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ASSESSMENT OF LAND RESOURCES PRODUCTIVE POTENTIAL INFLUENCE ON AGRICULTURAL PRODUCTS GROSS OUTPUT IN UKRAINE

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Abstract

Ukraine is a country exporting vegetable agricultural products. Agriculture continues to actively develop and fill the state budget, despite political and economic problems, lack of agricultural land market. The productive potential of agriculture requires constant monitoring and effective regulation of land use. A case study was carried out for 2013–2016 at the administrative districts level of the Forest-Steppe Province of Kyiv Oblast, to analyze and evaluate the existing development of productive potential of agricultural areas. The dependence between the point of ecological and agrochemical evaluation of agricultural land and the result of water erosion of soils and their influence on gross output and its profitability was observed. An estimation of the differential productivity of grain crops is carried out. The economic (mathematical) description of the dependence between the productive potential of soils, its qualitative properties, the influence of erosion processes and grain crop yields is given. The production and economic losses caused by the reduction of the productive potential of agricultural land were calculated.

Key words**:** *productive potential, agricultural production of Ukraine, soil erosion, yield, ecological and agrochemical assessment point*

INTRODUCTION

Agriculture is one of the main sectors in the Ukrainian economy, which forms the gross domestic product and fills the state budget of the country. The production of agricultural products fully ensures satisfaction of the domestic market demand and generates exports.

The yield of agricultural crops, in particular grain crops, by regions and in general in Ukraine, tends to increase. The growth of the crop yields of the main crops was facilitated by the opening of the Ukrainian agrarian market to western technologies and more productive crop varieties. However, Ukraine has not reached the same level as Western European countries, even with positive dynamics over the past twenty years, despite 44% yield increase. In general, in France, Germany, Italy, Spain, soil quality is not better than one of Ukrainian black earth, but the yield of major crops is twice as high as in Ukraine. This means that, in addition to proper agricultural technology and environmental requirements Western European countries support and improve the quality of arable land. According to the Educational and scientific institute for economics and ecology of nature use ukrainian agricultural producers receive 79% of their profits due to natural soil fertility and only 21% as a result of technologies introduction (stand 09.12.2015) [4]. Therefore, Ukrainian agricultural enterprises receive high yields, which means additional profits, due to the high quality of soils.

However, there are several problems in general in the state, as well as in certain regions that restrain the development of agriculture. Most of arable lands has erosion influenced soils. Fertilization of soils during last 25 years wasn't fully effective, which adversely affected the overall quality of soils.

The question arises: which indicators should be used for the further forecast of crop yields.

For more effective research it is necessary to analyze these dynamics at the regional level.

The territory of the Forest-Steppe Province of Kyiv Oblast has been selected for the study as the territorial basis of natural-agricultural regionalization.

The purpose of the case study is to analyze and assess the impact of the productive potential of land resources on the gross output of agricultural products in the Forest-Steppe Province of Kyiv Oblast.

As a part of preparation to this case study a **literature review** was made.

Demidov *et al.* (2008) described the impact of energy-depleting crops on soil fertility and the consequences of intensive cultivation of these crops in case of non-compliance with crop rotation [2].

Kvasha (2011) proposed ways to improve the mechanisms for creating a market equilibrium in agricultural production [5].

Pankiv (2008) analyzed environmental problems in modern land use and proposed the main areas of land protection [7].

Shuvar (2011) emphasized the main problems of reducing the fertility of soils in Ukraine: inefficient agricultural use and intensified impact of degradation processes [8].

Panagos and Meusburger (2014) described the general system for erosion processes monitoring and their effectiveness in the European Union (EU) [6].

Borrelli and Paustian (2016) considered the problems of soil potential changing as a basis for growing agricultural products and impact on it of climate change and erosion processes [1]. They also considered the influence of agricultural and environmental conditions on erosion processes and analyzed the balance of nutrients in soils.

MATERIALS AND METHODS

To determine the economic (mathematical) description of the relationship between the productive potential of soils, its qualitative properties, the increase in yield and the impact of erosion processes, we use the formula as an algorithm for finding a solution for rational use of agricultural land.

In order to determine the impact of soil quality on the yield of gross plant products, in particular grains, it is necessary to calculate the approximate yield. To do this you need to know the qualitative soil condition, which is reflected in the points of ecological and agrochemical assessment.

According to the published methodology of agrochemical estimation of agricultural lands by the state institution "Soil Protection Institute of Ukraine", one (1) point of the **ecological and agrochemical evaluation** is equal to 0.41 quintals per hectare of grain units. That is, having 50 points of ecological-agrochemical assessment, we will receive 20.5 q/ha of natural productivity. Natural yield in this case is the minimum that can be obtained on these soils, using the productive fertility of the soil, without introducing agrotechnologies [9].

The coefficient of crop increment is an indicator of how many times the actual yield is greater than the natural. The coefficient of growth of yield is an indicator, which contains agrotechnology, agricultural machinery, high yield varieties of plants. It is relevant only for a specific research object, which is characterized by almost identical natural conditions and soil quality. The indicator, which is the largest among the administrative districts, is selected, if there is no obvious erosion on the territory with the maximum increase. For the territory of the Forest-Steppe Province of Kyiv region, the growth rate of the crop will be 3.4 for all administrative districts.

The coefficient of soil degradation (water erosion effect). By calculations of Dobryak et al. (2009), 19% of the total arable land of Ukraine are degraded and unproductive soils. Of course, their share is different for each administrative district. Their use is always risky. They have different degrees of impact on soil quality, which in the future will negatively affect the yield of crops [3]. This coefficient ranges between 0.7 and 1 in increments of 0.05.

The balance coefficient (humus and fertilizer) is characterized by the amount of used fertilizers and the actual humus balance in soils. When fertilizers are used in sufficient quantities, the humus balance is deficient. Humus balance does not directly affect the quality of the soil, on which also the yield of

crops depends. In the past 20 years, in general, organic and mineral fertilizers use have been insufficient in Ukraine. While natural fertility is very high, the deficit of humus balance did not negatively affect the yield of important crops. Beginning in the 2000s, a negative tendency was observed with a decrease in the qualitative characteristics of soils due to insufficient fertilization. Also, this negative trend is indicated by a decrease in the score of ecological and agrochemical assessment of soils. Consequently, the balance coefficient (humus and fertilizer), apart from erosion, began to affect the yield of crops, restraining it. This coefficient ranges between 0.7 and 1 in increments of 0.05.

The differential yield for grain crops (q/ha) can be calculated according to the following formula:

$$Dy = Pea * 0.41 * Ci * Cd * Cb$$

where:

Dy – The differential yield for grain crops (q/ha);

Pea – score of the ecological and agrochemical evaluation;

Cg = 0.41 – coefficient for grain crops (1 point = 0.41 q/ha);

Ci – coefficient of crop increment;

Cd – coefficient of soil degradation (water erosion effect);

Cb – balance coefficient (humus and fertilizer);

Pea*0.41 – natural fertility, if Dy is less than natural fertility, the cultivation of agricultural crops is ineffective.

The results are displayed in the Table 2.

RESULTS AND DISCUSSIONS

First of all, we briefly analyze the existing productive potential of agricultural land on the basis of collected data and then the results of our calculation.

Agriculture in Ukraine is one of the leading industries. Its Forest-Steppe Province of Kyiv Oblast, as an element of natural and agricultural zoning, has the most favorable conditions for the development of agriculture. This is facilitated by: convenient economical and geographical location, favorable natural and climatic conditions, developed logistics network of roads, production and market infrastructure, as well as the possibility of using and attracting investment. According to the Main Department of Statistics in Kyiv Oblast, 559 agricultural enterprises are registered, 541 of them are non-state and 18 state enterprises. The total area of agricultural land used by these enterprises is 1,517.5 thousand hectares. 361 agricultural enterprises were registered in the Forest-Steppe Province. The total area of agricultural land used by these enterprises is 630 thousand hectares. Almost 93% of these lands are rented by agricultural enterprises [10].

Crop production in Ukraine prevails over animal husbandry. In the Kyiv Oblast there is a ratio of 62% (crops) to 38% (animals). The main areas of crop production on this territory are the cultivation of grain crops, sunflower, sugar beet, soya, rapeseed, and others. The largest gross output of plant products in the Forest-Steppe Province of Kyiv Oblast is represented by following of crops: corn for grain, sugar beet, wheat, sunflower seeds, soybeans, barley and rape. Their share in the grown is 98% on the territory of the research object and 75% in the Kyiv Oblast. Corn for grain, sunflower and rape occupy more than half of the fields in the Forest-Steppe Province of Kyiv Oblast. These crops intensively deplete the soil in case of intensive cultivation and interrupting the crop rotation [10].

In Table 1 it can be seen that the Makarivsky, Kyiv-Svyatoshinsky and Fastivsky districts have the lowest ecological and agrochemical score of 26-42 points, which affects the low level of gross output. Also, having similar qualitative soil composition, the gross output in the Makarivsky district is almost twice as high as in the Kyiv-Svyatoshinsky district.

Stavishchensky, Rokitnyansky and Taraschansky districts have some of the most favorable soil-climatic conditions on the investigated territory. According to the state institution "Institute of Soil Conservation of Ukraine" (Stand 11.08.2017) on the territory of these regions, the ecological-agrochemical assessment score characterizes the condition

of the soils as medium and high quality in the range of 50-66 points.

Table 1. Interdependence between environmental and agrochemical estimation, gross output and profitability in the Forest-Steppe Province of Kyiv Oblast for 2013–2016

№	Administrative units, raion (district)	Ecological and agrochemical score in points for 2015	Yield of grain crops, q/ha	Gross output		Profitability, %
				Of research object, %	Of Kyiv Oblast, %	
1	Kyiv-Sviatoshinsky	28	39.0	0.7	0.3	10
2	Makarivsky	26	37.7	1.2	0.6	19
3	Fastivsky	42	57.3	0.7	0.3	34
4	Bohuslavsky	41	50.4	2.5	1.2	38
5	Obukhivsky	59	54.8	2.0	1.0	27
6	Rokytniansky	66	56.0	4.1	2.0	27
7	Stavyschensky	50	52.7	4.4	2.1	30
8	Taraschansky	48	50.6	4.0	1.9	27
9	Volodarsky	46	51.5	5.6	2.7	45
10	Kagarlytsky	67	56.5	5.7	2.7	35
11	Skvyrsky	60	50.1	6.5	3.1	23
12	Bilotserkivsky	64	53.4	6.9	3.3	36
13	Tetiivsky	50	54.8	6.1	2.9	26
14	Vasylkivsky	60	58.1	28.4	13.7	85
15	Myronivsky	52	51.4	21.2	10.2	13
Total for research object		51	51.6	100.0	48.2	32

Source: The Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

According to the data of the Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), the share of manufactured products in Vasylkivsky and Myronivskiy districts is 13.7% and 10.2%, the largest in the Forest-Steppe Province of Kyiv Oblast. These districts have almost the same ecological and agrochemical score of 52-60, which characterizes the state of the soil as medium and high quality. However, in terms of profitability, these districts are fundamentally different. Vasylkivskyi district has a profitability of 85%, almost the highest profitability among districts of Kyiv Oblast. Unlike Mironivskyi district, where the profitability rate with 13% stays at the level with Makarivsky and Kyiv-Svyatoshinsky districts. Profitability is a more economical category, and besides the quality of soils and the amount of cultivated crops, it is also influenced by demand on the foreign market.

There is a dependence between the ecological and agrochemical score, the gross output and the profitability of agricultural enterprises. Territories with similar qualitative features give almost the same amount of products and profitability of farms, the deviation caused by different agrotechnics and a more successful selection of the nutritional complex.

Also, the indicators of gross output and profitability are affected by existing erosion processes on agricultural land. There are significant areas of soil that are negatively affected by water erosion on the territory of the Forest-Steppe Province of the Kyiv Oblast. On these soils, the stock of humus, nitrogen, phosphorus, potassium and other

nutrients decreases, which leads to loss of productive soil fertility.

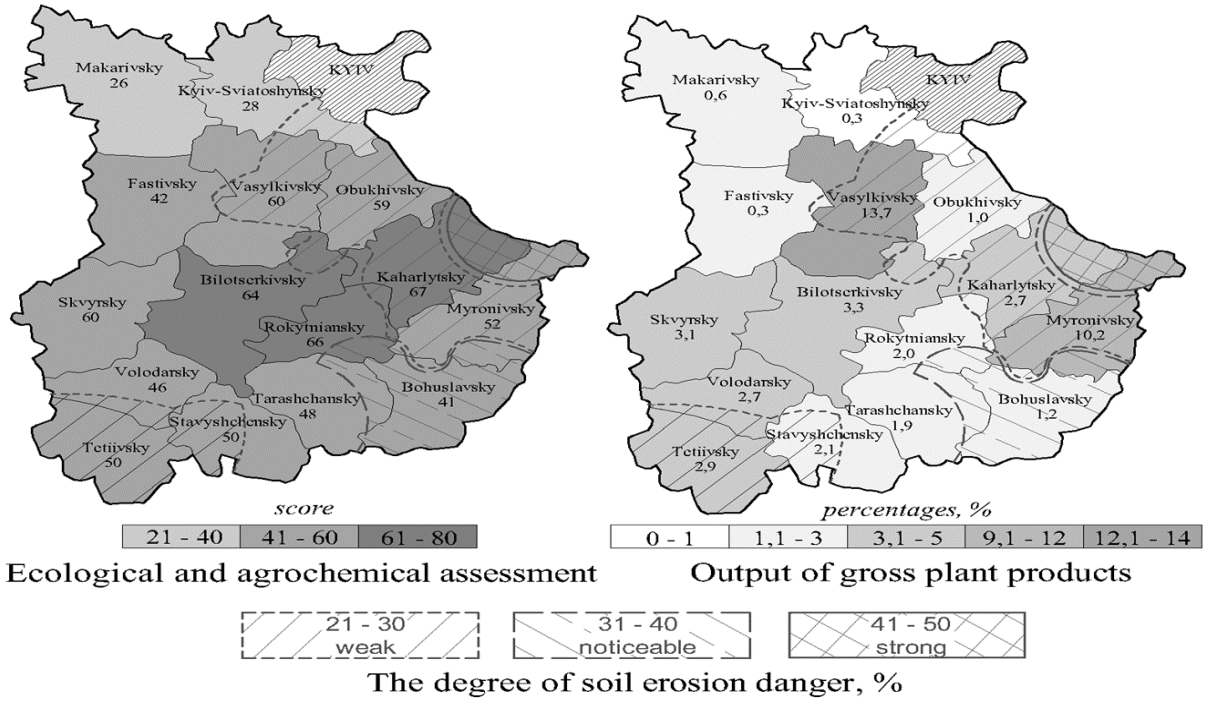

Fig.1. Influence of erosion on soil quality and yield of plant products in the Forest-Steppe Province of Kyiv Oblast for 2013–2016 years
Source: Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

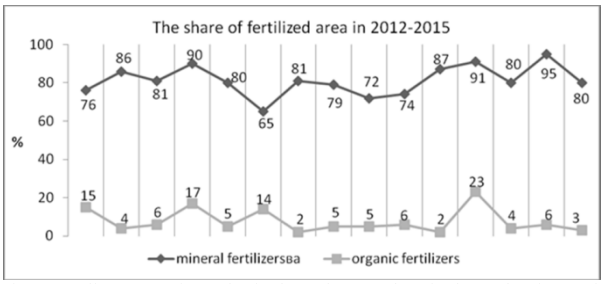

Fig.2. Indicators of ecological and agrochemical evaluation of agricultural land quality in the context of the administrative districts of the Forest-Steppe Province of Kyiv Oblast for 2010–2015- The share of fertilized area in 2012-2015 (%)
Source: Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

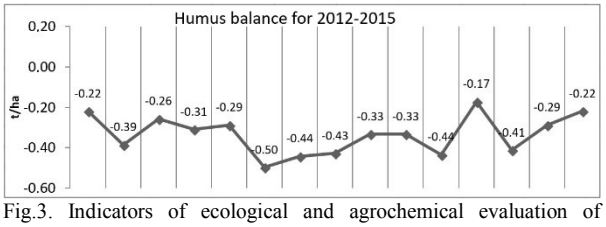

Fig.3. Indicators of ecological and agrochemical evaluation of agricultural land quality in the context of the administrative districts of the Forest-Steppe Province of Kyiv Oblast for 2010–2015, Humus Balance for 2012-2015 (t/ha)
Source: Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

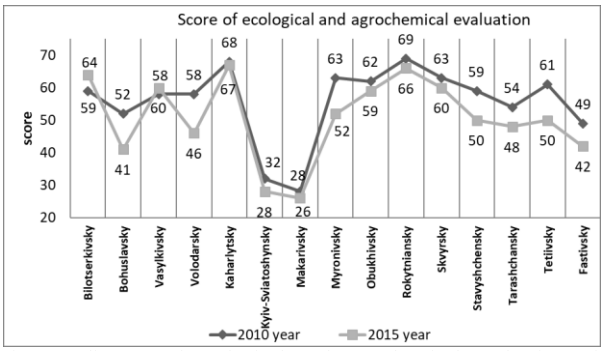

Fig.4. Indicators of ecological and agrochemical evaluation of agricultural land quality in the context of the administrative districts of the Forest-Steppe Province of Kyiv Oblast for 2010–2015, Humus Balance for 2012-2015 (t/ha) – Score of ecological and agro-chemical evaluation.
Source: Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

In general, the productive potential of agricultural land can have three elements of obtaining plant products. The first element of obtaining gross output due to the natural fertility of soils. The second element is the non-exhaustion of soils, i.e. the quality-derived soil characteristics reduced by harvested crops and can be returned in the form of fertilizers and have a positive balance

of humus. The third element is like the second, but it multiplies the qualitative properties of soils and has a deficit-free humus balance.

In carrying out an analysis of existing use of productive potential of agricultural land on the territory of the Forest-Steppe Province of Kyiv Oblast, the amount of gross agricultural output is achieved exclusively due to natural fertility, which decreases with each passing year. For 20 years, it tends to decrease and produces negative indicators of humus accumulation. Soil quality is one of the main indicators that affects the final cost of grown products (Fig. 1, Fig. 2, 3 and 4).

The next step is to calculate the differential yield for grain crops (q/ha) using the formula described in materials and methods chapter:

$$Dy = Pea * 0.41 * Ci * Cd * Cb$$

The results of these calculations are displayed in the Table 2.

Table 2. Calculation of the differential yield of grain crops in the context of administrative districts of the Forest-Steppe Province of Kyiv Oblast for 2013–2016

№	Administrative units, raion (district)	Pea – score of the ecological and agrochemical evaluation for 2015	Cg – coefficient for grain crops	Ci – coefficient of crop increment	Cd – coefficient of soil degradation	Cb – balance coefficient	Dy – The differential yield for grain crops, q/ha	Sy – Yield according to statistics, q/ha
1	Kagarlytsky	67	0.41	3.4	0.75	0.8	56.0	56.5
2	Bilotserkivsky	64	0.41	3.4	1	0.8	71.4	53.4
3	Skvyrsky	60	0.41	3.4	1	0.7	58.5	50.1
4	Rokytniansky	66	0.41	3.4	0.8	0.75	55.2	56
5	Vasylkivsky	60	0.41	3.4	0.9	0.8	60.2	58.1
6	Obukhivsky	59	0.41	3.4	0.85	0.8	55.9	54.8
7	Myronivsky	52	0.41	3.4	0.8	0.8	46.4	51.4
8	Taraschansky	48	0.41	3.4	0.9	0.8	48.2	50.6
9	Tetiivsky	50	0.41	3.4	0.9	0.85	53.3	54.8
10	Stavyschensky	50	0.41	3.4	0.9	0.9	56.5	52.7
11	Bohuslavsky	41	0.41	3.4	0.8	0.8	36.6	50.4
12	Volodarsky	46	0.41	3.4	0.9	0.85	49.1	51.5
13	Fastivsky	42	0.41	3.4	1	0.95	55.6	57.3
14	Makarivsky	26	0.41	3.4	1	0.95	34.4	37.7
15	Kyiv-Sviatoshinsky	28	0.41	3.4	1	0.95	37.1	39
Average		51	0.41	3.4	0.9	0.8	51.6	51.6

Source: The Main Department of Statistics in Kyiv Oblast (Stand 11.06.2017), State institution "Soil Protection Institute of Ukraine" (Stand 11.08.2017) and calculations of authors

As a result of the calculation of grain crop yields, it was possible to reach the medial value of the data of the State Statistics Service. The correlation coefficient between the differential yield and the actual yield on the average statistical data was 0.81, which is high for the comparison of two values that lie in one linear plane of the calculation. Consequently, spatial differential yield can be considered very close to statistical yields within the margin of error up to 3%.

However, calculated differential yield in certain districts: Bilotserkivsky, Myronivsky and Bohuslavsky differ from the statistical

yield significantly. This difference is due to a sharp change in the score of ecological and agrochemical assessment for these areas, as well as other factors inherent in these areas. Excluding the data of these districts from the general calculation will not affect the significance of the study and lead to increase of correlation coefficient, which without excluding, should be 0.73.

To compare the changes in the productive potential of arable land, a similar calculation was made, using the score of the ecological-agrochemical assessment for the 2010 survey tour, which is shown in Figure 4. Other indicators remain stable. Thus, the average differential yield of grain in terms of administrative districts was 55.3 q/ha in 2010, which is 10% more than the differential as well as statistical yield for 2013-2016 – 51,6 q/ha. Consequently, with the same application of agronomic technologies, it was established that the reduction of soil quality, led to a loss/shortage of 10% of the grain crop gross output for each year. It is a significant decrease over the term of the study.

Having an average sale price of grain crops in the administrative districts of Kyiv Oblast, we can calculate the economic losses of farmers from potentially lost harvest.

Thus, in 2013, agricultural producers could receive additional income of UAH 16 million, which at the rate of 2013 was $ 2 million. In 2014, additional profit could be up to UAH 81 million, which is equal to $ 5 million. In 2015 – UAH 148 million, equivalent to $ 9 million. In 2016 – UAH 324 million, or $ 12 million. Therefore, over the past four years, agricultural enterprises and farmers has lost an additional net income of $ 28 million due to soil quality degradation.

CONCLUSIONS

As a result of the study, the influence of productive potential of land resources on agricultural products' gross output in the Forest-Steppe Province of Kyiv Oblast was proved. Reducing the quality of soils causes a loss of 10% of the grain crop for each year, even with increased yields due to weather conditions and growing technologies.

The negative trend in quality indices of agricultural soils reduction with insufficient fertilization of soils and existing erosion processes affects the gross output of agricultural products. Reducing the quality of soils leads to increased economic losses and violates the humus balance which restoration requires a significant amount of years. It leads as well to significant financial losses by agricultural enterprises and farmers ($28 million in 4 years).

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