertilization inevitably causes an acute shortage of certain nutrients. Thus, the estimated data on the balance of nutrients in agriculture in the L'viv region in 2017

indicate that a total of 189 Nitrogen, 52 Phosphorus, 128 kg/ha of potassium are lost. Nutrient losses exceed revenues, respectively, a negative balance of Nitrogen (22 kg/ha), Phosphorus (10 kg/ha) and Potassium (22 kg/ha) is formed (Table 5).

Table 5. Nutrition balance and intensity of nutrition balance in soils [17]

Years	Income, kg/ha	Removal, kg/ha	Balance, kg/ha	Balance intensity, %
1981–1985	358.5	240.4	118.1	149
1986–1990	443.8	283.2	160.6	157
1991–1995	317.8	347.5	-29.7	91
1996–2000	83.7	131.1	-47.4	64
2001–2005	64.2	127.1	-62.9	51
2006–2010	123.5	175.9	-52.6	70
2011–2015	208.1	320.3	-112.2	65
2016	323.2	359.6	-36.4	90
2017	314.5	368.0	-53.5	85

The calculation of the balance of humus allows us to trace the nature of changes in its content in the existing structure of sown areas and the level of application of mineral and organic fertilizers. According to estimates, the balance of humus in the soils of the region in recent years has been acutely deficient and ranged from -0.75 t/ha in 2001–2003 to -0.27 t/ha in 2015. The main reason for this is the extremely low application of organic fertilizers. On average, during 2006–2017, less than 1 ton of manure per 1 ha of sown area was applied in the region's farms, while the minimum rate for ensuring a deficit-free balance of humus for the Forest-Steppe is 6-8 t/ha. In 2016 and 2017, the estimated balance of humus is positive and is, respectively, 0.06

and 0.01 t/ha. The increase in humus content is due to the humification of plowed crop residues (straw of cereals, corn stalks, sunflower, rape, sugar beet tops) [17].

The analysis of the performed calculations of the balance of nutrients, humus and generalization of the results of ecological and agrochemical condition of soils shows the strengthening of the complex of degradation phenomena, in particular the reduction of the content of nutrients. To stop degradation processes and restore soil fertility, it is necessary to increase the application of organic and mineral fertilizers and chemical ameliorants.

high level of economic soil fertility, a significant share of agricultural land in the land structure and the possibility of growing crops are favorable factors of investment attractiveness of agricultural land use.

4. Conclusions and Recommendations

Our analysis allows us to draw the following conclusions:

1. Favorable geopolitical location of L'viv region of Ukraine, cross-border cooperation, well-developed infrastructure,

2. It is established that the most reliable and dynamic information about the state of soils of agricultural lands of the

region is contained in the results of agrochemical surveys, which we propose to use to improve the criteria for regional assessment of investment attractiveness of land.

3. The current ecological and agrochemical condition of soils of L'viv region is the basis for the formation of a reliable system of indicators of regional investment attractiveness of soils of agricultural land for the needs of foreign and domestic investors, especially during the implementation of Ukraine's European integration strategy.
4. Problematic aspects in creating a favorable investment climate in L'viv region are primarily increased development (agronomization) of soils of agricultural lands, i.e their excessive plowing, exceeding the allowable mechanical load, intensive and unregulated technologies, which are common causes of soil degradation, in particular.
5. Features of market conditions and demand for crops (blueberries, flax, hemp, etc.), the cultivation of which requires acidic soils can not only reduce the cost of chemical reclamation, but also to involve in agricultural production unproductive soils, including Histic Gleysols, Gleysols, Histic Gleysols and Histosols.
6. The proposed indicators of investment attractiveness of soils of L'viv region of Ukraine are the key to the introduction of a balanced type of land use, which is characterized by high crop yields and deficit-free balance of nutrients in soils, and thus minimize possible investment risks.

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