ECOLOGICAL AND ECONOMIC ASPECTS OF LAND USE: PRODUCTIVITY, ENVIRONMENTAL PROTECTION MEASURES, AND LAND PARCEL DIVISION

Oleksandr MAKARCHUK, State Biotechnological University, Ukraine, email: sanijdelii@gmail.com
Yulia SENICHKINA, State Biotechnological University, Ukraine, email: julia6668899@gmail.com
Serhii VYNOHRADENKO, State Biotechnological University, Ukraine, email: s.vinogradenko15@gmail.com

Abstract

This study focuses on the issues of environmentally sustainable land use and its economic efficiency. The paper examines the theoretical and methodological foundations for ensuring the sustainable development of land resources and analyzes the natural and economic conditions of land use in the Krasnograd district of the Kharkiv region. The relevance of this research is driven by the need to implement environmentally safe land use as a crucial component of sustainable development. Rational use of land resources contributes to increased productivity, soil fertility preservation, and minimization of negative environmental impacts. The study employs methods of system analysis, cartographic modeling, economic-statistical assessment, and comparative approaches to determine land use efficiency. The primary focus is on optimizing the structure of agricultural land, implementing modern soil cultivation technologies, reducing anthropogenic pressure, and ensuring the rational use of land resources. The practical significance of the study lies in the development of recommendations that can be used by local governments, agricultural enterprises and environmental organizations. The proposed project solutions include changes in the structure of crop rotation, measures to prevent soil erosion, improving land allocation for farm buildings and other approaches to rational land use. The results obtained can be adapted to other regions with similar natural and economic conditions.

Keywords: sustainable development, soil protection, soil erosion, crop rotation, environmental protection measures

Introduction

Land is a basic resource for the existence and development of human society, playing a key role in the production and satisfaction of human needs. At the same time, agriculture is an important sector that ensures food security and is linked to the fundamental right to food and nutrition. In the context of current environmental challenges and economic transformations in Ukraine, the issues of rational and environmentally friendly land use are becoming particularly relevant. In particular, there is an increase in production pressure on natural resources and a growing need to implement effective measures to protect them.

The development of land relations is a complex and multifaceted process that is impossible without clear regulation and a balanced approach to the use of land resources. In today's environment, especially after the Russian invasion, land use issues are gaining both theoretical and practical importance. On the one hand, it is about generating profits and ensuring the production of sufficient agricultural products. On the other hand, it is the need to protect land, rationalize the use of chemical fertilizers and pesticides, control product quality and maintain soil fertility.

According to O. Shkuratov, it is time for a new ecological and economic thinking based on a harmonious combination of environmental priorities of agricultural production with the economy, that is, the transition of the system of ecological and economic land use to the principles of environmentally sound development (Shkuratov, 2019).

The formation of environmentally safe agricultural land use requires the creation of appropriate legislative, financial, economic, managerial and technological conditions aimed at restoring and improving the quality of land (Vynohradenko et al., 2023). For this purpose, it is important to take into account the cause-and-effect relationships between environmental and economic aspects of management. According to R. Taratula, environmentally friendly land use in the broad sense means improving the environment while ensuring food security, and in the narrow sense it involves the development and implementation of effective technological, economic and legal measures for the rational use of land, its conservation and restoration of productivity (Taratula, 2018).

Research aim: Today, Ukraine is facing a difficult environmental and economic situation due to inefficient use of land resources. Much of the arable land is degraded due to erosion, industrial waste pollution, depletion of soil fertility, and imbalance between arable land, natural fodder lands, and forests, which negatively affects the sustainability of agricultural landscapes. Irrational land use leads to an increase in the area of unproductive land, an increase in the anthropogenic burden and a decrease in the economic efficiency of agricultural production (Makarchuk et al., 2024). At the same time, the modern development of the agricultural sector requires the introduction of new approaches to land management aimed at preserving soil fertility, optimizing the structure of land and minimizing negative environmental impact. However, most modern technologies remain highly costly and energy-intensive, making it difficult to implement them on a large scale. Reduced soil protection measures, excessive use of chemical fertilizers and lack of a comprehensive approach to environmental policy pose a threat of further land degradation (Kupriianchyk, 2020). This requires deeper research into environmentally sound agricultural land use, development of effective environmental protection measures and improvement of land management methods to ensure its sustainable use and restoration.

Purpose of the study. To improve the theoretical and practical foundations of ecological and economic efficiency of land use in the Krasnohrad district of Kharkiv region on the basis of environmentally sound land use.

Main objectives. To achieve this purpose, the main objectives were identified: substantiation of the theoretical foundations of environmentally sound land use, analysis of legislative and regulatory support, study of the current land use conditions and development of proposals for improving the environmental and economic efficiency of land use for sustainable development of local economy.

In solving the problem of greening land use, the main tasks are to optimize the ratio of agricultural and natural lands, and to organize soil protection in the context of individual crop rotation arrays of fields and working plots. Taking these indicators into account has a significant impact on the efficiency of agricultural enterprises (Khodakivska, 2015).

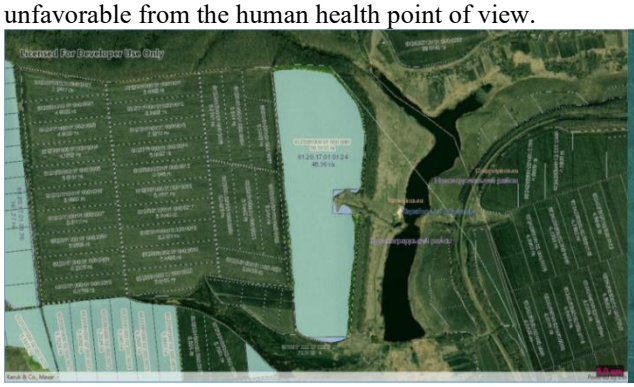
Research object and methods

The object of the study The object of the study is the territory of Kharkiv region, for a more detailed consideration of the problem, a land plot in the Krasnohrad district, which is located in the western part of the region, is selected, the site requires immediate implementation of measures for the effective and rational use and protection of land, and requires great attention in research and further improvement, because it has an angle of inclination of ~ 10° and the loss of the field protection forest belt and part of the field is already being monitored (Fig. 1, Fig. 2).

Methods of study. The research used the following methods: analysis, monographic, and abstract and logical. The analysis method was used to study the characteristics of agricultural land and aspects of land management in the system of land relations. The monographic method was used to determine the effectiveness of the proposed solutions that ensure the rational use and protection of land. The abstract and logical method was used to determine the essence of agricultural land management and their special status.

Research results and discussion

Among European countries, Ukraine has the highest integral indicator of negative anthropogenic impacts on almost all of its territory, and the ecological situation and environmental quality are characterized as acutely critical and unfavorable from the human health point of view.



Source: compiled by the author (Makarchuk)

Fig. 1. Land plot location layout

Source: compiled by the author (Makarchuk)

Fig. 2. Field problem area

Soil erosion is one of the most serious environmental problems in Europe as well, threatening agriculture, biodiversity and landscape stability. According to the European Environment Agency, approximately 13% of the continent's agricultural land (about 115 million hectares) is affected by erosion. The most vulnerable are the countries of the Mediterranean region (Spain, Italy, Greece), where erosion is accelerated by droughts and improper agricultural practices. In France, erosion destroys an average of 1.5-2.5 tons of soil per hectare annually, while in Switzerland this figure reaches 5-6 tons/ha in mountainous regions.

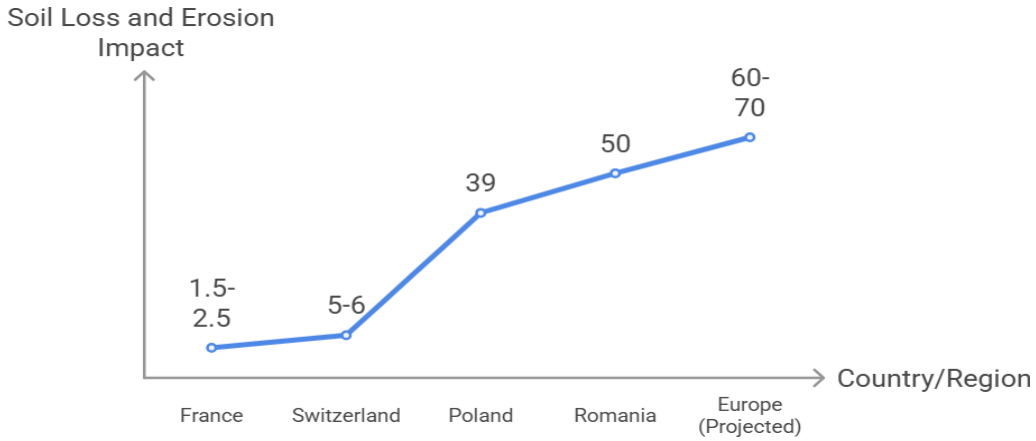
In Switzerland, research by the Federal Institute for Forest, Snow and Landscape Research (WSL) has shown that steep slopes in mountainous areas are particularly prone to erosion due to heavy rainfall and lack of stable vegetation. For example, in a study area near Dallenville, a loss of 1730 m³ of soil was recorded between 2021 and 2024, of which only 370 m³ was deposited in riverbeds. The main factors of erosion here are surface runoff, landslides, and rock falls. To reduce these processes, Switzerland uses digital terrain models, laser scanning, and sediment traps to monitor the extent of erosion and evaluate the effectiveness of environmental protection measures. (WSL, 2015)

In other European countries, erosion is also caused by intensive land use, deforestation, and climate change. For example, in Poland, about 39% of agricultural land suffers from water erosion, while in Romania this figure reaches 50%. In response to these challenges, EU countries are actively implementing erosion control measures: contour farming, cover crops, restoration of forest strips and implementation of agroforestry. Some countries, such as Germany and France, apply soil conservation systems that include reduced tillage and the use of natural barriers against water erosion.

According to forecasts, in the absence of effective erosion control measures, soil loss in Europe could increase by 60-70% by 2070. Such trends are clearly visible in the graph (Fig. 3). To prevent catastrophic consequences, it is necessary

to expand scientific research, promote environmentally responsible agriculture, and develop international cooperation in the field of soil protection (Husarova, 2025).

Thus, it becomes clear that it is necessary to radically change the nature and structure of land use in Ukraine, especially in the agricultural sector, reorienting the directions and structure of agriculture according to ecological and economic principles, as well as switching to a model of sustainable development of the national production complex. The mechanism of environmentally safe land use is an integral part of the economic mechanism of nature management. Therefore, a number of measures should be coordinated with other economic mechanisms and natural processes operating in a single economic management system (Podlevska, 2016).



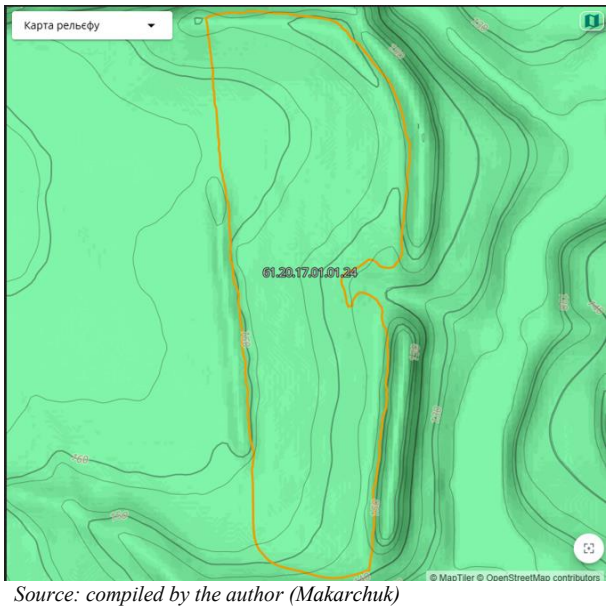
Source: compiled by the author based on WSL, 2015

Fig. 3. Graph of soil erosion and degradation in Europe

The communal agricultural land plot leased by LLC Mriya for commercial agricultural production is located in Zachepylivka village council of Krasnohrad district, Kharkiv region. The total area of the district is 4.91 thousand km² or 491.300 hectares.

Source: compiled by the author (Makarchuk)

Fig. 4. Boundaries layout of land plot agricultural groups



Source: compiled by the author (Makarchuk)

Fig. 5. Boundaries and relief layout of land plot

Krasnohrad district, located in the forest-steppe zone of Kharkiv region, is characterized by a temperate continental climate with warm summers and moderately cold winters. The average annual temperature is about +7.5°C, with an average temperature of +20.2°C in July and -6.9°C in January. Annual precipitation ranges from 500-550 mm, which is typical for the forest-steppe zone of Ukraine.

The relief of the area is an undulating plain with slight elevations and declines, which creates conditions for the development of water erosion. The hydrographic network includes several small rivers and artificial reservoirs used for irrigation and fishing.

The soil cover of Krasnohrad district mainly consists of typical and podzolized chernozems (humus), which are characterized by high natural fertility. However, intensive agricultural use of land without correspondence to agrotechnical standards leads to soil degradation, as shown in Figs. 4, 5.

Water erosion causes the top fertile layer of soil to be washed away, resulting in lower crop yields. Deflation, or wind erosion, is also a serious problem, especially in open areas without sufficient vegetation cover. Disturbances in the water and chemical regimes of soils are manifested in the form of salinization, increased acidity, waterlogging or overdrying. These processes negatively affect the soil structure, its water permeability and aeration, which ultimately reduces crop productivity (Danyliak, 2024.). The result of such actions was a markedly reduced field yield, as shown in Table 1.

Table 1. Harvest results for 2022-2024

Harvest year	Crop culture	Net weight, kg.
2022	Sunflower	128 180
2023	Corn for grain	324 470
2024	Sunflower	95 510

Source: (Kernel, 2024)

In order to preserve and restore soil fertility in Krasnohrad district, it is necessary to implement a set of measures aimed at preventing erosion, restoring vegetation cover, increasing the content of organic matter in the soil, and rationally managing the water regime. This includes the introduction of soil-protective crop rotations, contour reclamation of the territory, slope alkalization, creation of forest belts and other agroforestry measures..

Crop acreage is planned taking into account the fulfillment of obligations to sell crop products, create seed funds, meet the needs of the farm's employees for food, etc..

The works are financed at the expense of the land user, LLC Mriya. To ensure the rational use of land resources and bioclimatic potential, the project envisages the introduction of crop rotation. It is a key element of agriculture that combines various interrelated processes, including tillage, fertilization, seed production, shelterbelt afforestation and land reclamation. On the territory of Mriya, part of the land is moderately degraded, slightly washed away and easily clayey, so it is advisable to introduce a soil protection crop rotation. It involves a system in which crops will be grown that will help reduce soil washout and provide the farm with the necessary products.

Soil protection crop rotation.

The total area is 48.4 hectares.

1. Winter wheat (48.4 ha),
2. Barley (48.4 ha),
3. Corn for grain (48.4 ha),
4. Winter wheat (48.4 ha),
5. Barley (30.0 ha) + Beans (18.4 ha) annual legumes for green manure%, total area is (48.4 ha).

To ensure the rational use of land resources and bioclimatic potential, the project envisages the introduction of crop rotation with flexible crop rotation, which involves replacing some crops with others based on their biological affinity and market demand. Other options for crop rotation are also being considered, but these changes should not violate the biological basis of crop rotation and the principles of sustainable soil use.

The main measures to fight soil erosion are the use of proper tillage methods, effective agronomic practices, creation of protective structures and implementation of crop rotations that restore and maintain soil fertility.

The project, which is being implemented on a land plot leased to LLC Mriya for commercial agricultural production, provides for the following measures to prevent soil erosion and degradation:

- creation of terraces and water protection structures to reduce surface water runoff;
- implementation of agroforestry methods, in particular, planting forest strips and protective strips on slopes;
- contour plowing and the use of cover crops to stabilize the soil cover;
- use of mulching to preserve moisture and prevent erosion;
- ensuring rational land use and protection of land from negative impacts such as salinity, overdrying, compaction and pollution.

In the future, the project envisages the implementation of erosion control and soil restoration measures. One of the steps is to develop a design concept for a 3D terrain model that will allow to assess the structure of the terrain and ensure effective design of water protection structures and agrotechnical measures. These measures will help to preserve natural resources, reduce the negative impact of agricultural activities on the environment and ensure sustainable development of agricultural production.

Conclusions

Rational use of land resources is an important component of sustainable development of the agricultural sector. An analysis of land use conditions in Krasnohrad district showed that a significant part of agricultural land is negatively affected by erosion, soil depletion and inefficient management. Implementation of an environmentally sound approach to land use is necessary to increase productivity, preserve the natural potential of land and reduce anthropogenic pressure.

The study identified the main factors affecting the efficiency of land use, analysed and developed recommendations for optimizing the structure of land. The main measures include the introduction of soil-protective crop rotations, the use of modern tillage methods, improved land distribution and reduction of the negative impact of agrotechnical activities.

The achieved results can be used by local governments, agricultural enterprises and environmental organizations to develop effective land use strategies. The proposed recommendations will contribute not only to increasing the economic efficiency of the agro-industrial complex, but also to ensuring the long-term environmental sustainability of the region, which in turn will increase the prospects for economic growth.

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